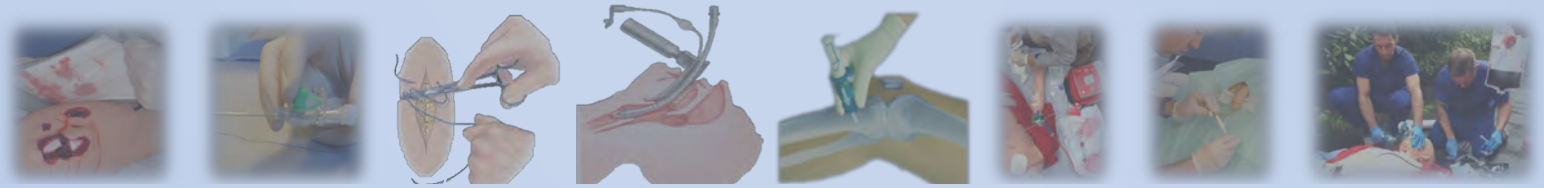
Diver Medic Technician

Course Manual



TRAUMA TRAINING

PREFACE

The Diver Medic Technician (D.M.T.) is an intensive 10-day programme aimed at providing candidates with the skills and knowledge to recognise the seriously injured casualty and to provide appropriate interventions to manage the patient in the offshore diving environment.

The programme adopts an adult learning approach with an emphasis on the practical application of underlying knowledge within the confines of the candidate's professional role. To that end, the programme aims to be both interactive and practical in its delivery.

Teaching will draw upon the evidence based, nationally agreed guidelines and expert consensus opinion where such evidence exists.

Teaching is provided using clinical lectures, practical skills stations and team scenarios.

Knowledge and skills are assessed by means of continual assessment, written examinations and simulated casualty assessment.

Those candidates who reach the required standard are awarded a D.M.T. certificate, which is accredited by International Marine Contractors Association (IMCA).

Lectures and small group teaching sessions are delivered by: Commercial Divers, Doctors, Critical Care Nurses who are highly experienced in hyperbaric medicine, pre-hospital emergency care and battlefield medicine.

This manual is designed to accompany the 10-day course. The aim is to reinforce all of the elements covered.

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Section 1

Casualty Assessment

MANAGING THE SCENE 1.1

In pre-hospital care, when dealing with all emergency situations, it is just as essential to be able to draw conclusions from your observations at the accident scene. Therefore, an understanding of the forces involved and patterns of injury is essential if injuries, which may be life threatening, are not to be missed.
This forms the basis of scene assessment.

Scene Assessment

The history of the incident begins at, for example, at the point of impact of one moving object with a second object. That second object may be either moving itself or it may be immobile. We must understand the exchange of energy that takes place, the direction of the forces involved and therefore recognizes the extent of injuries that may be caused by an accident.

Obviously we must know the details of the accident: who hit what and at what speed, what the stopping distance was and any mechanisms involved in restraining or protecting the individual. Understanding the energy exchange, which takes place and by answering these questions, the rescuer may be able to predict the injuries the accident victim may have sustained. As a general rule of thumb, if an incident involves sudden cessation of high velocity the chances of injuries are high.

Along with high energy incidents are injures which have gross physiological effects.

This is why it is very important to be **highly** suspicious of certain types of incidents that **involve worrying mechanisms of injury**.

These Include:

- Falls (2-3 times victim's height).
- High velocity incidents involving:
  - Blasts
  - Vehicles / craft.
  - Machinery
- Reduced conscious level.
- Penetrating injuries (head, chest, abdomen).

It is worth remembering that it may be true that the incident began at the point of impact, but behind this point in time lies information, which may have a bearing on the patient.

An example of this would be a casualty who has fallen off a structure. On initial assessment, the cause of his injuries appear to be attributed to the impact of falling 10 feet, where in fact, the pre-events have major impact upon his outcome. If this were to be ignored, the casualty's pre-existing diabetic hypoglycaemic event may be missed.

So, when assessing the scene, look for pre-incident clues and post-incident clues.

Approaching a Casualty 1.1.1

You Are Responsible For The Safety Of:

- 1st - yourself.
- 2nd - the scene.
- 3rd - the Casualty.

Hazards/Dangers That May Exist At A Scene May Include:

- The offshore environment.
- Moving vehicles / craft.
- Fighting / angry crowds.
- Fire.
- Cold.
- Electricity.
- Chemicals.
- The weather!

Safety Can Be Seen To Have Four Dimensions:

- Left and right.
- Up and down.
- Front and back.
- And the 4th dimension... Time.

Always be alert for dangers, which may have caused the incident or have resulted from the incident. Safety assessment is time dynamic. As the scene changes safety risks may appear and disappear (for example fires may be extinguished but the ground becomes slippery, cars may drive around corners). It is therefore important to ensure that safety appreciation is updated frequently and not confined to the single assessment at the beginning of the rescue.

S.A.F.E. Approach 1.1.2

With Regards To Safety It Is Advisable To Always Use A SAFE Approach:

S: Shout for help.
A: Assess the scene.
F: Free from danger.
E: Evaluate the casualty.

The SAFE approach is a vital step in overall safety, both to the casualty & his potential rescuers.

The first element of the approach is **S**houting for help. It is very rare that a first aider alone can actually provide definitive care, so alerting fellow bystanders can give a first aider a vital life-line to alerting medical services while they give potentially life-saving initial treatment.

Secondly we **A**ssess the environment for potential or actual dangers. Once they are eliminated or reduced to an acceptable level, the first aider may approach the casualty. It is important to recognize that sometimes it it impossible to actually achieve this in sufficient time for a casualty to survive. A classic example is of a casualty on an electrified railway. The power MUST be switched off before a rescuer can approach the casualty. If this is not achieved then the only result will be an increase in the number of casualties & the number of people needing treatment

Thirdly we **F**ree the casualty from danger. If an environment cannot be made safe then an attempt to remove the victim to a safer area may be attempted. It is important to note that a degree of judgment is needed and any movement must be beneficial to a casualty. For example, if a casualty has been in a car accident there is a chance that they may have had a spinal injury and it is important that they are stabilized insitu until medical help arrives. However if the vehicle is on fire and they will certainly die without moving it is clearly beneficial if they are moved to safety.

Lastly we can **E**valuate. This is a natural progression onto our Quick Look Primary Survey & Secondary Survey. Which will be discussed next.

A Systematic Approach to Casualty Management 1.1.3

As discussed the main principles of First Aid are to:

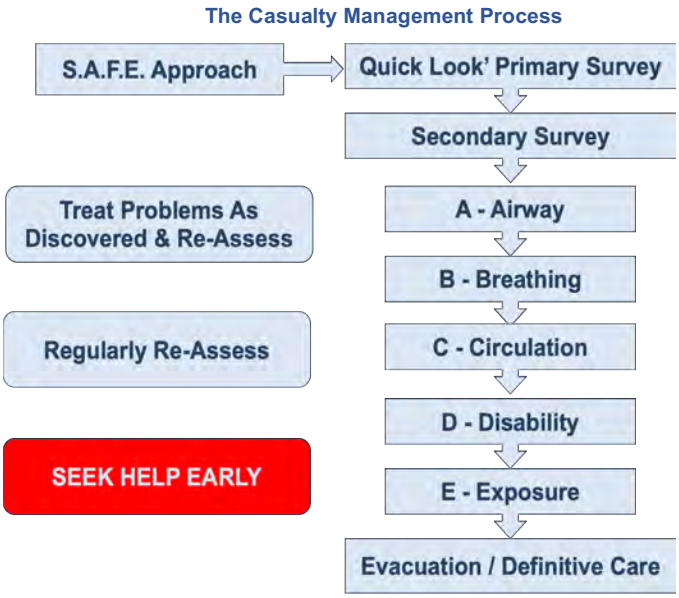
- Preserve life.
- Prevent the situation from worsening.
- Promote recovery.

It is important to achieve these goals in as efficient fashion as possible. It is for this reason that a systematic approach to **EVERY** casualty should be implemented.

This systematic approach has 7 main principle elements,

Which Are:

- Calling for help **Early**.
- **Rapid** 'Quick Look' Primary Assessment.
- **Treat life-threatening** problems as you assess.
- **Assess** effects of treatment.
- **Systematic** Secondary Assessment.
- Definitive **Treatment** / Decision to **Evacuate**
- **Reassessment.**



CASUALTY SURVEY 1.2

'Quick Look' Primary Survey 1.2.1

An assessment of the casualty begins as the First Aider approaches the casualty. Talk to the casualty. Introduce yourself and reassure them that help is at hand. Ask the individual, and/or bystanders, what has happened. If the patient verbally responds to voice commands this tells you, in gross assessment terms, that the patient has an airway, is breathing and has a blood pressure strong enough to adequately perfuse the brain. Remembering that this is an *initial assessment* and their status may change at any moment.

Often the cause may seem obvious, for example, a lying ladder suggests a possible fall from a height, whilst at other times the answers you get could provide vital clues to the diagnosis. Remember, the casualty may have more than one injury.

This “quick look” should only take a few seconds as you approach the casualty.

A Systematic Approach To The Quick Look Primary Survey Is:

The Primary Survey

- Are there ‘worrying mechanisms of injury’?
- Can the casualty complete a full sentence?
  - Airway Implications.
  - Breathing Implications.
  - Cardiovascular Implications.
  - Neurological Implications.
- How does the casualty look ?
  - Demeanor.
  - Colour.
- Immediate impression / Triage status. As with every element of the first aid approach, life-threatening injuries should be dealt with as they are discovered. With regards to triage categorization, this is particularly relevant if there are numerous casualties with a finite amount of first aiders for establishing treatment priorities and evacuations.

Triage categories established in the rapid Quick Look approach are provisional and may be corrected once the casualty is properly assessed.

Emergencies 1.2.2

The first step of treating a medical emergency is in the detection of this emergency. The immediate life threatening conditions which a DMT may discover can be remembered with the mnemonic **ATOMFC :**

- **A**irway obstruction. (Airway section of Secondary Survey)
- **T**ension pneumothorax. (Breathing section of Secondary Survey)
- **O**pen pneumothorax. (Breathing section of Secondary Survey)
- **M**assive haemothorax. (Breathing section of Secondary Survey)
- **F**lall chest. (Breathing section of Secondary Survey)
- **C**ardiac tamponade. (Circulation section of Secondary Survey)

All of the appropriate interventions for these are discussed in the Clinical Skills Section. All of these conditions are detectable in the A.B.C.D.E. survey (which highlights its importance).

Secondary Survey 1.2.3

The purpose of a secondary survey is to provide a systematic approach to the assessment of any casualty. The assessment follows an A, B ,C ,D & E approach.

Which stands for:

- **A**IRWAY
- **B**REATHING
- **C**IRCULATION
- **D**ISABILITY
- **E**XPOSURE

This approach is a well-established *‘gold standard’* approach used in all branches of medical care WORLDWIDE.

This Approach Should Be Applied With A Set Of Simple Rules:

- Be Systematic. A➔B➔C➔D➔E
- Treat Illnesses as they are discovered.
- Once an intervention is made. Reassess.
- Seek help early.
- Reassess.

There is a very good reason why this technique is employed by all branches of medicine worldwide. IT WORKS!

A: Airway 1.2.4

Can the casualty talk? If the patient is *silent* or has a *noisy* airway then the airway should be checked for patency to ensure that it is open and clear that there is no potential for obstruction to occur.

The most common cause of upper airway obstruction is an altered level of consciousness and pharyngeal obstruction by the tongue. Left unmanaged, airway obstruction may lead to hypoxia (lack of oxygen) and ultimately death.

If the airway is compromised then it will have to be opened and cleared. Once an airway is opened and secured it must be maintained. Obviously this must be done initially without moving the neck. However if it is not possible to open the airway without some movement of the cervical spine then the airway assumes the greater priority.

The Airway

Airway obstruction can occur from many causes ranging from the position of the tongue, injuries or the presence of an obstruction within the mouth, air passage to the lungs (perhaps after inhalation, vomiting or regurgitation) or larynx or upper part of the trachea (foreign bodies, epiglottitis, allergic reactions or laryngo-tracheal injuries).

The Airway Should Be Assessed Using A Look, Listen & Feel Approach;

Look

- Are there any visible obstructions. (Inspect the mouth for any foreign bodies and remove anything obvious. DO NOT PERFORM BLIND FINGER SWEEPS. Well fitting dentures may be left in place. Check the airway for any vomit, blood or secretions).
- See-saw respiratory pattern. (A clear airway enables the chest and abdomen to move outwards during inspiration, and inwards during expiration. 'Seesawing' results in the chest moving outwards on inspiration whilst the abdomen moves inwards).
- Distressed, choking.

Listen

- Wheezing: Acute airway constriction.
- Snoring: pharyngeal obstruction by the tongue.
- Crowing: laryngeal spasm.
- Gurgling: fluids in the upper airway.
- Stridor: obstruction of the upper airway.

Feel

- For air movement; by placing the back of your hand or side of your face over the mouth of the patient.

Top to Toe

It is during the Airway section that a DMT would perform the neck examination in the top to toe survey. The mnemonic **TWELVE*** is very important (see Top to Toe Section) in assessing for neck injuries.

* **T**rachea **W**ounds **E**mphysema **L**arynx **V**eins **E**verytime

B. Breathing 1.2.5

Signs that can be seen or felt will be more reliable to elicit than those requiring a stethoscope. Access to examine the chest is likely to be hindered by diving equipment and clothing. A careful examination to exclude penetrating injury, however small, is the intention.

Breathing Assessment

Use The RISE & FALL Approach:

- **R**ate. The DMT **must** assess the number of breaths per minute.
- **I**njuries: search for all penetrating trauma.
- **S**ymmetry of chest wall movement. Is the left side equal to the right.
- **E**ffort of breathing. Is there accessory muscle movement, nasal flaring or exhaustion.
- **F**eel: bone crepitus and surgical emphysema.
- **A**ssess resonance. Percuss the chest. hyper-resonance indicates a pneumothorax; hypo-resonance implies haemothorax.
- **L**isten to both sides of the chest. For reduced or absent breath sounds, if the background noise allows.
- **L**ook at the patient's back (if not already done!).

Top to Toe

It is during the breathing section that a DMT would perform the shoulder & chest examination in the top to toe survey (see Top to Toe Section).

C. Circulation 1.2.6

We are attempting to establish whether there is an adequate cardiac output and there is an adequate blood volume to provide tissue perfusion.

The Circulation Survey Should Be Conducted In A Rapid Systematic Fashion Using The Look & Feel Approach.

- Can the casualty speak coherently? (only a casualty with an adequately perfused brain can talk coherently).
- **Look**
  - Sweaty / Clammy / Pale.
  - Obvious blood loss.
- **Feel.**
  - Peripheral perfusion.
  - Temperature. Feel the peripheral limb temperature and compare this to central temperature.
- **Vital Skills:**
  - **Pulse :** Rate regular, weak, bounding. (it is essential that the DMT obtains the pulse per minute),
  - Capillary Refill Time.
  - Estimated B/P.

D. Disability (Central Nervous System) 1.2.7

The objective here is to provide a rapid base-line of the neurological status of the casualty. The initial aim of the isability is to ensure cerebal perfusion and oxygenation.

In The Initial Neurological Assessment May Be Assessed Using The AVPU System.

- **A** = **A**lert.
- **V** = Responds to **v**erbal stimulus. -
- **P** = Responds to **p**ainful stimulus.
- **U** = **U**nresponsive.

A	Alert	Fully Conscious.
V	Responds to Voice	Reduced Consciousness.
P	Responds to Pain	Severely Reduced Consciousness
U	Unresponsive	Comatose.

A reduced level of consciousness **is life threatening**. When the patient is only responding to pain, or is unresponsive, the casualty cannot protect their own airway, as the normal protective airway reflexes may be absent/inadequate. Remember that reduced level of consciousness is the *commonest cause of airway obstruction* in the seriously ill.

Pupil Response

Check the pupil size and reaction to light (See Pupil Examination). This may be helpful in determining chemical or physical brain injury.

Top to Toe

It is during the breathing section that a DMT would perform the head examination (see Top to Toe Section).

If A Neurological Involvement Is Suspected Conduct:

- Glasgow Coma Score.
- Full Neurological assessment.

E. Exposure / Environment 1.2.8

The 'exposure' element is often refered to as the 'everything else'. The remaining elements of the 'top to toe survey are completed.

A balance has to be taken between causing more problems, exacerbating hypothermia and the possibility of missing a pointer to a life-threatening problem. It is important to check to see that clothing, boots or the surface the patient is on is not absorbing or masking any signs of severe external bleeding.

However removing a casualty's clothing in a pre-hospital situation is fraught with difficulty & a casualty's dignity should be maintained **at all times**.

Casualty Examination

Top to Toe

- Abdomen / Pelvis.
- Arms & Legs.
- Back.

(see Top to Toe Section)

HEAD TO TOE EXAMINATION 1.3

A rapid "head to toe" involves patting down the patient for areas of pain, gross deformity or large haematoma / frank bleeding and is easily achievable in about 15 seconds. There is no reason this could not be performed throughout the A.B.C.D.E. assessment.

The rapid assessment is essentially a "pat down", observing for key abnormalities.

These Abnormalities Include:

- Asymmetry.
- Pain.
- Deformity.
- Large haematoma / frank bleeding.
- Distensions.
- Rashes.

Head Ex

The Body Is Broken Down Into Key Areas:

Head **(Head in Disability portion of Secondary Survey)**

- The head should be inspected for signs of injury.
- The bones of the skull and face should be palpated for tenderness and surgical emphysema.
- The eyes should be checked for the pupillary reflexes and the presence of foreign bodies or chemicals.

Neck **(Neck in the Airway portion of Secondary Survey)**

Neck signs can be remembered by the acronym **TWELVE:**

Trachea : Is it central? Shifting may indicate a tension pneumothorax.
Wounds : Any wounds or haematomata?
Emphysema: A local laryngeal injury, or tracked up. the neck from a pneumothorax?
Larynx : Is it intact? Is there any crepitus?
Veins : Are they distended (cardiac tamponade; tension pneumothorax)?
Everytime ! : And definitely before covering up these signs with a collar.

Neck Examination

Shoulders and Chest (Breathing portion of Secondary Survey)

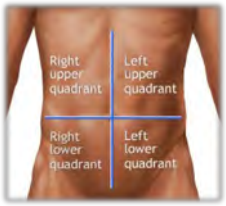
- Place your hands on opposite shoulders and compare them.
- Run your fingers down the collar-bones checking for signs of a fracture.
- Gently squeeze and rock the ribs.
- The chest examination ant the RISE-FALL examination conducted during the 'Breathing' portion of the secondary survey are essentially the same.
  - o The chest should then be examined completely looking for deformities, paradoxical movement, pattern bruising or abrasions, or the signs of any penetrating injury.
  - o The chest wall should be palpated for surgical emphysema.
  - o The chest should also be percussed to see whether there are any suggestions of hyper-resonance or dullness.

Chest Examination

Abdomen (Exposure portion of Secondary Survey)

- The abdomen should then be palpated through each of its quadrants.
- Look for tenderness or rebound guarding.

Abdominal Examination



Pelvis (Exposure portion of Secondary Survey)

- Gently spring the pelvis for signs of a fracture. (pelvic fractures carry a vey high mortality rate).
- Look for incontinence or bleeding.
- Look for abrasions or pattern bruising on flank / perineum / scrotum.

Legs and Arms (Exposure portion of Secondary Survey)

- Feel each leg for abnormalities.
- Feel each arm for abnormalities.
- Look for other clues (medic alert bracelets, needle marks etc).
- Look for clues and make sure nothing will injure the patient as you roll them.
- Have a witness if you remove items from pockets.
- Be very careful if you suspect there could be sharp objects such as needles.
- Loosen any tight clothing.

Arm Examination

The Back (Exposure portion of Secondary Survey)

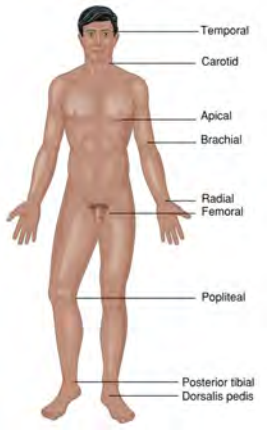
- It is essential not to omit examination of the spine and the examination of the back.
- If spinal injury is suspected, then the patient should be log rolled.
- This examination should include inspection and palpation of the posterior wall of the thorax as well as the posterior aspects of the abdomen and the spine itself.

PULSE TAKING 1.4

The pulse is a series of pressure waves within an artery caused by contractions of the left ventricle of the heart. It can be felt where an artery is near the surface of the body. In a healthy person the resting heart rate is 60-80 beats per minute.

The pulse is recorded to obtain information on the heart rate, pattern of beats and strength of the pulse. It is not just the pulse rate that is recorded - its rhythm and strength are also measured. The rhythm should be regular in a healthy person. The pulse should be strong and easily palpated - if it is bounding or weak then this is an indication that there is a possible problem.

Pulse Points



The Radial Pulse

The Carotid Pulse

To Record A Pulse You Will Need:

A watch that has a second hand.

How to Take a Pulse:

- Place your first and second finger along the artery.
- Apply light pressure until you feel the pulse.
- Count the pulse for a full minute in order to detect any arrhythmias (abnormal rhythms).

The site most commonly used to palpate the pulse is the wrist (radial).

Other Pulses Sites Are:

- **Radial**: on the thumb side of the wrist where the radial artery passes over the radius.

- **Carotid:** to the right or left of the trachea anterior to the sternocleidomastoid muscle. Assessing both sides simultaneously will adversely affect the blood pressure.
- **Femoral:** at the right or left groin where the femoral artery passes over the ischium.
- **Ulnar:** on the inner surface of the wrist.
- **Brachial:** in the antecubital fosa where the brachial artery passes over the ulna.
- **Temporal:** at the temple where the temporal artery passes over the temporal bone.
- **Popliteal:** at the posterior surface of the knee where the popliteal artery passes over the articular surface of the femur.
- **Dorsalis:** on the dorsum of the foot where the dorsalis pedis artery passes over the proximal phalanges (between the first and second toe).
- **Posterior Tibial:** on the lateral surface of the ankle where the posterior tibialis artery passes over the lateral malleolus.

CAPILLARY REFILL TIME (C.R.T.) 1.5

Capillary refill is the rate at which blood refills empty capillaries and is a common measure of peripheral perfusion. It can be measured by pressing the soft pad of a finger or toe until it turns white, and taking note of the time needed for colour to return once pressure is released.

C.R.T.

Capillary refill can also be measured by pressing on the sternum for five seconds with a finger or thumb; this is useful in a casualty who is extremely cold.

Normal capillary refill time (CRT) is less than 2 seconds. If the refill time is elongated then it can be asserted that a person is suffering from a reduced tissue perfusion such as shock.

A CRT of greater than 5 seconds is considered severe.

CRT can be **very** inaccurate in very cold or wet conditions.

BLOOD PRESSURE MEASUREMENT 1.6

Measuring Blood Pressure manually can be difficult if not practised regularly. However it is important for a DMT to be able to do this using a sphygmomanometer. It is important to interact with the patient when making the measurement.

It is important that the patient is rested and relaxed for the measurement.

How To Perform A Manual Blood Pressure Reading Using A Sphygmomanometer;

1. Find the brachial pulse.
   This is where the stethoscope will be placed.
   This pulse may be quite weak.

2. Size the cuff.
   The bladder must cover 80% of the arm.
   If not, change the cuff.

3. Apply the cuff to the upper arm.
   The centre of the bladder in line with the brachial artery.

4. Close the valve on the sphygmomanometer.
   Pump the bulb, checking the radial pulse, until this cannot be felt. Observe the reading.

5. Close the valve and inflate the cuff.
   Inflate until the dial reads 30 mmHg above your earlier estimated systolic pressure.

6. Position the diaphragm of the stethoscope.
   Over the brachial artery, hold in place with your thumb.

7. Gently open the valve.
Use a slow controlled release of air from the cuff.

8. Listen carefully for the first 'Bomp'.
Note the dial reading. This is the Systolic pressure.

9. The change in tone.
You will not be able to detect a 'Bomp' / or it changes tone this is diastolic pressure.

10. Open the air valve fully.
Deflate the cuff. Release the patient from the equipment.

Estimated Blood Pressure 1.6.1

A normal blood pressure is often $^{120}/_{80}$ mmHg (mm of mercury). A low blood pressure is very often associated with shock.

It is preferable that a blood pressure is *actually* performed with a sphygmomanometer by a DMT. However, a rough guide to the SYSTOLIC PRESSURE is the presence of a pulse in various locations.

This technique is often life-saving in a trauma situation and **MUST** be second nature to a DMT.

Estimated Blood Pressure Involves;

- A carotid pulse indicates a systolic pressure of around 60 mm Hg
- A femoral pulse a systolic pressure of around 70 mm Hg and
- A radial pulse a systolic pressure of around 90 mm Hg.

Absence of a radial pulse is a provisional diagnosis of hypo-perfusion. This can be a vital rapid skill in the emergency situation.

PULSE OXIMETRY 1.7

Pulse oximetry is a non-invasive method allowing the monitoring of the saturation of a patient's hemoglobin.
A sensor is placed on a thin part of the patient's body, usually a fingertip or earlobe.

Light of two different wavelengths is passed through the patient to a photo-detector.

Pulse oximetry measures solely oxygenation, **not ventilation** and is not a complete measure of respiratory sufficiency.

How does pulse oximetry work?

The pulse oximeter calculates the amount of light absorbed from a source in the probe (of two separate wave-lengths) when put onto a digit (finger / toe). This produces an estimate of oxygen saturation/ desaturation in the body. This is referred to as % SpO_2.

The oximeter is designed to pick up arterial pulsed flow rather than venous flow in its estimations, and needs arterial pulsed flow to do this.

Pulse Oximetry

- An SpO_2 of greater than 95% is considered normal.
- An SpO_2 of below 90% is considered abnormal.
- An SpO_2 of below 75% is potentially critical.

How To Use A Pulse Oximeter;

- Ensure a casualties finger / toe is dirt free & relatively warm.
- Apply sensor to site and activate.
- Wait 20 seconds.
- Monitor:
  - o SpO_2 %.
  - o Pulse rate.
  - o Pleth wave (which indicates peripheral perfusion).

SPO_2 Reading are affected by:
- Shock (hypo-perfusion).
- Excessive movement by the patient.
- Hypothermia or a cold extremity.
- Anemia.
- Carbon monoxide poisoning.
- Certain types of seizures.

TAKING A TEMPERATURE 1.8

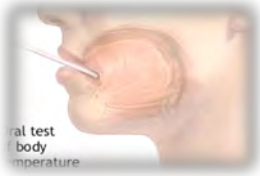
Modern, easy to use thermometers are now available, such as disposable strips that can be placed on the tongue

or forehead. For these thermometers follow the manufacturers instructions.

If you only have an 'old fashioned' mercury thermometer however, the following advice may help:

- Take care when handling the thermometer. (Mercury is toxic).
- Ensure that it has been properly cleaned.
- Hold the thermometer at the opposite end to the silver mercury bulb.
- Shake the thermometer until the mercury falls well below the 35°C mark.
- Place under the tongue of an adult *(who is fully conscious)*.
- Keep in place for 3 minutes.
- Read the temperature at the level to which the mercury has risen.

Taking a Temperature



PUPIL EXAMINATION 1.9

Pupil response is a vital part of neurological assessment. It is an integral part of the GCS process.

Pupil Response

How To Perform:

- Have the patient look at a distant object.
- Look at size, shape and symmetry of pupils.
- Shine a light into each eye and observe constriction of pupil.
- Flash a light on one pupil and watch it contract briskly.
- Flash the light again and watch the opposite pupil constrict (consensual reflex).
- Repeat this procedure on the opposite eye.

Normal Pupil Response:

- Pupil size is 3-5 mm in diameter.
- They react briskly to light.
- Both pupils constrict consensually.

Pinpoint Pupils

Abnormal Pupil Response:

Causes Of Unequal Pupil Sizes May Include:

- Bleeding inside the skull caused by head injury.
- Brain tumour or abscess.
- Infection of membranes around the brain caused by meningitis or encephalitis.
- Aneurysm.
- Excess pressure in one eye caused by glaucoma.

Dilated Pupils

Abnormal Pupils Include:

- Dilated pupils (enlarged).
- Pinpoint pupils (very small).
- Nonreactive pupils (pupils do not change size when exposed to light).
- Unequal pupils (One pupil larger than the other)

Unequal Pupils

Causes Of Abnormal Pupil Sizes May Include:

- Effects of drugs or chemical agents.
- Acute head injury.
- Raised intracranial pressure.
- Varying light conditions.

NEUROLOGICAL ASSESSMENT 1.10

Following a diving incident, it is important to undertake an assessment of the neurological status of the diver. Details of all signs and symptoms should be reported to the duty medic to assist them in identifying which, if any, part of the nervous system is functioning abnormally, and to determine the extent of the dysfunction.

The Assessment Process Involves Assessment Of:

- Level of consciousness.
- Sensory function.
- Motor function.
- Co-ordination.
- Cranial nerve function.

Assessment of Level of Consciousness

This should be determined when the patient is first seen. Initial assessment can be done using the AVPU system. If the casualty's conscious level is reduced (anything below Alert), then a full neurological assessment should be undertaken.

Neurological Assessment

It is difficult to define consciousness and to differentiate between levels or degrees of impairment. Terms such as confusion, drowsiness, stupor, semi-comatose and deep coma have obscure meanings, and are subject to varying interpretations by different observers.

The Glasgow Coma Scale (G.C.S.) is a simple assessment tool for consciousness, which standardises observations. It provides for accurate graphical recording of three aspects of behavioral response and the assessor is not required to interpret the observations.

Comparing current observations with previous results can make changes in the patient's level of consciousness.

The scale provides an assessment of overall brain functioning.

Glasgow Coma Scale (G.C.S.) 1.10.1

The Glasgow coma scale involves evaluation of eye opening and the best verbal and motor responses.

Within each of these three parameters, there are a variety of responses, which are arranged in scales of increasing dysfunction. Each aspect is assessed independently of the others.

The 3 Parameter Are:

- Eye Opening.
- Best Verbal Response.
- Best Motor Response.

Eye Opening

- **Spontaneous Opening** - **SCORE 4**
  The assessor approaches the patient and notes whether the eyes are open or closed. Spontaneous opening of the eyes indicates that the arousal mechanism in the reticular activating system of the brain stem is functioning.
- **Opening to Speech** - **SCORE 3**
  If the patient's eyes are closed, the observer speaks, addressing the patient by name. If there is no response to a normal speaking voice, the volume should be increased.
- **Opening to Pain** - **SCORE 2**
  Physical stimulation, usually in the form of pressure on the fingernail bed using a pencil or pen is applied. It is important that observers use the same method of applying physical stimulation to ensure consistent, accurate findings.
- **No Eye Opening** - **SCORE 1**
  If no response is demonstrated in either eye to increased pain stimuli, there is depression of the arousal system. The patient may be sufficiently alert to respond by opening his eyes, but is restricted by swelling of the eyelids. If the eyelids are swollen shut, the observer records this as a 'C'.

Best Verbal Response

The patient's ability to speak and to understand the language spoken is determined. If the patient is intubated or has a tracheostomy, verbal response cannot be observed and T is recorded. Speech is first used to stimulate a verbal response by asking the patient simple, direct questions. If there is no response a light touch is used or, if necessary, painful physical stimulation.

Patient Responses Are Rated As Being:

- **Orientated** - **SCORE 5**
  If able to respond as to who he or she is, where he or she is and give the year, month and day.
- **Confused** - **SCORE 4**
  If not fully orientated to time, place and person.
- **Inappropriate** - **SCORE 3**
  If the patient utters words in a disorganised way, swears or does not engage in meaningful conversation.
- **Incomprehensible** - **SCORE 2**
  When responses are limited to moaning, groaning or mumbling sounds with no recognisable words.
- **No Response** - **SCORE 1**
  When no sounds are made to noxious stimuli.

Best Motor Response

The best possible motor response in either arm is usually observed. The patient is asked to raise the arms and hold them outstretched for 10 seconds.

The ratings in order of decreasing levels of function include:

- **Obeys Commands** - **SCORE 6**

When the patient understands verbal or written instructions or gestures and performs the requested movement.

- **Localisation to Pain** - SCORE 5
  When there is no response to command. A painful stimulus is then applied, such as pressure on the patients finger-nail bed. The patient moves a limb in an attempt to locate and remove the stimulus.
- **Withdrawal to Pain** - SCORE 4
  Casualty withdraws from site of inflicted pain.
- **Flexion Withdrawal to Pain** - SCORE 3
  Occurs when the arm bends at the elbow in response to fingernail bed pressure or other local stimulation. Leg flexion is not a reliable gauge because with brain death, a spinal reflex may be present causing the legs to flex in response to localised pain. Abnormal flexion occurs when the arm flexes at the elbow and pronates, making a fist.
- **Abnormal Extension to Pain** - SCORE 2
  Occurs when the elbow straightens, and the arm abducts (usually with internal rotation) in response to localised pain applied to the fingernail bed. If one arm flexes and the other extends, the best response is recorded.
- **No Response** - SCORE 1
  Is recorded when no detectable movement or change in the tone of the limbs is observed in response to repeated and varied stimuli.

A Eye opening:		B Verbal response:		C Motor response:	
Spontaneous	4	Orientated	5	Obeys Commands	6
To voice	3	Confused	4	Localises	5
To Pain	2	Inappropriate	3	Pain Withdraws	4
None	1	Incomprehensible	2	Pain Flexes	3
		No Response	1	Pain Extends	2
				No Response	1
A		...../4		**G.C.S.**	
B		...../5			
C		...../6		...../15	

Giving these 3 parameters a numerical score derives the Glasgow Coma Score.

This is a 15 point scale where 15 denotes fully alert and 3 denotes unconscious / dead.

Pupil Response

Assessment of pupil responses and limb movements provides information and assists in localising lesions.

Each pupil is examined for size and reaction. Normally, the pupils are round in shape, equal in size and constrict in response to direct light. The size of each pupil is measured by comparing it with the pupil scale (see illustration).

Reaction		Pupil Size
+	Reacts	1 2 3 4 5 6 7 8
–	No reaction	
c	Eye closed	
sl	Sluggish	

	Left	Right
Pupil Size		
Pupil Reaction		

Pupil reaction is measured in response to light; the beam of a pen-torch is brought in from the patient's side and directed on one eye at a time. Constriction of the pupil is recorded as '**+**' or '**-**', when no reaction is obtained. If the eyes are closed (due to swelling / trauma) then '**C**' should be entered. If the pupil response is below normal speed '**SL**' (for sluggish) should be recorded.

Ideally, the surroundings should be dimly lit and the light beam of adequate intensity to obtain accurate results.

Limb Movement

Verbal commands are used to elicit movement in each limb. When the patient does not respond to commands, painful stimuli are applied to the nail bed of a finger or great toe.

Responses In Order Of Decreasing Function Are Recorded As:

- **Normal Power**
  When the limb movements are appropriate to the normal muscle strength for the patient.
- **Mild Weakness**
  One limb shows normal strength but its opposite is weaker.
- **Severe Weakness**
  When the difference between two limbs is very much marked.
- **Spastic Flexion**
  When there is slow, stiff movement of the arm with the flexed forearm and hand held against the body.
- **Extension**
  When the elbow or knee are straightened in response to painful stimulation.
- **No Response**
  When painful stimulation produces no movement and the limb remains limp.

Spastic Flexion

Extension

Arms	Normal Power	
	Mild Weakness	
	Severe Weakness	
	Spasmic Flexion	
	Extension	
	No Response	
Legs	Normal Power	
	Mild Weakness	
	Severe Weakness	
	Extension	
	No Response	

Limb Movement

It is important to compare each side and record differences between the right and left limbs and changes on the responses of an individual limb.

Abbreviated Mental Test Score 1.10.2

The AMTS can be used to rapidly assess for the possibility of cognitive impairment.

Ten questions are put to the patient. Each question correctly answered scores one point.

A score of 6 or less suggests possible cognitive cerebral dysfunction.

Mental Status	
Where is the current location ?	1
What is their Date of Birth ?	1
What is their Age?	1
What Time is it ?	1
What is the Year ?	1
Remember an Address	1
Recognition of two persons	1
What Year did World War Two end ?	1
Name of the current Prime Minister ?	1
Count backwards from 20 to 1	1
Abbreviated Mental Test Score (AMTS)	10

Assessment of Co-ordination and Proprioception (position sense) 1.10.3

The receptors in the muscles, joints and tendons all feed position-sense information to the cerebellum and the cortex. In turn the cerebellum and the cortex bring about vital postural reflexes and reflexes necessary for accurate movement. The basal ganglia also play an important role in the co-ordination of movement.

Damage to these parts of the nervous system may have an effect on gait and co-ordination of movement.

Observation

Careful observation of motor activity can give an indication of a problem with co-ordination and balance. Ask the patient to walk with the eyes open and then closed.

Note any unsteadiness. Note if the patient can stand on one foot. Poor balance and co-ordination should be reported to the duty medic.

On Examination:

Proprioception in joints:

To test proprioception, hold the sides of the big-toe between the forefinger and thumb. While the patient's eyes are shut, the toe is moved up and down and the patient should be able to state the final position of the toe. If the patient answers correctly, this indicates that the specific pathways to the cortex are intact.

Co-ordination

On Examination;

Romberg Sign

- **Romberg's Sign***:*
  The patient is observed standing with the eyes open and then closed. Deprivation of the visual information means that the brain has to rely on proprioceptive input and if this is not being transmitted then the patient will sway and find it difficult to keep balance.
- **Heel-Shin Test***:*
  The patient is asked to slide the heel of one leg straight down the shin of the other. Patients with cerebellar dysfunction are often unable to do this because of lack of co-ordination and the heel will follow a wavy path down the other leg.
- **Heel Toe Test:**
  The patient is asked to walk in a straight-line heel to toe.
- **Finger Nose Test:**
  The patient is asked to stand comfortably and then, with eyes shut and one arm outstretched, to bring his/her fingertip to the nose. Repeat for the other arm. Cerebellar dysfunction will cause the patient to overshoot or undershoot and miss the nose.
- **Rapid Alternating Movement Test:**
  The patient is asked to slap one hand on the palm of the other, alternating palm-up and palm-down. However, any exercise requiring rapidly changing movement will suffice. Another test is to quickly touch the thumb to the 1st, 2nd, 3rd, 4th, 3rd, 2nd, 1st finger, quickly repeating the exercise. Observe co-ordination.

Coordination		
Tick (✓) if normal (✖) if not.		
Romberg Test Sharpened	Eyes open & closed. Arms crossed chest. Heel to toe.	
Heel to Toe Test	Walks a line	
Finger to Nose Test	Both hands, eyes closed	
Rapid Movement Test	Thumb to fingers 1st 2nd,3rd,4th, 1st , Eyes closed.	

Assessment of Motor Function

Motor dysfunction of the limbs may be due to either damage to upper-motor neurone or lower-motor neurons.

Upper motor neurone (UMN) lesions are due to damage occurring anywhere between the cortex and L1 in the spinal

cord.

Since the spinal cord ends at this level, damage below this level cannot produce UMN symptoms. Lower motor neurons (LMN) or their spinal nerves exit at all segments of the spinal cord; therefore LMN symptoms can be seen as a result of damage to any segment from CI to S5.

Assessment of the patient's motor function should be carried out and the details should be given to the doctor to allow them to identify the level of the lesion and arrange appropriate treatment. When examining the motor function of limbs, the examiner is examining for asymmetry (compare the right and left limb).

Observation

The patient should be observed walking or sitting and if affecting movement, whether it causes weakness or complete paralysis. If the patient is able to walk, their gait should be observed.

Important Points To Note Are:

- Any signs of weakness.
- The affected part of the body.
- Whether the effect is unilateral or bilateral (does the patient tend to walk to one side?).

Muscle Power

If uncertain about grading, use '0' for nothing, '5' for normal or 'Ab' for abnormal.

0 = Nothing (absent)
1 = Tiny flicker of movement
2 = Movement but not against gravity
3 = Moves against gravity but not examiner
4 = Pushes against examiner but not normal strength
5 = Normal

Movement in brackets to be performed by patient		Lt	Rt
Upper Body			
Shoulder	Abduction: Arms, push down Adduction: Arms, pull up		
Tricep Reflex	Strike the tendon on the tendon just above the elbow. The tricep should twitch		
Bicep Reflex	Hand on abdomen. Your index finger in elbow joint and tap forefinger. (elicit a tendon jerk.)		
Elbow	Extension: Bent elbows, push Flexion : Bent elbows, Pull		
Finger Spread	Strength against resistance		
Wrist Strength	Fingers out straight		
Grip Strength	Use two of your fingers		
Lower Body			
Hip Flexion	Flexion: Legs, pull up Extension: Legs, push down		
Patellar Reflex	Legs dangling, tap just below knee-cap		
Ankle	Extension: Foot, push down Flexion : Toes, pull up		
Achilles Reflex	Foot flexed, pressure applied, on sole,		
Plantar Reflex	Firm stroke lateral aspect from foot - base of big-toe.		

Examination

To test motor function, extremity strength and tendon reflexes are tested. Examine both upper and both lower limbs, and compare right and left limbs.

Muscle Strength Is Graded As Follows:

0 = **Paralysis** : No motion possible.

1 = **Profound Weakness**: Flicker or trace of muscle contraction.

2 = **Severe Weakness** : Can contract muscle but cannot move joint against gravity.

3 = **Moderate Weakness** : Overcomes gravity, but not the resistance of the examiner.

4 = **Mild Weakness** : Able to resist slight force of the examiner.

5 = **Normal** : Equal strength bilaterally, and able to resist examiner.

Reflexes Are Either:

- Absent.
- Diminished.
- Exaggerated.
- Normal.

Bicep Reflex

Tricep Reflex

Upper Limb

Ask The Patient To:

- Move each part of the limb - fingers, hands, shoulders. Extend both arms with the fingers outstretched.
- Ask him to close his eyes and hold this position for 20 sec. Observe the position of the hands and their stability.
- Observe for any tremor, or progressive or sudden dropping of one arm. Push and then pull his hand against the resistance of the examiner's hand.
- A reduced strength or asymmetry should be noted. Squeeze the examiners fingers - weakness or asymmetry is noted.
- **Triceps Reflex**
  It is important that the limb being tested is as relaxed as possible. Strike the tendon (not too firmly) on the tendon on the back of the arm, just above the elbow. The arm should extended.
- **Biceps Reflex**
  The patient, lying on his back, places his hand on his abdomen. The examiner puts his index finger in the patients elbow joint and taps his forefinger. This should elicit a tendon jerk.

Patellar Reflex

Lower Limb

Ask The Patient To:

- Move each part of the limb; toes, ankle, knee and hip joint. Push and then pull his foot against resistance from examiner's hand.
- A reduced strength or asymmetry should be noted.

- **Patellar Reflex**
  It is important that the limb is relaxed. The patient should sit with the legs dangling and the feet clearing the ground. If the patient is not relaxing his limb, ask him to clasp his hands and pull. This manoeuvre relaxes the legs.
  The examiner can gently push the leg to be tested, which should swing freely in response.
  Alternatively, with the patient lying flat, the knees can be elevated and supported by the examiner. Again, the legs must be relaxed.
  A gentle tap on the patellar tendon, just below the knee-cap, should elicit a knee jerk.

- **Achilles Reflex**
  This is best carried out if the foot is slightly dorsiflexed by applying gentle pressure to the sole of the foot with one hand (at the forefoot).
  With the other hand tap the Achilles tendon, while the gentle pressure is maintained against the sole. The forefoot should gently plantar flex.

- **Plantar Reflex**
  The plantar surface of the foot is stroked firmly and briskly from the outside border of the heel, along the side of the foot and across to the base of the big toe. The normal response is for all the toes to 'claw'. It is *abnormal* of the big toe to extend and the other toes to fan out.

Plantar Reflex

Achilies Reflex

Assessment of Cranial Nerve Function 1.10.4

i. Olfactory (the sense of smell).

Test:

- Each nostril is tested with different smells e.g. coffee, chocolate, peppermint etc.
- This test is **not** usually carried out in an emergency.

ii. Optic (Visual acuity)

Test. Vision Should Be Tested For Distance And Near Vision:

- *Visual field:* Patient sits upright and faces the examiner.
  - Examine one eye at a time.
  - While looking straight ahead, the patient should be able to see your finger held in front of them.
  - Move the finger to the right and left, above and below.
- To test the peripheral vision, the patient looks straight ahead.
  - The examiner should bring his finger around from behind the patient to the side.
  - The patient should state when he first sees the finger.

iii. Oculomotor & iv. Trochlear (Eye movements)

Test:

- Look up and maintain gaze for 30 seconds.
  - Note if the gaze cannot be maintained without the eyebrow being raised.
- Ask the patient to make horizontal eye movements (right to left) and vertical movements up and down.
- Test vertical movements when deviated to the side. They should be able to maintain each gaze for 5 seconds.
- Report any abnormalities, such as one eye lagging.

Both eyes should look straight ahead while at rest. Anything else is abnormal. Comatose casualties may have slow roving eyes. Other abnormalities include: eyes deviated to one side or up / downwards.

Diplopia: (This is the medical term for double vision, and if experience by the patient, should be reported to the doctor).

Test:

- Using object such as colour glass or plastic, or if unavailable, the examiners finger test horizontal and vertical movements.
- Ask the patient to report if they see two images, and whether they are side-by-side or one above the other.
- Note at what position the images appear furthest apart.
- Report any double vision.

Pupils: Normally the pupils should be central, circular and equal in size, and constrict on direct and indirect light.

Test. Pupil Size: Check For Dilatation Or Constriction:

- Compare right and left pupils and note any inequality in pupil size.
- Shine a small torch into the patient's eye and normally the pupil should constrict. Examine both eyes.
- Report any abnormalities immediately to the doctor (failure to react to light, dilated pupils, small pinpoint pupils).

Nystagmus: Involuntary rhythmic oscillation of the eyes, in the primary position of gaze, or on deviation of the eyes horizontally or vertically.

Test:

- Ask the patient to look at the examiner's finger.
- Follow it through vertical and horizontal movements, and hold the gaze at each position.
- Note should be taken of the direction of gaze in which nystagmus is seen, and also of the nystagmus itself.
  - This can be either pendular type, in which the oscillations to either side of the fixation point are equal, like the swing of a pendulum, or of jerking type with a quick phase and slow phase of unequal duration.
  - The direction of the quick phase is used to describe the direction of the nystagmus.
  - Nystagmus may also have a rotatory action as well as the more common horizontal or vertical components.
- Nystagmus should be clearly described to the doctor.

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v. Trigeminal

The trigeminal nerve carries sensation from the face, anterior part of the scalp, mouth and nasal passages.

Test: For Sensation:

Test for pain, light touch and temperature on the forehead, the cheek and over the lower jaw and the anterior two thirds of the tongue.

: For Motor Function:

- Ask the patient to open and close the jaw against resistance .
- Weakness on one or both sides should be noted.

Corneal reflex: This consists of a brisk blinking action of the eyes when the cornea is touched.

- Apply a wisp of cotton wool lightly to the cornea. (The wool should be brushed **gently** across it and not jabbed).
- Normally, contact with either cornea will cause a brisk blinking of both eyes.
- A sluggish or absent corneal reflex is abnormal (indicating damage to the 5th cranial nerve).
- The patient may report that he is unable to the feel the sensation on his cornea.

Jaw jerk:

- Grasping the tip of the patients mandible between the thumb (on top) and the forefinger and encourage the patient to let the jaw hang limply on the examiners supporting finger with the mouth half open.
- A brisk tap with the patella hammer, on the examiner's thumb will elicit a reflex tendon jerk.
- The jaw jerk is normally relatively sluggish.
- A very brisk response is abnormal and should be noted.

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vii. Facial

The facial nerve innervates the muscles of facial expression.

Test: Inspection will reveal any wasting, involuntary movements, rigidity, spacticity or gross weakness.

- Ask the patients to wrinkle his forehead, smile, show their teeth and try to whistle.
- The two sides should perform symmetrically.
- Note any weakness or asymmetry.
- Ask the patient to close his eyes tightly (normally the eyelashes should be 'buried' in the screwed-up eyelids).

Corneal reflex: see method of testing previous paragraph. Damage to the 7th cranial nerve will lead to failure of blinking only on the affected side, regardless of which side is stimulated.

Glabellar reflex:

- This is elicited by percussion with a finger over the root of the nose.
- The normal response is a brisk bilateral blinking of the eyes.

---

viii. Vestibulocochlear

Auditory and vestibular. Potential hearing damage / postural nystagmus. Vestibular is **not** routinely tested.

Test (auditory division):

- Ask the patient to close his eyes and occlude one ear.
- Then from a distance of 3 feet whisper a word.
- The patient should be able to recognise the word.
- Continue approaching the patient until the whisper is heard and the word is recognised.
- A tuning fork may also be used.

---

ix. Glossopharyngeal

This nerve transmits sensation from the upper mouth and throat area.

Test: Gag Reflex:

- Touch the back of the patient's throat with a tongue depressor.
- This should cause a gagging response.

---

x. Vagus

This nerve has many functions, including inverting the roof of the mouth and vocal cords.

Test:

- The patient is asked to say 'aah' while watching for the palate to rise.
  - Note the tone of the voice - hoarseness may also indicate vagus nerve involvement.
- Report any abnormalities.

xi. Accessory Controls the turning of the head from side to side.

Test:

- Placing one hand against the side of the patient's head provides resistance.
- Ask the patient to turn his head against resistance.
  - Note any weakness.
- Ask the patient to shrug his shoulders.
  - Note any asymmetry.
- Report any abnormalities.

xii. Hypoglossal This nerve of the tongue. Normally when the tongue is stuck out, it should be central.

Test:

- Ask the patient to stick out his tongue.
- If the nerve is damaged, the tongue will twist to the side.

Cranial Nerves		
Tick (✓) if normal (✱) if not		
Nose (I)		
Smell Optional in acute setting	Test familiar smell (eg Coffee)	
Eyes (II, III, IV, VI)		
Vision	Still head, Finger Count & sign reading, look for nystagmus at extremes of H Shape	
Visual Fields	Finger Wiggle, Diagonal from extreme of visual field inwards.	
Pupils	P.E.R.L.	
Face (V, VII)		
Movement	Scrunch eyes & try to pry open. Blow out cheeks. Clench teeth & open mouth against resistance.	
Sensation	Light touch in ophthalmic / maxillary / mandibles	
Ears (VIII)		
Hearing	Rub your fingers next to their ears. Compare their hearing with yours.	
Vagus (X)		
Vagal Test	Say AHHH, note if palette rises. Observe for hoarseness	
Neck (XI)		
Twisting neck	Against resistance, get them to try & maintain a midline	
Shoulder Shrug	Against resistance.	
Mouth (XII)		
Tongue	Stick out tongue to ensure it is midline	
Gag Reflex Optional in acute setting	Touch back of throat with tongue depressor.	

Assessment of Sensory Function 1.10.5

Sensory dysfunction may arise as a result of damage to the parietal cortex, the ascending pathways, or the receptors. If the diver has a spinal bend it is likely that the ascending pathways will be affected.

The ascending tracts cross-over to the opposite side at some stage, either in the spinal cord or in the brain stem. This explains why a stroke affecting a particular side of the sensory cortex produces numbness or paraesthesia (pins and needles) in a specific part of the body, on the opposite (contralateral) side.

Neurological damage to the spinal cord may produce numbness or paraesthesia on either the contralateral side if the site of damage is before the tracts cross, or the ipsilateral (same) side if the site of damage occurs after the tracts have crossed.

Sensation

Ask the patient if they are experiencing any abnormal sensations such as numbness, pain, a hot or cold sensation, pins and needles, or weakness.
The specific site should be determined. To test sensation, the patient's the eyes must be closed.

They Should Be Asked Whether The Sensation Is:

- Normal / diminished / increased / absent (compared to the other side).
- Unilateral / bilateral.
- Deteriorating /stable / improving.

In Suspected DCI, The Following Sites Should Be Examined:

- The torso.
- The abdomen.
- The limbs.

Assessment of Sensation

Assessment of sensation should be related to the associated neurological dermatome region (See Neuro section in A&P), which will relate to the cranial nerve involved in sensory loss.

The Assessment Of Sensation Includes:

Pain

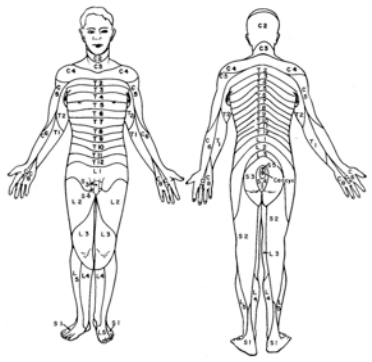
- A relatively sharp instrument can be used for this test, but not one sharp enough to draw blood.
- It should be drawn swiftly across the skin.
- The normal reaction is for the patient to show the flexion reflex (pain withdrawal) in response to this.

Light Touch

- **Lightly** brushing the skin with a cotton wool wisp, or very lightly with one's finger.
- The patient is asked to indicate the site.

Sensation

Shade / Code area of altered sensation relating to spinal nerves.
Pain = **P**, Light Touch = **L.T.**, Vibration = **V**, Tingling = **T**

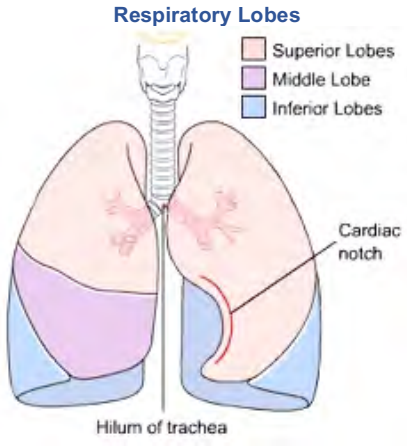


Vibration

- The vibrating tuning fork is placed on the skin above a bony prominence (anklebone / elbow).
- The patient is asked to describe what is felt.
- Normally a buzzing sensation should be felt.

Question the patient about their desire to urinate or have a bowel movement. Lack of desire should be reported to the doctor. Monitor fluid intake and urinary output closely output.

RESPIRATORY AUSCULTATION 1.11



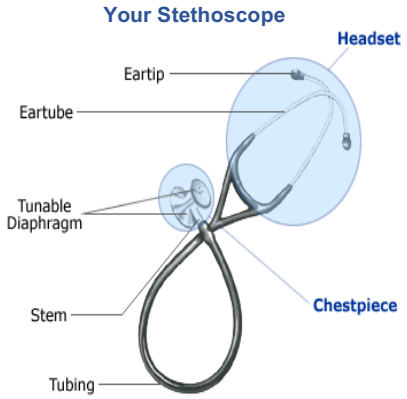
The lungs are located in two cavities on either side of the heart. Though similar in appearance, the two are not identical. Both are separated into lobes by fissures, with three lobes on the right and two on the left. The lobes are further divided into segments and then into lobules, hexagonal divisions of the lungs that are the smallest subdivision visible to the naked eye.

The medial border of the right lung is nearly vertical, while the left lung contains a cardiac notch. The cardiac notch is a concave impression moulded to accommodate the shape of the heart.

Once inspired air progresses through the mouth or nose, it travels through the oropharynx, nasopharynx, the larynx, the trachea, and a progressively subdividing system of bronchi and bronchioles until it finally reaches the alveoli where the gas exchange takes place.

Inspiration is normally longer than expiration.

Breath sounds are produced by turbulent airflow within the smaller and larger airways. They are categorised by the size of the airways that transmit the sounds to the chest wall and your stethoscope. The general rule is, the larger the airway, the louder and higher pitched the sound.



Normal (vesicular) breath sounds, produced by small airways and alveoli, are low pitched quiet and normally heard over most lung fields. The inspiratory component predominates and there is a gap between **expiration** and inspiration.

Auscultation

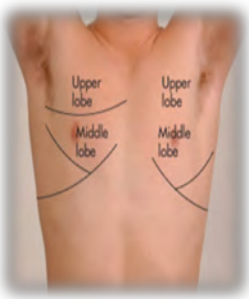
Auscultation is perhaps the most important and effective clinical technique you will ever learn for evaluating a patient's respiratory function.

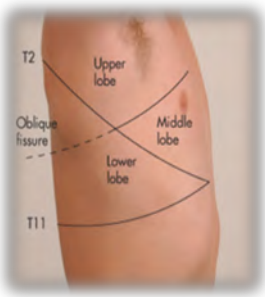
Before You Begin, There Are Certain Things That You Should Keep In Mind:

- Try to create a quiet environment as much as possible.
- Ensure proper positioning (sitting up, chest is not leaning against anything).
- Your stethoscope should be touching the patient's bare chest.
- Ask patient to breathe with mouth open and deeply (to increase tidal volume).
- Use either the bell or diaphragm. The frequency of breath sounds and added sounds is such that either can be used.
- If the patient's chest is particularly hairy, the bell is preferable, as it will reduce extraneous scratching sounds from hair movement.

While Auscultating The Chest It Is Important To Be Systematic:

- Front (Anterior) of chest: auscultate from side to side and top to bottom (apex to base).
- Auscultate over equivalent areas and compare the volume and character of the sounds and note any additional or *extra lung sounds.*
- Compare sounds during inspiration and expiration and note location and quality.
- Back (Posterior) of chest: repeat procedure.
- Side (Lateral) of chest: repeat procedure.
- Assess vocal resonance. Ask the patient to say 'ninety-nine, ninety-nine' and compare the sounds at equivalent positions on each side of the chest.





Discovering Abnormalities

As You Auscultate Ask Yourself: -

- Are breath sounds present?
- Are breath sounds equal on both sides?
- Are there any added sounds such as crackles, rhonchi (snoring), wheezes or pleural rubs?
- Is there any bronchial breathing?

Bronchial sounds may be heard in certain pathologies such as when small airways or alveoli have been damaged. They are noises from the larger airways and are harsher. In bronchial breathing the sounds gradually increase through inspiration, but stop near the end of inspiration (when air would normally be flowing round the alveoli). The expiratory component then dominates.

Bronchial breathing occurs in consolidation, collapse or fibrosis.
Breath sounds are **decreased** when normal lung is displaced by air (emphysema or pneumothorax) or fluid (pleural effusion or haemothorax).

Breath sounds **shift from vesicular to bronchial** when there is fluid in the lung itself (e.g. pneumonia).

Absent or decreased sounds are inaudible (absent) or reduced in volume (decreased) compared with other areas of the lung when the lungs are examined with a stethoscope. They reflect reduced airflow to a portion (segment) of the lungs; over inflation of a portion of the lungs, such as with emphysema; air or fluid around the lungs; or sometimes increased thickness of the chest wall, namely pneumothorax or haemothorax.

Extra Lung Sounds	
Crackles	Crackles rales or crepitations - are small clicking, bubbling, or rattling sounds in the airway. They occur when air opens closed alveoli (air spaces). Typical ways to describe crackles include moist, dry, fine, coarse.
Rhonchl	Rhonchi are sounds that resemble snoring. They are produced when air movement through the large airways is obstructed or turbulent.
Wheezes	Wheezes are high-pitched, musical sounds produced by narrowed airways, often occurring during expiration.
Pleural rub	Sounds like creaking leather. Due to pleural inflammation.

EAR EXAMINATION 1.12

The Otoscopic Exam Is Performed By:

- Gently pulling the auricle upward and backward. This process will move the acoustic meatus in line with the canal.
- Hold the otoscope like a pen and using a little finger as a fulcrum. This prevents injury if the patient suddenly turns.
- Inspect the external auditory canal and evaluate tympanic membrane. Note the:
  - Colour (red, white, yellow).
  - Translucency (transparent, opaque).
  - Position (retracted, neutral or bulging) of the drum.
  - Identify the pars tensa with its cone of light, the handle and short process of malleus, and the anterior and posterior folds of the pars flaccida and position of the malleus handle.

Normal Findings:

Auditory canal:

- Some hair, often with yellow to brown cerumen.

Ear-drum:

- Pinkish gray in colour, translucent and in neutral position.
- Malleus lies in oblique position behind the upper part of drum.

Your Otoscope

Questions to Ask Yourself:

Can I Clearly See All The External Auditory Canal?

- The canal may be absent, stenotic, oedematous, or filled with wax, debris, blood, or a foreign body.

Can I See The Tympanic Membrane Or The Handle Of The Malleus, Or Both?

- Wax or other material can again obscure the deeper part of the canal.
- Rarely the membrane and malleus may be completely absent (for example, after certain ear operations).
- The handle may be visible even if most of the pars tensa is absent; (the handle gives you an indication of where the membrane should have been).

Normal Tympanic Membrane

Is The Tympanic Membrane Intact?

- Note the difference between a retracted drum and a perforation. The blood vessels in the middle ear give you a clue.

- If there is any debris or white keratin around the edge of the pars tensa or, more commonly, over the pars flaccida the patient may have an occult cholesteatoma (skin debris within the middle ear cavity).

Is The Tympanic Membrane The Right Colour And Transparency?

- Although the normal appearance of the membrane varies greatly, a gold or blue colouration or a dull membrane usually indicates fluid in the middle ear.
- Small chalk patches are extremely common.
- Thicker tympanosclerotic plaques are usually due to previous surgery.

Extostoses

Abnormal Findings:

Excessive Cerumen (Ear Wax):

- If you can only view 50% of the TM, then cleaning is recommended.

Cerumen

(Wax)

Otitis Externa (Outer Ear Infection):

- May be present if the ear canal is red, tender, swollen.
- Painful when wiggling or pulling on the outer ear.
- The canal may be filled with yellowish-green pus.

Otitis Externa

Otitis Media (Middle Ear Infection):

- The eardrum may look red and swollen. Scarring, retraction of the eardrum, or bulging of the eardrum may also be viewed.
- The tympanic membrane may be ruptured, allowing the pus in the middle ear space to drain into the ear canal.
- Even though the rupture of the tympanic membrane suggests a traumatic process, it is almost always associated with the dramatic relief of pressure and pain.

Extostoses:

- Bony growth in canal wall.
- Associated with cold-water swimming.

Otitis Media

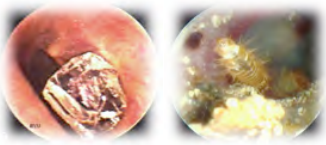
Foreign Body:

- The external ear canal is prone to foreign body contamination.
- Particularly for divers who do not wear fully enclosed helmets.

Ear Canal Barotrauma:

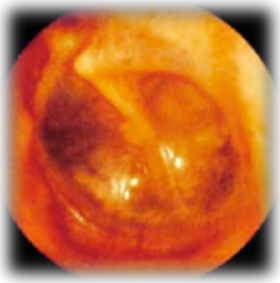
- Fluid may appear behind the tympanic membrane, causing it to bulge and appear red.
- In other cases, the eardrum may be retracted or sunken.
- Very often middle ear barotrauma is classified using the TEED System:
  - TEED Classification of Middle Ear Barotrauma:
    - Type I - congestion of umbra.
    - Type II - entire drum red.
    - Type III - haemorrhage and fluid.
    - Type IV - haemorrhage and free blood in middle ear.
    - Type V - perforation.
    - Type VI - Severe perforation.

Foreign Body

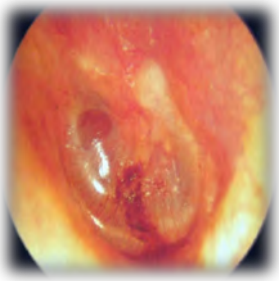


TEED Type I

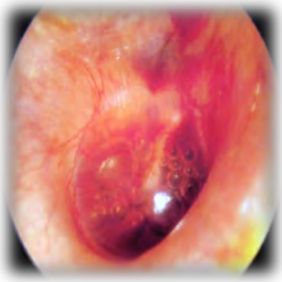
TEED Type II



TEED Type III



TEED Type IV



TEED Type V

TEED Type VI

As has been discussed earlier in this chapter a thorough primary and secondary survey is key to identify and treating life-threatening injuries.

The use the “ABCDE” approach has some key advantages.

These Include:

- A detailed history is not essential to begin the evaluation.
- The ability to identify & treat the greatest threat to life first.
- Once a life-threatening injury is discovered, clinical intervention is not delayed.
- The lack of a definitive diagnosis does not impede the application of an indicated treatment.

Trauma Teams

Trauma is best managed by a team approach. With an effectively led team, a casualty with potentially deadly injuries may be rapidly assessed and treated in a cohesive manner due to the fact that all elements of the survey may be conducted simultaneously.

Trauma Team Roles Include:

- Airway.
- Airway 2 (assistant).
- Circulation.
- Runner.
- Scribe.
- Team leader.

To function properly it is vital that team members have designated roles and tasks.

The Specific Assessments / Interventions Of Each Role Include:

Airway

The **AIRWAY** team member carries out the Airway element of the secondary survey.

This Involves:

- The airway assessment.
- Top to Toe: Neck (T.W.E.L.V.E).

Whilst describing these roles their specific interventions are discussed. These skills are fully detailed in later sections of this manual.

Immediate Interventions Should Be Given If Needed:

- Airway suction application.
- Chin lift / jaw thrust application.
- Oral / nasal airway insertion.
- Definitive airway insertion (E.T. tubes / iGEL’s).
  - Initiating a R.S.I. (for casualties with GCS > 6).

The Airway team member should assume spinal injury in all patients with multi-system trauma.

Immediate Spinal Precautions Should Be Commenced If Needed:

- C-spine immobilisation should be applied immediately.
- C-spine collar should be applied as soon as possible.
- Definitive immobilisation should be instigated once assessment complent.

All airway findings & interventions should be reported to the Team Leader. Logistical support may be sought from the team, however the ‘Airway’ team member works closely with the ‘Airway Assistant’.

Secondary Airway Role

The Airway team member also has a secondary role. This is to conduct the **Disability** element of the secondary survey. The reason for this is two-fold, firstly all neurological deficits have gross airway implications and the Disability is all ‘head’ related and this is the position where the Airway team member stands.

The Disability assessment involves:

- Assessing an A.V.P.U. neurological assessment.
- Assessing pupil response.
- Top to Toe: head examination.

Immediate interventions should be given if needed

- Addressing airway implications of a reduced conscious level.
- Applying primary dressing to head injuries.

All findings & interventions should be reported to the Team Leader (after Breathing & Circulation reported). Logistical support may be sought from the team.

Airway Assistant (Airway 2)

The Airway Assistant team member carries out the **Breathing** element of the secondary survey.

This Involves:

- The R.I.S.E. - F.A.L.L. respiratory assessment.
- Top to Toe: Shoulders & Chest examination.
- The application of a SpO_2 monitor (if available).

Immediate Interventions Should Be Given If Needed:

- Ventilate with 100% oxygen.
  - Non-rebreather mask if breathing adequate (O_2 @ 15L/min).
  - Ventilate with B.M.V. if inadequate breathing (O_2 @ 15L/min).
- Needle decompression (if tension pneumothorax suspected).
- Occlusive / valve dressing (If sucking chest wound present).
- Assist with RSI:
  - Applying cricoid pressure.
  - Evaluating ETT / iGEL position.
  - Securing tube.

All findings & interventions should be reported to the Team Leader. Logistical support may be sought from the team.

Circulation

The **Circulation** element of the secondary survey is carried out by the **Circulation** team member.

This Involves:

- Taking a Pulse Rate (and evaluating its character).
- Estimating Blood Pressure (Does the casualty have a Radial Pulse).
- C.R.T.
- The application of a cardiac monitor (if available).

Immediate Interventions Should Be Given If Needed:

- Apply pressure to sites of external hemorrhage (**Immediately** if catastrophic hemorrhage is self evident).
- Applying tourniquet (**Immediately** if catastrophic hemorrhage is self evident).
- Establish IV access.
  - 2 large I.V. bore cannula's (18g minimum).
- Commencing I.V. fluid.
  - 250mls of crystalloid (Hartmans / Saline 0.9%) immediately then reassess.
- Assist with RSI:
  - Giving sequential drugs (under direction of Team Leader / Dive Doctor).

All findings & interventions should be reported to the Team Leader. Logistical support may be sought from the team, however the Circulation member generally works closely with the Runner.

Runner

The **Exposure** element of the secondary survey is carried out by the **Runner** team member.

This Involves:

- Top to toe:
  - Abdomen examination.
  - Pelvis examination.
  - Legs examination.
  - Arms examination.
  - Back examination. Using a logroll if spinal injury suspected with Airway to lead.
- Complete disrobing of casualty.
- Logistical support of team.

Immediate Interventions Should Be Given If Needed:

- Limb splinting.
- Pelvis wrapping.
- Primary dressings.

All findings & interventions should be reported to the Team Leader. Logistical support may be sought from the team.

Scribe

The scribe's main role is that of documentation.

It is necessary to fully document a casualty's resuscitation & experience has shown that an attempt to document afterwards is generally difficult.

There Are Some Key Qualities Of A Good Scribe:

- The ability to document in an accurate timeline.

- Use the available resuscitation documentation.
- Separate information into appropriate fields (Airway / breathing etc).
- To allow the team leader to identify patterns in casualty.
- To works silently.

The Role of a Team Leader 1.13.1

It is often said that 'The first task of a leaderless team is to select a leader'. A team leader is a vital in resuscitation; good leadership is often the difference between life & death.

Effective leadership is a powerful combination of well-executed knowledge, good team direction and an assertive approach.

The real factors that improve the chances of a casualty surviving a trauma are; good communication, effective cooperation and efficient coordination. It is only with effective leadership that these factors may be achieved.

The Key Qualities Of A Leader Are:

- To be an effective 'role model'.
- Dedication.
- Magnanimity.
- Humility / integrity.
- Openness / Fairness.
- Assertiveness / Confidence / Creativity.
- A sense of humour (only a little though).

There is an iron clad golden rule of being a team leader, and it is **DO NOT TAKE ON A CLINICAL ROLE.** The Team Leader role is to oversee the trauma management; this is made impossible if they are actually involved in the actual trauma resuscitation.

The Key Areas Of Effective Team Management Are:

- Practice scenarios (essential, a well oiled team is an effective team).
- Pre-brief (break down the situation and plan the resuscitation to the team).
- Assign roles:
  - Give clear roles & responsibilities (Airway, Airway Assistant, Circulation, Runner).
  - Assigning roles BEFORE treatment commences.
  - Delegate task to individual, not to the room.
  - Be prepared to split the team if more casualties present.
- Ask team member to repeats back to instructions & confirm.
- Anyone on team may validate decisions (But it should not be a debate).
- Post debrief (better done the next day- lessons learnt).

The Common Pitfalls Of A Team Leader.

- The Team Leader taking a clinical role (The cardinal sin).
- Over complicating the situation.
- Identification of individual members by name, instead of roles.
- Not defining team members duties - who does what?
- Not keeping team updated.
- Not reassessing the casualty's A,B,C,D,E's.
- Forgetting the casualtie's perspective

CASUALTY TRIAGE 1.14

Triage, derived from the old French verb *trier* (meaning to sieve or sort), is the process by which both treatment and transport priorities are allocated to casualties.

The aim of triage is to get the right casualty the right care in the right place at the right time.

Treatment protocols concentrate on what to do with individual patients. Identifying the "sickest" casualty and prioritising their treatment and evacuation is essential to reduce mortality and morbidity.

In times of high casualty flow the principle of "doing the most for the most" is paramount. Triage enables this.

Triage is a military innovation and was first applied by Baron Dominic Jean Larrey, Chief Surgeon to Napoleon. The concept has been adopted widely in civilian and commercial settings for major incident and disaster medical management.

Triage Priorities

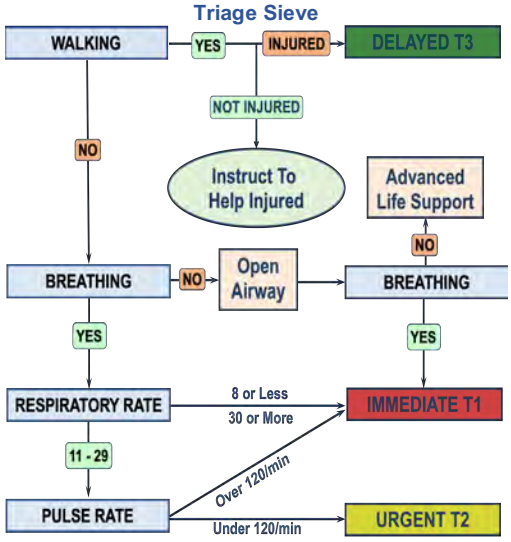
- **T1 Priority** **-IMMEDIATE-**
  These are casualties with life, limb or sight-threatening injuries (for example any of the A.T.O.M.F.C. conditions). Treatment is essential within an hour.
- **T2 Priority** **-URGENT-**
  These are casualties with serious injuries that require treatment within 2 hours (for example, fractured shaft of femur however, this could be categorised as T1 if the fracture was open and the haemorrhage was substantial).

- **T3 Priority** **-DELAYED-**
  These are casualties whose injuries can safely wait for up to 4 hours before treatment (for example, minor wounds, burns or fractures).

- **T4 priority** **-EXPEXTANT-**
  This priority should **NOT** be awarded routinely. T4 is reserved for those patients whose injuries are so severe that despite treatment the prognosis is hopeless (e.g. > 90% burns; open head injury with unresponsiveness). Using resources to treat these patients at times of high demand would jeopardise the potential survival of other salvageable casualties.

- **Dead** **-DEAD-**
  It is important to recognise death and to label bodies as dead. This prevents repeated assessment of the dead.

Triage Sieve



Triage Sieve

The *Triage Sieve* is a part of the rapid 'first look' primary survey It is suitable for initial assessment at point of wounding, or when the casualty load is high at successive points in the evacuation chain. It is designed for the DMT, to provide safe triage.

The T4 (Expectant) category is **not** part of the Triage Sieve. The decision to withhold further resuscitation is one to be made by a doctor, generally in an isolated environment work environment.

Triage Labeling

After assigning a triage category to each patient, the triage officer must label each casualty to identify that triage has been done and to help direct the treatment resources to the most needy patients.

At the simplest level triage labelling can be achieved by writing on the casualty's cheek.

The Elements Of An Effective Label Are:

- Simplicity of use.
- Can be reconfigured rapidly to show a change in priority.
- Assists the user to perform the Triage Sieve and Triage Sort.
- Is robust for field use.
- Can be easily attached to the patient.
- Has space for personal identifier and clinical information.

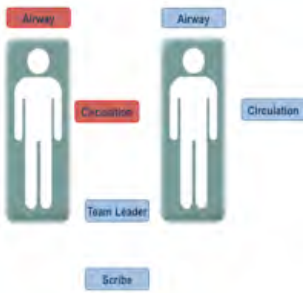
Triage Label

Multiple Casualties 1.14.1

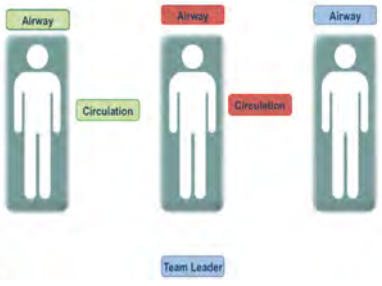
A simple rule can be used for multiple casualties, to decide who needs treatment first. A rough 'rule of thumb' is that the casualty who is the quietest needs treatment first, whereas the one making the most noise is the least seriously ill.

Obviously the rapid identification of the most severely injured casualty is paramount in their successful resuscitation.

2 T1 Casualties / 6 Medics



3 T1 Casualties / 6 Medics



The team leader is often the person to triage the casualty's (however a trusted 2nd in command can also do this). Once a rapid triage is completed treatment interventions may be planned with the available resources and personnel.

The greatest priority being given to the casualty's with the higher triage category.

This does not mean that you ignore T3 casualties; a sole medic may administer their assessment & care.

If the shear number of casualty's overwhelms the available personnel, then the team leader may make the decision to split the available personnel into smaller teams.

This does not mean the leader now takes on a clinical role.

In truly exceptional circumstances the T4 category may be instigated. However this is generally a task for a qualified doctor. The decision to cease resuscitation on a severely injured colleague is an amazingly difficult decision, but the golden rule of multiple casualty care is the survival of the many, not the few.

Section 2

Clinical Skills

AIRWAY MANAGEMENT 2.1

Causes Of Airway Obstruction 2.1.2

The Airway Can Be Obstructed By:

- The tongue.
- A foreign object.
- Swelling and trauma.

Obstruction by the Tongue

The most common source of upper airway obstruction is the tongue. In the stuporous or comatose patient, the jaw becomes slack and as a consequence, the tongue tends to fall back against the posterior wall of the pharynx, thereby closing off the airway.

A patient with partial obstruction from the tongue will have snoring respirations.

A patient whose airway is completely obstructed will have no respirations at all.

Obstruction of the airway by the tongue is simple to correct using one of several manoeuvres that elevate the base of the tongue away from the back of the throat.

Obstruction By A Foreign Object (Choking)

The offending object is usually a piece of food. When a piece of food lodges in the airway, the patient becomes completely aphonic, that is, unable to talk, groan, or cry out.

Signs Of Choking:

- Victim cannot speak or make any sound.
- Universal distress signal for choking - victim clutches his neck between his thumb and index finger.
- Dusky or cyanotic skin.
- Exaggerated by ineffective breathing movements.
- Collapse.

Obstruction From Swelling And Trauma

The upper airway may become obstructed not only by the tongue or foreign bodies, but also by swelling of its component tissues. Laryngeal oedema can occur from burns to the airway and from allergic reactions.

The most severe form of allergic reaction, anaphylaxis, may occur in sensitive individuals on exposure to a food, medication, inhalant, or sting to which they are allergic. Usually he will begin to notice itching of the palate and a sensation of a 'lump in the throat' (That sensation is produced by swelling of the larynx).

There may also be swelling of the posterior pharynx, uvula, and vocal cords. The net effect is to produce progressive upper airway obstruction. The patient's voice grows hoarse. Finally the airway may close off completely. The entire sequence of events can occur within minutes.

Manual Airway Manoeuvres 2.1.3

Head Tilt- Chin Lift:

The rescuer places one hand on the patient's forehead and applies firm pressure backward with the palm to tip the patient's head maximally back.

The head tilt is usually augmented by using the other hand to support the patient's chin (head tilt - chin lift).

Head Tilt –Chin Lift

To Preform A Head Tilt – Chin Lift:

- Use one hand to press backward on the patient's forehead (head tilt).
- Place the fingers of your other hand under the bony part of the chin and pull the chin forward (chin lift), so that the teeth are nearly brought together.
- Avoid closing the patient's mouth, (unless you are performing mouth to nose ventilation).
- If the patient has loose dentures, use the thumb to hold them in position.
- Keep your fingers on the bony part of the chin and not to compress the soft tissues under the chin (this may itself cause airway obstruction).

Triple Airway Manoeuvre

Triple Airway Manoeuvre

This manoeuvre is useful when using a pocket mask to provide artificial ventilation.

To Preform A Triple Airway Manoeuvre:

- Place your fingers behind the angles of the patient's jaw.

- Forcefully displace the mandible forward.
- Tilt the head backward.
- Retract the patient's lower lip with your thumbs.

Jaw Thrust

Jaw Thrust

The Head Tilt-Chin Lift & Triple Airway Manoeuvers' involve some extension of the neck and therefore could be dangerous where there is a cervical spinal injury.

In these cases a modified technique, the jaw thrust, may be used.

To Preform A Jaw Thrust Manoeuvre:

- Kneel above the head of the patient, knees apart to give you balance.
- Hold the head with your hands to keep their head and neck in line with the body.
- Place your middle and index fingers under the jaw line of the patient (under their ears).
- Lift the jaw upwards with your fingers (This lifts the tongue from the back of the pharynx).

Airway Suctioning 2.1.4

Manual Suction

Airway suctioning is a vital part of a medic's immediate interventions. Airway suctioning way help clear airway secretions (blood, vomit, inhaled water, secretions & pulmonary odeama) and improve ventilation / oxygenation.

Suction units may be hand powered, electrically powered or vacuum driven.

All Suction Units Should Have The Following:

- Strong vacuum.
- Collection bottle.
- A transparent connection tube.
- A variety of sterile disposable suction catheters.
- Sterile water for rinsing the system.

Electric Suction

Suction catheters may be; flexible catheters used for suctioning the nose / pharynx & through an endotracheal tube or a rigid tonsil tip suction catheter (Yankauer catheter) that is useful for suctioning the mouth and pharynx of an unconscious patient.

Suctioning The Mouth And Throat

A patient who is suctioned should first be pre-oxygenated for at least 3 minutes.

Each suctioning attempt should be brief, with a period of oxygenation in between.

Use a yankauer catheter to suction the mouth and throat of an unconscious patient. This can remove large volumes of fluid quickly, along with small food particles.

Suctioning Procedure:

- Pre oxygenate casualty.
- Position yourself at the patient's head, and turn his head to the side.
- Open the patient's mouth and inspect for obstructions (magill's forceps may be used to clear the mouth of any debris).
- Insert the suction catheter into the mouth so that the convex side goes along the roof of his pharynx.
- Keep the vacuum off until the suction tip is in place.
- Then move the catheter tip around the pharynx to 'vacuum clean' it out.
- Use the tonsil tip catheter only under direct vision. (Never jam it blindly into the patient's mouth or throat).
- Remove the catheter and rinse the catheter thoroughly with water while you re-oxygenate the patient.

If the patient's mouth is clamped shut and you cannot open it, you may consider using a flexible rubber catheter to suction the back of the throat through the nose, the catheter moistened with water before use.

Oro-Pharangeal Airways 2.1.5

Every unconscious patient is in danger of death by asphyxia - the tongue may fall back and block the entrance to the trachea.

Oropharyngeal airways (OPA) are plastic curved devices used to hold tissue (such as the tongue) away from the airway to keep it open without the need to maintain a manual airway maneouver.

An OPA should only be used in a deeply unresponsive patient who is unable to maintain their airway. In responsive patients, they can cause vomiting and aspiration.

Inserting an airway of the correct size will usually help to keep the airway open.

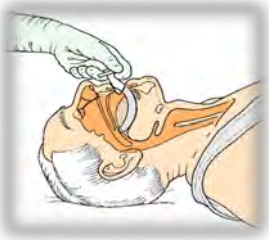
Insertion Technique For Oro-Phalangeal Airway.

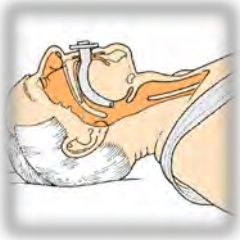
- Clear the airway using magills / suctioning.
- The correct size oro-pharyngeal airway is chosen by measuring against the patient's head (the flange is aligned with the centre of the lips and the tip to the angle of the jaw).

- Hold the flanged end and turn the airway down so that the curved surface is facing upward toward the roof of the mouth. (The airway is curved to follow the contours of the upper surface of the tongue).
- When you have inserted approximately half of the length, rotate the airway 180º and advance until the flanged end rests just outside the lips.
- If the patient shows any signs of rejecting the airway - remove the device. Check that air is passing through it.

Oro-Phalangeal Airway Insertion

Size / Colour	Intended Use
000	Neonates
00	Babies
0	Infants
1	Children
2	Small adults
3	Large adults
4	Very large adults





Select & Measure The Correct Sized Tube | Step 1 | Step 2

Naso-Pharangeal Airways 2.1.6

The nasopharyngeal airway (NPA) is a soft rubber or plastic hollow tube that is passed through the nose into the posterior pharynx. Patients tolerate NPAs more easily than OPAs, so NPAs can be used when the use of an OPA is difficult, such as when the patient's jaw is clenched or the patient is semiconscious and cannot tolerate an OPA

The NPA

Choosing the Right NPA

Size is really dependent upon the diameter of the patient's nostril; however, it is the length that is an important consideration, similar to the OPA the NPA is measured against the facial profile, (the flange is aligned with the nostril and the tip to the angle of the jaw).

The NPA is designed to go down the right nostril (the concave shape of the tube and the bevel of the tip facilitate this approach. The bevel on the tip keeps the NPA away from the septum).

If the nostrils are small, inserting a smaller NPA will defeat the object of its placement, as it will be too short.

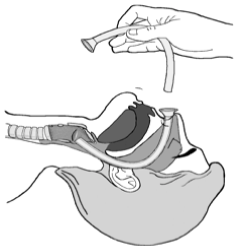
Sizing The NPA

Size:
6 - 7mm - Over 12 yrs old
7 - 8mm - Medium Adult
8 - 9mm - Large Adult

Inserting the Nasopharyngeal Airway

- Ensure that the mouth and pharynx are clear.
- Pre-oxygenate the patient.
- Select the appropriately sized NPA.
- Insert the safety pin through the flange (keeping the pin to one side allowing suctioning).
- Lubricate the Airway with water-soluble lubricant.
- Insert into the right nostril, gently directing straight back towards the ear in a rotating motion.
  - o If it will not pass with ease remove and try the other side or a smaller airway.
  - o DO NOT FORCE, it can cause haemorrhage thereby aggravating airway management.
  - o When inserted check that air is passing through it, suction may be required.

Inserting The NPA



You may still require airway management with manual manoeuvres - Head Tilt - Chin Lift - Jaw Thrust.

Contraindications Of NPA Insertion

- Nasal injury.
- Known anticoagulant therapy.
- Severe facial / skull injuries.

Endotracheal Intubation 2.1.7

Endotracheal intubation is the placement of a tube into the trachea to maintain a patent airway in those who are unconscious or unable to breathe independently. Compared to the use of pharyngeal airways (oropharyngeal or nasopharyngeal). ET intubation is considered the gold standard of securing a compromised airway.

The Indications For ET Intubation Include:

- Loss of the normal airway gag / cough reflex.
- The need to deliver positive pressure ventilation.
- Protection of the airway from gastric aspiration.

- Airway burns / trauma.
- To facilitate bronchial toilet.
- In preparation for aero-medical transfer.
- Protection against aspiration and gastric insufflation

Previously restricted to the anaesthetic and operating rooms, advances such as rapid sequence induction (RSI) have meant that intubation is often performed in emergency or pre-hospital settings.

These situations are by their nature high-risk and there is some evidence that pre-hospital endotracheal intubation in adult major trauma patients with head injury actually increases mortality.

Tracheal intubation is considered the 'gold standard' definitive airway. It completely isolates the trachea reducing the risk of gastric aspiration & increasing the ease to artificially ventilate a casualty.

To perform a tracheal intubation the casualty has to be profoundly unconscious or heavily sedated.

ET intubation requires a **high** degree of clinical competence.

Intubation Equipment Includes:

- Laryngoscope (An instrument to view the larynx).
  - Handle (With fresh batteries).
  - Blade (Various sizes).
  - Bulb (which should be secure).
- Endo Tracheal Tubes.
  - Selection of sizes - cut to length (DMT should check airtight cuff and secure connectors).
- Catheter mounts (Undamaged and intact).
- Sundries:
  - Lubricating jelly.
  - Magill forceps
  - Stethoscope.
  - Bougie / Stylet.
  - Oropharyngeal airways.
  - 20ml syringe (for inflating).
  - Ribbon gauze / tape.
- Suitable suction apparatus

E.T. Tube Insertion Equipment

Sizing the Tube

As a rough guide for adults, you can estimate. The width of tube to use by taking the width of the patient's third finger (often called the middle).

The length of the tube to use may be estimated by doubling the distance between the patient's ear lobe and angle of the mouth.

Age:	8-12 yr.	Adult Female	Adult Male
Tube Size (cm)	6-7	7.0 - 8.5	7.5 – 9.5
Length (cm)	19.0-20.0	20.0 - 23.0	21.0 - 25.0
Blade Size:	2-3	3-4	4 - 5

Preparing the Tube

Endotracheal tubes are packaged uncut, and will be too long for oral intubation. You will therefore need to cut them to the correct length to prevent accidental intubation of the right main bronchus.

Take The Tube From The Sterile Pack:

- Cut it to the right length (21 – 23 cm for females / 22 – 24 cm for males at the incisors).
- Fully insert the connector (ensuring a firm fit).
- Return it to the pack in a clean state and reseal.

Intubation Management

Intubation should take no longer than 30 seconds. Try holding your breath during intubation. If you need to breathe so does the patient. Then if necessary, start again.

You must take great care during the intubation, because you may cause damage to the upper airway by inappropriate use of the laryngoscope.

Head manipulation to realign the axes.

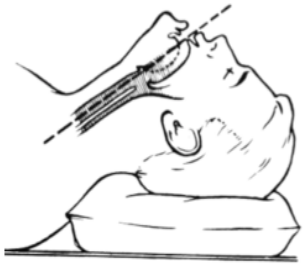
The cervical spine is flexed forward (ventrally) by placing the occiput on a pillow support. This manouvre straightens out the normally dorsiflexed attitude of these vertebrae.

The head is extended (dorsiflexed) on the cervical spine at the atlanto-occcipatal joints. The result of these two manipulations is that the oropharyngeal and pharyngotracheal axes are approaching alignment: In this anatomical diagram it is noticed that while the axes are approaching alignment, the dorsum of the tongue and the epiglottis prevent visualisation of the larynx through the mouth orifice. Note: the intubation trainer is already fixed in this position

Pre-Oxygenate And Prepare Equipment

While your colleague pre-oxygenates the patient, prepare your equipment. The patient should be pre-oxygenated for at least 2 minutes.

Sniffing The Morning Air Position



Position Of The Patient

The ideal position is for the patient to be flat on their back with nothing beneath the shoulders but a small pillow or pad under the neck. This produces flexion of the neck, and extension of the head. It is generally known as the 'sniffing the morning air position'.

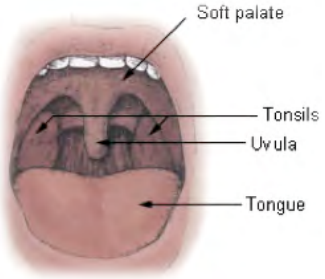
Open The Mouth

Open the mouth using your right hand. Hold the laryngoscope with the **left hand**, inspect for loose teeth and dentures, removing as necessary. Apply suction as required for a maximum of ten seconds then re-oxygenate.

Identify The Following:

- **Tonsil. First landmark.** Pass the laryngoscope along the right side of the tongue until the tonsil or tonsillar area is seen.
- **Uvula. Second landmark.** At the tonsillar level, pass the blade to the left, following the edge of the soft palate if required, until you see the uvula. This will clear the tongue to the left and out of the way.
- **Epiglottis Third landmark.** View the rounded tip of the epiglottis.
- Position the tip of the blade anterior to the epiglottis, and gently lift the epiglottis upwards, along the axis of the handle. This reveals the larynx and vocal cords. Do not lever the laryngoscope on the teeth.

Intubation Landmarks



View The Larynx

Often only the posterior third of the larynx is easily viewed. You will be able to see it more clearly by applying gentle pressure, backwards and upwards, on the neck skin over the larynx. The laryngeal opening should look like a blunt diamond-shaped hole running front to back.

The Mallampati Classification

This is used to predict the ease of intubation.

It is determined by looking at the anatomy of the oral cavity; specifically, it is based on the visibility of the base of uvula, faucial pillars (the arches in front of and behind the tonsils) and soft palate.

A high Mallampati score (class 4) is associated with difficult intubation.

Mallampati Class 1

Full visibility of tonsils, uvula and soft palate

Mallampati Class 2

Visibility of hard and soft palate, upper portion of tonsils and uvula

Mallampati Class 3

Soft and hard palate and base of the uvula are visible

Mallampati Class 4

Only hard palate visible

Laryngoscope

A rigid or flexible endoscope passed through the mouth and equipped with a source of light, for examining the larynx.

Utilising with a patient, who has residual degree of protective reflex in the upper airway, may produce laryngospasm, retching, vomiting, or if the patient bites on the inserted blade, broken teeth.

To minimise these complications, it is good practice to use the laryngoscope in patients that are deeply unconscious (GCS less than 8).

When these patients are identified and treated in this way, the blade should be gently placed into the mouth and slowly "walked" along the floor of the tongue, until the length of the blade is presented in the airway and able to lift the structures, for further visualisation of the laryngeal inlet.

During the "walking" phase, the practitioner must be ready to quickly remove the blade at the first sign of a reaction to the procedure and have suction at hand to deal with reflux/vomiting.

Laryngoscope

Laryngoscopy Do's & Don'ts

DO hold the laryngoscope along the shaft of the handle.

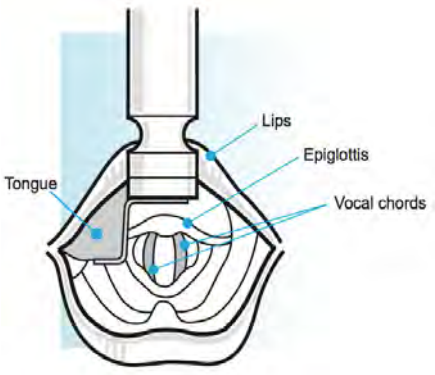
DO keep your back and your left arm straight, lift the laryngoscope away from you at a 45° angle.

DO ensure that the lower lip is retracted away from the lower teeth during the insertion of the laryngoscope.

DO lift laryngoscope in the direction of the arrow and in line with its handle.

DO NOT trap the lower lip between laryngoscope blade and teeth.

DO NOT lever the handle backward otherwise upper teeth will be damaged.



Bimanual laryngoscopy

Is the single most practical and effective airway management technique for facilitating intubation during laryngoscopy. It can be applied in seconds. It can transform a "difficult airway" or "difficult intubation" (poor view, intubation failure, repeat attempts) to a well-visualized larynx and first-pass intubation success.

Bimanual laryngoscopy. The force on the neck is opposite direction of lift by the laryngoscope.

Inserting The ET Tube

Only insert the tube if you have reliably identified the larynx. It may be helpful if a colleague pulls the right side of the mouth out of the way so that the tube does not obstruct your view.

Pass the lubricated endo-tracheal tube, under direct vision, through the laryngeal inlet, between the vocal cords, into the trachea.

A bougie, or stylet, may also be helpful to position the tube in the larynx.

Pass only enough tube so that the cuff is just below the cords.

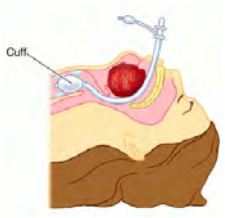
If you are in doubt about whether the tube is in the correct place, remove it, aspirate if necessary, re oxygenate and start again.

Intubation

Connect

After successful intubation, connect the catheter mount and the BMV and ventilate the lungs. At this stage most of the inflated air around the tube escapes and you hear a characteristic sound.

Cuff Inflation



Inflate The Cuff

Connect the syringe to the cuff inflation tube and inject air until the leaking sound ceases.

Then clamp the inflation tube (or if a one-way valve is fitted to the inflation tube, simply remove the syringe).

Both sides of the chest should rise and fall with ventilation.

Check Position

Auscultate both sides of the upper chest and the stomach.

Ensure both lungs are being ventilated and then fix the tube in position.

Position & Ventilation

Ventilate

Use the highest possible oxygen concentration to ventilate the patient. Occasionally check the ventilation - check for bilateral chest movement and breath sounds.

Oro-Pharyngeal Airway

It is helpful to insert an appropriately sized oro-pharyngeal airway alongside the endo-tracheal tube. This holds the tube steady and prevents the patient from biting and blocking the tube if there is an improvement in the level of consciousness or the patient convulses.

Intubation Procedure Recap:

Pulse Oximetry

- **Pre-oxygenate:**
  - Use 100% oxygen with a non-rebreather or bag-valve-mask.
  - Oxygenate for at least 30 seconds.
  - Keep pulse oximeter greater than 95% at all times.
  - Prepare equipment.
- **Assess airway**
  - Note landmarks, swelling, deformities.
  - Assess Mallampati Score.
  - Remove dentures, assess tongue size, dental obstruction, visibility of oro-pharynx.
  - Degree of neck mobility, maintain cervical spine stability as necessary.

CO_2 Analysis

- **Open airway:**
  - Suction or manually extract foreign material.
  - Chin lift, jaw thrust.
  - Use artificial airways if needed: oro-pharyngeal, nasopharyngeal.
- **Positioning:**
  - Position patient into “sniffing morning air” position if possible.
  - Restrain as necessary.
- **Laryngoscopy:**
  - Standing at the supine patient’s head, gentle insert laryngoscope blade with left hand.
  - Use suction as necessary with right hand.
  - Visualize glottic opening/vocal cords.
- **Intubation:**
  - Advance ETT with right hand through cords.
  - Remove stylet / bougie.
  - Inflate ETT cuff with 5 – 10 ml air via syringe.
- **Ventilate:**
  - Bag and valve with oxygen.
- **Confirm Tube Placement:**
  - Chest / gastric auscultation.
  - CO_2 monitor.
  - Chest x-ray (if possible).
- **Secure Tube:**
  - With ribbon / tape.

Remember

The laryngoscope may damage the teeth and the ET tube may damage the larynx. If the procedure takes more than 30 seconds, re-oxygenate and start again. Be gentle - never use force - if necessary be prepared to use a smaller tube.

Secure Tube

Potential Problems With Intubation

Difficult to Intubate

Some Patients May Be More Difficult To Intubate Because They Have:

- A receding lower jaw with an obtuse angle of the mandible.
- A short muscular neck and a full set of teeth.
- Prominent upper incisor teeth.
- A long narrow mouth with a high, arched palate.
- Carious or insecure upper teeth.
- Abnormalities of the cervical spine, where flexion of the skull on the neck.

If intubation proves impossible, revert to basic airway management techniques.

Vomiting And Regurgitation

There is always a risk of vomiting or regurgitation during intubation. This risk is increased in emergency patients who have recently been eating or drinking. Always have a wide-bore catheter or Yankauer suction attachment close at hand.

Clenching Of Teeth

Clenching of teeth may prevent intubation. It is not current policy to include blind intubation as a paramedic technique. So in this situation, abandon intubation and manage the airway with appropriate basic airway techniques.

Patient Resists Intubation

Where a patient has sufficient reflex activity to resist intubation, the patient cannot generally be intubated without drug therapy. So use basic airway techniques. Consider whether the patient truly needs intubating.

Facial Trauma

Though the face may be severely injured and bleeding, the internal anatomy is generally undisturbed.

Provided suction is adequate to clear the airway of blood and secretions, you can usually carry out intubation without difficulty. If the facial skeleton (particularly the maxilla or mandible) is fractured it may make intubation easier.

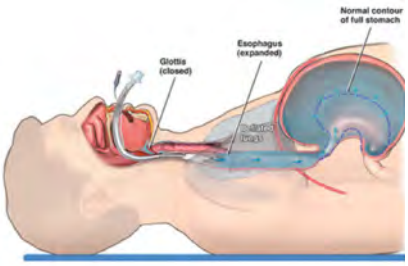
It will not be unusual for some movement of the fragments to take place but this should not unduly affect the procedure.

Burns To Airway

In cases of burns to the airway, caused by inhalation of flame or hot gases, the normal appearance of the upper airway may be severely disturbed. The resultant swelling can rapidly lead to upper airway obstruction, and you may have difficulty identifying the normal landmarks.

Sometimes pressure over the chest may release a bubble of air, which escapes from the larynx and the origin of this bubble may be the only clue to the laryngeal opening. You may need a smaller-than-usual tube, but cut to a longer length, if the airway has narrowed. Early intubation in these cases is recommended.

Oesophageal Intubation



Oesophageal Intubation

This life-threatening error should never occur if the correct protocols are followed. Oesophageal intubation can happen where you find access is difficult, or anatomical problems make it impossible for you to see the larynx. When it does happen, you must recognise it rapidly before hypoxic damage occurs.

Note These Signs:

- The oesophageal opening is flaccid, (the larynx is a sharply defined front-to-back one).
- Gas escaping from the oesophagus (a characteristic low frequency 'belch').
- A very large volume of air will be required to 'seal' the cuff.
- Chest movement will be slight, or absent (occasionally, gas blowing into the stomach may mimic chest movement).
- Air entry will be minimal or absent on chest auscultation.
- Return of gas during 'expiration' is minimal.
- The clinical state of the patient fails to improve.

Despite all these signs, oesophageal intubation may still occur. The best way to avoid it is to see the tube enter the larynx.

Right Main Bronchus

The left main stem bronchus is more horizontal than the right.

Intubation Of The Right Main Bronchus

This may occur as a result of using a tube that is too long. Recognise it by poor ventilation of the left side, and correct it by slowly withdrawing the tube until you see left-side chest movement. Secure the tube, and recheck air entry regularly.

Pneumothorax

You might suspect this from the patient's history.

Diagnose it by absent or distant breath sounds over the affected side, and minimal chest movement. These signs are similar to bronchial intubation, but in a pneumothorax they will not improve when you withdraw the ET tube.

If the condition is not treated it may progress to tension pneumothorax with consequent cardiovascular collapse.

Recognising it depends partly on you suspecting its presence in every patient with a potential chest injury.

Secure ET Tube

Induced Bradycardia

Bradycardia may be induced during intubation by increased parasympathetic tone.

If a patient with a pre-existing bradycardia requires intubation, the doctor may consider prophylactic atropine – (dose 250 to 500 mg IV for adults).

Displacement Of Tube

The endotracheal tube may become displaced by movement of the head and neck whilst moving the patient.

The importance of securing a tube with tape / ribbon cannot be over emphasized. The DMT should ensure the correct cm mark at the incisors & maintain in place, tension should **never** be applied to the ET tube.

The use of catheter mounts (which reduce tension) is strongly advised. Tubes should be doubly tied prior to moving a casualty and it is common for a ventilation apparatus to be temporarily (no more than 15 seconds) disconnected prior to moving a 'tubed' casualty between stretchers.

All movements should be led by the 'Airway' team member with an intubated casualty.

Laryngeal Spasm

Laryngeal spasm may occur if there is excessive movement of the endotracheal tube during insertion. If this occurs, remove the ET tube, oxygenate the patient, until the spasm subsides.

After a few minutes, pre-oxygenate the patient again and reattempt intubation.

Total Airway Obstruction

In circumstances when the airway is totally obstructed and intubation has failed, cricothyroid puncture may be the only pre-hospital solution.

Cervical Spinal Injury

Where you suspect this, apply a stiff cervical collar immediately. Only attempt intubation if other means of airway care are inadequate. Carry it out with minimal neck movement.

In the event of the patient being bradycardic from the effects of parasympathetic dominance, consider prophylactic atropine (dose 250 to 500 mg IV) before attempting intubation. This is to prevent further reflex slowing of the heart rate.

Extubation Of An Intubated Casualty

Extubation

In all patients where the clinical condition improves to the point that intubation is no longer necessary.

Remove The ET Tube Using This Procedure:

- Assess weather the casualty is able to be extubated. Can they:
  - Breath on their own (sufficiently without ventilator support).
  - Obey a simple command (such as stick out your tongue).
  - Do they have a cough / gag reflex (does slightly wiggling the tube initiate this).
- Administer oxygen at the highest possible concentration.
- Sit the casualty into an upright position.
- Aspirate the mouth and oro-pharynx with suction.
- Do NOT aspirate through the ET tube.
- Do NOT remove the oropharyngeal airway.
- After aspiration, deflate the cuff and remove the tube in one quick movement at the end of INSPIRATION. (Inspiration is chosen because it is at this point that the vocal cords are at their widest).
- Re-aspirate the mouth and pharynx.
- Check ventilation and observe constantly for adequacy of rate and depth.
- Administer oxygen at the highest concentration possible.

Remember: Continually monitor the airway for patency after extubation

i-GEL Supraglottic Airway Intubation 2.1.8

The **i-gel** airway is a novel and innovative supraglottic airway management device. It is designed to create a non-inflatable anatomical seal of the pharyngeal, laryngeal and perilaryngeal structures whilst avoiding the compression trauma that can occur with inflatable supraglottic airway devices.

Adult iGEL's

A supraglottic airway without an inflatable cuff has several potential advantages including easier insertion, minimal risk of tissue compression and stability after insertion (i.e. no position change with cuff inflation).

The **i-GEL** is designed as a latex free, sterile, single patient use device. The buccal cavity stabiliser has a widened, elliptical, symmetrical and laterally flattened cross sectional shape (but still round airway channel), providing good vertical stability and axial strength upon insertion. This houses a standard airway channel and a separate gastric channel.

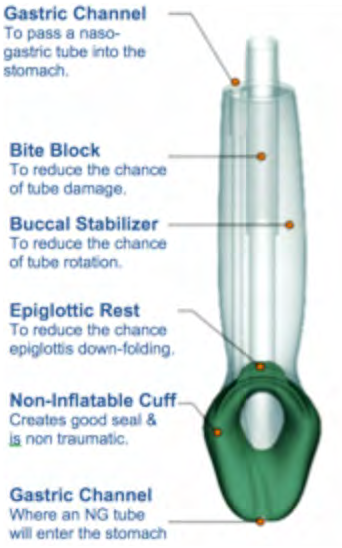
i-Gel Size	Patient Size	Patient Weight (Kg)	Comparative E.T.T. Size
1	Neonate	2.5	3.0 mm
1.5	Infant	5 – 12	4.0 mm
2	Small Paediatric	10 – 25	5.0 mm
2.5	Large Paediatric	25 – 35	5.0 mm
3	Small Adult	30 – 60	6.0mm
4	Medium adult	50 – 90	7.0 mm
5	Large Adult	90 +	8.0 mm

Size Selection

Select the appropriate size **i-GEL** by assessing the patient's anatomy. The **i-GEL's** cuff may look smaller than traditional supraglottic devices with an inflatable cuff of the same numerical size.

WARNING:
Whilst size selection on a weight basis should be applicable to the majority of patients, individual anatomical variations mean the weight guidance provided should always be considered in conjunction with a clinical assessment of the patient's anatomy.

Adult iGEL



Pre-Use Checks

- Inspect the packaging and ensure it is not damaged prior to opening.
- Inspect the device carefully, check the airway is patent and confirm there are no foreign bodies / lubricant obstructing the airway or gastric channel.
- Carefully inspect inside the bowl of the device, ensuring surfaces are smooth and intact and also that the gastric channel is patent.
- Discard the device if the airway tube or the body of the device looks abnormal or deformed
- Check the 15mm connector fits the patient connection.

Pre-Insertion Preparation (Adult i-GEL. Sizes 3, 4 and 5):

- Always wear gloves.
- Open the i-GEL package, and on a flat surface take out the protective cradle containing the device.
- In the final minute of pre-oxygenation, remove the i-GEL and transfer it to the palm of the same hand that is holding the protective cradle, supporting the device between the thumb and index finger. Place a small bolus of a water-based lubricant, onto the middle of the smooth surface of the cradle in preparation for lubrication.
- Grasp the i-GEL with the opposite (free) hand along the integral bite block and lubricate the back, sides and front of the cuff with a thin layer of lubricant. Check that no bolus of lubricant remains in the bowl of the cuff. Avoid touching the cuff.
- Place the i-GEL back into the cradle.

Step 1

Step 2

Step 3

WARNING:
The i-gel is supplied in a protective cradle or cage pack to ensure the device is retained in the correct flexion prior to use and also acts as a base for lubrication. The i-gel must always be separated from the cradle or cage pack prior to insertion. The cradle and cage pack are not introducers and must never be inserted into the patient's mouth.

NB. The i-GEL must always be separated from the cradle prior to insertion. The cradle is not an introducer and must never be inserted into the patient's mouth.

Recommended Insertion Technique of iGEL:

A Proficient User Can Achieve Insertion Of The I-GEL In Less Than 5 Seconds:

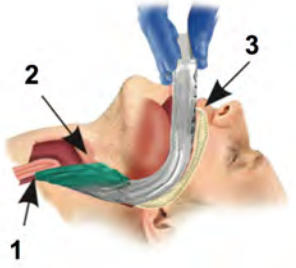
- Grasp the lubricated i-GEL firmly along the integral bite block. Position the device so that the i-GEL cuff outlet is facing towards the chin of the patient.

- The patient should be in the 'sniffing the morning air' position with head extended and neck flexed. The chin should be gently pressed down before proceeding to insert the i-GEL.
- Introduce the leading soft tip into the mouth of the patient in a direction towards the hard palate.
- Glide the device downwards and backwards along the hard palate with a continuous but gentle push until a definitive resistance is felt.
- At this point (Step 3) the tip of the airway should be located into the upper oesophageal opening *(1)* and the cuff should be located against the laryngeal framework *(2)*. The incisors should be resting on the integral bite-block *(3)*.
- The i-gel should be taped down from 'maxilla to maxilla'.
- If required, an appropriate size nasogastric tube may be passed down the gastric channel.

Step 1

Step 2

Step 3



WARNING:
Do not apply excessive force on the device during insertion. It is not necessary to insert fingers or thumbs into the patient's mouth during the process of inserting the device. If there is early resistance during insertion a 'jaw thrust' , 'Insertion with deep rotation' or triple maneouvre is recommended.

Important Notes To The Recommended Insertion Technique

- Sometimes a feel of 'give-way' is felt before the end point resistance is met. This is due to the passage of the bowl of the i-GEL through the faucial pillars (pharyngo-epiglottic folds).
- Once resistance is met and the teeth are located on the integral bite block, do not repeatedly push i-GEL down or apply excessive force during insertion.
- No more than three attempts in one patient should be attempted.

Use 'Incisor Line'

Tape Tube To Avoid Extubation

WARNING
In order to avoid the possibility of the device moving up out of position prior to being secured in place, it is essential that as soon as insertion has been successfully completed, the i-GEL is held in the correct position until and whilst the device is secured in place.

NB: DO NOT attempt to forcibly remove the device if the patient is biting on it. Wait until the patient, on vocal command, has fully opened their mouth or opens their mouth spontaneously.

Problem Solving With the iGEL

Incorrect Position

A horizontal line (Adult sizes 3, 4 and 5 only) at the middle of the integral bite-block represents the correct position of the teeth. If the teeth are located lower than the distal tip of the bite block, then it is likely the device has been incompletely inserted.

In this instance, remove the i-GEL and reinsert with a gentle jaw thrust applied by an assistant. If that does not resolve the problem, use one size smaller i-GEL.

Once it has been established that ventilatory parameters are satisfactory and there is no leak through the gastric channel, the i-GEL should be held in place whilst the device is secured with tape 'maxilla to maxilla'.

Correct Position

Air Leakage Through The Gastric Channel

A small air leak, air venting, through the gastric channel may be a useful mechanism to protect against gastric insufflation, but an excessive leak means the device is incompletely inserted.

In such instances, remove the device and reinsert with a gentle jaw thrust applied by an assistant, a deep rotation or triple maneouvre to achieve an optimum depth of insertion.

Inadequate Seal Pressure

If it is felt that a higher seal pressure is desired, it is advised that a larger size than that recommended on weight basis is used.

However, even if the seal pressure in a given patient would allow it, peak airway pressure of ventilation must not exceed 40cm H_2O, in order to prevent barotrauma.

Rapid Sequence Induction (R.S.I.) 2.1.9

A Rapid Sequence Induction (RSI) involving the rapid induction of general anesthesia and tracheal intubation of a patient.

Unless a casualty is profoundly unconscious it is unlikely they could ever tolerate the presence of an intra-tracheal or supra-glottic device due to over-stimulation of the gag-cough reflex.

The R.S.I. has become the staple of pre & intra hospital intubation management.

The R.S.I. is always administered under the supervision of appropriately qualified medical personnel.

R.S.I. Kit

An R.S.I. Consists Of:

- An opiate based pre induction agent (See Section 7).
- A sedative induction agent. (See Section 7).
- A neuromuscular relaxant. (See Section 7).

There Are Several Indication For An Emergency R.S.I.:

- Actual or potential airway compromise:
  - o Airway burns.
  - o G.C.S. <8 (The conscious level may be low enough to endanger their airway, but a partial gag or cough reflex may still be present).
  - o Facial / neck trauma.
- A.G.E.
- Ventilation inadequacy (The casualty simply cannot breath without respirator support).
- Traumatic brain injury.
- Facilitation of procedures (Extraction from crushing, or prior to aeromedical transfer).
- Humanitarian (Such as major burns).

The R.S.I. Process

The intubation process with the assistance of an R.S.I. may be remembered as 'The 6 P's'. This forms a rational and stable approach to the controlled and safe intubation of a casualty regardless of the setting.

The R.S.I.'S 6 P Process:

Preparation (T minus 10 min)

- Suction airway.
- Provide B.M.V. Ventilation.
- Ensure adequate venous access.
- Allocate team tasks (Airway- Intubate, Airway Assistant- B.M.V. & cricoid pressure, Circulation- Drug administration).
- Position patient (Sniffing the morning air).
- Evaluate for difficult airway (Using the Mallampati classification).
- Check and prepare equipment (laryngoscope, E.T. tube. Draw up and label drugs. SpO_2 monitoring).

Cricoid Pressure

1) Cricoid Cartilage . 2) Thyroid Cartilage.

Pre-oxygenation (T minus 5 min)

- 100% O_2 via non-rebreather / BIBS (In a breathing casualty).
- Use BMV if insufficient respiration.

Pre-Medication (T minus 2 min)

- Give Pre-induction agents (under instructions of doctor).
- A 'quick look' of the vocal cords may be possible if appropriate agent used.

Cricoid Pressure

Pressure on the Cricoid Cartilage during intubation has two purposes:

- Reducing the chance of gastric regurgitation (By compressing the oesophagus).
- To aid in viewing of the glottis.

Paralysis (T = ZERO)

- Administer Induction agent (under instructions of doctor).
- Apply cricoid pressure (The phrase 'Cricoid pressure on' should be announced).
- Give neuromuscular blockade (under instructions of doctor).

Passage of E.T. Tube (T plus 30 – 45 sec)

- Intubate (Observe passage of ET tube between the cords).
- If SpO_2 < 90% abort intubation.
  - o Provide ventilation with B.M.V. & high flow O_2.
  - o Resume insubation when SpO_2 is > 90%.

Post Intubation Care (T plus 45 sec)

- Confirm placement (Auscultate lungs & stomach).
- Inflate cuff.
- Cease cricoid pressure (The phrase 'Cricoid pressure off' should be announced).
- Detect $ETCO_2$. (If possible).
- Secure tube.
- ABG and CXR (if possible).
- Reassess O_2 needs
- Continue sedation (Sedative & opiate infusions are standard).
- Evaluate definitive care needs (Oro / nasogastric tube. Urinary catheter).

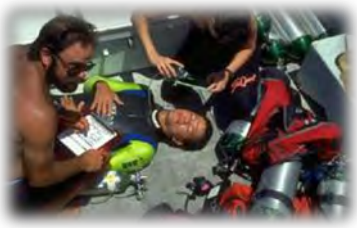
BREATHING MANAGEMENT 2.2

Oxygen Administration 2.2.1

Oxygen is a colourless, odourless gas essential for life. Air contains oxygen at a concentration of approximately 21%.

Oxygen is widely used in emergency medicine, both in hospital and by emergency medical services or advanced first aiders.

High Flow Oxygen Is Definitively Indicated For Use In:



- Resuscitation.
- Major Trauma.
- Gas inhalation.
- Major Haemorrhage.
- Shock / Anaphylaxis.
- **Helium / oxygen** Convulsions.
- Hypothermia.

Oxygen Therapy Is Indicated In Nearly All Diving Accidents (with the notable exception of oxygen toxicity):

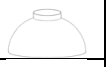
- Decompression Illness. (D.C.I.)
- Arterial Gas Embolism. (A.G.E.)
- Cerebral Arterial Gas Embolism. (C.A.G.E.)
- Near-drowning.
- Barotraumas and pneumothoraces.

The Benefits Of Oxygen Include:

- Oxygenation of hypoxic tissue. Hypoxia is present in all-critical illnesses. Which is why early O_2 administration is so important.
- Reducing tissue oedema and temporarily relieves symptoms.
- Increase pressure gradient to facilitate elimination of nitrogen.
- Has a psychosomatic property. The application of O_2 has a profound placebo effect, which has been clinically proven.

In the pre-hospital situation the administration of O_2 is through the use of stored oxygen cylinder.

Diving Industry Commonly Accepted Cylinder Colour Coding (IMCA D 043)

Gas Type		Shoulder Colour
Oxygen	O_2	
Air (20%≤O_2≤23%)	Air	
Helium / oxygen	He/O_2	
Oxygen / carbon dioxide	O_2/Co_2	
Oxygen / nitrous oxide	O_2/N_2O	

The Cylinder

Most oxygen cylinders are pressurised to 137 bar. Medical gas cylinders, regardless of the supplier, are colour coded according to a national standard. Within the diving industry breathing gas commonly adheres to IMCA D043 regulations with regards to the colour coding of the cylinders (See chart).

Oxygen is generally has a white shoulder collar and a black body. There are two labels found on cylinders. The large label is found on the body or shoulders of the cylinder.

Cylinder Size	Volume of O_2	Duration of Cylinder	Fittings
C Size	170L	11 min @ 15L	2 pin index
D Size	340L	22 min @ 15L	2 pin index
CD Size	460L	30 min @ 15L	Multi-function
E Size	680L	45 min @ 15L	2 pin index
F Size	1360L	90 min @ 15L	Bull nose
HX Size	3040L	202 min @ 15L	Multi-function
G Size	3400L	226 min @ 15L	Bull nose

It Provides The Following Information:

- The type of gas.
- Hazards.
- Safety precautions.
- Volume of gas.
- The substance identification number.
- Gas specification.
- The smaller label on the cylinder valve will provide:
- The batch number.

- Date of filling.
- Date of expiry.

Universal Safety Points To Remember Are:

- DO NOT smoke or use naked lights in the presence of oxygen. (Concentrations of oxygen above 25% especially in confined spaces is dangerous. At these levels oxygen can saturate clothing, blankets).
- The outlet face must not be damaged.
- Avoid excessive force when turning the valve key or connecting any apparatus.
- Oil or grease must not come into contact with the outlet, valves or associated equipment.
- Never allow cylinders to run empty - a medical cylinder should be changed if it is less than a **quarter** full.
- Keep empty cylinders separate from full ones.
- Do not roll the cylinders when moving them.
- Store cylinders in a well-ventilated place.

Regulators

Various devices are used for administration of oxygen. In most cases, the oxygen will first pass through a pressure regulator, used to control the high pressure of oxygen delivered from a cylinder (or other source) to a lower pressure.

This lower pressure is then controlled by a flowmeter, which may be preset or selectable, and this controls the flow in a measure such as litres per minute (lpm). The typical flowmeter range for medical oxygen is between 0 and 15 lpm with some units able to obtain up to 25 liters per minute.

Multi-function Regulator

The regulator is fitted to the cylinder to reduce the pressure of gas from cylinder pressure to the 'working pressure', usually 4bar. Often a contents gauge is incorporated into the regulator assembly.

The working part of the oxygen system is the therapy head - usually a flowmeter. This might be attached directly to the regulator assembly or, in the case of piped oxygen systems, is plugged in using a British Standard probe to a 4bar socket.

The usual type of flowmeter has a control knob, which regulates the flow of oxygen in litres per minute. From the flowmeter the oxygen is connected to the facemask by a delivery tube.

Built In Breathing System (BIBS)

BIBS are designed to supply oxygen during therapeutic treatment in a hyperbaric / saturation chamber to a breathing patient (Respiratory rate > 8 BPM). It can also be utilised to provide an emergency breathing gas source should the chamber environment become chemically contaminated or experience a fire.

Built In Breathing System

BIBS are generally designed with an overboard dump, it has both supply and exhaust hoses. Exhaled gas is piped to the outside of the chamber thus preventing the potentially hazardous build up of oxygen within the chamber environment.

An increase in oxygen level above 23% equivalent at atmospheric pressure (0.2 3 bar ppO_2) within a hyperbaric chamber can be a fire risk, and can also be detrimental to the health of the patient/diver if long exposure is experienced.

The main use of BIBS masks is for therapeutic decompression commencing at 18m. BIBS are optimised to offer minimum-breathing resistance at the relatively low rates of breathing and shallow depths associated with this procedure.

Oxygen Masks

Oxygen masks allow oxygen delivery from the flowmeter to be mixed with outside air. Most are made of clear plastic and are disposable. Oxygen masks are designed for breathing patients (Respiratory rate > 8 BPM). The masks will freely exhaust exhaled gas into the environment, they are generally not used in a hyperbaric environment.

The percentage of oxygen concentration selected for the patient is determined by the choice of mask and the oxygen flow rate. In an acute situation High Flow / High Percentage is administered which dictates the choice of delivery mask to be used.

Non Rebreather Manual

Non-Rebreathing Mask (NRM) or Trauma Mask

This type of mask will be used when very high concentrations of oxygen are required. It is generally the first choice for the administration of oxygen in the pre-hospital situation to a breathing patient (Respiratory rate > 8 BPM).

The NRM covers the nose and mouth and attaches with the use of an elastic cord around the patient's head. The NRM has an attached 1.5 liter reservoir bag. Before an NRM is placed on the patient, the reservoir bag is inflated to greater than two-thirds full of oxygen, at a rate of 15 liters per minute (lpm).

Exhaled air is directed through a one-way valve in the mask, which prevents the inhalation of room air and the re-inhalation of exhaled air. The valve, along with a sufficient seal around the patient's nose and mouth, allows for the administration of high concentrations of oxygen, approximately 85% O_2.

Mixed Concentration

Mixed Concentration Mask

This type of mask is perfectly suitable for most instances of oxygen therapy **following** trauma or sudden illness.

Remember to check which mask is being used (low, medium or high concentration) and follow the instructions on the wrapper.

Fixed Flow Venturi Mask

This type of mask is used when it is required to maintain a fixed percentage of oxygen therapy, e.g. for **chronic** chest conditions.

A desired percentage may be chosen in accordance with the appropriate litre flow.

It is not to be used for an acutely unwell casualty.

Venturi Mask

Procedure for Administration of Oxygen

Always Follow The Same Sequence When You Assemble Oxygen Equipment:

- Ensure that the patient **is** breathing.
- Remove the manufacturer's seal.
- Check for damage to the cylinder outlet.
- Turn the cylinder away from your and open the valve to release a small amount of gas (to clear any dust etc).
- Check that the regulator / therapy head and cylinder outlet fittings are compatible.
- Screw on the regulator/therapy head making sure that it is seated firmly against the seal and there are no gas leaks. Do not over-tighten.
- Ensure the flowmeter is in the off position.
- Turn on the oxygen - check the contents gauge.
- Check the flowmeter - then turn off.

Demand Valve Mask

Administering The Oxygen:

- Ensure an open airway.
- Assess need for oxygen and the percentage required.
- Explain to the patient the need for oxygen. Show the patient the mask.
- Set up therapy equipment with correct mask.
- Ensure cylinder is turned on fully.
- Turn the flow meter to the correct rate.
- Check the flow by holding the mask to the ear.
- Fit mask to the patient. Use straps provided & ensure a good seal with minimum leaks.
- Assess the effects of therapy.
- Use pulse oximetry (if available).

Oxygen is classified as a medicinal product. Therefore its use must be reported. Keep a record of the concentration, effects and the length of time oxygen was administered.

Bag And Mask Valve Ventilator (BMV) 2.2.2

A bag valve mask, abbreviated to BVM and sometimes known by the proprietary name Ambu bag, is a hand-held device used to provide positive pressure ventilation to a patient who is not breathing or who is breathing inadequately (<8 BPM). The device has become a standard of pre-hospital resuscitation.

Bag & Mask Valve Ventilator

The device is used extensively to ventilate a patient in the minutes before a mechanical ventilator is attached. The device is self-filling with air, although additional oxygen (O_2) can be added.

Use of the BVM to ventilate a patient is frequently called "bagging" the patient. Bagging is regularly necessary in medical emergencies when the patient's breathing is insufficient or has ceased completely.

The BVM resuscitator is used in order to manually provide mechanical ventilation in preference to mouth-to-mouth resuscitation (either direct or through an adjunct such as a pocket mask).

The Equipment Components Are:

- Self-inflating bag. Generally has a 2 litre capacity and will operate with room air or an external O_2 supply.
- Reservoir bag. When an O_2 supply is connected, it primarily fill the self inflating bag & then overflow into the reservoir.
- Patient valve. A one-way inhalation and exhalation valves. The inhalation valve has a relief valve, which is usually preset at 40

cm H_2O to avoid over-inflation. The exhalation valve allows for exhalation without the need to remove the mask from the face. The value may be connected to face mask or a standard 15mm E.T. tube / iGEL for esuscitation.

- Face-mask. These are made in several sizes. They should have an occlusive seal to the face.

How to Use

- Position the mask over the mouth and nose and hold it place by the thumb and index finger. The other three fingers grasp the lower jaw and lift it into the mask to obtain a facial seal. (The anaesthetist's grip).
- Face-masks are clear to allow observation of the lips and mouth and so that (you can watch for blood or vomit entering the mask).
- Ideally the patient should have a definitive (E.T. / iGEL) airway placed as soon as possible. But as an interim measure an airway adjunct (naso-pharangeal / oro-pharangeal) airway should be used.
- The bag is squeezed by the DMT at a rate of 12-16 breaths per minute; (approx. 600mls of gas / a $^3/_4$ squeeze of the bag)
- Oxygen should be supplemented to the self-inflating bag.

Mechanical Ventilation 2.2.3

Mechanical ventilation is a method to mechanically assist or replace spontaneous breathing. This involves a machine called a ventilator.

There Are Two Main Divisions Of Mechanical Ventilation:

- Invasive Positive Pressure Ventilation (IPPV)
- Non-Invasive Positive Pressure Ventilation (NIPPV).

It should be recognized that the use of mechanical ventilation cannot and will not cure a disease process, but provides support for the patient until resolution of the symptoms is accomplished.

There are different types of ventilators and modes it is essential that the DMT is familiar with the ventilator you currently use.

However there are some standard modes of ventilation and techniques that maybe employed almost universally.

Ventilation Modes Include:

- Pressure controlled.
- Volume controlled.
- Spontaneously controlled.

Continuous Mandatory Ventilation (CMV)

A volume controlled mode of ventilation. A preset Tidal Volume (T.V.) is set in conjunction with a preset Respiratory Rate (Freq) to give a predetermined Minute Volume (M.V).

Peak airway pressures (PIP) will vary with this mode due to compliance and resistance of lungs. CMV is used when the patient is unable to initiate **any** spontaneous breathing and may be quite distressing for a patient who is sedated rather than fully anaethnatised / comatosed.

Synchronized Intermittent Mandatory Ventilation (SIMV)

A volume controlled mode of ventilation. A preset Tidal Volume (T.V.) is set in conjunction with a preset Respiratory Rate (Freq) to give a predetermined Minute Volume (M.V). This mode also allows the patient to breathe spontaneously, the machine will synchronise the ventilated / mandatory breaths with the patient's spontaneous breath and deliver Pressure Supported (P.S.) breaths when triggered. Suitable for fully ventilated patients who are starting to breathe / wean from ventilator.

Pressure Controlled Ventilation (PCV)

A Pressure Controlled (P.C) mode of ventilation. A preset pressure measured in cmH_2O is set to achieve a required T.V. in conjunction with a preset Respiratory Rate (Freq) to give a predetermined Minute Volume (M.V). This mode also allows the patient to breathe spontaneously, the machine will synchronise the ventilated / mandatory breaths with the patient's spontaneous breath and deliver Pressure Supported (P.S.) breaths when triggered. Suitable for fully ventilated patients who are starting to breathe / wean from ventilator. PCV is considered less likely to cause barotrauma due to more controllability of the PIP.

Bi-Level Positive Airway Pressure (BiPAP)

BiPAP is a spontaneously controlled ventilation mode. It delivers a preset inspiratory Pressure Support (P.S.) and Positive End Expiratory Pressure (PEEP). BiPAP may be used in several ways: For a ventilated patient who is starting to wean from ventilator or As a Non-Invasive Positive Pressure Ventilation (NIPPV). , where the ventilator

FiO_2
The Fraction of Inspired Oxygen. Or the percentage that is preset for delivery.

Peak Inspiratory Pressure (PIP)
The highest level of pressure applied to the lungs during inhalation. Above 45 cmH_2O is detrimental to alveolar tissue.

Positive End Expiratory Pressure (PEEP)
Pressure maintained in the airways at the end of exhalation. Keeps alveoli from collapsing.

Mean Airway Pressure (MAP)
The mean pressure applied during positive-pressure ventilation (cmH_2O).

Tidal Volume (T.V.)
Volume of air moved in / out of the lungs during breathing (500-600mls is considered normal).

Minute Volume. (M.V.)
The volume of gas respired in one minute. Freq x T.V= M.V.

Frequency (Freq)
The preset respiratory rate on a ventilator.

I:E Ratio
The ratio of the duration of inspiration to the duration of expiration. A range of 1:1.5 to 1:2 is normal in ventilation.

Pressure Support (P.S.)
Additional ventilator pressure given to a spontaneously triggered breath.

Pressure Control (P.C.)
Preselected ventilator pressure measured in cmH_2O to achieve a desired T.V..

Triggering
A patient initiated breath. A triggering pressure may be selected.

may be connected to a tight fitting (BIBS type) mask and ventilated whilst fully conscious.
This is particularly appropriate in conditions such as ARDS.

Types Of Resuscitation Ventilators Off-Shore

The type of medical equipment available in the off-shore environment is a rapidly evolving issue. Well-resourced operations may be provided with cutting edge pre-hospital designed sophisticated equipment. Whereas the resuscitation equipment held at some other sites may be grossly antiquated by modern medical standards but still be 'compliant' with industry legislation.
Here is a variety of differing equipment that may be seen off-shore.

Sabre MARS Manual and Automatic Resuscitation System

A very basic SIMV (volume controlled) transport ventilator,

Sabre MARS Resuscitator

It Has:

- Preset Frequency of 18 – 22 breath's per minute. (I:E ratio 1:2).
- Variable Tidal Volume based on weight (Small adult 600ms / large adult 900mls).
- A relief valve set preset at 45ch H_2O PiP to avoid barotrauma to lungs. If activate it will sound an audible alarm.
- A demand flow-trigger. To give assisted breath in the breathing patient.
- May be operated with an E.T. / iGel tube or a tight fitting mask.
- Respiratory gas powered.

Dräger Oxylog 1000 Ventilator

A basic CMV (volume controlled) transport ventilator.

Dräger Oxylog 1000

Which Has:

- Variable Frequency between 5 – 35 breath's per minute. (I:E ratio 1:2).
- Variable Minute Volume (5 - 35 L).
- Variable PiP (25 - 55 cmH_2O) pressure limiter.
- FiO^2 selector (60% or 100).
- A high & low audible / visual Peak Airway pressure (Paw) alarm.
- An inspiratory airway pressure gauge.
- Expiratory variable PEEP valve may be attached (expiratory gas may be scavenged if in a hyperbaric environment).
- May be operated with an E.T. / iGel tube.
- Respiratory gas powered.

Siaretron 1000 IPER Hyperbaric Ventilator

A multi-mode **hyperbatic** ventilator: SIMV (volume controlled), PCV (pressure controlled), CMV (volume / pressure controlled) & BiPAP ventilator.

Saiaretron 1000 iper

Which Has:

- Multi-mode professional ventilator.
- Rated to 6 bar.
- Hyperbaric earthed 24v power supply, Hyperbaric 4 hr lithium battery.
- Variable O_2 & HEO_2 (50/50 to 100%).
- Expiratory gas scavenged.

Flutter Valve Dressing 2.2.4 For an Open Pneumothorax

If a penetrating thoracic injury creates a pneumothorax, air may be sucked into the pleural cavity (if the hole is larger than the size of a 50p piece).
This is commonly referred to as a 'Sucking Chest Wound'.

Flutter Dressing Kit

Commercially available occlusive dressings are available which have integral one way valves built into them are widely used by military & paramedics (Asherman Chest Seal™ / Boilin Chest Seal™). However it is relatively easy to create a valvular dressing from readily available first aid kits.

Creating a Flutter Valve Dressing:

- Initially cover the defect with a sterile dressing and apply pressure.
- Sit casualty upright.

- Assemble Flutter Valve Kit (Sterile Gauze, Zinc Oxide Tape).
- Open the gauze (keep the inside of the packet sterile).
- Clean & dry penetration site & surrounding area with the gauze.
- Apply sterile side of plastic gauze packet over wound.
- Secure the packet on three sides with tape.
  - The open side should be at the bottom so leakage from the wound can free drain.
- Observe for air 'burping' out of the wound.

Valve Dressing

Needle Thoracocentesis 2.2.5

Needle thoracocentesis is the most rapid method of decompressing a tension pneumothorax and it does not require specialised equipment, it is the method selected for use in field medicine.

Needle decompression may be used with a tension pneumothorax caused by either a closed or open pneumothorax.

This procedure is not indicated for a simple pneumothorax, or a haemothorax alone without signs or symptoms of tension.

Equipment Includes:

- A cannula: (10g-14g without wings).
- 1/2 inch adhesive tape.
- Sterile 10ml syringe half filled with saline.
- 3 way tap (optional).
- Alcohol swabs.
- A one-way valve (such as a Heimlich valve or an improvised finger from a latex glove).

Needle Decompression Kit

14g Cannula

Heimlich Valve

The Position Site For Decompression

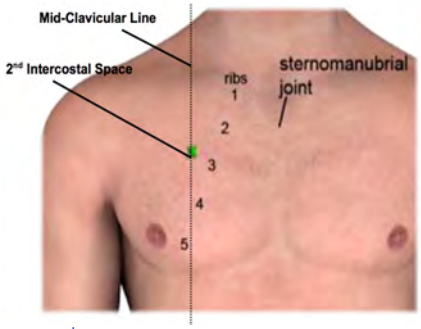
The 14g cannula is inserted into the affected pleural space at the second intercostal space on the mid-clavicular line.

The mid-clavicular line is at the midpoint of the clavicle.

The importance of this area is the lack of anatomical structures that could be injured. The internal mammary artery is just lateral to the sternal border (1 cm), hence the use of the midclavicular line. (The lung is compressed toward the mediastinum & it will be out of the way if the needle is placed high, into the second intercostal space).

The intercostal nerve, artery, and vein pass just beneath each rib, so the needle insertion should be passed just over the 3rd rib into the 2nd intercostal space.

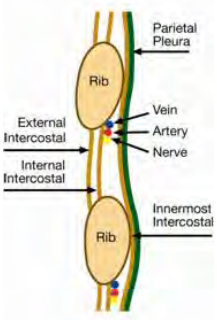
Needle Decompression Insertion Site



2nd Intercostal Space / Mid-Clavicular Line

The Procedure

Rib Anatomy



Needle Decompression

- Prepare the equipment you will need.
  - Remove the bungs (white cap & air trap) from the cannula.
  - Attach syringe to cannula (ensure half filled with saline).
  - Inserts cannula through cut section of thumb of glove.
- Re-auscultate the chest to confirm which side has the tension pneumothorax is.
- Locate the second inter-costal space at the mid-clavicular line (the 1st rib is under the clavicle, so the 2nd rib is the first to be palpated).
- With a firm rotary motion clean the area with an alcohol swab.
- Feeling carefully, locate the upper margin of the third rib at the mid-clavicular line.
- Place the tip of the cannula (bevel side down) against the skin at a 90° angle.
- Insert the cannula, sliding it over the top curve of the (third) rib.
- Once inserted, hold the cannula still.
  - If chest decompression has occurred a rush of air will be heard. (or bubbling if using the syringe / saline).
- Attach the one-way valve (Heimlich-type or finger from a sterile glove) to the hub of the catheter via a 3-way tap.
- Secure the catheter to the chest with tape loops.
- Tape should also be placed around the hub to secure the valve.
- Auscultate the chest and recheck the patient's respiration and other vital signs.
- Refer the casualty **urgently** for a formal chest drain insertion

CARDIOVASCULAR MANAGEMENT 2.3

Intravenous Cannulation 2.3.1

Indications For The Use Of Peripheral I.V. Cannulae

The majority of IV cannulations can be attributed to either one or a combination of the following needs:

- To maintain / restore hydration.
- Administration of drugs.
- As a precaution in critical illness.

Considerations For IV Access

While there are no true contraindications for IV therapy or IV cannulations, it should be remembered that all cannulations are associated with certain risks, so IV cannulation should only be used when a true need for intravenous access exists.

Selection Of Venepuncture Site

When choosing a suitable venepuncture site, consider both the required cannula size and the size and state of the available veins. A large bore cannula will require a vein with a large lumen.

These General Rules Should Be Observed When Possible:

- Avoid veins in the lower extremities.
- Avoid areas of joint flexion.
- Avoid median cubital veins (these should be reserved for venous blood sampling).
- Avoid veins close to arteries and deeper lying vessels.
- Maintain patient mobility by using veins on the non-dominant side.

Other Considerations Are:

- Flow rate – (high flow rates will require a large vein and a larger cannula).
- Type of infusate – (potent drugs and/or irritant solutions will also require a large blood flow to assist haemodilution).
- Expected duration – (a smaller size cannula will minimise venous irritation).
- Cannula dimensions:
  - Outer diameter – (a cannula must never totally occlude a vein).
  - Length – (the longer cannula will require a longer, straighter vein).
  - Condition of accessible veins.
  - Lumen and blood flow.

Most difficulties arise when few or no veins in a good condition are available. It may be necessary to consult a more experienced colleague if in doubt of the correct choice.

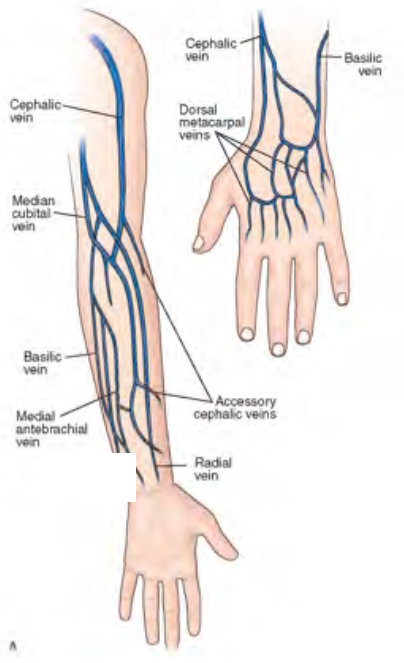
It is tempting to cannulate small visible but impalpable superficial veins in these difficult cases. This is rarely successful.

Time spent ensuring maximal venous dilatation followed by very careful inspection and palpation of the whole forearm and dorsum of the hand for a palpable vein, is always time well spent.

It must be remembered in the critically ill patient (Particularly in Class III shock & above) gaining vascular access can be extremely difficult, even for a very experienced medic.

Therefore in a critical situation early cannulation is essential or an alternative device such as an Intraosseous Cannulation.

Vascular Access



Choosing A Vein For Cannulation

Superficial veins are those whose course is close to the surface of the body, and have no corresponding arteries. When choosing a vein the DMT should consider what the cannula is being used for, if it is to give occasional IV antibiotics then a smaller vein may be selected, if the casualty requires rapid IV fluid then a larger vein should be selected.

The Major Superficial Veins Of The Arm Are The:

- Metacarpal (used for cannulation & administration of small drugs).
- Cephalic (used for cannulation & large IV fluid administration).
- Basilic (used for cannulation & large IV fluid administration).
- Median cubital, cephalic and basilic ('the antecubital fossa' used for venepuncture).

IV Cannula Dimensions

Again, a good choice of cannula size cannot be made without first considering the site selected.

A smaller cannula will permit a higher blood flow around the cannula thus improving the haemodilution of fluids and drugs administered. Improved haemodilution will reduce the damaging effect of irritant solutions to the vein. Similarly, the degree of mechanical irritation and insertion trauma is minimised by the use of the smaller gauge cannulae.

The manufacturer's information on flow rates will make the choice of cannula easier.

Cannula Colours and Sizes Note that the smaller the number the larger the cannula size			Approximate flow rate l/hr		
Colour	Common Applications	Gauge	Crystaloid	Plasma	Blood
Orange	Used in theatres or emergency for rapid transfusion of blood or intravenous fluids	14G	16.2	13.5	10.3
Grey	Used in theatres or emergency for rapid transfusion of blood or intravenous fluids	16G	10.8	9.4	7.1
Green	Blood transfusions, parenteral nutrition, large volumes of fluids	18G	4.8	4.1	2.7
Pink	Blood transfusions, intravenous infusions	20G	3.2	2.9	1.9
Blue	For small veins or used in children for most medications and fluids	22G	1.9	1.7	1.1

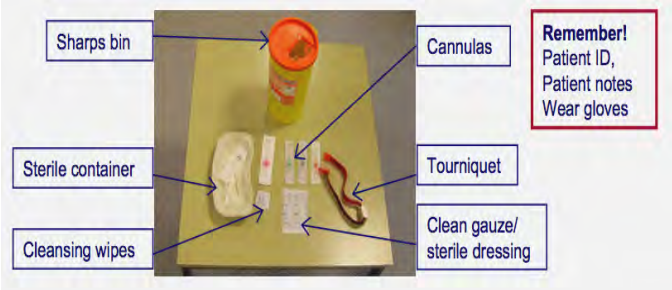
For an IV set-up requiring fluid deliveries of 1-3 litres per day, a relatively small cannula, 22G or 20G, is adequate.

However a golden rule of trauma care is that a **minimum of two 18g** cannulas should be placed in any resuscitation situation.

The Cannulation Procedure

Prepare The Equipment:

- Assemble all the necessary equipment:
  - Appropriate sized cannula.
  - Gloves
  - Tourniquet.
  - Sterilising wipes.
  - Sterile gauze.
  - Cannula dressing.
  - Sterile syringe with 0.9% Saline flush.
  - Sharps bin.



Prepare The Puncture Site

- Clean the puncture site and the surrounding area thoroughly with the skin prep product.
- If an alcohol skin prep product is used, ensure that the surface is allowed to dry properly (usually 1 -3 minutes).

Prepare Yourself

- Wash hands thoroughly & wear protective gloves.

Create Adequate Venous Filling

- A well-defined vein will make a major contribution to successful venepuncture. Use a tourniquet, massage, ask the patient to "pump" a fist, use moderate heat or drop the limb below the level of the heart.

The Cannulation Procedure Steps:

1. Apply the tourniquet 5-10cm above the cannulation site.

2. Clean skin with a sterilizing agent (such as Chloraprep). Allow the skin to dry thoroughly.

3. Check cannula size and expiry date.

4. Open the “wings” of the cannula. Shape it to the contours of the arm.

5. Ensure that the bevel of the needle is pointing upwards.

6. Hand position: index finger on injection port, thumb at the end of the cannula.

7. At an angle between 15-30° Insert the cannula into the vein until..

8. A flashback is seen at the base of the cannula.

9. Gently advance the cannula into the vein 1 mm & drop angle to 5º.

10. Advance the cannula, (**NOT** the needle). Observe for 'catheter flashback'.

11. Advance the cannula until the 'hub' meets the skin.

12. Gauze may help to absorb any leakage during removal of the needle.

13. Remove the tourniquet.

14. Press over the end of the cannula (within the vein) , whilst removing the needle.

15. Dispose of the needle into a sharps bin (whilst continuing to press over the vein).

16. Insert the bung onto the end of the cannula.

17. Secure the wings & Apply the dressing.

18. Flush with saline, note: resistance, swelling or pain, which indicates extravasation.

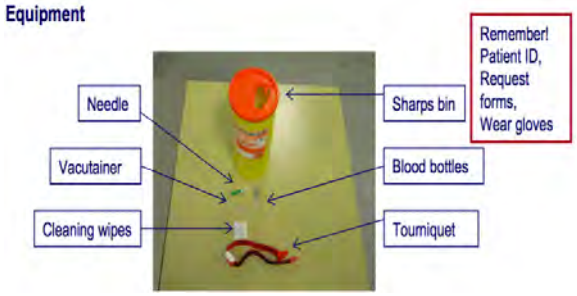
Venepuncture (Blood Collection) 2.3.2

Venepuncture is often performed to collect a sample of blood.

Blood analysis is becoming much easier, even in remote locations with the advent of transportable analysis kits. It is therefore likely that a knowledge of blood collection will be useful for a DMT.

Prior To Venepuncture Consider The Following:

- Collect and prepare the equipment.
  - Appropriate sized needle (18g is normal) & vacutainer barrel.
  - Gloves
  - Tourniquet.
  - Sterilising wipes.
  - Sterile gauze & tape.
  - Appropriate blood bottles (provided by medic / Dive Doctor).
  - Sharps bin.



Prepare Yourself

- Wash hands thoroughly.
- Wear protective gloves.

The Venepuncture Procedure Steps:

1. Apply the tourniquet 5-10cm above the venepuncture site.

2. Clean skin with a sterilizing agent (such as Chloraprep). Allow the skin to dry thoroughly.

3. Assemble the vacutainer / needle collection system.

4. Bevel upwards, insert the needle into the vein between 15° - 30° angle.

5. Hold the vacutainer / needle still (steady your hand against the patients arm).

6. Push the bottle into the barrel, until the grey spike pierces the rubber stopper.

7. The vacuum causes blood to flow into the bottle. (If blood doesn't flow then the needle is not in a vein).

8. The blood flow will stop when the correct amount has entered the bottle. Safely remove bottle.

9. Prior to removing the needle, remove the tourniquet.

10. Using a piece of gauze, gently press over the venepuncture site whilst removing the needle.

11. Dispose of the needle into a sharps bin (whilst continuing to press over the vein).

10. Apply a dressing or plaster over the venepuncture site.

Post Cannulation / Venepuncture

In the prevention of local venous reactions as well as infection related complications, care of the puncture site and IV equipment is of key importance.

There Are Two Major Sources Of Bacterial Contamination:

- **Cutaneous microorganisms - skin flora.**
  - Careful cleansing of the puncture site prior to cannula insertion is the main preventative measure.
  - Aseptically covering with a sterile dressing gives a degree of protection against contamination.
  - It is necessary to inspect the puncture site daily for signs of complications.
  - Wet or soiled dressings must be changed.
  - Redness, tenderness or swelling all indicate local venous reactions and call for removal of the cannula.
  - Cannula's inserted under 'Trauma' conditions should be considered contaminated & removed ASAP.
- **Contamination from hands or equipment in contact with the IV cannula.**
  - During routine manipulations, that contact with the luer-lock fittings, injection ports and cannula surfaces is avoided as far as possible.
  - All attachments to the cannula should be conducted using an strict Aseptic No Touch Techniques.

Complications Of IV Cannulation

Haematoma

Haematoma can occur as a result of failure to puncture the vein properly during cannula insertion.

Haematoma

Management of Haematoma's:

- To avoid try not to puncture a vessel that is not clearly defined.
- Haematomata can be avoided by applying pressure to the puncture site for 3-4 minutes with the limb elevated.

Infiltration

Infiltration is the penetration of the cannula through a veins wall into the surrounding tissue.

It is common particularly when larger cannulas, when they are sited in articulated joints or when a poor cannulation technique is used.

Infiltration can be very damaging to the subcutaneous tissue. Leakage of hypertonic or alkaline solutions can cause tissue necrosis. It can also deprive the patient of fluid and cause an oedema that limits the use of adjacent veins.

Infiltration

Management of Infiltration:

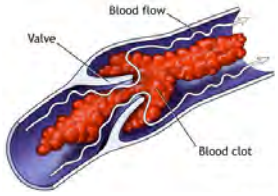
- Use a proper insertion technique & detect infiltration at an early stage.
- Observe for swelling of the tissue as fluid infuses.
- Immediate re-siting of the cannula to a distant point is necessary.

Thrombolic Embolism

Thromboembolism occurs when a blood clot on the cannula or vein wall becomes detached and is carried by venous circulation to the heart and pulmonary circulation.

The danger of thromboembolism is proportional to the size and amount of thrombic material released.

Thrombolic Clot



Management of Thrombolic Embolism:

- Insert a cannula small enough to allow a continuous blood flow in the vessel selected.
- Reduce movement of the canualla by securing doubly with tape.
- If the infusion stops running (because of clot formation on the cannula-tip), careful aspiration may restore flow.
- An injection or flushing of the cannula can dislodge the clot and introduce it into the circulation.

Air Embolism

Air embolism is a potential hazard during all forms of IV therapy. In peripheral cannulation, the risk of air embolism is limited by the small peripheral venous pressure (3-5cm H_2O), but increased pressure can occur in peripheral veins if the infusion site / extremity is elevated above heart level.

Air Embolism

Management of Air Embolism:

- Air has to be removed from the giving set, prior to connection to the cannula.
- Tightly fitting luer-lock connectors should be used throughout the usage of the IV site.
- If an air-emboli is suspected the DMT should draw back with a syringe & closely monitor for AGE symptoms.

Thrombophlebitis

Phlebitis, or inflammation of the vein, can be due to infection, but can also be the result of chemical or mechanical irritation. Infective thrombophlebitis can initiate septicemic shock.

The causative factors include; cannula size, bacterial contamination of entry site, length of time the cannula has been insitu, movement of the cannula whilst insitu and the types of fluids administered.

Thrombophlebitis

Management of Thrombophlebitis:

- Reduce the risk factors.
  - Clean the entry site well.
  - Use the smallest cannula fit for your purpose.
  - Remove 'Trauma Cannula's' ASAP (they are generally large & inserted under less sterile conditions).
  - Ensure the cannula is well dressed & secured with tape to limit movement.
- Observe for signs of phlebitis (redness / tenderness / inflammation / pus at insertion site).
- If signs are present immediately remove and re-site the cannula (generally in a different limb).
- Remove the cannula after 4 days regardless of lack of phlebitis.

Key Points to Problem Free Cannulation

Trauma Cannulation

Cannulas inserted under trauma conditions are more likely to become infected because of the sheer urgency of the insertion process. And the cannulas are much more likely to be wide bore (18-14g). It is therefore typical for a removal &a re-cannulation process to occur whilst stabalising a casualty.

Duration of Cannulation

The effect of duration of cannulation can be minimised by resiting the cannula at regular intervals before any development of venous reactions take place. No peripheral cannula should remain in **more than 4 days**.

Infusate

The effect of irritant solutions or drugs can be minimised by selecting a low flow rate and the use of a small gauge cannula to promote rapid dispersal of the irritant.

Contamination
Careful skin preparation and a strict hygiene regimen during insertion, maintenance of puncture site and handling of IV equipment will reduce complications resulting from infection.

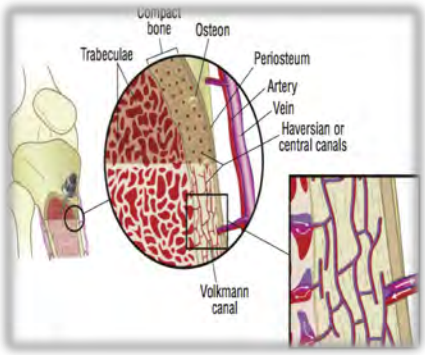
Mechanical Irritation
The use of small gauge cannulae will minimise insertion trauma and mechanical irritation to the intima of the vein. The cannula & giving set should be secured to the skin with tape & a sterile dressing.

Intraosseous Cannulation (Bone Infusion) 2.3.3

Casualty's with life-threatening traumatic injuries often need immediate intravenous access for the delivery of medications and for fluid replacement.

Reliance on a DMT to successfully insert a I.V. cannula in these circumstances has two problems:

- They may not have the skill level for establishing I.V. access, or be engaged in other lifesaving activities.
- If the casualty is in Stage III shock (or above) it may be impossible because of collapsed blood vessels.



FAST1

Intraosseous Devices
An intraosseous device is a cannula, which actually is physically inserted into a bone and then intravenous infusions are administered which are theoretically absorbed by the rich blood supply.

Intraosseous devices were first widely used in the 1940s during World War II using a device to access the sternum. However, the advent of plastic intravenous catheters made peripheral intravenous access much more practical and simple, and research on and use of intraosseous devices decreased.

Intraosseous Anatomy
The anatomy of target bones (sternum, tibia, and humerus) for intraosseous devices is similar. The bones are composed of soft, sponge-like cancellous bone (a loose bone lattice filled with bone marrow and commonly referred to as the medullary canal) and hard compact outer bone, which provides the structural strength of the bone. The bone has an excellent blood supply which includes the medullary canal and the blood vessels of the periosteum, providing a direct path to the central circulation.

Bone Injection Gun (B.I.G.)

When fluids and medications are introduced into the medullary canal, then flowing directly into the vascular system. The overlying bony cortex of bone provides a rigid outer structure, creating a non-compressible space that can be easily accessed with intraosseous devices when peripheral veins are collapsed (as in profound shock).

The IO (intraosseous) route has consistently been found to be a fast, reliable means of obtaining vascular access, even when practiced by medics with a limited training or in the profoundly shocked casualty.

Modern Intraosseous Use
The use of an intraosseous device for trauma patients reemerged in recent years due to it wide military use and its advocation by the Advanced Trauma Life Support course (the cornerstone of trauma care in the medical world).

Modern IO devices are either spring loaded or electric drill inserted. These devices are quickly inserted; most are successfully placed in less than 1 minute from the time of opening the package.

DMT Intraosseous Use
The use of intraosseous devices in the commercial diving world has increased over the last decade. In a recent DMAC 15 Rev 4 publication, it was advocated that 2 spring-loaded IO device should be a standard part of dive site equipment.

There are currently two commercially available spring loaded IO devices: the BIG® Gun & the Fast1®.

Feature	Big Injection Gun (B.I.G.)	FAST1
Insertion sites	• Proximal tibia	• Sternum
Insertion	• Manual Pressure	• Manual Pressure
Fluid Rate	• 20-40ml / min. • 125ml / min (pressure bag).	• 20-40ml / min. • 125ml / min (pressure bag).
Advantages	• Small & Lightweight • Adult & Paediatric. • Multiple insertion sites (4 total)	• Small & Lightweight • Single insertion site.
Disadvantages	• May be overlooked during transport.	• No alternative insertion site. • May require 2 hands insert. • Difficult to use C-Spine collar.
Contraindications	• Limbs with fractures • Limbs Severe osteoporosis • Infection over insertion site • Inability to identify landmark	• Severe osteoporosis. • Sternal fracture. • Inability to secure patch to skin (eg, burns, wounds, infection). • < 50KG in Weight.

FAST1
The FAST1 is the only currently approved spring-loaded intraosseous device that is placed in the sternum.

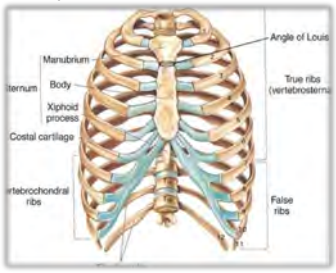
Blood flows from the sternum directly into the central circulation via the internal mammary. See chart.

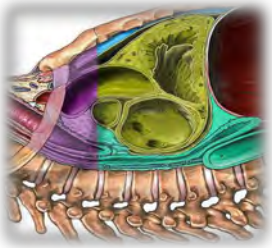
Bone Injection Gun (B.I.G.).
The BIG was developed in Israel in the 1990s.

The BIG is a spring-loaded device that delivers a trocar and needle directly into the tibia or humeral bone.

FAST1 Insertion Procedure

1. Locate Penetration Site
Perpendicular on the surface of manubrium. 90^0 Angle.





2. Prepare The Site
Clean Sternum. (sterilise).
Local Anaesthetic. (In conscious patients).

3. Place Target Patch
Locate sternal notch with index finger. Ensure patch well adhered to skin.

4. Insert Introducer
90^0 To Sternum. Inside target hole. Push firmly until release felt.

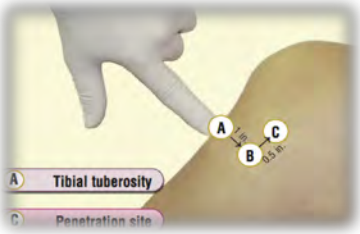
5. Expose Infusion Tube.
Dispose of trocar in a sharps bin. Flush with saline 0.9% & connect infusion.

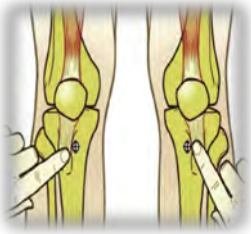
6. Secure Protector Dome
Press firmly to adhere velcro ™. Confirm placement. Run I.V. fluid at desired rate.

There may be a moderate amount of blood seepage once the FAST1 is inserted so ensure that plenty of sterile gauze is available. Absolute contraindications to the FAST1 include a fractured sternum & a body weight below 50kg. The device is meant for short-term use & should be removed once vascular access has been established.

B.I.G. Insertion Procedure

1. Locate Penetration Site
From tibial Tuberosity 25mm Medial, 12mm Proximal.
(From protrusion on knee, 1" towards groin, $^1/_2$ " up).





2. Prepare The Site
Clean insertion site. (sterilise).
Hold the bottom of BIG at 90^0 angle

3. Remove Red Pin
Squeeze & gently remove the red pin.
N.B. Keep it safe & clean for use.

4. Apply Pressure.
Firmly press, with palm of hand maintaining 90^0 angle.

5. Remove The Introducer
Pull up & wiggle in a side to side Motion.

6. Secure Needle
Using red pin. Slide around IO & Tape on both sides securely.

7. Remove The Trocar
Dispose of carefully in a sharps bin.

8. Connect IV Extension
Confirm placement, aspirate & Flush with 10mls saline 0.9%.

9. Connect IV Fluid
Run I.V. fluid at desired rate.

Absolute contraindications to the use of this device include a fracture to desired bone.
The device is meant for short-term use & should be removed once vascular access has been established.

Intravenous Fluid Administration 2.3.4

Intravenous therapy is the infusion of sterile liquid substances directly into a vein. It is commonly referred to as a drip because many systems of administration employ a drip chamber, which prevents air from entering the blood stream (air embolism), and allows an estimation of flow rate.

Intravenous therapy may be used to correct electrolyte imbalances, to deliver medications, or as fluid replacement to correct dehydration

Compared with other routes of administration, the intravenous route is the fastest way to deliver fluids and medications throughout the body.

There are two main types of IV fluid : Crystalloid solutions & colloid-plasma substitutes.

Crystalloids

Crystalloids

A crystalloid is an **isotonic** IV fluid, which has a neutral osmotic balance with fluid in the body (Stored in the intravascular, extracellular & intracellular space). Therefore a crystalloid fluid once infused into the intravascular space will diffuse easily into the other fluid compartments.

The most commonly used are Normal Saline 0.9% and Hartmann's solution (also known as Ringer's lactate).

Crystalloid fluid is the first choice in the **initial** management of hypovolaemic shock and the established therapy in IV fluid management.

Colloids

Colloids

A colloid is a **hypertonic** IV fluid, which has a negative osmotic balance in relation to bodily fluid. The structure of a colloid is usually a viscous glucose / starch / sodium / protein substance. Once infused it will be maintained in the intravascular space (some even drag fluid from the extracellular space).

A colloid is generally given in an emergency situation to restore circulating intravascular volume; it is always given in conjunction with a crystalloid fluid.

The most commonly used are Gelofusine / 6% HES (hydroxyethyl starch) / Hypertonic Saline (2.5% - 9%) / Packed Blood Products.

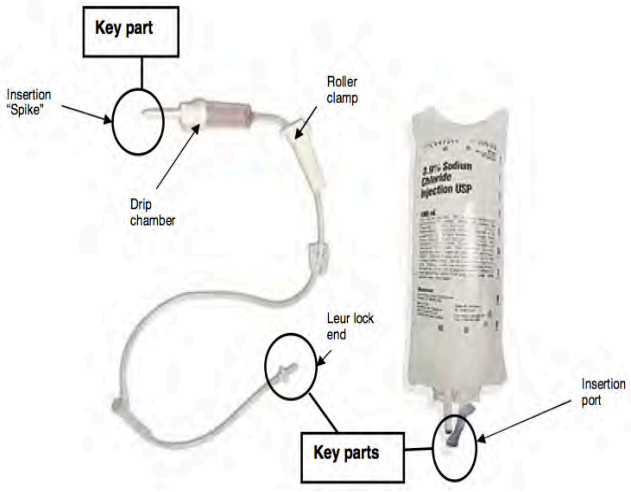
Colloids remain in the circulation longer than crystalloids and are not sustained fluid replacement.

Intravenous Giving Set

Intravenous fluid is administered via a sterile infusion set (giving set). The most commonly used is the twin-chambered type. It has a sharp plastic needle that is sheathed at the chamber end of the set. This is inserted into the fluid end of the bag.

At the patient end of the set there is a luer connector. A variable roller clamp is fitted to the tubing, which can regulate the flow of fluid.

Before using a giving set pack, check the expiry date and package integrity. You will also need adhesive tape or elastic bandage.



Securing The Cannula

Always Doubly Tape

Preparing And Connecting The Giving Set:

- Using an Aseptic No Touch Technique (ANTT). Open the giving set package. Move the flow regulator to the closed position.
- Check for tubing defects.
- Using ANTT. Unsheathe the needle of the giving set.
- Using ANTT. Push it firmly through the entry port of the fluid container.
- Half fill the giving set chamber by pumping their walls.
- Open the flow regulator slowly.
- Let the fluid flow through the entire line.
- Make sure there are no are bubbles in the tube.
- Close the roller clamp. The giving-set is now ready to use.
- Using ANTT. Connect the giving set to a cannula. (Securely screwing the leur connector).
- Doubly secure the giving set tubing with tape.

Calculating Drip Rates

Manually controlled drips measure the drops per minute. To calculate the volume in drops it is important to know what type of drip chamber your giving set uses (this is always displayed on the package):

- **Standard Giving Set.** Has a drip rate of 20 drops per ml for crystalloids and 15 drops per ml for colloids.
- **Microdrop Giving Set.** Has a drip rate of 60 drops per ml.

A Standard Formula For Drip Rate Calculation Is:

Drip Rate (Drops / min) = Volume of the infusion (mls) x drops / ml
Time in Hrs x 60 (*or time in minutes*)

Another Drip Rate Calculation:

Drip Rate (Drops / min) = Volume of the infusion (mls) ➔ Hrly Volume x chamber rate
Time in Hrs 60 (Mins)

Example: *You are asked to give 1L of Normal (0.9%) saline over 8 hrs. Calculate*

First Work Out How Many Mls Per Minute You Need To Give:

1000mls = 125mls per hr ➔ 125mls per hr = 2mls ➔ (standard giving set) **= 40 drops per min**
8 60

Hazards And Complications Of Infusion

Most hazards and complications are avoidable by following the recognised techniques.

Air Embolism

This can occur when protocols for priming the giving set are not strictly adhered to, allowing air to enter the body intravenously. Embolisms can be life threatening.

- Refer to AGE treatment in Diving Section.

Circulatory Overload

This can occur when fluid replacement exceeds blood loss / circulating volume. The elderly and those with pulmonary congestion (A.G.E., Tension Pneumothorax, Cardiogenic Shock) are particularly at risk.

The Major Symptoms Experienced Are:

- Breathlessness / tachypnea.
- Pink frothy sputum.
- V Q miss-match (casualty will quickly become hypoxic).
- Distended neck veins.

When Circulatory Overload Is Suspected:

- Seek medical support.
- Stop the infusion.
- Sit the patient in an upright position.
- Administer oxygen therapy.
- Administer medication as prescribed (Intravenous Furosemide is typical).
- Closely monitor patient.

Infusion Fails To Run

CHECK	SOLUTION
Is the container empty?	Close off the giving set and replace the container if instructed.
Is the height of IVI adequate for the container?	Reposition fluid container to adequate height.
Are the chambers filled?	Disconnect the giving set, fill the chambers, run the fluids through and reconnect.
Is the giving set turned on?	Turn on the giving set.
Are there any kinks in the giving set?	Remove the kink.
Is there a displaced cannula?	Close off the giving set and remove the cannula and replace with a new one.
Is there a clot in the cannula?	Close off the giving set and remove the cannula and replace with a new one.
Has the tourniquet been left on?	Remove the tourniquet.
Has a tourniquet effect been caused by tight clothing?	Loosen any tight clothing.
Has the position of the casualty's arm affected the IVI?	Straighten and splint the cannulated limbs.

Drawing Up From An Ampoule Or Vial 2.3.5

Standard Hypodermic Assembly

A standard hypodermic assembly consists of a syringe and a needle. Syringes come in different sizes, 0.5ml - 50ml. Along the barrel of the syringe is the scale which, indicates what volume has been drawn up into the syringe.

Hypodermic needles range from 25g – 17g. The larger the gauge then the smaller the needle.

Syringe & Hypodermic Needles

To Assemble The Standard Syringe:

- Wear gloves - use an A.N.T.T. to open the syringe / needle package.
- Aseptically onnect the needle (with its protective cap) to the syringe tip.

Ampoule Or Vial 2.3.6

Prefilled Syringes

Prefilled syringes are supplied as a plastic barrel / needle assembly and a cartridge containing the medication.

These are in widespread use for pre-hospital emergency care.

Pre-Filled Syringes

To Use A Prefilled Syringe:

- Check the drug label & expiry date on the cartridge.
- Inspect the contents of the cartridge (discolouration, cloudiness, or particulate matter).
- Aseptically remove the cap from both the medication cartridge and the plastic barrel.
- Insert the cartridge into the barrel and twist it into place.
- Hold the syringe needle up and tap on it & expel air with plunger.
- The syringe is now ready to use.

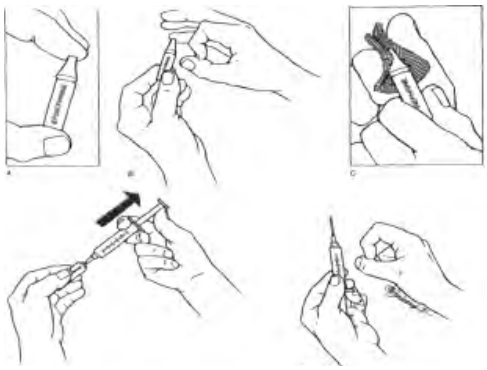
Drawing Up Ampoules

An ampoule is a glass container in which a single dose of a sterile injectable drug preparation is sealed.

To Draw Up Medication From An Ampoule Into A Syringe, The Procedure Is As Follows:

- Prepare a syringe of the appropriate volume with a needle of the appropriate gauge.
- Identify the name / concentration / expiry date of the drug.
- Note the volume of the drug you need to draw up.
- Tap the stem of the ampoule to move the solution down into the well of the ampoule.
- Grasp the top of the ampoule in a gauze pad.
- Break off the top of the ampoule at the stem.
- Aseptically insert the needle into the ampoule.
- Pull back on the plunger on the syringe to draw up the specific volume of medication.
- Expel any air present in the syringe and recap the needle.
- The medication is now ready to be aseptically administered.

Drawing From An Ampoule



Drawing Up Vials

A vial is a glass container storing a drug for injectable use. It differs from an ampoule in that a vial is sealed with a rubber stopper and may contain multiple doses.

To Draw Up A Solution From A Vial:

- Prepare a syringe & needle of the appropriate size / gauge.
- Identify the name / concentration / expiry date of the drug.
- Note the volume of the drug you need to draw up.
- Disinfect the rubber stopper of the vial with an alcohol / disinfectant wipe.
- Draw air into the syringe in a volume equal to that of the solution to be used.
- Aseptically insert the needle through the rubber stopper and inject air into the vial.
- Invert the vial, and draw up the specified volume of medication required.
- Withdraw the needle from the vial.
- Expel any air present in the syringe, and carefully recap the needle.
- The medication is now ready to be aseptically administered.

Drawing From A Vial

Intravenous Medication Administration 2.3.7

The I.V. route of drug administration is a fast, effective way of administering drugs. Whilst it is the fastest route of administration, if an adverse reaction is noted, it will potentially be a profound response.

There are several ways of administering intravenous medications:

I.V. Needle Free Ports

IV Giving Set Medication Administration

Many modern giving sets have the ability to administer medication through the IV giving set via injection ports. The ports may be rubber injectable / more modern needleless ports.

The Procedure For Giving A Medication Through An IV Line:

- Disinfect the administration port on the IV line.
- Uncap the needle from your syringe.
- Aseptically, carefully insert the needle into the port.
- Pinch the tubing distal to the port (to prevent the drug from flowing backward into the IV bag), and inject the medication slowly.
- Remove the needle, and dispose of the needle and syringe safely.
- Open the control clamp wide to flush any remaining medication from the line. Then readjust the clamp so that the IV is running at the correct rate.
- Monitor the patient carefully for signs of an adverse reaction.

Adding Medication To An IV Bag

Certain drugs are added to the intravenous solution itself, rather than administered directly to the patient, particularly drugs whose effects must be carefully titrated (such as lidocaine when given as a drip or nor-epinephrine).

The Method Of Adding Medications To An IV Bag:

- Set up the IV bag and administration set in the usual manner.
- Identify the name / concentration / expiry date of the drug.
- Note the volume of the drug you need to draw up. (Calculate the concentration in relation to the fluid you are adding it to: If you require a 1mg / ml in 250mls of Saline, then your drug dose will be 25mgs in total).
- Close the control clamp on the administration set.
- Disinfect the rubber stopper on the IV bag. Puncture the stopper with the needle, and inject the desired volume of medication into the bottle or bag.
- Withdraw the needle, and discard the needle and syringe carefully.
- Agitate the IV bag gently to ensure that the added drug is well mixed in the solution.
- Label the bag with the name of the medication added, the date and time, the amount added, the resulting concentration of medication in the IV bag, and your name (e.g. Lidcoaine, 500mg added, Jan 5th, 2013, 11:20 am, concentration now 2mg/ml, John Smith).
- Regulate the flow (drops/ml per minute) as instructed by the doctor, in order to deliver the desired dose of medication.
- Monitor the patient carefully for signs of an adverse reaction.

I.V. Fluid Additive

Administering An IV Bolus Medication

Direct intermittent injection (also known as intravenous push or bolus) involves the injection of a drug from a syringe directly into a vascular access device.

The Method Of Administering An IV Bolus:

I.V. Bolus

- Identify the name / concentration / expiry date of the drug.
- Note the volume of the drug you need to draw up & prepare it as per manufactures instructions.
- Assess cannula site for patency.
- Using the ANTT. Serilise injection port with sterilising swab (allow to dry).
- Close the control clamp on the administration set (Ensure that the infusion is compatible with the bolus drug).
- Using the ANTT. Insert the syringe securely into injection port. Slowly administer bolus drug (2-5 minutes).
- Observe cannula site for vessel collapse / infiltration.
- Administer a saline 0.9% flush (If a further bolus drug is prescribed administer a saline 0.9% flush between the doses).
- Open the control clamp, then readjust the clamp so that the IV is running at the correct rate.
- Monitor the patient carefully for signs of an adverse reaction.

INJECTION TECHNIQUES 2.4

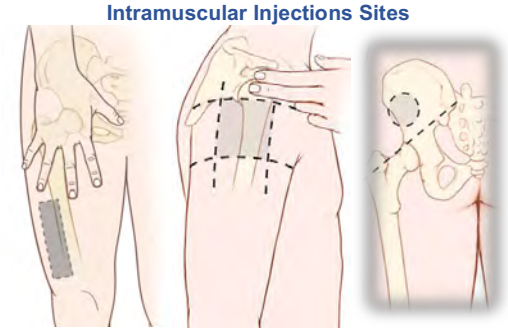
Intramuscular Injections

Intramuscular (or IM) injection is the injection of a substance directly into a muscle. It is used for medication that

is administered in small amounts. The I.M. route can offer a relatively fast route of drug absorption. Intramuscular injections are often given in the deltoid muscle of the arm, the vastus lateralis muscle of the leg, and gluteal muscles of the buttocks.

Intramuscular injections are relatively contraindicated in shock, the injected medication may not be mobilised from this muscle due to hypo-perfusion (and if shock is reversed, a large dose of medication may suddenly be adsorbed all at once).

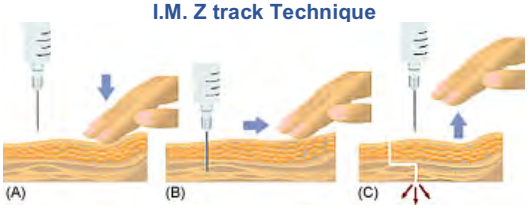
Intramuscular Injections Sites



The Technique Of Intramuscular Injection Is As Follows:

- Identify the name / concentration / expiry date of the drug.
- Using the ANTT Prepare it as per manufactures instructions using a 2-5 ml syringe, and attach a 21-23 gauge needle.
- Locate the injection site, (thigh, deltoid muscle or the upper outer quadrant of the buttock).
- Disinfect the injection site.
- Using the Z track technique (which reduces drug leakage). Press & pull the tissue over the desired muscle.
- Hold the syringe in you other hand like a dart, and quickly thrust the needle into the tissue at a 90° angle.
- Pull back slightly on the plunger of the syringe (to ensure that the needle has not entered a blood vessel).
- If there is no blood return into the syringe, inject the medication.
- Quickly withdraw the syringe, and apply firm pressure over the injection site.
- Dispose of the needle and syringe in an appropriate puncture proof container.
- Monitor the patient for an adverse reaction to the medication.

I.M. Z track Technique

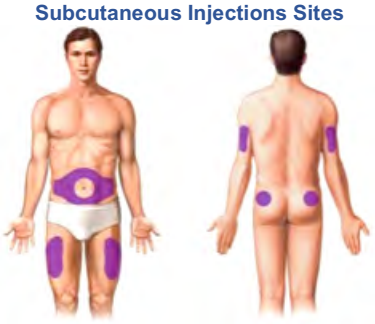


Subcutaneous Injections

Subcutaneous injections involve injecting medication into the sub-dermal fat layer.

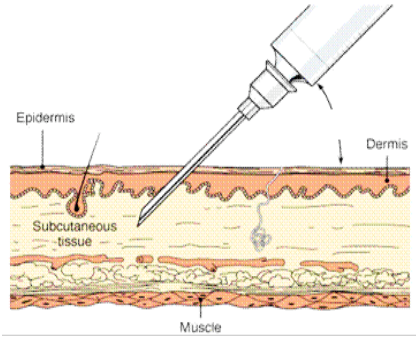
Drugs can be relatively rapidly absorbed & this route is popular with drugs such as insulin, heparin & morphine.

Subcutaneous Injections Sites



The Technique Of Subcutaneous Injection Is As Follows:

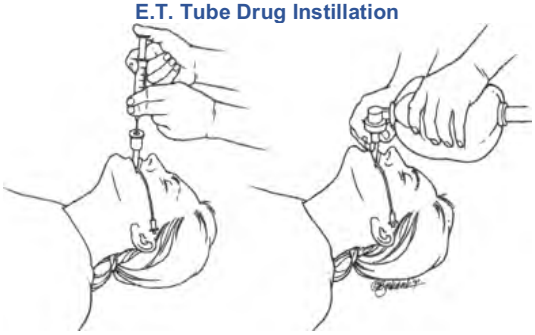
- Identify the name / concentration / expiry date of the drug.
- Using the ANTT Prepare it as per manufactures instructions using a 1 - 0.5 ml syringe, and attach a 25 gauge needle.
- Locate the injection site, (thigh, buttock, abdomen or upper arm).
- Disinfect the injection site.
- Gently pinch the fat over the injection site, and pull it away from the underlying muscle.
- Insert the needle into the subcutaneous tissue at a 45° 90° angle to the skin.
  - Pull back slightly on the plunger of the syringe (to ensure that the needle has not entered a blood vessel).
- If there is no return of blood into the syringe, inject the medication.
- Quickly withdraw the syringe, at the same angle as it was inserted, and apply firm pressure over the injection site.
- Dispose of the needle and syringe appropriately.
- Monitor the patient for an adverse reaction to the medication.



Giving Medications Through An Endotracheal Tube

The endotracheal route is indicated primarily for patients in cardiac arrest when an intravenous line cannot be established. In such cases atropine, lidocaine, and epinephrine (and only those drugs) may be given down the endotracheal tube, with absorption nearly as rapid as via the intravenous route.

E.T. Tube Drug Instillation



The Procedure For Giving Medication Through An Endotracheal Tube Is As Follows:

- Ventilates the patient, with 100% oxygen.
- Dilute double the usual dosage of the required medication in a syringe containing 10ml of sterile water.
- Disconnect the bag-valve device from the endotracheal tube.
- Rapidly squirt the contents of the syringe down the tube.
- Immediately reconnect the bag to the endotracheal tube.
- Ventilate the patient briskly to facilitate passage of the medication down the trachea.
- Monitor the patient for an adverse reaction to the medication.

ARTERIAL TOURNIQUET's 2.5

Tourniquets are an effective means of arresting life-threatening haemorrhage from a limb injury. Their use reduced over concerns regarding their potential complications. However, in a few rare situations tourniquet application will be necessary and life-saving.

The military have been at the forefront of reintroducing tourniquet use into modern practice. Soldiers require a rapid system of haemorrhage control, which can be self applied while under fire.

It is for this reason that modern, quickly applied tourniquets have been developed over the last decade (such as the Combat Application Tourniquet: CAT).

The use of an arterial tourniquet is not meant to replace traditional haemorrhage control measures (direct / indirect pressure), it is meant to accompany them.

The use of the CAT (or similar devices) in the commercial diving industry is indicated due to the increased potential of trauma and the remote nature of diving operations.

Combat Application Tourniquet

Reasons to Use Tourniquets in Commercial Diving

- Life threatening limb hemorrhage not controlled by simple methods.
- Penetrating and / or blast injury to limbs.
- Incidents, where there are limited resources and delayed transport to definitive care.
- Point of hemorrhage from a limb is not accessible due to entrapment (unable to provide direct pressure.)
- Multiple casualties with limb hemorrhage (and lack of resources to maintain simple methods of hemorrhage control).

Problems with Tourniquet Use

- The majority of external hemorrhage can be controlled by direct pressure.
- Previously tourniquets have been used inappropriately when not clinically indicated (so the risks have outweighed the benefits. In a recent research of military tourniquet use 47% of 110 tourniquet applications were not clinically indicated).
- Preventing arterial blood flow to a limb will result in ischaemia (restriction in blood supply).
  - o Continuous application for longer than 2 hours can result in permanent nerve / muscle injury.
  - o Muscle damage is nearly complete by 6 hours, with likely limb amputation.
  - o Therefore a tourniquet can be left in place for 2 hours with little risk of permanent ischaemic injury. An incorrectly applied tourniquet can cause increased bleeding from distal injuries and damaged arteries (if there is occlusion of the lower pressure venous outflow, but inadequate occlusion of arterial blood flow).
- Periodic loosening of a tourniquet to reduce limb ischaemia has often led to incremental exsanguination (bleeding out) and death.
- An arterial tourniquet is very painful and has led to inadequate tightening or inappropriate pre-hospital removal.

Principles of Tourniquet Application

- Be familiar with a purpose made arterial tourniquet, rather than using an improvised device.
- Tourniquet must completely and consistently occlude arterial blood flow (both in legs and arms).
- There is an inverse relationship between tourniquet width and the minimal pressure required to occlude blood flow (As width increases, the amount of tissue that must be compressed increases, requiring an increased tightening).
- If the tourniquet is ineffective it should be tightened or repositioned.
- If still ineffective (unlikely) the DMT may consider a second tourniquet placed proximal to the first.
- The time of application must be recorded and handed over to the receiving medic.

Combat Application Tourniquet (C.A.T.) 2.5.1

The 6 steps in C.A.T. application:

1. Open & apply proximal to bleeding site.
   Thread through the 1st buckle. Pull tight.

2. Pass through 2nd buckle. Then pull tight.
   The friction will lock the band in place.

3. Then pull the tourniquet very tight.
   Adhere the band to the Velcro fastener.

4. Twist the windlass rod until bleeding stopped.
   Assess that the distal pull is also absent.

5. Place windlass rod inside retainer clip.
   Reassess for bleeding, if present repeat step 4.

6. Place Velcro fastener over the windlass rod.
   Document time of tourniquet application.

Removal of an Arterial Tourniquet 2.5.2

The decision to remove an arterial tourniquet should never be made by a DMT, it should be a dive doctors. The decision to remove will depend on: if any other injuries have been stabilised; the current haemodynamic status of the patient; estimated journey time to hospital; and the medical resources available.

If transit time is expected to be within 2 hrs, the tourniquet should remain in situ until the patient is in a medical facility where direct surgical control of haemorrhage can be given.

Tourniquet Removal

If the transit time is more than 2hrs (or the other life-threatening injuries have been managed adequately) and the patient has stable vital signs, a ''trial of tourniquet removal'' may be attempted. It is possible that after a period of time of reduced arterial flow from tourniquet use, clotting will have occurred sufficiently to arrest haemorrhage, allowing simpler methods to be effective and reducing the complications from continued tourniquet use.

Before release of the tourniquet the DMT should have secured wound packing (including haemostatic agents) and application of direct pressure over the bleeding point. If careful release of the tourniquet then results in a return of uncontrollable external haemorrhage, the tourniquet should be replaced and not removed until the patient is in an operating theatre.

NASO-GASTRIC TUBES INSERTION 2.6

Gastric Distension

Gastric distension results from air being trapped in the stomach. As the stomach diameter increases from the trapped air, it pushes against the diaphragm and interferes with lung expansion. The abdomen becomes increasingly distended, and resistance may be felt to BVM ventilation. The stomach may also be prone to distension in a hyperbaric environment when a diver cannot burp (such as in unconsciousness).

Naso-Gastric Tube

Gastric distension that cannot be managed with these non-invasive techniques may require insertion of a gastric tube.

Gastric Tubes

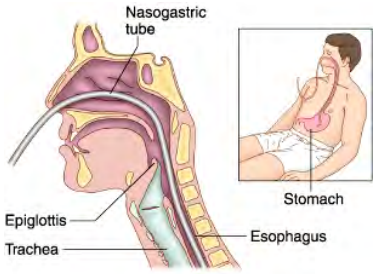
Gastric decompression for gastric distension or emesis control can be accomplished through nasogastric (NG) or oro-gastric decompression.

Naso Gastric Tube Insertion:

- Prepare the patient / Equipment.
  - o Select the appropriate tube size.
  - o Measure the tube in relation to nostril / stomach distance (55cm is average).
  - o Lubricate the NG tube with a water, based lubricant.
  - o Locate the larger nostril (normally the right nostril).
  - o Place the patient in the fowler position (60° angle) with the head in a neutral position.
  - o Pre-oxygenate.
- Insert Tube:
  - o Advance the tube gently along the nasal floor and into the stomach (pre determined cm).
  - o Have the patient swallow (a glass of water is useful) during insertion may help advance the tube into the oesophagus and prevent tracheal insertion.
- Confirm tube placement.
  - o Auscultate the epigastric region while injecting 30 to 50 ml of air.
  - o Note gastric contents in the NG tube (It will turn litmus paper pink).
- Secure the NG tube in place using pre made nasogastric tape or elastoplast.
- Attach a drainage bag bellow the level of the patient's stomach.
- The stomach may be manually decompressed with a 50ml catheter tipped syringe.

Measure Tube

Naso-Fix Adhesive



Contra-indications for Naso-Gastric tubes.

- High risk of aspiration
- Gastric stasis
- Gastro-oesophageal reflux
- Upper gastrointestinal stricture
- Nasal injuries
- Base of skull fractures (**absolute contra-indication**).

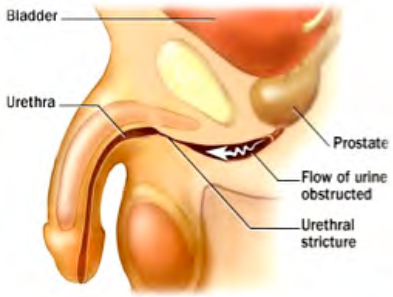
URETHRAL CATHETERIZATION 2.7

Urethral catheterization is a routine medical procedure that facilitates direct drainage of the urinary bladder.

Indications For Urinary Catheterization

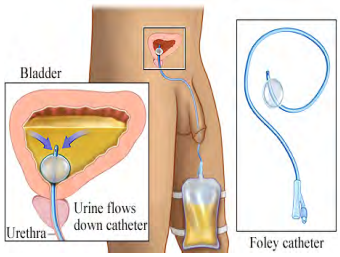
- Acute urinary retention: (anesthesia, opioids or nerve injury as in Spinal DCI).
- Acute bladder outlet obstruction: (prostate enlargement, blood clots, or urethral compression due to pelvic trauma).
- Need for accurate measurements of urinary output in the critically ill.
- To improve comfort and monitoring prior to medical evacuation.
- Patient requires strict prolonged immobilization.

Male Anatomy



The Procedure Of Urinary Catheterization

Catheterization of the bladder is not a pleasant experience for the patient. Your explanation of what is going to be done and why it is being done will be very important in establishing the patient's trust and gaining the patient's cooperation.



Equipment

The equipment for urinary catheterization should be sterilized and pre-packaged as a set. Commercial catheterization kits are now widely available and quite suitable.

If You Make Up Your Own Kit, It Should Contain At Least The Following:

- Sterile gloves x 2 pair.
- Catheter Pack:
  - Sterile cleansing sponges.
  - Sterile bowel.
  - Sterile fenestrated towels.
  - Forceps x 2.
- Foley catheter (size 12 – 16 ch).
- 10 ml syringe of sterile saline 0.9%.
- Antiseptic solution.
- 50-ml catheter tipped syringe.
- Lignocaine gel B.P. 2%.
- Sterile drainage bag.
- Tape for securing the catheter.

Catheterisation Equipment

Clean Penis

Administer Local Anesthesia

Catheterization of a Male

- Wash with soapy water & place a towel beneath the patient's penis.
- Using ANTT open items onto sterile field (see aseptic dressing section).
- Wash your hands, and apply **both** pair of sterile gloves.
- Retract the patient's foreskin & hold the penis by the shaft (using sterile gauze).
- Use the forceps / sponge to wash the glans with antiseptic solution.
- Place the fenestrated drape over the penis & dispose of outer gloves.
- Lubricate the end of the catheter and the urethral with the lignocaine & massage the gel down the urethra (allow at least 2 minutes of anesthesia).
- Raise the shaft of the penis straight up, and introduce the catheter.
- Advance it almost to its bifurcation.
- Inflate the balloon with 10 ml of sterile saline.
- Pull back gently on the catheter (so the balloon will rest against the prostatic urethra).
- Connect the catheter to tubing of the drainage system.
- Tape the tubing, not the catheter, to the inner surface of the patient's thigh; avoid tension on the catheter.
- Do not allow it to empty all at once (very rapid decompression of the bladder may cause profound vagal stimulation and slow the heart). Allow 100 ml at a time to be evacuated, then clamp the connecting tubing for a few moments. Unclamp, allow another 100 ml to pass, and clamp again. Continue until the bladder has emptied, at which point the tubing may be left unclamped.

Insert Until Bifurcation

Inflate Balloon

Check Points

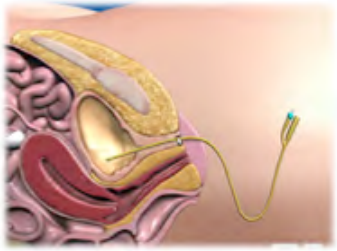
If it is not possible to advance the catheter up the urethra, do not force it. Try a smaller size or stiffer catheter. Re-orientate the penile shaft and try again.

If it is still impossible, specialist assistance may be required.

Withdraw Catheter

Catheterization of a Female

Female Catheterisation



The Process For Female Catheterisation Has Some Key Differences.

- Wash urethral opening with soapy water & place a towel beneath the patient's buttocks.
- Using ANTT open items onto sterile field (see aseptic dressing section).
- Wash your hands, and apply **both** pair of sterile gloves.
- Place sterile towels across the patient's thighs and under the buttocks.
- Place a collecting vessel for urine between the patient's legs.
- Separate the labia minora using gauze swabs (one hand should be used to maintain labial separation until catheterisation is completed).
- Clean around the urethral orifice with an antiseptic solution.
- Discard outer gloves.
- Lubricate the catheter with a sterile anaesthetic gel.
- Introduce the tip of the catheter into the urethral orifice.
- Advance the catheter until 6-8 cms have been inserted.
- Inflate the balloon, having ensured that the catheter is draining adequately.
- Withdraw the catheter slightly and connect it to the drainage system.
- Tape the catheter and drainage system to the thigh.
  Make the patient comfortable and ensure that the area is dry.

Locate Urethral Opening

Check Points

Female: In a large patient, it may be difficult to separate the legs and labia and hold the catheter single-handedly. Request assistance to act as another pair of hands to part the labia.

It is important not to inflate the balloon unless you are sure it is well inside the bladder and not inside the urethra. Once inflated, ability to withdraw the catheter a few cm before it comes to a halt confirms that the balloon is correctly positioned. If you cannot do this, deflate the balloon and reposition.

Female Catheterisation

INFECTION CONTROL & WOUND MANAGEMENT 2.8

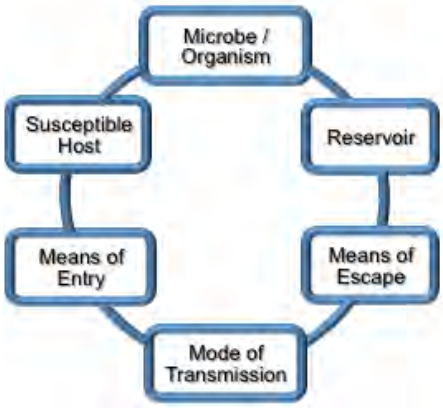
Infection control is concerned with preventing infection. It is an essential part of health care.

Infection occurs when an organism enters the body and starts to grow. However, disease only occurs if the organism starts to multiply and produce symptoms. Our bodies have a great capacity to fight off organisms. Diseases result when these protective mechanism fail or are compromised.

The most dangerous organisms are those that are both very virulent and contagious. All organisms must enter the body in order to cause disease. The organism must stick or adhere to a specific cell, invade, colonize and inflict some type of damage to the host.

The 'spread' of infection is only possible if a certain number of elements are in existence. These elements form a link, which is commonly referred to as the 'Chain of Infection'. As with all chains, they are only as strong as the weakest link and if a single link is broken then infection CAN NOT occur.

The Chain Of Infection



There Are Six Links In The Chain Of Infection:

- Causative Agent (Bacteria, Fungus, Virus or Prion).
- Reservoir.
- Portal of Exit.
- Mode of Transmission.
- Portal of Entry.
- Susceptible Host.

Causative Agent (Microbe / Organism)

Infectious agents: bacteria, viruses, parasites and fungi.

Reservoir

This is a place where organisms can thrive and multiply. This may be either inside the body or external (water, AC units, or in a parasite such as a mosquito).

Portal of Exit

In order for an organism to survive and repeat the cycle of infection, it must have a way to exit the reservoir. If

the organism was growing in stagnant water in an air conditioning unit it may spread when the unit is switched on. In other cases, it may spread from humans through coughs, body fluids or faeces.

Mode of Transmission

Organisms may be transmitted by direct or indirect contact. Direct contact occurs when an individual comes into contact with the reservoir. Indirect contact occurs when the organism is able to withstand the harsh environment outside the host for long periods of time and still remain infective.

Portal of Entry

Organisms need a point of entry. Some enter via mucous membranes such as the mouth, eyes or nose. Others enter via breaks in the skin (surgical incision or a laceration).

Susceptible Host

Most humans are not easily infected. Organisms usually cause infections in people who are weak or sick.

The main way of breaking 'The Chain Of Infection' is by instigating an aseptic approach.

An Aseptic approach is the process by which we prevent microbial contamination during invasive procedures or care of breaches in the skin's integrity.

There are two types of Asepsis: Medical Asepsis & Surgical Asepsis.

Medical Asepsis

Medical asepsis is concerned with eliminating the spread of microorganisms through simple preventative measures. The essential component of maintaining medical asepsis involves sterilization of organisms through:

Mechanical Disinfection.

Physically removing potentially infected material. Scrubbing items clean, or removing. Effective hand washing is an **excellent** mechanical disinfectant.

The standard hand washing technique is called the Ayllife method. Generally with performed with hot soapy water for a minimum of 30 seconds.

It is equally important to thoroughly dry the hands after washing.

Chemical Disinfection.

Using cleaning agents such as bleach, chlorine or ammonia. Alcohol hand gel is considered a chemical disinfectant.

Heat Disinfection.

Boiling or heating to very high temperatures is a common sterilisation technique for surgical instruments.

Radiological Disinfection.

Advanced processes such as gamma irradiation, also simple field techniques such as sun bleaching.

Surgical Asepsis

This is operating in 'the absence' of bacterial contamination, a classic example being an operating theatre. To maintain surgical asepsis a sterilized item will only come into contact with another sterile item.
In the management of pre-hospital wounds it is common to utilise a combination of both medical & surgical aseptic techniques.

Clean Technique

Is a modified aseptic technique and aims to avoid wound contamination and prevent cross-infection.
Sterile materials are required, but the dressing technique can be greatly simplified.

The aim of dressing any wound is to promote healing and prevent the transfer of organisms. Therefore, choice of a suitable dressing material is an important part of infection prevention and the healing process.

To perform an effective 'Clean Technique' the DMT should always apply surgical gloves and utilize an aseptic no touch technique.

Aseptic Non-Touch Technique

The Aseptic Non-Touch Technique (ANTT) means that when handling sterile equipment, only the part of the equipment **not** in contact with the susceptible site is handled. It is essential to ensure that hands, even though they have been washed, do not contaminate the sterile equipment or the patient.

The principle is that you **cannot** infect a key part if it is **not** touched. Any key part must only come into contact with other key parts; non-key parts should be touched with confidence.

The 4 Principles of the ANTT

- Always wash hands effectively
- Never contaminate key parts
- Touch non key - parts with confidence
- Take appropriate infective precautions

Wounds Classification 2.8.1

An injury, especially one in which the skin or another external surface is torn, pierced, cut, or otherwise broken.

Types of Wounds

Contusion

A bruise. Caused by ruptured capillaries. This may have been due to a blunt blow, or by bleeding from undefined damage, such as a fracture. Organs such as the spleen, liver & kidneys can become contused.

Abrasion

A graze. The top layers of skin are scraped off, usually as the result of a friction burn or sliding fall. Often containing particles of dirt, which cause infection.

Laceration

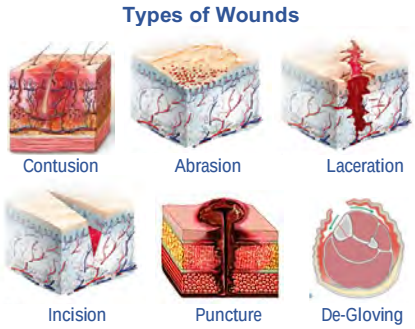
A rip or tear in the skin. More likely to have particles of dirt than a clean wound, although usually bleeds less.

Incision

Usually caused by a sharp object such as a knife. Deep wounds may involve complications such as severed tendons or blood vessels. This wound could 'gape open' and bleed profusely.

Puncture

As a result of standing on a nail or being stabbed. The wound could be very deep and yet appear very small a diameter. Damage may occur to underlying organs and severe internal bleeding may be present.



Ballistic Injury

Caused by a high velocity bullet / missile, which may be driven into and then exit the body. A small entry wound could be accompanied by a large 'crater' exit wound. Severe bleeding and damaged organs usually results.

De-gloveing

Severing of the skin from the body, resulting in 'creasing' or a flap of skin leaving a bare area of tissue. Caused by the force of the injuring item sliding along the length of the skin.

Chronic wounds

Caused by a relatively slow process. Chronic wounds include pressure, venous, and diabetic ulcers.

Principles Of Wound Healing 2.8.2

Normal wound healing is a process that proceeds unimpeded unless there is undue interference from infection, tissue devitalisation, poor repair technique, or underlying conditions such as diabetes.

Virtually all healing events - inflammation, angiogenesis, epithelialisation, fibroblast growth, scar remodelling - are under the control of specific mediators derived from a variety of sources (platelets, macrophages, lymphocytes, etc).

Categories of Wound Healing

For clinical purposes, wound healing is often categorised into three types of closure or intentions: primary, secondary and tertiary. Based on time from injury, level of contamination and degree of tissue devitalization, this classification guides the choice of closure strategy.

Primary Closure (Primary Intention)

Immediate primary closure can only be carried out on lacerations that are relatively clean and minimally contaminated, with minimal tissue loss or devitalization.

These wounds are most often created by shearing forces. They can be closed with sutures, wound tapes or staples. Repair of wounds is optimal when carried out within 6 to 8 hours, often referred to as the "Golden Period", from the time of injury.

Because there are no hard and fast rules that govern every possible situation, the following recommendation is made: any injury that can be converted to a fresh-appearing, slightly bleeding, nondevitalized wound, with no visible contamination or debris after aggressive cleansing, irrigation and debridement, is a candidate for primary closure.

Secondary Closure (Secondary Intention)

Skin infarctions, ulceration, abscess cavities, punctures, small cosmetically unimportant animal bites are often better left to heal by secondary intention.

They are closed with sutures and are allowed to gradually heal by granulation and eventual reepithelialization. After an appropriate program of wound care, they can become candidates for later skin coverage, if necessary, by grafting. These wounds have a pronounced inflammatory response and are prone to significant wound contraction over time.

Tertiary Closure (Delayed Primary Closure: DPC)

Certain wounds are candidates for closure after being cleansed, debrided and observed for 4 to 5 days.

These are wounds that are too contaminated to close primarily, but have not suffered significant tissue loss or

devitalization. Wounds that fall into this category are often older; excessively contaminated with soil, faeces, saliva or human or animal bites

A common cause of wound contamination is high-velocity / pressure induced wounds: this includes hyperbaric sustained injuries, high-pressure washer injuries or ballistic damage.

It is **very common** for wounds sustained whilst diving to be candidates for DPC.

Factors Complicating Wound Healing

There are many sources of potential interference with wound healing. These include bacterial contamination, anatomical and technical factors (such as environment) and associated conditions.

Wound Infection

The most common and serious complication of wound and laceration repair is infection. Because all accidentally induced wounds occur in unsterile conditions, they have to be considered contaminated with bacteria and other organisms. The skin acts as an effective barrier against the penetration of bacteria into the deeper layers of tissue & superficial fascia.

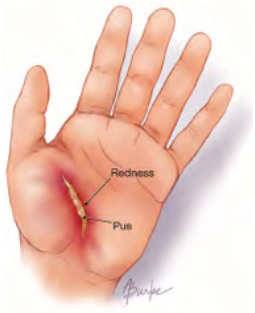
Any violation of the epidermis provides a pathway for bacterial invasion.

Soil, in particular clay, can impair healing. Soil and grit of any kind can lead to permanent tattooing if not aggressively removed.

Presentation Of A Wound Infection:

- Fever (Temperature over 37.5ºc. Over 38.5ºc indicates sepsis).
- Redness / inflammation / heat.
- Tenderness / pain.
- Pus or Discharge.

Wound Infection



Management Of A Wound Infection:

- Prevent wound infection (apply strict medical / surgical asepsis).
- If infection symptoms present sway site for C&S and give to dive medic.
- Administer topical / oral / intravenous antibiotics as prescribed.
- Ensure wound is clean & debrided / maintain asepsis.
- Anti-pyretical & anti-inflammatory drugs are useful (such as paracetamol & ibuprofen).

Wound Management 2.8.3

The management of wounds is an essential element of a DMT's role. As discussed there are many different types of wounds but there management may follow a generic management strategy.

Management Of A Wound:

- **Infection Control.** Wash your hands and put on disposable gloves. Apply ANTT principles.
- **Stop the bleeding.** Apply bleeding management. Hold the pressure continuously for at least 3 minutes and if possible elevate the wound (Don't check to see if the bleeding has stopped, this may dislodge the clot that's forming).
- **Assess the wound.** Identify what type of wound it is to establish a dressing choice.
- **Clean the wound.** Utilize the ANTT.
  - Rinse out the wound with sterile saline or cleaning wipes.
  - Clip hair close to the wound.
  - Ensure the wound is dried with gauze.
  - If dirt or debris remains in the wound, use tweezers cleaned with alcohol to remove the particles.
- **Dress the wound.** Utilize the ANTT and apply an appropriate dressing with confidence. Try and ensure any dressing is occlusive to avoid latter contamination.
- **Infection Control.** Dispose of all waste in a clean fashion. Wash your hands and dispose of gloves.
- **Action Plan.**
  - Does the injury require medical intervention?
  - Give the casualty advice on wound care.
  - Review the wound every 24 hrs & maintain sterility.
  - If the dressing gets wet, remove it immediately and apply a new one.
  - After the wound has healed enough to make infection unlikely, exposure to the air.

Seek Medical Advice If:

- You cannot control bleeding.
- There is a penetrating injury.
- You're unable to clean all the dirt from the wound.
- The cut is more than 1cm long, is on the face, appears deep, or has

Dressing Choice

Sterile dressings: these consist of a dressing pad attached to a bandage in sterile packaging. Various sizes are available.

Non-adhesive sterile dressings: some dressing pads are designed so that they do not stick to the damaged skin.

Adhesive sterile dressing pads. These consist of a dressing pad attached to an adhesive outer edge (essentially a large plaster). Various sizes are available.

Gauze pads: these can be used to clean around a wound. They can also be used for extra padding or absorption.

Skin closure tapes: these sticky strips are used to hold the edges of a cut together before applying a dressing.

Plasters. Plasters protect small cuts or grazes after they have been cleaned and dried.

Bandages.
Bandages are used to hold dressings in place, usually on limbs, or to help support a sprain.

Stretch bandage: for holding dressings in place. The skin around a cut may swell so the bandage must be able to stretch.

Crepe bandage: a soft, stretchy bandage that holds dressings in place. It also provides support and compression for a sprain.

Tubular bandage: this sleeve-like bandage supports sprained joints.

Triangular bandage: Use as a 'sling' for an injured arm.

edges that separate.
- If there is nerve, tendon or vascular injury: loss of sensation, numbness or movement, loss of pulse or colour.
- There are signs of infection: swelling.
- They have not had a tetanus vaccination within 5 yrs.
- If you are unsure.

Embedded Objects 2.8.4

An object embedded in a wound (other than a small splinter) should not be removed, as it may be stemming bleeding.

Management Of Embedded Objects As Follows:

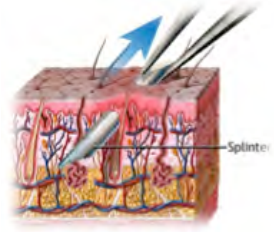
- Do not attempt to remove the object. Apply a ring pad (easily fashioned from a triangular bandage) or gauze around the wound and apply a clean dressing.
- Apply pressure around the object to stop bleeding, but do not apply pressure on the object.
- If a limb is affected, raise it, unless you suspect a fracture.
- Seek medical help from dive medic.
- Ensure casualty's tetanus immunisation is up-to-date.

Embedded Object

Splinters

If a splinter is embedded deeply, difficult to remove or on a joint, leave it in place and follow the advice for embedded objects above.

Splinter Removal



Other Splinters Can Be Removed As Follows:

- Carefully clean the area with warm soapy water.
- Using a pair of clean tweezers, grip the splinter as close to the skin as possible. Gently pull the splinter out at the same angle that it entered.
- Gently squeeze around the wound to encourage a little bleeding.
- Wash the wound again, then dry and cover with a dressing.
- Ensure casualty's tetanus immunisation is up-to-date.

Wound Cleaning 2.8.5

In Delayed Primary Closure a wound is often left open for a medically defined period of time and surgically cleaned, sometimes over a period of days.

Because wound cleaning can be uncomfortable if not outright painful, most wounds should be anaesthetised before cleaning.

Not only will the patient be more comfortable, but the cleaning can be more vigorous and effective.

For wounds that are visibly and heavily contaminated the parallel injection technique or an appropriate nerve block can be used, if need be, to avoid this hypothetical complication.

Wound Cleaning

Foreign Material

As part of wound preparation it is very important to determine the presence or absence of foreign bodies in the wound. Foreign materials of all types should be considered harmful and as having the potential for causing infection if left in the tissues. Although irrigation removes most debris, direct visualisation and removal by instruments are often required.

An alert patient can report the "sensation" of a foreign body still in the wound.

Wound Soaking

Wound soaking is a common practice in wound care. Soaking may loosen debris, break up blood coagulum, and help cleanse a wound.

Wound soaking can loosen, soften and remove gross contaminates from the skin surrounding the wound, but it is not a substitute for thorough mechanical skin cleansing and wound irrigation.

Irrigation

"The solution to pollution is dilution" is an old maxim of wound care that still rings true today. Wound irrigation is the most effective way to remove debris and contaminates from within a laceration.

Irrigation is also the single most effective method of reducing bacterial counts on the wound surfaces, hi comparing methods of irrigation for highly contaminated wounds, high pressure streams of saline are clearly superior to low pressure streams such as those that might be obtained with a bulb type syringe.

Wound Irrigation

Wound Periphery Cleansing

The main purpose for wound periphery cleansing or "scrubbing" is to remove any visible contamination and dried blood. Periphery cleansing alone is insufficient for wound preparation without accompanying irrigation. The end point of the skin cleansing is when the area surrounding the wound or laceration is visibly clean. There is no fixed scrubbing time. If the skin itself cannot be cleansed of all particulates then the risk for "tattooing" increases.

Visible particulate matter "ground" into the skin can become permanently entrapped within the epidermis and dermis of the skin. These particulates need to be removed by sharp debridement. Because tattooing can have serious cosmetic consequences on the face, consultation and referral to a facial plastic surgeon should be considered if routine measures fail.

ASEPTIC TECHNIQUE 2.9

The aseptic technique is an integral part of surgical asepsis and in all clinical interventions. Poor aseptic technique is the leading cause of infections in the ill casualty. The technique described below demonstrates the aseptic dressing of a wound. However the exact same principal is used in all invasive procedures, such as: catheterisation, cannulation, and needle decompression.

Therefore it is vital that a DMT is aware of and capable of performing this.

The Aseptic Technique.

1. Preparation of Equipment
Plan what you will need: Dressing pack, syringe etc.

2. Preparation of Yourself
Hand-washing using aliffe technique & ANTT principles.

3. Arrange Sterile Contents
Using strict ANTT, open contents onto sterile field.

4. Open Sterile Gloves
Using strict ANTT, open contents onto sterile field.

5. Put On Sterile Gloves
Put dominant hand inside a glove,(only touching inner cuff) .

6. Put On Sterile Gloves
Put other hand in 2nd glove, (only touching sterile inner cuff) .

7. Put On Sterile Gloves
Smooth out the gloves: (only touching sterile inner cuff) .

8. Put On Sterile Gloves
Once sterile gloves applied, only touch sterile items.

9. Irrigate The Wound
Flush wound with sterile saline. (Don't touch the wound).

10. Clean With Moist Gauze
From inside outwards. Then dry in same way.

11. Apply Sterile Dressing
Using a strict ANTT, apply an occlusive dressing.

12. Post Procedure
Dispose of items in clinical waste. Wash hands.

LOCAL ANAESTHESIA 2.10

Local anesthesia is commonly used prior to suturing or to deliver complete pain cessation to a specific site

Allergy to Local Anaesthetics

Allergic reactions are uncommon (True allergic responses occur in less than 1% of patients receiving local anaesthetics).

Allergic reactions are characterised by either delayed appearances of skin rashes or the acute onset of localised or general urticaria (multiple, smooth, raised, pinkish and itchy swellings). Rarely, anaphylactic shock can occur.

Management Of Allergic Responses:

- Use no anaesthetic for patients who have small lacerations. (Often the pain of injection exceeds the pain of placing sutures).
- Ice placed directly over the wound can provide a short period of decreased pain sensation.

Anaesthetic Solutions

Lignocaine is the most commonly used anaesthetic (The drug has a rapid onset of action in local infiltration).

Lignocaine is available in 2 strengths: 1% and 2%.

Lidocaine Local Anaesthetic

1% Lignocaine is used on large superficial wounds and lacerations and up to 20ml of 1% can be used at one time.

2% is used for deeper wounds and up to 10ml can be used at a time. Lignocaine's tissue spreading properties are good, and it readily penetrates nerve sheaths.

Duration of action for direct wound infiltration is approximately 20 to 30 minutes.

Anaesthetic Techniques

Most minor lacerations and wounds can be managed by administering a local anaesthetic directly into or around (parallel to) the wound area. Other wounds are best served by the application of a nerve block.

The following are descriptions of the techniques for administering local anaesthetics.

Direct Wound Infiltration

Direct infiltration through the wound is indicated for most minimally contaminated lacerations in anatomically uncomplicated areas.

Direct Wound Infiltration

Injecting directly into the wound is technically easy to do and, because intact skin is not pierced, needle stick pain is less. Some patients may express concern, or even alarm, at this prospect. Explaining the advantages of less pain will allay those fears.

Anatomy

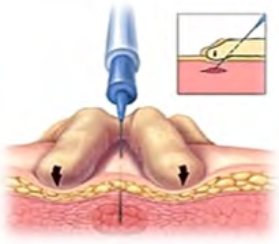
The proper plane of injection is immediately beneath the dermis at the junction of the superficial fascia.

Tissue resistance is less in this plane, and sensory nerves are easily reached by the spreading solution. Trying to inject directly into the dermis meets with great resistance. Injecting deep down into the fatty fascia unnecessarily delays onset.

Techniques For Direct Infiltration

- Identify the name / concentration / expiry date of the drug.
- Use ANTT. Prepare it as per manufactures instructions using a 2-5 ml syringe, and attach a 25-30g needle.
- Locate the injection site & disinfect.
- Insert the needle through the open wound into the superficial fascia (subcutaneous fat) parallel to and just deep to the dermis.
- Pull back on the plunger of the syringe (to ensure you have not entered a blood vessel).
- If there is no blood return into the syringe, inject anesthesia.
- Remove the needle and inject another bolus at an adjacent site, but just inside the margin of anaesthesia of the previous injection.
- Repeat this process until all edges and corners of the wound are anaesthetised.(A simple laceration approximately 3 to 4 cms in length requires 3 to 5 mls of an anaesthetic solution).
- Dispose of the needle and syringe in an appropriate puncture proof container.
- Monitor the patient for an adverse reaction to the medication.

Direct Wound Infiltration



Parallel Margin Infiltration (Field Block)

This technique is an alternative to direct wound infiltration and has the advantage of requiring fewer needle sticks. It is preferred in wounds that are grossly contaminated so that the needle does not inadvertently spread debris or bacteria into uncontaminated tissues, although this potential complication has not been clearly documented.

Anatomy

The same plane for direct wound infiltration is used, but it is approached through intact skin.

Technique For Parallel Margin Infiltration:

- Prepare as for direct infiltration.
- Insert needle into the skin at one end of the laceration.
- Advanced to the hub parallel to the dermis-superficial fascia plain.
- Aspiration is followed by a slow injection of a "track" of anaesthetic as the needle is withdrawn down the tissue plane into the insertion site.
- Reinsert the needle at the distal end of the first track.
- Reinsertion and injection is repeated on all sides of the wound until complete infiltration has been achieved.
- Dispose of the needle and syringe in an appropriate puncture proof container.
- Monitor the patient for an adverse reaction to the medication.

Digital Nerve Block

Recommended for lacerations distal to the level of the midproximal phalanx of the finger or toe. It is the procedure preferred for nail removal, paronychia drainage, as well as repair of lacerations of the digits.

Anatomy

There are four digital nerves for each finger or toe. The palmar digital nerves have the most extensive sensory distribution and are responsible for digital finger and fingertip sensation. Although the dorsal nerves have a lesser distribution, there is sufficient overlap with the palmar nerves that all four branches on each finger must be blocked to achieve complete digit anaesthesia.

The digital nerves are adjacent to the phalanges.

Technique for Digital Block

- Prepare as for direct infiltration.
- Insert needle & approach to the dorsal digital nerve followed by redirecting the needle to the palmar nerve. (No more than of 4ml of 1% lignocaine is recommended into each portion of the web space just distal to the metacarpal-phalangeal joint).
- Deposition into the web space prevents build up of excessive pressure on the digital nerves and blood vessels.
- The needle is advanced until it touches bone. (Approximately 0.5ml of anaesthetic is delivered dorsal to the digital nerve).
- The needle is then slightly withdrawn and redirected adjacent to the bone of the phalanx to the volar surface of the digit and 1ml of solution is deposited at the site of the volar or palmar nerve.
- Repeat on the opposite side of the digit to achieve full finger or toe anaesthesia.
- Dispose of the needle in sharps bin.

Digital Block

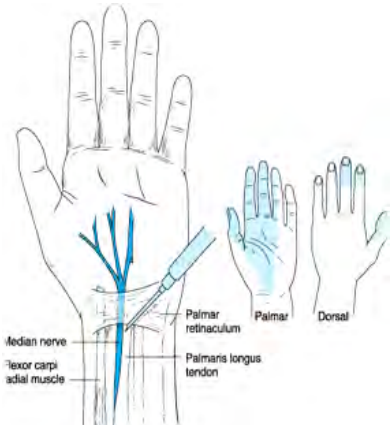
Median Nerve Block

For lacerations / wounds of the palmar aspect of the thumb, index, and middle fingers and the radial half of the palm.

Anatomy

The median nerve can be found at the proximal flexor crease of the wrist between the palmaris longus and the flexor carpi radialis tendons. The two tendons can be identified by having the patient voluntarily close his or her fingers into a fist and lightly flex the wrist. The nerve can also be located 1cm to the ulnar side of the flexor carpi radialis.

Median Nerve Block



Technique for Median Nerve Block

- Prepare as for direct infiltration.
- On identifying the palmaris longus tendon, introduce a 25g needle immediately radial to it.
- The needle is passed just deep to the flexor retinaculum. A "popping" sensation can be felt as the needle traverses the dense retinaculum.
- Pass the needle slowly deeper into the wrist (If paraesthesias are elicited, 2 mls of solution is deposited adjacent to but into the nerve. If non are elicited 3 to 5 mls of solution is injected, from deep to superficial as a track).
- Anaesthesia might not be complete for at least 20 minutes.
- Dispose of the needle in sharps bin.

SUTURING 2.11

Wounds and lacerations can be managed with a few well-chosen instruments and a limited number of wound closure products.
Although the type of instrument remains relatively constant, each wound has different requirements for wound closure materials. Absorbable and non-absorbable sutures, as well as a variety of wound tapes and staples, can be selected according to the specific patient problem.

Suturing Instruments

Suturing Instruments

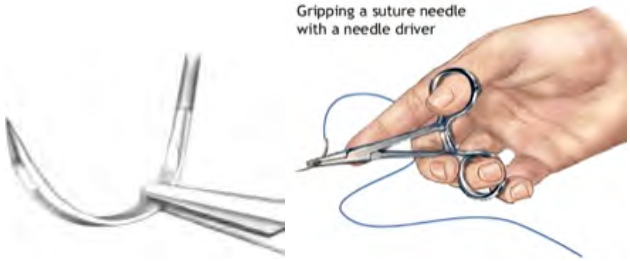
Wound Care Can Be Carried Out With The Following Sets Of Instruments:

- Needle holders.
- Tissue forceps.
- Skin hooks.
- Suture scissors.
- Iris (tissue) scissors.

Needle Holders

A 4¼ inch Webster needle holder with serrated carbide-tipped jaws can accommodate most curved suture needles. Occasionally, large needles are used and an instrument such as a 6-inch Webster needle holder is necessary.

Needle Holders



Technique for Handling Needle Holder

Just as important as the choice of needle holder is the technique used for holding and arming it with a needle. The rings are only used to clamp and unclamp the jaws by closing and releasing the locking mechanism. When introducing the needle into the skin, better precision can be gained by grasping the needle holder close to the jaws.

- Close the tip of the jaws onto the body of the needle. (Grasp needle at right angles, approximately one third of the way down the body shaft from the end to which the suture is attached).
- Grasp and control tissue with forceps or skin hooks. (Skin hooks are preferable to forceps because the "crushing" or "pincer" effect of forceps is eliminated).
- Forceps are still widely used. The currently recommended forceps are 4¼ inch Adson's with small teeth. (Teeth decrease the need to apply excessive force to grasp tissue. Forceps without teeth are to be discouraged because their jaws crush tissue).

Tissue Forceps

Technique for Handling Forceps

- Grasp the superficial fascia gently (the wound edge is stabilised for needle placement, and inadvertent damage to the dermis is avoided).
- The needle entry point can be immobilised and supported without closing the jaws.

Scissors

Scissors

Three types of scissors are useful in emergency wound care: iris scissors, dissection scissors and suture scissors. Four-inch iris scissors, both curved and straight, are used in debridement and wound revision. They are very sharp and excellent for cutting tissue.
For heavier tissue revision (as might be necessary for wound undermining) blunt-tipped 6 inch Metzenbaum dissection scissors are recommended.
Standard 6 inch, single blunt-tip suture scissors are most useful for cutting sutures, adhesive tape, sponges, and other dressing materials.

Technique for Handling Scissors

- Scissor tip control is essential, when cutting close to the knots of deep or dermal closures with absorbable sutures.
- Just before cutting, the tips are rotated slightly to avoid cutting the knot itself.

Suture Materials

There are two main classes of suture materials: absorbable and non-absorbable.
In general, absorbable sutures are placed deep for closure of dead space in large wounds or to reduce closure tension. Non-absorbable sutures are most commonly used for skin closures.

Non-absorbable Suture Materials

Monofilament nylon (Ethilon, Dermalon) is most commonly used for skin closure. It is minimally tissue reactive, able to resist infection and has tensile strength that ensures wound security. The main disadvantage of nylon is the difficulty in achieving good knot security (at least 4 to 5 carefully fashioned "throws" or knots are required to achieve a secure final knot).

Polypropylene (Prolene) is another non-absorbable monofilament. It is stronger than nylon, has better wound security & is able to resist infection. However, it has greater memory than nylon and is somewhat more difficult to work with.

The main uses of polypropylene are for percutaneous and subcutaneous pull out closures.

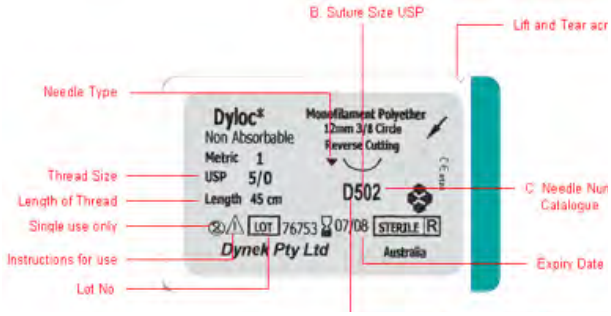
Polybutester (Novafil) is stronger than other monofilaments. It does not have significant memory and therefore does not maintain its packaging shape like nylon and polypropylene do (therefore it is easier to work with and has greater knot security). A unique feature of polybutester is that it has the capacity to adapt or "stretch" with increasing wound oedema.

When compared with nylon, this suture material has a lower risk of scarring.

Less commonly used for minor wound clousure are the braided, non-absorbable suture materials. These include cotton, silk, braided nylon and multifilament Dacron.

Braided synthetics have a greater tendency to cause wound infection. These materials, however, have excellent workability and knot security. Because of the latter properties, braided sutures have some usefulness on the face where maximal control and precision are needed.

Suture Information

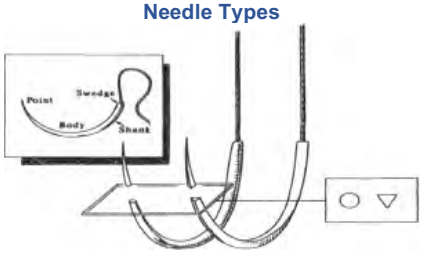


Suture (Brand Name)	Description	Absorbed	Common Uses
Fast catgut	Twisted/fast absorption	30 Days	Facial lacerations in children
Plain catgut	Twisted/rapidly absorbable	70 Days	Vessel ligation, subcutaneous tissues
Chromic catgut	Twisted/absorbable	90 Days	Mucosa
Polyglycolic acid (Dexon)	Braided/absorbable	60 – 90 Days	GI, subcutaneous tissues
Polyglactin 910 (Vicryl Rapide)	Braided/absorbable	42 Days	Skin repair needing rapid absorption
Polyglactin 910 (Vicryl)	Braided/absorbable	56 – 70 Days	Bowel, deep tissue
Poliglecaprone 25 (Monocryl)	Monofilament/absorbable	91 -119 Days	Skin, bowel
Polydioxanone (PDS)	Monofilament/absorbable	6 mths	Fascia, GI
Polyglyconate (Maxon)	Braided/absorbable	6 mths	GI, muscle, fascia
Panacryl	Braided/absorbable	2 yrs	Fascia, tendons
Polytetrafluoroethylene (PTFE)	Monofilament	Non Absorbable	Vascular grafts, hernia
Nylon (Dermalon, Ethilon)	Monofilament	Non Absorbable	Skin, drains
Nylon (Nurolon)	Braided	Non Absorbable	Tendon repair
Polyester (Ethibond, Tycron)	Braided	Non Absorbable	Cardiac, tendon
Polypropylene (Prolene)	Monofilament	Non Absorbable	Vessel, fascia, skin
Silk	Braided	Non Absorbable	GI, vessel ligation, drains

Needle Types

The vast majority of wound closures can be accomplished with a limited number of needles. Curved needles have two basic configurations: tapered and cutting. For wound and laceration care, the cutting needle is used almost exclusively. The cutting needle is made so the outer edge is sharp so as to allow for smooth and non-traumatic penetration of the skin, and the inner portion is flattened so that the needle puncture wound is not inadvertently enlarged as the suture passes through the hole and the knot is tied.

Needle Types



Suturing Patterns

The following are the common techniques of skin approximation. Critical to any suturing technique is making certain that the edges of the wound closely approximate without overlapping or inversion and that there is no tension.

Remember "approximation without strangulation" or eversion of the skin edges gives the best results (Figure 1 & Fig 1.5).

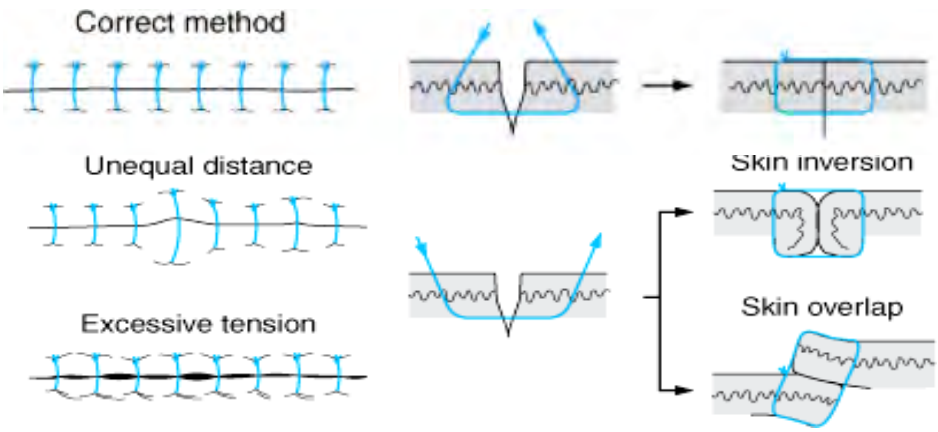


FIGURE 1
Proper method for simple interrupted suturing of a skin

FIGURE 1.5
Icorrect techniques that result in poor scars from skin overlap, skin inversion, or necrosis of the skin edges due to excessive tension.

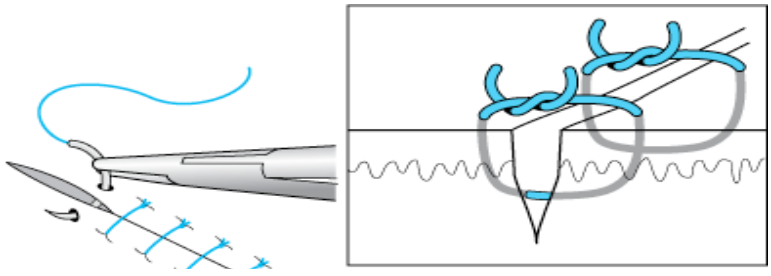


FIGURE 2
Simple Interrupted Sutures.
"Bites" are taken through the thickness of the skin, and the width of each stitch should equal the distance between sutures to avoid inverting the skin edges.

Figures 2, 3, 4, 5, and 6 illustrate the commonly used suturing patterns. These include simple interrupted suture (Figure 2), running (locked or unlocked) suture (Figure 3), vertical mattress suture (Figure 4), horizontal mattress suture (Figure 5), and subcuticular suture(Figure 6)

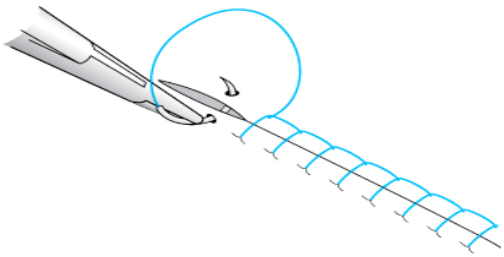
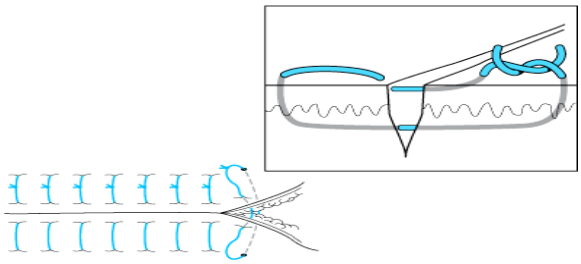


FIGURE 3
Continuous Running Suture.
Technique allows rapid closure but depends on only two knots for security and may not allow precise approximation of the skin edges. "Locking" each stitch, as shown, may increase scarring.

FIGURE 4
Vertical interrupted mattress sutures.
Technique allows precise approximation of skin edges with little tension but can result in more scarring than simple stitches. Needle is placed in the skin in a "far, far, near, near" sequence.



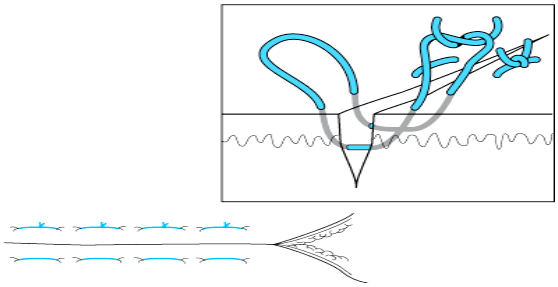
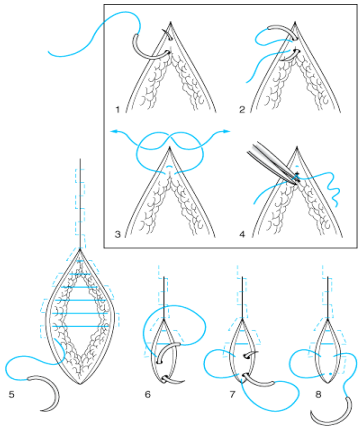


FIGURE 5
Horizontal Interrupted Mattress Sutures.
This everting stitch is more frequently used in fascia than in skin. It is often used in calloused skin, such as the palms and soles.

FIGURE 6
Subcuticular closure is usually performed with continuous, horizontally applied intradermal sutures. These sutures are ideal for linear cosmetic closure because they eliminate possible cross-hatching deformities. If nonabsorbable suture material (eg, 5-0 or 6-0 Prolene) is used, the knot is placed on the skin and pulled taut. If absorbable (5-0 or 6-0 Dexon or Vicryl) is used, the knot is usually buried as shown. The knot is tied in part 8, the needle passed through the skin, and the suture material cut flush.



Surgical Knots

There are three basic knot-tying techniques: one-handed and two-handed ties and the instrument tie.
Figure 7 shows the technique for tying a two-handed square knot. Practical for DMT's.
Figure 8 shows the technique for a one-handed tie. Very difficult for DMT's.
Figure 9 shows the technique for an instrument tie. Ideal for DMT's.

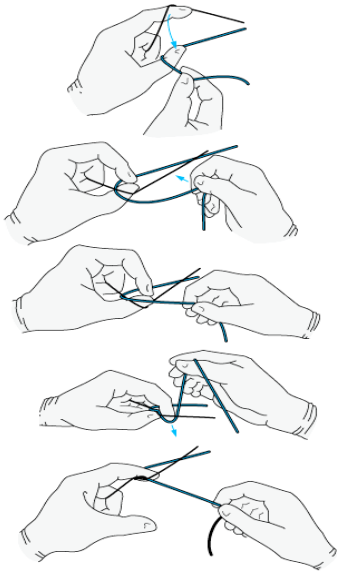
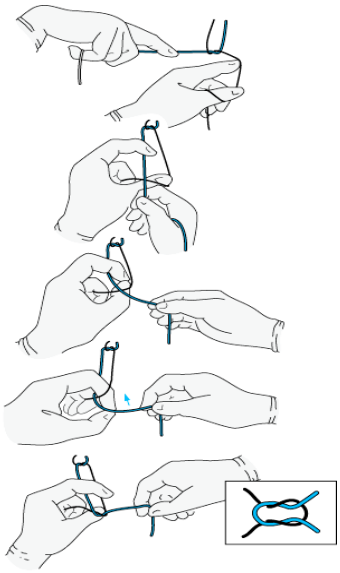


FIGURE 7

Technique for tying Two-Handed Square Knot.

Suture ends are uncrossed as step A begins. Hands must be crossed at the end of the first loop tie to give a flat knot; hands are not crossed at the end of the second loop tie.



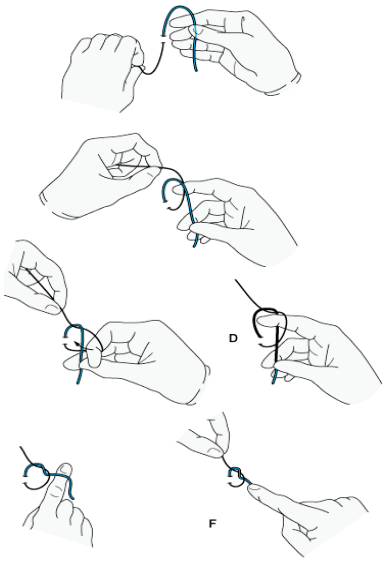
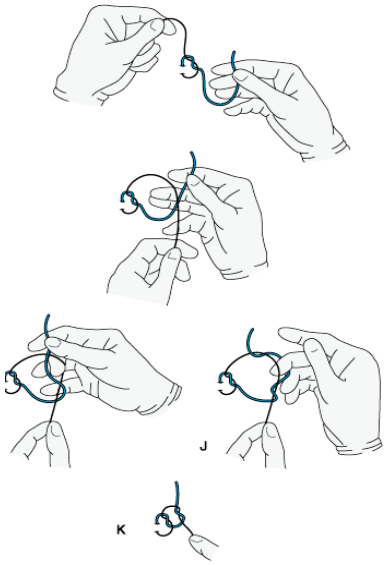


FIGURE 8

One-Handed Tie.

The right hand sets up the loop and manipulates the working strand.

Very difficult technique.



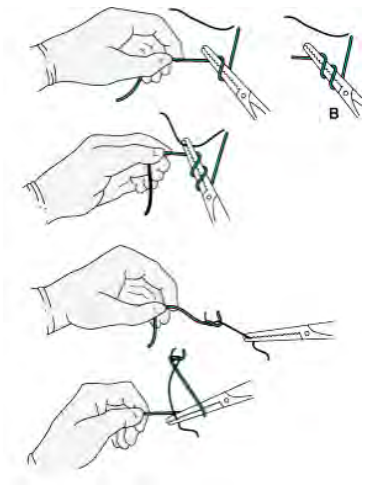
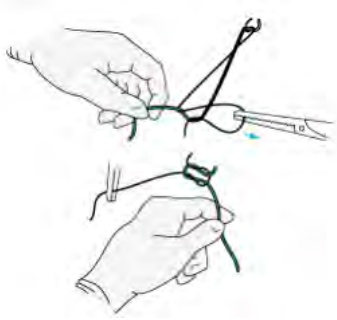


FIGURE 9

The Instrument Tie.

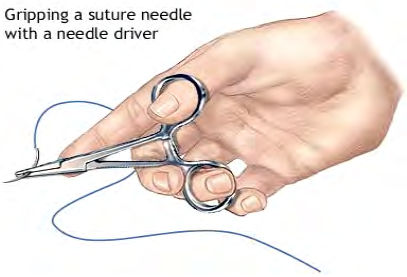
Begin with either a single or double (illustrated) looping of the lower end of the suture around the needle holder. The first loop is laid flat without crossing the hands. Hands must be crossed after the second loop tie to produce a flat square knot.

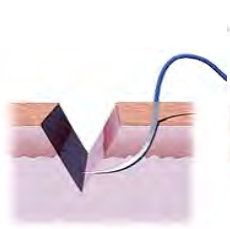
Ideal For DMT

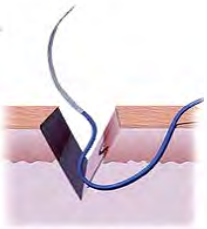


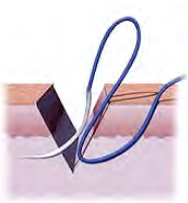
Recap :-

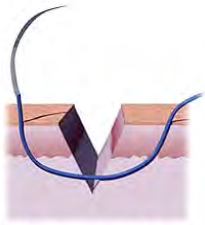
Sewing a wound closed, using a *simple interrupted suture* with an *instrument tie* knot.




Needle pushed through skin and out into the base of the wound


Suture pulled through first side of wound


Needle pushed into the base of the opposite side of the wound


Needle rotated out through second side of the wound

1
Grip the needle with the needle holder at a 90° angle 1/3 down the body.

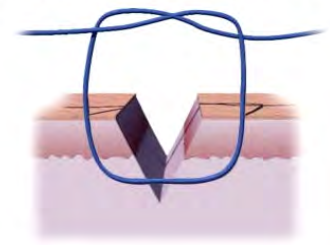
2
Push the needle through the skin and into the base of the wound. Then pull the suture through the first side of the wound.

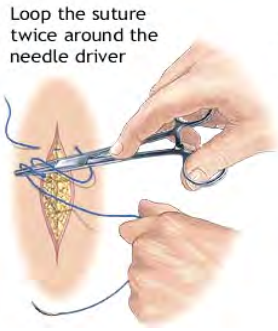
3
Push the needle through the base of the opposite side of the wound and bring it out as before. Tie the suture to close the wound.

4
When the suture is properly in place, it should form a U-shape.

5
To tie a suture, first loop it around the needle driver twice. Next, grab the short end of the suture with the needle driver.

6
Start by creating the first knot of a loop. Next, make a second single loop in the opposite direction. This completes the square knot.





Suture Removal 2.11.1

The longer a suture is left in the skin, the more scarring it produces. Using a topical antibiotic ointment on the wound is helpful in decreasing suture tract epithelialization. Epithelialization results from crusting around the suture that may increase scarring.

Sutures can be safely removed when a wound has developed sufficient tensile strength. Situations vary greatly, but general guidelines for removing sutures from different areas of the body are as follows: face and neck: 3–5 days; scalp and body: 5–7 days; extremities: 7–12 days.

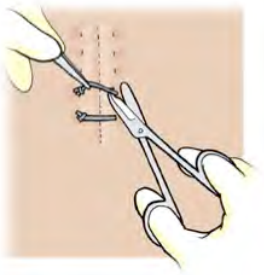
The length of time absorbable sutures remain in tissues is shown in the Suture Table.

Suture Removal Kit

Suture Removal Procedure:

- Apply ANTT principles.
- Gently clear away any dried blood with saline solution and gauze.
- Verify that the wound is sufficiently healed to allow suture removal.
- Use a forceps to gently elevate the knot out off the skin.
- Cut the suture as close to the skin as possible (so that a minimal amount of "dirty suture" is dragged through the wound).
  - When removing continuous sutures, cut and pull out each section individually.
  - **Never** pull a knot through the skin.
  - Often the suture material is pulled tight to the skin, and it is difficult to remove the stitch with thick scissors.
  - A no. 11 scalpel with the blade pointed up is helpful in this situation.
- Clean the site & inspect for signs of infection.
- Dispose of all sutures as clinical waste.

Suture Removal



CERVICAL SPINE MANAGEMENT 2.12

The Casualties Who Should Receive Immobilisation Are:

- Patients whose mechanism of injury arouses suspicion of possible injury (e.g. high velocity car crash, fall of greater than twice the patient's height, ejection from vehicle).
- Patients with pre-existing disease of the spine.
- Patients with neurological signs.
- Altered level of consciousness at the time of assessment (Including intoxication).
- Spinal pain (pain in the midline on gentle palpation).
- Patients with other injuries, the pain of which may actually distract them from their spine and symptoms.

Actions On Suspecting Cervical Injury

Immidiate Actions:

- Instruct casualty to limit movement.
- Use "Manual in-line alignment".
- Gently straighten limbs (Try & treat the casualty in position found).

Important
The casualty can only be considered 'Immobilised' when all of these steps are initiated.

Definitive Actions: (Whilst Manual In-Line Immobilisation Maintained).

- Application of Cervical Spinal Collar (C-Spine Collar).
- Use of controlled log roll maneouver if necessary.
- Application of a Spinal Immobilising Stretcher.
- Application of head immobilisation blocks.
- Application of restraint straps.

Manual In-Line Stabilisation

In a trauma team, cervical care is generally the responsibility of the 'Airway' team member. Once a clear airway has been created, if there is a suspicion of an injury to the cervical spine, the head and neck should be maintained in a position that minimises the risk of any further damage to the spinal cord.

Manual In-Line Stabilisation

This Is Best Achieved By Using Manual In-Line Stabilisation:

- The palms of the rescuer's open hands are placed either side of the victim's head (taking care not to cover their ears).
- Neutral alignment is achieved by aligning the nose with the centre of the sternum with the centre of the pubic bone on the pelvis.
- If the head and neck are in an unnatural position then an attempt should be made to bring them back into a midline position (alignment of nose, sternum and pubic bone) to facilitate stabilisation and effective evacuation.
- If however, if resistance is felt, or in the conscious patient, pain is increased, then the neck should be moved to as near as possible to the mid line.

Rigid C-Spine Collar

Cervical Spinal Collar

- A rigid and appropriately sized C-spine collar should be fitted in accordance with the manufacturer's instructions as soon as it is reasonably practicable in an emergency situation when a spinal injury is suspected.
- It must be remembered that the application of the C-Spine Collar is not a 'definitive' immobilisation, In-Line mobilisation must be maintained after the application of the collar until complete mesures are achieved.
- f it proves impossible to create or maintain a patent airway without moving the victim's neck, then the airway must take priority.

A. Size the C-Collar from the tip of the chin to the top of trapezius.

B. The head must be immobilised during application in the vertical.

C. and horizontal positions.

If The Neck Has To Be Moved To Facilitate An Airway, The General Guidelines Are:

- Use the minimum amount of neck movement necessary to clear the airway.
- Jaw Thrust technique is ideal.
- Do not use excessive force.
- Do not try to overcome resistance.
- Carry out the movement slowly and smoothly.
- Re-check the patient's sensation and limb movement following a repositioning (i.e. spine board or log roll).

Log Roll

- In the trauma situation it is often vital to roll a casualty with a suspected injury, either to examine for injuries, if they begin to vomit or to apply a spinal stretcher.
- The head, neck and upper body must be kept in line as you turn the patient.

Log Roll

Log Roll Procedure:

- The log roll is ideally a 4-person technique.
- **In-line immobilization is maintained through out the entire maneouver.**
- Position (1) takes control of the head and neck. (The Airway team member & the leader of the manouveur).
- Team members 2, 3 & 4 should be positioned as illustrated.
- Choose to roll away from the affected side where appropriate. Ensure there is adequate slack in all lines (IV lines; ventilator tubing; monitoring leads).
- Position (1) uses the command "Ready – Steady – Roll" (to ensure synchronous movement when rolling onto the side).
- A 5th person must perform a spinal, back examination and place the spine-board.
- Position (1) uses the command "Ready – Steady – Roll" to roll the patient onto their back.
- Head blocks and harness should be fully secured

The Spinal Board

The spinal board has two roles. The first and perhaps best is in the extrication of patients with suspected spinal injury, where the board can be slid behind the patient, or underneath them to effect a safe and stable removal from a hazardous environment.

The second is in immobilisation, with the addition of head blocks and patient straps. With the spine board and cervical collar a patient can be effectively immobilised for removal from scene.

Spinal Board

The Scoop Stretcher

The scoop stretcher, whilst being uncomfortable for the patient and a cause of pressure areas for the spinally injured patient, still forms a useful part of the medic's equipment.

Widely used in the offshore environment, the scoop can be used to transfer a patient between long board and vacuum mattress.

Scoop Stretcher

Head-Blocks

Are made of plastic wrapped foam blocks, vinyl foam blocks or cardboard. They are adhered to the backboard by surgical tape or Velcro.

Vinyl blocks and plastic wrapped blocks will not absorb body fluids, are easy to cleanup and can be disinfected.

These devices, use in conjunction with a proper technique to "package" a patient can significantly reduce the possibility of further spinal injury.

In-Line Immobilisation is maintained throughout the application of the head blocks.

Spider Harness

A common casualty restraint system, which is used to complete the cervical spinal immobilisation and secure a casualty for transport is the 'Spider Harness'.

Spider Harness

How To Apply The Spider Harness:

- Hold folded strap above patient's chest (with strap loops at bottom pointing to patient's feet).
- Unfasten the retaining fastener (which holds entire strapping system together).
- Using both hands, divide the strap in the middle, letting it fall open naturally.
- Place strap on patient's chest with the center strap folds pointing towards the patient's feet and the V-Strap on the patient's chest.
- Pull the top cross strap (foot strap) towards the patient's feet.
- Unfasten the hook and loop on each cross strap and run through the holes in the backboard or scoop stretcher and then back around and fasten it to itself.

Section 3

Immediate Care

INTERMEDIATE LIFE SUPPORT 3.1

The actions of a DMT in a cardiac arrest situation can be life saving.

A cardiac arrest is different from (but may be caused by) a heart attack. Cardiac arrest, is the cessation of normal circulation of the blood due to failure of the heart to contract effectively, and if this is unexpected can be termed a sudden cardiac arrest or SCA.

Sudden cardiac arrest is a leading cause of death in Europe, affecting about 700,000 individuals a year. In the majority of out of hospital cases the victim is initially in a heart rhythm called ventricular fibrillation (V.F.).

The immediate effect of a cardiac arrest is that the absence of blood circulation prevents delivery of oxygen to the body. Lack of oxygen to the brain causes loss of consciousness, which then results in abnormal or absent breathing. Brain injury is likely if cardiac arrest goes untreated for more than five minutes. For the best chance of survival and neurological recovery immediate treatment is essential.

The Chain Of Survival 3.1.1

Basic life support (BLS) or **Cardio-Pulmonary Resuscitation** (CPR) is a level of medical care that can be provided by laypersons who have received BLS training. BLS is used in the pre-hospital setting, and can be provided without medical equipment.

It is important to realize that CPR alone is **highly unlikely** to actually revive a person who has suffered a cardiac arrest.

Its fundamental use is to ensure that the main organs (particularly the brain) are perfused with oxygen in the time it takes medical help to arrive. As discussed, the majority of Sudden Cardiac Arrests are in a ventricular fibrillation rhythm. V.F. is classed as a 'shockable' rhythm and can be converted back to a 'normal' rhythm if the casualty has access to a defibrillator as soon as possible after a cardiac arrest. V.F. will eventually change into a heart rhythm called asystole over a period of minutes. Asystole is classed as a 'non-shockable' rhythm and a defibrillator is of no help. It is estimated that the chance of successful resuscitation reduces by 7-10% each minute a person is resuscitated without defibrillation.

It is for this reason that the public automated external defibrillator or AED, which can be used for defibrillation has become so common within the UK. Their early use can increase the chance of survival from 5% to more than 50%.

Basic Life Support 3.1.2

What follow is a detailed description of a rescuer's actions upon finding a casualty who has suffered from a cardiac arrest. It is the United Kingdoms Resuscitation Councils (UKRC) actual guideline with the associated Basic Life Support Algorithm.
All elements of this process comply with The S.A.F.E. approach ➔ Quick Look Primary Survey assessment.

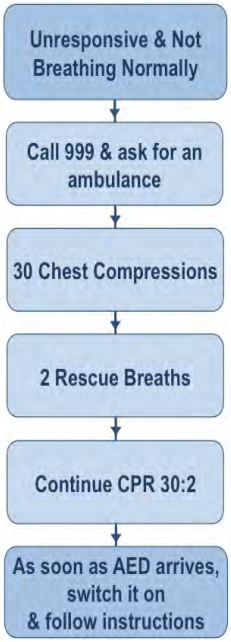
Adult 2015 UKRC BLS sequence is as follows:

SEQUENCE	TECHNICAL DESCRIPTION
SAFETY	Make sure you, the victim and any bystanders are safe
RESPONSE	**Check the victim for a response** • Gently shake his shoulders and ask loudly: "Are you all right?" If he responds leave him in the position in which you find him, provided there is no further danger; try to find out what is wrong with him and get help if needed; reassess him regularly
AIRWAY	**Open the airway** • Turn the victim onto his back Place your hand on his forehead and gently tilt his head back; with your fingertips under the point of the victim's chin, lift the chin to open the airway
BREATHING	**Look, listen and feel for normal breathing for no more than 10 seconds** In the first few minutes after cardiac arrest, a victim may be barely breathing, or taking infrequent, slow and noisy gasps. Do not confuse this with normal breathing. If you have any doubt whether breathing is normal, act as if it is they are not breathing normally and prepare to start CPR

NOTE: In the first few minutes after cardiac arrest, a casualty may be barely breathing, or taking infrequent, noisy gasps. Do not confuse this with normal breathing. If you have any doubt, act as if it is not normal.

SEQUENCE	TECHNICAL DESCRIPTION
DIAL 999	**Call an ambulance (999) (Or Emergency Medic Response)** Ask a helper to call if possible otherwise call them yourself. Stay with the victim when making the call if possible.
SEND FOR AED	**Send someone to get an AED if available** If you are on your own, do not leave the victim, start CPR
CIRCULATION	**Start chest compressions** Kneel by the side of the victim. Place the heel of one hand in the centre of the victim's chest; (the lower half of the sternum). Place the heel of your other hand on top of the first hand. Interlock the fingers of your hands and ensure that pressure is not applied over the victim's ribs. Keep your arms straight. Do not apply any pressure over the abdomen or the bottom end of the bony sternum. Position your shoulders vertically above the victim's chest and press down on the sternum to a depth of 5–6 cm. After each compression, release all the pressure on the chest without losing contact between your hands and the sternum; Repeat at a rate of 100–120 min.
GIVE RESCUE BREATHS	**After 30 compressions open the airway again using head tilt and chin lift and give 2 rescue breaths** • Pinch the soft part of the nose closed, using the index finger and thumb of your hand on the forehead. • Allow the mouth to open, but maintain chin lift. • Take a normal breath and place your lips around his mouth, making sure that you have a good seal. • Blow steadily into the mouth while watching for the chest to rise, taking about 1 second as in normal breathing; this is an effective rescue breath. • Maintaining head tilt and chin lift, take your mouth away from the victim and watch for the chest to fall as air comes out. • Take another normal breath and blow into the victim's mouth once more to achieve a total of two effective rescue breaths. Do not interrupt compressions by more than 10 seconds to deliver two breaths. Then return your hands without delay to the correct position on the sternum and give a further 30 chest compressions. • Continue with chest compressions and rescue breaths in a ratio of 30:2 **If you are untrained or unable to do rescue breaths, give chest compression only CPR (i.e. continuous compressions at a rate of at least 100–120 min)**
IF AN AED ARRIVES	**Switch on the AED** Attach the electrode pads on the victim's bare chest. If more than one rescuer is present, CPR should be continued while electrode pads are being attached to the chest. Follow the spoken/visual directions. Ensure that nobody is touching the victim while the AED is analysing the rhythm. **If a shock is indicated, deliver shock** • Ensure that nobody is touching the victim. • Push shock button as directed (fully automatic AEDs will deliver the shock automatically). • Immediately restart CPR at a ratio of 30:2. • Continue as directed by the voice/visual prompts. **If no shock is indicated, continue CPR** • Immediately resume CPR. • Continue as directed by the voice/visual prompts.
CONTINUE CPR	**Do not interrupt resuscitation until:** A health professional tells you to stop. You become exhausted. The victim is definitely waking up, moving, opening eyes and breathing normally. **It is rare for CPR alone to restart the heart. Unless you are certain the person has recovered continue CPR**

U.K. Resuscitation Council 2015 Basic Life Support Algorithm



Continue Resuscitation Until:
- Qualified help arrives and takes over.
- The victim starts breathing normally.
- You become exhausted.

Defibrillation 3.1.3

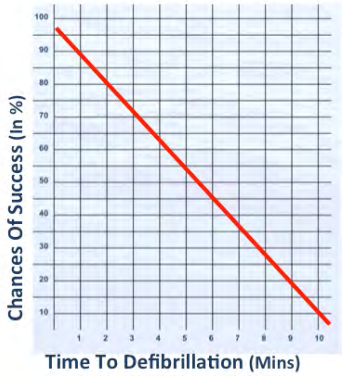
In the UK approximately 30,000 people sustain cardiac arrest outside hospital and are treated by emergency medical services each year.

Defibrillation is well established as the only effective therapy for cardiac arrest caused by ventricular fibrillation (V.F.) or pulseless ventricular tachycardia (V.T.). The scientific evidence to support early defibrillation is overwhelming; the delay from collapse to delivery of the first shock is the single most important determinant of survival.

The chance of successful resuscitation reduces by 7-10% each minute a person is resuscitated without defibrillation.

If defibrillation is delivered promptly, survival rates as high as 75% have been reported. The chances of successful defibrillation decline at a rate of about 10% with each minute of delay; basic life support will help to maintain a shockable rhythm but is **not** a definitive treatment.

The Resuscitation Council (UK) recommends a policy of defibrillation with the minimum of delay in victims of V.F. / V.T. cardiac arrest.



What Is An Automated External Defibrillator ?

An automated external defibrillator or AED is a portable electronic device that automatically diagnoses the potentially life threatening cardiac arrhythmias of ventricular fibrillation and ventricular tachycardia in a patient, and is able to treat them through defibrillation; the application of electrical therapy which stops the arrhythmia, allowing the heart to re-establish an effective rhythm.

Types Of AED's

AEDs are sophisticated, reliable, safe, computerised devices that deliver electric shocks to victims of cardiac arrest when the ECG rhythm is one that is likely to respond to a shock. Simplicity of operation is a key feature: controls are kept to a minimum, voice and visual prompts guide rescuers. Modern AEDs are suitable for use by both lay rescuers and healthcare professionals.

All AEDs analyse the victim's ECG rhythm and determine the need for a shock.

In the diving community AED's that are hyperbarically rated are being introduced. The depth rating of these devices are constantly being increased. Some companies modify the AED units to be operated externally and having the defib pads connect through a hull penetrator.

Hyperbaric A.E.D.

Operating An AED 3.1.4

General Things To Remember Before Using An AED:

- All AED's use a 1-2-3 operating system.
- Try to relax and stay calm.
- The AED automatically provides voice and text prompts to guide you through each step of its use.
- The defibrillator pads must have good contact with the patient's skin. The pads have a layer of sticky, conductive gel beneath the protective backing.
- It may be necessary to dry the patient's skin or to clip or shave excessive chest hair to provide good contact between the defibrillator pads and the patient's skin.

How To Use An AED

A.E.D. 1-2-3 Operating System

The Operation Of An AED Relies On A 3-Step Process:

- Step 1: Switch on the AED.
- Step 2: Attach pads & allow AED to detect cardiac rhythm.
- Step 3: Follow AED verbal / visual instructions. Deliver shock if it is advised.

Step 1 1

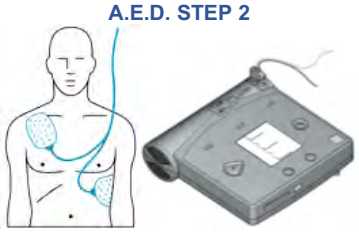
- Press the On/Off button to turn on the AED (this is always identified as **1**).

A.E.D. STEP 1

Step 2 (ECG analysis and CPR interval) 2

- Follow the instructions provided by the AED's voice and text prompts.
- Remove clothing from the patient's upper body. If needed, wipe moisture from the patient's skin and clip or shave excessive chest hair.
- Open the defibrillator pads package. Pull off the protective backing from pads.
- Place the sticky side of each pad on the patient's bare skin, exactly as shown on the drawing on each pad.
- Follow the instructions provided by the AED's voice and text prompts.
- As soon as the AED detects that the defibrillator pads are connected, it automatically begins analyzing the patient's heart rhythm.
- **Do not** touch the patient during rhythm analysis.
- If '**no shock**' is advised, the AED provides voice and text prompts to tell you to continue CPR for 2 minutes.
- After 2 minutes the AED provides voice and text prompts to tell you to discontinue CPR while it reanalyzes the ECG rhythm.

A.E.D. STEP 2

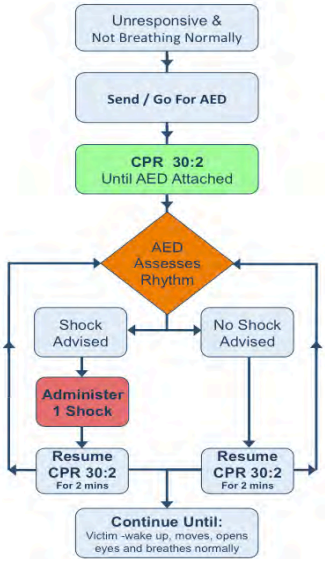


Step 3 **(Shock delivery)** 3

- Do Not touch the casualty while the AED is charging, it continues to analyze the patient's heart rhythm. If the rhythm changes and a shock is no longer appropriate, the AED disarms. Voice and text prompts advise you what action to take.
- There are four ways you can tell that an AED is ready to deliver a shock:
  - o You hear a voice prompt telling you to deliver a **Shock**.
  - o You see the **Shock** button flashing.
  - o You hear a steady tone.
  - o You see a text prompt telling you to press the (**Shock**) button. (Which is always marked with a **3**).
- Observe the vicinity & ensure nobody is touching the casualty or that they are not touching anything conductive.
- Remove O_2 from the casualty.
- Give loud verbal instructions:
  - o *'Oxygen away'*
  - o *'Everybody clear. Preparing to shock'*
  - o *'SHOCKING!'*
- Press the **Shock** button to deliver the shock. (Numbered **3**)
- After you press the Shock button, a voice prompt confirms that the shock was delivered.
- The AED provides voice and text prompts to tell you to continue CPR for 2 minutes. Discontinue this only if the casualty shows signs of life.

NOTE: If you do not press the Shock button within 30 seconds of being prompted, the AED will automatically disarm itself and provide a pause. It will resume analyzing heart rhythm after 30 seconds.

U.K. Resuscitation Council A.E.D. Algorithm



A.E.D. STEP 3

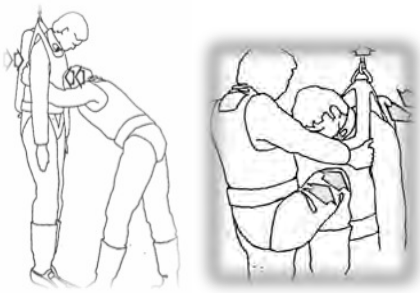
Diving Bell's and CPR 3.1.5

Rescue of a diver in difficulties while operating out of a diving bell presents some unique sets of circumstances, which have to be met by a combination of innovative techniques, specialised equipment and rigorous training.

Several techniques have evolved for in-bell CPR, usually involving the diver remaining in the hoist and resuscitated vertically. Modern bells have an increased amount of deck space, so it is possible to lie a casualty down (with their feet elevated up a bell wall) and conduct a more 'normal' resuscitation.

There are several critical points to remember whatever the technique advised for the particular bell that the DMT is using.

Diving Bell C.P.R. Techniques



These Are:

- Give external cardiac compressions with counter point pressure.
- Maintain an airway (O.P. or N.P. airway).
- If mouth-mask is impossible, administer BIBS O_2 at a high flow rate & conduct continuous compressions.
- Evacuate from depth as a priority.
- Notify the supervisor to have a hyperbaric capable AED locked in on arrival to the chamber.

Unfortunately there have been few reported successful resuscitations within a diving bell environment.

Recovery Position 3.1.6

An unconscious person cannot maintain their own airway; unconsciousness (unlike sleep) will disable many of the autonomic airway protective reflexes such as the 'gag reflex' and the 'cough reflex'.

Many fatalities occur where the original injury or illness which caused unconsciousness is not inherently fatal, but where the unconscious casualty then subsequently occludes their airway.

When an unconscious person is lying face upwards, there are two main risk factors which can lead to suffocation: Fluids, possibly blood but particularly vomit, can collect in the back of the throat, causing the person to asphyxiate. When a person is lying face up, the oesophagus tilts down slightly from the stomach toward the throat. This, combined with loss of muscular control, can lead to the stomach contents flowing into the throat, called *passive regurgitation*. Fluid, which collects in the back of the throat, can also flow down into the lungs; stomach acid can attack the inner lining of the lungs and cause aspiration pneumonia.

It is possible to achieve limited protection of the airway by repositioning the casualty.

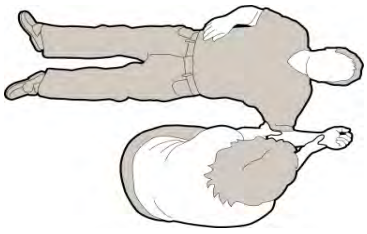
Recovery Position

There are several variations of the recovery position, each with its own advantages. No single position is perfect for all victims. The position should be stable, near a true lateral position with the head dependent, and with no pressure on the chest to impair breathing.

The Resuscitation Council (UK) recommends this sequence of actions to place a victim in the recovery position:

STEP 1

Remove the casualty's glasses and straighten both legs.
Move the arm nearest you outwards, elbow bent with palm uppermost.



STEP 2

Bring the far arm across the chest,
and hold the back of that hand against the cheek.

STEP 3

With your other hand, grasp the far leg just above the knee, and pull it up, keeping the foot on the ground.
Keeping the casualty's hand pressed against their cheek, pull on the leg to roll them towards you, onto their side.

STEP 4

Adjust the upper leg so that the hip and knee are bent at right angles and tilt the head back to keep the airway open.

- If you have to use the recovery position, try not to move any suspected injuries.
- If the victim has to be kept in the recovery position for **more than 30 min** turn him to the opposite side to relieve the pressure on the lower arm.
- Urgently call Duty Medic.

Vomiting 3.1.7 (A.T.O.M.F.C.)

It is common for a patient who has stopped breathing to vomit. This is a passive action in the unconscious person, so you may not hear or see it happening. You might not find out until you give a rescue breath (as the air comes back out of the patient it makes gurgling noises).

Proceed By:

- If the patient has vomited, turn them onto their side and allow the vomit to drain out.
- Use suctioning to 'clear' the airway.
- Hygiene during resuscitation:
  - Wipe the lips clean.
  - If possible use a protective barrier such as a 'face shield'. (Important if the casualty has any infectious disease such as TB, Hepatitis or S.A.R.S.).
  - Wear gloves if available and wash your hands afterwards.

Drain Vomit

Improvised Barrier

Choking 3.1.8 (A.T.O.M.F.C.)

Because recognition of choking (airway obstruction by a foreign body) is the key to successful outcome, it is important not to confuse this emergency with fainting, heart attack, seizure, or other conditions that may cause sudden respiratory distress or loss of consciousness.

Foreign bodies may cause either partial or complete airway obstruction.

These Include:

- Tongue (common if conscious level is severely reduced).
- Food (chicken bones, pips).
- Pen Tops.
- Secretions (blood, drool, water, vomit).

Presentation of Choking:

General Signs

- Attack occurs while eating.
- Victim may clutch his neck.

Signs Of Partial Airway Obstruction

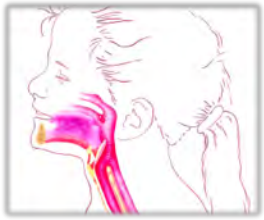
- Victim speaks and answers yes.
- Victim is able to speak, cough, and breathe.

Signs Of Severe (Complete) Airway Obstruction

Response to question 'Are you choking?'.

- Victim unable to speak / appears panicked.
- Victim is unable to breathe.
- Attempts at coughing are silent.
- Victim may be unconscious.

Partial Airway Obstruction



Severe Airway Obstruction

Management of Choking

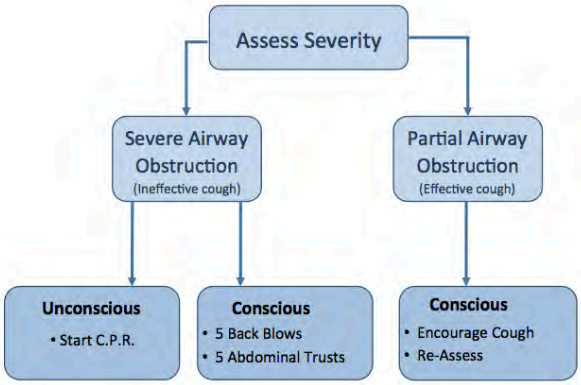
If The Victim Shows Signs Of Mild Airway Obstruction:

- Encourage him to continue coughing, but do nothing else.

Shows Signs Of Severe Airway Obstruction And Is Conscious:

- Give up to five back blows.
  - o Shout for help, but don't leave the patient yet.
  - o Bend the casualty forwards so the head is lower than the chest.
  - o Give up to 5 firm blows between the shoulder blades with the palm of your hand. Check between blows and stop if you clear the obstruction.

U.K.R.C. Choking Algorithm



If The Obstruction Is Still Not Cleared:

- Give up to 5 Abdominal thrusts.
- Stand behind the casualty. Place both your arms around their waist.
- Make a fist with one hand and place it just above the belly button (below the ribs) with your thumb inwards.
- Grasp this fist with your other hand, then pull sharply inwards and upwards.
  - o Do this up to 5 times. Check between thrusts and stop if you clear the obstruction.
- If the obstruction is still not cleared:
  - o Repeat steps 1 and 2
  - o Keep repeating steps 1 and 2.
- If the treatment seems ineffective, shout for help. Ask someone to call medical help, but don't interrupt the treatment whilst the patient is still conscious.

Abdominal Thrust
Hand Positions

Signs Of Severe Airway Obstruction And Is Unconscious:

- Support the casualty carefully to the ground.
- Start BLS
- Continue CPR until the victim starts breathing normally, or you become exhausted

After successful treatment, patients with a persistent cough, difficulty swallowing or with the feeling of an 'object still stuck in the throat' should also see a qualified medic.

AIRWAY / BREATHING DISORDERS 3.2

Compromised Airway / Breathing 3.2.1 (A.T.O.M.F.C.)

Death from a compromised airway is the most common cause of death in the acutely ill casualty, regardless of whether the cause is originally airway in origin.

The casualty who has severe shock will develop reduced cerebral perfusion, which will cause a reduction in conscious level (due to hypoxia), which will lead to loss of the normal protective reflexes (gag & cough) and eventually lead to respiratory arrest. Therefore the level of consciousness is intrinsically linked to airway loss & death.

The fully conscious, talking patient is able to maintain his own airway. However a patient's status may deteriorate at any time and they must constantly be reassessed.

Scaled Airway Interventions

Presentation of a Compromised Airway / Breathing

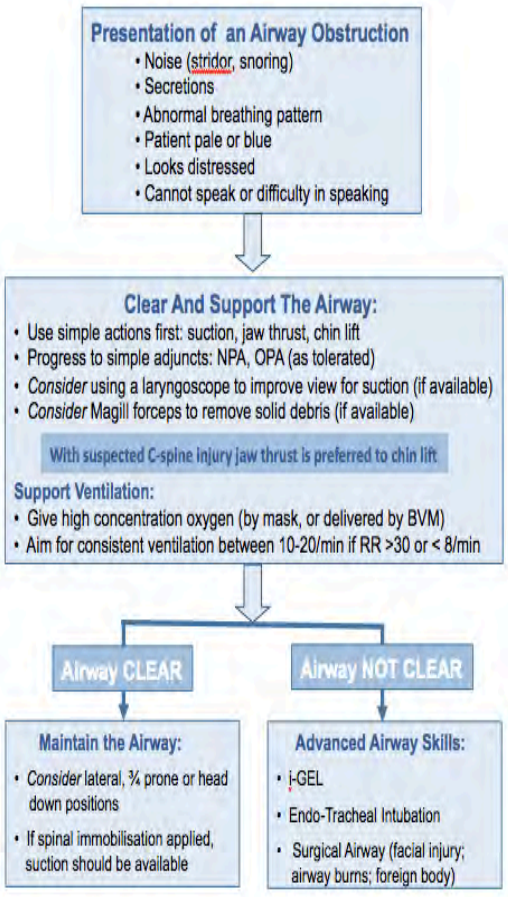
- Choking presentation.
- Airway Secretions (saliva, blood, vomit, odaema).
- Abnormal airway sounds: snoring / stridor / wheeze.

- Neck signs (T.W.E.L.V.E) : Deviated trachea / wounds / emphysema / disrupted larynx / engorged neck veins.
- Breathing (RISE – FALL): Abnormal rate / visible injuries (front & back) / asymmetrical movement / accessory muscle use / chest wall emphysema / hyper-hypo resonant / abnormal breath sounds: crackles–silence.
- Low SpO_2 on pulse-oximeter.
- Cyanosis.

Scaled Breathing Interventions

Management of a Compromised Airway / Breathing

- Conduct primary / secondary survey & record observations.
- Open airway manually & inspect.
  - o Heat tilt / chin lift / Jaw thrust.Recovery position.
- Observe for & clear obstructions.
  - o Suction of secretions / vomitus.
  - o Treat for choking.
  - o Manually clear obstructions with magills forceps.
- Insert simple airway ajunct as tolerated:
  - o Oro-pharangeal airway / Naso-pharangeal airway.
- Use an advanced airway Manoeuvre as indicated.
  - o I-GEL supraglotal airway (Refer to duty medic if sedation required).
  - o Endo-Tracheal Intubation (Refer to duty medic if sedation required).
  - o Surgical Airway (by qualified medical personnel).
- Give High Flow O_2 (or high partial pressure via BIBS)
  - o Via BIBS / NonRebreather mask if Resp Rate >9 or < 40 (BPM).
  - o Sit casualty in an upright position to promote lung expansion.
- Ventilate casualty with a B.M.V. (Connected to high flow O_2)
  - o If resp rate is ≤ 8 or ≥ 40 (BPM).
- Treat cause of airway / breathing compromise.
- Continue to reassess regularly….DO NOT leave a casualty with a compromised airway.
- Prepare to evacuate (as per company S.O.P's).



The Casualties Who Require A Secured (E.T.-Tube / I-GEL) Airway Include:

- Airway injuries:
  - o Neck injuries / unstable mid-face / jaw trauma.
  - o Anaphalaxis.
  - o Signs of inhalation injury / burns (E.T. tube).
- Gross breathing defects:
  - o Apnoea (not breathing / resp rate < 8 BPM).
  - o Large flail segment or respiratory failure.
- Multi-trauma / gross cardiovascular injuries.
- Neurological impairment:
  - o Glasgow Coma Scale <8 / A or U on AVPU scale.
  - o Traumatic brain injuries.
  - o Sustained seizure activity.
  - o High aspiration risk.
- In preparation for aeromedical transfer.

Asthma 3.2.2 (A.T.O.M.F.C.)

Asthma is a condition caused by an immune reaction in the lungs, often in response to substances such as dust, traffic fumes, or pollen. Muscles surrounding the bronchioles go into spasm and constrict, making it very difficult for the patient to breathe.

Most asthma sufferers carry an inhaler, usually a blue inhaler for relieving an attack, which dilates the bronchioles to relieve the condition.

An asthma attack is a traumatic and potentially life-threatening experience for the casualty.

Presentation of Asthma:

- History of previous asthma attacks.
- Abnormal airway sounds: **wheeze.**
- Breathing (RISE – FALL): **Rapid rate** / no visible injuries (front & back) / symmetrical movement / **gross accessory muscle use** / no emphysema / **hypo-resonant** / abnormal breath sounds: **wheeze / absent.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Low SpO_2 on pulse-oximeter.
- Rapid pulse rate (tachycardia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).

Inhaler Therapy

- Casualty will become exhausted in a severe attack.
- May become unconscious and stop breathing in a prolonged attack.

Management of Asthmatic Attack:

- Identify and remove the cause of the asthmatic attack.
- Alert medical personnel / supervisor.
- Conduct primary / secondary survey & record observations.
- Help the casualty to sit upright, leaning on a table or chair if necessary.
- Help the casualty to use their prescribed inhaler. (This can be repeated every few minutes if the attack does not ease).
- Implement compromised airway / breathing management (O^2 Therapy).
- Be calm & reassuring.
- If the attack is prolonged or worsening send for medic & resuscitation equipment.
- Implement shock treatment if condition worsening (Insert wide bore I.V. cannulas).
- Keep the casualty upright - even if they become too weak to sit up on their own.
  - Only lay an asthma attack patient down if they become unconscious.
- Be prepared to carry out resuscitation.

Volumatic

Hyperventilation 3.2.3

'Hyperventilation' means 'excessive breathing'. Hyperventilating reduces the carbon dioxide level in the blood, which can produce a dangerous alkalosis.

Hyperventilation often result from gross anxiety or 'panic attack'. Hyperventilation is often mistaken for asthma. The difference in the two conditions is the large volumes of air that can be heard entering the lungs of the hyperventilating patient, compared with the tight wheeze of the asthmatic.

Presentation of Hyperventilation

- Attention seeking behaviour. Feeling of a 'tight' chest / inability to breathe.
- Breathing (RISE – FALL): **Rapid rate** / no visible injuries (front & back) / symmetrical movement / **gross accessory muscle use** / no emphysema / normal resonance / normal breath sounds
- Flushed skin, no cyanosis.
- Pins and needles / cramps in hands & feet.
- **Normal** SpO_2 on pulse-oximeter.
- If the attack is prolonged, the casualty may pass out and stop breathing for up to 30 second.

"The contrasting difference between asthma & hyperventilation is the large volume of air that can be heard entering the lungs of the hyperventilating patient, compared to the tight wheeze of the asthmatic."

Management of Hyperventilation

- Conduct primary / secondary survey & record observations.
- Be firm and calm, but reassuring with the casualty.
- Explain to the casualty that they are hyperventilating.
- 'Coach' the casualty's breathing.
- Get them to breath SLOWLY & DEEPLY into a paper bag for no more than 5 minutes. (This normalizes the CO_2 levels)
- Call for medical advice if the attack is prolonged or you are in doubt.

Drowning 3.2.4 (A.T.O.M.F.C.)

There are two recognised types of drowning: Drowned and Near Drowned. A fluidic substance has asphyxiated a Drowned casualty and a Near Drowned casualty has been partially asphyxiated.

A casualty who drowns does not usually inhale large amounts of water into the lungs. 90% of deaths from drowning are caused by a relatively small amount of fluid entering the lungs, interfering with oxygen exchange in the alveoli. The other 10% are caused by muscle spasm near the epiglottis and larynx blocking the airway.

Drowned Victim

The casualty will usually ingest large amounts of water, which might then be vomited as they are rescued or resuscitation takes place.

Other factors may contribute to the cause of drowning, such as: hypothermia, an underlying medical condition such as epilepsy or heart attack.

Historically the term 'secondary drowning' has been used to describe a delayed respiratory reaction in the near-drowned victim. This is actually attributed to Acute Respiratory Distress Syndrome.

Drowning and Diving

The diving reflex is a primitive reflex, (attributed to a "mammalian reflex" found in seals and lower mammals) which causes a sharp drop in the heart rate when the body is suddenly immersed in cold water. Peripheral blood vessels

constrict, reducing blood flow to the body surface and extremities.

In addition to these oxygen conservation effects, the breath-holding period is extended by about 15%. This is probably due to a depression of the body's sensitivity to the CO_2 levels, which normally stimulate the breathing reflex.

The diver has a further advantage in that he is breathing a higher than usual PPO_2 and his tissues will be carrying more oxygen.

Temperature Of The Water:

Under normal conditions brain damage would occur within 3 to 5 minutes. In cold water drowning, however, the effects of cold and the diving reflex reduce the brain's oxygen requirements considerably.

The rapid development of hypothermia can serve a protective function, particularly regarding brain viability in patients with prolonged submersion.
The survival of a child submerged for 66 minutes in a creek with a water temperature of 5° C is the longest documented submersion with good neurological outcome.'
Hypothermia, which is organ protective, also contributes to neurological recovery after prolonged submersion, probably by decreasing the metabolic needs of the brain. Coldwater submersion may induce severe cardiac dysrhythmias.

Duration Of Submersion:

The longer the duration of submersion, the less likely the patient is to survive. When rescue operations have been in progress for more than 30 minutes, victims retrieved from warm water in summer months or in warm southern waters usually are considered nonviable. Because cold-water submersion for up to 60 minutes has been associated with neurological recovery, most patients rescued from cold-water drowning should receive resuscitative life-support measures. Resuscitation is indicated unless there is physical evidence of death (e.g., putrefaction and rigor mortis).

Cleanliness Of The Water:

Contaminants in water have an irritant effect on the pulmonary system, leading to bronchospasm and an increased tendency toward poor gas exchange. They also can cause a secondary pulmonary infection with delayed severe respiratory compromise.

Presentation of Drowning

- Coughing.
- Panic / exhaustion.
- Abdominal swelling (It is common to gulp water, which will increase the chance of vomiting)
- Hypothermia / bluish skin.
- Spitting up water or fluid that is usually pink or frothy.
- Unconsciousness. (The majority of drowning victims are actually discovered 'lifeless' in the water).
- Absence of breathing.

Management of Drowning

Avoid Getting Into Water

- Avoid getting into the water. 'Reach or throw - don't GO'.
- Alert Medical personnel / supervisor.
- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
- Attempt to drain water if inhaled (Suction, inclined recovery position).
- Monitor for & treat any hypothermia.
- Continually assess casualty.
  - o Be prepared to initiate ARDS treatment.
- Assess for & treat shock.
- Prepare to evacuate / treat in medical facility.

Acute Respiratory Distress Syndrome (ARDS) 3.2.5 (A.T.O.M.F.C.)

ARDS may be caused by direct or indirect lung injury.
It is characterised by acute pulmonary changes such as destruction of surfactant-producing alveolar cells, alveolar collapse and destruction, and destruction of pulmonary capillaries. The permeability of the capillaries increases with massive flooding of the alveoli and bronchi with fluid. The resulting pulmonary oedema creates areas of hypoventilation, shunting, and severe hypoxemia.
The massive fluid shift from the intravascular compartment to the lungs may produce hypovolemia.

Lung Damage Follows A Typical Pattern:

- Inflammation of the lung.
- Damage to the surfactant.
- Impaired gas exchange. (VQ Mismatch).

- Systemic release of inflammatory mediators.
- Further inflammation & reduced gas exchange (++VQ Mismatch).
- Pulmonary oedema.
- Hypoxia.
- Multiple Organ Failure (MOF).

Direct Lung Injury Causes of ARDS:

- Near drowning (when surfactant washed away, much worse in polluted water).
- Aspiration of vomit (highly acidic vomit can cause rapid inflammatory alveolar changes).
- Toxic gas inhalation (Any caustic gas, however Pulmonary Oxygen Toxicity is essentially ARDS).
- Pulmonary infection. (localised & systemic release of inflammatory mediators causing alveolar damage).

Indirect Lung Injury Causes of ARDS:

- Severe sepsis (A Systemic Inflammatory Response (SIR's) will inflame pulmonary circulation resulting in VQ mismatch & MOF).
- Major trauma (trauma initiate a massive SIR's response).
- Reperfusion injury (common in crush injuries / release of a tourniquet. SIR's response caused by release of necrotic tissue).

Presentation of ARDS:

- Insidious onset over 12-24 hrs.
- Abnormal airway sounds: **wheeze.**
- Neck Signs: **Distended neck veins.**
- Breathing (RISE – FALL): **Rapid rate** / no visible injuries (front & back) / symmetrical movement / **gross accessory muscle use** / no emphysema / **hypo-resonant** / abnormal breath sounds: **wheeze / global creps / absent.**
- Pink frothy sputum (pulmonary odeama).

Low SpO_2 on pulse-oximeter.

- Rapid pulse rate (tachycardia).
- Non-palpable radial pulse (Reduced blood pressure).
- Reduced conscious level (cerebral hypoxia / toxemia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).

Management of ARDS:

- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
  - Positive pressure ventilation with high PEEP is common.
  - NIPPV can be used in short term. (Non-Invasive Positive Pressure Ventilation).
  - Bronchial toilet may be clinically indicated (Via E.T. tube).
- Assess for & treat shock. (Always Insert an I.V. cannula, give I.V. fluid as instructed).
- Continually assess casualty.
- Alert medical personnel / supervisor & prepare to evacuate (as per company SOP's).

Open Pneumothorax 3.2.6 (A.T.O.M.F.C.)

Two layers of membrane called the 'pleura' surround each lung. Between these two membranes is the 'pleural cavity', containing a thin layer of 'serous fluid', this allows the layers to move against each other as we breathe.

If the chest is injured, the inner layer of the pleura could become perforated and the alveolar of the lung damaged. Air may then be drawn from the lung into the pleural cavity (Pneumothorax), causing the lung to collapse.

Pneumothorax

There Are Two Types Of Pneumothorax:

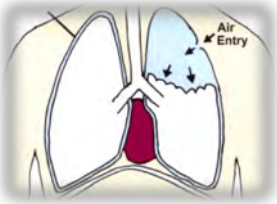
- Open Pneumothorax (the outer layer of the pleura is damaged, air can be sucked from outside of the chest into the pleural cavity).
- Closed Pneumothorax (The alveolar are ruptured & air escapes into the pleural layer, common in barotrauma or blast injuries). **See Diving Medicine Section For Management Of A Closed Pneumothorax.**

Open Pneumothorax

An open pneumothorax is a traumatic penetrating thoracic injury. If the hole in the chest is less than $^2/_3$ the size of the trachea air will selectively enter the chest through the normal means (airway-lungs), however if the hole is larger than this (above the size of a 50p piece) then air will be sucked into the pleural cavity. This is commonly referred to as a 'Sucking Chest Wound'

If air continues to be sucked into the pleural cavity, pressure in the collapsed lung can build *(tension pneumothorax)*. This pressure build up can squeeze the heart, the major veins returning to the heart and the uninjured lung.

Sucking Chest Wound

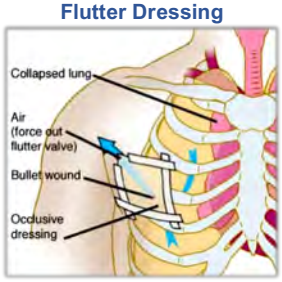


Presentation of an Open Pneumothorax

- Abnormal airway signs: **Distress / wheeze.**

- Neck Signs: Trachea deviation (late sign) / possible Wounds / distended **neck Veins / Emphysema present / L**arynx intact.
- Breathing (RISE – FALL): **rapid Rate** / **visible Injuries** (front & back) **bubbling & sucking** / **aSymmetrical movement** / **gross Effort & accessory muscle use** / **Feel emphysema / hyper-resonant on affected side** / breath sounds: **absent on affected side.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Painful breathing / complain of chest pain.
- Sound of air being drawn into the wound, with bubbling blood.
- Rapid pulse rate (tachycardia).
- Non-palpable radial pulse (Reduced blood pressure).
- Reduced conscious level (cerebral hypoxia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).

Flutter Dressing



Management of an Open Pneumothorax

- Immediately cover a sucking chest wound with your hand *(or the casualty's hand if they are conscious)* to prevent air entry.
- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
- Alert Medical personnel / supervisor & prepare to evacuate.
- Treat wound.
  - o Use an Ashermans Chest Seal dressing if available. If not:
  - o Use an improvised open pneumothorax flutter dressing.
- Assess for tension pneumothorax & implement treatment if present.
- Treat Shock. (Always Insert an I.V. cannula, give I.V. fluid as instructed).
- Continually assess casualty.
- If casualty is in a hyperbaric environment be aware that a pneumothorax can evolve into a tension pneumothorax on ascent.

Asherman's Chest Seal

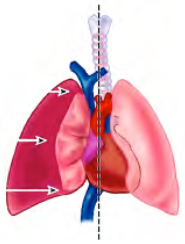
Tension Pneumothorax 3.2.7 (A.T.O.M.F.C.)

A tension pneumothorax is the progressive build-up of air within the pleural space, usually due to a lung laceration (due to an external penetrating injury or internal alveolar rupture), which allows air to escape into the pleural space but not to return.

Positive pressure ventilation may exacerbate this 'one-way-valve' effect. Progressive build-up of pressure in the pleural space pushes the mediastinum to the opposite hemi-thorax, and obstructs venous return to the heart. This leads to circulatory instability and may result in traumatic cardiac arrest.

A tension pneumothorax is possible after physical trauma to the chest, blast injury or as over expansion barotraumas whilst diving.

Tension Pneumothorax



Presentation of Tension Pneumothorax

- Abnormal airway signs: **Distress / wheeze.**
- Neck Signs: Trachea deviation (late sign) / possible Wounds / distended **neck Veins / Emphysema present / L**arynx intact.
- Breathing (RISE – FALL): **rapid Rate** / possible **visible Injuries** (front & back) / **aSymmetrical movement** / **gross Effort & accessory muscle use** / **Feel emphysema - hyper-resonant on affected side** / breath sounds: **absent on affected side.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Painful breathing / complain of chest pain.
- Low SpO_2 on pulse-oximeter.
- Rapid pulse rate (tachycardia).
- Non-palpable radial pulse (Reduced blood pressure).
- Reduced conscious level (cerebral hypoxia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).

Needle Decompression

Management of Tension Pneumothorax

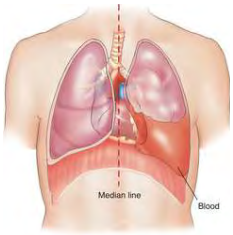
- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
- Alert Medical personnel & prepare to evacuate (as per company SOP's).
- Treat Shock. (Always Insert an I.V. cannula, give I.V. fluid as instructed).
- Perform a needle thoracocentesis on the affected side & monitor effect.
  - o Attach a Heimlich valve & monitor.
  - o Casualty will require a formal chest drain inserted by qualified personnel.
- Continually assess casualty.
- Manage any wounds.
- If casualty is in a hyperbaric environment be aware that a tension pneumothorax can worsen and become a cardiac tamponade even on ascent.

Massive Haemothorax 3.2.8 (A.T.O.M.F.C.)

A haemothorax is a condition that results from blood accumulating in the pleural cavity. This is usually due to a penetrating wound disrupting the systemic or pulmonary vessels.

Each hemi-thorax can hold up to 2·5 litres of blood, well enough to induce category IV shock & probably fatal.

Presentation Of A Massive Haemothorax



Left Haemothorax

- Abnormal airway signs: **Distress / wheeze.**
- Neck Signs: Trachea central / possible Wounds / distended **neck Veins /** no **E**mphysema **/ L**arynx intact.
- Breathing (RISE – FALL): **rapid Rate** / possible **visible Injuries** (front & back) / **aSymmetrical movement** / **gross Effort & accessory muscle use** / **Feel hypo-resonant on affected side** / breath sounds: **absent on affected side.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Painful breathing / complain of chest pain.
- Low SpO_2 on pulse-oximeter.
- Rapid pulse rate (tachycardia).
- Non-palpable radial pulse (Reduced blood pressure).
- Reduced conscious level (cerebral hypoxia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).
- Hypovolaemic Shock.


Haemothorax Drainage

Management Of A Massive Haemothorax

- Conduct primary / secondary survey & record observations.
- Alert Medical personnel / supervisor.
- Implement compromised airway / breathing management.
- Treat Shock. (Always Insert an I.V. cannula, give I.V. fluid as instructed).
- Implement haemorrhage management.
- Casualty will require a formal chest drain inserted by qualified personnel as a matter of URGENCY.
- Continually assess casualty.
- Prepare to evacuate (As per company SOP's).

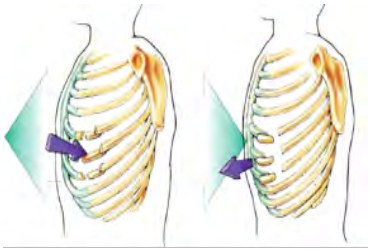
Flail Chest 3.2.9 (A.T.O.M.F.C.)

This is a condition where the ribs surrounding the chest have become fractured in several places, creating a 'floating' section of the chest wall.

As the casualty breathes, the rest of the chest wall moves out, but the flail segment moves inwards. As the chest wall moves back in, the flail segment moves outwards.
These are called 'paradoxical' chest movements.

Presentation of Sucking Flail Chest

- Abnormal airway signs: **Distress.**
- Neck Signs: Trachea central / possible Wounds / distended **neck Veins / Possible Emphysema / L**arynx intact.
- Breathing (RISE – FALL): **rapid Rate** / possible **visible Injuries** (front & back) / **aSymmetrical PARADOXICAL movement on affected side** / **gross Effort & accessory muscle use** / **Feel hypo-resonant on affected side** / breath sounds: **creps on affected side.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Painful breathing / complain of chest pain.
- Low SpO_2 on pulse-oximeter.
- Rapid pulse rate (tachycardia).
- Non-palpable radial pulse (Reduced blood pressure).
- Reduced conscious level (cerebral hypoxia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).
- Signs and symptoms of a fracture (see musculo-skeletal injuries).


Flail Chest

Management of Sucking Flail Chest

- Alert Medical personnel / supervisor & prepare to evacuate.
- Conduct primary / secondary survey & record observations.
- Place the casualty in the position they find most comfortable - sat up, inclined towards the injury if possible.
- Place large amounts of padding over the flail area.
- Implement compromised airway / breathing management.
- Monitor for & treat a tension pnemothorax if present.
- Treat Shock. (Insert an I.V. cannulas & give iv fluid as instructed).
- Place the arm on the injured side in an elevated sling. Squeeze the arm gently against the padding to provide gentle, firm support to the injury.


Flail Chest Management

CIRCULATION DISORDERS 3.3

Shock 3.3.1

The medical term shock is defined as 'inadequate tissue perfusion, caused by a fall in blood pressure or blood volume.

'Inadequate tissue perfusion' means an inadequate supply of oxygenated blood to body tissue.
It is **always** serious and can quickly result in death if not treated.

Normal System

The Common Types Of 'Life Threatening' Shock Are:

- Hypovolaemic Shock.
- Cardiogenic Shock.
- Septic Shock.
- Neurogenic Shock.
- Anaphylactic Shock.

For Practical Purposes All Types Of Shock Can Be Split Into 3 Areas:

- The Heart.
- The Vascular System.
- The Circulating Fluid / Blood.

Generic Presentation of Shock:

Compensation phase (depending on the fitness of a casualty, they will increase their vascular tone & intravascular load through the production of adrenaline, nor-adrenaline, aldosterone)

- Tachypnea (fast respiratory rate).
- Sweating (Often Cold & Clammy).
- Tachycardia of 120-130 beats per minute.

De-compensation phase (The casualty had depleted there 'vascular reserves' & can no longer compensate)

- Fast, shallow breathing.
- Rapid, weak pulse.
  - Non–Palpable radial pulse.
  - Will lose femoral pulse in Cat IV Shock.
- Elongated CRT.
- Confusion, anxiety, even aggression.

End Phase (Cerebral hypoxia due to reduced perfusion):

- Deep, sighing breathing (air hunger).
- Unconsciousness. (With AIRWAY compromisation)

Shock Category	Category I Compensated	Category II Compensated	Category III De-compensated	Category IV De-compensated
Airway	Patent	Patent	Compromised	Collapsed
Breathing	Normal (12 B.P.M)	Raised (14-16 B.P.M.)	Rapid (> 20 B.P.M.)	Air Hunger (> 45 B.P.M.)
Circulation	Pulse Rate: Normal	Pulse Rate: Normal	Pulse Rate: Rapid	Pulse Rate: Undetectable
	Radial Pulse: Normal	Radial Pulse: Palpable	Radial Pulse: Absent	Radial Pulse: Absent
	C.R.T.: 2 seconds	C.R.T.: 2-4 seconds	C.R.T.: 5 seconds	C.R.T.: Absent
Disability Conscious Level	Alert	Alert	Voice / Pain	Pain / Unresponsive
Exposure Skin	Normal	Pale	Pale / Blue	Blue / Cold

Shock Classification:

The progression through the Compensated to end stage de-compensated shock is commonly classified from grade I to grade IV. It is a useful tool in the pre-hospital situation & a great predictor of eventual patient outcome.

Grade IV shock is often associated with imminent death.

Vascular Access & I.V. Fluids

Generic Management of Shock

- Alert Medical personnel / supervisor & prepare to evacuate.
- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
- Identify & deal with injury or causes of shock.
- Insert I.V. cannula and administer I.V. fluid as instructed (250 ml bolus & assess effects, at least 2 ≥ 18g canulla's).
  - In severe shock (Category III & IV) Intra-osseous cannulation is often necessary.
- Lay the casualty flat with legs elevated (*Caution... For no more than 10 mins).**
- Continually assess casualty.
- Implement the management of the unconscious casualty.
- Consider urethral catheterization. **

Elevate Legs (For Short Periods)

*The biological response to shock is to increase peripheral resistance and cardiac output by increasing the contractility of the heart, heart rate, and arterial vasoconstriction, which results in an increased blood pressure. This response is called a 'baroreflex'.
Legs elevation increases the amount of vital circulating volume to the vital organs (by as much as 1.5 litres). However if a casualty's legs are elevated it can interfere with this normal 'baroreflex' response. Therefore it is essential that this is a short term measure.

** Urine output can be an excellent indicator of organ perfusion. Normal output is ½ ml per kg per hr (at least 30ml / hr).

Hypovolaemic Shock 3.3.2

Hypovolaemic (hypo=low + volaemic = volume)

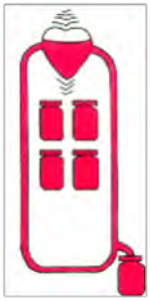
This type of shock is caused by sudden loss of blood volume. Without the required volume of blood, the heart cannot pump enough blood to make up for the blood loss and organs begin to fail.

Water makes up 55% of blood. If the body becomes dehydrated because water is lost or fluid intake is inadequate, the body tries to maintain cardiac output by making the heartbeat faster. But as the fluid losses mount, the body's compensation mechanisms fail, and shock will occur.

Typical Causes Of Hypovolaemic Shock Are:

- External / external bleeding.
- Burns.
- Heat illness.
- Vomiting and diarrhoea (loss of body fluids).

Fluid / Blood Loss



Presentation of Hypovolaemic Shock:

- All elements of Generic Shock Symptoms.
  - Appearance: Cold, pale, clammy (cold sweat).
- Fluid loss (blood, sweating, vomit, diarrhea, burns).
- Acute Thirst.

Management of Hypovolaemic Shock

- Implement generic shock measures.
- Search for site of fluid loss & implement control measures.
  - Haemorrhage control.
  - Heat illness treatment.
  - Burns management.
  - D&V management.

Control Bleeding

Cardiogenic Shock 3.3.3

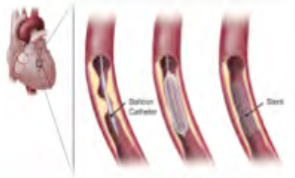
Cardiogenic shock occurs when the heart becomes damaged, from a heart attack for example. In a weakened state the heart is unable to pump the blood effectively and supply to the body's tissues.

Typical Causes Of Cardiogenic Shock Are:

- Cardiac disease.
  - Myocardial infarction (heart attack).
  - Cardiomyopathy.
  - Arrhythmia.
  - Valve Disease.
- Trauma
  - Pericardial Tamponade.
  - Rupturing of the Heart.
- Pulmonary Embolism (including Arterial Gas Embolism).

Weak **Heart**

Cardiac Angioplasty



Presentation of Cardiogenic Shock:

- All elements of Generic Shock Symptoms.
  - Appearance: Cold, pale, clammy (cold sweat). Exceptionally cold limbs.
- Clinical signs of underlying cause (chest pain, palpitations, chest trauma).
- Distended jugular veins.
- Pulmonary oedema (involving fluid back-up in the lungs due to insufficient pumping of the heart).

Hyperbaric Therapy For A.G.E

Management of Cardiogenic Shock

- Implement generic shock measures.
- Search for and treat underlying cause (angina management, surgery, hyperbaric therapy).
- Give IV fluid **CAREFULLY** (it is easy to increase pulmonary odeama with rapid IV fluid).

Septic Shock (Septicaemia) 3.3.4

Septic shock occurs when bacteria in the body multiply to unsafe levels and begin releasing toxins into the blood stream. This can result from bacterial infections like pneumonia and meningitis.

The immunological response to the bacterium causes dilation of the blood vessels & the hyperthermic reaction caused severe fluid depletion through perspiration and leakage of blood plasma from the intravascular system to the extra.

It can cause multiple organ failure. The mortality rate from septic shock is approximately 50%

Causes Of Septic Shock Are:

- Overwhelming bacteriamia (including meningitis, wound infections, bowel perforation & pneumonia).

- Hypovolaemic shock (reduced gut perfusions causes bowel bacteria to 'translocate' to the vascular system).
- Major Trauma (Also called 'cold sepsis', massive inflammatory mediator release in response to large injuries).
- Re-perfusion (if a tourniquet or crushed limb is released, an endotoxin load can be dumped into the circulation).

Vascular inflammation & Fluid Loss

Presentation of Septic Shock:

- All elements of Generic Shock Symptoms.
  - o Appearance: Warm, flushed, clammy (hot sweat). Possible cold extremities.
- Rapid 'Bounding' pulse (due to vascular dilation).
- Signs of Infection (sputum, discharge, inflammation).
- High temperature > 37.6°C (The higher the temperature, the more serious > 38.5°C = serious).

Antibiotics

Paracetamol / Ibuprofen

Later Signs

- Fall in body temperature below the normal level of 36°C
- Loss of peripheral pulse.
- Skin becomes cool and mottled (blotchy).
- Severe Odeama (due to 3rd spacing of intravascular fluid, it 'shifts' to the extracellular space).
- Severe Confusion (due to cerebral hypoxia / toxemia).
- Reduced conscious level.

Management of Septic Shock:

- Implement generic shock measures.
- Search for and treat underlying cause (antibiotic therapy, surgical intervention).
- Give IV fluid **CAREFULLY** (it is easy to increase pulmonary odeama with rapid IV fluid replacement, but septic casualties often require large fluid resuscitations. It is for this reason that early E.T. intubation is common).
- Give medication as prescribed (anti-pyretical agents: paracetamol / ibuprofen. Antibiotics: often IV. Hydrocortisone I.V.).
- Fever management / cooling.

Neurogenic Shock 3.3.5 (Spinal Shock)

Neurogenic shock (or Spinal Shock) can result from severe central nervous system damage (brain injury, cervical or high thoracic spinal cord). This is a very important shock variant for the DMT due to the risk of a **spinal DCI.**

The trauma causes a sudden loss of the sympathetic nervous stimulation to the blood vessels. This causes them to relax (vasodilation) resulting in a sudden decrease in blood pressure (secondary to a decrease in peripheral vascular resistance).

It commonly results in low blood pressure, heat loss and warm, dry skin. Hypothermia may also occur after neurogenic shock because the body loses its ability to adequately siphon blood from the extremities back to the core & a rapid peripheral cooling of the blood.

Typical Causes Of Neurogenic Shock Are:

- Direct spinal trauma.
- Indirect spinal trauma.
- Spinal space occupying lesion (tumour, gas embolism, infection).

Dilated System

Presentation of Neurogenic Shock:

- All elements of Generic Shock Symptoms.
  - o Appearance: Warm, dry, flushed skin.
- Bounding pulse (Peripheral vasodilation).
- Venous pooling (blood collecting in the veins of the lower extremities).
- Poikilothermia (body temperature that varies with the temperature of its surrounding).
- Priapism (Permanent penile erection).

PASG Trauma Trousers

Management of Neurogenic Shock:

- Implement generic shock measures.
- Search for and treat underlying cause (immobilisation, hyperbaric therapy).
- Give IV fluid replacement (casualties often require large fluid resuscitations).
- Avoid removing tight constrictive clothing.
- Elevate legs (for 10-minute intervals. Avoid if spinal fracture suspected).
- Pneumatic anti-shock garments (PASG) or 'trauma trousers' have proved useful (by pushing 3rd spaced fluid back into the central circulation).

Anaphylactic Shock 3.3.6 (Allergic Reaction) (A.T.O.M.F.C.)

Anaphylaxis is an extremely dangerous allergic reaction. The name 'anaphylaxis' means 'without protection' and indeed, the condition is caused by a massive over-reaction of the body's protection (immune) system.

When the body detects a foreign element, the autoimmune system releases anti-inflammatory anti-histamines to suppress the invader. However in the casualty with anaphylaxis, both anti-histamine & histamine (in massive amounts) are released. Histamine is a powerful 'pro-inflammatory' mediator, which will commence a cascade of adverse reaction.

Severe anaphylactic reactions are very rare and affect only a small percentage of the population. Essentially the body turns on itself. An anaphylactic casualty will actually initiate this response on the 'second' encounter with the foreign body (their immune system will identify the agent & create an antibody to initiate its response the 'next' time it encounters it).

Dilated Vasculature
Fluid Loss &
Weakened Heart

Histamine Has Several Effects When It Is Released In Mass-Quantities:

- Gross inflammation makes blood capillary walls 'leaky' (Causing a fall in blood volume).
  - It makes blood vessels dilate (causing a fall in blood pressure).
- It constricts the bronchioles in the lungs (due to alveolar arteriole dilation).
- It weakens the strength of the heart's contractions (causing a fall in cardiac output).
- It makes the skin come out in a rash (due to the pro-inflammatory mediators in the circulation).

The Causes Of Anaphylaxis

Anaphylaxis Rash

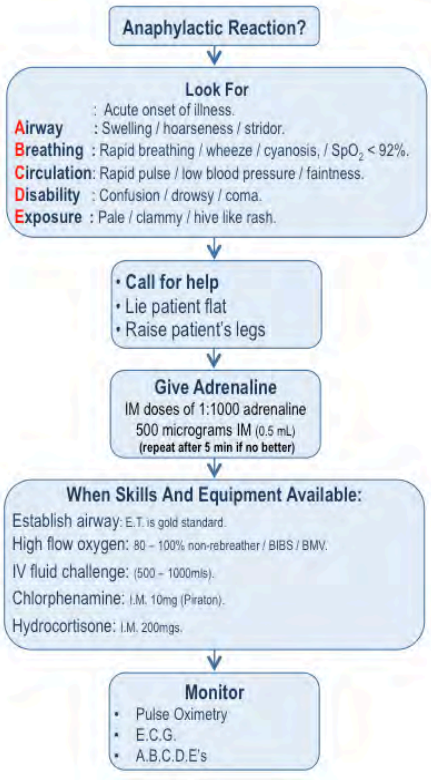
Typical Causes Of Anaphylactic Shock Are:

- Reactions to drugs (such as penicillin).
- Insect stings / venom.
- Foods (peanuts / seafood / preservatives).
- Pollen.
- Latex.
- Animal fur.

Presentation of Anaphylactic Shock:

- All elements of Generic Shock Symptoms.
  - Appearance: Itchy skin with red, blotchy / hot hives over chest-neck. Clammy pale extremities.
- Airway Signs: swelling of tongue, lips & face.
- Abnormal airway sounds: inspiratory / expiratory **wheeze.**
- Neck Signs: Trachea central / no Wounds / distended **neck Veins /** no **E**mphysema **/** Larynx swollen.
- Breathing (RISE – FALL): **Rapid rate** / no visible injuries (front & back) / symmetrical movement / **gross accessory muscle use** / no emphysema / **hypo-resonant** / abnormal breath sounds: **wheeze / absent.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Low SpO_2 on pulse-oximeter.
- Bounding pulse (Peripheral vasodilation).
  - Radial pulse will quickly be lost (as venous pooling / 3rd spacing occurs).
- Reduced conscious level (due to cerebral hypoxia / toxemia).

U.K.R.C. Adult Anaphylactic Algorithm



Management of Anaphylactic Shock:

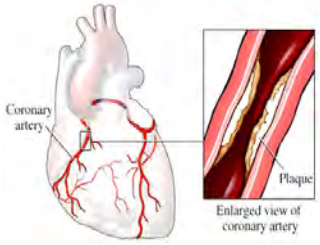
- Implement generic shock measures.
- Search for and remove underlying cause (food, drug, animal).
- Alert medical personnel / supervisor highlight the presence of anaphylaxis & its **urgency.**
- Implement compromised airway / breathing management (O^2 Therapy).
- Be calm & reassuring.
- If the attack is prolonged or worsening resuscitation equipment.
- Implement the UKRC treatment algorithm.
  - Give I.M. Adrenaline (1:1000 - 500 mcg's / 0.5ml). **Repeat** after 5minutes if no improvement.
  - Give IV fluid (500 – 1000mls).
  - Give I.M. Chlorphenamine 10mg (Piraton).
  - Give I.M. Hydrocortisone 200mgs.
- Continually monitor casualty.

Coronary Artery Disease 3.3.7

Angina (angina pectoris) caused by the build up of a cholesterol plaque on the lining of the coronary arteries. Cholesterol is a fatty chemical, which is part of the outer lining of cells in the body. A cholesterol plaque is a hard, thick substance caused by deposits of cholesterol on the artery wall. Over time, the build-up of the plaque can cause narrowing and hardening of the artery.

During exercise, the heart requires more oxygen, but the narrowed coronary artery cannot increase the blood supply to meet this demand. As a result an area of the heart will suffer from a lack of oxygen. The patient will feel pain in the chest (amongst other symptoms) as a result.

Angina / Unstable Angina



Acute Coronary Syndrome Can Be Divided Into 3 Types:

Angina

Typically, an angina attack occurs with exertion, and subsides with rest.

Unstable Angina

If the narrowing of the artery reaches a critical level, angina at rest (called 'unstable angina') may result. There is a high risk of suffering a heart attack.

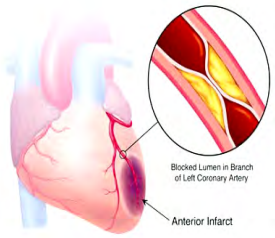
Myocardial Infarction (Heart Attack)

A heart attack (myocardial infarction) is often caused when the surface of a cholesterol plaque in a coronary artery cracks and has a 'rough surface'. This can lead to the formation of a blood clot on the plaque, which completely blocks the artery resulting in the death of an area of the heart muscle.

Unlike angina, the death of the heart muscle from heart attack is permanent and will not relieved by rest.

Trigger factors associated with Acute Coronary Syndrome:

Myocardial Infarction



- Previous medical history of heart disease.
- Smoking.
- Stress.
- Anaemia.
- Physical exercise.
- Extreme temperatures.
- Eating a heavy meal.

Presentation of Acute Coronary Syndrome (ACS):

It should be remembered that every heart attack is different. Only a few of the signs symptoms may be present, indeed up to a quarter of heart attacks suffered are silent without any chest pain.

- Chest pain (Normally central chest pain and can feel like tightness or squeezing).
- Referred Pain:
  - Usually the left arm is affected but it can affect both arms.
  - Jaw & neck.
  - Back.
  - Abdomen.
- Relation to exercise:
  - Angina: **relieved** on rest.
  - Unstable Angina: **Not** relieved on rest.
  - Myocardial Infarction: **Not** relieved on rest.
- Overwhelming anxiety (similar to having a panic attack).
- Wheezing / Shortness of Breath.
- Nausea / vomiting / indigestion.
- Cardiogenic shock.
  - Sweating or cold, sweaty skin.
  - Rapid or irregular heart beat.

Radiating Chest Pain

Management of Acute Coronary Syndrome

A.C.S. Treatment

- Conduct primary / secondary survey & record observations.
- Cease strenuous activity & assess.
- Is the pain alleviated?
- Instigate emergency therapy if pain is **not** relieved:
  - Alert medical personnel / supervisor & prepare to evacuate (A.C.S. is SERIOUS and life threatening).
  - **O**xygen.
  - **N**itrates.
  - **A**spirin.
  - **H**eparin (Low molecular weight).
- Reassess A.B.C.D.E. Regularly.
- Monitor blood glucose levels.
  - Keep below 10mmols.
- Instigate cardiogenic shock management as necessary.
- Evacuate (E.T.H.A.N.E. – M.I.S.T.).

NOTE: Aspirin reduces the clotting ability of the blood. Chewing the tablet allows the drug to absorb quickly into the blood through the skin of the mouth, so it works faster.

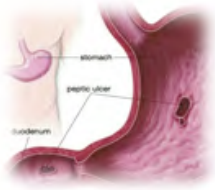
Differential Chest Pain Diagnosis

Many conditions produce the symptom of chest pain. Therefore it is important for the medic to be suspicious and consider the alternate reasons that this symptom may present.

These Include:

- Cardiovascular
  - o Acute Coronary Syndrome.
  - o Altered Heart Rhythm.
  - o Aortic aneurysm.
  - o Pulmonary Embolism (Including Arterial Gas Embolism).
- Gastric
  - o Ulcer
  - o Hernia.
  - o Gastritis.
- Respiratory.
  - o Pneumothorax.
  - o Pneumonia / lung disease.
- Anxiety (panic attack / hyperventilation).
- Drugs.

Gastric Ulcer



Lung Disease

Fainting 3.3.8 (Syncope)

Fainting or syncope is a temporary loss of consciousness generally caused by transient cerebral hypoxia due to a sudden drop in blood pressure.

Unlike a seizure, the person who faints usually regains alertness soon after regaining consciousness. Fainting can also be a symptom of a more serious, underlying condition.

There Are Several Variant Causes Of Syncope:

Vasovagal Syncope

Due to sudden stimulation of the vasovagal nerve, which may have profound cardiovascular effects.

It May Be Initiated By:

- Sudden exposure to an unpleasant sight or experience.
  - o Sudden stress, emotional upset, fear or anxiety.
- Bodily function: coughing, defecating, laughing.

Vasovagal Syncope

Postural Hypotension

Failure to compensate blood pressure. May present if casualty suddenly stands up.

It May Be Initiated By:

- Low blood volume (Dehydration / Heat Illness / blood loss).
- Underlying Medical Condition (hypotension / cardiac failure).
- Medication (anti-hypertensive's / diuretics).

Presentation of Syncope:

- Blurred vision or dizziness.
- Temporary loss of consciousness, falling to the floor.
- Slow pulse.
- Pale, clammy skin.
- Quick recovery.

Fainting

Management of Fainting:

- Conduct primary / secondary survey & record observations.
- Be suspicious... Fainting may be a *symptom.*
  - o Treat underlying cause.
- Implement Shock Management.
- Continually assess casualty & record observations.
- Reassure the casualty as they recover. Do not allow them to sit up suddenly.

If the casualty does not recover quickly or you are unsure inform duty medic.

Haemorrhage 3.3.9 (Blood Loss)

Haemorrhage is a loss of blood from the blood vessels. Continued bleeding will lead to collapse and death. The DMT must aim to control severe bleeding.

The amount of blood in our body varies in relation to our size. A rough rule of thumb is that we have approximately 500mls to every 7kgs of body mass, so the average adult has 4.5 to 6.5 litres of blood.

Types of bleeding

Arterial

Blood in the arteries is under direct pressure from the heart pumping and spurts in time with the heartbeat. A wound to a major artery could result in blood 'spurting' several metres and the blood volume will rapidly reduce. Blood in the arteries is rich in oxygen and is 'bright red'.

Bleeding Wound

Venous

Veins are not under direct pressure from the heart, but veins carry the same volume of blood as the arteries. A wound to a major vein may 'ooze' profusely.

Capillary

Bleeding from capillaries occurs in all wounds. Although the flow may appear fast at first, blood loss is usually slight and is easily controlled.

Effects Of Blood Loss

The body has a 'compensatory' response to severe blood loss, the vascular beds will constrict to utilize the reduced blood volume to supply vital organs. As blood loss increases the blood vessels cannot constrict any further and the heart cannot beat any faster, so blood pressure falls, resulting in unconsciousness (due to cerebral hypoxia) and then death (exsanguination).

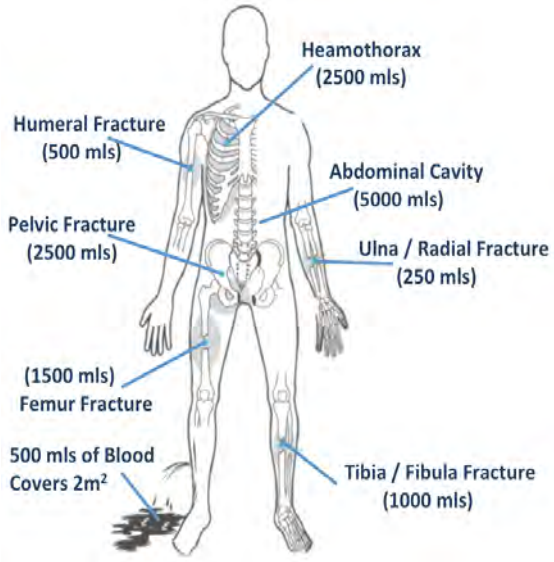
Blood Loss	Category I Shock 10% (500mls) Compensated	Category II Shock 20% (1000mls) Compensated	Category III Shock 30% (1500mls) Uncompensated	Category IV Shock 40% (2000mls) Uncompensated
Airway	Patent	Patent	Compromised	Collapsed
Breathing	Normal (12 B.P.M)	Raised (14-16 B.P.M.)	Rapid (> 20 B.P.M.)	Air Hunger (> 45 B.P.M.)
Circulation	Pulse Rate: Normal Radial Pulse: Normal C.R.T.: 2 seconds	Pulse Rate: Normal Radial Pulse: Palpable C.R.T.: 2-4 seconds	Pulse Rate: Rapid Radial Pulse: Absent C.R.T.: 5 seconds	Pulse Rate: Undetectable Radial Pulse: Absent C.R.T.: Absent
Disability Conscious Level	Alert	Alert	Voice / Pain	Pain / Unresponsive
Exposure Skin	Normal	Pale	Pale / Blue	Blue / Cold

The volume of blood lost is critical. The more blood lost then the greater the Hypovolaemic shock. For every 500mls (10% total blood volume) lost then the casualty will advance a stage in shock category.
A loss of 30% of blood volume is critical – the patient's condition rapidly deteriorates from this point onwards due to a loss of vascular compensation (De-compensation).

The table below shows the effects, signs and symptoms of blood loss.

Bleeding Sites

It is quite possible to haemorrhage huge volumes of blood and never spill a drop onto the floor. Large internal cavities such as the pelvis, abdomen & chest can store large amounts of blood & are difficult to control because direct pressure cannot be placed upon the actual bleeding vessel, this is termed non-compressible.
The long bones can also produce huge storage capacities for blood, the thigh may store up-to 1500mls of blood & the calf 1000mls. The result of this may result in a critical category IV shock with extensive trauma to one limb.
As a general rule a limb injury is a 'compressible haemorrhage' & a torso injury is a 'non-compressible haemorrhage'.



Presentation of Bleeding:

Compressible Bleeding

- Obvious signs of bleeding.
- Signs of hypovolaemic shock.

Non-Compressible Bleeding

- Signs of hypovolaemic shock.
- Bruising / swelling at site of injury.
- Pain, or a history of recent pain at the site of injury.

Management of Bleeding:

Management of external bleeding.

- Conduct primary / secondary survey & record observations.
- Classify bleeding:
  - Compressible / Non-Compressible.
  - Arterial / venous / capillary.
  - Category of shock (Compensated / Non-Compensated).
- Any patient with blood loss that is over 10% should be treated for hypo-volaemic shock.
- Control bleeding using **stepped** approach:
  - **Elevation:**
    Keeping the wound above the level of the heart will decrease the pressure at the point of injury, and will reduce the bleeding. This mainly applies to limbs and the head.

Elevation

  - **Direct / Indirect Pressure:**
    Placing direct pressure on the wound with a field dressing will constrict the blood vessels manually, helping to stem any blood flow. Placing indirect pressure (pressure to the artery supplying a limb, such as femoral / brachial) can stem the flow.
    Regardless of which pressure is applied, time & force are the most critical factors. The aim is to allow clot aggregation; therefore a minimum of 3 minutes of pressure must be given (it is possible to apply pressure for up-to 30 minutes) at a force greater than arterial pressure

Direct Pressure

(120mmHg).

- **Tourniquet:**
  The decision to use a tourniquet on a hemorrhaging limb is taken after: elevation / pressure have failed or if the limb is so catastrophically injured that these measures are impossible.

Tourniquet

- Implement compromised airway management.
- Implement hypovolaemic shock management. (O_2 , I.V.I. Etc).
- Manage the wound using sterile a pressure dressing (see wound management section).
- Continually assess casualty.
- If the casualty does not recover quickly or you are unsure inform duty medic.

Pressure Dressing

Abdominal Dressing

Management Of Internal Bleeding:

- **EMERGENCY** casualty will require urgent surgical intervention.
- Contact duty medic / supervisor.
- Implement Compromised Airway Management.
- Prepare to evacuate (As per company S.O.P's).
- Manage the wound using sterile a pressure dressing (see wound management section).
- Implement Shock Management. (O_2 , I.V.I. Etc).
- Continually assess casualty & record observations.

Management of Haemorrhage in Divers

There are several key factors to consider when dealing with blood loss in the diving industry.

Diving Gear

It is extremely difficult to evaluate volume of blood-loss in the water and very hard to detect bleeding in a diver wearing a dry suit or h
ot water suit.

Systemic Vascular Resistance

The divers suit may be cut off to deal with any injury, however when a divers suit is suddenly removed there can be a dramatic drop in systemic vascular resistance. This reduces the perfusion of blood to the central organs and increases the blood flow to the peripheries. This normal effect is easily compensated for when the diver is fit. However if the diver is suffering from shock (particularly neurogenic shock) this drop in vascular resistance can have profound cardiovascular effects that will increase the severity of shock.

Hyperbaric Immunological Effect

An additional factor in diving with regard to bleeding is the effect it has on the clotting system.

The Effects of Water On Clot Formation

The normal fibrin mesh / platelet aggregation process of blood clotting is greatly inhibited when an open wound is wet thereby washing away the body's attempt to 'plug the hole'. Therefore if a diver has an active bleed whilst wearing a hot water suit, the actual flowing water will actively wash away any clot formation.

ELECTRIC SHOCK 3.4 (Electrocution)

Death by electricity is called "electrocution", other effects are called electric shocks.

Volts V Amps

It is usual to say that "amperes kill and volts burn". In fact, other factors explain these accidents and their several manifestations.

Intensity causes immediate clinical signs. It depends on the voltage of the current and the resistances according to the relation I = U/R (U=voltage in volts; R= resistances in ohms; I=intensity in Amperes).

Resistances to the current vary, depending on; the path they take (body and cutaneous resistances can vary), clothes (serial resistances), moisture (low resistances). This explains that for the same voltage, the effects of the current can be variable. A 1 milliampere intensity produces a simple jolt; the muscular contraction appears near about 10 milliamperes; an 80 milliampere current can create a cardiac arrest.

The voltage which vary from 110 to 250 000 volts or more, is the second important point, its action being due to the Joule effect releasing heat and causing burns;

Presentation of Electrical Shock:

They are numerous and quite different according to the type of current:

- Low voltage currents (50 to 380 volts) create an immediate vital risk because of the cardiac and respiratory disruptions.

- High voltage cause further serious and deep burns.

Cardiovascular Effects

- Ventricular fibrillation : especially due to the low intensity current (less than 4 amperes) with a path crossing the heart (from arm to arm; or from head or arm to leg).
- Other cardiac consequences : excitability troubles (extra-systole), conduction troubles, temporary repolarisation troubles can be seen in the ECG several days after a serious electric shock. Arterial spasms and thrombosis.

Current	Reaction
.001 Ampere	Perception level. Just a faint tingle.
.005 Amperes	Slight shock felt; not painful but disturbing. Strong involuntary reactions to shock can lead to injuries.
0.006 - 0.025 Amperes (women)	Painful shock, muscular control is lost.
0.009 - 0.030 Amperes (men)	This is the freezing current or let-go range.
0.050 - 0.100 Amperes	Extreme pain, respiratory arrest, severe muscular contractions. Individual cannot let go. Death is possible.
1 - 4.3 Amperes	Ventricular fibrillation. Muscular contraction and nerve damage occur. Death is most likely.
10 Amperes	Cardiac arrest, severe burns and probable death.

Muscular Actions

Severe muscular contractions can occur when alternating current is used.

- The casualties' hand may spasm fixing it to the contact point or more rarely projected away causing trauma (high voltage).
- Thoracic and diaphragmatic muscles contractions can involve difficulty and even complete respiratory arrest.
- Large muscular damage may result if the shock wave passes through a large muscle group. The resulting damage my result in Rhabdomylosis (crush injury syndrome).

Burns

Because of their depth, high voltage current can produce serious burns, reaching muscle tissues, vessels and nerves (whose electric resistance is low).

High Voltage: Lightning / Arc Welding Injuries

This may be direct exposure or indirect exposure (upto 1000 meters from a lightning impact). Clinical manifestations include: Cardiac arrhythmias, rhabdomylosis, neurological signs: amnesia, lack of orientation, or in more serious cases, different levels of coma or temporary neurological stroke and burns.

Management of Electrical Shock:

- SAFE approach.
  - o Maintain 'ARC Cordon' if high voltage exposure.
  - o Ensure electrical source isolated.
- Conduct primary / secondary survey & record observations.
- Implement compromised airway management.
- Contact duty medic / supervisor.
- Manage any wounds / burns (see wound / burn management section).
- Implement shock management. (O_2 , I.V.I. Etc).
  - o Use the parkland fluid replacement regime (see burns section).
  - o Aim for a urine output of 1 ml per kg.
- Monitor and assess casualty.
  - o If no cardiac disturbances are present 1 hr after electrocution it is safe to assume cardiac stability.
- Prepare to evacuate (As per company S.O.P's).

DISABILITY / NEUROLOGY (Central Nervous System) 3.5

Injuries to the head often lead to unconsciousness, which in turn compromises the airway. Permanent damage to the brain may result from a head injury.

Concussion 3.5.1 (A.T.O.M.F.C.)

Concussion is a condition caused by 'shaking' of the brain. The brain is cushioned within the skull by 'cerebro-spinal fluid', so if the head receives a blow the brain can bounce from one side to the other, causing widespread disruption to its normal electro-chemical functioning.

Presentation of Concussion:


Concussive Injury

- Brief or partial loss of consciousness *(usually less than 3 minutes).*
- Blurred vision.
- Dizziness / dazed.
- Loss of memory.
- Personality change / slurred speech.
- Stiff neck.
- Nausea & vomiting.
- Consistent mechanism of injury.

Management of Concussion:

- Contact duty medic / supervisor.

- Conduct primary / secondary survey & record observations.
- Reassess regularly. (Use neuro exam including AVPU /GCS). If the casualty's conscious level is severely reduced (G.C.S. ≤ 8, only responding to Pain in AVPU).
  - o Implement compromised airway management.
  - o Implement shock management. (O_2, I.V.I. Etc).
- Continue to monitor concussion casualty if:
  - o There has been any period of unconsciousness.
  - o There is gross nausea.
  - o There are personality changes.
  - o For the next few days, the casualty should be reviewed by the duty medic.
- Prepare to evacuate (as per company S.O.P's).

Concussive Head Injury

Open & Closed Head Injuries 3.5.2 (Skull Fractures / Cerebral Compression) (A.T.O.M.F.C.)

The skull, like any bone may fracture if enough force is applied. A skull fracture is serious because the broken bone may directly damage the brain, or cause bleeding, which in turn results in cerebral compression.

In cerebral compression the brain is placed under extreme pressure, caused by bleeding or swelling in the closed cranial cavity.

Open Head Injuries:

Penetrating Skull Injury

An open head injury is always caused by trauma, either blunt injury or penetrating.

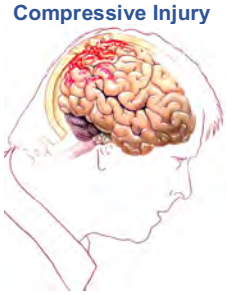
- There is a significant risk of damage to the brain and the cerebral vascular supply.
- Infection is a real risk. External bacteria may contaminate the brain, causing encephalitis or the surrounding meninges, causing meningitis.

Closed Head Injuries:

A closed head injury is also generally traumatic.

- There is a reduced chance of infection & probable direct trauma.
- However there is no 'release' of accumulated pressure.
- Cerebral compression may occur due to an increase of pressure in the brain. This pressure may be due:
  - o An accumulation of blood / fluid within the skull.
  - o Swelling of injured brain tissues.
- Cerebral compression may also be caused by:
  - o Hemorrhagic stroke.
  - o Infection.
  - o Space occupying lesion.

Compressive Injury



Presentation of Cerebral Compression / Skull Fracture:

- Visible injury.
- Consistent mechanism of injury.
- Possible concussion.
- Watery / blood streaked fluid coming out of the ear / nose.
- Confusion / reduced conscious level / airway compromise.
- Generalised clonic / tonic seizure.
- Unequal pupils (caused by an increased pressure in on cerebral hemisphere).
- Slow strong pulse (a sign of medulla oblongata compression).
- Noisy slow breathing (a sign of medulla oblongata compression).
- Bilateral dilated pupils (also known as coning, a sign of medulla oblongata **terminal** compression).

Increased Intracranial Pressure On One Hemisphere

Increased Intracranial Pressure On BOTH Hemispheres

Management of Concussion, Compression or Skull Fracture:

- Contact duty medic / supervisor. (*URGENTLY* if the casualty has been unconscious, their levels of response deteriorate, or you suspect fractured skull).
- Conduct primary / secondary survey & record observations.
- Reassess regularly. (Use neuro exam including AVPU /GCS).
- Suspect cervical injury and instigate immobilisation measures.
- If the casualty's conscious level is severely reduced (G.C.S. ≤ 8, only responding to Pain in AVPU).
  - o Implement compromised airway / breathing management.
- Implement shock management. (O_2, I.V.I. Etc).
- Manage seizures.
- Prepare to evacuate (as per company S.O.P's).
- Control bleeding by applying gentle pressure around the wound, but if there is bleeding or discharge from an ear, don't try to plug the ear or stop it bleeding.
- Manage any wounds (see wound management section).
- Look for and treat any other injuries.

WARNING! Nasopharangeal airways can be dangerous in casualties with basal skull fractures. There is a potential of pushing the airway through a fracture into cerebral tissue.

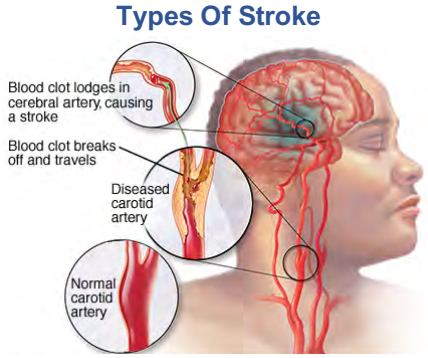
Stroke 3.5.3 (Cerebro-Vascular Accident) (A.T.O.M.F.C.)

A stroke (Cerebro-Vascular Accident - CVA) is the rapidly developing loss of brain function due to disturbance in the blood supply to the brain.

There Are 3 Main Causes:

Thrombotic Stroke

In thrombotic stroke, a thrombus (blood clot) usually forms around atherosclerotic plaques. Since blockage of the artery is gradual, onset of symptomatic thrombotic strokes is slower. A thrombus itself (even if non-occluding) can lead to an embolic stroke. The effects are intermittent and cause a Transient Ischemic Attack (TIA).



Embolic Stroke

This is blockage of a cerebral artery by an embolus, a travelling particle or debris in the arterial bloodstream originating from elsewhere. There are several things, which may cause an emboli, they include:

- A thrombus (From an atherosclerotic plaque or Deep Vein Thrombosis - DVT).
- Fat Embolism (in a large fracture, the fatty bone marrow may leak into the circulation).
- A Cerebral Arterial Gas Embolism (C.A.G.E.). (Diving or blast injury related).
- Emboli from tumor cells or clumps of bacteria.

Haemorrhagic Stroke

A cerebral bleed. This may be trauma related, or a spontaneous aneurism rupture. The bleed causes compression of tissue from an expanding collection of blood. This can distort and injure tissue. In addition, the pressure may lead to a loss of blood supply to affected tissue with resulting infarction.

Presentation Of Stroke:

If you suspect stroke you should carry out the 'FAST' test:

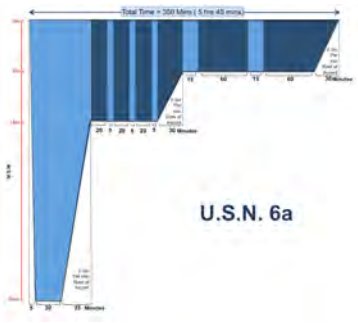
FACIAL	Weakness	(Can the person smile? Has their mouth or eye drooped?).
ARM	Weakness	(Can the person raise both arms and hold them parallel?)
SPEECH	Problems	(Can the person speak clearly and understand what you say?)
TIME	to medical help	(If they fail any test, a stroke is a medical emergency).

Other Signs And Symptoms To Look For Include:

- Loss of balance or coordination.
- Sudden severe headache. / confused and emotional state.
- Impaired vision in one or both eyes.
- Unequal pupil size.
- Loss of bladder or bowel control.

Management Of A Stroke

- Contact duty medic / supervisor. (*URGENTLY* if there has been unconscious, their levels of response deteriorate, or you suspect fractured skull).
- Conduct primary / secondary survey & record observations. (Use neuro exam including AVPU /GCS).
- If the casualty conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU).
  - o Implement compromised airway / breathing management.
- If casualty has recently dived be highly suspicious of a C.A.G.E.
  - o If suspected follow company S.O.P. (Typically USN Table 6a).
- Implement supportive measures:
  - o Lay the conscious casualty down, with head and shoulders raised.
  - o Reassure the casualty - do not assume that they don't understand.
  - o Support any paralyzed limb.
  - o Do not give anything to eat or drink.
- Look for and treat any other injuries.
- Prepare to evacuate (As per company S.O.P's).
- Reassess neurology regularly.



Seizures 3.5.4

A seizure, occasionally referred to as a fit, is defined as a transient symptom of "abnormal excessive or synchronous neuronal activity in the brain". The outward effect can be as dramatic as a wild thrashing movement (generalised clonic-tonic seizure) or as mild as a brief loss of awareness.

It can manifest as an alteration in mental state, convulsive movements, and various other symptoms (such as déjà vu). The medical syndrome of recurrent, unprovoked seizures is termed epilepsy, but seizures can occur in

people who do not have epilepsy.

Generalized Seizure

The Causes Of Seizures Include:

- Epilepsy.
- Hypoxia (due to reduced cerebral perfusion: shock / cardiac arrest).
- Gas toxicity (including oxygen toxicity).
- Stroke.
- Metabolic Imbalance (including acid-base / glucose / electrolyte disturbances).
- Drug toxicity.
- Trauma (bleeding or general raised intracranial pressure due to odaema).
- Infection (localised infections: encephalitis – meningitis. Or systemic: septicemia).
- Space occupying lesion (tumor, abscess, bleeding).
- Febrile convulsion's (common in young children, due to immature hypothalamus).

Types of Seizures

Out-dated terms such as "petit mal", "grand mal", "Jacksonian", "psychomotor", and "temporal-lobe seizure" have fallen into disuse.

It Has Become Common Practice To Break Seizures Down Into 2 Main Distinctions:

Partial or Focal Seizures

These are seizures, which affect only a small region of the brain. Casualties tend to retain consciousness. Partial seizures are often precursors to larger seizures, where the abnormal electrical activity spreads to a larger area of (or all of) the brain, resulting in a generalized seizure. They are often known as an aura.

Déjà vu is actually a partial seizure, it is an aberrant rerouting of a current experience through a memory portion of the brain, giving the sufferer the impression that they have experienced the situation previously.

Generalized Seizures

This type of seizure impairs consciousness and distorts the electrical activity of the whole or a larger portion of the brain. Generalized seizures can be sub-classified into a number of categories, depending on their behavioural effects:

- **Absence Seizure.** An interruption to consciousness, the person experiencing the seizure seems to become vacant and unresponsive (usually up to 30 seconds). Slight muscle twitching may occur.
- **Myoclonic Seizure.** Involve an extremely brief (< 0.1 second) muscle contraction and can result in jerky movements of muscles or muscle groups.
- **Atonic Seizures.** Involves the loss of muscle tone, causing the person to fall to the ground. These are sometimes called 'drop attacks' but should be distinguished from similar looking attacks that may occur in narcolepsy or cataplexy.
- **Clonic-Tonic Seizure.** It involves an initial contraction of the muscles (**clonic phase**), which may involve tongue biting, urinary incontinence and the absence of breathing. This is followed by rhythmic muscle contractions (**tonic phase**). This type of seizure is usually what is referred to when the term 'epileptic fit' is used colloquially.

Management of Partial Seizure:

- Remove any sources of danger, such as a knife or hot drink in their hands.
- Help the casualty to sit down in a quiet place and reassure them.
- Inform / contact duty medic / supervisor.
- Assess casualty & record observations. (Use neuro exam including AVPU / GCS).
- Stay with the patient until they are fully alert.
- Ensure that any partial seizure is *INVESTIGATED*, making sure it is not 'shrugged off' by a casualty.

Management of Generalized Seizure:

Tonic Phase

Clonic Phase

The following management is aimed at the more typical clonic-tonic seizure.

During The Seizure:

- Maintain safety:
  - Help the casualty to the floor to avoid injury if possible.
  - Gently cushion the patient's head to help avoid injury.
  - Loosen any tight clothing around the neck to help the patient breathe.
  - Move any objects that may harm the casualty and ask bystanders to move away.
- If you are concerned about the airway, roll the casualty onto their side.
- Take note of the exact time the seizure started and its duration.
- Look for probable causes of the seizure.

Make An Urgent Medical Call If:

- The seizure lasts more than 3 minutes.

- The patient's levels of response do not improve after the seizure within 10 minutes.
- The patient has a second seizure.
- The patient is not diagnosed as epileptic or this is their first seizure.

NEVER place anything in the casualty's mouth (especially your fingers!).
NEVER try to hold the patient down or restrain them.
NEVER move the casualty (unless they are in danger).

As Soon As The Seizure Stops:

- Contact duty medic / supervisor. (*URGENTLY* if the casualty has been unconscious, their levels of response deteriorate).
- Conduct primary / secondary survey & record observations. (Use neuro exam including AVPU /GCS)
- If the casualty's conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU).
  - o Implement compromised airway / breathing management.
- Implement Shock Management as appropriate.
- If casualty has recently dived be highly suspicious of a gas toxicity hit or C.A.G.E..
  - o If suspected follow company S.O.P. (Typically USN Table 6a for C.A.G.E., Cessation of O_2).
- Look for and treat any other injuries / cause of seizure.
- Prepare to evacuate (As per company S.O.P's).
- Reassess neurology regularly.
- Consider urethral catheterization if neurology remains reduced.

MUSCULO-SKELETAL DISORDERS 3.6

Sprains & Strains 3.6.1

A sprain is defined as an injury to a ligament at a joint. A strain is defined as an injury to muscle. Usually caused by sudden wrenching movements.

Sprains Are Graded 1, 2 Or 3 Depending On Severity:

Grade 1 Sprain (First Degree)
The most common and requires the least amount of treatment and recovery. The ligaments are often over-stretched, and damaged microscopically, but not actually torn. The ligament damage has occurred without any significant instability.

Grade 2 Sprain (Second Degree)
Is more severe and indicates that the ligament has been more significantly damaged, but there is no significant instability. The ligaments are often partially torn.

Grade 3 Sprain (Third Degree)
This indicates that the ligament has been significantly damaged, and that instability has resulted. The ligament has been torn or completely avulsed.

Sprain

Strains Are Also Graded 1, 2 Or 3 Depending On Severity:

Grade 1 Strain: (First Degree)
Consists of minor tear or bruising within the muscle.

Grade 2 Strain: (Second Degree)
This is a partial tear of the muscle.

Grade 3 Strain: (Third Degree)
A severe or complete rupture or avulsion of the muscle.

Muscular Strain

Presentation of Sprains & Strains:

- Pain (the limb hurts and is difficult to move).
- Bruising or swelling over injury site.
- A burning sensation in the area of the injury.
- Muscle cramp or spasm.
- A possible audible "popping" at time of injury.
- A gap, dent or other defect in the normal outline of the muscle.

Remember: minor fractures can easily be mistaken for sprains and strains. The only way to *rule out* a fracture is by actual x-ray.

Management of Sprains & Strains:

The best treatment for a sprain or strain is to follow the **R.I.C.E.** mnemonic:

- **R**est. Rest the injury.
- **I**ce. Apply an ice pack to the injury (this helps to reduce swelling). Apply for 10 minutes, every 2 hours, for 24 hours.
- **C**ompression. Apply a firm (not constrictive) bandage to the injured area. This reduces swelling. The bandage can be applied over a ice pack for the first 10 minutes.
- **E**levation. Elevate the injury. This reduces swelling by aiding venous return.
- Analgesia management (see medication section).

R.I.C.E. Therapy

Dislocations 3.6.2

A dislocation is where a bone becomes partially or fully dislodged at a joint, usually as a result of wrenching movement or sudden muscular contraction. The most common dislocations are the kneecap, shoulder, jaw, thumb or a finger.

There may also be a fracture at or near the site of the dislocation, and damage to ligaments, tendons, cartilage and muscles.

It can be difficult to distinguish between a fracture and a dislocation.

Dislocated Shoulder

Presentation of a Dislocation:

- Deformity & inability to move the dislocated area.
- Pain & tenderness in the injured area.
- Swelling in the injured area.
- Difficulty using or moving the injured area in a normal manner.
- Discolouration, warmth, bruising, or redness in the injured area.
- An associated sprain / strain injury.

Management of a Dislocation:

Closed Reduction

- Contact duty medic / supervisor. (*URGENTLY* if the dislocation is interrupting blood or nervous supply).
- Conduct primary / secondary survey & record observations.
- R.I.C.E. management.
- Treatment is usually closed reduction as soon as possible, it requires:
  - A medic capable of undertaking closed reductions.
  - Anaesthetic sedation (normally I.V. propofol).
  - Opiate level analgesia (normally I.V. fentanyl or morphine).
  - Personnel who can apply compromised airway / breathing management precautions.
- Implement shock management as appropriate. (O_2, I.V.I. Etc).
- Do not give anything to eat or drink until medically reviewed.
- Place limb in a supported sling.
- Look for and treat any other injuries.
- Prepare to evacuate (as per company S.O.P's).

Fracture 3.6.3

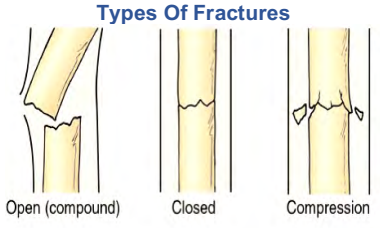
Injury can be caused to the bones, muscles and joints by different types of force.

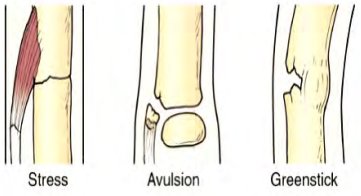
These Are:

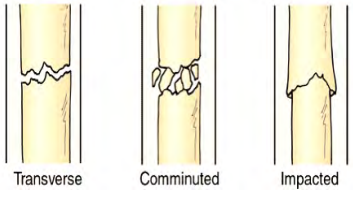
- Direct Force. Damage results at the location where the force was applied, e.g. as the result of a blow or kick.
- Indirect Force. Damage occurs away from the point where the force, e.g. a fractured collar bone, due to an outstretched arm.
- Twisting Force. Damage results from torsion forces on the bones and muscles, e.g. 'twisting an ankle'.
- Pathological. Injury results because the bones have become brittle or weak, due to disease or old age.

A fracture can be defined as a 'break in the continuity of the bone'.

Types Of Fractures







The Basic Categories Of Fracture Are:

- Closed (Simple) This is a break or crack in the bone, with no complications. It may be divided into:
  - Linear Fracture: The fracture is parallel to the bone's long axis.
  - Transverse Fracture: The fracture is at a right angle to the bone's long axis.
  - Oblique Fracture: The fracture is diagonal to a bone's long axis.
  - Spiral Fracture: At least one part of the bone has been twisted.
- Incomplete Fracture: The bone fragments are still partially joined.
- Open (Compound): The bone has broken the skin, which may (or may not) still be protruding from the wound. This type of injury has a high risk of infection.
- Compression Fracture: A closed fracture that occurs when two or more bones are forced against each other. Common in spinal injuries.
- Stress Fracture: It is a common overuse injury. It is most often seen in athletes who run and jump on hard surfaces.
- Avulsion Fracture: A closed fracture where a piece of bone is broken off by a sudden, forceful contraction of a muscle. Common in athletes and can occur when muscles are not properly stretched before activity.
- Green Stick: The bone is split, but not totally severed. Green Stick fractures are often mistaken for sprains and strains, because only a few of the signs and symptoms of a fracture are present. Common in children.
- Comminuted (Multi-fragmentary fracture): In this the bone splits into multiple pieces.
- Complicated: With this type of injury, there are complications, which have arisen as a result of the fracture, such as trapped blood vessels or nerves.
- Impacted Fracture: An impacted fracture is similar to a compression fracture, yet it occurs within the same bone. It is a closed

fracture, which occurs when pressure is applied to both ends of the bone, causing it to split into two fragments that jam into each other.

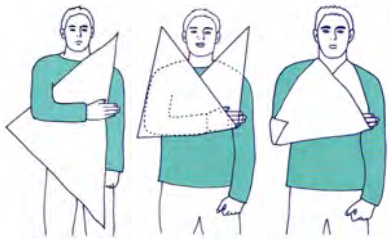
Presentation of a Fracture:

- Pain at the site of the fracture. Strong analgesia or nerve damage may mask the pain.
- Loss of C.S.M. at or distal to the injury:
  - **C**olour: Suggesting there may be vascular impairment.
  - **S**ensation: Suggesting that there may be nervous damage.
  - **M**ovement. Suggesting that there may be muscular / tendon involvement..
- Unnatural movement. An 'unstable fracture', care should be taken to prevent the fracture from moving.
- Swelling or bruising. Dramatic muscular damage may cause **compartments syndrome** or **hypovolaemic shock**.
- Deformity. If a leg is bent at a 90° angle, it's broken!
  - Irregularity Lumps or depressions. Along the surface of the bone, where broken ends of the bone may overlap.
- Crepitus. The feeling and sound of bone grating on bone when broken ends rub on each other.
- Pulmonary Emboli: Large bone fractures (femur, pelvis) carry a risk of releasing a fat embolism from the bone marrow.

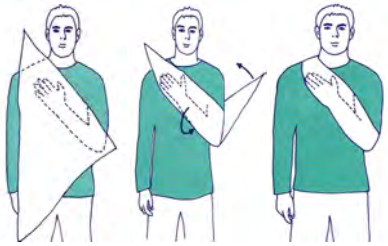
Management of a Fracture:

- Contact duty medic / supervisor. (*URGENTLY* if there are signs of shock, P.E. or C.S.M. impairment).
- Conduct primary / secondary survey & record observations.
- Reassure the casualty, limit limb movement.
- Implement compromised airway / breathing management as necessary.
- Implement Shock Management as appropriate. (O_2, I.V.I. Etc).
- Implement bleeding management as appropriate.
- Implement wound management as appropriate.
- Keep injury still with your until it is properly immobilised.
  - The casualties might be able to do this on their own.
- Don't let the casualty eat or drink (they may need an operation).
- Implement R.I.C.E. management.
- Give analgesia in-line to pain level (& instructions of medic).
- Look for and treat any other injuries.
- Prepare to evacuate (As per company S.O.P's).

Support Sling



Elevated Sling



For A Limb Injury:

- Place the arm in a sling against the trunk of the body.
- Arm fractures are normally placed in a support sling.
- Collar-bone fractures are normally supported by elevated sling (keeping the elbow down at the patient's side).
- SAM Splints may be very useful to aid immobilization.
- Check circulation and sensation beyond the injury.
  - Use manual traction with **Extreme** caution.

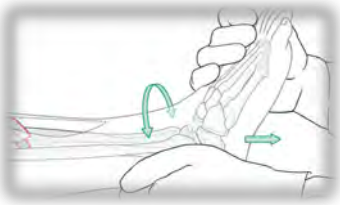
SAM splint

Traction

Traction is usually used to align a bone or bones by a gentle, steady pulling action. It is used to: alleviate pain and re-establish blood supply / nerve conduction. The pulling force may be transmitted to the bone through skin tapes or a manual pulling.

Traction may be used as a preliminary treatment, before other forms of treatment. The use of traction by the untrained DMT should be for life or limb saving reasons only. There is a danger that traction of a limb could make a neuro-vascular problem worst.

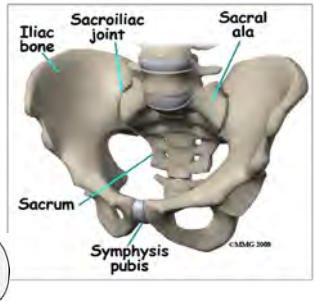
Manual Traction



Pelvic Fracture 3.6.4

Fracture of the pelvis has the greatest mortality rates of skeletal injury.

- Overall pelvic fracture mortality: 16%.
- Closed pelvic fracture and hemodynamical instability mortality: 27%.
- Open pelvic fracture mortality: 55%.



The main reason for such a high mortality rate is due to the passage of major arteries & veins and the highly vascular nature of the pelvic bone itself. Therefore direct injury is likely to cause large blood loss and secondary damage to the vessels passing through the cavity resulting in large retroperitoneal bleeding.

Type A Type B Type C

Classification of a Pelvic Fractures:

- Type A. (Stable) Minimally displaced.
- Type B. (Partially Stable) Incomplete disruption of posterior arch. Open book injury (external rotation). Internal rotation ("bucket-handle") Usually mechanically stable. External rotation injury can be unstable.

- Type C. (Unstable) unilateral complete disruption of one or both arch's. **All**
- are mechanically unstable.

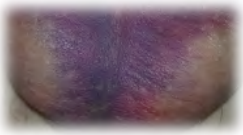
Injury To The Pelvis Is Also Associated With Other Injuries:

- Femoral Vessel disruptions.
- Sacral nerve injuries.
- Rectal perforation.
- Vaginal perforation.
- Bladder and vesical injuries.
- Spinal injuries.
- Femoral fractures.
- Long-term disability.

Internal Pelvic Structures

Pelvic Bruising

Scrotal Bruising



Presentation of a Pelvic Fractures:

- Pelvic tenderness.
- Pelvic instability - gentle compression (Once).
- Haematuria / blood at urinary meatus.
- Abdominal / Flank / Pelvic bruising.
- Perineal / scrotal haematoma.

Management of a Pelvic Fracture:

- Implement fracture management as appropriate.
- Evaluate site for blood loss & implement haemorrhage control.
- Immediate pelvic stabilisation.
  - o Pelvic stabilisation device.
  - o Improvised pelvic wrap.
- Urgent surgical intervention.
  - o External fixator.

Pelvic Stabilisation Sling

Pelvic Wrap

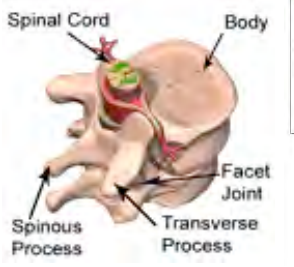
Spinal Injuries 3.6.5

Spinal injuries occur in approximately 2% of trauma patients. Although this figure is relatively low, suspecting and correctly treating the injury is essential, because poor treatment of a patient with a spinal injury could result in paralysis or even death.

The spinal cord is an extension of the brain stem, and travels down the back of the spinal vertebrae. Vital nerves, controlling breathing and movement of limbs travel down the spinal cord.

The weakest part of the spinal column is the neck, and indeed a neck injury can be the most severe type of spinal injury, because the nerves controlling breathing may become severed.

The Vertebrae

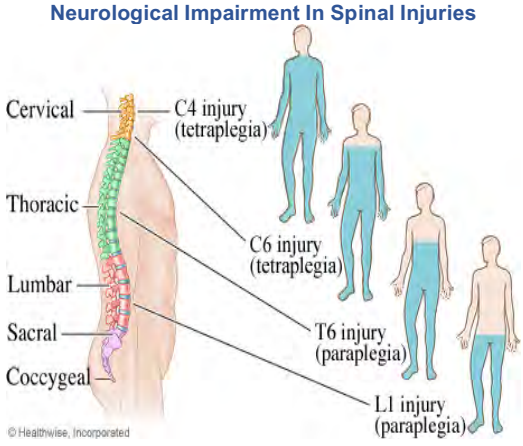


The Spine

Suspect Spinal Injury If The Casualty Has:

- Sustained a blow to the head, neck or back (especially with unconsciousness).
- Fallen from a height (≥ 2-3 times the victims height).
- Dived into shallow water.
- High velocity incidents (vehicle / machinery).
- Been involved in a 'cave in' accident (e.g. crushing, or collapsed environment).
- Multiple injuries.
- Pain or tenderness in the neck or back (pain killers or other severe injuries may mask the pain).

Neurological Impairment In Spinal Injuries



Presentation of a Spinal Injury:

Remember - if some of these signs and symptoms are present, nerves may already be damaged. You should treat a patient who you ***suspect*** has a spinal injury to *prevent* signs and symptoms from developing.

- Airway impairment (in high cervical spine injuries).
  - o Pain or tenderness in the neck or back.
  - o Signs of a fracture in the neck or back.
- Breathing difficulties.
  - o Loss of breathing (in high cervical spine injuries).
  - o Increased respiratory effort (low cervical / high thoracic injuries).
- Neurogenic Shock (Spinal).
- Neurological signs: (Dependent on site of spinal injury).

- Loss of control / feeling of limbs (at or below the site of injury).
- Altered sensations in the limbs (pins and needles or burning).
- Incontinence.
- Erection (priapism).

- History of spinal injury.
- Casualty unwilling to move.

Management of a Spinal Injury:

If The Patient Is Conscious:

In-Line Immobilisation

- Reassure the patient. Instruct them not to move.
- Keep the patient in the position you find them.
  - Do not allow them to move, unless they are in severe danger.
- Implement manual in-line immobilisation.
- **Do not** move the patient unless they are in severe danger.
- Conduct primary / secondary survey (Use full neuro exam including AVPU / GCS).
- Apply spinal immobilization. (Stiff neck collar, head blocks, spinal board using log-rolling technique).
- Implement compromised airway / breathing management if required.
- Contact duty medic / supervisor. (*URGENTLY* if signs spinal / neurogenic shock).
- Implement shock management as appropriate.
- Implement bleeding management as appropriate.
- Implement wound management as appropriate.
- Give analgesia according to pain level & instructions of medic.
- Manage hypothermia. (Common in neurogenic shock).
- Look for and treat any other injuries.
- Urethral catheterization. (Inability to void bladder is common in spinal trauma / Spinal D.C.I.).
- Prepare to evacuate (As per company S.O.P's).

Full Spinal Immobilisation

The main priority of spinal care is to 'Do No Harm'

If The Patient Is Not Breathing Normally Or Has A Reduced Conscious Level:

If the spinal injury is sufficiently high in the cervical vertebrae respiratory control may be affected. In addition head injuries are common in casualties with cervical injury.

If A Severely Reduced Respiratory Effort But A Normal Conscious Level /Are Present:

- Maintain spinal immobilization.
- Assist breathing with the use of a B.M.V. using High Flow O_2.
- Be prepared to clear airway with suctioning.
- Contact duty medic / supervisor. (*URGENTLY* the casualty will require a tracheotomy at a medical facility).
- Prepare to evacuate (As per company S.O.P's).

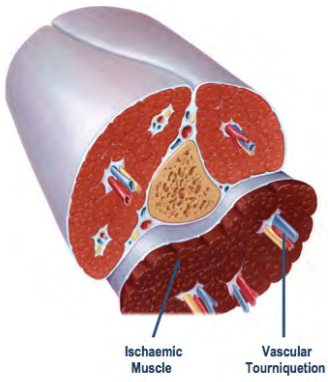
If A Reduced Respiratory And A Reduced Conscious Level Are Present:

- Maintain spinal immobilization.
- Use the 'jaw thrust' technique to open the airway.
- If the casualty's conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU).
  - Protect airway with appropriate device (Naso-pharyngeal / Oro-pharyngeal airway, iGEL, Endo-tracheal intubation).
- Assist breathing with the use of a B.M.V. using high flow O_2.
  - Prolonged maintenance ventilation will be required.
  - Sedation therapy is mandatory.
  - Be prepared to clear airway with suctioning.
- Closely monitor and manage cardiovascular system.
- Contact duty medic / supervisor. (*URGENTLY* as the casualty will require a medical facility).
- Prepare to evacuate (as per company S.O.P's).

Compartment Syndrome 3.6.6

Compartment syndrome occurs when swelling of the muscles in muscle compartment (generally in a limb) suffer increased pressure in the tissues and eventually swell to the point that blood supply is stopped.

The condition is trauma related, either direct injury to the muscle, which causes rupture of the tissues & blood vessels or indirect: such as a fracture of the limb where the bone lacerates muscular tissue. Normally it present in large muscular limbs (the forearm, calf or thigh) but it has been observes in smaller muscular compartments (hands, feet & buttocks).



The Process Of Compartments Syndrome Follows A Logical Path:

- Initial traumatic injury.
- Bleeding / swelling of a closed muscular sheath.
- Venous tourniquetion (reducing the venous return from the sheath, increasing swelling).

- Localised tissue ischemia (causing anaerobic metabolism, which increases swelling).
- Increased tissue swelling (and decreased muscle perfusion).
- Arterial Tourniquetion.
  - If ischemia continues, muscle and nerve tissues die, causing permanent loss of function.
  - Muscle damage will be irreversible after 4-6 hrs.
  - Nerve damage will be irreversible after 12-24 hrs.

The overall effect of compartments syndrome is identical to arterial tourniquetion. Time is the most critical factor, if untreated tissue death will occur.

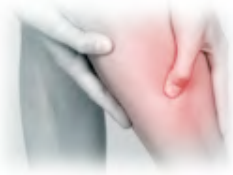
There is also the relative risk of rhabdomyolysis once the condition has been alleviated. It is for this reason that compartments syndrome is always treated as an emergency.

Presentation of Compartment Syndrome:

The definitive presentation of the syndrome is identified with the six 'P's':

- **Pressure;** Early finding & only objective finding. Refers to palpation of compartment and its tension or firmness.
- **Pain;** Classically out of portion to injury. Exaggerated with passive stretch of the involved muscles. May be masked with analgesia.
- **Paresthesia;** An early sign. Peripheral nerves are sensitive to ischemia. Damage occur in 75 minutes.
- **Pallor;** Indicates direct damage to vessels rather than compartment syndrome.
- **Pulselessness;** Indicates direct damage to vessels rather than compartment syndrome.
- **Paralysis;** Very late finding (Irreversible nerve and muscle damage present).

Pain
Out Of Proportion To Injury



Further signs of Compartments Syndrome:

- Consistent mechanism of injury.

Management of Compartment Syndrome:

- Contact duty medic / supervisor. (*URGENTLY* if there are signs of shock or C.S.M. impairment).
- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management as necessary.
- Implement fracture management as appropriate.
- Evaluate site for blood loss & implement haemorrhage control.
- Reassure the casualty, limit limb movement.
  - Maintain the limb to neutral alignment.
  - Splint the limb.
- Loosening an external constriction, such as:
  - A tight bandage.
  - Splitting a cast.
  - Remove restraining clothing.
- Prepare to evacuate (As per company S.O.P's).
  - Casualty will require an urgent surgical fasciotomy (an opening of the muscle facia to release the pressure).
- Monitor for & implement rhabdomyolysis therapy as instructed.

Surgical Fasciotomy

Rhabdomyolysis 3.6.7 (Crush Injury Syndrome)

Rhabdomyolysis is a condition in which damaged skeletal muscle tissue breaks down rapidly. Breakdown products of damaged muscle cells are released into the bloodstream; some of these, such as the protein myoglobin, are harmful to the kidneys and may lead to kidney failure.

Crush injuries most commonly occur as a result of environmental, industrial or traffic accidents. Blood flow to a limb (e.g. an arm or a leg) is impaired by the weight of a crushing object. Rhabdomyolysis may also be caused by a sudden release of a tourniqueted limb, as in arterial tourniquetion or Compartment Syndrome.

If the blood flow to the limb is impaired for 2hrs or more, the toxins will build up so that if they are released into the systemic circulation (which will happen when the crushing object is removed). The circulating 'damaged' muscular debris can have dramatic effects; there will be a sudden release of the electrolyte potassium (which can cause **cardiac arrest**), the debris is generally toxic, which will cause an inflammatory response and in an attempt to excrete the debris it is common for the myoglobulin to swamp or 'clog' the glomerulus of the kidney causing acute renal failure.

Crush Injury

Presentation of Rhabdomyolysis:

- Presence of causative agent (Limb crushed, application of tourniquet, compartment syndrome).
- Cardiac disturbances (irregular, rapid pulse).
- Urine disturbances.
  - Urine output ≤ $^1/_2$ ml per kg (on average urine output should be 40ml per hr).
  - Urine is dark & 'coke cola' coloured.
  - The urine has excessive 'foam'. (Due to the myoglobulin proteins).
- Excessive nausea & vomiting.

Rhabdomyolysis Urine

Management of Rhabdomyolysis:

Treatment For Crushing Less Than 2 Hours:

- Release the casualty as quickly as possible if you can.
- Conduct primary / secondary survey & record observations.
- Implement compromised airway management.
- Contact duty medic / supervisor.
- Prepare to evacuate (As per company S.O.P's).
- Manage bleeding.
- Manage any wounds (see wound management section).
- Implement shock management. (O_2, I.V.I. Etc).
- Closely monitor and assess casualty for cardiac and renal disturbances.

Treatment For Crushing More Than 2 Hours:

- DO NOT release the casualty.
- Contact duty medic / supervisor.
- Conduct primary / secondary survey & record observations.
- Manage pain.
- Manage bleeding.
- Manage any wounds (see wound management section).
- Implement shock management. (O_2, I.V.I. Etc).
- Monitor casualty until ready to remove crushed limb (attach cardiac monitor if available & insert urethral catheter).
- Release crushed limb.
  - Closely monitor A.B.C.D.E's.
  - Monitor urine output hourly.
  - Administer 'forced diuresis' with I.V. fluids (aim for a urine output of 1ml per / kg).
  - Observe urine (for classic signs).
  - Take venous bloods for analysis by dive doctor.
- Prepare to evacuate (As per company S.O.P's).

Amputation 3.6.8

Amputation is the complete or partial severing of a limb, or appendage (finger / toe), it is extremely traumatic and potentially life threatening due to the real possibility of rapid exsanguination by a catastrophic haemorrhage.

Amputated Hand

Presentation of Amputation:

- Fairly obvious missing limb or appendage.
- Uncontrollable haemorrhage.
- Hypovolemic shock.
- Reduced conscious level (cerebral hypoxia).

Management of Amputation:

- Manage bleeding.
  - Implement the stepped approach (it is common to quickly advance to tourniquetion if bleeding profuse).
  - For an amputated toe / finger, a band tourniquet over the base of the appendage may be used.
  - Indirect vascular pressure is very often useful.
- Alert Medical personnel / supervisor & prepare to evacuate (as per company S.O.P's).
- Conduct primary / secondary survey & record observations.
- Implement compromised airway management.
- Manage the wound (see wound management section).
- Implement shock management. (O_2, I.V.I. Etc).
- Continually assess casualty.
- Manage pain.
  - Pain is generally overwhelming & sedation with airway control is often necessary.
  - For an appendage, a local anaesthetic block is very useful.
- Wrap the amputated part in a plastic bag (sterile if possible), and then put the package on a bag of ice to preserve it for transport to the hospital.
- Prepare to evacuate (As per company S.O.P's).

THE SKIN 3.7

It is assumed that an offshore worker with an important skin problem either can't pass the pre-employment physical or will bring their own medications for known problems.

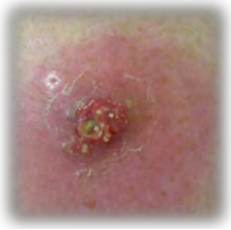
Non-Infective Skin Disorders 3.7.1

The initial response should be to address the cause of the disorder.

The Problem May Be:

- A drug reaction.
- An Infective agent.
- Something in contact with the skin.
- Constant rubbing or scratching.

Carbuncle



Healthy skin has a tremendous ability to heal itself without treatment if the provoking factor is removed.

Normal Preventative Measures:

- Avoid irritant medicines (discuss with duty doctor).
- Maintain a high standard of hygiene.
- Use protective garments.
- Ensure a good / balanced nutritional intake.
- Avoid suspicious jobs or areas.
- Cover the affected skin with a dressing or ointment.
- Stop scratching- Itching is a symptom seen in many different skin disorders and leads to scratching. Scratching causes release of chemicals from certain cells in the skin. These chemicals cause more itching, thus the "itch-scratch cycle".

Generic Treatments

These are useful for a variety of problems, perhaps in addition to more specific measures.

For Red, Itching, Oozing Skin:

- Soak the affected area:
  - o Apply warm for infections, cool for other problems.
  - o Soak hands or feet in a basin.
  - o Apply a wet strip of towel or gauze to other body areas.
  - o Apply for 15-30 minutes 2-3 times a day.

Anti-histamine Creams

The Following Are Soothing, Mixed With Ordinary Tap Water (Boiled & Then Cooled):

- Table salt, 10mg (2 teaspoons) per litre of water.
- Baking soda (sodium bicarbonate) 40mg (8 teaspoons) per litre of water.
- Epsom salt (magnesium sulfate) 40mg per litre of water.

For Severe Discomfort, These Interventions May Be Included:

- Diphenhydramine (or piriton) cream-apply a thin film over the area, cover with a dressing, repeat 4 times a day until improvement occurs, then begin simple soaks.
- Cortisone cream (and derivatives), apply the same as diphenhydramine.
- Oral medicines-These can be helpful for itching, especially during sleep. (They may cause drowsiness, so avoid or use with care around machinery or when operating equipment).
- Diphenhydramine-daytime 25-50 mg. every 4-6 hours, bedtime 50-100 mg.
- Dry skin: Apply any oily material such as lotion, petroleum jelly. An oily layer on the surface prevents evaporation of water and increases the moisture content of the skin.

Bacterial Skin Infections 3.7.2

Folliculitis (Barber's Itch)

Folliculitis

This is most common on the face, the back of the neck, or in friction or rubbing areas. It may result from being shaved by unclean barber utensils.

The infected hair follicles result in many superficial pimples in the affected area.

Management of Folliculitis:

- Inform duty medic.
- Initiate general principles & generic treatment.
- Open each pimple with the tip of a sterilised needle and scrub gently with soap.

- If not healed in 2-3 days, give oral antibiotics for 3-5 days as prescribed.

Boil (Furuncle)

Furuncle

Usually due to an infection in a hair follicle, which penetrates deeper into the skin.

Management of Boils:

- Inform duty medic.
- Initiate general principles & generic treatment.
- Give antibiotics as prescribed.
- If the boil "comes to a head" with pus appearing in the centre in a soft area, open it with the tip of a sterilised needle and gently press out the pus.

Carbuncle

A carbuncle is a collection of boils connected by channels under the skin. The most common location is the back of the neck. Often there is fever and spasm of the neck muscles. It may come to a head or drain at several points.

Management of Carbuncle's:

- Initiate standard boil treatment.
- Intravenous antibiotics may be needed.
- Paracetamol / ibuprofen to manage fever.
- Consider evacuation if the problem appears worse after 36-48 hours treatment.

Erysipelas (Holy Fire)

Erysipelas

This is a strep infection of the skin, often on the cheek but can occur anywhere. It usually starts with a minor scratch or break in the skin.

The skin is hot, red, thick or swollen and can often be indented with a fingertip. The typical appearance shows a sharp border between the infected and normal skin, which can be traced with a hall point pen and seen to advance in a few hours.

Management of Erysipelas:

- Inform duty medic.
- Initiate general principles & generic treatment.
- Give antibiotics as prescribed. (It is usually better in 24-36 hours, healed in 3-5 days).
- Paracetamol / ibuprofen to manage fever.

Impetigo

Impetigo

This is a local infection of the skin caused and spread by bacteria from under the fingernails, usually due to scratching insect bites or minor skin irritations.

It starts as a small bump or blister-like area which turns into a honey-colored crust or scab with a "stuck-on" appearance. It itches but is not tender.

Management of Impetigo:

- Inform duty medic.
- Initiate general principles & generic treatment.
- Minor cases usually heal by removing the crust, scrubbing with soap & covering.
- Have the patient cut his fingernails short and scrub the hands several times a day.
- For numerous lesions, more severe lesions give antibiotics as for folliculitis as prescribed.

Fungal Skin Infections 3.7.3

Fungal infections are relatively common in warm humid conditions such as a saturation chamber.

Generic Treatments Principles:

Athlete's Foot

- Inform duty medic.
- Maintain high standard of hygiene.
- The skin should be kept clean & dry.
- Wear loose garments and frequent changes of underwear or socks.
- Give anti-fungal medication as prescribed (tolnaftate, haloprogin, miconazole, clotrimazole).
- Apply the medicine 4 times a day or more often in severe cases until improvement is noted.

Tinea Pedis (Athlete's foot)

There is itching, burning or stinging between the toes and cracking and peeling of the skin. There may be deep, blister like areas in severe cases. Secondary infections are common in severe cases.

Management Of Athlete's Foot:

- Inform duty medic.
- Initiate general principles & generic treatment.
- If secondary infection present give antibiotics as perscribed along with the anti-fungal medicine.

Tinea Cruris (Jock Itch)

Jock Itch

This is very common in humid climates. It starts in the crease between the scrotum and inner thigh, then spreads to those areas. On the thigh, the infected skin is dark pink or light brown with a definite border from normal skin. The first symptom is usually itching, later becoming tender and inflamed.

Management of Jock Itch:

- Inform duty medic.
- Initiate general principles & generic treatment.
- Jockey-type shorts should be avoided and the area should be kept clean and dry.

Tinea Versicolor

Tinea Versicolor

A harmless, but very common superficial infection. Seen on the upper portions of the chest, back and arms. It appears as light patches, which do not tan.

Commonly re-occurs in warm weather (then fades in the winter). Mainly a cosmetic problem.

Management of Tinea Versicolor:

- Inform duty medic.
- Treat with dandruff shampoos containing selenium sulfide (apply for 10-20 mins then rinse).
- Repeat daily until better, then twice weekly.

Parasitical Skin Infections 3.7.4

A parasite is an organism that lives on or inside another organism (the host). Parasites usually enter the body through the mouth or skin. Parasites that enter through the mouth are swallowed and can remain in the intestine or burrow through the intestinal wall and invade other organs.

Parasites that enter through the skin bore directly through the skin or are introduced through the bites of infected insects (called vectors because they convey or transmit organisms that cause disease).

Lice

Head and body lice are usually due to poor hygiene but they spread readily in crowded quarters (even to people with good hygiene). Head lice nits can often be seen on shafts of the hair. Body lice are not usually seen but hide in seams of clothing. Pubic lice (crabs) may be seen or one may see tiny, dot-like droppings in underwear. Pubic lice are usually acquired during sexual activity.

Lice

Management of Lice:

- Inform duty medic. & Isolate casualty.
- Apply lindane lotion or shampoo as prescribed.
- For body lice, boil the clothing or wash in strong detergent.
- In some geographical areas, body lice may cause trench fever and typhus.

Scabies

Scabies

A small mite, which burrows under the skin and lays eggs. It usually begins on the hands, wrist, feet and ankles.

It appears as small bumps or blisters, frequently seen in a pattern of lines or "runs". It itches most at night and spreads readily to close contacts.

Management of Scabies:

- Inform duty medic. & Isolate casualty.
- Treat with lindane lotion (apply a thin layer. Leave on the skin 8-12 hours, then rinse off. Repeat in 5 days).
- Under-garments and bedclothes should be washed in a strong detergent.

Burns 3.7.5

Burns are injuries to tissues caused by extreme temperatures (hot or cold), friction, electricity, radiation, or chemicals. Scalds are a type of burn caused by a hot liquid or steam.

Estimating The Severity Of A Burn

When a DMT is dealing with a burnt casualty, it is essential to take into account the 6 factors that combine to affect the severity of a burn.

These are:

Size

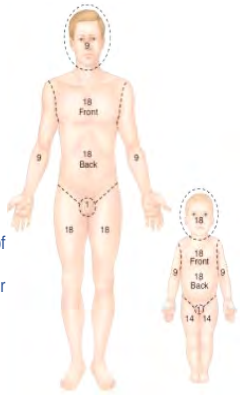
The size of the burn is given as a percentage of the body's Total Surface Area (T.S.A.). The "rule of nines" is used to determine the total percentage of area burned for each major section of the body by breaking down total areas into 9% sections.

An easy way to estimate TBSA burned is to use the casualty's open hand (The palm of the casualy's opened hand is equal to 1% of their body area).

Burn Estimation

An area equal to the size of the palm of the patient's hand is equal to 1% of their body surface area

The Rule of 9's



Cause

The cause of the burn influences the overall severity - for example, electrical burns may cause deep internal burns. Some chemicals (such as hydrochloric acid) cause poisoning in addition to burns.

Age

The age of the victim affects the recovery rate. Children will burn at lower temperatures than adults. Elderly casualty's burns take longer to heal and they may be more susceptible to infection.

As a predictor of overall mortality from a burn a rule of thumb is to add *Age + Percentage of Burn.* The closer to 100, the higher the mortality rate. For example, a 25 yr old with 14% burns is classed as severe but he would be expected to survive (the combined number is 39). However an 80yr old casualty with the same percentage burn would have a much higher mortality rate (combined % is 94).

Temperature

The intensity / temperature of a heat source combined with the duration of exposure dictate the overall severity of a burn.

43°c will cause cell breakdown in 6hrs, 96°c will cause a burn almost instantly.

Skin Temperature	Duration	Damage Caused
43°c	6 Hours	Cell breakdown begins
70°c	1 Second	Cell destruction
80°c	0.1 second	Curable burn (second-degree)
96°c	0.1 second	Incurable burn (third-degree)

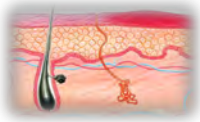
Depth

The deeper the burn, the more the tissue has been damaged and therefore the more severe the injury.

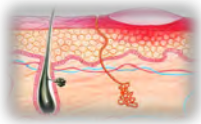
The Depth Of Burns Can Be Defined As:

- **Superficial** (1st Degree)
  This involves only the outer epidermis layer, and most commonly occurs from scalds or sunburn. The burn looks red, sore and swollen. If larger than 5% it is considered serious.
- **Partial Thickness** (2nd Degree)
  Affecting the epidermis and the dermis. The burn looks raw and blisters will form. A 9% burn will cause hypovolemic shock.
- **Full Thickness** (3rd Degree)
  All layers of skin are burned and the subcutaneous layer is affected. The burn may look pale, charred or waxy. The nerve endings may be burned away, so pain may be absent. A full thickness burn is **always** life threatening.

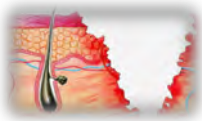
Superficial (1st Degree)



Partial Thickness (2nd Degree)



Full Thickness (3rd Degree)



Location

The location of the burn can affect the severity; inhalation of hot gases is potentially life threatening, burns to the eyes may cause permanent blindness, burns to the chest may restrict chest expansion and burns to the limbs may cause limb tourniquetion.

Generic Presentation of a Burn:

- Airway involvement (discussed separately).
- Potential breathing difficulty (circumferential chest burn, airway involvement).
- Hypovolaemic shock (due to large blood plasma loss).
  o Tachycardia. Absence of radial pulse. Prolonged C.R.T.
- Cardiac Arrhythmias (due to plasma loss, tissue death, potassium release).
- Gradual reducing level of consciousness.
- Effects of toxic gas.
- Excessive pain.
- Tissue loss:
  o Potential for infection.

Cool Burn

- o Adherence of clothing to skin.
- o Heat loss if large TBSA affected.
- o Potential circumferential limb injuries.

Flamazine™

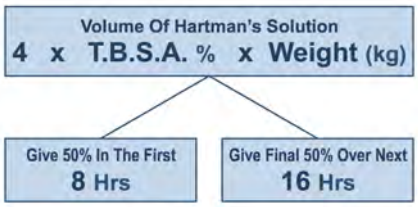
Management of Minor Burns (<5% Superficial / <0.5% Partial Thickness):

- Conduct primary / secondary survey.
- Assess burn (Size, Cause, Age, Location, Depth, Temperature):
  - o TBSA burnt.
  - o Is it an electrical or chemical burn?
- Cool the burn:
  - o Cold running water for 15 minutes.
- Management wound.
  - o Gently remove watches and jewellery, if possible.
  - o A hydrating / cooling / antibacterial cream may be useful (Flamazine™).
  - o Wrap the wound loosely with a non-adherent dressing.
- Management of pain.

Management of Major Burns:

- Do not put yourself in danger.
- Conduct primary / secondary survey & record observations.
- Assess burn (Size, Cause, Age, Location, Depth, Temperature). Be suspicious of airway burns.
- Contact duty medic / supervisor.
- Implement Compromised Airway Management.
- Implement Shock Management as appropriate. (O_2, I.V.I. Etc).
  - o Fluid resuscitation: Parkland Formula: 4 x Wt x TBSA burned. 50% in 1st 8hrs. 50% in following 16hrs.
- Insert urethral catheter & record measurement hourly.
  - o Aim for a urine output of 1ml / kg.
- If large TBSA burn present, hypothermia is common.
- Give analgesia according to pain level & instructions of medic.
- Look for and treat any other injuries.
- Prepare to evacuate (as per company S.O.P's, the urgency of which can be assessed by the burn assessment.)

Parkland Formula



Non-Adherent Dressing

Wound Management.

- Remove watches, rings etc, as burned areas will swell.
- Clothing that has **not stuck** to the burn may be removed very carefully.
- Sterile antibacterial burns cream such as *Flamazine* may be applied as directed by Duty Medic.
- Dress the burn with a non-adherent dressing.
  - o Cling film is one of the best dressings for a burn - discard the first two turns from the roll and apply it lengthways *(don't wrap it tightly around a limb).* Secure with a bandage.
- Alternative dressings could be; sterile plastic bag, low adherent dressings or specialized burns dressings.

NEVER burst blisters (it protects against infection)
NEVER apply lotions, ointments or fats - it might introduce infection.
NEVER use adhesive dressings
NEVER remove clothing that has stuck to the burn

Airway / Inhalation Injury (A.T.O.M.F.C.)

Inhalation injury is not a single entity. It consists of a variable combination of 3 factors:

Airway Burn

Caused by inhalation of hot gases (flame, smoke and steam). The injury is normally confined to the upper airway and leads to oedema with the risk of obstruction. The swelling develop instantly or slowly (2 and 36 hours).

Airway Burns

Lung Injury

Occurs if the products of combustion are inhaled into the lower airway where they dissolve into the fluid lining the bronchial tree and alveoli. This leads to a *direct chemical lung injury,* which instigates an Acute Respiratory Distress Syndrome response, often delayed by hours or even days.

Systemic Toxicity

Occurs from absorption of inhaled products of combustion. This is the most common cause of death due to fires in enclosed spaces. The most important agents are carbon monoxide and cyanides.

Airway swelling occurs progressively for many hours following inhalation injury and may not be evident when the casualty is first seen. It is important to anticipate those at risk of developing airway obstruction.

The Presence Of Any Of The Following Indicates The Possibility Of An Inhalation Injury:

- A history of exposure to fire or smoke in an enclosed space.
- Exposure to blast.
- Abnormal airway signs: **Singed nasal hairs / inflamed oropharynx / burns or sooting of face.**
- Abnormal airway sounds: **wheeze / stridor / hoarseness or any change in voice.**
- Breathing (RISE – FALL): **Rapid rate** / **visible chest injuries** (front & back) / **gross accessory muscle use** / **hyper-resonant** / abnormal breath sounds: **wheeze / harsh cough / soot in saliva.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Low SpO_2 on pulse-oximeter.

Management of Airway Burns:

Time is critical, if an airway burn is found it should be treated as an emergency EVEN if the casualty appears relatively unaffected.

An asymptomatic casualty can become critical within a short space of time.

Airway Burns

- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
- In the presence of an airway burn endotracheal intubation is mandatory. (Remember that the swelling is likely to be increasing. In the majority of cases the patients will be conscious and endotracheal intubation will be impossible without first anaesthetising the patient.).
- Urgently contact duty medic.
- Instigate shock management. ALWAYS insert I.V. Cannulae.
- Treat other burns in accordance with burns management.
- Prepare to evacuate (As per company S.O.P's).

Electrical Burns

Caused by heat that is generated by an electrical current flowing through the tissues of the body.

It is important to note that an electrical burn has an entry point and an exit point, and that all the tissue in-between has suffered damage. The extent of the internal burns can be estimated by the severity of the entry and exit wounds. An electric shock may cause cardiac arrest.

Management of Electrical Burns:

S.A.F.E. Approach

- Implement electric shock management.
- Implement burns management.
- Conduct primary / secondary survey & record observations. (Pay particular attention for irregular heart rate. This may indicate a cardiac arrhythmia).
- Assess Burn (Size, Cause, Age, Location, Depth / Time). Observe for an **entry** & **exit** point.
- Contact duty medic / supervisor.
- Wound management. (Irrigate the area of the burns, including the path between entry and exit, for at least 10 mins).
- Prepare to evacuate (as per company S.O.P's).

Chemical Burns

Chemicals may either corrode the skin or create heat *(though an exothermic reaction).* It is important to be aware any chemicals used in your workplace.

Management of Chemical Burns:

- Make the area safe - contain the chemical if possible and protect yourself from coming into contact with it.
- Take care to protect yourself wearing appropriate PPE (Personal Protective Equipment).
- Assess Burn (Size, Cause, Age, Location, Depth). Be suspicious of airway burns.
- Implement general burn management.
- Identify chemical & refer to its COSHH information.
  - Implement chemical specific treatment.
- Decontaminate affected area:
  - Dry powder chemicals can be carefully brushed off the skin before irrigating.
  - Irrigate the chemical burn with lots of running water (for at least 20 minutes).
  - Try not to wash the chemical onto unaffected areas of the body.
  - Ensure pools of contaminated water do not collect underneath the casualty.
  - Remove contaminated clothing carefully whilst irrigating the burn.
- If an eye is contaminated, irrigate as above, and ensure that the water runs away from the un-affected eye.

Work Place Chemicals

Blast Injuries 3.8

Exposure to an underwater blast will result in damage far in excess of that caused by a similar air blast. This is because water is an incompressible substance and transmits the pressure waves with the velocity of sound underwater. The surface, seabed or obstacles may also reflect the pressure wave. When the pressure wave hits the diver, it is transmitted through their body and will damage tissues adjacent to gas spaces.

With air explosions much of the pressure wave is reflected by the body surface, since it represents an interface

between mediums of different densities. The density of the body and water are similar. Underwater the pressure wave passes through the body except at areas capable of compression, i.e. gas spaces.

Therefore damage will be found at these interfaces:

- Lungs.
- Sinuses.
- Ear cavities.
- The Gastro Intestinal Tract.

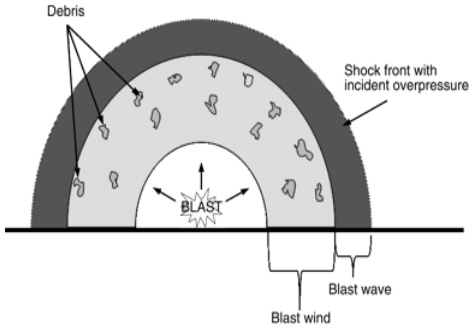
Presentation Of Blast Injuries

Primary Blast Injuries (Greatly enhanced underwater)

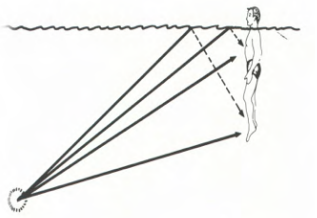
Dry suits could reduce the damage caused, since they would be the first water-air interface struck.

- Respiratory: Blast lung. Pulmonary contusions / thrombosis. A.G.E.
  - o Acute respiratory failure.
  - o Disseminated Intravascular Coagulation (DIC).
- Ears: Tympanic Membrane (TM) rupture, ossicle dislocation & disruption of oval or round window.
  - o Hearing loss.
  - o Tinnitus / vertigo.
  - o Bleeding / discharge from external canal.
- Abdominal: Abdominal haemorrhage and perforation. Intestinal barotrauma more common with underwater air blast injuries.
  - o Mesenteric ischaemia from gas embolism may cause delayed rupture of large or small intestine.
  - o Abdominal pain, nausea, vomiting, heamatemesis.
  - o Rectal pain / testicular pain.
  - o Unexplained hypovolaemic shock.
- Cerebral: Traumatic brain injury (TBI). C.A.G.E. Stroke.
  - o Concussion.
  - o Headache, fatigue, poor concentration, lethargy, anxiety, and insomnia.
- Eye : (Globe rupture, retinitis, lid laceration, traumatic cataracts, injury to optic nerve).
  - o Eye pain.
  - o Foreign body sensation.
  - o Blurred vision / decreased vision.
  - o Drainage (Blood, straw coloured).

Injury Type	Cause Of Injury	Organs Affected
Primary	Direct Impact On The Tissue Of Over-Pressure (Shock Wave)	Gas Filled Structures : Ears, Sinuses, Lungs, Git Tract
Secondary	Primary & Secondary Missiles Energised By The Blast	Head, Torso & Limb Penetrating & Non Penetrating Trauma. Damage To Solid Organs
Tertiary	Physical Displacement Of The Body By Blast Wind	Head and neck injury. Limb Fractures. Traumatic amputations. Damage to CNS, great vessels & solid organs.
Quarternary	Miscellaneous Noxious Effects Incidental To Blast Dust, Fires, Hot Gas.	Lungs, skin.



Pressure Exposure In Water



Secondary Blast Injury

- Penetrating ballistic or blunt injuries.
  - o Penetrating foreign object in casualty's body.
  - o Solid organ & bony injury.
  - o Wounds can be grossly contaminated.

Secondary Blast Injuries

Tertiary Blast Injuries

- Due to persons being thrown into fixed objects by wave of explosions.
- Structural collapse may cause extensive blunt trauma.
- Rhabdomyolysis (Crush Injury Syndrome).
- Compartment syndrome.

Quaternary Blast Injuries

- Explosion related injuries or illnesses not due to primary, secondary, or tertiary injuries.
  - o Drowning.
  - o Burns (chemical and thermal).
  - o Toxic inhalation.
  - o Radiation exposure.
  - o Asphyxiation (hypoxia, carbon monoxide and cyanide) .

ANY DIVER who experiences an underwater blast is likely to have suffered some injury. No external injuries may show, but they may develop serious clinical symptoms and signs over the next couple of days, as a result of internal bleeding, etc. Therefore even in the absence of any physical injury a diver who has experienced a blast should be treated as an emergency.

Management of Blast Injuries:

- Conduct primary / secondary survey & record observations.
- Assess for potential primary, secondary, tertiary & quaternary injuries.
- Contact duty medic / supervisor. (*URGENTLY* stating 'blast injury').
- Treat specific injuries as discovered. (Be aware that pressurising casualty in a hyperbaric environment may delay potential surgery).
- Implement compromised airway / breathing management.
- Implement shock management as appropriate. (O_2 , I.V.I. Etc).

- Manage wound as discovered.
- Give analgesia according to pain level & instructions of medic.
- Insert urethral catheter and observe for blood.
- Insert a naso-gastric tube to decompress the stomach.
- Prepare to evacuate. (As per company S.O.P's. A blast injury is ALWAYS an emergency).

CLIMATIC INJURIES 3.9

The body works best when its temperature is close to 37°C. This temperature is maintained by an area in the centre of the brain called the 'hypothalamus'. If the core temperature varies by just 2°C either way there will be an adverse biological reaction.

If the body becomes too hot we produce sweat, which evaporates and cools. The blood vessels near to the skin dilate *(flushed skin)* and the cooled blood is circulated around the body.

If the body becomes too cold we shiver, which creates heat by muscle movement. Blood vessels near to the skin constrict *(pale skin),* keeping the blood close to the warmer parts of the body. Hairs on the skin become erect, trapping warm air *(goose pimples).*

Injuries resulting from exposure to extremes of temperature can be 'localized': (*sunburn or frostbite),* or 'generalised' *(such as hypothermia or heat stroke).*

Hypothermia 3.9.1 (A.T.O.M.F.C.)

The onset of hypothermia occurs when the body's core temperature falls below 35°C. If the body's core temperature falls below 26°C the condition will most likely be fatal. However resuscitation has been successful on people with body temperatures as low as 10°C.

The underlying cause of hypothermia is over exposure to cold temperatures. However different conditions and types of patient will increase the risk.

These Include:

- The hypothalamus (temperature control centre) of a baby or young child is under developed, and hypothermia can result from as little as being in a cold room.
- Elderly or infirm patients do not generate as much body heat, so prolonged periods in a cold environment can lower the core temperature.
- Wet clothing, or immersion in cold-water results in the body cooling much faster than it would in dry air. Water conducts heat away from the body.
- A person who is not clothed properly in windy conditions will have cold air continually in contact with the skin, resulting in faster cooling of the body.

Presentation of Hypothermia:

- Cold, pale and dry skin.
- Uncontrollable shivering:
  - Shivering will stop when the core temp drops even further.
- Neurological impairment:
  - Slurred speech (may be mistaken for intoxication).
  - Tiredness, stumble, and falling.
  - Unexpected behaviour changes.
  - Disturbed vision.
  - Unconsciousness.
- Control centre disturbances:
  - Slow shallow breathing.
  - Slow weak pulse (the pulse can fall lower than 40 beats per minute).
  - Death.

Insulate Casualty

Management of Hypothermia:

- Conduct primary / secondary survey & record observations.
- Reassess regularly. (Use neuro exam including AVPU /GCS).
  - If conscious level is severely reduced (G.C.S. ≤ 8, Only responding to pain in AVPU).
  - Implement compromised airway / breathing management.
- Contact duty medic / supervisor. (*URGENTLY* if the core temp ≤ 35°C).
- Warm casualty externally:
  - Remove any wet clothing and quickly replace with dry.
  - Place blankets or other insulating materials under and around the patient and cover the head (use a survival bag and shelter if casualty outside).
- Warm casualty Internally:
  - Give the casualty warm drinks and food.

  - Administer warmed I.V. fluid (38°c is normal).
  - Insert a urethral catheter (Warmed sterile fluid may be irrigated into the bladder).
  - Insert a naso-gastric tube (Warmed sterile fluid may be irrigated into the stomach).
- Implement Shock Management as appropriate.
- Implement unconsciousness management.
- Close monitoring should be maintained.
- Prepare to evacuate (as per company S.O.P's).
- If the casualty has 'died':
  - Resuscitation should be commenced.
  - They should be resuscitated until their body temperature has reached above 35.5°c.

NEVER give a patient alcohol (it dilates blood vessels, which will make the patient colder).

NEVER place direct sources of heat on or near the patient (they draw blood to the skin, causing a fall in blood pressure).

BEWARE: A hypothermic heart is in grave risk of 'ventricular fibrillation', which causes cardiac arrest.

BEWARE: If they appear dead. You MUST resuscitate. (The casualty must be warm & dead before they are certified).

Hypothermia and Diving

Commercial divers are at risk but because of the high conductivity of helium. There is a considerable respiratory heat loss associate with mixed gas use. It is mandatory to have a heated suit and, if he is below 150 metres, a heated gas supply. In a stranded bell the greatest risk to survival is hypothermia.

Many of the symptoms of hypothermia may not be apparent to the diver in the water and the supervisor should exercise special care. He should ensure that the diver returns to the surface or the bell immediately if his hot water supply fails. The diver himself will very quickly become unable to make a rational decision.

It is important to note that the hypothermic diver has two preservative mechanisms active; the higher partial pressure of oxygen will reduce cerebral hypoxia and the low temperature will instigate cryonic cerebral preservation. It is for these reasons that resuscitation should be maintained, even if the casualty appear beyond survival.

Management of Hypothermic Diver:

Bell Survival

- In a lost bell scenario, instigation of survival measures is a priority.
  - Remove wet gear / clothes.
  - Dry as best as possible.
  - Wear survival bag.
  - Use breathing apparatus to minimize respiratory heat loss.
  - Return to surface as soon as possible.
- His condition should be monitored closely and he should be given CPR if necessary.
- Instigate standard hypothermia therapy.

Frostbite 3.9.2

Frostbite is a condition caused when an extremity *(such as a finger or an ear)* is subject to cold conditions. The cells of the limb become frozen. Ice crystals form in the cells, which causes them to rupture and die. Frostbite may also be accompanied by hypothermia. Serious frostbite can result in the complete loss of a limb, particularly fingers or toes.

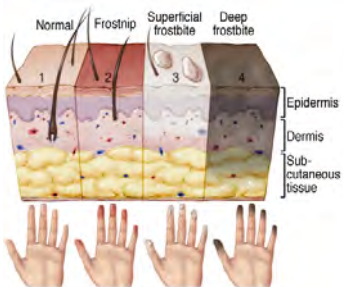
Trench Foot
This is caused by prolonged exposure to wet, cold conditions. The cells do not freeze, so full recovery is usual. The symptoms and treatment are similar to frostbite.

Chilblains
The most common cold injury, caused by exposure to dry cold. Again the cells do not freeze. There may be itching, reddish-blue skin and swelling. With time, blisters may form. Treat as frostbite.

Presentation of Frostbite:

- Cold to the touch.
- Altered skin sensation:
  - Prickly, tingling, burning or have reduced sensation.
- Altered skin colour / texture (dependant on degree of injury):
  - Hard, pale, white, blue.
- As the injury is warmed / re-perfused:
  - Skin may become red, swollen, blistered and painful.
- Gangrene can occur in advanced stages.

Stages of Frostbite



Management of Frostbite:

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor. (*URGENTLY* if the casualty has been unconscious or core temp ≤ 35°C).
- Implement Hypothermia Management.
- Stop the freezing becoming worse if the casualty is still outdoors - place hands in their armpit or hold it with your hands.
- Move the patient indoors or in shelter.
- Gently remove rings, watches etc.
- Place the injury in warm water *(not with a frozen hand!).*
- Don't rub the injury - this will cause damage.
  - Don't re-warm the injury if there is a risk of it refreezing.
- Give analgesia for intense pain. (Aspirin for its anti-platelet effect & Ibuprofen for its anti-inflammatory effects.)
- Prepare to evacuate (As per company S.O.P's).

NEVER rub the affected area.
NEVER use direct or dry heat to warm the injury.
NEVER re-warm the injury if there is a danger of it refreezing

CAUTION:
To prevent frostbite always wrap the ice pack in a cloth and apply it for a maximum of 10 minutes. Allow the skin to return to normal temperature before repeat applications.

Heat Exhaustion 2.9.3

Heat exhaustion is the body's response to loss of water and salt through excessive sweating. The most common cause of this condition is working or exercising in hot conditions.

Heat exhaustion occurs when the core body temperature rises above 38°C. If it is not treated, it can quickly lead to heat stroke.

Heat Exhaustion

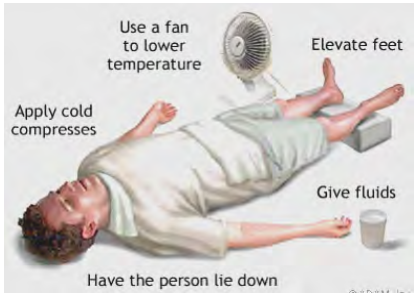
Presentation of Heat Exhaustion:

- Sweating profusely.
  - Pale and clammy skin.
- Headache, dizziness, extreme tiredness.
- Hypovolemic shock (due to excessive fluid loss).
  - Nausea & vomiting.
  - Cramps in legs or abdomen (due to salt loss).
  - Decreased urine output (urine is vey concentrated / dark).
  - Rapid pulse & respiration rate.
- Increasingly confused.

Management of Heat Exhaustion:

- Conduct primary / secondary survey & record observations.
- Reassess regularly. (Use neuro exam including AVPU /GCS) If the casualty's conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU).
  - Implement compromised airway / breathing management.
  - Contact duty medic / supervisor. (*URGENTLY* if the casualty has been unconscious or core temp ≥ 39^{O}C).
- Cool the casualty:
  - Take the casualty to a cool, shaded area.
  - Remove excessive clothing and lay them down.
  - Use a fan (It is best used above the casualty to move air around them).
- Re-hydrate the casualty:
  - Oral rehydration solutions (*'Dioralyte') or* isotonic drinks are best as they also replace lost salt.
- Implement shock management as appropriate. (O_2, I.V.I. Etc,).
- Close monitoring should be maintained.
- Treat for heat stroke as necessary.
- Prepare to evacuate (as per company S.O.P's).

Heat Exhaustion Treatment



Heat Stroke 2.9.4 (A.T.O.M.F.C.)

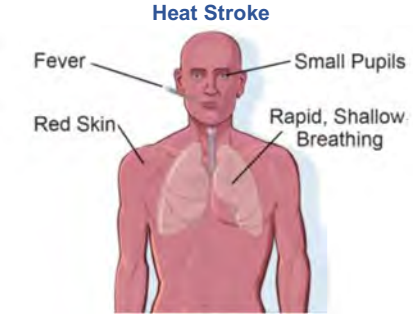
Heat stroke is deadly. It results from failure of the hypothalamus *(temperature control centre)* in the brain.

The sweating mechanism fails, the body is unable to cool down and the core temperature can reach dangerously high levels *(over 40°C)* within 10 to 15 minutes. Cellular death will occur at 44ºc.

The condition can be caused by a high fever or prolonged exposure to heat and often follows heat exhaustion.

Presentation of Heat Stroke:

Heat Stroke



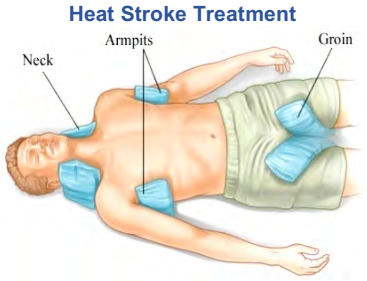
- Symptoms of Heat Exhaustion.
  - Fatigue, headache and irritability.
  - Nausea, vomiting and diarrhoea.
- Increased cerebral / hypothalamus temperature.
- Diminished sweating.
  - Hot flushed dry skin.
- Body temperature will raise above 40°c.
  - Strong bounding pulse & rapid respirations.
  - Neurological Impairment.
    - Disturbed or uncharacteristic behaviour.
    - Reduced conscious level.
- Death. (44ºc).

Treat Heat Stroke as an **EMERGENCY**

Management of Heat Stroke:

- Conduct primary / secondary survey & record observations.
- Implement heat exhaustion management.
- Reassess regularly. (Use neuro exam including AVPU /GCS) If the casualty's conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU). Protect airway.
- Implement Compromised Airway Management.

- **Urgently** Contact duty medic / supervisor.
- If the casualty has a seizure implement seizure management.
- Prepare to **URGENTLY** evacuate.



Methods of cooling:

- Remove outer clothing.
- Cool the casualty rapidly, using whatever methods you can: Wrapped ice packs over major arteries (carotid, femoral, axilla) is very effective.
- Continually sponging / spraying with cool water, and drying the casualty to speed evaporation.
- Implement Shock Management (I.V.I. therapy with cooled I.V. fluid).
- *Cool NG / bladder / rectal lavage.*
- *Keep cooling until temperature drops to 38°c.*

DIABETES 3.10

Diabetes is a loss blood sugar (glucose) level ballance, either because the body doesn't produce enough insulin, or because body cells don't properly respond to the insulin that is produced.

Insulin is a hormone produced in the pancreas, which enables body cells to absorb glucose, to turn into energy. If the body cells do not absorb the glucose, the glucose accumulates in the blood (hyperglycemia), leading to vascular, nerve, and other complications.

The normal blood sugar is between 4-6 mmols. However a blood sugar between 6-9 mmols is considered acceptable in diabetics.

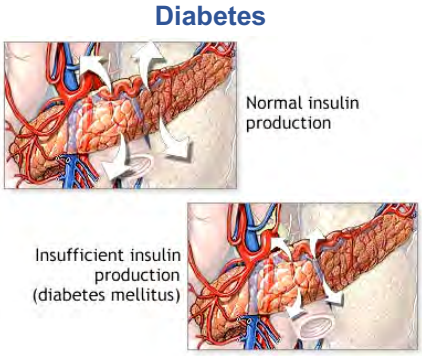
There Are Many Types Of Diabetes, The Most Common Of Which Are:

Type 1 Diabetes (Juvenile):

Which is a complete failure to produce insulin in the pancreas. Very often this presents in childhood. Almost exclusively the required treatment is injection of insulin several times per day.

Type 2 diabetes (Late Onset):

Which is either a partial failure to produce insulin in the pancreas or insulin resistance of cells. 'Overworking' of the pancreas & its insulin production can very often trigger this, common in extreme obesity and excessively fit individuals (athletes).



There Are Three Main Methods Of Treatment:

Diet

This patient still produces some insulin naturally, so can control the condition by reducing the amount of sugar that they eat. Tends to be Type 2 Diabetes.

Medication

The pancreas still produces a small amount of insulin naturally, and medication (Metformin, Glibenclimide) can be given to stimulate more insulin production. Tend to be Type 2 Diabetes.

Insulin

The pancreas produces little or no insulin, synthetically produces insulin will need to be injected 2 or more times a day in order to keep sugar levels under control. Tend to be Type 1 Diabetes or severe Type 2.

Low Blood Sugar (Hypo-glycemia)

Low blood sugar occurs mainly with diabetic patients who are insulin dependent, as the level of insulin in the body is now a 'fixed' amount because it is injected.

Because the patient has injected this 'fixed' amount of insulin, they have to balance the amount of food that they eat.

The Blood Sugar Levels Will Fall If:

- The patient does not eat enough food.
- The patient over exercises *(burning off sugar).*
- The patient injects too much insulin.

Unlike other cells in the body, the brain can only use glucose *(sugar)* as its source of energy. Therefore if the sugar in the blood becomes low, the brain cells are literally starved.

High Blood Sugar (Hyper-glycemia)

Hyperglycaemia occurs if diabetes has not been treated effectively by the methods mentioned above.

The blood sugar levels increase as acids build up. The signs and symptoms are a result of the body trying to excrete this acid build up.

Hyperglycemia occurs during times of infection and inflammation when a diabetics metabolic system is raised. When the body is stressed, endogenous catecholamines are released that - amongst other things - serve to raise the blood glucose levels.

The Main Causes Of High Blood Sugars In Diabetics Are:

- Infective or inflammatory conditions.
- Exercising heavily.
- Taking an insufficient amount of insulin.
- Taking an excessive amount of carbohydrates.

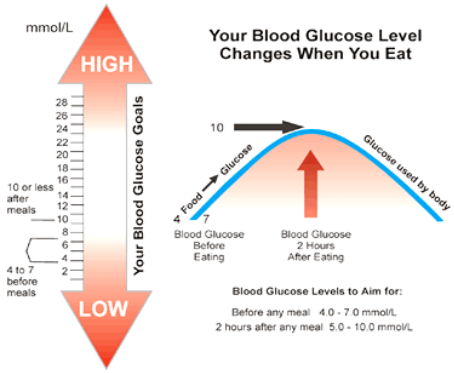
Presentation of Low Blood Sugars (Blood Sugar <2.9mmols):

- Blood sugar low.
- Fast onset (2 - 60mins).
- Breathing: shallow & rapid.
- Rapid heart rate.
- Neurological impairment:
  - o Weakness / Dizziness
  - o Confusion
  - o Bizarre Coordination (**Beware:** appear very similar to Alcohol Intoxication).
  - o Unconsciousness within hr.
  - o Permanent cerebral impairment.
- Pale, cold & sweaty.

Presentation of High Blood Sugars (Blood Sugar >15mmols):

- Blood sugar high.
- Slow onset (12-48hrs).
- Breathing: Deep sighing breaths
  - o Fruity Odour on Breath.
- Rapid heart rate.
- Neurological impairment:
  - o Drowsy / Lethargic
  - o Eventual Unconsciousness leading to permanent cerebral impairment.
- Skin dry & warm.
- Excessive Urination (+ve to glucose & ketones on urinalysis).
- Profound Thirst
- Hunger

Normal Blood Sugars



Management of Altered Blood Sugars:

For a conscious casualty:

- Conduct primary / secondary survey & record observations (Use full neuro exam including AVPU / GCS).
- Take a blood sugar reading.
- Contact duty medic / supervisor. (*URGENTLY* if Blood Sugar ≤ 2mmol or ≥ 17mmols).
- Implement Shock Management as appropriate. (O_2 , I.V.I. Etc).
- If the blood sugar is ≤ 3mmols:
  - o Give a sweet drink *(isotonic sports drinks are best)* glucose tablets or sweet foods.
  - o If the casualty responds to treatment quickly, give them more food or drink.
  - o Recheck blood sugar level. If it remains low give more carbohydrates.
- If the blood sugar is ≥ 17mmols.
  - o Contact duty medic / supervisor. Explain that the casualty has hyperglycaemia.
  - o Give I.V.I. as instructed, normally Hartman's solution, (dehydration with low potassium (K+) is common).
  - o Give insulin as instructed by Duty Medic.
  - o Recheck blood sugar level. Report back sugar levels to Duty Medic & follow instructions.
  - o Look for and treat any of the causes of hyperglycemia (Infections; bacterial / fungal / viral).
  - o Prepare to evacuate (as per company S.O.P's).
- Consider urethral catheterization.

For an casualty with a reduced level of consciousness:

- If the casualty conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU).
- Implement compromised airway / breathing management.
- Continue to observe & document the casualty's neurological state & blood sugar.
- Insert urethral catheter. Perform urinalysis (Observe for Glucose, Ketones & ↓Ph).
- If the blood sugar is ≥ 17mmols:
  - o Give S/C or I.V. insulin as directed by Duty Medic.
  - o Continue to hydrate with I.V.I. (infusion containing K+)
  - o Perform venepuncture to send blood for analysis (U&E's, blood gas).

- Recheck blood sugar level. Report back sugar levels to Duty Medic & follow instructions.

- If the blood sugar is ≤ 3 mmols:
  - Give I.V. Glucose (20% -250mls or 50% -50mls via a large vein) or (I.M. Glucogon) or (buccal absorbed glucose).
  - Continue to Hydrate with I.V.I. (infusion containing K+)
  - Perform venepuncture to send blood for analysis (U&E's, blood gas).
  - Recheck blood sugar level. Report back sugar levels to Duty Medic & follow instructions.
- Prepare to evacuate (as per company S.O.P's).

POISONING 3.11

Poison is anything that kills or injures through its chemical actions. Most poisons are swallowed (ingested). The word poison comes from the Latin word - potare - meaning to drink.

Poisons can enter the body in 4 ways, they can be:

Ingested
Swallowed, either accidentally or on purpose, this includes food poisoning.

Inhaled
Breathed in, accessing the blood stream very quickly as it passes through the alveoli.

Absorbed
Through the skin *(see chemical burns).*

Injected
Through the skin, directly into tissue or into a blood vessel.

Poisoning

A Poison Can Also Be Divided Into:

Corrosive
Such as: acids, bleach, ammonia, petrol, turpentine, dishwasher powder, etc.

Non-Corrosive
Such as: tablets, drugs, alcohol, plants, perfume etc.

Presentation of Poisoning:

The signs and symptoms of poisoning are wide, varied and dependent on the substance. Look for clues such as:
Smell on the breath. Containers or bottles. Tablets or drugs. Syringe or drug taking equipment.

Other Signs That Can Accompany Poisoning May Be:

- Vomiting or retching or diarrhoea.
- Pain (dependent on entry of toxin).
- Burns around the mouth and lips. Stains or odours on the person, clothing or area.
- Irregular pulse, raised temperature.
- Altered breath smells.
- Confusion or hallucination.
- Unconsciousness.
- Cyanosis.
- Breathing problems.
- Many conditions may be secondary to poisoning:
  - Seizures.
  - Drug / alcohol intoxication.
  - Symptoms of Shock.

Possible Poisons

Possible Treatment

Management of Poisoning:

For A Corrosive Substance:

- Don't endanger yourself - make sure it's safe to help. Apply P.P.E. as appropriate.
- Conduct primary / secondary survey & record observations (Use full neuro exam including AVPU / GCS).
- Contact duty medic / supervisor. (*URGENTLY*).
- Discover poisoning agent: refer to COSHH guidelines & follow.
- Implement compromised airway / breathing management.
- Implement shock management as appropriate. (O_2, I.V.I. Etc).
- Implement anaphylaxis management.
- Dilute the substance or wash it away if possible:
  - Substances on the skin - see chemical burns.
  - Ingested substances - get the casualty to rinse out their mouth, and give frequent sips of water.
  - Oral carbon / charcoal is common (Mixed with water & given oraly or rectally)
- Follow instructions from duty medic.
- Prepare to evacuate (as per company S.O.P's).

NEVER make the patient vomit. This may put the airway in danger.

For an casualty with a reduced level of consciousness:

- If conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU).
- Implement compromised airway / breathing management.
- Continue to observe & document the casualty's neurological state.
- Insert urethral catheter. Perform urinalysis (Observe for Glucose, Blood, Protein, Ketones & ↓Ph / ↑Ph).
- Prepare to evacuate (As per company S.O.P's.

It helps if you :
- Pass on the containers or information about the substance.
- Find out how much has been taken & when.
- Keep a sample of any vomit for analysis.

Food Poisoning (Gastroenteritis) 3.11.1

Gastroenteritis is an inflammation of the gastric tract typically with diarroea & vomiting. Gastroenteritis can be due to infections by viruses, bacteria, parasites, and fungus. (The most common cause is Rotavirus / Norovirus, Bacterial cause include: Campyolobacter, E-coli, Salmonella, clostridium).

Generally highly contagious, spread via the oro-feacal route, but may also be spread in vomit (generally rotavirus spores, making it amazingly contagious).

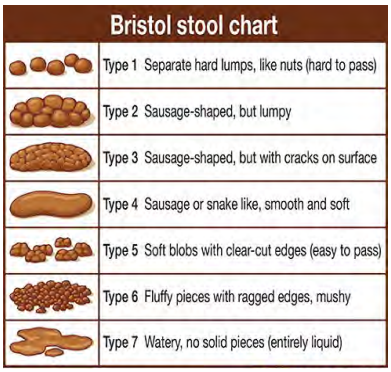
Food may become contaminated with bacteria or viruses if it remains at room temperature for several hours, the bacteria multiply and increase the risk of infection in those who consume the food.

Foods commonly associated with gastroenteritis include raw or undercooked meat, poultry, seafood, and eggs, unpasteurized milk and soft cheeses; and fruit and vegetable juices. It is estimated that three to five billion cases of gastroenteritis resulting in 1.4 million deaths occur globally each year.

Possible Symptoms

Presentation of Food Poisoning:

- Vomiting or retching.
- Diarrhoea. (This may seem infective & be grossly malodourous).
- Abdominal cramps / pain.
- Possible fever.
- Dehydration:
  - Low urine output.
  - Dry mouth.
  - Fatigue.
  - Headache and muscle pain



Management of Food Poisoning:

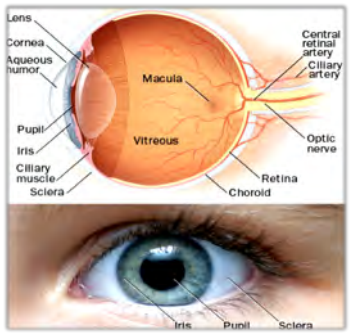
- Don't contaminate yourself - Apply P.P.E. as appropriate.
- Conduct primary / secondary survey & record observations & stool consistency (Using a Bristol Stool Chart).
- Contact duty medic / supervisor, highlight the possibility of an infectious condition.
- Isolate the affected:
  - If possible, ensure separate eating & toileting facilities.
  - Trace who has been in contact with & shared food with the victim.
  - Ensure OCM aware of potential contagion event.
- Encourage hand washing:
  - Before & after toileting & eating.
  - Hot soapy water is better than alcohol gel.
- Hydrate casualty:
  - Address fluid & electrolyte loss.
  - Large IV fluid with additional electrolytes resuscitation is common.
- Try to find cause of poisoning:
  - Possibly isolate contaminated food / water source.
  - Collect a sample of faeces for c&s.
- Give medication as required:
  - Many gastroenteritis's are bacterial, so antibiotics are useful.
  - Anti-emetics are useful.
  - Beware of Anti-motility agents (such as Imodium) May induce mega-colon.

EYE DISORDERS 3.12

Eye injuries are irritating and painful, and some have the potential to be very serious. Even a superficial graze to the cornea can lead to scarring, resulting in permanent damage and deterioration in vision. Prompt first-aid treatment can be helpful.

Any injuries or infections of the eyes must be treated seriously. They should normally be referred to expert medical help. But if such professional help is not available, here are some simple steps that can be carried out to diagnose and treat common eye injuries and infections.

Eye Anatomy



Three Things Can Gauge The Seriousness Of An Eye Injury;

- The history of the injury.
- The amount of damage, which is immediately visible.
- The effect on vision.

Eye Abrasions 3.12.1

The front of the eye is extremely sensitive and abrasions can be very painful. If the cornea (clear part of the eye covering the iris) is injured it is prone to infection & gross inflammation.

Presentation of Eye Abrasions:

- Tears.
- Blurred vision.
- Pain and Increased sensitivity or redness round the eye.
- Continuous feeling that there is something in the eye.

Management of Eye Abrasions:

Eye Dressing

- Conduct primary / secondary survey (examine eye) & record observations.
- Instruct casualty NOT to rub eye.
- If there is something in the eye, irrigate the eye with clean water or sterile fluid from a sealed container, to remove anything loose from the eye.
- Contact duty medic / supervisor. Follow instructions from Duty Medic.
- Do not remove anything that will not be flushed out of the eye with water.
- Implement Wound Management. Secure a sterile dressing over the eye.
- Instruct casualty to minimise blinking.
- Prepare to evacuate (ss per company S.O.P's).

Black Eyes 3.12.2

A black eye is bleeding beneath the skin around the eye. This can indicate a more extensive injury like a skull fracture, compression or brain injury, particularly if the area around both eyes is bruised or if there has been head trauma.

Black Eye

Presentation of Black Eyes:

- Swelling and bruising around eyelids and surrounding area.
- Tender to the touch.
- Possibly blurring of vision.
- May feel dizzy.
- Eye may close up due to swelling.

Management of Black Eyes:

- Implement Eye Abrasion management.
- Steadily apply a small cold compress to reduce any pain and swelling of the eye area without putting any pressure onto the eye.
- Monitor eye for deterioration.
- Contact duty medic / supervisor. Follow instructions from Duty Medic.

Foreign Bodies 3.12.3

The problem begins suddenly - people often complain that 'something got into my eye.' There may be pain - especially on blinking - either because the surface layer on the front of the eye has been damaged or because it is still being damaged with each blink if a sharp foreign body is hidden under the eyelid. There is some watering.

There Are Three Places Where A Foreign Body May Have Lodged:

- It may be on the cornea.
- Under the eyelid.
- Inside the eye (a risk for the worker with high pressure gas).

Eye Examination:
To find the foreign body you need a good light and, ideally, a magnifying glass. First the cornea must be carefully examined. If no foreign body is found on the cornea, it is vital to check the inner surfaces of the upper and lower eyelids thoroughly. To do this properly it is necessary to turn the eyelid back - a skill known as 'everting'.

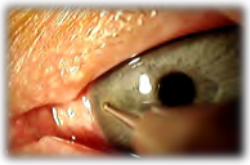
Presentation of Foreign Bodies:

- See Abrasions.
- Visible Foreign body.

Management of Foreign Bodies

- Implement Eye Abrasion management.
- If a foreign body is seen on the conjunctiva, irrigate the eye with sterile water.
- If irrigation fails, lift the foreign body off using a moist swab or the damp corner of a clean handkerchief or similar. Using a sterile eye bud is advocated.
- If it is suspected that there is a foreign body underneath the upper eyelid, ask the casualty to gently pinch their eyebrow and pull the upper eyelid over the lower eyelid. If this fails to dislodge the foreign body, blinking while irrigating may be successful.
- If a foreign body is deeply embedded, you could cause great damage. In this case patients **must** be referred to an *eye specialist*.

Removal of Foreign Body



Chemical Eye Injury 3.12.4

A chemical injury to the eye can cause permanent damage and blindness.

Eye Irrigation

Presentation of Chemical Injury:

- Severe burning pain in the eye.
- Redness and swelling around the eye.
- Inability to open the eye.
- Copious watering of the eye.

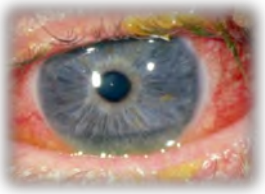
Management Chemical Injury:

- Implement Eye Abrasion management.
- The priority of the treatment is diluted and dispersed:
  - Use P.P.E. and Irrigate the affected eye for at least 10 minutes (you may need to prise the eyelids open).
  - Alternatively, use a bag of I.V.I. Saline 0.9% & giving set, lie casualty down & irrigate eye.
  - Ensure the eyelid is thoroughly irrigated and avoid contamination of the unaffected eye.
  - Apply a sterile eye pad or a clean non-fluffy pad over the injured eye.
- Prepare to evacuate (as per company S.O.P's).
- If possible, identify the chemical involved to help medical staff prescribe the best possible treatment.
- Advise the casualty that movement of the injured eye, which could aggravate the injury.

Conjunctivitis 3.12.5 ("Pink Eye")

This is an acute inflammation of the conjunctiva (the outermost layer of the eye and the inner surface of the eyelids), most commonly due to an allergic reaction or an infection (usually viral, but sometimes bacterial).

Conjunctivitis



Presentation of Conjunctivitis:

- Pain - from mild itching to severe pain.
- Yellow-green discharge (may even be pussy, causing eyelids to stick together on waking).
- Inflammation - of varying degree.
- Floaters over the eye.

Management of Conjunctivitis:

- Implement eye abrasion management.
- Consult Duty Medic.
- Take swab of eye & dispatch to Duty Medic.
- Apply antibiotic ointment – (normally chloramphenicol eye ointment - four times a day.)

EAR DISORDERS 3.13

Ear Infections 3.13.1 (Otitis Externa)

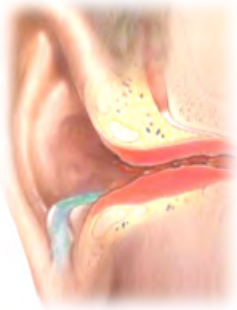
Exposure to water or humid atmospheres can produce maceration or softening and wasting of the skin of the ear canal. The canals itch or feel sore, and, if cleaned or scratched with implements like Q-tips, paper clips or pencils the macerated skin is further irritated and may become infected. Predominantly the infection is bacterial but occasionally fungal. The resulting infective condition is called otitis externa. Divers who are exposed to water

with a high bacterial count, i.e. polluted water, are at special risk. Divers who have skin allergies or seborrhoeic dermatitis are particularly vulnerable and may develop otitis externa from showering or shampooing even when they are not diving or swimming.

Under normal conditions these bacteria are unable to survive in the ear because of the harmless bacteria already in residence. During saturation diving, the high humidity and the oxy-helium atmosphere kill the harmless bacteria and leave the field free for painful infections.

It is for this reason that prophylactic management is useful for the saturation diver:

Otitis Externa



Prevention of Otitis Externa:

- The preventative ear-drops are usually a silver acetate solution which makes the outer ear canal too acidic to support bacteria. When the solution dries it leaves a thin film across the surface of the skin, which further inhibits infection.
- The preventative drops should be taken on a regular basis as instructed (usually about every 8 hours) after diving and showering. One bottle must be provided for each ear to prevent cross infection.
- Swabs of the divers' ears are also taken on a regular basis and may be sent ashore or checked in a bacteriology laboratory on board the installation. The results will indicate the presence of unwanted bacteria before the diver experiences any symptoms and usually allow successful treatment in the chamber.

Antibiotic Ear Drops

Presentation of Otitis Externa:

- Acute ear pain, often severe, accentuated by manipulation of the pinna or by pressure on the tragus.
- Itching and burning of the ear canal.
- Conductive hearing loss may result from oedema of the skin and tympanic membrane.
- Serous or purulent yellow-green discharge.
- Inflamed, swollen and tender external ear canal.
- The canal often is so tender and swollen that the entire ear canal and tympanic membrane cannot be adequately visualized (complete otoscopic examination may be delayed until the acute swelling subsides).
- The condition may progress to complete obstruction of the ear canal, abscess, and/or spread of infection into the surrounding tissues.

Antibiotic Ear Drops

Management of Otitis Externa:

- Conduct primary / secondary survey (including an examine ear) & record observations.
- Contact duty medic / supervisor. Follow instructions from Duty Medic.
- Cleanse the ear canal.
- Apply specific topical antibiotic therapy. (e.g., ofloxacin, gentamicin, ciprofloxacin), as directed.
- Analgesia management as indicated by pain. (Less severe cases can be managed by irrigating the auditory canal, using lukewarm tap water and carefully drying the canal after irrigation. After drying, a mild acid solution should be applied. This process should be repeated several times daily.)
- Swimming and diving should cease until symptoms have cleared completely.
- In severe, acute episodes with fever and lymphadenitis, oral or I.V. antibiotics may be indicated. Give as prescribed.
- Prepare to evacuate if nil improvement (As per company S.O.P's).

DENTAL DISORDERS 3.14

Avulsed Tooth 3.14.1

After a direct blow to the mouth the casualty may have a permanent tooth knocked from its socket. The tooth is intact, down to its root, from which hangs the delicate periodontal ligament that used to attach to alveolar bone and provide the tooth with its blood supply.

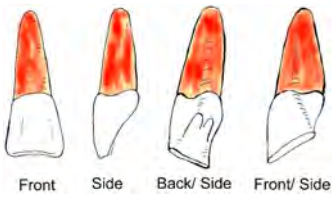
Presentation of Avulsed Tooth:

- The complete tooth is knocked out, root and all.

Avulsed Tooth

Management of Avulsed Tooth:

- Conduct primary / secondary survey (Examine mouth) & record observations.
- Contact duty medic / supervisor. Follow instructions from duty medic.
- Implement bleeding management (getting the casualty to bite on a sterile pack).
- Implement compromised airway / breathing management.
- The chance for successful re-implantation depends on first aid plus receiving dental care within a few hours.



- Wash it gently with clean running water. Do not wipe the tooth or rub off any fibrous attachments.
- Do not remove the blood clot from the tooth socket. Insert the tooth completely into the socket, lining up the biting edge with the adjacent teeth.
- Splint the tooth in place with wax, thickness of metal foil or similar material, folding it into a "U" shape in front of and behind the tooth.
- Mold well to surrounding teeth.
- Press gauze or cotton around the gums if necessary for bleeding.
- Drink liquids through a straw.

Implanted Tooth

- If dental care is more than 2-3 hours away, successful re-implantation is unlikely. Dispose of the tooth, allow the socket to heal and a false tooth will be fitted later.
- Manage pain with appropriate analgesia.
- Monitor for signs of infection & give antibiotics as prescribed.
- Prepare evacuate to dental facility if nil improvement (As per company S.O.P's).

Jaw Fracture 3.14.2

A fractured jaw is a break in the jaw bone. A dislocated jaw means the lower part of the jaw has moved out of its normal position at one or both joints where the jaw-bone connects to the skull (temporo-mandibular joints).

A broken or dislocated jaw usually heals completely after treatment. However, the jaw may become dislocated again in the future.

Presentation of a Fractured Jaw:

Fractured Jaw

- Usually preceded by a blow to the jaw or chin.
- Difficulty speaking.
- Pain in the face or jaw, located in front of the ear on the affected side, which gets worse with movement.
- Sites of fracture are usually the side of the chin and near the ear.
- Casualty very often cannot match their teeth together normally.
- Presence of a haematoma under the tongue.
- The casualty may also hear or feel movement of the broken jaw.
- For a break near the ear, the jaw may move toward the broken side on opening.
- There may be tingling or numbness of the lower lip (lower jaw) or beside the nose (upper jaw).

Management of a Fractured Jaw:

Fractured Jaw Management

- Conduct primary / secondary survey (Examine Jaw) & record observations. (Observe closely for airway impairment. Airway management takes priority over jaw fractures)
- Contact duty medic / supervisor. Follow instructions from Duty Medic.
- Implement bleeding management as appropriate.
- Implement Compromised Airway Management.
- Implement Shock Management as appropriate. (O_2, I.V.I. Etc).
- If there are missing teeth, a facial wound at the fracture site or exposed bone in the mouth, start antibiotic therapy as prescribed.
- If there are wounds in the mouth, brush the teeth if possible; use a clean brush, no toothpaste.
- Irrigate the wounds with salt water, and repeat several times daily if possible without disturbing the fracture.
- Apply Fracture immobilization.
  - Close the jaw, match the teeth as normally as possible, moving the jaw back into alignment if necessary.
  - Pass several wraps of a bandage under the jaw and over the top of the head to splint the fracture.
  - If there are severe facial injuries, be sure splinting the jaw dose not threaten the airway.
  - Hold their head still with your hands. Keep the head and neck in line with the upper torso.
- Implement wound management as appropriate.
- Give analgesia according to pain level & instructions of medic.
- Look for and treat any other injuries.
- Prepare to evacuate (as per company S.O.P's).

Dental Infections 3.14.3

Almost all dental infections are the result of poor hygiene. Thin layers of debris and bacteria build up under the edge of the gum (called plaque). In time, this hardens (calculus), irritating and inflaming the gum. Bacteria penetrate the damaged gum, causing local infection. If it becomes worse, infection invades the tissue supporting the tooth and even the jawbone itself.

Types of Dental Infection

Gingivitis

The most common form of gingivitis is in response to bacterial biofilms (also called plaque) adherent to tooth surfaces, termed *plaque-induced gingivitis*, and is the most common form of periodontal disease. In the absence of treatment, gingivitis may progress to periodontitis, which is a destructive form of periodontal disease.

Pyorrhoea

A more advanced infection with loss of gum tissue, supporting tissue and loosening of teeth.

Pericoronitis

Inflammation of gingival tissue around the crown of a partially erupted tooth. The lower molars are the usual site. Gingiva around the crown is red, swollen, and painful. It is seen almost exclusively in those teeth, which are partially erupted. Pericoronitis is caused by bacterial infection of the gingiva.

Gingivitis

Presentation of a Dental Infections:

- Inflammation, redness and tenderness all over the gums.
- Bleeding. The teeth and gums of a person who has gingivitis become so sensitive that they start bleeding even while brushing or flossing.
- Discharge of pus.
- Toothache.
  - o Severe, continuous pain.
  - o Gnawing or throbbing pain.
  - o Sharp or shooting pain.
- Pain when chewing.
- Sensitivity of the teeth to hot or cold.
- Bitter taste in the mouth.
- Breath odour. One of the main symptoms of gum infection, especially of peridontitis, is bad breath. You may have a foul mouth odour, which may not go away even after trying out different treatment methods.
- Possible fever.
- It is also common to experience mouth ulcers during gum infection.

Management of Dental Infections:

- Conduct primary / secondary survey (Examine oral cavity) & record observations. (Observe closely for airway impairment. Airway management takes priority over jaw fractures)
- Contact duty medic / supervisor. Follow instructions from duty medic.
- Implement compromised airway management.
- Give analgesia according to pain level & instructions of medic. (Paracetamol & NSAID's are useful)
- Local heat pack can give some analgesic effect.
- Irrigate mouth with warm salt water (at least 3 times a day).
- Commence appropriate antibiotic therapy as prescribed & monitor effect.
- If a gum-boil appears, it can be lanced and drained with the tip of a hypodermic needle.
- Look for and treat any other injuries.
- Prepare to evacuate to dental facility if nil improvement (as per company S.O.P's).

Oral Antibiotics

Section 4

Diving Medicine

HISTORY OF DECOMPRESSION ILLNESS 4.1

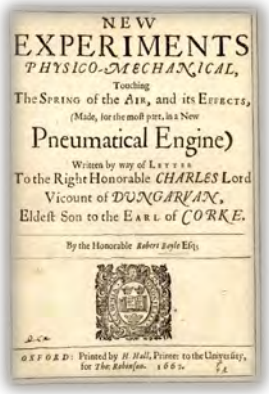
The "bends" is today readily associated with SCUBA diving. It is, in fact, an old-fashioned term used originally to describe the appearance of workers returning from 'caissons' during the construction of bridges in the 19th century. The air inside these underwater enclosures was pressurised to counteract the weight of the surrounding water. Following their shifts, some men would return to the surface suffering joint pain that made it difficult for them to stand straight. Their appearance was similar to the 'Grecian bend' adopted by fashionable women of the time - hence the name. Many workers died or suffered permanent disability because of "Caisson disease", as the condition became known.

Caisson Workers

The connection between the workers' return to the surface and their symptoms led to the introduction of surface based recompression chambers to treat the afflicted. However, the reason for the condition was not fully recognised until 1878, when Paul Bert published his theory that the cause was the formation of nitrogen bubbles within the body. He also correctly stated that it was possible to avoid their harmful affects by ascending to the surface gradually - and that hyperbaric chambers worked, in part, because they decreased the size of bubbles.

Bert noted the work of the scientist Robert Boyle. In 1667, Boyle observed that following exposure to a compressed atmosphere, and subsequent decompression, a bubble formed in the eye of a viper. The animal also appeared distressed by the experience.

As stated by Boyle's Law, ascending from a hyperbaric environment towards the surface results in an increase in the volume of a fixed amount of gas, including those found in the body. In the case of oxygen, the body quickly reabsorbs the extra volume as the cells use it up. Carbon dioxide, a waste product of metabolism, is excreted through the lungs very efficiently and therefore does not present a problem when decompressing.


NEW
EXPERIMENTS
PHYSICO-MECHANICAL,
Touching
The SPRING of the AIR, and its EFFECTS,
(Made, for the most part, in a New
Pneumatical Engine)
Written by way of LETTER
To the Right Honorable CHARLES Lord
Vicount of DUNGARVAN,
Eldest Son to the EARL of CORKE.
By the Honorable Robert Boyle Esq;
OXFORD: Printed by H. Hall, Printer to the University,
for Tho. Robinson. 1660.

The body does not use nitrogen, however, which forms almost 79% of the air. For the purposes of discussing decompression, it is an 'inert' gas, as is helium. Unless enough time is allowed for the inert gas to be excreted through the lungs, any collection within the body's tissues can increase in volume to the point where bubbles are formed.

These can lead to the formation of emboli (singular: embolus) that cause adverse physiological effects by impeding blood flow and/or damaging tissues or nerves. It should be noted that the presence of inert gas bubbles does not in itself lead to problems - what is important is the eventual size of these bubbles, their location, and the ability (or inability) of the body to rid itself of them before they cause damage.

The first recorded chamber was built and run by a British clergyman named Henshaw. He built a structure called the *domicilium* that was used to treat a multitude of diseases. The chamber was pressurized with air using bellows.

Steel Ball Hospital

The French surgeon Fontaine, who built a pressurized, mobile operating room in 1879, continued the idea of treating patients under increased pressure.

Dr. Orville Cunningham, a professor of anaesthesia, ran what was known as the "Steel Ball Hospital." The structure, erected in 1928, was 6 stories high and 64 feet in diameter. The hospital could reach 3 atmospheres of pressure. The hospital was closed in 1930 because of the apparent lack of scientific evidence indicating that such treatment alleviated disease. It was deconstructed during World War II for scrap to aid the war effort.

DYSBARISM 4.2 (The Diseases of Diving)

Dysbarism refers to medical conditions resulting from changes in ambient pressure. Various activities are associated with pressure changes. Diving is the most common, but pressure changes also affect people who work in other pressurized environments (caisson workers), and people who move between different altitudes.

Within diving the term dysbarism can be used to describe a host of diving conditions.

These Include;

- Barotraumas.
- Arterial Gas Embolisms (A.G.E.)
- Decompression Sickness.

Acute Decompression Illness 4.2.1

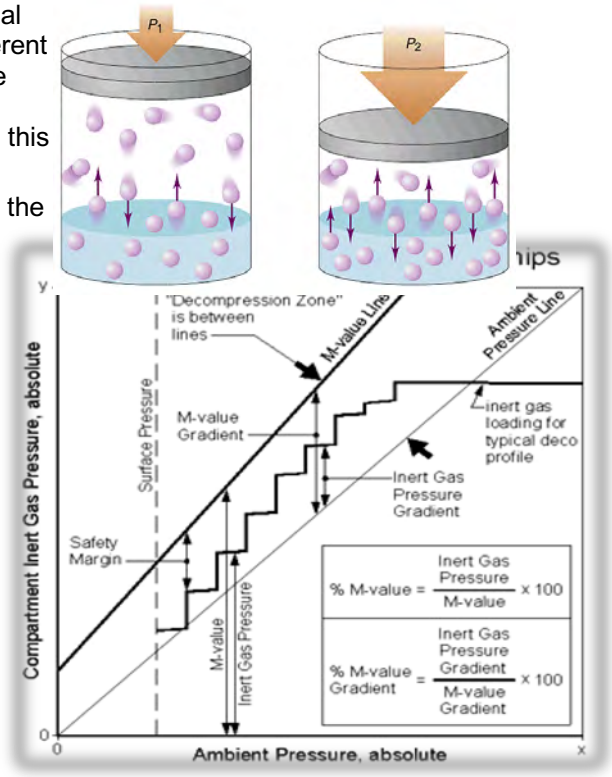
Decompression Illness (DCI) is a term that has been used for over 50 years. DCI includes both A.G.E.'s and Decompression Sickness.

Acute decompression illness (DCI) is a syndrome of numerous possible manifestations, which may develop following decompression. It is thought to be initiated by bubbles of inert gas in the body tissues and blood stream. Although the means where, by these bubbles cause tissue dysfunction have yet to be fully understood, the manifestations have been recognised for many years and are described below.

Disease Mechanisms

There Are A Number Of Sources Of These Gas Bubbles:

The partial pressure of inert gas in arterial blood is approximately the same as the partial pressure in the gas mixture, which is being breathed. For example, at sea level, both air and arterial blood contain approximately 0.79 bar of nitrogen. During most dives or hyperbaric exposures, the partial pressure of the inert gas being breathed increases with depth and the concentration of that gas in arterial blood increases accordingly. For example the partial pressure of nitrogen in air at 2 bar is approximately 1.58; when this is breathed the partial pressure of nitrogen in the arterial blood is also approximately 1.58 bar. This effect is the same with different mixes and inert gases such as helium. Under these circumstances, the partial pressure of inert gas in tissues will gradually increase due to blood/tissue gas transfer until it equals the ambient partial pressure. In this state the tissues are considered to be saturated.



During decompression, inert gas moves in the opposite direction, from the tissues into the blood, where it is carried to the alveoli in the lungs and exhaled. If this process occurs in a controlled manner, so that the inert gas tension in the tissues does not reach a sufficient level of super saturation (exceeding M values) then bubbles of gas will not form and the decompression will progress uneventfully. However, if the rate of decompression is such that the capacity of the tissues, cardiovascular system and lungs to remove inert gas is exceeded, bubbles of that gas may start to form in tissues or blood.

Bubbles in venous blood, for example, are efficiently removed from the circulation by the lungs and numerous studies have demonstrated the presence of such bubbles in asymptomatic divers. Furthermore, bubbles may form in some tissues (such as adipose tissue) without causing overt disease. However, other tissues, particularly nervous tissue, are much more sensitive and the presence of even a small number of gas bubbles may result in abnormal tissue function.

Arterial gas bubbles. The lungs are excellent filters of gas bubbles. However, this capacity is finite; if the bubble burden is such that this is exceeded, they will transit the lungs and enter the arterial circulation. This can occur after heavy gas tissue loading and a rapid decompression.

The transit of venous bubbles to arterial blood may occur before the pulmonary filter is overwhelmed. In approximately 25-30% of the normal, adult population, the septum that separates the upper chambers of the heart contains a potential or actual defect, which is known as a Patent Foramen Ovale or PFO (This is a relic of the foetal circulation and normally results in no ill effects). However, it does offer a possible route for bubbles to bypass the pulmonary filter and consequently, along with other right-to-left shunts, has the potential to promote the arterialization of otherwise relatively harmless venous bubbles.

Bubbles in arterial blood physically obstruct small blood vessels and thereby cause tissue ischaemia (oxygen starvation through reduced blood flow).

This Localised Ischaemia Create A Cascade Reaction Which;

- Initiates local tissue inflammatory reaction.
- Increases localised tissue ischaemia.
- Increased endothelial permeability + leakage of plasma.
- Increased local pressure.
- Resulting in further inflammatory reaction & activation of the immunological complement.

Although it is recognised that tissue bubbles may arise from two fundamentally different processes it is often difficult, in individual cases, to be certain of the origins of the disease-provoking gas. Indeed, with respect to some organ systems, such as the ear and lungs, it may occasionally be difficult to distinguish between a bubble-induced condition and the results of barotrauma.

Consequently, it is now recognised that, for practical purposes, the distinction between the conditions that used to be known as decompression sickness and arterial gas embolism was artificial. As a result, the term decompression illness, which encompasses the two, is increasingly being used to reflect this.

Manifestation of D.C.I. 4.2.2

DCI is a multi-system disease with single organ involvement is uncommon.
The effects of the gas bubble load tends to attack the densest of tissue (or the slowest compartments), these are the nervous system, tendons / synovial joints, lymphatic tissue and adipose (fat).
DCI may present with a bewildering array of symptoms, which can lead the clinician to suspect what the underlying system effected is.

DCI type	Bubble location	Signs & symptoms (clinical manifestations)
Neurologic	Brain	• Altered sensation, tingling or numbness paresthesia, increased sensitivity hyperesthesia. • Confusion or memory loss. • Visual abnormalities (Including NYGAGMUS). • Unexplained mood or behaviour changes. • Seizures, unconsciousness.
Neurologic	Spinal cord	▪ Ascending weakness or paralysis in the legs. ▪ Girdling abdominal or chest pain. ▪ Urinary incontinence and fecal incontinence.
Audio-vestibular (Neurologic)	Inner ear	▪ Loss of balance. ▪ Dizziness, vertigo, nausea, vomiting. ▪ Hearing loss.
Constitutional (Probable Neurologic)	Whole body	▪ Headache. ▪ Unexplained fatigue. ▪ Generalised malaise, poorly localised aches.
Musculoskeletal	Mostly large joints (elbows, shoulders, hip, wrists, knees, ankles)	Localized deep pain, ranging from mild to excruciating. Sometimes a dull ache. Active and passive motion of the joint aggravates the pain. ▪ The pain may be reduced by bending the joint to find a more comfortable position.
Pulmonary	Lungs	▪ Dry persistent cough. / Shortness of breath. ▪ Burning chest pain under the sternum, aggravated by breathing.
Cutaneous	Skin	• Itching, usually around the ears, face, neck, arms, and upper torso. • Sensation of tiny insects crawling over the skin. • Mottled or marbled skin usually around the shoulders, chest and abdomen, with itching. • Swelling of the skin, accompanied by tiny scar-like skin depressions (pitting odeama).
Lymphatic	Lymphatic Vessel	▪ Localised tissue swelling / oedema. ▪ Possibly due to blockage of the lymphatic vessels draining a specific group of lymph nodes (usually in trunk, head or neck).

Traditional Classification Of DCI 4.2.3

As discussed, DCI as a disease / syndrome has been in existence for over 150 years. It is not surprising then that the disease has had many names and tools to describe its effects.

In addition to the "bends", the effects of "Caisson disease" have several other descriptive terms, the "chokes", "staggers" and "niggles".
From the 1950's the label 'decompression sickness' (DCS) was introduced in place of "Caisson disease".

Decompression Sickness Was Divided Into Three Subsections:

- Arterial Gas Embolisms.
- Type 1.
- Type 2.

The different classification reflects the effect, and therefore the severity, of the condition. Diagnosing DCS as one (or both) of just two categories does not enable proper identification or discrimination.
Arterial Gas Embolisms are discussed later in Barotraumas. However, the two types are described here.

Type 1 D.C.I.

Type 1 DCS can occur when bubbles affect the tissues around skeletal joints. Decompression sickness might also present as a skin (cutaneous).

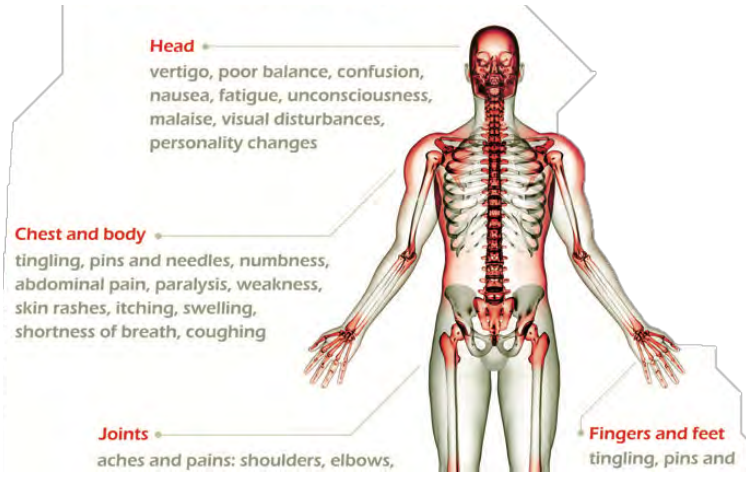
- Local pain, usually in joints of arms or legs (knees, elbows and shoulders).
- Pain made worse by exercise.
- Itching, blotchy skin rash, mottling, raised section of the skin.

Type 2 D.C.I.

Type 2 Decompression Sickness reflects involvement of the Central Nervous System (CNS) and / or the cardio-respiratory system.
More than half of those diagnosed with DCS will be classified as Type 2. Cerebral symptoms arise from interruption of the blood supply to the main part of the brain, and include confusion, reduced mental function and unconsciousness.
Involvement of the cerebellum may lead to tremors, loss of balance ("staggers") and a lack of co-ordination (ataxia). Balance may also be affected by damage to the vestibular part of the inner ear.

Symptoms Include:

- Dizziness.
- Ringing in ears.
- Difficulty in seeing.
- Shortness of breath.
- Rapid breathing.
- Choking.
- Severe pain.
- Pain in abdomen.
- Extreme fatigue.
- Loss of sensation (numbness).
- Weakness of extremities.
- Staggering.
- Paralysis.
- Collapse or unconsciousness.



The advantages of using the 'classical' classification system are overall familiarity, for over 50 years it has been the accepted description of the manifestation of DCI.

However there are multiple disadvantages in the use of this classification system; precise mechanistic diagnosis is often impossible due to the fact that DCI frequently have multiple manifestations.

It is common for multiple physicians to describe a condition as both Type 1 & Type 2 leading to a wide variations in diagnosis and ultimate treatment.

Modern Terminology Of DCI 4.2.4

Since the late 1990's a much more modern, descriptive-manifestation system of classifying DCI was introduced (At a 1991 Undersea and Hyperbaric Medical Society workshop).

Since decompression illness can interfere with the function of a wide range of body tissues, the number of potential signs and symptoms is truly enormous. Rather than using a somewhat artificial classification on the decompression disorders (types I and II), a better understanding of DCI is likely to result if a descriptive system is used.

This System Is Split Into Three Components:

- Time of **onset** of symptoms.
- The **evolution** of symptoms.
- The actual **symptoms**.

Onset

The time of symptom onset is a key factor in the diagnosis of DCI 98% of all DCI's will present within exit from the water. The term "acute" is used to distinguish these conditions from possible "chronic" consequences of diving such as dysbaric osteonecrosis.

- **Acute.** The condition has manifested recently.
- **Chronic.** The condition has manifested some time ago..

Evolution

The evolution term is used to describe the development of the condition PRIOR TO RECOMPRESSION. DCI is frequently a rapidly changing condition.

The Evolution Of The Symptoms May Be Described As:

- **Progressive.** A progressive condition would be if the number or severity of symptoms or signs is increasing.
  - o Increasing severity of limb pain and the involvement of additional joints.
  - o A neurological presentation in which the loss of motor or sensory function is becoming more profound.
  - o The development of a new manifestation.
  - o Terms such as "rapidly" or "slowly" may be used to enhance the description of this evolution.
- **Static.** This is self-explanatory. Neither the severity nor number of manifestations is changing substantially.
- **Spontaneously Improving.** DCI that improves, without recompression.
  - o Cutaneous skin bends. (Substantial improvement must occur for this term to be applied).
  - o As with other evolution terms, "improving" should only be used to describe events prior to recompression.
- **Relapsing.** Occasionally, cases that have improved spontaneously undergo a secondary deterioration.
  - o Common with neurological manifestations.
  - o When a condition gets worse in the absence of spontaneous improvement it is described as

"progressive".
- "Relapsing" should be reserved for cases, which have, at some stage in their evolution, undergone substantial and spontaneous improvement.

Symptom Manifestations

There are a number of manifestations of decompression illness, which occur commonly, and these are outlined below. They may occur alone or in combination.

- **Limb Pain**. One the most frequent manifestation of DCI (second to lethargy / fatigue).
  - Deep aching pain in or around one or more joints.
  - Following 'bounce' dives, the upper limbs and the shoulder is involved particularly frequently.
  - Conversely, in saturation divers, it is the lower limbs and the knees, which are involved most commonly.
  - The pain is usually poorly localised; it may resolve spontaneously and is then known as a 'niggle'. Niggles may flit from joint to joint.
  - If the pain gets worse, it becomes more readily localised and is described as a dull, boring ache, similar in character to tooth ache. Sometimes the joint is held in a particular position that is least painful, but pain is seldom made worse by movement.
  - If the pain is in a lower limb, weight bearing may be poorly tolerated on that limb.
  - The 'classical' signs of inflammation: redness, swelling, warmth to the touch and tenderness are **missing.**
- **Girdle Pain**. This is a poorly localised, aching or 'constricting' sensation, generally in the abdomen or pelvis.
  - Girdle pain is generally considered ominous since it frequently portends neurological deterioration.
- **Neurological.** Involvement of the nervous system may be subtle and multi-focal. Consequently symptoms can be of bewildering variety and very difficult to localise. Both the central and peripheral nervous systems may be involved and the manifestations can be broken down into the loss of certain functions:
  - Aberration of thought processes, loss of memory, speech disorders, alteration to the level of consciousness including seizures; loss of co-ordination; loss of strength or sensation.
  - Dysfunction of special senses and loss of sphincter control, especially of the bladder.
  - Loss of consciousness to the point of disorientation is a frequent finding and coma may occasionally ensue.
  - Motor and other sensory deficits.
  - Signs such as a change of mood, dulling of intellect and loss of short-term memory.
- **Neurological (Spinal).** Spinal cord is involved in neurological DCI with some frequency. It may appear to be involved alone or with other parts of the nervous system.
  - Short, deep dives with a rapid ascent to the surface are commonly involved.
  - The onset of symptoms commonly occurs shortly after dive (about half of cases are symptomatic within 10 minutes).
  - Less than 10% of serious cases present more than 4 hours after completing the dive.
  - In severe cases, the condition is often heralded by the onset of girdle pain.
  - Shortly afterwards, the patient may notice pins and needles, numbness and muscular weakness in the legs.
  - Which may rapidly progresses to paraplegia.
  - Neurogenic (spinal) shock may complicate the clinical picture.
  - The bladder is frequently involved (difficulty to void or full retention).
- **Audio-Vestibular (Neurological).** This is a unique subclass of neurological decompression illness. It is thought that there are two mechanisms whereby the audio-vestibular system may be involved: barotrauma (perilymph fistula / oval round window rupture) and tissue injury resulting from the formation of bubbles from dissolved gas.
  - Targets of these micro-bubbles include; the cochlea, the eighth nerve nuclei and cortical pathways.
  - It is very difficult to distinguish between these mechanisms or sites of injury by clinical examination alone.
  - The syndrome includes: vertigo (a sense of rotation), tinnitus, nystagmus or loss of hearing after a dive.
  - Nausea and vomiting may accompany these symptoms.
  - Previously there has been hesitation before prescribing recompression in such cases for fear of further tissue damage.
  - Recompression does not have an adverse effect on pathology due to round or oval window rupture.
- **Pulmonary. (The Chokes)** Related to the lungs: decompression pulmonary barotrauma and the cardiopulmonary consequences of massive venous gas embolism.
  - The mechanisms are distinctly different; it may be difficult to distinguish between them immediately in a clinical setting, because many of the symptoms and some of the signs are shared.
  - Those which imply pulmonary (or, rarely, cardiac) involvement in decompression illness are: chest pain, cough, haemoptysis, shortness of breath, cyanosis and, rarely, cardiogenic shock.

- Progressive disease (where the symptoms are worsening) may be due either to a tension pneumothorax or massive gas embolism of the lungs.
- Where there has been a dive, which has induced a low gas burden, it is most likely that a pneumothorax. This may be diagnosed clinically from the classic signs (described in the Gas Embolism section).

- **Cutaneous.** The skin may be affected in two manifestations of decompression:
  - Cutaneous DCI generally presents with severe itching around the shoulders or over the trunk.
  - This develops into an erythematous rash, which may progress to cyanotic mottling or marbling of the skin.
- **Lymphatic.**
  - Lymph nodes may become enlarged and tender and this may be associated with oedema.
  - The skin feels thickened and may have the 'pitted' appearance of orange peel.
  - If pressure is applied to the skin for about a minute or so, a visible indentation remains.
- **Constitutional.** There are a number of non-specific symptoms that occur after diving and which, if severe or accompanied by other manifestations, may be considered part of the decompression illness syndrome.
  - Symptoms include headache, fatigue, malaise (may include nausea and vomiting) and anorexia (loss of appetite)

Applying The Terminology

By including the onset, evolution and manifestation terms in the phrase "decompression illness", a highly flexible diagnostic label can be applied to any case. This label imparts a great deal of information and because it does not require the observer to guess at either a mechanism of the disease or location of the lesion, it should be possible for these terms to be applied consistently.

This is an important tool because the diagnosis of DCI is overall a clinical one (there is no diagnostic blood test or xray).

The disadvantage of this system is that it is generally verbose and it marginally ignores pathophysiology (rather than distinguish between musculo-skeletal and neurological pain, it simply uses 'limb pain').

The advantages of this system are; an improved data collection with regards to manifestations of DCI, No real need for precise mechanistic diagnosis, a uniformity of reporting cases of DCI and once a clinician is use to the system it is relatively easy to use.

Examples Of How The Terminology Is Used Include:

Acute , Relapsing, Neurological, DCI

or:

Acute, Progressive, Limb Pain And Cutaneous DCI

In rare, highly complex cases, rather than enumerate a long list of manifestations, it may be appropriate to use the term 'multi-system'.

Example Diver

25 year old male, diving on air.

- 2 dives:
  - 32 metres for 45 minutes total dive time.
  - 2 hour surface interval.
  - 32 metres for 35 minutes total dive time.

Worsening pain in left shoulder, with associated tingling in left hand, 30 mins after surfacing from 2nd dive.

Description:

Acute Progressive Neurological and Limb Pain DCI.

Additional DCI Factors 4.2.5

While the descriptive diagnostic terminology imparts a considerable amount of information, it is inadequate, of itself, to summarise a case of decompression illness. DCI is a poorly understood syndrome and if a better understanding is to evolve, it is important that additional information is collected:

% Cases	First Symptoms
42%	Within 1 Hour
60%	Within 3 Hours
83%	Within 8 Hours
98%	Within 24 Hours
100%	Within 48 Hours

The Time Of Symptom Onset

DCI usually presents within a 24hr period following a dive although rarely it can present outside of this. Symptoms may become apparent before surfacing in saturation and occasionally in bounce dives, particularly where decompression has been omitted.

Most symptoms occur after surfacing and the majority of serious neurological or pulmonary symptoms are usually manifest within about 30 minutes.

The onset of limb pain also occurs in this time period but this may be delayed for many hours after a dive. It should be remembered that decompression illness might be provoked or made worse many hours after a dive if the diver takes a flight. If a diver has been asymptomatic for 48 or more hours after a dive and has not flown, then symptoms, which develop subsequently, are probably not DCI.

The time of onset of symptoms influences prognosis, a short latency implies severe disease (e.g A.G.E. / C.A.G.E.), late severe symptoms indicates a secondary pathology (such as haemorrhage).

An exceptionally delayed DCI should not be completely discounted due to the possibility of 'diver denial', this is a basic reluctance of an individual diver to admit that they have relevant symptoms.

Gas Burden

When considering possible mechanisms for DCI, it is desirable to estimate the amount of gas that is likely to be present in the various tissues. Consequently it is important that the dive profile is recorded as accurately as possible with the inclusion of the gas mix breathed. Where a dive computer or depth-time recorder was worn, the information should be retrieved from this source.

Presence of Risk Factors

It is important to evaluate the possible risk factors associated with the dive, these risk factors include;

- Dive profiles (Sawtooth pattern / shallow to deep dives / rapid ascent / multiple daily dives / omitted decompression / new dive / exercise at depth / during or after decompression).
- Individual diver (Age-fitness-weight of diver / dehydration / Patent foramen ovale (PFO) / Limb tourniquetion).
- Temperature (High temperatures lead to dehydration > blood plasma loss > reduced venous off-gassing. Low temperatures cause vasoconstriction & reduced off-gassing, particularly in adipose tissue).
- Altitude exposure. (This does not have to be flying alone; a mountain ascent is an equal risk factor).

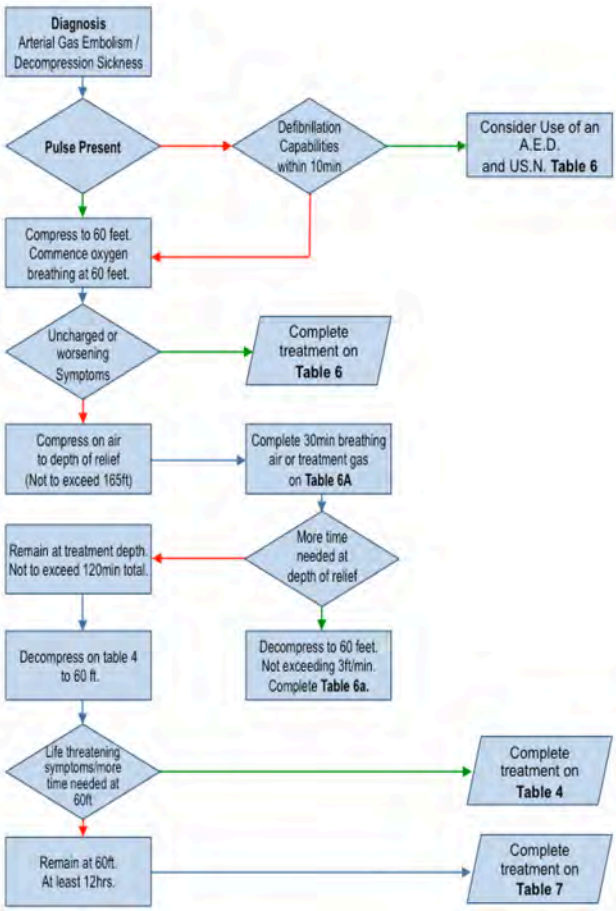
Treatment of D.C.I. 4.2.6

Immediate Actions in D.C.I.

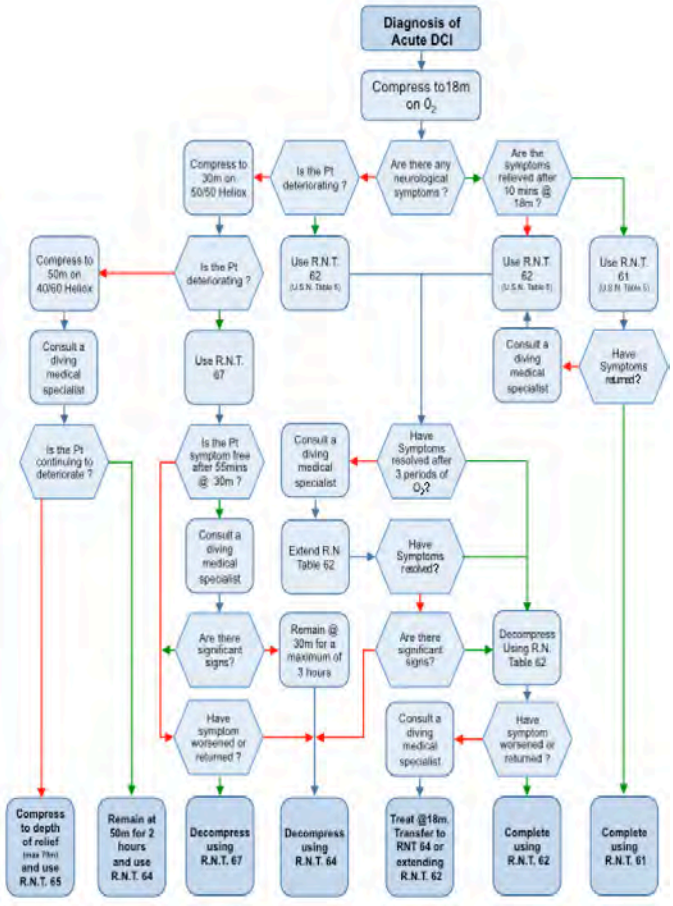
If a diver is suspected of suffering decompression illness the following immediate actions should take place.

- Contact duty medic / supervisor.
- Conduct primary / secondary survey (including full neuro exam) & record observations.
  - Apply D.C.I. manifestation criteria (ONSET – EVOLUTION – SYMPTOMS).
- Lay the casualty flat and administer high flow O_2.
- Implement airway / breathing management.
- Implement Shock Management as indicated.
- Start immediate recompression on appropriate treatment table (as advised by medical specialist or if unavailable company SOP).
  - Use appropriate treatment algorithm such as the R.N or U.S.N.
- Repeat, and complete physical examination when patient is at treatment depth in recompression chamber.
  - Continue to apply treatment algorithm in accordance with the divers condition.

United States Navy D.C.I. Treatment Algorithm



Royal Navy D.C.I. Treatment Algorithm



**The Treatment tables are printed in a full-page format in the DOCUMENTATION section. The R.N. tables are discussed at length in this section.*

ARTERIAL GAS EMBOLISM'S (A.G.E.) 4.3

A gas embolism occurs when a bubble of gas causes a blockage of the blood supply to the heart, brain or other vital tissue. The condition is worsened if the embolism occurs at depth as the bubble will increase in size as the pressure decreases.

When divers hold their breath or have local air trapped in their lungs during ascent, the pressure-volume relationships will cause a rapid over expansion.

Alveoli can rupture or air can be forced across apparently intact alveoli. If air bubbles enter the pulmonary veins, they are swept to the left side of the heart and pumped out into the aorta. Bubbles can enter the coronary arteries supplying the heart muscle, but they are more commonly swept up the carotid arteries to embolise the brain.

As the bubbles pass into smaller arteries, they reach a point where they can move no further and here they occur immediately or within 5 minutes after surfacing.

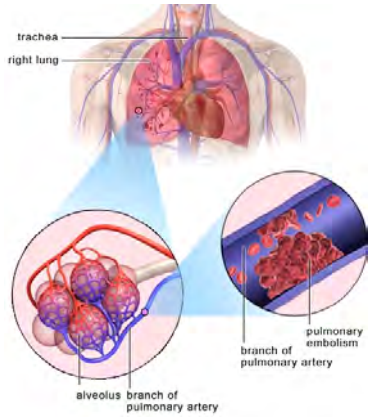
Pulmonary Arterial Gas Embolism (P.A.G.E.) 4.3.1

Decompression pulmonary barotrauma is a syndrome, which results in dissolved gas rapidly coming out of solution and entering either the interstitial space within the lung, the pleural cavity or the blood stream.

At the simplest level, if gas that has been breathed while at depth is trapped within the lung during ascent, then the resulting expansion in volume of that gas, in accordance with Boyle's Law, may be sufficient to cause the architecturally delicate pulmonary tissue to rupture and overwhelming the pulmonary filter.

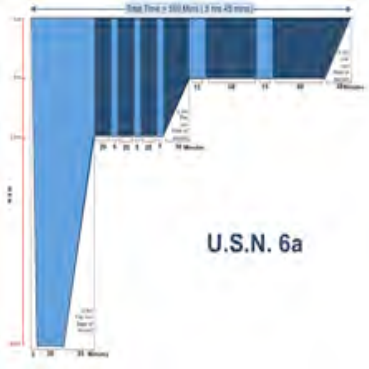
The gas may be trapped as a result of breath holding, or as a result of pulmonary pathology.

Presentation of Pulmonary Arterial Gas Embolism



- Rapid onset symptoms (usually < 10 minutes):
  - 9% occur during ascent.
  - 83% occur in less than 5 minutes of surfacing.
  - 8% occur between 5-10 minutes.
- Possible pneumothorax (associated pulmonary barotrauma rupture).
- Abnormal airway signs: **Distress / wheeze / Haemoptesis** (Bloody, frothy sputum).
- Neck Signs: Trachea Deviation possible / distended **neck Veins / possible Emphysema.**
- Breathing (RISE – FALL): **rapid Rate** / **possible aSymmetrical movement** / **gross Effort & accessory muscle use** / **hypo-resonant on affected side** / breath sounds: **absent or gross crepitus.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Low SPO_2 levels.
- Cardiogenic shock.
- Chest pain (usually behind the breastbone).
- Neurological signs:
  - Visual disturbances such as blurring.
  - Seizure (Focal / Generalised).
  - Sudden unconsciousness (usually iafter surfacing but sometimes before surfacing).
- Pulmonary / Cardiac Arrest.

A.G.E. Recompression Table (U.S.N. 6a)



Management of Pulmonary Arterial Gas Embolism

- Conduct primary / secondary survey (Including neuro exam) & record observations.
- Contact duty medic / supervisor (URGENTLY).
- Implement tension pneumothorax management as indicated.
- Implement airway / breathing management (ALWAYS initiate O_2, R.S.I. is often required for intubation).
- Implement Shock Management as indicated. (O_2 , I.V.I. etc).
- Positioning the patient in a horizontal -15% inclination.
- Start immediate recompression (as advised by medical specialist or if unavailable company SOP often USN 6a is appropriate).
- Continually assess casualty & record observations.
- Prepare to evacuate (as per company S.O.P's).

Cerebral Arterial Gas Embolism (C.A.G.E.) 4.3.2

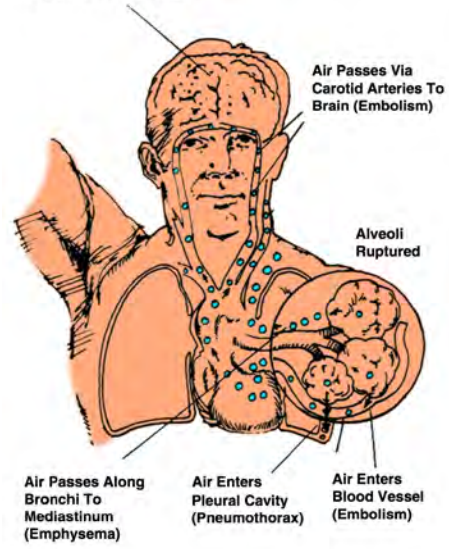
Arterial gas emboli arise from gas bubbles in the pulmonary capillaries, which then pass to the pulmonary veins to the left side of the heart (possibly causing coronary artery emboli). The gas will pass via the internal carotid and vertebro-basilar arteries to the brain.

The gaseous foam or bubbles block arteries of the 30-60 micron and cause distal ischemia and neuronal swelling. As the bubble passes over the endothelium, there are direct cellular effects (within 1-2 minutes). The bubble itself has surface effects causing local swelling, downstream coagulopathy with focal hemorrhages.

There is immediate increased permeability of the blood-brain barrier, loss of cerebral auto-regulation, rise in CSF and a rise in the systemic blood pressure.

CAGE is a life-threatening emergency with the clinical picture of a stroke and requires immediate medical treatment in line with a P.A.G.E.

C.A.G.E.
(Cerebral Arterial Gas Embolism)



Presentation of Cerebral Arterial Gas Embolism

- Symptoms of P.A.G.E. (including rapid onset).
- Neurological changes;
  - Stroke (F.A.S.T.).
  - Headache.
  - Blindness (partial or complete).
  - Numbness and tingling.
  - Weakness or paralysis.
  - Seizure (Focal / Generalised).
  - Sudden unconsciousness (usually immediate after surfacing but sometimes before surfacing).
- Pulmonary / Cardiac Arrest.

Management of Cerebral Arterial Gas Embolism

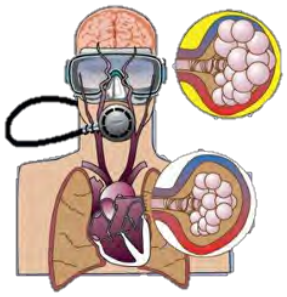
- Implement P.A.G.E. management.
- Contact duty medic / supervisor (URGENTLY often evacuation for neurosurgical review is necessary).
- Implement seizure management.
- Implement stroke & cerebral compression management.
  - Often stabilization with ventilation & sedation is mandatory.
  - Maintain a flat or a 15° reverse trandelenberg position.
- Prepare to evacuate (as per company S.O.P's).

Reverse Trandelenberg Position

PULMONARY BAROTRAUMA'S 4.4

Barotrauma is physical damage to body tissues caused by a difference in pressure between an air space inside or beside the body and the surrounding fluid.

Barotrauma typically occurs to air spaces within a body when that body moves to or from a higher pressure environment, such as when a diver or an airplane passenger ascends or descends, or during uncontrolled decompression of a pressure vessel. Boyle's law defines the relationship between the volume of the air space and the ambient pressure.



Damage occurs in the tissues around the body's air spaces because gases are compressible and the tissues are not. During increases in ambient pressure, the internal air space provides the surrounding tissues with little support to resist the higher external pressure. During decreases in pressure, the higher pressure of the gas inside the air spaces causes damage to the surrounding tissues if the gas becomes trapped.

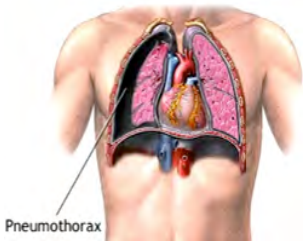
Pneumothorax 4.4.1

A pneumothorax may occur when alveolar gas escapes into the pleural space. This is an over expansion injury which has caused alveolar over expansion & rupture.

This is not a life-threatening condition because it is possible to survive with one intact lung and it is most unusual for both lungs to be involved simultaneously. Occasionally, the leak is such that gas escapes into the pleural space with each breath, but is unable to return to the lung. Under these circumstances the volume of the pneumothorax gradually increases.

This is known as a tension pneumothorax.

Over-expansion Pneumothorax



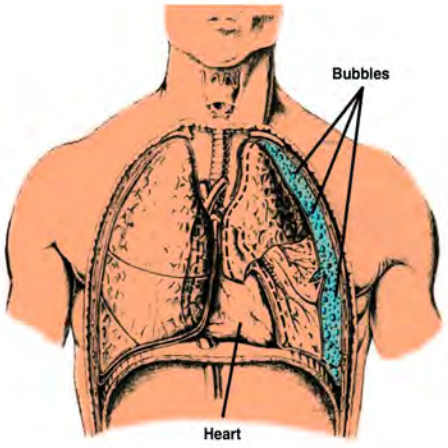
Presentation of a Pneumothorax (severe)

- Commonly the pneumothorax is small and there are few physical signs.
- Abnormal airway signs: **Distress / wheeze.**
- Neck Signs: Trachea deviation (late sign) / distended **neck Veins / Emphysema present / L**arynx intact.
- Breathing (RISE – FALL): **rapid Rate / aSymmetrical movement / gross Effort & accessory muscle use / Feel emphysema / hyper-resonant on affected side** / breath sounds: **absent on affected side.**
- Difficulty speaking (will need to take a breath in the middle of a sentence).
- Painful breathing / complain of chest pain.
- Rapid pulse rate (tachycardia).
- Non-palpable radial pulse (Reduced blood pressure).

Right Sided Pneumothorax

- Reduced conscious level (cerebral hypoxia).
- Pale, clammy skin / Grey or blue lips and skin (cyanosis).

Closed Pneumothorax



Management of a Pneumothorax

A Small Pneumothorax Can Be Treated Conservatively:

- Contact duty medic / supervisor.
- Conduct primary / secondary survey & record observations.
- Administer high flow O_2 on the surface.

Large Pneumo-Thoraces And **All** Tension Pneumothoraces Require Draining.

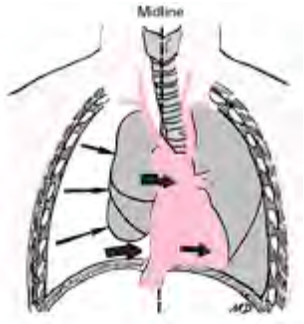
- Conduct primary / secondary survey & record observations.
- Implement compromised airway / breathing management.
- Alert Medical personnel / supervisor & prepare to evacuate.
- Observe for & treat A.G.E.'s.
- Assess for tension pneumothorax & implement treatment if present.
- Treat Shock. (Always Insert an I.V. cannula, give I.V. fluid as instructed).
- Continually assess casualty.
- If casualty is in a hyperbaric environment be aware that it can evolve into a tension pneumothorax on ascent.

Tension Pneumothorax 4.4.2

This dangerous condition has already been discussed (section 3.2.7). With regards to diving, a Tension Pneumothorax is almost exclusively an over expansion event. The presence of a diving over expansion tension pneumothorax is related an increased incidence of A.G.E's and D.C.I. in the victim.

Presentation of Tension Pneumothorax

Over-Expansion Tension Pneumothorax



- Standard Tension Pneumothorax presentation.
- Possible P.A.G.E. / C.A.G.E.
- Possible Neurological / musco-skeletal D.C.I.
- Mediastinal and subcutaneous emphysema in neck / shoulders.

Management Of Tension Pneumothorax

- Contact duty medic / supervisor.
- Conduct primary / secondary survey & record observations.
- Administer high flow O_2 on the surface.
- Implement Tension Pneumothorax treatment (See clinical skills 3.2.7)
  - Needle Decompression should always include a Heimlich valve in a chamber environment.
- Implement shock management. (O_2, I.V.I. etc).
- Implement A.G.E. / D.C.I. / Mediastinal and subcutaneous emphysema management.
- Continually assess casualty & record observations.
- Prepare to evacuate (as per company S.O.P's).
- A trained medic should place a chest drain on the affected side as soon as possible.

Mediastinal and Subcutaneous Emphysemia 4.4.3

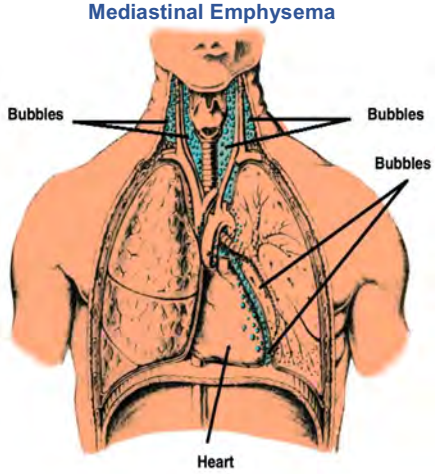
If gas escapes into the interstitial tissue space, it may track along the outside of the airways and blood vessels to the hila of the lungs and from there into the mediastinum.

This is the space between the lungs, which contains the heart, great vessels, and major airways. The presence of a little gas in the mediastinum is often symptomless.

Occasionally, considerable quantities of gas escape from the lung and this may track down into the abdomen and, rarely, the pelvis. The gas is retroperitoneal and may outline the liver and kidneys. It is unusual for such gas to generate symptoms.

However, if tissues are stretched by a substantial amount of gas, may be felt.

Mediastinal Emphysema



Presentation of Mediastinal And Subcutaneous Emphysemia.

- Often symptomless.
- A change in the tone of the voice or hoarseness.
- Swelling or crepitation (the skin "crackles') in the neck & face.

- A sensation of fullness in the chest or throat.
- Mild to moderate retrosternal pain.

Subcutaneous Emphysema

Management Of Mediastinal And Subcutaneous Emphysemia.

- Usually resolves gradually without specific treatment.
- If there are troublesome symptoms, resolution will be accelerated by:
  - o Giving 100% O_2 on the surface.
  - o Recompression as per company S.O.P. (in the very rare instances where there are serious symptoms).

BAROTRAUMA SQUEEZE'S 4.5

A *squeeze* occurs whenever fixed volume gas spaces within the body or diving gear are not pressure counterbalanced to surrounding depth.

The human body automatically adjusts to any change in the pressure of the surrounding environment; it usually does so without the person involved noticing the change.

Most of the body is composed of plasma that can transmit imposed pressure without deformation, but there are a few areas where this is not true. If the gas pressure within some air-filled cavities of the body, such as the middle ear or the bony sinuses of the skull, is not easily equalised with the surrounding pressure, an individual undergoing even mild pressure changes (such as those that occur diving or flying) may be aware of the pressure difference.

In more severe cases, pain, accompanied by fluid and blood in the middle ears and sinuses, may be the result of a "squeeze" in these areas.

Such effects are exaggerated in divers because the water that surrounds them is much denser and heavier than air. The ability of diving equipment automatically to deliver breathing gases that are the same pressure as the surrounding depth of water makes diving possible, but these compressed gases must infiltrate into all the rigid bony cavities (the middle ear, sinuses, and chest cavity) to equalise the pressure inside, or the resulting deformations will lead to pain caused by compression and contraction of tissues.

If the pressure difference is allowed to increase, blood vessels may haemorrhage and rupture.

Types of Squeezes Include:

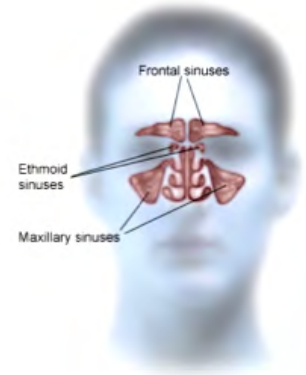
- Sinus Squeeze.
- Ear squeeze.
- Thoracic Squeeze.
- Face or Body Squeeze.
- Tooth Cavities Squeeze.

Sinus Squeeze 4.5.1

The sinus cavities are air pockets located within the skull bones that have openings into the nasal passages. These cavities are lined with a mucous membrane.

Sinus squeeze normally is the result of diving with a cold or head congestion. Adequate ventilation and pressure equalisation in the para-nasal sinuses are important in diving. Both descent and ascent depend to a large degree on adequate nasal function. Inflammation and congestion of the nasal mucosa caused by allergies, smoking, chronic irritation from prolonged or excessive use of nose drops, upper respiratory tract infections, or structural deformities of the nose can result in blockage of the para-nasal sinus openings.

Sinus Squeeze



The inability to equalise pressure on descent creates negative relative pressure within the sinus cavity, deforming the mucous membrane and causing swelling, fluid exudation, haemorrhage, and pain. Para-nasal sinus barotrauma also may occur during ascent. The key mechanism is thought to be one-way blockage of the sinus opening by cysts or polyps located within the sinus that allow pressure equalisation during descent but not during ascent.

Presentation of Sinus Squeeze:

- Sensation of fullness or pain over the involved sinus or in the upper teeth.
- Numbness of the front of the face.
- Bleeding from the nose.

Management of Sinus squeeze:

- Appropriate equalization technique.
- Cessation of compression / ascending.
- Nasal vasoconstrictors / oral antihistamines (To promote nasal mucosal shrinkage of the sinus.)
- If severe pain and nasal bleeding are present or if there is a yellow or greenish nasal discharge, with or without fever, a specialist should be seen promptly.
- Individuals with a history of nasal-sinus disease should have an E.N.T. evaluation before beginning to dive.

External Ear Squeeze 4.5.2

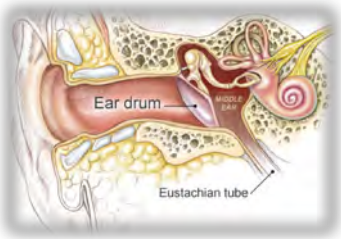
Injury to the external ear canal due to inability to equalise the external ear space as a result of an obstruction. This is generally caused by tight hoods, ear-plugs, and most commonly wax. In this case, if the Eustachian tube is functioning normally, the pressure in the external ear canal is negative relative to the outside atmosphere, the air in the nose and in the middle ear. The ear drum bulges outwards, blood and tissue fluid is forced under the skin of the external ear canal forming blood blisters and ultimately the ear drum may rupture.

Notable presentation includes severe ear pain and possible inflammation of the external ear canal. Worsening of this condition by increasing the pressure differential may lead to a ruptured eardrum resulting from the squeeze.

Rupture may occur with as little as 100 hGmm difference between the external auditory canal and the middle ear (only 1metre of sea water).

Presentation Of External Ear Squeeze:

External Ear Squeeze



- Fullness or pressure in region of the external ear canals.
- Pain.
- Blood or fluid from external ear.
- Rupture of ear-drum (entrance of cold water into the middle ear).
  - Extreme dizziness (vertigo).
  - Nausea, and possible vomiting.

Management of External Ear Squeeze:

- Appropriate equalization technique.
- Cessation of compression / ascending.
- Ear-drum rupture should be treated according to the procedures for treating middle ear barotraumas.

Middle Ear Squeeze 4.5.3

This is the most common transient ear problem associated with diving or barotrauma. It is defined as physical damage between the eardrum and eustachian tube, which is caused by inadequate pressure equalisation between the middle ear and the external environment.

Most commonly it is due to blockage of the Eustachian tubes, with catarrh or mucus. Nasal conditions such as congestion and discharge increase the likelihood of poor eustachian tube function during the dive. Absence of pre-dive symptoms does not guarantee that a diver will not develop middle ear barotrauma.

Presentation Of A Middle Ear Squeeze:

- The symptoms of middle ear squeeze consist initially of pain and a sensation of ear blockage.
- Conductive hearing loss (but may not be the primary complaint because of the intense ear pain).
- Mild tinnitus and vertigo.
- Blood in middle ear / eardrum.
- If the ear drum ruptures;
  - The pain is usually relived.
  - Cold water may enter the middle ear causing:
    - Dizziness.
    - Nausea.
    - Ringing in ears.
    - Acute or chronic infection with resultant temporary or permanent deafness.
- Excessive Valsalva manoeuvre may cause damage to the oval window.

Management of Middle Ear Squeeze:

- Divers should attempt to re-establish pressure balance as quickly as possible.
- If unable to resolve this difficulty quickly, the diver should ascend to the surface.
- Often, returning to the surface is all that is necessary to relieve the symptoms of mild ear squeeze, (but it may take a few days for the fluid or blood to drain from or be absorbed from the middle ear cavity).
- A nasal decongestant spray, nose drops, a mild vasoconstrictor medication, or an antihistamine taken by mouth may help.
- Chewing gum, yawning, or swallowing may also help.
- If examination reveals that the diver has a rupture of the ear drum, the diver should:
  - Be seen by a physician.
  - Stay out of the water until the tear has healed, which usually occurs quickly (unless an infection in the ear delays the repair process).
  - Monitor the healing process and take steps to control infection in the damaged ear.

Barodontalgia (Tooth Cavities Squeeze) 4.5.4

Pain or injury of a tooth or a filling caused by increasing pressure on faulty fillings or decayed teeth.

Airspace underneath a filling may cause implosion on descent, a venting tooth cavity may fail on ascent leading to explosion of filling from tooth, or in extreme cases the tooth itself may explode.

Barodontaglia

Presentation Of Tooth Squeeze:

- Pain in affected tooth and maxillary sinus pain.
- Tooth may implode.

Management Of Tooth Squeeze:

- Stop descent - return to surface.
- Analgesic management as required.
- Dental review.

Face or Body Squeeze 4.5.5

This is caused by sudden non-equalisation of a facemask, suit, or hardhat resulting from failure of surface gas supply / non-functioning of non-return valve, or a rapid increase in depth without compensating gas pressure.

Pain caused by local tissue compression and possible haemorrhage of blood vessels in affected tissue.

Presentation of Face / Body Squeeze:

- Pain around eyes and the site of the squeeze.
- Blood-shot eyes.
- Bleeding into skin, around eyes, or from nose may occur.
- Puffed-swollen cheeks.

Face Squeeze

Management of Face / Body Squeeze:

- Mild - none.
- Severe - stop diving until clear.
- Analgesia medication as necessary.

Thoracic (Lung) Squeeze 4.5.6

This barotrauma is caused by compression of lungs to less than their residual volume resulting from an extremely deep free dive (breath holding) or pronounced body squeeze.

May cause lung damage due to blood and tissue fluids being forced into the alveoli and air passages.

Presentation Of Thoracic Squeeze:

- Feeling of chest compression during descent.
- Pain in the chest.
- Difficulty in breathing on return to the surface.
- Bloody sputum.

Management Of Thoracic Squeeze:

- In severe cases, the diver requires assistance to the surface.
- Implement reduced consciousness care.
- Implement airway / breathing interventions.
- Medically assess & evaluate.

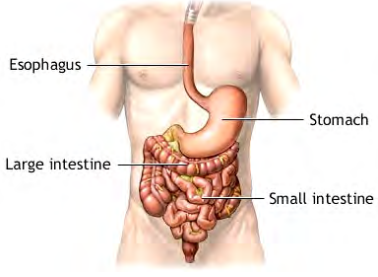
G.I.T. Barotrauma 4.5.7

Discomfort in the stomach and / or bowel due to distension with expanding gas. This is caused by trapped gas expanding on ascent.

Divers become more susceptible to this condition after; air swallowing at depth, drinking fizzy drinks (particularly during a chamber dive) or using effervescent medication before the dive.

Presentation of Gastrointestinal Expansion

- Abdominal discomfort.
- Abdominal pain (sharp in nature.).



Management of Gastrointestinal Expansion

- Usually self-curing by belching or passing wind.
- If severe, slow down rate of ascent.
- If occurring in chamber; chew peppermints.

DISORDERS OF DIVING 4.6

Adiabatic Compression 4.6.1

Adiabatic compression is the term used to explain Charles's Law relation to diving. Temperature increases with pressure. In a hyperbaric vessel (decompression chamber or bell), temperature will increase on compression (when the bell is blown down or the chamber pressurized).

It is important that pressurization speeds set down by your diving company are not exceeded.

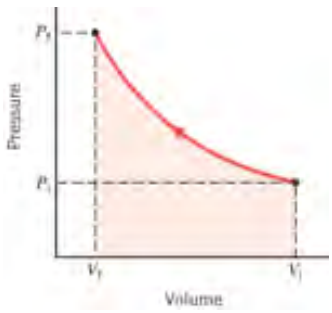
Oxy/Helium is about 6 times more heat conductive than air, if the humidity is high (over about 85%), then the body's ability to sweat and loose heat is reduced, resulting in an increase risk of heat exhaustion / stroke.

Normally the chamber environment should be maintained around 27 or 28°C and 75% humidity.

Prevention of Adiabatic Compression:

- Do not exceed pressurisation speeds.
- Monitor chamber temp during compression (check temp reader is calibrated).
- Do not overheat chamber prior to compression.
- Keep chambers in hot climates shaded.

Adiabatic Compression



Management of Adiabatic Compression:

- Conduct primary / secondary survey & record observations.
- Douse chamber exterior with cold water (cover with blankets and soak).
- Flush chamber with correct mixture.
- Decompress if emergency (chamber atmosphere will cool down).
- Use chamber heating system (if appropriate) on "cold cycle" to act as "heat sink".
- Cool occupants with cold water (shower, ice, sponge), and give cool fluids
- Implement heat illness measures for chamber occupants.
- Seek medical advice from duty medic.

Aseptic Bone Necrosis 4.6.2

Aseptic bone necrosis is dead bone tissue in the absence of infection or disease process occurring in part of a bone, which is otherwise normal. This is thought to be caused by an absence of a blood supply to part of the bone due to condition such as trauma, iatrogenic (physician-induced) side effects of treatment using steroids or radiation, some blood disorders or alcoholism. Aseptic bone necrosis is often referred to as Avascular Necrosis.

Towards the end of the last century, aseptic bone necrosis was found to occur in men who worked in caissons; as a result this condition was originally known as Caisson Disease of Bone.

Dysbaric Osteo-necrosis (DON) 4.6.3

This is aseptic bone necrosis occurring in divers and compressed air workers. The earliest description of this condition was in 1888 and X-ray findings were first described in compressed air workers in 1911.

The condition was first described in divers in 1941. It is thought to be a chronic occlusion of bone blood vessels by bubbles or other mechanisms related to accumulation of gas in the tissues.

Lesions have been seen in 17% of caisson workers and definite lesions in 3% of commercial divers.

DON generally affects the; humerus, femur and tibia.

Dysbaric Osteo-necrosis

Presentation of Dysbaric Osteo-necrosis;

- Possibly symptomless.
- Sudden and persistent pain in a joint.
- Gradually increasing pain, stiffness and loss of movement of a joint;
  - o Indicating the development of degenerative arthritis.

Management of Dysbaric Osteonecrosis

- If DON is discovered ceasing diving is recommended.
- Severe lesions will require orthopedic surgical intervention.

High Pressure Nervous Syndrome (HPNS) 4.6.4

High Pressure Nervous Syndrome (HPNS) is a derangement of central nervous system function that occurs during deep helium/oxygen dives, particularly saturation dives.

The cause is unknown. HPNS is first noted between 150m – 200m, and the severity appears to be both depth and compression rate dependent.

With slow compression, depths of 350m may be achieved with relative freedom from HPNS.

Beyond that, some HPNS may be present regardless of the compression rate.

Attempts to block the appearance of the syndrome have included the addition of nitrogen or hydrogen to the breathing mixture and the use of various drugs. No method appears to be entirely satisfactory.

Presentation of HPNS:

HPNS

- Nausea.
- Fine tremor – imbalance.
- Coarse tremor.
- Loss of manual dexterity - In-coordination.
- Jerky movements.
- Loss of alertness - Disorientation.
- Abdominal cramps and diarrhoea develop occasionally.
- In animal experiments convulsions have also been recorded.
- In severe cases; vertigo, extreme indifference to his surroundings, confusion.

In 1965 the Royal Navy Physiological Laboratory was conducting a series of deep dives in a compression chamber to depths of 200 – 350m. The condition appeared to improve after 90 mins at depth, and the subjects gradually returned to normal.

EXAMPLE: In a series of dives, the following symptoms were reported. Using a compression rate of 2.5m/min without rest stops:

- At 200m: Tremors appeared.
- At 240m: Changes in the brain activity was recorded by electro-encephalogram.
- At 320m: Development of muscular in-coordination.
- At 330m: Subjects beginning to experience loss of alertness.
- At 350m: Subjects develop extreme indifference, and decreased comprehension.

Some reports have recorded bouts of sleep occurring from which the subject is readily awakened. Difficulty in right-left orientation has also been reported.

The development and severity of High-Pressure Nervous Syndrome appears to be related to the rate of compression at great depths being particularly more noticeable at faster rates.

Investigations into other possible contributory causes, such as the effects of oxygen, carbon dioxide, temperature, and fluid shift within the tissues due to gas pressure, have been found to have little, or no part in the incidence of HPNS.

It has been found that the inclusion of nitrogen, or other heavier narcotic gases has significantly reduced the cost of the mixture, alleviated the effects of voice distortion, and reduced the dangers of excess heat loss. For this reason it is common to use a "TRI-MIX" of oxygen, nitrogen and helium when diving deeper than 200m.

Prevention / Management of HPNS:

- Follow the general rule, "the deeper the dive, and the slower the rate of compression".
- Use appropriate gas mix.
- Include rest stops on compression.
- Monitor divers closely for signs of HPNS.
- Exclude – abort diver with severe symptoms.

Hydrostatic Nervous Syndrome 4.6.5

A similar condition to High Pressure Nervous Syndrome may occur when the subject has been exposed to extreme depths for long periods. It is **not** dependent on rate of compression.

Although the symptoms of this condition are similar to those of HPNS, the exact mechanism of this action is not fully understood. The main difference is in its occurrence after the depth has been stable for some time. The main form of treatment in both cases when symptoms are severe is to gradually decompress the individuals involved until the symptoms disappear.

Compression Arthralgia 4.6.6

Hyperbaric arthralgia is pain in the joints due to raised ambient pressure.

Compression Arthralgia

A diver suffering from hyperbaric arthralgia sometimes hears a creaking and cracking from his joints and feels as if his joint surfaces are dry (no "joint fluid"). Joints hurt especially on movement. The condition is aggravated by a too-rapid compression.

A compression rate of not more than 1m / min often avoids the painful effects of this condition although the cracking of the joints continues.

Tinnitus 4.6.7

Tinnitus or spontaneous noise or ringing in the ear can occur with middle ear disease that causes a conductive hearing loss, in terms of diving a perilymphic fistula or audio-vestibular DCI (very rare) may be the underlying cause. but it is usually associated with inner ear or brain disease.

HEARING LOSS Is Classified In To Three Categories:

- Conductive hearing loss, caused by;
  - Complete occlusion of the external auditory canal by wax.
  - Inflammation, swelling of the ear-drum or lining of the middle ear.
  - Fluids in the middle ear.
  - Changes in middle ear gas densities, pressure gradients across the ear drum.
  - Fixation of the ear bones, or loss of elasticity of the eardrum caused by scaring or large perforations.
- Neuro-sensory or nerve hearing loss, caused by nervous or vascular insufficiency in the inner ear;
  - Head injury.
  - Stroke.
  - Bubbles (DCI).
  - Round or oval window rupture.
  - Excessive noise exposure, or various other inner ear disease or conditions.
- Mixed or combined conductive and neuro-sensory hearing loss caused by simultaneous dysfunction of the middle and inner ear.

Management of Tinnitus:

- Seek ENT specialist review.
- Treat underlying cause of Tinnitus.

Vertigo 4.6.8

The occurrence of vertigo underwater is dangerous, being a potential cause of fatal underwater accidents. Normal balance under physiological conditions on dry land is maintained by the inter-action of gravity and a series of sensory organs. Joints and muscles, vision, and the vestibular organs all give complementary information to the brain about position in space, movements etc.

Underwater a profound change takes place. Buoyancy reduces the value of clues from joints and muscles. Darkness precludes visual clues and a great deal more reliance is placed upon sensations from the semi-circular canals and the vestibular apparatus generally.

Under calm conditions a diver gains extra clues from incidental observations such as bubble streaming, and buoyancy of objects with known behaviour at the depth involved, but under emergency or panic conditions this information too may not be available and sensation from the ear organs becomes a vital matter for survival.

DCI can cause gas release in the semi-circular canals or vestibule, causing physical disruption of the hair cells, which detect the relative movement of the labyrinthine fluids.

Presentation of Vertigo:

- False sensations of movement of the subject or of his surroundings, known as vertigo.
- Spinning sensation, such as is felt after getting off a roundabout,
- Swaying or falling sensation.
- Nystagmus – (a flickering movement of the eye).
- Severe nausea.

Vertigo

Management of Vertigo:

- Gain orientation as soon as symptoms of vertigo present.
- Report episodes & undergo review by dive doctor.
- Treat underlying cause.

Alternobaric Vertigo 4.6.9

Unequal or asymmetrical clearing of the middle ear during descent or ascent, and particularly during ascent, can cause vertigo. Regardless of the cause, vertigo and its accompanying spatial disorientation are hazardous if they occur during a dive.

Management of Alternobaric Vertigo

- Avoid diving if; there is difficulty clearing ears or if a Valsalva manoeuvre on the surface produces vertigo.
- If there is vertigo, ear blockage or ear fullness during compression, they should;
  - Stop any further descent.
  - Ascend until the ears can be cleared.

Omitted Decompression 4.6.10

In situations such as blow-up, loss of air supply, bodily injury or other emergencies, a diver may be required to surface prematurely, without taking the required decompression.

Surface decompression has been a recognised feature of commercial diving for many reasons for decades. It has earned the title 'bend and mend' as an overall policy.

Surface Decompression

Management of Omitted Decompression;

- Use appropriate tables / company procedures for surface decompression.
- Be suspicious. Observe diver for possible dysbaric condition (D.C.I. / A.G.E. / barotrauma).
  - o If present apply appropriate treatment & compression table.
- If the diver shows no ill effects from omitted decompression, the diver should;
  - o Be monitored for at least 4 hours.
  - o Stay within the vicinity of a recompression chamber for 24-48hrs.
- Recompression may be considered as a precaution.
- In-water treatment for omitted, asymptomatic decompression should **not be performed**.

DECOMPRESSION THERAPY 4.7

It is important that a D.M.T. orientates themselves to their company's S.O.P.'s with regards to treatment of DCI with compression therapy.

Standard recompression algorithms are readily available, but it is not uncommon for specific operators to modify or enhance treatment algorithms.

In the Miscellaneous Section we have included both the Royal Navy & the United States Navy D.C.I. Management algorithm as examples of possible treatments that a Duty Medic may instigate.

We have included a 'Tender Responsibilities' section in this chapter, which highlights the R.N. Tables 66, 62 & 67. These responsibilities can be altered to suit any chamber.

Personnel Requirements For Chamber Operations

The minimum team for conducting any recompression operation consists of a Diving Supervisor, an inside Tender D.M.T., outside Tender and depending on the circumstances, a Diving Physician.

Diving Supervisor

The diving supervisor is in charge of the operation and must be familiar with all phases of chamber operation and treatment procedures. The supervisor must ensure that communication, logging, and all phases of treatment are as per company SOP's.

Diving Physician

The diving physician is trained in the treatment of diving accidents. Although it may not be possible to have a diving physician present during all treatments, it is essential that the diving supervisor be able to consult by telephone or radio with a diving physician.

Chamber Tender / DMT

The inside tender / DMT must be familiar with all treatment procedures and with the signs, symptoms and treatment of diving related injuries and illnesses. They are responsible for the direct care of the casualty & communicating their condition with the dive supervisor / duty medic.

Choosing the Right Personnel

When a recompression treatment is conducted for pain-only decompression illness, an experienced physician or DMT should tend the patient inside the chamber.

If it is known before the treatment begins that specialised medical aid must be administered to the patient, or if a gas embolism is suspected an appropriately trained medic should accompany the patient inside the chamber. If the chamber is sufficiently large, a second tender may also enter the chamber to assist during treatment. Inside the chamber, the tender ensures that the patient is lying down and positioned to allow blood circulation to limbs.

When a diver is being recompressed, all the tending personnel must work as a team for the benefit of the patient. Whether the inside or the outside tender operates the chamber will be dictated by the availability of qualified personnel and the circumstances of the casualty being treated.

If the patient has symptoms of serious DCI or gas embolism, the team will require additional personnel. If the treatment if prolonged, a second team may have to relieve the first.

Whenever possible, patients with serious DCI or gas embolism should be accompanied inside the chamber by a DMT or a diving physician, but treatment **should not** be delayed to comply with this recommendation.

Effective recompression treatment requires that all members of the treatment team be thoroughly trained and practised in their particular duties. It is also advisable to cross train members to carry out the duties of their teammates.

Chamber Attendant / D.M.T. Responsibilities 4.7.1

State Of readiness

Since a recompression chamber is emergency equipment, it must be kept in a state of readiness. The chamber needs to be well maintained and equipped with all necessary accessory equipment. *A chamber is not to be used as a storage compartment.*

Key Responsibilities Include:

- Ensuring that the pre-dive checklist is completed.
- Ensuring the cleanliness of the chamber interior.
- Ensuring provision of chamber medical supplies in line with SOP's / DMAC regulations.
  - o Ensure medical specific items are available in line with patient needs.
- Effectively communicating with the chamber supervisor.
- Ensuring the patient does not carry forbidden items into the chamber.
- Are there factors that preclude the casualty from the treatment:- of a cold / flu, a toothache or pregnancy.
- Fully assess patient:
  - o Providing assistance with the patient's activities of daily living as required.
- Ensuring exhaust & equalization valves are in the 'closed' position.
- The tender manually ensures the seal of the inner lock.
- Ensuring the patient's wear hearing protection during various treatment stages (descent, and flushing).
- Monitor the patient's for aural discomfort, halting the ascent as required until the pain has been relieved.
  - o Administrating treatment gas to the patient when instructed by the chamber supervisor.
  - o Monitor effects of treatment gas.
  - o Ensuring that the patient's are in a position that permits free blood circulation to all extremities.
  - o Ensuring that BIBS mask is comfortable, well sealed and free of gas leaks.
- Discontinuing treatment gas to the patient when instructed by the chamber supervisor.
- Providing normal assistance to the patient's as required.
- Providing first aid as required by the patient's.
- Responding to any internal chamber emergencies in accordance with S.O.P's.
- Assisting in post treatment chamber / BIBS cleaning.
- Preparing chamber for subsequent treatment.
- Ensure the completion of the post-dive checklist.

General Chamber Safety Precautions:

- Do not use oil / petroleum based products on or anywhere near the chamber or associated equipment.
- Ensure the securing dogs (medical lock) are in good operating condition and seals are tight.
- Do not allow open flames, smoking materials, or any flammables to be carried in the chamber.
- Do not permit electrical appliances to be used in the chamber (unless verified by SLST).
- Ensure the patient's does not interfere with chamber operations.
- Do not permit products in chamber that may contaminate or off-gas into the chamber atmosphere.

Tender Decompression Needs

The experience of being in a hyperbaric chamber physiologically is identical to diving. And just like scuba diving the length of time an attendant can stay at depth is dictated by how much nitrogen they absorb from the air (79% of air is nitrogen).

All chamber supervisors are highly experienced diving supervisors who are experts at calculating tenders decompression needs in accordance with internationally recognized dive tables.

During various stages of the treatment table the chamber attendant is instructed to 'go on oxygen'.

This has two actions. Firstly, no further nitrogen is being breathed and therefore any accumulation of the gas ceases. Secondly the attendant will actually 'off gas', as absorbed nitrogen will be removed at an accelerated rate due to an increased osmotic pull.

Tenders should not fasten the oxygen masks to their heads, but should hold them on their faces. The risk of the tender getting oxygen toxicity is amazingly low (they only consume a fraction of the oxygen that the patient does). If however the tender does experience oxygen toxicity, the exclusion of head straps ensures that the oxygen will simply fall away from the airway.

U.S. Navy Dive Tables

Table 9-9. Air Decompression Table (Continued).
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
170 FSW														
5	5:40	AIR									0	5:40	0	D
		AIR/O_2									0	5:40		
10	5:00	AIR									2	7:40	0.5	G
		AIR/O_2									1	6:40		
15	5:00	AIR									7	12:40	0.5	J
		AIR/O_2									4	9:40		
In-Water Air/O_2 Decompression or $SurDO_2$ Recommended														
20	4:40	AIR								1	29	35:20	1	L
		AIR/O_2								1	15	21:20		
25	4:20	AIR							1	6	48	58:00	1	N
		AIR/O_2							1	4	23	33:20		

Royal Navy Table 62 Recompression Therapy (U.S.N. Table 6) 4.7.2

This table is used for the great majority of cases of DCI. Its use is dictated by patient response in the treatment algorithm.

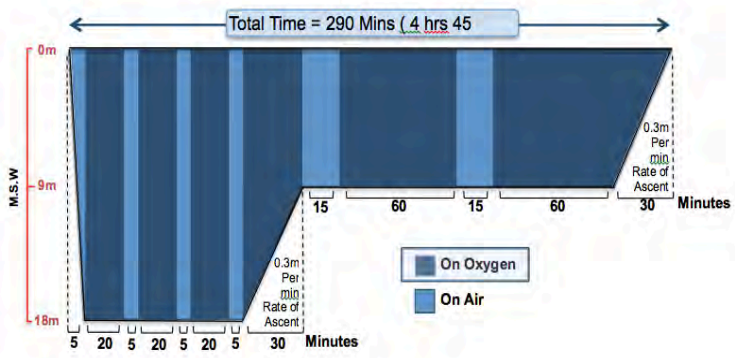
Proceed As Follows:

- Descend to 18m over 3-5 minutes stopping only if the patient or attendant has difficulty in clearing their ears.
- The timing of the treatment starts on reaching 18m.
- Upon reaching 18m the patient is re-assessed.
  - The assessment should take no more than 2-3 minutes.
  - The patient's condition to have stabilised or improved, if the algorithm is followed strictly, the decision to change to R.N. Table 61 may be made (however many specialist believe that the R.N.T. should always be completed).
  - However, patients who have presented with serious symptoms may continue to deteriorate at 18m. In such cases, the chamber should be compressed to 30m on air with the patient breathing 50/50 Heliox (50% oxygen / 50% helium). Decompression will then normally be completed using RN Table 67.
- If the time between reporting symptoms and receiving treatment is greater than 8 hours or if the symptoms have remained static or improved incompletely after three 20 minute periods on 100% O_2 at 18m, RN Table 62 may be extended with one or two further O_2 breathing periods, separated by a 5 minute air break.
- If the signs and symptoms have not resolved after 2 extensions at 18m further advice from the diving medicine specialist should be sought.
- Symptoms may recur during ascent to 9m or at 9m. In such circumstances;
  - STOP THE ASCENT and return to 18m.
  - Consult a Diving Medicine Specialist.
- RN Table 62 may be extended for one or two 1 hour O_2 breathing periods at 9m, separated by 15 minutes air breaks.

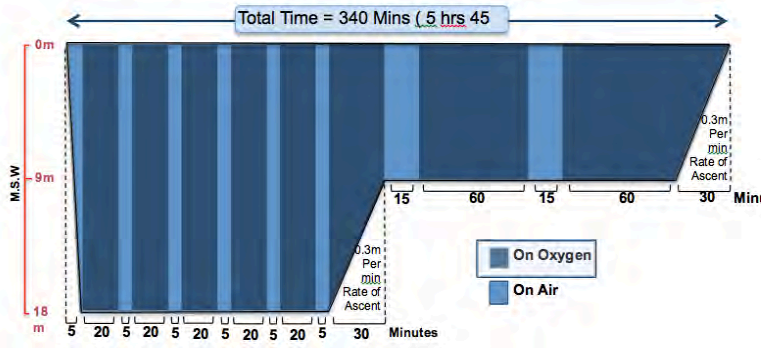
Attendant Decompression Needs;

- For an unmodified R.N.T. 62 or a R.N.T 62 with one extension, at 9m or 18m, the attendant must:
- Breathe O_2 for the last 30 minutes at 9m and during the ascent from 9m to the surface (60 minutes in total). If RN Table 62 is extended more than once, then the attendant should breathe O_2 for the whole of the final O_2 period at 9m and the ascent to the surface (90 minutes in total).
- If the attendant has undergone a hyperbaric exposure in the preceding 24 hours, an additional 60 minute period breathing O_2 at 9m (150 minutes in total) should be undertaken.

Royal Navy Table 62



Royal Navy Table 62++ (with 2 extensions)



Royal Navy Table 67 Recompression Therapy 4.7.3 (Comex 30 Heli/Ox)

This table, a modified version of the COMEX 30 table, is to be used for the treatment of more serious or more threatening cases of D.C.I.

These Cases Include;

- Gross Neurological symptoms within 24hrs of diving.
- Diving deeper than 50m.
- Diving on mixed gas.
- The patient continues to deteriorate following an initial compression of 18m on 100% O_2.

- Omitted decompression on very deep dives, when the diver has completed less than 15 minutes of stops and the stops missed were at depths in excess of 18m.
- On the advice of a Diving Medicine Specialist for the treatment of DCI.

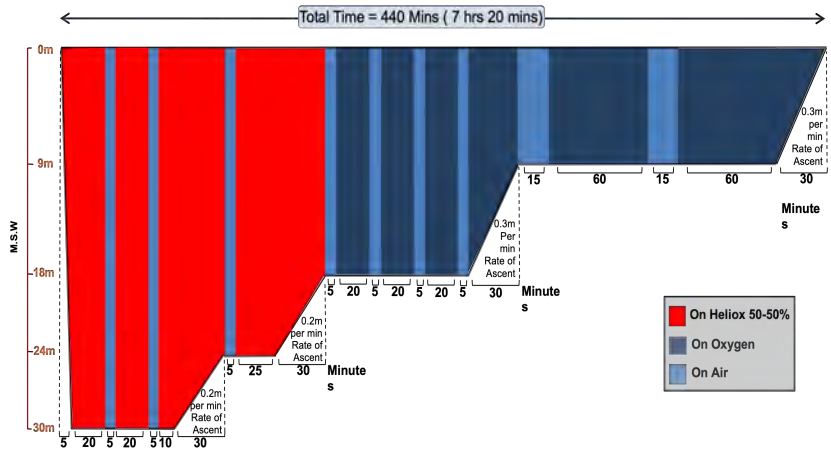
Proceed As Follows:

- The patient starts breathing 50:50 O_2:He on the surface, or from 18m when transferring from RN Table 62.
- Descent to 30m over 5-10 minutes stopping only if the patient or attendant has difficulty in clearing their ears.
- The timing of the treatment starts on reaching 30m.
- Upon reaching 30m the patient must be reassessed.
  - This assessment should take no more than 2-3 minutes.
- If symptoms have remained static or improved incompletely after 55 minutes at 30m up to 5 additional 20 minute periods breathing 50:50 O_2:He, separated by 5 minute air breaks, may be added on the advice of Diving Medicine Specialist.
  - On completion of extensions decompression should be by RN Table 64 with 50:50 O_2:He breathed during the ascent from 30-24m.
  - A 5 minute air break is taken on arrival at 24m with 50:50 O_2:He breathed during the remaining 25 minutes of the 24m stop and the ascent from 24-18m.

Attendant Decompression Needs;

- For an unmodified RN Table 67 the attendant must breathe O_2 during both 60-minute O_2 periods at 9m and during the ascent from 9m to the surface (total 150 minutes).
- If the RN Table 67 is extended at 18m, by either one or two additional O_2 periods, it must also be extended by an additional 60 minute O_2 period at 9m during which time the attendant is to breathe O_2 (210 minutes).
- If the RN Table 67 is extended at 9m the attendant must breathe O_2 for an additional 60-minute period (total 210 minutes).
- If the attendant has undergone a hyperbaric exposure in the preceding 24 hours RN Table 67 should be extended at 9m to permit the attendant to breathe O_2 for an additional 60-minute period (total 210 minutes).

Royal Navy Table 67



Failure Of Recompression Treatment 4.7.4

Four major complications may effect the recompression treatment of a patient.

These Are:

- Worsening of the patient's condition during treatment.
- Recurrence of the patient's original symptoms or development of new symptoms during treatment.
- Recurrence of the patient's original symptoms or development of new symptoms after treatment.
- Failure of symptoms of decompression illness or gas embolism to resolve despite all efforts using standard treatment procedures.

When any of these complications occurs, the advice of diving medicine experts should be sought immediately, because alternative treatment procedures have been developed and used successfully when standard treatment procedures have failed.
These special procedures may involve the use of saturation diving decompression schedule; cases of this type occur more frequently when a significant period of time has elapsed between the onset of symptoms and the initial recompression.

GAS TOXICITY 4.8

Gas toxicity is defined as ill health caused by absorbing airborne gas via the:

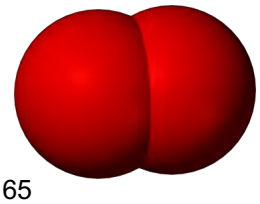
- Respiratory system.
- Skin.
- Mucous membrane.

The Factors That Influence The Casualty's Response To The Agent Are:

- The specific gas (some gases are far more toxic than others).
- Exposure time.
- Concentration / partial pressure of the gas.
- Workload (the higher the workload, the higher the respiratory rate, the higher the absorption of gas).
- General fitness.

Pulmonary Oxygen Toxicity 4.8.1

If O_2 is breathed at a high partial pressure for long periods it becomes toxic, particularly to the lungs. If a very high partial pressure of O_2 is breathed, even for short periods of time, it may rapidly become toxic to the brain (C.N.S. Oxygen Toxicity).



For practical purposes, pulmonary oxygen toxicity will not arise from normal air 'bounce' diving to less than 50 metres.

This is because decompression considerations will limit exposure to O_2 to within safe limits. Diving near the time/depth limits, particularly when such dives are performed repetitively, may provoke pulmonary O_2 toxicity in sensitive individuals.

Patients being treated with fully extended recompression Tables 62 and 63 or Tables 64 and 65 may also experience pulmonary O_2 toxicity, particularly where repeated treatments are applied.

Unit Pulmonary Toxic Dose

Where prolonged exposure to hyperbaric oxygen is necessary, such as during recompression therapy, an estimate of the reduction in vital capacity (VC) can be calculated from the following equation: Where kp is a factor derived from the $p0_2$ using the table below, and "t" the duration of exposure (in minutes).

The "Kp" Table For UPTD Calculation Is: **UPTD = kp X t**

The appropriate kp value is multiplied by the period of time (in minutes) spent at each oxygen partial pressure. These values are then summed to generate the total UPTD value for the exposure. Standard USN Table 6 or RN 62 Treatment Table without extensions are equivalent to 625 UPTD's.

Below is a table, which presents approximate values for expected decrement in vital capacity as a result of various UPTD exposures. It should be recognised that individuals may vary considerably in their response to high partial pressures of oxygen and the UPTD value is useful only as a guide. Generally, a dose of 1425 UPTD is considered to be the upper limit of acceptable exposure.

Normally, a complete recovery from the effects of pulmonary O_2 toxicity can be expected. The time taken for recovery depends largely on the extent of the exposure and where there is a substantial decrement of vital capacity, this may take days or weeks.

UPTD Units	% Decrease in VC
615	2 %
825	4 %
1035	6 %
1230	8 %
1425	10 %
1815	15 %
2190	20 %

$p0_2$(BA)	kp	$p0_2$(BA)	kp	$p0_2$(BA)	kp
0.5	0.00	1.3	1.48	2.1	2.64
0.6	0.26	1.4	1.63	2.2	2.77
0.7	0.47	1.5	1.78	2.3	2.91
0.8	0.65	1.6	1.93	2.4	3.04
0.9	0.83	1.7	2.07	2.5	3.17
1.0	1.00	1.8	2.21	2.6	3.31
1.1	1.16	1.9	2.36	2.7	3.44
1.2	1.32	2.0	2.49	2.8	3.57

Presentation of Pulmonary Oxygen Toxicity

- Tickling sensation in the throat which is worse on inspiration.
- Irritating cough.
- A sensation of substernal burning.
- Coughing becomes uncontrollable.
- Shortness of breath eventually prevents even mild exertion.
- Acute Respiratory Distress Syndrome will present in severe cases.

Management of Pulmonary Oxygen Toxicity

- Reduce the concentration of O_2 in the breathing mixture, (preferably to 0.2 BAR. *$IP0_2$).*
- If substernal burning is present in patients who are responding well to treatment; discontinue oxygen.
- If significant neurological deficit remains and improvement is continuing (or if deterioration occurs when oxygen breathing is interrupted), oxygen breathing should be continued as long as considered beneficial or until pain limits inspiration.
- If oxygen breathing must be continued beyond the period of substernal burning, or if the 4 hour air breaks on long air tables cannot be used because of deterioration upon the discontinuance of oxygen, the oxygen breathing periods should be changed to 20 min on oxygen, followed by 10 min breathing chamber air.

C.N.S. Oxygen Toxicity 4.8.2

There is no fixed O_2 exposure at which toxicity becomes apparent. Instead, susceptibility varies both between individuals and within the same person from day to day. As a consequence, there is no cerebral equivalent of the UPTD.

The onset of C.N.S. Oxygen Toxicity is unlikely in resting individuals at depths of 15m or shallower, and very unlikely at 10m or shallower no matter what the level of activity.

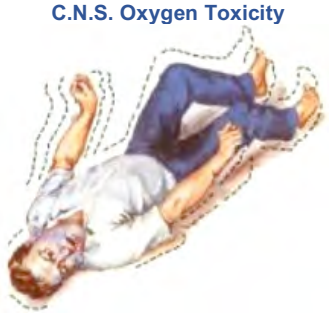
However, patients with severe cerebral decompression illness may be abnormally sensitive to oxygen.

Presentation of C.N.S. Oxygen Toxicity

The classic presentation of CNS Oxygen Toxicity is: V.E.N.T.I.D.C.:

- **V**ision (Tunnel vision) which may include any abnormality, such as tunnel vision (a contraction of the normal field of vision, as if looking through a tube) .
- **E**ars (Ringing/Tinnitus) which may include any abnormality of hearing.
- **N**ausea may be intermittent.
- **T**witching appears first in the lips or other facial muscles but may affect any muscle. (This is the most frequent and clearest warning of oxygen poisoning.
- **I**rritability which includes any change in behaviour, such as anxiety, confusion, and unusual fatigue.
- **D**izzinessan apparent increase in breathing resistance, noticeable clumsiness or lack of co-ordination.
- **C**onvulsions such as generalized clonic tonic seizure.

C.N.S. Oxygen Toxicity



Management of C.N.S. Oxygen Toxicity:

- Reduce the concentration of O_2 in the breathing mixture, (preferably to 0.2 BAR. *$IP0_2$).*
- Conduct primary / secondary survey & record observations.
- Implement Seizure Management.
- Stop decompression. (Refer to company SOP's).
- Contact duty medic / supervisor.
- Prepare to evacuate (as per company S.O.P's).

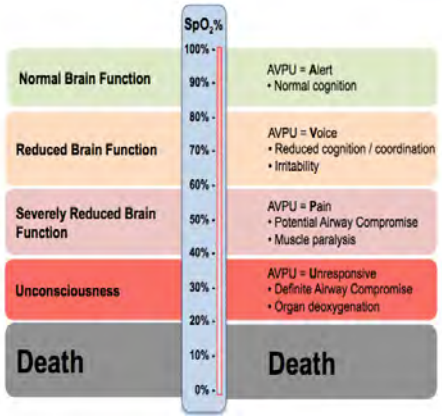
Convulsions While In Water Diving:

- The diver's depth should be kept as constant as possible until at least the tonic phase of the convulsion ends.
- He should then be returned to the surface.
- Implement airway / breathing management.
- If a diver surfaces because of an oxygen convulsion or must be surfaced to prevent drowning.
  o Observe for pulmonary barotrauma / A.G.E. / D.C.I.
- On reaching safety, remove the breathing apparatus and place the casualty in fresh air to recover.
- Treat for near drowning.

***Note**. Paradoxically, the symptoms of c.n.s. O_2 toxicity may be made transiently worse when the inspired $P0_2$ falls. This is the so-called 'Off Phenomenon'. Consequently the onset of symptoms or signs may be delayed by up to 5 minutes after leaving the water, coming off O_2, or during a decompression stop where the partial pressure of O_2 is reduced.*

Hypoxia 4.8.3

The term 'hypoxia' means 'low oxygen in the blood' (When 0_2, is less than 0.16bar) The term 'Anoxia' means 'an absence oxygen in the blood'.



The Causes Of Hypoxia / Anoxia Are Varied:

- External (reduced / absent O_2 supply in breathing gas).
- Airway impairment.
- Breathing impairment.
- Circulation impairment.
- Respiratory control centre impairment.

Presentation of Hypoxia

- See Hypoxia in Immediate Care Section.
- Cyanosis (Blueing of fingers, earlobes).
- Hyperventilation.

- Increased heart rate.
- Poor co-ordination.
- Sudden collapse.

Presentation of Anoxia

- Profound cyanosis (Blueing of fingers, earlobes).
- Death.

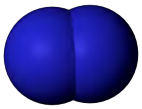
Management of Hypoxia / Anoxia;

- See Hypoxia in First Aid Section.
- Give high flow O_2 and monitor effects.
- Be prepared to resuscitate.

Nitrogen Narcosis 4.8.4

Narcosis while diving (also known as narced, inert gas narcosis or "the raptures of the deep"), is a reversible alteration in consciousness that occurs while diving at depth.

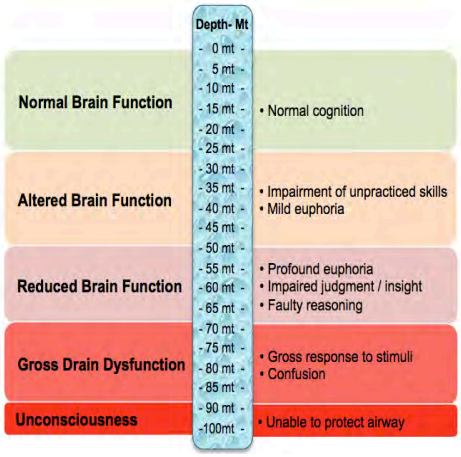
The Greek word *ναρκωσις* (narcosis) is derived from narke, "temporary decline or loss of senses and movement, numbness".



Narcosis produces a state similar to alcohol intoxication or nitrous oxide inhalation, and can occur during shallow dives, but usually does not become noticeable until greater depths, beyond 30 metres.

Presentation of Nitrogen Narcosis

Responses significantly slow down.
Loosing shortterm memory.
Lack of insight.
Faulty reasoning.
Calculation errors.
Idea fixations.
Increased anxiety, anger or euphoria.
Narrowing of a divers mental focus.



Management of Nitrogen Narcosis

- Decrease depth.
- Change mix (Nitrox?).

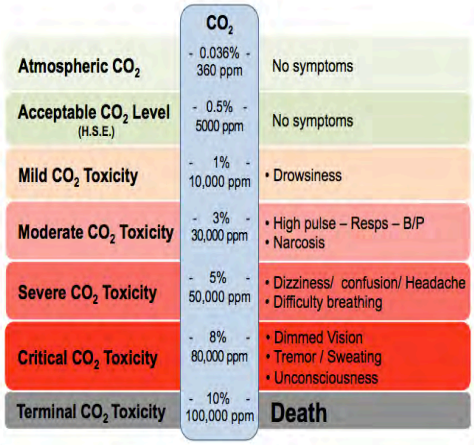
Hypercapnia (CO_2 Poisoning) 4.8.5

Also known as hypercarbia, is a condition where there is too much carbon dioxide (CO_2) in the blood. CO_2 is a gaseous product of the body's metabolism and is normally expelled through the lungs.

Acceptable levels of CO_2 (As set by H.S.E.) is 5000 ppm or 0.5% in a breathing mix for 8 hrs maximum.

Causes of Hypercapnia;

- Increased workload.
- Pre existing medical condition.
- Failure of CO_2 absorption (closed / semi closed).
  - o Channelling.
  - o Soda lime canister exhausted.
- Large dead space.
- CO_2 in gas mix.



Presentation of Hypercapnia

- Increase in respiration & pulse rate.
- Headache.
- Sweating.
- Dizziness.
- Nausea.
- Anxiety.
- Unconsciousness.

Management of Hypercapnia

- Manage unconsciousness / reduced consciousness as per Immediate Care.
- Ventilate environment / breathing mix.
- Change soda lime.
- Flush chamber.
- Equalize chamber with entry lock.

Carbon Monoxide Poisoning 4.8.6

Carbon monoxide poisoning occurs after enough inhalation of carbon monoxide (CO).

CO is a colourless, odourless, tasteless, and initially non-irritating toxic gas.

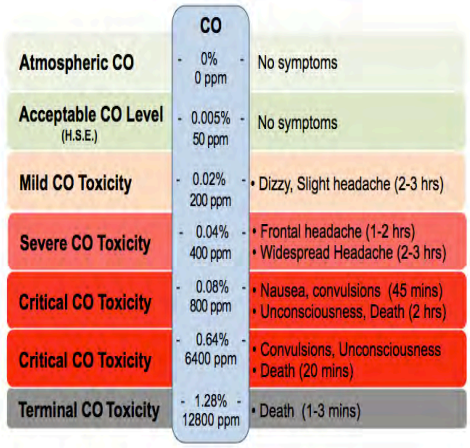
CO is a product of incomplete combustion of organic matter due to insufficient oxygen supply to enable complete oxidation to carbon dioxide (CO_2). It is often produced in domestic or industrial settings by older motor vehicles and other gasoline-powered compressors, heaters, and cooking equipment.

Exposures at 100 ppm or greater can be dangerous to human health. Generally caused in diving by a badly sited compressor intake or from oil breakdown in an overheating compressor.

CO has affinity to Haemoglobin 200 times greater than O_2.

Presentation of Carbon Monoxide Poisoning

- Breathlessness on exertion.
- Lassitude.
- Dizziness / headache.
- Tinnitus.
- Confusion Loss of consciousness.
- Cherry red complexion (unreliable, rare and fatal).



Management of Carbon Monoxide Poisoning

- Change gas supply.
- Jump standby to assist divers ascent.
- Recompression (As per company SOP usually RNT 60 / 61).
- Administrating pure O_2 by BIBS (flushes out CO).
- Instigate reduced consciousness management.

Hydrogen Sulfide Poisoning 4.8.7

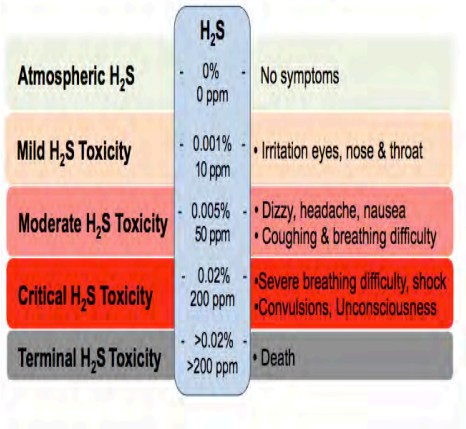
H_2S is an extremely hazardous, toxic compound. It is a colourless, flammable gas that can be identified in relatively low concentrations, by a characteristic *rotten egg* odor. The gas occurs naturally in coal pits, sulfur springs, gas wells, and as a product of decaying sulfur-containing organic matter, particularly under low oxygen conditions. It is therefore commonly encountered in places such as sewers, sewage treatment plants (H_2S is often called *sewer gas*), mines, and the holds of fishing ships.

H_2S occurs naturally in the mud around the well-head of a drill rig. The gas is heavier than air and initially leaves a sulfurous (rotten egg) odour before permanently destroying the sense of smell and therefore becoming tasteless and odourless. Due to the fact the gas is heavier than air / $HE0_2$ it forces the air or gas mix above it leaving any unsuspecting diver to asphyxiate due to lack of oxygen.

When a diver is working on this site they can accumulate this mud on their equipment, bringing it back to the bell/chamber/deck upon their return. This allows the gas to escape into its surrounding environment.

Presentation of Hydrogen Sulphide Poisoning

- Initial smell of rotten eggs.
- Headaches / Vertigo.
- Loss of smell.
- Cough / Haemoptysis.
- Confusion.
- Nausea and vomiting.
- Asphyxiation.
- Possible loss of consciousness.
- Seizure.
- Death.



Management of Hydrogen Sulfide Poisoning

- If presence of H_2S is suspected then evacuate to a high point until the area is confirmed clear.
- Administer pure O_2 (flushes out H_2S).
- Instigate reduced consciousness management.

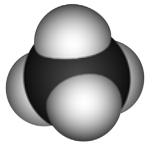
Hydrocarbon Poisoning 4.8.8

Within the commercial oil industry there is often an associated risk of hydrocarbon vapour contamination.

There is likelihood for contamination of the bell atmosphere from vapourised contaminants carried on dive suits and umbilical's.

Potentially fatal, levels of hydrocarbons can accumulate in the enclosed environment of a diving bell.

Hydrocarbon vapour has a profoundly sedative quality, so even if fatal levels are not reached immediately, divers may be incapacitated before they can initiate environmental flushing measures.



Presentation of Hydrocarbon Toxicity

Hydrocarbon vapours in the bell and can reach anaesthetic concentrations within minutes.

- Divers can suffer the effects within a few breaths.
- Even before unconsciousness, the ability to react normally becomes impaired:
  - 52% of the anaesthetic level of cyclo-hexane causes convulsions.
  - 44% of the anaesthetic level of benzene causes uncontrolled jerking of limbs.
  - 33% of the anaesthetic level of toluene leads to hyperactivity.
  - 13% of the anaesthetic level of xylene causes tremors, which could impair actions.

Bell Vapour Analysis

Management of Hydrocarbon Poisoning

- Ensure hydrocarbon analysis equipment is functioning & divers are trained in its use.
- Immidiatly don BIBS & flush compartment on contamination.
- Closley observe & manage casualtys who have sucomed to the effects of hydrocarbon exposure.
- Decontaminate bell (as per company SOP's).

DANGEROUS MARINE ANIMALS 4.9

Venomous / Poisonous Marine Inhabitants 4.9.1

Poisons are substances that are harmful when a sufficient quantity is absorbed by an organism.

Venom is a general term referring to a biotoxic agent. A biotoxin is a biologically produced peptide or protein, which can interfere with enzyme or cellular receptors:

Types Of Biotoxins Include:

- Haemotoxins.(destruction of red blood cells & interference with blood clotting cascade).
- Cardiotoxins (Toxic to the heart. These toxins may cause the heart to beat irregularly or stop beating, causing death).
- Cytotoxins. (Toxic to cells).
- Neurotoxins. (Affects the nervous system / inhibits neuron cellular processes).

Venomous Fish (excluding Stonefish, Zebrafish, Scorpionfish) 4.9.2

Identification of a fish following a sting is not always possible; however, symptoms and effects of venom do not vary greatly.

Venomous fish are rarely aggressive and usually contact is made by accident. Dead fish spines remain toxic. Venom is generally denatured in heat and may be neutralized by hot water.

Prevention

Avoid handling suspected venomous fish. Venomous fish are often found in holes or crevices or lying well camouflaged on rocky bottoms. Divers should be alert for their presence and should take care to avoid them.

Presentation of Venomous Fish Envenomation;

- Severe pain (may seem disproportionately high to apparent severity of the injury).
- Numbness / hypersensitivity around the wound.
- The wound site may become cyanotic with tissue becoming pale and swollen.

Lion Fish

General Symptoms May Include:

- Nausea / vomiting.
- Sweating / mild fever.
- Anaphylaxis.
- Respiratory distress and collapse.

Management Of Venomous Fish Envenomation

- Get victim out of water; watch for fainting.
- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor.
- Implement shock (anaphylactic) management. (O_2, I.V.I. Etc).
- Monitor and assess casualty until help arrives.
- Manage any wounds:
  - Wash wound with salt water or sterile saline solution.
  - Suction is **not** effective to remove this toxin.
  - Soak wound in hot water for 30 to 90 minutes (heat may break down the venom. The water should be as hot as the victim can tolerate but not hotter than 50°C).
  - Use hot compresses if the wound is on the face.

Mandarin Fish

- Clean and debride wound. Spines and sheath frequently remain. Be sure to remove all of the sheath as it may continue to release venom.
- Use an antiseptic or antibiotic ointment and sterile dressing.
- Restrict movement of the extremity with immobilising splints.

- Manage pain with analgesia as prescribed. (Infiltration of the wound with 0.5% to 2.0% xylocaine **without** adrenaline is helpful).
- Administer tetanus prophylaxis as perscribed.
- Review by duty medic.
- Prepare to evacuate (as per company S.O.P's).

Highly Toxic Fish (Stonefish, Zebrafish, Scorpionfish) 4.9.3

Stings by stonefish, zebrafish and scorpionfish have been known to cause fatalities. While many similarities exist between these fish and the venomous fish of the previous section, a separate section has been included because of the greater toxicity of their venom and the availability of antivenom.

The antivenin is specific for the stonefish but may have some beneficial effects against the scorpionfish and zebrafish.

These fish are widely distributed in temperate and tropical seas and in some arctic waters. They are shallow water bottom dwellers. Stonefish and scorpionfish are flattened vertically, dark and mottled. Zebrafish are ornate and feathery in appearance with alternating patches of dark and light colour.

Scorpion Fish

Presentation of Highly Toxic Fish Envenomation;

- Exceptional pain (disproportionately high to apparent severity of the injury and may last for days).
- The wound site may become cyanotic with tissue becoming pale and swollen.

Stone Fish

General Symptoms May Include:

- Nausea / vomiting.
- Sweating / mild fever.
- Anaphylactic shock.
- The venom is an unstable protein, which acts as a myotoxin on skeletal, involuntary and cardiac muscle.
  This may result in:
  - Muscular paralysis.
  - Respiratory depression.
  - Peripheral vasodilatation.
  - Shock.
  - Cardiac dysrhthmias.
  - Cardiac arrest.

Zebra Fish

Management of Highly Toxic Fish Envenomation

- Implement venomous fish management.
- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor.
- Observe the patient carefully for the possible development of life-threatening complications.
- **Give Antivenin as prescribed.**
- Institute tetanus prophylaxis, analgesic therapy and antibiotics for other fish stings.

Sea Urchins 4.9.4

There are various species of sea urchins with widespread distribution. Each species has a radial shape and long spines. Penetration of the sea urchin can cause intense local pain due to a venom in the spine or from another type of stinging organ called globiferous pedicellariae.

Sea Urchin

Prevention

Avoid contact with sea urchins. Even the short spined sea urchin can inflict its venom via the pedicellariae stinging organs. Protective footwear and gloves are recommended. Spines can penetrate wetsuits and booties.

Presentation of Sea Urchin Envenomation;

- Intense pain at site of sting.
- Numbness / generalised weakness / paraesthesia.
- Nausea & vomiting.
- Cardiac dysrhythmias.

Management of Sea Urchin Envenomation;

- Conduct primary / secondary survey & record observations.

- Contact duty medic / supervisor.
- Manage bleeding.
- Implement Shock Management. (O_2 , I.V.I. Etc).
- Manage anaphylaxis / allergic reaction.
- There are **no specific antivenins available**.
- Manage any wounds (see wound management section).
  - o Remove spine fragments gently, being careful not to break them into fragments that remain in the wound.
  - o Bathe the wound in vinegar or isopropyl alcohol.
  - o Soaking the injured extremity in hot water up to 50°C may help (Caution should be used to prevent scalding).
  - o Clean and debride the wound. Topical antibiotic ointment should be used to prevent infection.
  - o Take culture swab and administer antibiotics for secondary infections if prescribed.
  - o Remove as much of the spine as possible (Some small fragments may be absorbed by the body).
  - o Administer tetanus prophylaxis as appropriate.
  - o Get medical attention for deep wounds.
- Surgical removal may be necessary. This may be required when spines are near nerves and joints.
- X-rays may be required to locate these spines.
- Spines can form granulomas months later and may even migrate to other sites.

Sea Sponges 4.9.5

Sponges are composed of minute multi-cellular animals with spicules of silica or calcium carbonate embedded in a fibrous skeleton. Exposure of skin to the chemical irritants on the surface of certain sponges or exposure to the minute sharp spicules can cause painful skin condition called dermatitis.

Prevention

Avoid contact with sponges and wear gloves when handling live sponges.

Sea Sponge

Presentation of Sea Urchin Envenomation;

- Relative pain at site of contamination.
- Localised inflammation.

Management of Sponge Contact

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor. (Urgently).
- Implement Shock Management. (O_2 , I.V.I. Etc). As appropriate.
- Adhesive or duct tape can effectively remove the sponge spicules.
- Vinegar (or 3% -10% acetic acid) can be topically applied (sponges may be secondarily inhabited by stinging coelenterates).
- Antihistamine and topical steroid creams may be applied to reduce the early inflammatory reaction.
- Antibiotic ointment is effective in reducing the chance of a secondary infection.
- Prepare to evacuate (as per company S.O.P's).

Venomous Immediate Action Summary		
Organism	**Detoxification**	**Treatment**
Stingray **Lionfish** **Scorpion Fish** **Catfish**	Submerge injury in hot water for 30-90 min.	• Irrigation with normal saline. • Exploration and debridement. • Antibiotics and analgesics. • Anti-tetanus agent. • Observe to rule out systemic envenomation. • Compression bandaging. (With caution)
Stonefish	Submerge injury in hot water for 30-90 min.	• Same as outlined for stingray. • Stonefish antivenin for systemic reactions.
Sea Urchin **Starfish** **Sponges**	• Submerge injury in hot water for 30-90 min. Removal of any spines or pedicellariae.	• Same as outlined for stingray. • Exploration and removal of any spines.
Fireworms	• Irrigate with seawater (not fresh water). • Topical 5% acetic acid / Ammonia. • Use forceps to remove spines (Very Tiny).	Same as outlined for stingray.

Stinging Cells (Coelenterates) 4.9.6

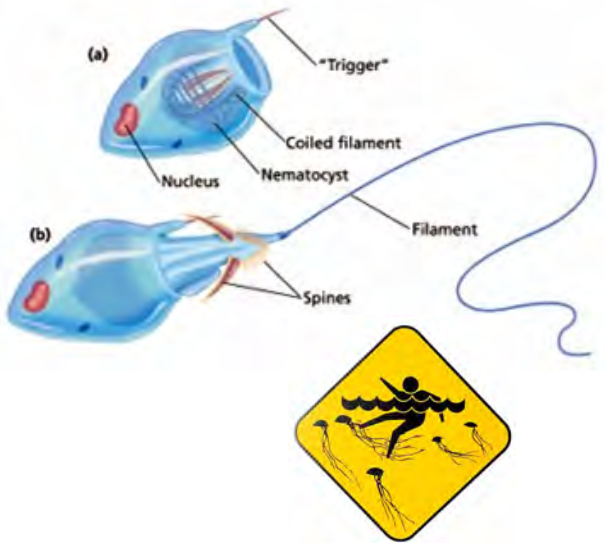
Coelenterates contain thousands of specialized stinging cells (nematocysts) capable of penetrating the skin with harpoon-like threads and injecting venom upon contact.

The potency of venom varies from species to species.

Coelenterates Are Divided Into Two Groups:

- Ctenophora
  - Comb Jellyfish.
- Cnidaria
  - True Jellyfish.
  - Sea anemones.
  - Corals.

Nematocysts



Jellyfish

Hazardous Types Of Coelenterates Include:

- Portuguese man-of-war.
- Box jellyfish.
- Lion's mane jellyfish
- Irukanjis.
- Sea nettle / sea blubber.
- Fire Coral
- Sea anemone.
- Bubble or Grape Coral.

Jellyfish vary widely in colour (blue, green, pink, red, brown) or may be transparent. They appear to be balloon-like floats with tentacles dangling down into the water. The most common stinging injury is the jellyfish sting. Jellyfish can come into direct contact with a diver in virtually any oceanic region, worldwide.

When this happens, the diver is exposed to literally thousands of minute stinging organs in the tentacles called nematocysts. Most jellyfish stings result only in painful local skin irritation.

Deaths from Portuguese man-of-war stings have also been reported.

Prevention

Do not handle jellyfish. Beached or apparently dead specimens may still be able to sting. Towels or clothing contaminated with the stinging nematocysts may even cause stinging months later.

Avoidance of Tentacles

In some species of jellyfish, tentacles may trail for great distances horizontally or vertically in the water and are not easily seen. Divers should avoid close proximity to jellyfish to avoid contacting their tentacles, especially when near the surface.

Portuguese Man Of War

Presentation of Sea Nematocyst Sting;

- The box jellyfish and Portuguese man-of-war are the most dangerous types.
- Localised severe pain and inflammation.
- The box jellyfish (found in the Indo-Pacific) can induce death within 10 minutes:
  - Respiratory failure
  - Cardiovascular collapse.
  - Muscular paralysis.

Protection Against Jellyfish

Wet suits, body shells, or protective clothing should be worn when diving in waters where jellyfish are abundant. Petroleum jelly applied to exposed skin (e.g., around the mouth) helps to prevent stinging.

Management of Jellyfish Stings

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor.
- Implement Shock Management. (O_2, I.V.I. etc). as appropriate. (Anaphylaxis is a relative risk).
- Antivenin **is available** to neutralize the effects of the box jellyfish (Chironex fleckeri).
- Without rubbing, gently remove any remaining tentacles using a towel or clothing.
- For preventing any further discharge of the stinging nematocysts, use vinegar (3 -10% solution of acetic acid).
- Picric acid, human urine, and fresh water also have been found to either be ineffective or even to discharge nematocysts and should not be used.
- Reassess regularly. Refer to Duty Medic if no improvement.
- Symptomatic treatment can include topical steroid therapy, anaesthetic ointment antihistamine lotion, systemic antihistamines or analgesics.

Do not use alcohol or preparations containing alcohol. Methylated spirits or methanol, 100 percent alcohol and alcohol plus seawater mixtures have all been demonstrated to cause a massive discharge of the nematocysts. In addition, these compounds may also worsen the skin inflammatory reaction.

Coral

Coral, a porous, rock-like formation, is found in tropical and subtropical waters. Coral is extremely sharp and the most delicate coral is often the most dangerous because of their razor-sharp edges.

Coral cuts, while usually superficial, take a long time to heal and can cause temporary disability.

Prevention

Extreme care should be used when working near coral. Often coral is located in a reef formation subjected to heavy surface water action, surface current, and bottom current. Surge also develops in reef areas. For this reason, it is easy for the unknowing diver to be swept or tumbled across coral with serious consequences. Be prepared.

Coral should not be handled with bare hands. Feet should be protected with booties, coral shoes or tennis shoes.

Wet suits and protective clothing, especially gloves (neoprene or heavy work gloves) should be worn when near coral.

Playthoa Coral

Presentation of Coral Stings:

Some varieties of coral can actually sting a diver since coral is a coelenterate like jellyfish.

- Localised severe pain and inflammation.
- The slime of this coral may cause a serious skin reaction (dermatitis) and may be fatal if exposed to an open wound.
- Secondary infections often occur and may be recognised by a red and tender area surrounding the wound.
- Some of the soft coral of the genus *playthoa* contains a deadly poison (within the body - not in the stinging nematocysts).

Management of Coral Stings:

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor.
- Manage bleeding.
- Implement shock management. (O_2, I.V.I. Etc).
- Manage any wounds (see wound management section).
  - o Clean wound with saline, debride the wound removing all foreign particles.
  - o Cover with a clean dressing.
- Monitor and assess casualty until help arrives.
- Administer tetanus prophylaxis as appropriate.
- Topical antibiotic / steroid therapy, systemic antihistamines and analgesics.
- Systemic steroids may be needed to manage the inflammatory reaction due to trauma and dermatitis.
- Prepare to evacuate (as per company S.O.P's).

Anti-histamine Cream

Stinging Cell Immediate Action Summary		
Organism	**Detoxification**	**Treatment**
Fire Coral Anemones	• Irrigate with seawater (not fresh water). • Topical 5% acetic acid / Ammonia. • Shave affected area.	• Irrigation with normal saline. • Exploration and debridement. • Antibiotics and analgesics. • Anti-tetanus agent. • Observe to rule out systemic envenomation. • Compression bandaging. • Topical corticosteroid cream for dermatitis.
Portuguese man-of-war Sea Nettles	• Irrigate with seawater (not fresh water). • Topical 5% acetic acid / Ammonia. • Shave affected area. • Use forceps or gloves to remove tentacles.	• Same as outlined for Fire Coral. • Close observation. • Hospitalise if systemic symptoms.
Box Jellyfish	• Irrigate with seawater (not fresh water). • Topical 5% acetic acid / Ammonia. • Shave affected area. • Use forceps or gloves to remove tentacles.	• Same as for Portuguese man-of-war. • Give Chironex antivenin. • Close observation. • Hospitalise if systemic symptoms.
Irukanji	• Irrigate with seawater (not fresh water). • Use forceps or gloves to remove tendrils.	• Same as for Portuguese man-of-war. • Intravenous Magnesium. • Strong Analgesia.

Tetrodotoxin 4.9.7

Tetrodotoxin, also referred to as "zombie powder" by those who practice voodoo. Tetrodotoxin, frequently abbreviated as TTX, is a potent neurotoxin with no known antidote.

Tetrodotoxin blocks action potentials in nerves, essentially preventing any affected nerve cells from firing by

blocking the channels used in the process.

Puffer Fish

The Toxin Is Present In:

- Blue Ringed Octopus (Produced via bacteria).
- Cone Shell.
- Porcupinefish.
- Puffer Fish (ingested from the gut).

Blue Ringed Octopus

The octopus inhabits tropical and temperate oceans. Species vary depending on region. It has a large sac surrounded by 8-10 tentacles. The head sac is large with well-developed eyes and horny jaws.

The octopus will hide in caves, crevices and shells. It possesses a well-developed venom apparatus in its salivary glands and stings by biting.

The blue-ringed octopus common in Australian and Indo-Pacific waters may inflict fatal bites. The venom of the blue-ringed octopus is a neuromuscular blocker called tetrodotoxin.

Blue Ringed Octopus

Prevention

Extreme care should be used when reaching into caves and crevices. Regardless of size, an octopus should be handled carefully with gloves. It is ill advised to spear an octopus, especially the large octopuses found off the coast of Northwestern United States, due to the risk of being entangled by the octopus' tentacles. If killing an octopus becomes necessary, stabbing it between the eyes is recommended.

Presentation of Blue Ringed Octopus Bite:

A victim may not feel a bite at all. The neurotoxin may immediately paralyze the pain receptors.

- Octopus bites consist of two small punctures.
- A burning or tingling sensation results and may soon spread.
- Swelling, redness and inflammation are common.
- Visual disturbances .
- Muscular paralysis.
- Vomiting.
- Respiratory difficulty / collapse.
- Cardiovascular collapse.
- Bleeding may be severe and the clotting ability of the blood is often retarded by the action of an anticoagulant in the venom.

Management of Octopus Envenomation

Blue-ringed venom is **heat stable** and acts as a neurotoxin and neuromuscular blocking agent.

Venom **is not** affected by hot water therapy.

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor.
- Manage bleeding.
- Implement Shock Management. (O_2 , I.V.I. Etc).
- Manage any wounds (see wound management section).
  - o Clean and debride the wound and cover with a clean dressing.
  - o Apply direct pressure with a pressure bandage and immobilise the extremity in a position that is lower than the heart using splints and elastic bandages.
- Constantly monitor & resuscitate as appropriate.
- **No antivenin is available.**
- Manage paralytic, cardiovascular and respiratory complications.
- Respiratory arrest is common and intubation with mechanical ventilation may be required.
- Duration of paralysis is between 4 and 12 hours.
- Administer tetanus prophylaxis as appropriate.

Cone Shells

The cone shell is widely distributed in all regions and is usually found under rock, coral or crawling along sand.

The shell is most often symmetrical in a spiral coil, colourful, with a distinct head, one to two pairs of tentacles, two eyes, and a large flattened foot on the body.

A cone shell sting should be considered as severe as a poisonous snakebite. It has a highly developed venom apparatus: venom is contained in darts inside the proboscis, which extrudes from the shell.

Cone Shell

Prevention

Avoid handling cone shells. Venom can be injected through clothing and gloves.

Presentation of Cone Shell Envenomation:

- Severe stinging or burning sensation at the site of the puncture.
- Symptoms develop within minutes of the sting and effects can last up to 24 hours.
- Numbness and tingling at puncture site:
  - o Numbness and tingling spreading to the rest of the body (mouth and lips severely affected).
- Muscular paralysis - difficulty with swallowing and speech.
- Visual disturbances.
- Respiratory distress may occur due to neuromuscular block.

Management of Cone Shell Envenomation;

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor. **Urgently**.
- Implement shock management. (O_2, I.V.I. etc) as appropriate.
- Direct pressure with a pressure bandage and immobilisation in a position lower than the level of the heart using splints and elastic bandages is recommended.
- Reassess Regularly. (Use neuro exam including AVPU /GCS)
  - o If the casualty conscious level is severely reduced (G.C.S. ≤ 8, Only responding to Pain in AVPU). Protect airway with appropriate device* (jaw thrust, Oro-pharangeal Airway, iGEL Endo-tracheal intubation & ventilate).
- **No antivenin is available.**
- Manage pain: (Local anaesthetic with no adrenaline may be injected into the site of the wound if pain is severe).
- Administer tetanus prophylaxis as appropriate.
- Prepare to evacuate **Urgently** (As per company S.O.P's).

Tetrodotoxin Immediate Action Summary

Organism	Detoxification	Treatment
Puffer Fish	• Toxin only present inside of fishes gut. • Activated charcoal orally if animal ingested.	• Close observation • Airway support. • Renal haemofiltration. • Shock management.
Cone Shell	• Submerge injury in hot water for 30-90 min. • Use forceps to remove spine.	• Airway support. • Irrigation with normal saline. • Exploration and debridement. • Antibiotics and analgesics. • Anti-tetanus agent. • Observe to rule out systemic envenomation. • Compression bandaging. • Topical corticosteroid cream for dermatitis.
Blue Ringed Octopus	• Irrigate with seawater (not fresh water).	• Same as outlined for cone shell. • Do not elevate limb above heart level. • Airway intubation is commonly needed. • Advanced cardiovascular support.

Sea Snakes 4.9.8

The sea snake is an air-breathing reptile, which has adapted to its aquatic environment by developing a paddle tail.

It injects a poison that has 2 to 10 times the toxicity of cobra venom. The bites usually appear as 4 puncture marks but may range from 1 to 20 punctures. Teeth may remain in the wound. The neurotoxin poison is a **heat stable** non-enzymatic protein; hence, sea snake bites should not be immersed in hot water as with venomous fish stings.

Sea snakes inhabit the Indo-Pacific area and the Red Sea, and have been seen 150 miles from land.

The most dangerous areas in which to swim are river mouths where sea snakes are more numerous and the water more turbid. The sea snake is a true snake, usually three to four feet in length but may reach nine feet. It is generally banded. The sea snake is curious and is often attracted. Usually it is not aggressive except during its mating season.

Due to its small jaws, bites often do not result in envenomation.

Sea Snake

Prevention

Wet suits or protective clothing, especially gloves may provide substantial protection against bites and should be worn when diving in waters where sea snakes are abundant. Also, shoes should be worn when walking where sea snakes are known to exist, including in the vicinity of fishing operations.

Do not handle sea snakes. Bites often occur on the hands of fishermen attempting to remove snakes for nets.

Presentation of a Sea Snake Envenomation;

- Bites are usually painless (as with many neurotoxins).
- The bite appears as 4 puncture marks. (Teeth may remain in the wound).

- Early symptoms include headache, a thick-feeling tongue, thirst, sweating, and vomiting.
- Symptoms that can occur after 10 minutes to several hours.
- Generalized aching, stiffness, and tenderness of muscles.
- Progressive flaccid paralysis (including respiratory system).
- After 3–8 hours, myoglobin presents (urine becomes 'coke cola' coloured).
- After 6 to 12 hours, severe hyperkalemia.

Management of Sea Snake Envenomation

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor (Urgently).
- Implement Shock Management. (O_2 , I.V.I. Etc) as appropriate. Anaphylaxis is common.
- Apply direct pressure using a compression bandage and immobilise the extremity in the dependent position with splints and elastic bandages (This prevents spreading of the neurotoxin through the lymphatic circulation).
- Incise and apply suction (if able to perform);
  - The cut should be small (one centimetre), linear and penetrate no deeper than the subcutaneous tissue.
  - The suction should only be performed if it is possible to do so within two minutes of the bites.
  - The incision and suction by inexperienced personnel has resulted in inadvertent disruption of nerves, tendons and blood vessels.
- Reassess regularly. (Use neuro exam including AVPU /GCS) If the casualty conscious level is severely reduced (G.C.S. ≤ 8, Only responding to pain in AVPU). Protect airway with appropriate device* (jaw thrust, oro-pharyngeal airway, iGEL Endo-tracheal intubation & ventilate).
- Implement Shock Management. (O_2 , I.V.I. Etc).
- Manage pain: (Local anaesthetic with no adrenaline may be injected into the site of the wound if pain is severe).
- Treat Rhabdomyolysis.
- If symptoms of envenomation occur within one hour, antivenin should be administered as soon as possible.
- Administer tetanus prophylaxis as appropriate.
- Prepare to evacuate **Urgently** (as per company S.O.P's).

The venom is a **heat stable protein**, which blocks neuromuscular transmission. Myonecrosis with resultant myoglobinuria and renal damage are often seen. Hypotension may develop

Sea Snake Immediate Action Summary		
Organism	**Detoxification**	**Treatment**
Sea Snake	• Irrigate with seawater (not fresh water). • Use forceps to remove fangs.	• Airway support. • Compression bandaging. • Irrigation with normal saline. • Exploration and debridement. • Specific antivenin. • Antibiotics and analgesics. • Anti-tetanus agent. • Observe to rule out systemic envenomation. • Topical corticosteroid cream for dermatitis.

Coral Cuts 4.9.9

Coral frequently causes lacerations, and abrasions to inexperienced divers. These injuries may initially appear minor in nature, but because of foreign material, such as pieces of coral, nematocysts, infected slime etc., they frequently become inflamed and infected.

Coral may also harbour stinging nematocysts.

Secondary bacterial infection is common after penetrating or abrasive marine injuries.

The Organisms Include:

- Staphylococcus aureus (the most common source resulting in cellulitis).
- Vibro vulnificus (a gram –ve bacteria specific to the marine environment).
- Tetanus is also a relative risk.

Prevention

Coral cuts can be avoided by the use of protective clothing, gloves, swim fins with heel cover and active treatment of minor abrasions.

Presentation of Coral Cuts;

- The laceration, usually on the hand or foot, causes little trouble at the time of injury.
- Some hours later there may be a 'smarting' sensation, and a mild inflammatory reaction around the cut (This may be due to the presence of discharging nematocyst).
- Over 1 - 2 days, local swelling, erythema, and tenderness develop around the site (Usually this abates in 3 to 7 days).
- Fever, chills, arthralgia, malaise, (systemic effects of a severe bacterial infection).

- Occasionally an abscess, or ulcer will form and discharge pus.
  - o Celluitis, and/or lymphadenitis may accompany the acute stage.
  - o This may become chronic with osteomyelitis a possibility.
  - o Healing may take months to years if complications ensue.

Management of Coral Cuts;

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor.
- Manage bleeding.
- Implement Shock Management. (O_2 , I.V.I. etc).
- Manage any wounds (see wound management section).
  - o This involves early antisepsis, and total removal of foreign material (e.g. with soft brush).
  - o The wound should be dressed with antibiotic powder, or ointment.
  - o Swab should be taken for culture, and sensitivity.
- Tetanus prophylaxis may be advisable.
- Cellulitis, lymphangitis etc. indicates the need for a broad-spectrum systemic antibiotic (e.g. ampicillin, tetracycline).
- Bed rest, elevation of the affected limb, and other general supportive measures.

Marine Attacks 4.9.10

Attacks by marine animal are actually **very** rare.

Main Dangers To Diver:

- Morays (and Conger).
- Octopi.
- Aggressive fish (Barracuda, Triggerfish Jacks).
- Marine mammals (seals, sea lions, Orka, dolphins).

Orka (Killer Whale)

Marine Attack Causes Are Varied:

- Misidentification of diver.
- Defensive reaction.
- Occur when feeding fish or animals.
- Probability of attack overestimated.
- Blood loss in water can be dramatic.

Moray Eels

While some temperate zone species of the moray eel are known, it primarily inhabits tropical and subtropical waters. It is a bottom dweller and is commonly found in holes and crevices or under rocks and coral.

It is snake-like in both appearance and movement and has tough, leathery skin. It can grow to a length of 10 feet and has prominent teeth.

A moray eel is extremely territorial and attacks frequently result from reaching into a crevice or hole occupied by the eel.

Moray Eel

Prevention

- Extreme care should be used when reaching into holes or crevices.
- Avoid provoking or attempting to dislodge an eel from its hole.

Presentation of Moray Eel Bites;

- It is a powerful and vicious biter and may be difficult to dislodge after a bite is initiated.
- Bites may vary from multiple small puncture wounds to the tearing, jagged type with profuse bleeding if there has been a struggle.

Mild envenomation may occur from a toxin that is released from the palatine mucosa in the mouth of certain moray eels. The nature of this toxin is not known. Treatment is supportive.

Management of Moray Eel Attacks

- Implement shark attack management.
- A medic should evaluate severe hand injuries immediately.
- Implement bleeding / wound management.
- Tetanus prophylaxis may be advisable.
- Antibiotic therapy should be instituted early.
- Immediate specialized care by a hand surgeon may be necessary for tendon and nerve repair of the hand to prevent permanent damage and loss of function of the hand.

Shark Attack

Shark attacks on humans are infrequent. Since 1965, the annual recorded number of shark attacks is only 40 to 100 worldwide.

Tiger Shark

Shark Attacks Are Rare:

- 2,251 attacks worldwide since 1580 (with 464 attacks being fatal.)
- Chance of getting attacked is 1 in 11.5 million. (obviously higher if your career is in the water).
- Chance of getting killed by a shark is less than 1 in 264 million.

These attacks are unpredictable and injuries may result not only from bites, but also by coming in contact with the shark's skin.

Sharkskin is covered with very sharp dentine appendages, called denticles, which are reinforced with tooth-like centres.

Contact with sharkskin can lead to wide abrasions and heavy bleeding.

Shark Pre-Attack Behaviour

Pre-attack behaviour by most sharks is somewhat predictable.

A shark preparing to attack swims with an exaggerated motion, its pectoral fins pointing down in contrast to the usual flared out position, and it swims in circles of decreasing radius around the prey.

An attack may be heralded by unexpected acceleration or other marked change in behaviour, posture, or swim patterns. Should surrounding schools of fish become unexplainably agitated, sharks may be in the area.

Sharks are much faster and more powerful than any swimmer. **All sharks** must be treated with extreme respect and caution.

There Are Different Modes Of Shark Attacks:

Great White Shark

- Indifference (rare).
- Approach with swift visual inspection (without follow-up).
- Approach with surveillance circling (without follow up, contact or attack).
- Approach with brush-past (without follow-up) **(wounding possible).**
- Charge with collision (generally upwards trajectory) **(wounding possible).**
- Charge with single or double investigative bite without tearing.
- Charge with biting and removal of flesh **(death in 45% of cases).**
- Multiple feeding-frenzy charge **(death in 100% of cases).**

Hammer Head Shark

Management of Shark Attacks;

- Conduct primary / secondary survey & record observations.
- Contact duty medic / supervisor.
- Manage bleeding / amputation / crush injury.
- Manage any wounds (see wound management section).
  - Culture infected wounds for both aerobes and anaerobes (Clostridium and Vibrio contamination are common).
  - Give antibiotics as prescribed.
  - Administer tetanus prophylaxis as per duty medic's instructions.
- Implement shock management. (O_2, I.V.I. Etc).
- Prepare to evacuate (as per company S.O.P's).
- Monitor and assess casualty until help arrives.

Section 5

Casualty Management

PRE-TRANSPORT STABILISATION 5.1

Rapid pre-transfer stabilisation can dramatically increase casualty survival rate.
Casualties with serious or multiple injuries starts to deteriorate rapidly. In trauma medicine the term the 'golden hour' is very common.

The golden hour is the time immediately after injury, and it is well recognized that the immediate effective resuscitation with a rapid but systematic packaging of a casualty for transport are key goals in overall mortality rate. For every 30-minute period after the Golden Hour, the patient's chances of survival are *cut in half*.

A 'Scoop & Run' approach should be avoided if at all possible. Once the decision to evacuate a casualty has been made, the DMT's caring for them should commence the process of preparing the casualty for their evacuation.

A systematic approach should be made in the transfer of a casualty. This can be applied using the A.B.C.D.E.:

Airway Support (With Spinal Care):

Spinal immobilisation

It is likely that transportation of a casualty with cervical injuries may increase the severity of the injury.

Any Suspected Spinal Injury Should Be Transferred With:

- Definitive immobilisation, which includes:
  - Cervical Spinal Collar.
  - Head blocks.
  - Vacuum mattress / Spinal board / Scoop stretcher.

Spinal Immobilisation

Airway Support

A conservative approach should be made with regards to airway management. If the casualty has a prolonged evacuation time to a medical facility, it should be assumed that their airway needs might deteriorate. It is therefore common for a casualty who is seriously injured to be electively intubated with a R.S.I. prior to transport to maintain stability. The attempted intubation of a casualty in-flight is often unsuccessful.

The Approach To Transport Airway Support Should Include:

- Endo-Tracheal Tubes
  - Ensure E.T. tube **Doubly** Secured with tape.
  - E.T. cuff should be filled with H_2O for air transport.
- Suction:
  - Hand powered. With catheters.
- Appropriate airway transport equipment:
  - OPA, NPA, E.T., cricothyroid puncture kit.

Secure Airway

Breathing Support:

An assessment of the casualties respiratory support needs is vital prior to transport. The presumption should be made that respiratory support will need to be increased during transport. Therefore provisions should be made to accommodate this.

The Main Elements For Pre-Transport Stabilisation Are:

- Positioning:
  - Inclined upright position (if possible).
- Ventilation:
  - Transport ventilator. Aeromedical-hyperbaric capable & fully charged.
  - D.M.T's should be trained in the use of specific equipment used.
- Oxygen therapy: (A high percentage to compensate for a drop in partial pressure).
  - Appropriate mask for transport.
  - Adequate O_2 supply for intended journey, return & additional ⅓.
  - Multi-function oxygen regulators (with high and low pressure).
- Chest tube:
  - A heimlich valve attached for air-evacuation.
- Appropriate breathing transport equipment:
  - B.M.V. ventilator. O_2 masks. Thoracocentesis Kit (2x 14g Cannula & Heimlich valve).

Position For Optimal Breathing

Administer Oxygen

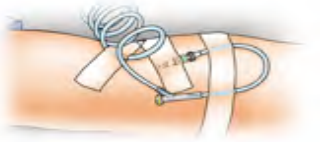
Circulation Support:

An assessment of the casualty's cardiovascular needs is vital prior to transport. As always, the presumption should be made that the casualty will become haemo-dynamically unstable during transport. Therefore provisions should be made to accommodate this.

The Main Elements For Pre-Transport Stabilisation Are:

- I.V. Access:
  - o Large bore (Min 18g) cannulae x 2.
  - o Cannulas / drips should be **Doubly** Secured with tape.
- I.V. Fluids:
  - o Crystalloid, colloid. Enough for transfer & return.
- Drugs:
  - o Resuscitation & maintenance drugs (vasoactive / sedation / gastric)
  - o Enough for transfer & return.
- Bio-medical Electronic equipment:
  - o Drug Infusion Device:
    - – Aeromedical-hyperbaric capable & fully charged.
  - o Defibrillator:
    - – Aeromedical-hyperbaric capable & fully charged.
  - o Monitors:
    - – Pulse, Resps, ECG, SpO_2, B/P, temperature.
    - – Aeromedical-hyperbaric capable & fully charged.

Doubly Secure I.V.



Transport Equipment

Disability Support (Neurological)

Assessment of the casualty's neurological state is vital prior to transport. If a casualty has been intubated then the continual administration of sedative drugs is common. It is important to be aware that these drugs can have a profound haemo-dynamic effect (normally dropping of blood pressure). Therefore provisions should be made to accommodate this.

The aim is when using sedative drugs to administer enough to keep the patient sedated but not enough to fully anaesthetise.

RASS	RASS Description
+4	Combative, violent, danger to staff.
+3	Pulls at tube(s) or catheters; aggressive
+2	Nonpurposeful movement, fights ventilator
+1	Anxious, apprehensive , but not aggressive
0	Alert and calm
-1	Awakens to voice (eye opening) >10 sec
-2	Light sedation, briefly awakens to voice (eye opening) <10 sec
-3	Moderate sedation, movement or eye opening.
-4	Deep sedation, no response to voice, movement or eye opening to stimulation.
-5	Unarousable, no response.

The Main Elements For Pre-Transport Stabilisation Are:

- Monitoring
  - o G.C.S.
- Sedation therapy:
  - o As prescribed. (sliding scale in accordance to the casualties neurological / sedation level).
  - o Maintain sedation to -2 / -3 level.
- Analgesia:
  - o Give analgesia as prescribed using a pain score system.
  - o Pre load with analgesia **before** transfer.

Exposure / Environment

It is vital that the DMT evaluates the mode, duration & environmental elements of the casualty's transfer. The aim is obviously for a problem free evacuation and this is only achieved by systematic prior preparation.

The Main Elements For Pre-Transport Stabilisation Are:

- Packaging: It is vital that the casualty is well secured prior to transport.
  - o Spider Harness / Straps.
  - o Mummy wrapping blanket.
  - o Drains / IV's / catheters / tubes secure & visible.
- Limb immobilisation:
  - o Splint all fractures.
  - o Ensure adequate padding.
  - o Ensure visible view-ports.
- Thermal control:
  - o Blankets / clothing.

Casualty Packaging

Regardless Of How Packaging Is Achieved, The Rescuer Should Ensure These Elements Are Addressed:

- Airway
  - 0 Security of airway. Ensuring that the casualty airway is patent.
  - 0 Security of airway device. Ensuring that the casualty airway device WILL NOT fall out in transit.
- Breathing
  - 0 Adequacy of casualty's respiration.
  - 0 Adequacy of breathing gas supply.
- Cardiovascular
  - 0 Stability of casualty CVS.

- 0 Stability of vascular access devices.
- 0 Appropriate monitoring.

- Analgesia
  - 0 Immediate relief.
  - 0 Maintained relief.
- Immobilisation
  - 0 Secure spinal immobilisation.
  - 0 Splintage of fractured / injured limbs.
- Security
  - 0 Casualty is stable / comfortable for transit.
  - 0 Medic is prepared for transit.

Holding

You may find yourself in the unfortunate position of not being able to immediately evacuate your casualty. If this is the case you will have to provide for their basic day-to-day bodily needs.

In Conjunction With These You Will Have To Provide Some Degree Of After Care For Your Casualty:

- Regular observations.
- Updating of medical documentation.
- All treatments are refined and any tubes, cannulae or dressings are secure.
- Maintenance of or changing of dressing.
- Casualty is hydrated / fed.
- Casualty is moved to avoid pressure sore development.

Casualty Transport Checker		
Issue	**Generic**	**Specific**
Spinal Care / Immobilisation	Spinal immobilisation	Collars, blocks, tape. Vacuum mattress / spinal board
	Limb immobilisation	Splints, with adequate padding & view ports
Airway	Airway support	Ensure airway device **Doubly** Secured with tape.
	Spare Airway support	Masks, OPA, NPA, E.T., cricothyroid puncture kit.
	Suction	Hand powered. With catheters.
Breathing	Oxygen	Adequate supply for intended journey, return & additional ⅓.
		Oxygen Regulators with high and low pressure connectors for all types of delivery.
	Ventilator	Adjustable for tidal volume and frequency, with pressure monitoring as a minimum.
	Thoracocentesis Kit	14g Cannula & Heimlich valve.
Cardiovascular	I.V. Access	Large bore cannulae x 2 **doubly** Secured with tape.
	Fluids	Crystalloid, colloid. Enough for journey ++.
	Drugs	Resuscitation & maintenance. Enough for journey ++.
	Defibrillator	A.E.D.
	Monitors	ECG, SpO_2, B/P, temperature as a minimum.
Disability (C.N.S.)	Analgesia	Use analgesia scale, send enough for journey +/-.
Environmental	Thermal control	Blankets / clothing.
	Securing Device	Spider Harness, Straps, Mummy Wrapping blanket.
Sundries	Documentation	Dive Injury Report, Neuro Form, GCS Obs, First Aid Form, Fluid Balance, Accident Form, Accident form.
	Necessities	Clothing suitable for location & money.
	Immediate survival	Passport, water, food, money.
	Communications	radio, phone, locator beacon,

TRANSPORTING A DIVER WITH D.C.I 5.2

The diver should be transported with minimum agitation and as close as possible to sea level or at 1ATA. Mountainous roads should be avoided whenever an evacuation route by land is planned.

There Are Several Key Points In The Transport Of The DCI Casualty:

- The patient should always breath 100% oxygen during transport, if available.
  - o If symptoms of DCI / AGE are relieved or improve after breathing 100% oxygen, the patient should still be treated as if the original symptoms were still present.
- Ensure that the patient is adequately hydrated.
  - o Give oral fluids if the patient is able to take them.
  - o Otherwise, IV fluids should be started before transport.

Patients Are Adequately Hydrated When They Have Urinated With A Full Bladder.

- A patient with spinal DCS may be unable to empty the bladder and will therefore be in considerable pain.
- Urinary output should be closely monitored and the patient may need to be catheterised.

Transportation In An Aircraft Presents Problems.

Environmental pressure decreases with altitude, causing DCS bubbles to expand (Boyle's Law) and more gas to pass from the tissues into any bubbles.

- When a patient is evacuated by air, unpressurised aircraft should endeavour to fly at the lowest safe altitude.
  - o Even an altitude of 300m (1000ft) can make the symptoms of DCI worse.
- Most commercial aircraft maintain a cabin pressure of 2000m (6000ft), which will seriously aggravate DCI.
- If transport via pressurised aircraft is unavoidable then a 'sea level' transfer should be requested. (The aircraft does not actually fly at sea level, but the cabin is pressurised to 1ATA).

Transfer Under Pressure 5.2.1

When possible a diver Transfer Under Pressure facility is used. This allows for the Transfer Under Pressure, or TUP, of an ill or injured diver from a saturation complex offshore to a hyperbaric facility on the mainland. This is achieved by means of transportable chambers.

There Are Several Options:

T.R.C.S. (Transportable Recompression Chamber System).

A small one-man chamber, which locks onto the offshore system and receives the ill or injured diver. This can then be transferred by a suitable airframe.

- 6 bar max depth.
- NATO lock.
- Single casualty with tender capacity.
- Moved:
  - o Sea
  - o Land
  - o Fixed wing
  - o Helicopter (wide bodied).

T.R.C.S.
(Transportable Recompression Chamber System).

Hyperlite Hyperbaric Stretcher

Generally for recriational diver use. Single casualty without tender capacity.

- 2.1 bar max depth.
- Moved:
  - o Manually
  - o Sea
  - o Land
  - o Fixed wing
  - o Helicopter

Hyperlite Hyperbaric Stretcher

Hyperbaric Lifeboat

Essentially a floating multi-place chamber. Generally difficult to treat severely injured casualties.

- 40 bar max depth
- Multiple casualties with tender capacity
- Sea craft (Slow)

Hyperbaric Lifeboat

EMERGENCY RADIO FREQUENCIES 5.3

Maritime Emergency Frequencies

Ships with radiotelegraph station, while at sea, keep a 24 hours listening watch of 500 kHz and on 2182 kHz. Coastal radio stations keep a 24 hours listening watch on 500 kHz, 2182 kHz and some also on 8364 kHz. Ships with radiotelephone station, while at sea, keep a 24 hours listening watch on 2182 kHz. Coastal radio stations and ships with VHF radio keep listening on VHF frequency 156.8 MHz. (channel 16).

- 2182 kHz - telephony - alarm / speech
- 500 kHz - telegraphy - no longer monitored or protected as distress frequency
- 8364 kHz - telegraphy - alarm / Morse
- 156.8 MHz - telephony - speech.

Aeronautical Emergency Frequencies

Commercial air traffic keep a listening watch of 121.5 MHz. Military air traffic keep a listening watch on 243 MHz.
"SEA KING" helicopters can "home" on all emergency frequencies, except of 156.8 MHz (channel 16).

Rescue helicopters may keep communication on all maritime -and aeronautical emergency frequencies. Commercial helicopters can "home" on 500 kHz and 2182 kHz.

- 121.5 MHz - Civil aeronautical emergency frequency.
- 243 MHz - Military aeronautical emergency frequency.
- 121.5 Mhz/123.1 MHz - Communication frequency.

Distress Calling

Telegraphy 500 kHz - 8364 kHz.

- Alarm signal (Distress) - "May-Day".
- Alarm signal (Urgent Assistance) - "Pan-Pan".
- Alarm signal (Safety) - "Sécurité".

Telephony 2182 kHz.

- Alarm - Two-tone alarm signal.
- Distress message - "Alarm Signal" + message.

VHF Telephony 156.8 MHz (channel 16)

- Alarm - None.
- Distress message - "Alarm Signal" + message.

Distress Message Procedure

- Alarm Signal 3 times. (i.e.: May-Day, May-Day, May-Day, Pan-Pan-Pan, Sécurité-Sécurité-Sécurité)
- This is (Your name / call sign) 3 times.
- Your position.
- Type of distress or emergency situation.
- Type of assistance requested.
- Weather condition (wind-wave-visibility etc.)
- Other information: - number of person(s) involved.
- Injured person(s) - medical assistance required.
- Emergency radio beacon/communication.

Ship and rig to shore communication should be on 2182 kHz.
It is important that all marine units involved in the emergency should maintain radio communication with the same Coastal Radio Station that is controlling the emergency traffic.

- Air to ship communication is to be on 2182 kHz RIT. However, the rescue helicopters are equipped with, and will communicate with vessels on channel 16, **VHF** emergency radio, operating on 121.5 MHz or 123.1 MHz may be used as back-up if a total loss of communication is experienced.
- Aircraft and helicopters in an emergency or rescue operation will keep a listening watch on 121.5 MHz.

Emergency Position Indicating Radio Beacons

Air traffic keeps a listening watch on the International Aeronautical Distress Frequencies 121.5 MHz VHF.
Emergency position indicating beacons may therefore be used to indicate that an emergency or distress situation exists.

Rescue helicopters and aircraft can "home" on emergency beacons, thus saving search time.

E.T.H.A.N.E. 5.3.1

The following “packet “ of information is a systematic way to relay the essential details to the emergency services control.

This is important so that the appropriate response to the incident can begin as soon as possible.

ETHANE Can Be Used As A Neumonic For The Packet Of Information:

- Exact location
- Type of incident / injuries
- Hazards
- Access
- Number of casualties
- Emergency services on scene or required

An Example Is:

'We are at the Fulmar platform 217 miles due east of Dundee. There has been a fire in the galley. One male-aged 36 is not breathing with a suspected smoke inhalation. The fire has been extinguished. Access is by platform helipad, a medic wearing hi-viz vest will be waiting at the pad; a DMT is providing advanced life support. We need urgent evacuation with a paramedic equipped Air Ambulance.”

Secondly, you will be asked what the chief complaint is with the patient. Try to keep details to a minimum; a brief description of the problem is all that is required. If it has nothing to do with what's wrong with the patient now, then it isn't important. Things to remember are whether the patient has any serious medical history ie, diabetes, epilepsy etc. The M.I.S.T. information packet is best.

M.I.S.T. CASUALTY HANDOVER 5.4

The patient handover is a fundamental part of the reception of the casualty at hospital. Clinical information and the observations of the pre-hospital providers on the mechanism of injury are valuable in the ongoing evaluation of the casualty.

A MIST handover provides a short, rapid and structured format to present the critical information at hand over to a medical facility in a concise and structured format.

M.I.S.T. stands for: Mechanism, Injuries, Signs & Treatment.

- **M**echanism
  Brief details of events, e.g. motor vehicle crash, fell from 15ft roof. This information provides the hospital with a context and helps appraisal for predictable injuries.
- **I**njuries
  A concise description is given of the injuries discovered, e.g. broken leg, and their location.
- **S**igns
  The initial vital signs are relayed in an A.B.C.D.E. format. Any changes in the vital signs that have occurred en route should be stated.
- **T**reatment & **T**imes
  Some of these will be visibly obvious such as the use of a splint and when it occurred. These are essential pieces of information that dictate clinical priorities for the hospital Team.

Essential Information

WORKING WITH HELICOPTERS 5.5

Approaching the Helicopter

- Do not approach within 30 metres of a helicopter, or leave the aircraft without a clear signal from the aircrew to do so. A *thumbs up* by day, a *one flash of light* (by torch) by night.
- Always approach the aircraft from the correct direction.
  o In general, this is the 2–3 o’clock position.
  o Except for the Chinook / Merlin, which is approached from the 4/5 o’clock or 7/8 o’clock position.
- Particular care is to be taken when working on sloping or uneven ground.
  o Remember, on an uphill slope the rotor blades will be nearer the ground.

Casualties May Have To Be Loaded While The Rotor Blades Are Still Turning:

- Because of the downwash created by the rotor blades, all headgear is to be removed and loose articles secured, before approaching the aircraft.

General Safety

- No smoking inside or within 15 metres of the aircraft.
- Personal belongings must be kept to a minimum.

- Do not enter the inside of the cabin unless instructed to do so.
- Do not touch anything while inside the cabin unless instructed to do so.
- All helicopters are extremely noisy aircraft. This noise is to be considered a hazard and hearing protection is to be worn when in their vicinity (including casualties).
- Do not move about the aircraft during flight.

Casualty Considerations

Transporting a potentially ill casualty has some key factors that the medic must consider;

Problems Of Altitude:

- A decrease in air density.
- A fall in air pressure.
- Low temperature / humidity.
  - o Many aircraft cabins have very low humidity (often less than 15% humidity).

Flight Stressors:

There are several physiological elements that will need to be considered when transporting the ill casualty:

These Include:

- Hypoxia (cabin hypoxia. The reduced partial pressure of O_2 may have several adverse effects).
  - o Cardiovascular disease.
  - o Respiratory disease.
  - o Neurological disorders.
- Barotraumas. (Reverse squeezes).
- Flight motion:
  - o G-forces.
  - o Vibration.
  - o Noise.
  - o Motion sickness.
- The risks of reduced mobility (D.V.T. / Pressure Sores).

The aircrew must be informed of any flying restrictions imposed by the casualty's clinical condition prior to the flight.

Casualties on stretchers are to be brought to the aircraft feet first, except for the Chinook, when casualties are to be brought to the aircraft head-first.

Super Puma 5.5.1

The Puma is a single main rotor, twin engine helicopter. Its main role is to provide tactical support but is often used in a casevac role.

This extremely versatile aircraft, when conditions dictate, can accommodate usually two stretchers (but can take three) or six walking casualties (or a combination between the two maximums) in the rapid reaction role.

Super Puma

Danger Points

- Main rotor. The main rotor is 15·8m in diameter and drops to a low point of 3·65m on level ground.
- Tail rotor. The tail rotor is 3·05m in diameter and reaches a low point of 2·05m on level ground.
- Fragile windows and doors. The main cabin doors, the cockpit access door and the co-pilot's jettisonable panel are all made of light-alloy and transparent materials. Use care when operating the cabin door and stay well clear of these areas when in flight.

Approaching Super Puma (10 o'clock)

Loading Sequence

- The ready position is 30m out from the helicopter at the 10 o'clock position.
- Emplaning. Approach the helicopter **when** signalled to do so by the aircrew.
- The approach is from the ready position to the starboard cabin door.
- Casualties are loaded feet first and are secured with their heads forward (except when contraindicated by the casualty's injuries, particularly those with head injuries who, whenever possible, should **not** fly in a head-down position).
- The stretchers are loaded in the following sequence.
  - o Port rear.
  - o Starboard rear.
  - o Port centre.
- Unloading is the reverse of loading.

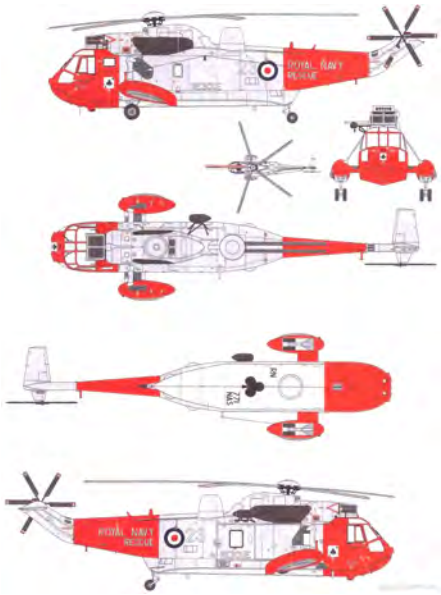
The Sea King 5.5.2

The Sea King is a single main rotored, twin engined, all weather tactical support helicopter. This aircraft is

extremely versatile but is primarily used for troop transport, carriage of under slung loads and search and rescue. In the rapid reaction role, up to six stretchers can be secured to the floor.

This layout is heavily dependent on the aircraft's configuration and the theatre of operation. In a combat zone, it will be more likely to carry four stretchers.

Sea King



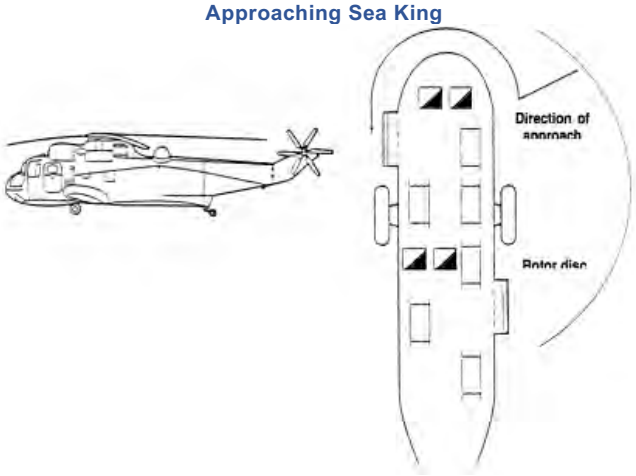
Danger Points

- Main rotor. The main rotor is 21·34m in diameter and drops low as the blades slow to a halt. **Do not enter the disc area during engine shut down.**
- Engine intakes and exhausts. The engine intakes are situated above the cockpit and the exhaust gases are blown to the side and may radiate up to 8m from the main rotor assembly.
- Tail rotor. The tail rotor is 3.96m in diameter and reaches a low point of 2·74m on level ground.
- Other danger areas include the Floatation Bag Canister covers (can travel up to 60m when operated). There is also an Ice Accretion Indicator at eye level on the forward port side.

Loading Sequence

- The ready position is 30m out from the aircraft at the 2 o'clock position.
- Emplaning. The approach is from the ready position to the main starboard side door. The casualties are loaded headfirst into the cabin and positioned with their head forward, the exception again being those with head injuries.

Approaching Sea King



Section 6
Documentation

INJURY DOCUMENTATION 6.1

It is useful for a DMT to complete appropriate documentation for every casualty treated.

Casualty observation forms are designed so that the DMT can keep a record of the exact treatment provided and is essential as a legal record.

The actual documentation completed is dependent upon the examination / condition which is being treated. We have included examples of several documents (which are included full scale in the miscellaneous section).

These Documents Include:

- First Aid Report Form.
- Diver Casualty Aid Form.
- Diver Neurological Assessment Form.
- Glasgow Coma Scale / Observation Chart.
- Diver Fluid Balance Form.

The Main Benefits Of Good Documentation Are:

- Communication.
- Quality assurance.
- Decision analysis.
- Legal documentation.
- Historical documentation.

The Main Purpose Of Good Documentation Are:

- Prevention of errors.
- Consistent with standards.
- Complete, accurate, relevant, factual, timely record of events.
- Legally prudent.
- Confidential.

Key Tips For Good Documentation:

- Orderly & sequential.
- Use only approved abbreviations.
- Record clarification requests and / or corrections.
- Chart only for yourself.
- Avoid vague statement.
- Stick to facts.
- Begin with time and end with appropriate signature & designation.

It is useful for a first aider to complete a First Aid Report Form for every patient treated. Please note that this does not replace the accident book, which would still have to be completed for an accident at work.

A patient report form is designed so the DMT can keep a record of the exact treatment provided. If a patient refuses treatment, make sure they are capable of making that decision (e.g. a fully conscious adult). Seek medical advice if they are not.

- Follow the advice given for completing the accident book when completing the form.
- A copy of the form can be given to receiving medical staff, as it will contain valuable information about the incident and treatment of the patient.
- To comply with the Data Protection Act, personal details on the report form must be kept confidential, so the report should be stored securely (e.g. in a lockable cabinet).

If time permits an **A.M.P.L.E.** history can be very useful.

This Stands For:

- **A** **A**llergies.
- **M** **M**edication.
- **P** **P**revious Medical History.
- **L** **L**ast Meal.
- **E** **E**vents

Incident Report Form 6.1.1

Any accident at work, no matter how small, must be recorded in an accident book, which may be filled in by any person on behalf of the casualty (or indeed by the casualty themselves).
The information recorded can help the employer identify accident trends and identify possible needs for improvement in the control of health and safety risks. It can be used for future first aid risk assessments and may be helpful for insurance investigative purposes.
The DMT often completes the accident book.

The Following Notes Are Given For Your Advice:

- An accident book is a legal document.
- Anything that has been written down at the time of an incident is usually considered to be 'stronger evidence' in court than something recalled from memory.
- Complete the report all at the same time, using the same pen (not pencil).
- To comply with the Data Protection Act, personal details entered in accident books should be kept confidential, so the book should be designed so that individual record sheets can be removed and stored securely.
- A member of staff should be nominated to be responsible for the safekeeping of completed accident records (e.g. in a lockable cabinet). Hand the completed accident record to that person.
- The person who had the accident may wish to take a photocopy of the report. If this is the case, they can do this before it is handed in. They should:
  - Keep a record of the accident report number.
  - The name, address and occupation of the person who had the accident.
  - The name, address, occupation and signature of the person who is completing the report.
  - The date, time and location of the accident.
  - A description of how the accident happened, giving the cause if you can.
  - Details of the injury suffered.
  - Subjective opinion should be avoided.

Accident Book

R.I.D.D.O.R. 6.1.2

The H.S.E. regulations for reporting an incident are according to RIDDOR, which stands for the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, 1995.
RIDDOR '95 requires the reporting of all work-related accidents, diseases and dangerous occurrences.

The Following Need To Be Reported:

- Deaths.
- Major injuries.
- Accidents resulting in over 3 days of injury time off work.
- Diseases.
- Dangerous occurrences.
- Gas incidents.

R.I.D.D.O.R. Reporting

All incidents can be reported to the H.S.E. in a variety of way (online, telephone, e-mail & post). Go to: www.hse.gov.uk/riddor/index.htm for more information.

Reporting accidents is clearly regulated and obliges compliance.

Casualty's Name:..... **Date :**...../...../20..... **Time**.....

History

Mechanism Of Injury	
Injuries Sustained	
Symptoms:	
Time & Treatment	

Allergies	Medication	Past Medical History	Last Eaten

Assessment (Secondary Survey)

A Airway Assessment

Airway Patency	Gag Reflexes	Cough Reflexes	Spinal Injury
Clear / Compromised	Y / N	Y / N	Y / N

T.W.E.L.V.E. Neck Signs * T – Trachea, W – Wounds, E – Emphysema, L – Larynx, V – Veins, E - Evacuate

Airway Interventions

Suction	Airway Adjunct	Type
Y / N	Y / N	NPA / OPA / iGEL / E.T

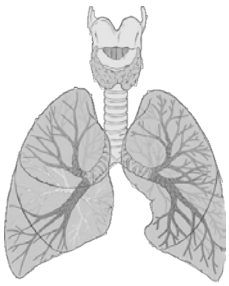
Spinal Immobilisation Measures Implemented

Manual Immobilisation / C-Collar / Head Blocks / Spinal Board

B Breathing Assessment

Breathing	Y / N
R - Breathing Rate	.....B.P.M
I – Injuries	Open / Flail / Contusion
S – Symmetry	Asymmetrical
E – Effort	Laboured / Gross / Distress
F – Feel	Deformity / Tenderness / Emphysema
A - Assess(Percussion)	Hyper-Resonant / Hypo-Resonant
L – Listen (Ausciltate)	Wheeze / Crackles / Reduced / Absent
L – Look :At back / armpits	

Mark Affected Areas



Breathing Interventions

O_2 Started (Time)	% O_2 Given	O_2 Ventilation Mode
.....	.....%	Non-Rebreather / BIBS / B.M.V. /

Open Pneumothorax	Circumferential Chest Burns
Flutter Dressing / Chest Seal	Incisional Escharotomy
Tension Pneumothorax	Pulmonary A.G.E.
Needle Decompression / Chest Drain	Hyperbaric Therapy / IPP Ventilation

Comments

C Circulation Assessment

Pulse (Heart Rate)	C.R.T. Capillary Refill Time	Estimated Blood Pressure
.....B.P.M	.....Secs	Radial (> 90 mmHg) Femoral (> 70 mmHg) Carotid (> 50 mmHg)
Symptoms of Shock	**Haemorrhage**	**Temperature**
Y / N	Compressible / Non-Compressible	.....°C

Circulation Interventions

Haemorrhage	Limb Haemorrhage Catastrophic	Time Applied
Trauma Dressing / Direct Pressure	Arterial Tourniquet	
Vascular Access	**I.V. Infusion**	

D Disability If AVPU scores V, P or U conduct full G.C.S.

Alert	**A Eye opening:**	**B Verbal response:**	**C Motor response:**
Voice	Spontaneous 4	Orientated 5	Obeys Commands 6
Pain	To voice 3	Confused 4	Localises 5
	To Pain 2	Inappropriate 3	Pain Withdraws 4
Unresponsive	None 1	Incomprehensible 2	Pain Flexes 3
		No Response 1	Pain Extends 2
			No Response 1
	A ...../4	**B** ...../5	**C** ...../6
Blood Sugar Level	.....mmol's	G.C.S. Score	...../15

Pupil Size	1 2 3 4 5 6 7 8	Left	Right

Pupil Reaction	+ Reacts - No reaction C Eye closed Sl Sluggish	
	Left	**Right**

Skull Injuries Found	Facial Injuries Found	CSF Leak Found (Nose / Ears)
Y / N	Y / N	Y / N

Interventions

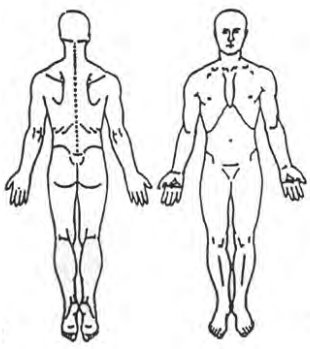
Dressings (Which Area)

E Exposure

Examine
- Abdomen
- Pelvis
- Arms & Legs
- *Back*

Examine For
- Asymmetry
- Pain
- Deformity
- Bleeding
- Distensions
- Rashes
- Alert bracelet

Mark Affected Areas



Abdominal Injuries	Pelvic Injuries	Upper Limb Injuries	Lower Limb Injuries	Back Injuries
Y / N	Y / N	Y / N	Y / N	Y / N

Interventions

Abdo Haemorrhage	Pelvic Trauma	Limb Fractures	Back Injuries
Pressure Dressing	Pelvic Splinting	Splinting / Sling	Immobilisation

Dressings (Which Area)

Diver Assessment Form 6.1.4

Casualty's Name:..... **Date :**...../...../20..... **Time**.....

Dive History

Gas Mix :	# Of Dives Today	Max Depth	Total Dive Time	Bottom Time	Dive Schedule
.....	.....	.....mt	.....min	.....min	.....
Symptoms Onset :	Acute / Chronic	Time Of Onset :	Before Dive / During Ascent / At Surface / ..... mins after Surfacing		
Evolution Of Symptoms:	Progressive / Static / Spontaneously Improving / Relapsing / Resolved				
Symptoms:	Neurological / Audio-Vestibular / Constitutional / Limb Pain / Pulmonary / Cutaneous / Lymphatic				
P.M.H. / previous D.C.I.					

Mental Status

Where is the current location ?		1
What is their Date of Birth ?		1
What is their Age?		1
What Time is it ?	To nearest Hour	1
What is the Year ?		1
Remember an Address	52 Old St, (repeat back at end of test)	1
Recognition of two persons	Show photograph of 2 famous people	1
What Year did World War Two end ?	1945!	1
Name of the Prime Minister ?	In THEIR country	1
Count backwards from 20 to 1		1
Abbreviated Mental Test Score (AMTS)		10

Coordination

Tick (✓) if normal (✱) if not.

Romberg Test Sharpened	Eyes open & closed. Arms crossed. Heel to toe.	
Heel to Toe Test	Walks a line	
Finger to Nose Test	Both hands, eyes closed	
Rapid Movement Test	Thumb to fingers 1st 2nd,3rd,4th, 1st , Eyes closed.	

Muscle Power

If uncertain about grading, use '0' for nothing, '5' for normal or 'Ab' for abnormal.
0 = Nothing (absent)
1 = Tiny flicker of movement
2 = Movement but not against gravity
3 = Moves against gravity but not examiner
4 = Pushes against examiner but not normal strength
5 = Normal

Movement in brackets to be performed by patient		Lt	Rt
Upper Body			
Shoulder	Abduction: Arms, push down Adduction: Arms, pull up		
Tricep Reflex	Strike the tendon on the tendon just above the elbow. The tricep should twitch		
Bicep Reflex	Hand on abdomen. Your index finger in elbow joint and tap forefinger. (elicit a tendon jerk.)		
Elbow	Extension: Bent elbows, push Flexion : Bent elbows, Pull		
Finger Spread	Strength against resistance		
Wrist Strength	Fingers out straight		
Grip Strength	Use two of your fingers		
Lower Body			
Hip Flexion	Flexion: Legs, pull up Extension: Legs, push down		
Patellar Reflex	Legs dangling, tap just below knee-cap		
Ankle	Extension: Foot, push down Flexion : Toes, pull up		
Achilles Reflex	Foot flexed, pressure applied, on sole,		
Plantar Reflex	Firm stroke lateral aspect from foot -base of big-toe. Abnormal if toes extends or fan.		

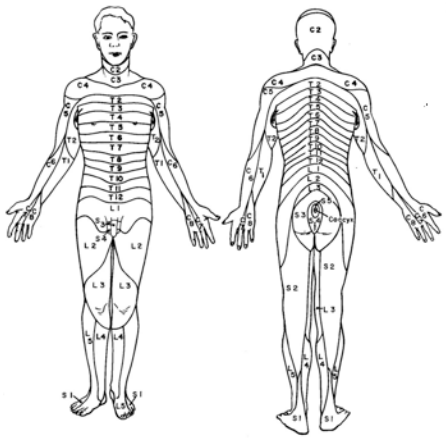
Cranial Nerves

Tick (✓) if normal (✱) if not

Nose (I)		
Smell Optional in acute setting	Test familiar smell (eg Coffee)	
Eyes (II, III, IV, VI)		
Vision	Still head, Finger Count & sign reading, look for nystagmus at extremes of H Shape	
Visual Fields	Finger Wiggle, Diagonal from extreme of visual field inwards.	
Pupils	P.E.R.L.	
Face (V, VII)		
Movement	Scrunch eyes & try to pry open. Blow out cheeks. Clench teeth & open mouth against resistance.	
Sensation	Light touch in ophthalmic / maxillary / mandibles	
Ears (VIII)		
Hearing	Rub your fingers next to their ears. Compare their hearing with yours.	
Vagus (X)		
Vagal Test	Say AHHH, note if palette rises. Observe for hoarseness	
Neck (XI)		
Twisting neck	Against resistance, get them to try & maintain a midline	
Shoulder Shrug	Against resistance.	
Mouth (XII)		
Tongue	Stick out tongue to ensure it is midline	
Gag Reflex Optional in acute setting	Touch back of throat with tongue depressor.	

Sensation

Shade / Code area of altered sensation relating to spinal nerves.
Pain = **P**, Light Touch = **L.T.**, Vibration = **V**, Tingling = **T**



Notes

Glasgow Coma Scale Observation Form 6.1.5

Name:	Hospital No:	Date:

Observations				
		HOURS		
		MINUTES		
GLASGOW COMA SCALE	Eyes Open	4	Spontaneously	Eyes closed by swelling = C
		3	To speech	
		2	To pain	
		1	None	
	Best verbal Response	5	Orientated	Endotracheal tube or tracheostomy = T
		4	Confused	
		3	Inappropriate words	
		2	Incomprehensible sounds	
		1	None	
	Best motor response	6	Obeys commands	Record the best response
		5	Localises pain	
		4	Withdraws from pain	
		3	Flexion to pain	
		2	Extension to pain	
		1	None	

Pupil scale (mm): 1, 2, 3, 4, 5, 6, 7, 8

Blood pressure and pulse rate: 240, 230, 220, 210, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 20, 10

Temperature °C: 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30

Respiration

Pupils: Right (Size, Reaction); Left (Size, Reaction)

Temperature	
R	Rectal
T	Tympanic
O	Oral
Ax	Axilla
S	Skin
+	Reacts
-	No reaction
C	Eye closed
Sl	Sluggish

Limb Movements §			
	Upper Limb	Normal Power	Record right (R) Record left (L) Separately if there is a difference between the two sides
		Mild weakness	
		Severe weakness	
		Spastic flexion	
		Extension	
		No response	
	Lower Limbs	Normal power	
		Mild weakness	
		Severe weakness	
		Spastic flexion	
		Extension	
		No response	

Fluid Balance Chart 6.1.6

Casualty's Name:..... **Date :**...../...../20.....

Examiners Name:..... **Time**.....

Time	IV Fluid	IV Amount	Oral	Total In	Urine	NG / Vomitus	Drain	Stool	Total Out	Balance
08:00										
09:00										
10:00										
11:00										
12:00										
13:00										
14:00										
15:00										
16:00										
17:00										
18:00										
19:00										
20:00										
21:00										
22:00										
24:00										
01:00										
02:00										
03:00										
04:00										
05:00										
06:00										
07:00										

First Aid Report Form 6.1.7

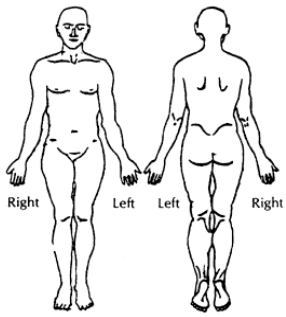
Inspection Date:		**Inspection Time:**			
First Aider					
Patient Name		**D.o.B:**		**Age:**	
Patient Contact Details					
Location of Incident:					

Patient Observation *(Record every 10 mins)*

Time	Breathing Rate	Pulse Rate	C.R.T.	Estimated B.P.	A.V.P.U. Score
	B.P.M.	B.P.M.	Secs	mmHg	
	B.P.M.	B.P.M.	Secs	mmHg	
	B.P.M.	B.P.M.	Secs	mmHg	
	B.P.M.	B.P.M.	Secs	mmHg	
	B.P.M.	B.P.M.	Secs	mmHg	
	B.P.M.	B.P.M.	Secs	mmHg	
	B.P.M.	B.P.M.	Secs	mmHg	
	B.P.M.	B.P.M.	Secs	MMHg	

A.V.P.U. Score			Breathing Rate	Pulse Rate	C.R.T.	Estimated B.P.
ALERT	Fully Alert	6	< 8 Emergency	< 40 Emergency	< 2 Secs	> 90 Mg Hb Palpable Radial Pulse
VOICE	Confused	5 Caution	< 12 Caution	40 – 60 High Caution		
	Inappropriate Words	4 Caution	12 - 16	60 - 90	2 – 3 Secs Caution	
	Utters Sounds	3 Caution	16 – 20 Caution	90 – 120 Caution	3 -4 Secs Caution	> 70 Mg Hb Palpable Femoral Pulse Danger
PAIN	Localises Pain	2 Danger	20 – 30 Caution	120 – 140 High Caution		
	Inappropriate Response	1 Emergency	30 – 40 High Caution	140 – 170 Danger	4 – 5 Secs Danger	
UNRESPONSIVE	No Response	1 Emergency	> 40 Emergency	> 170 Emergency	> 5 Secs Emergency	> 60 Mg Hb Palpable Carotid Pulse Emergency

A.M.P.L.E. Survey

Allergies	
Medication	
Past Medical History	
Last Eaten	
Mechanism of Injury (Events)	
Injuries Sustained & Symptoms	Airway: Breathing: Circulation: Disability: Exposure: 
Treatment & Times	
What Happened Afterwards ?	Casualty Went:- Home ☐ To Hospital ☐ To G.P. ☐ Back To Work ☐ In Ambulance ☐ Refusal of Treatment ☐

Signature of Patient	Date

Signature of First Aider	Date

Example of a First Aid Report Form. Please Photocopy & Use

Continuing Care Plan 6.2

1. BREATHING/AIRWAY

Potential / Actual Problem	Required Outcome	D.M.T. Interventions
1. Breathing spontaneously but respiratory inefficiency due to:	**1.** Early detection of respiratory distress: a. Ensure adequate respiration. b. Prevent / detect infection. c. Prevent aspiration of gastric contents.	**1.** Observe colour and respiratory pattern / rate: a. Auscultate breath sounds – Bilateral? Crackles? Wheeze? Stridor? b. Encourage deep breathing / coughing exercises. c. Record colour / consistency / amount of sputum.
2. Requiring high flow oxygen therapy.	**2.** Maintain adequate oxygenation.	**2.** Monitor percentage / P.P. of inspired O_2: a. Record oxygen saturations.
3. Unable to maintain airway: a. The need for an oro / nasopharyngeal airway. b. The need for an ET / iGEL airway.	**3.** Maintain adequate airway: a. Use stepped approach to choose airway. b. Minimise the risk of tracheal damage.	**3.** Secure tube & monitor correct position of airway: a. Change tapes daily or when soiled. b. Sterile endotracheal suctioning PRN.
4. The need for mechanical ventilation.	**4.** Support respiratory function: Promote weaning from ventilation.	**4.** Record ventilator parameters: a. Maintain close 1:1 patient observation. b. Follow Medics instructions on ventilation mode / settings. c. Ensure B.M.V. is available for bail out use.

2. CIRCULATION

Potential / Actual Problem	Required Outcome	D.M.T. Interventions
1. Disturbance of heart rate / rhythm.	**1.** Early detection and correction of arrhythmias.	**1.** Observe and record heart rate/rhythm: a. Document & report irregularities to Medic.
2. Hypertensive / Hypotensive.	**2.** Maintain and adequate BP.	**2.** Observe and record BP. a. Document & report irregularities to Medic.
3. Hyper / Hypothermia.	**3.** Maintain core temperature 35.0°C–37.0°C.	**3.** Cool/warm to maintain normal body temperature: a. Document & report irregularities to Medic.
4. The need for Intravenous Fluid	**4.** Maintain hydration state.	**4.** Maintain fluid balance. a. Give issued I.V.I. in boluses 250mls in acute situations. b. Observe for radial pulse / pulmonary odeama. c. Administer I.V.I. as instructed by medic. d. Use the drop rate to accurately administer flow
5. Infection sites.	**5.** Identify and treat infections.	**5.** Observe for high temperature / signs of infection: a. Take venous blood & deliver to Dive Doctor. b. Administer prescribed antibiotics & report effects.

3. MAINTAIING A SAFE ENVIRONMENT

Potential / Actual Problem	Required Outcome	D.M.T. Interventions
1. Casualty dependent on others.	**1.** Ensure patient safety: a. Promote independence. b. Maintain safe standard of care.	**1.** Give full explanations and reassurance: a. Observe & risk assess for potential patient dangers. b. Maintain a clutter-free environment. c. DMT should be aware of their limitations.
2. Potential hazards / equipment failure.	**2.** Early detection / resolution of equipment failure.	**2.** Ensure equipment is maintained and checked daily: DMT should be suitably trained in the use of all biomedical equipment.

Continuing Care Plan 6.2

4. RENAL / ELIMINATION

Potential / Actual Problem	Required Outcome	D.M.T. Interventions
1. Disturbance of kidney balance.	**1.** Urine output > 0.5ml / kg /hr: a. Accurately record fluid input / output.	**1.** Record fluid input & output accurately: a. Maintain fluid balance record chart. b. Record ALL input (Oral / I.V.I. / N.G.). c. Record urine output hourly. d. Report if urine drops bellow ½ ml per KG. e. Monitor insensible losses (Bowel / Sweat / Vomit). f. Observe / report evidence of oedema to Dive Doctor.
2. Electrolyte imbalance.	**2.** Early detection and correction.	**2.** Take venous blood. a. Use vacutainer system as trained or get briefed from medic. b. Give electrolytes supplements as prescribed.
3. Altered bowel habit / constipation / diarrhea.	**3.** Maintain normal bowel habit.	**3.** Monitor frequency and nature of stools & report to Dive Dr: a. Give laxatives as prescribed. b. Give immodium as prescribed.

5. NUTRITION

Potential / Actual Problem	Required Outcome	D.M.T. Interventions
1. Need to maintain an adequate nutrition.	**1.** Supplement diet to maintain nutrition: a. Aim for____calories / day.	**1.** Liase with Dive Doctor & establish a nutrition calorie goal: a. Record oral diet on food chart. b. Give dietary supplements as prescribed. c. Assist casualty with eating to maintain intake.
2. NBM and the need for enteral feeding: a. The need for a nasogastric tube.	**2.** To maintain adequate enteral nutrition: a. To access the GIT via an NG tube.	**2.** Ensure NG tube correctly positioned & secured: a. For free drainage: record & report volume. b. For NG feeding: give prescribed feed (fortisip, nutrison, build up or liquidized food / with whole milk: in hrly boluses via syringe. c. Document & ensure that adequate fluid / calorie intake achieved. d. Aspirate regime 4 hourly & ensure gastric absorption.
3. Experience Hyper / hypoglycaemia	**3.** Maintain Blood Sugar between 3.0-8.0 mmol	**3.** Check blood sugars daily / PRN & report results to Dive Dr: a. Administer insulin as prescribed. b. Administer carbohydrates as instructed.

6. PAIN

Potential / Actual Problem	Required Outcome	D.M.T. Interventions
1. Casualty has pain. a. The need for pain relief. b. The need for continuing pain assessment. c. Potential sedation.	**1.** Patient has manageable pain: a. Aim for no pain. b. For patient to be able to describe their pain. c. Avoid complications.	**1.** Treat pain: a. Liaise with doctor/protocol for analgesia management. b. Monitor the effects of analgesics using pain score system (See Section 7.5), Titrate analgesia. c. Observe patient for sedation effects of opiates (Pin point pupils, reduced conscious level). Give Naloxone as prescribed.

7. NEUROLOGICAL/SEDATION

Potential / Actual Problem	Required Outcome	D.M.T. Interventions
1. Reduced consciousness due to:	**1.** Early detection of changes in consciousness: a. To facilitate early airway support.	**1.** Record neurological observations hourly using the G.C.S: a. If G.C.S. < 13 consider oro / nasopharangeal airway. b. If G.C.S. < 9 consider E.T. / iGEL intubation. c. If respiratory rate < 8 support respirations with manual / mechanical ventilation.
2. The need for sedation / paralyzing agents.	**2.** Maintain patient stability.	**2.** Administer rapid acting opiate / sedation / paralyzing agents as prescribed: a. Administer prescribed agents strictly as ordered. b. Maintain dedicated intravenous access / ensure drugs do not mix. c. Monitor casualty with a sedation chart & report findings: reduce – increase sedation as ordered. d. Monitor casualty for cardiovascular impact of sedation drugs.

Continuing Care Plan 6.2

8. WOUNDS		
Potential / Actual Problem	**Required Outcome**	**D.M.T. Interventions**
1. Has a wound from injury / surgical intervention.	**1.** Promote normal healing.	**1.** Identify, assess, document & report any wounds: a. Dress wounds using A.N.T.T. principles. b. Apply appropriate dressing according to policy / Dr's Instructions. c. Redress as needed. Leave dressing in situ unless oozing. d. Monitor size, depth & recovery of wound.
2. Has an infected wound site.	**2.** Detect & treat infection.	**2.** Monitor for signs of wound infection & report to Dr if present: a. Pyrexia, Inflammation, Pain, Pus Discharge & Malodour. b. If present conduct a bacteriology swab & give to Dr. c. Clean irrigate wound as instructed. d. Give antibiotics as prescribed & monitor effects.
3. Has an actively bleeding wound.	**3.** Detect & treat hemorrhage.	**3.** Carry out stepped measures to stop bleeding: a. Assess bleeding: compressible – non-compressible. b. Elevation, pressure (at least 3 minutes) & arterial tourniquet. c. Treat as an emergency if a haemorrhage cannot be stopped.
4. Has a chronic wound.	**4.** Treat wound appropriately.	**4.** Identify wound / lesion & report to Dive Dr: a. Give treatment regime as prescribed. b. Treat as for N^{O} 1. c. Report wounds progress to Dive Dr.

9. SLEEPING		
Potential / Actual Problem	**Required Outcome**	**D.M.T. Interventions**
1. Potential sleep deprivation.	**1.** Maintain normal sleep pattern.	**1.** Document duration & quality of sleep. a. Prevent / detect sensory deprivation. b. Promote light / noise reduction at night. c. Orientate to time /place / date / day.

10. PERSONAL HYGIENE		
Potential / Actual Problem	**Required Outcome**	**D.M.T. Interventions**
1. Unable to maintain personal hygiene.	**1.** Maintain hygiene: Prevent eye / mouth infections.	**1.** Daily bed bath / washes: a. Keep skin clean & dry. b. Daily hair/nail care/ clean shave. c. Give oral/eye care PRN. Attempt to maintain dignity at all times (where possible).

11. LIFTING AND HANDLING		
Potential / Actual Problem	**Required Outcome**	**D.M.T. Interventions**
1. The risk of pressure sores.	**1.** Prevent / detect pressure sores.	**1.** Maintain risk assessment in casualties with reduced mobility: a. Assess casualty for points of contact (back of head, sacrum, bony prominences). b. Give continual pressure area care / ensure skin clean & dry. c. Give 2-3 hourly repositioning. d. Provide pressure-relieving mattress. e. Increase measures if blanching of pressure points. f. Liase with Medic.
2. Paralysis / unconscious.	**2.** Prevent joint stiffness / contracture / deformities.	**2** Assess casualty for contractures / stiffness: a. Give passive / active limb movement 2 hourly. b. Report any contractures to Medic.
3. Risk of Deep Vein Thrombosis.	**3** Observe for signs of DVT's.	**3** Observe for redness & swelling in limbs. a. Report findings toMedic. b. Give anti-coagulant therapy as prescribed. c. Apply anti-thrombolic stockings as prescribed.
4. The risk of manual handling injury to DMT's.	**4.** Reduce manual handling risk to DMT.	**1.** Maintain equipment and provide training for use of lifting devices. a. Use an ergonomic assessment of the casualties manual handling needs: b. Assess the: Task, Individual Capacity, Load & Environment. c. Reduce the risk to the lowest possible degree. d. Use lifting aids / hoists / low friction slides. e. Ensure DMT's are familiar with all manual handling equipment with training in its use.

Continuing Care Plan 6.2

12. INVASIVE DEVICE		
Potential / Actual Problem	**Required Outcome**	**D.M.T. Interventions**
1. Casualty has medical Prosthetics inserted. **1.** Airways.	**1.** For the medical device to be unproblematic.	**a.** Identify medical devices & document their insertion place & time. **1.** Maintain patency & care of airway device (as in section **1.**): a. Document type of airway, time of insertion & position. b. Replace airway devices every 7 days. c. Ensure clean tapes secure airway devices. d. Monitor oral cavity for damage & give oral hygiene.
2. Venous cannulas.	**2.** Maintain patency & avoid infection.	**2.** Maintain patency of venous cannula: a. Document insertion date & site inserted. b. Monitor for Inflammation, Pain, Pus Discharge & Malodour. c. Ensure cannula dressing secure & clean / maintain asepsis. d. Flush cannula 12hrly with saline 0.9%. e. Replace cannulas after 4 days in a different site. f. Assume that cannula's placed under 'trauma' conditions are contaminated, replace ASAP.
3. Intra-Osseous Device	**3.** Maintain patency & avoid infection.	**3.** Maintain patency of I.O. cannula: a. Document insertion date & site inserted. b. Monitor for Inflammation, pain, pus / discharge. c. Ensure I.O. device secure / maintains asepsis. d. Refer to product specifications about use. e. Maintain for no more than 24 hours.
4. The need for a urinary catheter.	**4.** Enables accurate urine measurement: a. Prevent/detect urinary infection. b. Prevent/detect urinary stricture. c. Urinalysis.	**4.** Observe aseptic technique to reduce infection risk: a. Observe for pyrexia / discharge / inflammation malodour. b. Clean catheter regularly. c. Avoid tension in catheter & strap catheter. d. Change catheter bag weekly & catheter as manufacturer recommends. e. Dipstick urine for urinalysis & report results.
5. N.G. Tube.	**4.** Maintain patency & avoid infection.	**5** Maintain patency & care of N.G. tube (as in section **5.**): a. Document type of N.G. Tube, time of insertion & position. b. Monitor nasal passage for tissue damage & maintain hygiene.

13. SPIRITUAL CARE		
Potential / Actual Problem	**Required Outcome**	**D.M.T. Interventions**
1. Unable to maintain personal faith needs.	**1.** Maintain Patients Faith needs.	**1.** Assist patient maintaining faith needs.: a. Maintain dietary restrictions associated with faith. b. Seek guidance about specific faith needs. c. Seek ministry from cleric / rabbi / iman etc. if patients condition serious.

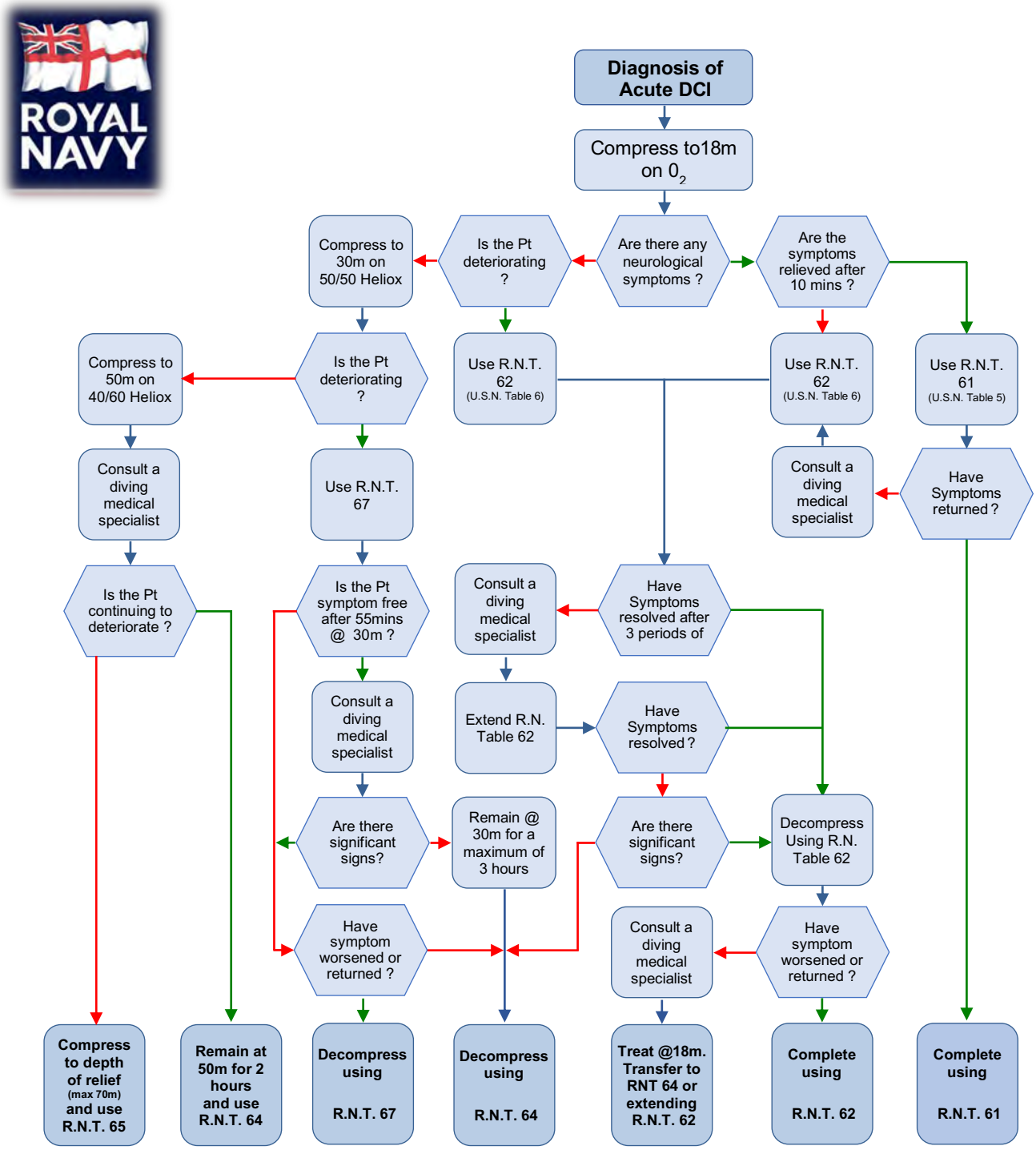
CHAMBER CHECK- LIST (Example) 6.3

Name:…… Date:……

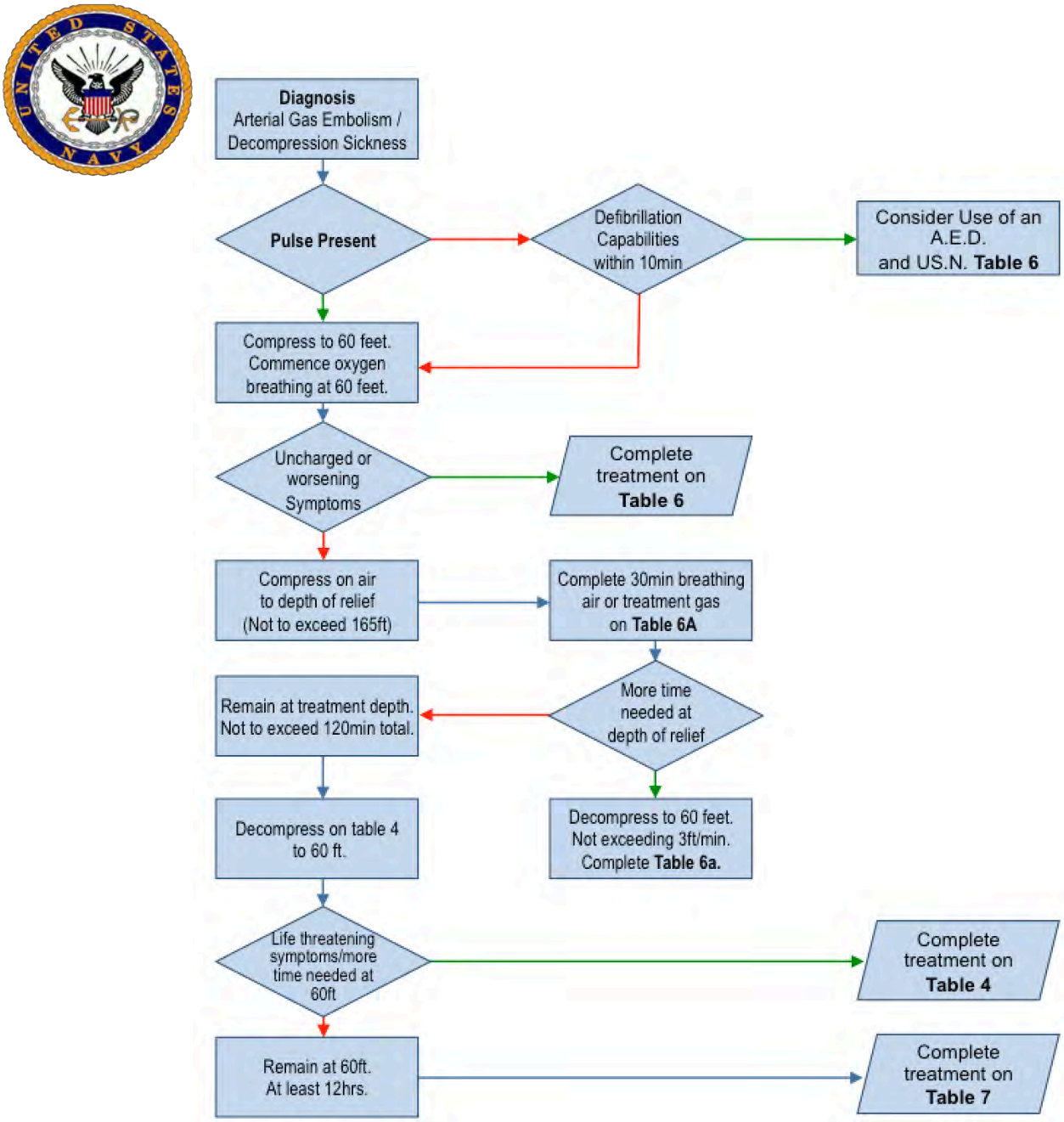
Sign:…….

Pre – Dive Checklist - Internal	
Main-Lock	**Initials**
All Non-Essential equipment and materials removed from chamber	
Pressurisation valve – **Open**	
Exhaust – **Open**	
O_2 dump – **Open**	
O_2 supply – **Open to pressurise BIBS; check for leaks**	
O_2 supply – **Closed**	
Individual supply and dumps – **Open as required**	
Sample valve – x 2 – **Open**	
Relief valve – **Taped open**	
Medical lock valve – **Closed**	
Tracking Valve – **TAPED OPEN**	
Heat Sensors – **Not Obstructed**	
Activation Switch – **Accessible**	
Blue Fire System Valves – **Taped Open**	
Equipment	
Medical kit – **Complete**	
Ear defenders – **Ready – Enough for dive**	
BIBS – **Prepared**	
Lights – **Working**	
Comms. **Check with supervisor**	
Video system working, **Check with supervisor**	
Sound powered phones Working	
Fire extinguisher - **Tested and certified**	
Equalisation valves – **Closed**	
Outer-Lock	
Pressurisation valve – **Open**	
Exhaust – **Open**	
O_2 dump – **Closed**	
O_2 supply – **Closed**	
Individual supply and dumps – **Closed**	
Sample valve – **Open**	
Relief valve – **Taped open**	
Tracking Valve – **TAPED OPEN**	
Heat Sensors – **Not Obstructed**	
Activation Switch – **Accessible**	
Blue Fire System Valves – **Taped Open**	
Fire resistant mattresses and blankets in chamber	

ROYAL NAVY D.C.I. TREATMENT ALGORITHM BR 2806 (4) 6.4



UNITED STATES NAVY DC.I. TREATMENT ALGORITHM 6.5



Section 7

Medical Supplies

MEDICAL EQUIPMENT TO BE HELD OFFSHORE DMAC 15 Rev 4 (2014) 7.1

Commercial diving operations include both surface supplied and saturation diving operations and cover a wide range of work activities. Appropriate medical equipment to be held at any particular site is best determined by an occupational health service with special knowledge of commercial diving operations. This list is designed to provide guidance on equipment to be held at the site where such advice is not available. It is recognised that in certain circumstances similar or greater facilities may be available from other sources, which are sufficiently close and reliable.

The list covers equipment and drugs suitable for the treatment of diving related disorders on the surface or in a recompression chamber and for other potential problems (e.g. trauma), which may occur during diving operations. The list takes account of situations where the diving operation may be remote from a vessel or installation sickbay and medical services. It includes equipment for use in an immediate first aid situation, equipment and drugs which may be used by personnel with advanced first aid training as well as equipment which would almost certainly only be used by medical staff. Medical staff who attend a casualty at a dive site may not necessarily be able to bring the appropriate equipment.

Each diving contractor's Diving Medical Officer is responsible for a review of the equipment and drugs, as some of the drugs mentioned in this note may not be available in some geographical areas and in such cases alternative drugs to those identified and 'suggested' should be considered. Compliance with the local laws relating to pharmaceutical products will also have to be considered, as these vary in different countries. It is anticipated that except in emergency situations, equipment other than that in the bell or chamber first aid kits would be for use by or on the direction of medical staff.

There should be an appropriate system for the control and maintenance of this medical kit and responsibility for this kit should be vested in the Diving Superintendent or vessel Medic. The respective responsibilities and authority of the parties involved need to be clearly documented and understood. This kit should be accompanied by a list of contents. This list provides an opportunity for stock control, shelf life control, and the recording of the use of the contents. These measures should be regarded as standard procedure. A specific logbook should be maintained with the equipment, in which these checks and all use of equipment and drugs is recorded.

The diving supervisor needs to have access to this medical kit at all times. Scheduled or controlled drugs should be held in a dedicated and secure double locked container (with the vessel's medical supplies or in the installation sickbay).

The medical kit should be appropriately labelled and then inspected regularly (during each mobilisation and at least every six months) to ensure that all items are in working order (e.g. batteries) and to exchange drugs and other equipment, which is nearing the end of its shelf life. These regular inspections should be recorded in the logbook. Consideration should be given to the need for pressure testing mechanical or electrical equipment. Local conditions may require a more frequent inspection regime.

People involved in the provision of care in diving situations should be part of a system of continuous training to help prevent skill fade.

At all times, including during transit to the diving worksite or diving support vessel, this medical kit must be kept dry and clean, locked in an appropriately labelled and dedicated light-resistant container. Care must be also taken to ensure that this equipment is stored within a temperature range of +4° to +25° Celsius.

The kit should be packaged and labelled in a logical manner that allows easy and rapid access to the contents, specifically those contents that are often used at the same time.

This is a guidance document based on current information. This medical kit will not cover all the aspects of medical care in a diving system and should be used in conjunction with the installation or vessel's medical kit. There should thus always be good communication between the diving team and the vessel medic.

Audits of any DMAC 15 kits should involve 'medical' staff (doctor or ship's Medic) with experience in the field, who understand the limitations of this guidance note, understand the diving project and the potential difficulties of the procurement of certain drugs depending on the county jurisdiction where the diving is taking place. A copy of DMAC 15 should accompany each kit with the final page completed as appropriate.

Equipment to be Held in a Diving Bell, Hyperbaric Welding Habitat or immediately available to be put into a Diving Chamber **(to be stored in a watertight bag or container)**

- 1 Tourniquet. (e.g. CAT tourniquet).
- 3 Polythene bags. (these can be used to cover burns or as waste bags).
- 1 Pocket resuscitator (preferably with a silicone filled face seal and a non-return valve or shield, for mouth-to mouth ventilation
- (Laerdal pocket maskor face shield).
- 2 Oropharyngeal airway size 3 and 4 (e.g. Guedel type).
- 1 Tuff cut scissors.
- 1 Medium dressing.
- 1 Large dressing.
- 2 Triangular dressing.

- 1 Roll of inch adhesive tape.
- 2 Crepe bandage 3 inch.
- 1 Hand operated suction pump.
- 1 Watertight bag.
- 1 Suction catheters (Preferably Yankeur).
- 1 Adult adjustable cervical spine collar.
- 2 Pairs of non-sterile gloves (non-latex if possible, appropriately sized).
- 2 Space blankets.

The same equipment should be available for rapid use in each living chamber of a saturation system and in each air diving chamber.

In 'living' chambers a foot or gas-powered suction pump may be preferred. The watertight bag is not required within 'dry' living chambers and it is acceptable that this equipment may be stored outside the system ready to be passed in immediately, as required.

Equipment to be Held in a Hyperbaric Rescue Unit (HRU) Compartment

(or within the surface compartment of a self propelled hyperbaric lifeboat):

- Arterial tourniquet (e.g. CAT tourniquet).
- Polythene bags.
- Resuscitation face mask (preferably with a silicone filled face seal and a non-return valve) or shield, for mouth-to mouth ventilation (e.g. Laerdal pocket mask or face shield).
- Oropharyngeal airway size 3 and 4 (e.g. Guedel type).
- Tuf cut scissors.
- Medium dressing.
- Large dressing.
- 2 Triangular bandages.
- 1 Roll of 1-inch adhesive tape.
- 2 Crepe bandages – 3-inch.
- 1 Hand operated suction pump.
- 1 Watertight bag.
- 1 Suction catheters (Preferably Yankeur).
- 1 Adult adjustable cervical spine collar.
- 10 Pairs of non-sterile gloves (non-latex if possible, appropriately sized).
- 2 Space blankets.

Sealable vomit and metabolic waste bags must be provided that allow for safe containment and disposal of this waste. Suggested: Absorbeze Maxi Sick Bags. Consideration should be given to the number of occupants and possible time expected before retrieval. A minimum of 15 per occupant is required.

Given the confines of the evacuation unit and the potential for contamination, anti-diarrhoeal preparations such as Imodium should be considered.

Fluid replacement supplies, which can be primarily water, to allow approx 100-150mls per man per hour, must be available. Rehydration preparations to maintain electrolytic balance should also be considered as essential to augment the fluid balance of both the dive and surface crew.

In the event of the requirement for hyperbaric evacuation, the following need to be available for immediate passing into the chamber prior to the divers entering the HRU. The surface support crew also need to be given the same medication:

Each team member (both divers and surface support crew) should chew 2 x 300µg tablets of hyoscine hydrobromide and have a Scopolamine patch placed behind one ear prior to evacuation into an HRU. The 2 hyoscine hydrobromide tablets will take effect within 30mins and last approximately 7-8 hours, after which the dermal patches will become effective and last approximately 72 hours.

The number of tablets and patches required depends on the number of people within both the dive team and surface support team, and will need to be calculated prior to each mobilisation.

There should be extra tablets and patches available for the dive and support team in case of failure of the adhesiveness of the dermal patches.

Equipment to held at the Dive Site

Diagnostic Equipment

- 1 Pencil torch.
- 1 Thermometer (electronic).
- 1 Low range rectal thermometer (Down to 28ºC)
- 1 Stethoscope.
- 1 Aneroid sphygmomanometer.
- 1 Reflex hammer.

- 1 Tape measure.
- 2 Tuning fork (128Hz & 256Hz).
- Pins for testing sensation (e.g. Neurotips).
- Tongue depressors.
- Blood sugar test strips.
- Urine testing strips.
- 1 Otoscope (with spare bulb, batteries & ear pieces).

Dressings

- 10 Packets gauze squares 10 x 10cm.
- 5 Packets cotton wool balls.
- 4 Triangular bandages.
- 4 Trauma care bandages.
- 12 Safety pins.
- 2 Adhesive bandages 75mm x 3m.
- 2 Adhesive bandages 25mm x 3m.
- 2 Crepe bandages 6 inch.
- 2 Crepe bandages 3 inch.
- 2 Large dressings.
- 2 Medium dressings.
- 40 Adhesive plasters.
- 2 Dressing bowls.
- 4 Eye pads.
- 1 Eye wash kit.
- 5 Silicone wound dressing (8cm x 10cm e.g. Mepitel)

Sterile Supplies - General

- 4 Universal containers.
- 2 Drapes 60 x 90 cm.
- 10 Alcohol swabs or sachets or skin disinfectant (e.g. Cetrimide solution).
- 10 pairs of sterile gloves (selection of sizes, preferably non-latex)
- 6 Sutures non-resorbable (e.g. nylon) (2/0 and 3/0), preferably with cutting needles attached.
- 2 Resorbable sutures (2/0 & 3/0), preferably with needles attached
- 5 x 20ml syringes.
- 5 x 10ml syringes.
- 5 x 2ml syringes.
- 10 x 18g needles.
- 10 x 21g needles.
- 1 Medium sized sharp bin.

Sterile Supplies - Specific

A specific sterile dressing pack should be obtained or made up, to lock into the chamber for specific procedures such as urinary catheterisation, thoraco-centisis and suturing, for example. To contain the equivalent of:

- 1 Kidney dish.
- 1 60-100ml bowl (Gallipot) .
- 10 Sachets of skin disinfectant (e.g. Cetrimide solution).
- 10 x 7.5cm 4-ply non-woven cotton swabs.
- 4 Dressing forceps.
- 2 Tissue backed drapes 60 x 90cm
- 1 Yellow bag (for disposal of used items).

Sterile Instruments

- 2 Spencer Wells forceps 5 inch.
- 1 Mosquito forceps.
- 1 Dressing forceps.
- 2 Disposable scalpels.
- 1 Forceps – fine toothed.
- 1 Dressing scissors.
- 1 Scissors – fine pointed.
- 1 Stainless steel ring cutter (for removal of rings and other piercings) – this does not need to be sterile.

Intravenous Access

- 3 Giving sets
- 4 IV cannulae 16g
- 4 IV cannulae 18g
- 4 Butterfly infusion sets 19g (optional)
- 2 Magnetic hooks
- 4 3-Way I.V. taps.

Intraosseous (IO) infusion system (A minimum of 2 devices)

It is suggested that spring loaded placement systems are used.If used, the DMTs must be appropriately trained in and up to date with the system chosen and used by each diving company. The use of battery operated placement systems in a hyperbaric chamber environment is contraindicated

Resuscitation

- Resuscitator to include reservoir and connection for BIBS gas (e. g. Laerdal type)*
- 3 Resuscitation masks with silicone face seals (varied sizes).
- I Pocket resuscitator with one-way valve or face shield for mouth-to-mouth ventilation. (e.g. Laerdal pocket mask with a silicone face seal and non-return valve)
- 4 Supraglottic airways sized for adult males (e.g. IGel sizes 3, 4 and 5, or Combitube) with catheter mounts and filters – if female divers on board ensure there are correctly sized airways for them.
- (Optional) Endotracheal tubes (E T tubes) (e. g. sizes 7, 8 and 9) with catheter mounts and filters**
- (Optional) Laryngoscope and batteries and spare bulbs. The use of Laryngoscopes with fibre-optic disposable blades is encouraged. This is required if ET tubes are stored.

- 2 Oropharyngeal airways sizes 3 and 4 (e.g. Guedel type).
- (Optional) 2 Nasopharyngeal airways (e.g. size 6 and 7 with flange).
- 1 Foot operated suction device.
- 1 Tourniquet to aid venous access.
- 2 Endotracheal suction catheters.
- 2 Wide bore suckers.
- Automated External Defibrillator (if this is to be used in the chamber it should either be appropriately tested for such use or it should be hard wired into the chamber)

- *Resuscitators may require modification to gas inlet to ensure adequate filling at pressure*

** *Endrotracheal tubes should be provided for use by doctors only*

Drugs Anatomical Therapeutic Chemical (ATC) codes are provided in brackets for guidance

Anaesthesia

Lidocaine injection without adrenaline (N01B B02)
Suggested: Lidocaine10mg/ml or 20mg/ml ampoules 5x10ml
Indication: Lidocaine is a useful local anaesthetic in concentrations up to 20%

Analgesia

Soluble aspirin tablets (N02B A01)
Suggested: Soluble aspirin, 20 x 300mg or 20 x 500mg tablets
Indication: Mild to moderate pain, pyrexia, chest pain of suspected cardiac origin 1 to 2 tablets every 4 to 6 hours

Paracetamol tablets (N02B E01)
Suggested: Paracetamol, 25 x 500mg tablets
Indication: Mild to moderate pain, pyrexia (fever)
1 to 2 tablets every 4 to 6 hours to a maximum of 8 tablets in 24 hour period

Codeine or dihydrocodeine tablets (N02A A08 or R05D A04)
Suggested: Codeine or dihydrocodeine, 20 x 25-30mg tablets
Indication: Moderate to severe pain
1 x 25 or 30mg tablet every 4 to 6 hours when necessary

Morphine injection (N02A A01)
Suggested: Morphine, 5 x 10mg ampoules
Indication: Severe and acute pain
Patients should be closely monitored for pain relief as well as for side-effects especially respiratory depression

Naloxone injection (V03A B15)
Suggested: Naloxone, 0.4mg/ml ampoules – 2 x 1ml
Indication: Opioid (morphine) overdose, respiratory depression due to administration of opioid (morphine) analgesia

Respiratory depression is a major concern with opioid analgesics and it may be treated by artificial ventilation or be reversed by naloxone. Naloxone will immediately reverse opioid-induced respiratory depression but the dose may have to be repeated because of the short duration of action of naloxone; however, naloxone will also antagonise the analgesic effect

The following drug is useful and acceptable as analgesia for moderate to severe pain where it is impossible to stock morphine:

Tramadol injection (N02A X02)
Suggested: Tramadol, 5 x 100mg ampoules
Indication: Moderate to severe pain.

Resuscitation Drugs **(refer to the appropriate resuscitation guidelines)**

Adrenaline/Epinephrine injection (C01C A24)
Suggested: Adrenaline, 10 x 10ml ampoules. 100µg/ml ampoules (1 in 10,000)
Indication: Emergency treatment for cardiopulmonary resuscitation
Important: Intravenous route or intraosseous route to be used in resuscitation, during CPR only

Amiodarone injection (C01B D01)
Suggested: Amiodarone, 6 x 150mg ampoules
Indication: Amiodarone is used for the treatment of arrhythmias particularly during CPR, particularly when other drugs are ineffective or contraindicated
In some countries Amiodarone is sold as a powder – ensure the correct amount of the appropriate solute is included if this is the case
Important: Intravenous route or IO route to be used in resuscitation during CPR only

Furosemide injection (C03C A01)
Suggested: Furosemide, 5 x 40mg ampoules

Indication: Oedema, pulmonary oedema, resistant hypertension

Nausea and Vomiting

Fentiazin or prochlorperazine injection (preferred) or oral (optional) (N05A B)
Suggested: Prochlorperazine, 5 x 25mg ampoules or Prochlorperazine, 20 x 5 mg tablets
Indication: Severe nausea, vomiting, vertigo, labyrinthine disorders (not for use in motion sickness)
Where available, prochlorperzine in 3mg buccal tablets (dissolves sublingually) is a good choice as opposed to the tablets as such as there is no need to swallow a tablet; 10 x 3mg tablets
See notes on equipment to be held in diving bell above.

Hyoscine hydrobromide (Scopolamine) tablets/dermal patches (A04A D01)
Suggested: Hyoscine, 40 x 300µg tablets (e.g. Kwells) Indication: Short acting drug for seasickness and hyperbaric evacuation. These tablets are chewable Suggested: Scopolamine, 20 x dermal patches (e.g. Scopoderm plasters) Indication: Long acting slow release drug for sea sickness and for hyperbaric evacuation. One patch to be placed behind one ear.

Allergic Reactions

Antihistamine for injection (R06A B)
Suggested: Chlorpheniramine, 2 x 10mg ampoules or dekschlorpheniramine, 2 x 5 mg ampoules
Indication: Symptomatic relief of allergy, urticaria, emergency treatment of anaphylactic reaction

Oral antihistamine (R06A E)
Suggested: Cetirizine, 20 x 10mg tablets
Indication: Symptomatic relief of allergies – non-sedating
There are different types of non-sedating oral antihistamines that can be substituted as needs be

Corticosteroid for injection (H02A B)
Suggested: Hydrocortisone 5 x 100mg ampoules
Indication: Hypersensitivity reaction e.g. anaphylaxis, angiodema, asthma

Adrenaline/epinephrine auto-injector (C01C A24)
Suggested: Epinephrine autoinjector (EpiPen autoinjector) 0.3mg of 1 in 1000 (1mg/ml) adrenaline (giving 300mcg) 2ml auto-injector
Indication: Emergency treatment of acute anaphylaxis

Drugs Various

Atropine injection (A03B A01)
Suggested: Atropine, 4 x 1ml ampoules (600µg/ml)
Although atropine is no longer recommended in the treatment of asystole or pulseless electrical activity in the European resuscitation guidelines, it may be useful in the treatment of bradycardia.

Glucose injection (B05B A03)
Suggested: Glucose 2 x 500mg/ml 50ml
Indication: Hypoglycaemia

Glyceryl trinitrate sublingual tablets (C01D A02)
Suggested: Glyceryl trinitrate sublingual tablets x 10 tablets Indication: Cardiac chest pain

Intravenous fluids (B05B B01)
Suggested: Crystalloid Infusion – 6 litres
Sodium Chloride Infusion 0.9% and / or Hartman's or Ringers lactate.
Company doctor to advise on exact make up.

Antipsychotic drug for injection (N05A A)
Suggested: Chlorpromazine, 2 x 50mg ampoules or levomepromazine, 2 x 25 mg ampoules
Indication: For relief of acute symptoms, schizophrenia and other psychoses, mania short-term adjunctive management of severe anxiety, psychomotor agitation, excitement, and violent or dangerously impulsive behaviour

Anxiolytics for injection (N05B A)
Suggested: Diazepam, 5 x 10mg ampoules
Indication: Short-term use in anxiety or insomnia, status epilepticus and for **muscle** relaxant effect where indicated

Anxiolytics for oral use (N05B A)
Suggested: Diazepam, 10 x 5mg tablets
Indication: Short-term use in anxiety or insomnia, status epilepticus

Anxiolytics for rectal use (N05B A)
Suggested: Diazepam, 10 x 5mg suppositories
Indication: Short-term use in status epilepticus

Treatment of Burns

Sulfonamides for topical use (skin) (D06B A01)
Suggested: Silver sulphadiazine cream, 1 tube of 1%
Indication: for example prophylaxis and treatment of infection in burn wounds, as an adjunct to short-term treatment of extensive abrasions; for conservative management of finger-tip injuries.

Antibiotics

Broad spectrum antibiotics for oral use (J01C A, J01C F or J01C R02)
Suggested: Co-amoxiclav, 21 x 625mg tablets (1 tablet 3 times per day for 7 days) or dicloxacilline 30 x 500 mg tablets
Indication: Broad-spectrum antibiotic
If this drug is not available the company doctor may choose to recommend a similar penicillinase resistant antibiotic
Suggested: A quinolone, for example:

- Ciprofloxacin, 20 x 750mg tablets (1 tablet 2 times per day for 10 days) OR
- Levofloxacin, 20 x 500mg tablets (1 tablet 2 times per day for 10 days)

Indication: A broad spectrum antibiotic useful in the treatment of Gram negative bacterial infections

Macrolide antibiotic for oral use (J01F A)
Suggested: Clarithromycin 14 x 250mg tablets (1 tablet twice daily for 7 days) or erythromycin 30 x 250 mg tablets (2 tablets twice daily for 7 days)
Indication: Susceptible infections in patients with penicillin hypersensitivity

Antibiotic ear drops with (S03C A) **or without** (S02A A) **corticosteroids**
Suggested: Sofradex (framycetin sulphate/dexamethasone/gramicidin) ear drops or hydrocortisone/polymyxine B ear drops one bottle 2–3 drops 3-4 times daily. May be substituted by other ear drops containing combinations of antibiotics (e.g. Polymyxine B, Neomycine a.o.) and corticosteroid (hydrocortisone, dexamethasone a.o.)
Sofradex drops can also be used for eye infections
Ciprofloxacin ear drops (may also be useful in the treatment of ear infections in saturation divers)

Antantifungal drug
Suggested: Clotrimazole cream
Indications: For fungal skin infections.

DRUG ADMINISTRATION 7.2

Definition Of A Drug And Drug Names

A drug is a chemical compound administered as an aid in the diagnosis, treatment or prevention of a disease or other abnormal condition. Drugs may be given in an attempt to alter the disease process itself or to relieve the symptoms of the process.

The drugs we use are derived from four principle sources: animal, vegetable, mineral, and synthetic.

Drug Names

Most drugs have several names. Drug names fall into one of four categories:

- **Official name**: This is the name under which the drug is listed in the British National Formulary (BNF), and other official publications.
- **Chemical name**: An exact description of the drug's chemical make-up. This is of interest mainly to chemists and others involved in the manufacture of drug's.
- **Generic name**: This is usually the name given to the drug by the company that manufactures it, before the drug has become official. The generic name is generally derived from the chemical name but is shorter and simpler.
- **Trade name:** This is the brand name, proprietary name, or trademark. A trade name has the symbol ® in the upper right-hand corner, indicating that the name has been registered as a trademark by a particular manufacturer. Since a given drug may be marketed by a number of manufacturers, it may have several different trade names.

Factors Affecting The Action Of Drugs

Drugs may produce their effects locally, systemically, or both. Local effects are those that result from the direct application of a drug to a tissue, such as when lotions are applied to the skin to relieve itching.

Systemic effects occur after a drug is absorbed by any route and distributed by the blood stream. The effect of any

given drug may vary depending on the patient, the dosage of the drug, the route by which the drug is given and the drug's metabolic fate.

Routes Of Administration 7.2.1

The action of a drug, most particularly the speed with which it works is also influenced by the way it enters the body, that is, the route of administration. The route of administration appropriate for one drug may be entirely inappropriate for another, so for any given drug, it is essential to know the routes by which it may be given.

Oral (Enteral)

This route is painless, convenient, and economical. Drugs taken by the mouth are absorbed at an unpredictable but generally slow rate from the stomach and intestines - usually somewhere between 30 and 90 minutes.

Because absorption is slow and unpredictable, drugs are rarely given by the oral route in emergency situations.

Rectal (Enteral)

Drugs may be administered rectally for their local effect. They may also be given rectally because they are irritating if given orally or because the patient is unable to take an oral medication (e.g. if he is vomiting).

Absorption across the rectal mucosa is rapid but unpredictable. In an emergency situation the rectal route of drug administration is rarely indicated.

The oral and rectal routes of administration are called 'enteral' routes. That is, they involve passage of the drug across membranes of the gut (entero-). All of the following routes of administration are parenteral routes. That is, they do not require absorption across the enteral membrane.

Intravenous (parenteral)

The intravenous route is the most rapidly effective and also the most dangerous route of administration. Drugs given intravenously go directly into the bloodstream and then to their target organs, without any appreciable delay in absorption. Therefore IV injection enables you to deliver a known quantity of a drug over a known period. That is, it allows the most accurate control of dosage. It is however a dangerous route, because the entire dose of the drug is delivered in one blast, so a toxic reaction is more likely.

Absorption of a drug given intravenously normally takes about 12 seconds. In cardiac arrest with cardiopulmonary resuscitation (CPR) in progress, a drug given intravenously will take 3-4 times longer than normal to reach its target organ because the cardiac output is only ¼ to ⅓ normal. Therefore it will take at last one or two minutes after giving an emergency drug during CPR to ensure that the drug has circulated adequately.

Drugs given intravenously should be given slowly, unless you receive contrary orders from the doctor.

Intramuscular (parenteral)

Drugs given by the intramuscular route take longer to act than those given intravenously, since they must first be absorbed from the muscle into the bloodstream. Medications given I.M. also have a longer duration of action than those given IV, since they are absorbed gradually over a period of minutes to hours. Absorption of medications given by the I.M. route or the S.C. route depends on adequate blood flow to muscles and peripheral tissues, which is not the case in shock or cardiac arrest.

An intramuscular injection usually involves volumes of about 1 to 5ml and is given into the deltoid muscle of the upper arm (the preferred site for pre-hospital applications) or into the upper outer quadrant of the gluteus muscle or the buttocks. The use of the deltoid muscle of the arm has the advantage that the rate of drug absorption can be slowed in the event of an adverse reaction.

Subcutaneous (parenteral)

Subcutaneous injections are given into the fat or connective tissue immediately underlying the skin. Subcutaneous injections are limited to small volumes (less than 2ml) of non-irritating substances. Medications administered by the subcutaneous route are absorbed more slowly and over a more prolonged period than when given intravenously. Peak drug effect usually occurs within 30 minutes.

Inhalation

Inhalation is used primarily for administration or aerosolised bronchodilators and nebulised drugs.

Endotracheal

Some drugs are very rapidly absorbed across the bronchial membranes and therefore may take effect nearly as quickly when sprayed down an endotracheal tube as when administered intravenously. The drugs that can be administered endo-tracheally can be remembered by the mnemonic **NAVEL**:

- **N**arcan
- **A**tropine
- **V**alium
- **E**pinephrine
- **L**idocaine

Do not give drugs other than those listed, by the endotracheal route. The technique of endotracheal drug administration is described in the 'Clinical Skills' section.

Sublingual

Sublingual administration refers to giving a medication under the tongue. That is the way in which nitroglycerine is most often administered. Drugs given sublingually are usually rapidly absorbed, with effects apparent within a few minutes.

Topical

Drugs may be applied topically, that is, on the surface of the body. Ordinarily, the intact skin is an effective barrier to absorption of drugs. However, some drugs have been specially prepared to cross that barrier at a very slow rate. This route is useful for the sustained release of drugs over a long period.

Nitroglycerine and oestrogens (for examples), can be given in the form of a patch pasted onto the skin.

Intra-cardiac

Intracardiac administration refers to the direct injection of drugs through the chest wall into the heart. This route is listed last, because it should be considered the last choice. While the intra-cardiac route is used by some to administer epinephrine during cardiac arrest, this route has no advantages over intravenous or endotracheal instillation, and it has several potential hazards.

The hazards include laceration of a coronary artery, pneumothorax, and inadvertent injection into the cardiac muscle rather than one of its chambers - in which case the epinephrine may cause intractable ventricular fibrillation. In addition, intracardiac injection requires interruption of cardiac compressions and artificial ventilation. For all of these reasons, the intracardiac route should only be only as a last resort when all efforts to establish an IV and insert an endotracheal tube have failed.

What You Need To Know About The Drug You Administer

For any drug used, the DMT must know the following information:

Therapeutic effect

What are the therapeutic effects of the drug? That is, what is the desired effect that giving the drug is supposed to accomplish?

Indications

What are the indications for the drug? That is, for what conditions(s) is the drug properly used?

Contraindications

What are the contraindications to use of the drug? That is, under what conditions should the drug not be used?

Dosage

What is the correct dosage of the drug, given the patient's age and weight, and how is the drug usually supplied (i.e. in what concentration)?

Side Effects

What side effects may be expected, secondary to the drug? Side effects need to be distinguished from idiosyncratic allergic reactions. Side effects are predictable effects, sometimes undesirable, that occur in addition to the therapeutic effects.

Idiosyncratic reactions are completely unpredictable. Allergic reactions are also unpredictable - unless the patient has had an allergic reaction to the same drug in the past- and may lead to life threatening anaphylaxis. Allergic reactions should be anticipated with any drug, whereas side effects are fairly specific to a given drug.

Mode Of Administration

What is the mode of administration of the drug? Drugs may be given, as mentioned earlier, through a variety of routes orally, intravenously, intramuscularly and so forth. A drug that is therapeutic when given by one route may be lethal when given by another.

Incompatibility

Is the drug incompatible with any other medication you might give or that the patient might be taking?

Safety Precautions

The danger of something going wrong in administering a drug, for example, administering the wrong drug or the wrong dose of a drug, can be minimised by following a set of safety precautions:

- Therefore it is critical that the DMT gather complete and accurate information about the patient to enable the doctor to make prudent decisions about drug administration.
- Ensure you understand the doctor's orders clearly.
  - If those orders are unclear or seem to be mistaken (e.g. dosage above the usual range, and unusual route of administration), ask the doctor to repeat the order. Never guess what the doctor ordered - if in doubt, ask.
  - Always repeat the **complete** orders back to the doctor before administering a medication, to confirm that you received the order accurately.
- If the patient is conscious, or if there is another reliable source of information, confirm that the patient is not

allergic to the drug that has been ordered.

- Read the label carefully as you take the vial or syringe from its box, and again before you give the drug.
  - Make a note of the drug concentration printed on the label and also of the drug's date of expiration.
- Check for defects in the vial or ampoule, and check that the fluid inside is not cloudy, discoloured, or precipitated.
  - If the medication is suspect in any way, do not use it.
- If you have orders to administer more than one drug, ensure that the drugs are not incompatible.
  - Some drugs will not mix with others (For example if sodium bicarbonate is mixed with calcium chloride an insoluble precipitate or calcium carbonate will form in the solution).
  - Should any cloudiness occur after a drug has been injected into IV tubing, clamp the tubing immediately and replace it with a new administration set.
- Notify the doctor when a drug has been administered.
- Monitor the patient for possible side effects.
- Dispose of the syringe and needle safely. Do not try to recap the needle, as the likelihood is quite high of sticking yourself in the process. Instead, dispose of the needle and syringe in a puncture proof container.

Sharps Bin

R.S.I. DRUGS 7.3

A Rapid Sequence Induction (RSI) involving the rapid induction of general anesthesia and tracheal intubation of a patient.

Unless a casualty is profoundly unconscious it is unlikely they could ever tolerate the presence of an intra-tracheal or supra-glottic device due to over-stimulation of the gag-cough reflex.

The R.S.I. has become the staple of pre & intra hospital intubation management.

The R.S.I. is always administered under the supervision of appropriately qualified medical personnel.

R.S.I. Kit

An R.S.I. consists of:

- An opiate based pre induction agent.
- A sedative induction agent.
- A neuromuscular relaxant.

There are several indication for an emergency R.S.I.:

- Actual or potential airway compromise:
  - Airway burns.
  - G.C.S. <8 (The conscious level may be low enough to endanger their airway, but a partial gag or cough reflex may still be present).
  - Facial / neck trauma.
- A.G.E.
- Ventilation inadequacy (The casualty simply cannot breath without respirator support).
- Traumatic brain injury.
- Facilitation of procedures (Extraction from crushing, or prior to aeromedical transfer).
- Humanitarian (Such as major burns).

Pre Induction Agents

Pre induction agents are commonly rapid acting opioids.

Fentanyl.

Fentanyl

- Rapid acting / short lasting opioid.
- Blunts hypertensive response to laryngoscopy and intubation.

Indications:

- Stable patients with raised intracranial pressure.
- Hypertensive emergencies.
- Raised intraocular pressure.
- Myocardial ischaemia.

Dose:

- 1 – 2 micrograms / kg IV over 60 to 120 seconds.

Induction Agents

An induction agent is an anaesthetic grade sedative. There are several used in R.S.I.'s.

Etomidate

In emergency settings, etomidate is one of the most frequently used sedative hypnotic agents. It has a key quality of not causing a dramatic fall in blood pressure.

Etomidate

Indications:

- Hypovolaemic shock.
- Traumatic brain injury.

Dose:

- 0.3 mg/kg IV push (UNSTABLE, 0.15 mg/kg IV).

Ketamine

Ketamine has analgesic and amnesic properties. Widely used in trauma medicine because of its favourable haemodynamic profile. Ketamine also has some preservation of laryngeal and respiratory reflexes when used.

Ketamine

Indications:

- The anaesthetic of choice when reliable ventilation equipment is not available.

Dose:

- 0.5 -2 mg/kg IV push.

Propofol

A sedative hypnotic with short acting / rapid onset (10 sec). Propofol can cause profound hypotension.

Indications:

Propofol

- Used for induction and maintenance of anesthesia (having replaced sodium thiopental for this indication).
- Used to maintain sedation in individuals who are receiving mechanical ventilation.

Dose:

- 1-3 mg/kg IV for induction.
- 100-200 mcg/kg/min for maintenance.

Neuromuscular Agent

A neuromuscular agent is a rapidly acting paralytic drug. Once its effect is established the casualty's autonomic reflexes will we suspended, making it much easier to intubate. This will also cause a complete cessation of breathing.

Suxamethonium

Suxamethonium acts as a depolarizing neuromuscular blocker. It is rapid acting. Suxamethonium can induce uncontrolled hyperkalaemia (high potassium levels which may induce cardiac arrest).

Indications:

Suxamethonium

- Popular in emergency medicine due its fast onset and short duration of action.

Contraindications:

- History of malignant hyperthermia.
- Spinal injury > 3 days old or denervation illness.
- Crush injury > 3 days old or rhabdomyolysis.
- Sepsis > 7 days duration.
- Severe burns > 24 hours old.

Dose:

- 1.5 mg/kg IV push.

Rocuronium

A non-depolarising neuromuscular blocking agent. Used in all cases when suxamethonium is contraindicated. Produces adequate paralysis in 45 – 60 seconds.

Rocuronium

Indications:

- Popular in anesthesia & emergency medicine due its predictable onset and short duration of action.

Dose:

- 1 mg/kg IV push.

B.N.F. DRUG FORMULARY 7.4

ADRENALINE *Epinephrine*

Category: Catecholamine / Positive Inotrope.

Indications: Emergency treatment of acute anaphylaxis; angioedema; cardiopulmonary resuscitation, priapism.

Cautions: For cautions in non-life-threatening situations.

Interactions: Severe anaphylaxis in patients taking beta-blockers may not respond to **"adrenaline"**, calling for bronchodilator therapy.

Dose: Acute anaphylaxis, by intramuscular injection (preferably midpoint in anterolateral thigh) of 1 in 1000 (1 mg/mL) solution. In Cardiac arrest (ventricular fibrillation, pulseless ventricular tachycardia, asystole, and pulseless electrical activity). **Adrenaline** (**epinephrine**) 1 in 10 000 (100 micrograms/mL) is recommended in a dose of 1 mg (10 mL) by intravenous injection repeated every 3–5 minutes if necessary. Administration through a central line results in a faster response than peripheral administration. However placement of a central line must not interfere with chest compressions; drugs administered peripherally must be followed by a flush of at least 20 mL Sodium Chloride 0.9% injection to aid entry into the central circulation.

AMOXICILLIN *Amoxil*

Category: Antibiotic (Penicillin based).

Indications: Urinary-tract infections, otitis media, sinusitis, oral infections, bronchitis, low or moderate-severity community-acquired pneumonia, invasive salmonellosis; listerial meningitis also oral infections, endocarditis treatment, anthrax, adjunct in listerial meningitis, *Helicobacter pylori*.

Side-effects: Penicillin hypersensitivity. nausea, vomiting, diarrhoea; rashes (discontinue treatment); rarely, antibiotic-associated colitis.

Dose: By mouth, 250 mg every 8 hours, dose doubled in severe infection; Otitis media, 500 mg every 8 hours; Pneumonia, 0.5–1 g every 8 hour. Anthrax, 500 mg every 8 hours; *Short-course oral therapy* Dental abscess, 3 g repeated after 8 hours.Urinary-tract infections, 3 g repeated after 10–12 hours. By intravenous injection *or* infusion, 500 mg every 8 hours increased to 1 g every 6 hours in severe infection. Listerial meningitis intravenous infusion, , 2 g every 4 hours for 10–14 days.

AMIODARONE HYDROCHLORIDE

Category: Antiarrythmic Agent.

Indications: Used in the treatment of arrhythmias, particularly for paroxysmal supraventricular, nodal and ventricular tachycardias, atrial fibrillation and flutter, and ventricular fibrillation.

Cautions: Hypokalaemia; severe bradycardia and conduction disturbances in excessive dosage; intravenous use may cause moderate and transient fall in blood pressure (circulatory collapse precipitated by rapid administration or overdosage).

Contra-indications: (except in cardiac arrest) Sinus bradycardia, sino-atrial heart block; unless pacemaker fitted avoid in severe conduction disturbances or sinus node disease; *intravenous use* in severe respiratory failure, circulatory collapse, or severe arterial hypotension; avoid bolus injection in congestive heart failure or cardiomyopathy

Side-effects: Nausea, vomiting, taste disturbances, jaundice; bradycardia; pulmonary toxicity (including pneumonitis and fibrosis); tremor, sleep disorders; hypothyroidism, hyperthyroidism; reversible corneal microdeposits (sometimes with night glare); phototoxicity, injection-site reactions; *less commonly* onset or worsening of arrhythmia.

Dose: By mouth, 200 mg 3 times daily for 1 week reduced to 200 mg twice daily for a further week; maintenance, usually 200 mg daily or the minimum required to control the arrhythmia By intravenous infusion, initially 5 mg/kg over 20–120 minutes with ECG monitoring; subsequent infusion given if necessary according to response up to max. 1.2 g in 24 hours. Cardiac Arrest, Pre-filled syringe containing 300mg / 10 mls (5% Dextrose), Given over 2 mins.

ASPIRIN *Acetylsalicylic Acid*

Category: Analgesic

Indications: Secondary prevention of thrombotic cerebrovascular or cardiovascular disease.

Cautions: asthma; uncontrolled hypertension; previous peptic ulceration.

Contra-indications: Haemophilia and other bleeding disorders.

Hepatic impairment: Increased risk of gastro-intestinal bleeding.

Side-effects: Bronchospasm; gastro-intestinal irritation, gastro-intestinal haemorrhage (occasionally major), also other haemorrhage.

Dose: Antiplatelet effect in a dose of 300 mg should be chewed. If "aspirin" is given before arrival at hospital, a note saying that it has been given should be sent with the patient.

ATROPINE SULPHATE

Category: Anticholinergic (Neurotransmitter blocker).

Indications: Bradycardia, cardiopulmonary resuscitation.

Side-effects: Constipation, transient bradycardia (followed by tachycardia, palpitation and arrhythmias), reduced bronchial secretions, urinary urgency and retention, dilatation of the pupils, photophobia, dry mouth, flushing and dryness of the skin.

Dose: Bradycardia, particularly if complicated by hypotension, should be treated with 500 micrograms of **"atropine"** sulphate given intravenously; the dose may be repeated every 3–5 minutes if necessary up to a maximum total dose of 3 mg. If there is a risk of asystole, or if the patient is unstable and has failed to respond to **"atropine"**, adrenaline should be given by intravenous infusion in a dose of 2–10 micrograms/minute, adjusted according to response.

CEFTRIAXONE *Cefaclor*

Category: Antibiotic (Non-Penicillin based).

Indications: Gram-positive and Gram-negative bacteria, serious infections such as septicaemia, pneumonia, and meningitis.

Side-effects: Diarrhoea, nausea and vomiting, abdominal discomfort, headache; allergic reactions including rashes, pruritus, urticaria, , fever and arthralgia, and anaphylaxis;; reversible interstitial nephritis, hyperactivity, nervousness, sleep disturbances, hallucinations, confusion, hypertonia, and dizziness

Dose: By deep intramuscular injection, *or* by intravenous injection over at least 2–4 minutes, *or* by intravenous infusion, 1 g daily; 2–4 g daily in severe infections; intramuscular doses over 1 g divided between more than one site; single intravenous doses above 1 g by intravenous infusion only.

CHLORPHENAMINE MALEATE *Piriton*

Category: Antihistamine.

Indications: Symptomatic relief of allergy such as hay fever, urticaria; emergency treatment of anaphylactic reactions.

Side-effects: Drowsiness is a significant side-effect with most of the older antihistamines although paradoxical stimulation may occur rarely, and antimuscarinic effects such as urinary retention, dry mouth, blurred vision, and gastro-intestinal disturbances.

Dose: By mouth, 4 mg every 4–6 hours, max. 24 mg daily.By intramuscular injection *or* by intravenous injection over 1 minute, 10 mg, repeated if required up to max. 4 doses in 24 hours.

CHLORPROMAZINE HYDROCHLORIDE *Largactil*

Category: Anti –psychotic.

Warning: Owing to the risk of contact sensitisation, pharmacists, nurses, and other health workers should avoid direct contact with "chlorpromazine"; tablets should not be crushed and solutions should be handled with care

Indications: Schizophrenia and other psychoses, Intractable hiccup; antiemetic.

Side-effects: *Parkinsonian symptoms* (including tremor), *dystonia* (abnormal face and body movements) *akathisia* (restlessness), which characteristically occurs after large initial doses and may resemble an exacerbation of the condition being treated.

Dose: By mouth, schizophrenia and other psychoses, 25 mg 3 times daily (*or* 75 mg at night), adjusted according to response, to usual maintenance dose of 75–300 mg daily (but up to 1 g daily may be required in psychoses); Intractable hiccup, 25–50 mg 3–4 times daily. By deep intramuscular injection, (for relief of acute symptoms but see also Cautions and Side-effects), 25–50 mg every 6–8 hours; By rectum in suppositories as **"chlorpromazine"** base 100 mg every 6–8 hours [unlicensed]

Note: For equivalent therapeutic effect 100 mg **"chlorpromazine"** base given *rectally* as a suppository ≡ 20–25 mg **"chlorpromazine"** hydrochloride *by intramuscular injection* ≡ 40–50 mg of **"chlorpromazine"** base or hydrochloride *by mouth.*

CHLORAMPHENICOL *Chloramphenicol Eye Ointment BPC 1%*

Category: Topical Antibacterial.

Indications: Bacterial eye infections.

Side-effects: transient stinging.

Dose: Frequency of application depends on the severity of the infection and the potential for irreversible ocular damage; antibacterial eye preparations are usually administered as follows:Eye drops Apply 1 drop at least every 2 hours then reduce frequency as infection is controlled and continue for 48 hours after healing. Eye ointment: Apply *either* at night (if eye drops used during the day) *or* 3–4 times daily (if eye ointment used alone).

CIPROFLOXACIN *Cipro*

Category: Antibiotic (Non-Penicillin based).

Indications: Active against both Gram-positive and Gram-negative bacteria. It is particularly active against Gram-negative bacteria, including salmonella, shigella, campylobacter, neisseria, and pseudomonas. Ciprofloxacin has only moderate activity against Gram-positive bacteria such as *Streptococcus pneumoniae* and *Enterococcus faecalis*; it should not be used for pneumococcal pneumonia. It is active against chlamydia and some mycobacteria. Most anaerobic organisms are not susceptible. Ciprofloxacin can be used for respiratory tract infections (but not for pneumococcal pneumonia), urinary-tract infections, infections of the gastro-intestinal system (including typhoid fever), bone and joint infections, gonorrhoea and septicaemia caused by sensitive organism.

Side-effects: Nausea, vomiting, dyspepsia, abdominal pain, diarrhoea (rarely antibiotic-associated colitis), headache, dizziness, rash (very rarely Stevens-Johnson syndrome and toxic epidermal necrolysis). Less frequent side-effects include anorexia, sleep disturbances, asthenia, confusion, anxiety, depression, hallucinations, tremor, blood disorders (including eosinophilia, leucopenia, thrombocytopenia), arthralgia, myalgia, disturbances in vision and taste. Other side-effects reported rarely or very rarely include hepatic dysfunction (including jaundice and hepatitis.

Dose: By mouth, respiratory-tract infections, 500–750 mg twice daily, Urinary-tract infections, 250–750 mg twice daily. Acute or chronic prostatitis, 500 mg twice daily for 28 days, Gonorrhoea, 500 mg as a single dose Most other infections, 500 mg twice daily By intravenous infusion over 60 minutes, 400 mg every 8–12 hours.

CLINDAMYCIN *Dalacin C*

Category: Antibiotic (Non-Penicillin based).

Indications: Staphylococcal bone and joint infections, ear, nose & orophyarnx, peritonitis; falciparum malaria.

Cautions: discontinue immediately if diarrhoea or colitis develops.

Side-effects: Diarrhoea, abdominal discomfort, oesophagitis, oesophageal ulcers, taste disturbances, nausea, vomiting, antibiotic-associated colitis; jaundice; leucopenia, eosinophilia, and thrombocytopenia reported; polyarthritis reported; rash, pruritus, urticaria, anaphylactoid reactions; pain, abscess after intramuscular injection; thrombophlebitis after intravenous injection.

Dose: By mouth, 150–300 mg every 6 hours; up to 450 mg every 6 hours in severe infections; Counselling Patients should discontinue immediately and contact doctor if diarrhoea develops; capsules should be swallowed with a glass of water. By deep intramuscular injection *or* by intravenous infusion, 0.6–2.7 g daily (in 2–4 divided doses); life-threatening infection, up to 4.8 g daily; single doses above 600 mg by intravenous infusion only; single doses by intravenous infusion not to exceed 1.2 g.

CLOTRIMAZOLE 1% *Canesten*

Category: Anti-Fungal Cream.

Indications: Fungal skin infections; vaginal candidiasis; otitis externa.

Cautions: Contact with eyes and mucous membranes should be avoided.

Side-effects: Occasional local irritation and hypersensitivity reactions include mild burning sensation, erythema, and itching. Treatment should be discontinued if these are severe.

Dose: Apply 2–3 times daily

CO-AMOXICLAV *Augmentin*

Category: Antibiotic (Penicillin based).

A mixture of amoxicillin and clavulanic acid.

Indications: Beta-lactamase-producing strains (where amoxicillin alone not appropriate) including respiratory-tract infections, bone and joint infections, genito-urinary and abdominal infections, cellulitis, animal bites, severe dental infection with spreading cellulitis or dental infection not responding to first-line antibacterial

Side-effects: Penicillin hypersensitivity, history of co-amoxiclav-associated or penicillin-associated jaundice or hepatic dysfunction. nausea, vomiting, diarrhoea; rashes (discontinue treatment); rarely, antibiotic-associated colitis.

Dose: By mouth, expressed as **"co"-"amoxiclav"**, one *250/125* strength tablet every 8 hours, increased in severe infections to one *500/125* strength tablet every 8 hours. Severe dental infections one *250/125* strength tablet every 8 hours for 5 days. By intravenous

injection over 3–4 minutes *or* by intravenous infusion, 1.2 g every 8 hours.

CO-TRIMOXAZOLE (Sulfamethoxazole & Trimethoprim)

Category: Antibiotic (Non-Penicillin based).

Indications: Pneumocystis carinii pneumonia;indicated for toxoplasmosis and nocardiasis. It should now only be considered for use in acute exacerbations of chronic bronchitis and infections of the urinary tract.

Side-effects: Nausea, diarrhoea; headache; hyperkalaemia; rash; *less commonly* vomiting; *very rarely* glossitis, stomatitis, anorexia, liver damage (including jaundice and hepatic necrosis), pancreatitis, antibiotic-associated colitis, myocarditis, cough and shortness of breath, pulmonary infiltrates, aseptic meningitis, depression, convulsions, peripheral neuropathy, ataxia, tinnitus, vertigo, hallucinations, hypoglycaemia.

Dose: By mouth, 960 mg every 12 hours By intravenous infusion, 960 mg every 12 hours increased to 1.44 g every 12 hours in severe infections. Note: 480 mg of **"co"-"trimoxazole"** consists of Sulfamethoxazole 400 mg and Trimethoprim 80 mg.

DEXAMETHASONE *Dex*

Category: Glucocorticoid (anti-inflammatory / immunosuppressant.)

Indications: Suppression of inflammatory and allergic disorders; diagnosis of Cushing's disease, congenital adrenal hyperplasia; cerebral oedema.

Side-effects: Perineal irritation may follow intravenous administration of the phosphate ester

Dose: Cerebral oedema, by intravenous injection 8–16 mg initially, then 5 mg by intramuscular injection *or* intravenous injection every 6 hours as required for 2–4 days.

DIAZEPAM *Valium*

Category: Benzodiazepine Sedetive.

Indications: Status epilepticus; febrile convulsions; convulsions due to poisoning. short-term use in anxiety or insomnia; adjunct in acute alcohol withdrawal; muscle spasm, peri-operative use.

Cautions: When given intravenously facilities for reversing respiratory depression with mechanical ventilation must be at hand.

Side-effects: respiratory depression; marked neuromuscular respiratory weakness including unstable myasthenia gravis; acute pulmonary insufficiency; sleep apnoea syndrome; not for chronic psychosis; should not be used alone in depression or in anxiety with depression.

Dose: By mouth, anxiety, 2 mg 3 times daily increased if necessary to 15–30 mg daily in divided doses. Insomnia associated with anxiety, 5–15 mg at bedtime. Status epilepticus, febrile convulsions, and convulsions due to poisoning, by intravenous injection, 10 mg at a rate of 1 mL (5 mg) per minute, repeated once after 10 minutes if necessary. By rectum as rectal solution, adult 10–20 mg, repeated once after 10–15 minutes if necessary.

DICLOFENAC POTASSIUM *Voltarol*

Category: Analgesic (Non Steroidal Anti-inflammatory Drug - *NSAID*).

Indications: Rheumatic disease and other musculoskeletal disorders; acute gout; postoperative pain; migraine.

Side-effects: Gastro-intestinal disturbances including discomfort, nausea, diarrhoea, and occasionally bleeding and ulceration occur. Systemic as well as local effects of NSAIDs contribute to gastro-intestinal damage; taking oral formulations with milk or food, or using enteric-coated formulations, or changing the route of administration may only partially reduce symptoms such as dyspepsia.

Dose: By mouth, 75–150 mg daily in 2–3 divided doses. By rectum in suppositories, 75–150 mg daily in divided doses. deep intramuscular injection into the gluteal muscle, acute exacerbations of pain and postoperative pain, 75 mg once daily (twice daily in severe cases) for max.By intravenous infusion (in hospital setting), acute postoperative pain, 75 mg repeated if necessary after 4–6 hours; max. 150 mg in 24 hours for 2 days.

DIHYDROCODEINE TARTRATE *DF118*

Category: Analgesic (Codine based).

Indications: Moderate to severe pain.

Side-effects: Paralytic ileus, abdominal pain, and paraesthesia.

Dose: By mouth, 30 mg every 4–6 hours, intramuscular injection, up to 50 mg repeated every 4–6 hours.

ERYTHROMYCIN

Category: Antibiotic (Non-Penicillin based).

Indications: Susceptible infections in patients with penicillin hypersensitivity; oral infections, campylobacter enteritis, syphilis, non-gonococcal urethritis, respiratory-tract infections (including Legionella infection), skin infections.

Side-effects: Nausea, vomiting, diarrhoea; rashes (discontinue treatment); rarely, antibiotic-associated colitis.

Dose: By mouth, 250–500 mg every 6 hours *or* 0.5–1 g every 12 hours,up to 4 g daily in divided doses in severe infections, Early syphilis, 500 mg 4 times daily for 14 days. Uncomplicated genital chlamydia, non-gonococcal urethritis, 500 mg twice daily for 14 days By intravenous infusion, adult 12.5 mg/kg every 6 hours; mild infections (when oral treatment not possible), 6.25 mg/kg every 6 hours.

DOXYCYCLINE

Category: Antibiotic (Non-Penicillin based).

Indications: Chronic prostatitis; sinusitis, syphilis, pelvic inflammatory disease; treatment and prophylaxis of malaria, adjunct to gingival scaling and root planing for periodontitis; oral herpes simplex, rosacea, acne vulgaris.

Side-effects: Nausea, vomiting, diarrhoea, dysphagia, and oesophageal irritation. Other rare side-effects include hepatotoxicity, pancreatitis, blood disorders, photosensitivity (particularly with demeclocycline), and hypersensitivity reactions (including rash, exfoliative dermatitis anorexia, dry mouth, flushing, anxiety, and tinnitus.

Dose: By mouth 200 mg on first day, then 100 mg daily; severe infections (including refractory urinary-tract infections), 200 mg daily. Early syphilis, 100 mg twice daily for 14 days; late latent syphilis, 100 mg twice daily for 28 days; neurosyphilis, 200 mg twice daily for 28 days. Uncomplicated genital chlamydia, non-gonococcal urethritis, 100 mg twice daily for 7 days.100 mg twice daily.

FLUCLOXACILLIN *Fluclox*

Category: Antibiotic (Penicillin based).

Indications: Otitis externa; adjunct in pneumonia, impetigo, cellulitis, osteomyelitis and in staphylococcal endocarditis.

Side-effects: The most important side-effect of the penicillins is hypersensitivity which causes rashes and anaphylaxis and can be fatal.

Allergic reactions to penicillins occur in 1–10% of exposed individuals; anaphylactic reactions occur in fewer than 0.05% of treated patients. Patients with a history of atopic allergy (e.g. asthma, eczema, hay fever) are at a higher risk of anaphylactic reactions to penicillins. also gastro-intestinal disturbances; *very rarely* hepatitis and cholestatic jaundice (see also Hepatic disorders above)

Dose: By mouth, 250–500 mg every 6 hours, at least 30 minutes before food. By slow intravenous injection *or* by intravenous infusion, 0.25–2 g every 6 hours. Osteomyelitis, up to 8 g daily in 3–4 divided doses, Surgical prophylaxis, by slow intravenous injection *or* by intravenous infusion, 1–2 g up to 30 minutes before the procedure; up to 4 further doses of 500 mg may be given every 6 hours.

FUROSEMIDE *Frusemide*

Category: Loop Diuretic.

Indications: Oedema, resistant hypertension.

Cautions: Hypoproteinaemia may reduce diuretic effect and increase risk of side-effects; hepatorenal syndrome; intravenous administration rate should not usually exceed 4 mg/minute, however single doses of up to 80 mg may be administered more rapidly.

Side-effects: Dehydration, mild gastro-intestinal disturbances, pancreatitis, hepatic encephalopathy, postural hypotension, temporary increase in serum-cholesterol and triglyceride concentration, hyperglycaemia (less common than with thiazides), acute urinary retention, electrolyte disturbances (including hyponatraemia, hypokalaemia, hypocalcaemia, hypochloraemia, and hypomagnesaemia), metabolic alkalosis, blood disorders (including bone-marrow depression, thrombocytopenia, and leucopenia), hyperuricaemia, visual disturbances, tinnitus and deafness (usually with high parenteral doses and rapid administration, and in renal impairment), and hypersensitivity reactions (including rash, photosensitivity, and pruritus).

Dose: By mouth, oedema, initially 40 mg in the morning; maintenance 20–40 mg daily. By intramuscular injection *or* slow intravenous injection initially 20–50 mg, increased if necessary in steps of 20 mg not less than every 2 hours; doses greater than 50 mg by intravenous infusion only; max. 1.5 g daily.

GENTAMICIN

Category: Antibiotic (Non-Penicillin based).

Indications: Septicaemia and neonatal sepsis; meningitis and other CNS infections; biliary-tract infection, acute pyelonephritis or prostatitis, endocarditis; pneumonia and listerial meningitis.

Side-effects: vestibular and auditory damage, nephrotoxicity; rarely, hypomagnesaemia on prolonged therapy, antibiotic-associated colitis, stomatitis; also reported, nausea, vomiting, rash, blood disorders.

Dose: To avoid excessive dosage in obese patients, use ideal weight for height to calculate dose and monitor serum-"gentamicin" concentration closely, Multiple daily dose regimen, by intramuscular *or* by slow intravenous injection over at least 3 minutes *or* by intravenous infusion, 3–5 mg/kg daily (in divided doses every 8 hours), see also Once daily dose regimen, by intravenous infusion, initially 5–7 mg/kg, then adjust according to serum-**"gentamicin"** concentration.

GENTISONE (Ear drops, hydrocortisone acetate 1%, gentamicin 0.3%)

Category: Antibiotic / anti-inflammatory.

Indications: Eczematous inflammation in otitis externa.

Dose: Ear, apply 2–4 drops 3–4 times daily and at night.

GLYCERYL TRINITRATE *GTN*

Category: Coronary vaso-dilator used in Angina.

Indications: Sublingual: prophylaxis and treatment of angina, Buccal: prophylaxis and treatment of angina; adjunct in unstable angina; acute and congestive heart failure.Injection: control of hypertension and myocardial ischaemia during and after cardiac surgery; induction of controlled hypotension during surgery; congestive heart failure; unstable angina.

Side-effects: postural hypotension, tachycardia (but paradoxical bradycardia also reported); throbbing headache, dizziness; *less commonly* nausea, vomiting, heartburn, flushing, syncope, temporary hypoxaemia, rash, application site reactions with transdermal patches; *very rarely* angle-closure glaucoma

Injection Specific side-effects following injection (particularly if given too rapidly) include severe hypotension, diaphoresis, apprehension, restlessness, muscle twitching, retrosternal discomfort, palpitation, abdominal pain.

Dose: Sublingually, 0.3–1 mg, repeated as required; see also under preparations

By intravenous infusion, 10–200 micrograms/minute, adjusted according to response; max. 400 micrograms/minute; consult product literature for recommended starting doses specific to indication. *Aerosol spray* treatment or prophylaxis of angina, spray 1–2 doses under tongue and then close mouth (**Caution** flammable).

HYDROCORTISONE *Cortisol*

Category: Steroid hormone, or glucocorticoid.

Indications: Adrenocortical insufficiency, shock; hypersensitivity reactions e.g. anaphylaxis and angioedema; asthma ; severe inflammatory bowel disease.

Side-effects: Immunosupression.

Dose: intramuscular injection *or* slow intravenous injection *or* infusion, 100–500 mg, 3–4 times in 24 hours or as required.

HYDROCORTISONE CREAM 1%

Category: Anti-inflammatory Steroid.

Indications: Mild inflammatory skin disorders such as eczemas

Contra-indications: Topical corticosteroids are contra-indicated in untreated bacterial, fungal, or viral skin lesions, in rosacea, and in perioral dermatitis; potent corticosteroids are contra-indicated in widespread plaque psoriasis.

Dose: Apply thinly 1–2 times daily.

HYOSCINE HYDROBROMIDE *Scopolamine*

Category: Anticholinergic.

Indications: Motion sickness; hypersalivation associated with clozapine therapy.

Side-effects: Drowsiness, dry mouth, throat and nasal passages in overdose cases progressing to impaired speech, thirst, blurred vision and sensitivity to light, constipation, difficulty urinating and tachycardia. Other effects of overdose include flushing and fever, as well as excitement, restlessness, hallucinations, or delirium.

Dose: Motion sickness, by mouth, adult, 150–300 micrograms up to 30 minutes before start of journey repeated every 6 hours if required; max. 900 micrograms daily; Hypersalivation associated with clozapine therapy, by mouth, 300 micrograms up to 3 times daily; max.

900 micrograms daily.

IBUPROFEN *Brufen*

Category: Analgesic (Non Steroidal Anti-inflammatory Drug - *NSAID*).

Indications: Pain and inflammation in rheumatic disease (including juvenile idiopathic arthritis) and other musculoskeletal disorders; mild to moderate pain.

Side-effects: Gastro-intestinal disturbances including discomfort, nausea, diarrhoea, and occasionally bleeding and ulceration occur. Systemic as well as local effects of NSAIDs contribute to gastro-intestinal damage; taking oral formulations with milk or food, or using enteric-coated formulations, or changing the route of administration may only partially reduce symptoms such as dyspepsia.

Dose: By mouth, Initially 300–400 mg 3–4 times daily; increased if necessary to max. 2.4 g daily; maintenance dose of 0.6–1.2 g daily may be adequate.

LIDOCAINE HYDROCHLORIDE *Lignocaine*

Category: Local anesthetic and antiarrhythmic.

Indications: As a local anesthetic is characterized by a rapid onset of action and intermediate duration of efficacy. Is suitable for infiltration, block and surface anesthesia.Is used intravenously for the treatment of ventricular arrhythmias.

Side-effects: Rare when lidocaine is used as a local anesthetic and is administered correctly. Most reactions associated with lidocaine for anesthesia relate to administration technique (resulting in systemic exposure) or pharmacological effects of anesthesia, but allergic reactions only rarely occur. When given intravenously: nervousness, tingling around the mouth, tinnitus, tremor, dizziness, blurred vision, seizures followed by depression, and with increasingly heavier exposure: drowsiness, loss of consciousness, respiratory depression and apnoea). Cardiovascular effects include hypotension, bradycardia, arrhythmias, and/or cardiac arrest – some of which may be due to hypoxemia secondary to respiratory depression.

Dose: To avoid excessive dosage in obese patients, dose may need to be calculated on the basis of ideal body-weight. By Infiltration, Infiltration anaesthesia, according to patient's weight and nature of procedure, max. 200 mg (or 500 mg if given in solutions containing adrenaline

Note: Intravenous regional anaesthesia and nerve blocks, seek expert advice.

MAGNESIUM TRISILICATE

Category: Antacid.

Indications: Dyspepsia.

Side-effects: Diarrhoea, belching due to liberated carbon dioxide; silica-based renal stones reported on long-term treatment.

Dose: By mouth, 1–2 tablets chewed when required *Tablets*, (Magnesium Trisilicate Tablets, Compound, BP magnesium trisilicate 250 mg, dried aluminium hydroxide 120 mg).

METRONIDAZOLE *Flagyl*

Category: Antibiotic (Non-Penicillin based).

Indications: anaerobic infections (including dental); protozoal infections; *Helicobacter pylori* eradication; skin.

Side-effects: gastro-intestinal disturbances (including nausea and vomiting), taste disturbances, furred tongue, oral mucositis, anorexia; *very rarely* hepatitis, jaundice, pancreatitis, drowsiness, dizziness, headache, ataxia, psychotic disorders, darkening of urine, thrombocytopenia, pancytopenia, myalgia, arthralgia, visual disturbances, rash, pruritus, and erythema multiforme; on prolonged or intensive therapy peripheral neuropathy, transient epileptiform seizures, and leucopenia.

Dose: Anaerobic infections (usually treated for 7 days and for 10–14 days in *Clostridium difficile* infection), by mouth, *either* 400 mg every 8 hours *or* 500 mg every 8 hours; by rectum, 1 g every 8 hours for 3 days, then 1 g every 12 hours; by intravenous infusion over 20 minutes, 500 mg every 8 hours; Acute ulcerative gingivitis, by mouth, 200–250 mg every 8 hours for 3 days; Acute oral infections, by mouth, 200 mg every 8 hours for 3–7 days.

MORPHINE SALTS *Morphine*

Category: Analgesic (Opiate based).

Cautions: Pancreatitis, cardiac arrhythmias, severe cor pulmonale.

Contra-indications: Delayed gastric emptying, acute abdomen; heart failure secondary to chronic lung disease.

Side-effects: Paralytic ileus, abdominal pain, anorexia, dyspepsia, exacerbation of pancreatitis, taste disturbance; hypertension, hypothermia, syncope; bronchospasm, inhibition of cough reflex; restlessness, seizures, paraesthesia, asthenia, malaise, disorientation, excitation, agitation, delirium.

Dose: The patient should be closely monitored for pain relief as well as for side-effects especially respiratory depression. Acute pain, by subcutaneous injection *or* by intramuscular injection, initially 10 mg, every 4 hours (or more frequently during titration), adjusted according to response. By slow intravenous injection, initially 5 mg every 4 hours (or more frequently during titration), adjusted according to response. Myocardial infarction, by slow intravenous injection (1–2 mg/minute), 5–10 mg followed by a further 5–10 mg if necessary.

NALOXONE HYDROCHLORIDE *Narcan*

Category: Opiate Antidote.

Indications: Overdosage with opioids; reversal of opioid-induced respiratory depression.

Cautions: physical dependence on opioids; cardiac irritability.

Dose: By intravenous injection, 0.4–2 mg; if no response repeat at intervals of 2–3 minutes to a max. of 10 mg (then review diagnosis); further doses may be required if respiratory function deteriorates.

NEOMYCIN SULPHATE

Category: Topical Antibiotic (Non-Penicillin based).

Indications: bacterial infection in otitis externa.

Contra-indications: Perforated tympanic membrane.

Side-effects: local sensitivity

Dose: By ear drops, Every 3-4 hrs, as directed by instructions.

Note: Preperations often combine Hydrocortisone / Dextemethasone & Acetic Acid 2%. Prolonged use increases chance of fungal infection.

PARACETAMOL — *Acetaminophen*

Category: Analgesic
Indications: Mild to moderate pain, pyrexia.
Cautions: Alcohol dependence.
Hepatic impairment: Dose-related toxicity—avoid large doses.
Side-effects: Rashes, blood disorders (including thrombocytopenia, leucopenia, neutropenia) reported; hypotension, flushing, and tachycardia also reported on infusion; **important:** liver damage (and less frequently renal damage) following **overdosage**.
Dose: By mouth, 0.5–1 g every 4–6 hours to a max. of 4 g daily.

PROMETHAZINE HYDROCHLORIDE — *Phenergan*

Category: Antihistamine & antiemetic.
Indications: As a sedative. For preoperative sedation and to counteract postnarcotic nausea.As anti-allergic medication to combat hay fever (allergic rhinitis), etc. To treat allergies.
Side-effects: Confusion in the elderly, drowsiness, dizziness, fatigue, more rarely vertigo, Dry mouth Respiratory depression in patients under age of 2 and in those with severely compromised pulmonary function. Constipation, Paresthesia, Short temper / Irritability.
Dose: By mouth, 10–20 mg 2–3 times daily. By deep intramuscular injection, 25–50 mg; max. 100 mg.
By slow intravenous injection in emergencies, 25–50 mg as a solution containing 2.5 mg/mL in water for injections; max. 100 mg.

PROCHLORPERAZINE — *Stemetil*

Category: Anti-Emetic.
Indications: Severe nausea, vomiting, vertigo, labyrinthine disorders.
Side-effects: Hypotension ,less sedating; extrapyramidal symptoms, respiratory depression may occur.
Dose: By mouth, nausea and vomiting, acute attack, 20 mg initially then 10 mg after 2 hours; prevention 5–10 mg 2–3 times daily; Labyrinthine disorders, 5 mg 3 times daily, gradually increased if necessary to 30 mg daily in divided doses, then reduced after several weeks to 5–10 mg daily; By deep intramuscular injection, nausea and vomiting, 12.5 mg when required followed if necessary after 6 hours by an oral dose.

SENNA — *Senakot*

Category: Laxative.
Indications: constipation
Side-effects: Stimulant laxatives increase intestinal motility and often cause abdominal cramp; they should be avoided in intestinal obstruction. Excessive use of stimulant laxatives can cause diarrhoea and related effects such as hypokalaemia.
Dose: 2–4 tablets, usually at night; initial dose should be low then gradually increased. Note: Acts in 8–12 hours.

SILVER SULFADIAZINE 1% — *Flamazine*

Category: Topical Antibacterial.
Indications: Burn wounds; leg ulcers and pressure sores; and extensive abrasions, finger-tip injuries.
Side-effects: Allergic reactions including burning, itching and rashes; argyria reported following prolonged use; leucopenia reported (monitor blood levels).
Dose: Topical, burns, apply daily or more frequently if very exudative; leg ulcers or pressure sores, apply daily or on alternate days (not recommended if ulcer very exudative); finger-tip injuries, apply every 2–3 days; consult product literature for details.

SODIUM BICARBONATE — *$NaHCO_3$*

Category: Antacid.
Indications: Severe metabolic acidosis.
Dose: By slow intravenous injection, a strong solution (up to 8.4%), or by continuous intravenous infusion, a weaker solution (usually 1.26%).

TETRACYCLINE

Category: Antibiotic (Non-Penicillin based).
Indications: Acne vulgaris, Non-gonococcal urethritis.
Side-effects: Nausea, vomiting, diarrhoea; rashes (discontinue treatment); rarely, antibiotic-associated colitis.acute renal failure, skin discoloration.
Dose: By mouth, 250 mg every 6 hours, increased in severe infections to 500 mg every 6–8 hours. Non-gonococcal urethritis, 500 mg every 6 hours for 7–14 days (21 days if failure or relapse after first course). Counselling Tablets should be swallowed whole with plenty of fluid while sitting or standing.

TRAMADOL HYDROCHLORIDE

Category: Analgesic (Opiate based).
Indications: moderate to severe pain.
Cautions: Impaired consciousness; excessive bronchial secretions; not suitable as a substitute in opioid-dependent patients.
Side-effects: Nausea and vomiting (particularly in initial stages), constipation, dry mouth, and biliary spasm; larger doses produce muscle rigidity, hypotension, and respiratory. Other common side-effects of opioid analgesics include bradycardia, tachycardia, palpitation, oedema, postural hypotension, hallucinations, vertigo, euphoria, dysphoria, mood changes, dependence, dizziness, confusion, drowsiness, sleep disturbances, headache, sexual dysfunction, difficulty with micturition, urinary retention, ureteric spasm, miosis, visual disturbances, sweating, flushing, rash, urticaria, and pruritus, diarrhoea; fatigue; *less commonly* retching, gastritis, and flatulence; *rarely* anorexia, syncope, hypertension, bronchospasm, dyspnoea, wheezing, seizures, paraesthesia, and muscle weakness.
Dose: By mouth, 25–100 mg not more often than every 4 hours; total of more than 400 mg daily not usually required, by intramuscular injection *or* by intravenous injection (over 2–3 minutes) *or* by intravenous infusion, 50–100 mg every 4–6 hours

ACUTE PAIN MANAGEMENT PROTOCOL 7.5

Acute Pain Management

Pain Score

0 = No pain on rest or movement
1 = No pain on rest, mild on movement
2 = Mild pain on rest, moderate on movement
3 = Continuous pain on rest, severe on movement

Mild Pain - Pain Assessment Score 1

- Regular Paracetamol 1g QDS (max. 4g/day) + (If not contraindicated) add regular ibuprofen 400mg.
- TDS or Diclofenac 50mg TDS (max. 150mg/day).

Moderate Pain - Pain Assessment Score 2

- Paracetamol 1g QDS + Codeine 30-60mgs QDS + (If not contraindicated) regular QDS ibuprofen 400mg.
- TDS or Diclofenac 50mg TDS.

Severe Pain - Pain Assessment Score 3

- Morphine hourly IM / IV / oral regime.
- Tramadol IM / Oral regime.
- Entonox on movement (if no decompression needs).
- These can be given with regular Paracetamol 1g QDS +/- regular ibuprofen 400mg TDS or Diclofenac 50mg TDS (if not contraindicated).

***Ensure appropriate antiemetic.**
****Ensure laxative where appropriate with repeat doses of codeine / opiate.**

O.D. = Once a day.

B.D. = Twice a day.

T.D.S. = Three times a day.

Q.D.S. = Four times a day.

ANTIBIOTIC PROTOCOL 7.6

Gastro-intestinal System	
Bacterial gastroenteritis	Ciprofloxacin
Biliary tract infection	Cefotaxime or Gentamicin
Peritonitis	Cefotaxime or Gentamicin + Metronidazole
Cardiovascular System	
Endocarditis	Flucloxacillin + low dose Gentamicin
Respiratory System	
Chest Infection (Mild Pneumonia)	Amoxicillin
Severe Pneumonia	Cefotaxime + Erythromycin or Co-amoxiclav
Atypical pneumonia	Erythromycin
Central Nervous System	
Meningitis	Cefotaxime
Meningitis due to listeriosis	Amoxicillin + Gentamicin
Urinary Tract	
Urinary Tract Infection	Amoxicillin or Ciprofloxacin or Cefotaxime
Acute pyelonephritis	Cefotaxime or Ciprofloxacin
Acute prostatitis	Ciprofloxacin
Genital Tract	
Syphilis	Doxycycline or Erythromycin
Uncomplicated gonorrhoea	Cefotaxime or Ciprofloxacin
Non-specific urethritis	Doxycycline
Pelvic inflammatory disease	Ciproflaxacin + Metronidazole
Blood	
Blood Infection (Septicaemia)	Cefotaxime ± Gentamicin ± Metronidazole
Musculoskeletal System	
Bone Infection (Osteo-myelitis)	Flucloxacillin or Clindamycin
Septic Arthritis	Flucloxacillin + Fusidic acid or Clindamycin
Eye	
Eye Infection (Conjunctivitis)	Chloramphenicol or Gentamicin drops
Ear, Nose and Orophyarnx	
Throat infections	Phenoxymethlypenicillin or Erythromycin
Sinusitis	Amoxicillin or Erythromycin or Doxycycline
Outer Ear Infection (Otitis Externa)	Flucloxacillin, Clindamycin or Neomycin Drops
Inner Ear Infection (Otitis Media)	Amoxicillin or Erythromycin
Skin	
Impetigo / erysipelas / cellulitis	Coamoxiclav or Clindamycin

Richmond Agitation Sedation Scale 7.7

R.A.S.S. Score	R.A.S.S. Description
+4	Combative, violent, danger to staff.
+3	Pulls at tube(s) or catheters; aggressive.
+2	Non-purposeful movement, fights ventilator.
+1	Anxious, apprehensive , but not aggressive.
0	Alert and calm.
-1	Awakens to voice (eye opening) >10 sec.
-2	Light sedation, briefly awakens to voice (eye opening) <10 sec.
-3	Moderate sedation, movement or eye opening.
-4	Deep sedation, no response to voice, movement or eye opening to stimulation.
-5	Unarousable, no response.

The aim the sedation score is to achieve optimal sedation without cardiovascular impairment in the intubated casualty.

A score of -1 to -3 is considered to be desirable.

Section 8

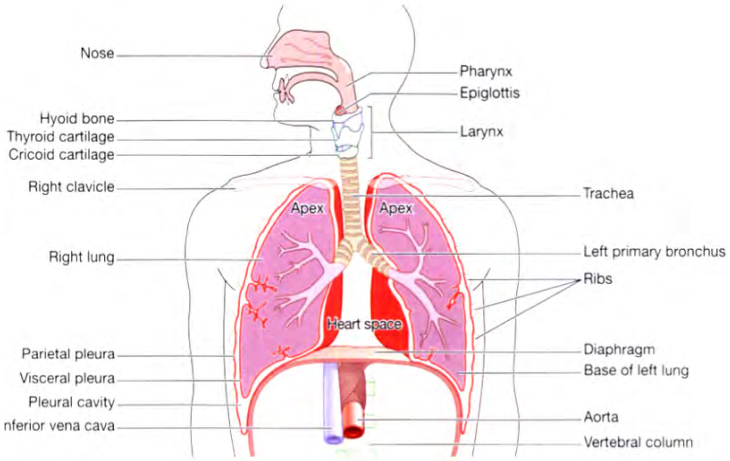
Anatomy & Physiology

RESPIRATORY SYSTEM 8.1

The cells of the body need energy for their chemical activity that maintains homeostasis. Most of this energy is derived from chemical reactions, which can only take place in the presence of oxygen (O_2). The main waste product of these reactions is carbon dioxide (CO_2). The respiratory system provides the route by which the supply of oxygen present in the atmospheric air gains entry to the body and it provides the route of excretion of carbon dioxide.

As the air breathed in moves through the air passages to reach the lungs, it is warmed or cooled to body temperature, moistened to become saturated with water vapour and 'cleaned' as particles of dust stick to the mucus which coats the lining membrane. Blood provides the transport system for these gases between the lungs and the cells of the body.

Exchange of gases between the blood and the lungs is called *external respiration* and that between the blood and the cells *internal respiration.*



The Organs Of The Respiratory System Are:

- Nose
- Pharynx
- Larynx
- Trachea
- Two bronchi (one bronchus to each lung)
- Bronchioles and smaller air passages
- Two lungs and their coverings, the pleura
- Muscles of respiration, the inter-costal muscles and the diaphragm

The Airway 8.1.1

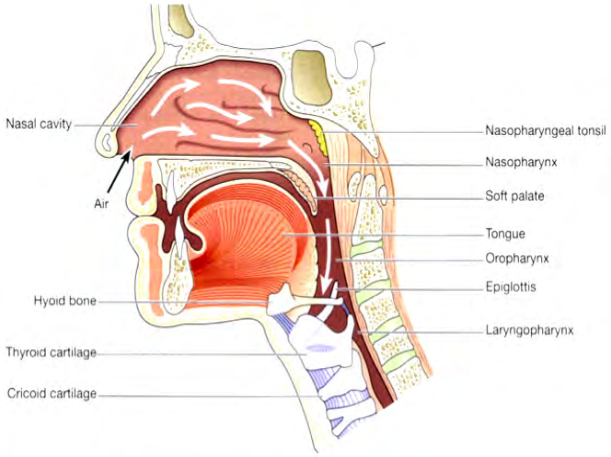
The Nose

Respiratory Function of the Nose

The nose is the first of the respiratory passages through which the inspired air passes. The function of the nose is to begin the process by which the air is *warmed, moistened and 'filtered'.*
The projecting *conchae* increase the surface area and cause turbulence, spreading inspired air over the whole nasal surface. The large surface area.

Filtering and Cleaning of Air.

This occurs as hairs at the anterior nares trap larger particles. Smaller particles such as dust and microbes settle and adhere to the mucus. Mucus protects the underlying epithelium from irritation and prevents drying. Synchronous beating of the cilia wafts the mucus towards the throat where it is swallowed or expectorated.



Humidification

This occurs as air travels over the moist mucosa and becomes saturated with water vapour. Irritation of the nasal mucosa results in *sneezing,* a reflex action that forcibly expels an irritant. maximises warming, humidification and filtering.

The Pharynx

The pharynx is a tube 12 to 14 cm long that extends from the base of the skull to the level of the 6th cervical vertebra. It lies behind the nose, mouth and larynx and is wider at its upper end.

For descriptive purposes the pharynx is divided into three parts: *nasopharynx, oropharynx* and *laryngopharynx.*

The Nasopharynx

The nasal part of the pharynx lies behind the nose above the level of the soft palate. On its lateral walls are the two openings of the ***eustacian tubes,*** one leading to each middle ear. On the posterior wall there are the *pharyngeal tonsils* (adenoids).

The Oropharynx

The oral part of the pharynx lies behind the mouth, extending from below the level of the soft palate to the level of the upper part of the body of the 3rd cervical vertebra. The lateral walls of the pharynx blend with the soft palate to form two folds on each side.

During swallowing, the nasal and oral parts are separated by the soft palate and the *uvula.*

The Laryngopharynx

The laryngeal part of the pharynx extends from the oropharynx above and continues as the oesophagus below, i.e. from the level of the 3rd to the 6th cervical vertebrae.

Functions of the Pharynx

Passageway for Air and Food

The pharynx is an organ involved in both the respiratory and the digestive systems: air passes through the nasal and oral parts, and food through the oral and laryngeal parts.

Warming and Humidifying

By the same methods as in the nose, the air is further warmed and moistened as it passes through the pharynx.

Taste

There are olfactory nerve endings of the sense of taste in the epithelium of the oral and pharyngeal parts.

Hearing

The auditory tube, extending from the nasal part to each middle ear, allows air to enter the middle ear. Satisfactory hearing depends on the presence of air at atmospheric pressure on each side of the *tympanic membrane* (ear drum).

Protection

The lymphatic tissue of the pharyngeal and laryngeal tonsils produces antibodies in response to anti- gens, e.g. microbes. The tonsils are larger in children and tend to atrophy in adults.

Speech

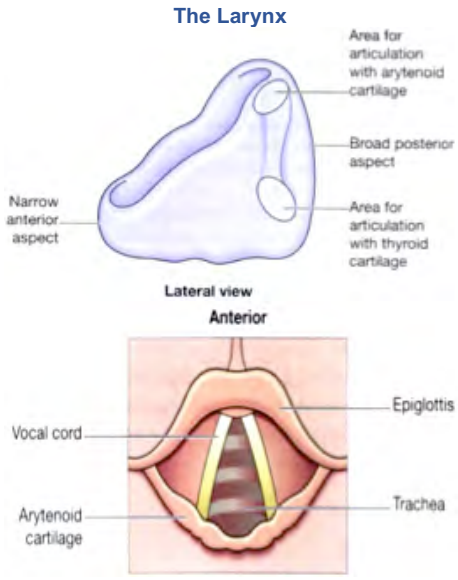
The pharynx functions in speech; by acting as a resonating chamber for the sound ascending from the larynx, it helps (together with the sinuses) to give the voice its individual characteristics.

The Larynx

The larynx is composed of several irregularly shaped cartilages attached to each other by ligaments and membranes.

The Main Cartilages Are:

- 1 Thyroid cartilage
- 1 Cricoid cartilage
- 1 Hyaline cartilage
- 2 Arytenoid cartilages
- 1 Epiglottis



The Thyroid Cartilage

This is the most prominent and consists of two flat pieces of hyaline cartilage, or *laminae,* fused anteriorly, forming the *laryngeal prominence* (Adam's apple). Immediately above the laryngeal prominence the laminae are separated, forming a V-shaped notch known as the *thyroid notch.*

The Cricoid Cartilage

This lies below the thyroid cartilage and is also composed of hyaline cartilage. It is shaped like a signet ring, completely encircling the larynx with the narrow part anteriorly and the broad part posteriorly.

The Epiglottis

This is a leaf-shaped fibroelastic cartilage attached to the inner surface of the anterior wall of the thyroid cartilage immediately below the thyroid notch. It rises obliquely upwards behind the tongue and the body of the hyoid bone. If the larynx is likened to a box then the epiglottis acts as the lid; it closes off the larynx during swallowing, protecting the lungs from accidental inhalation of foreign objects.

Interior of the Larynx

The *vocal cords* are two pale folds of mucous membrane with cord-like free edges, which extend from the inner wall of the thyroid prominence anteriorly to the arytenoid cartilages posteriorly.

When the muscles controlling the vocal cords are relaxed, the vocal cords open and the passageway for air coming up through the larynx is clear; the vocal cords are said to be *abducted*. The pitch of the sound produced

by vibrating the vocal cords in this position is low. When the muscles controlling the vocal cords contract, the vocal cords are stretched out tightly across the larynx —they are said to be *adducted.* When the vocal cords are stretched to this extent, and are vibrated by air passing through from the lungs, the sound produced is high pitched. The pitch of the voice is therefore determined by the tension applied to the vocal cords by the appropriate sets of muscles.

Functions of the Larynx

Production of Sound

Sound Has The Properties Of *Pitch, Volume* And *Resonance:*

- Pitch of the voice depends upon the *length* and *tightness* of the cords. At puberty, the male vocal cords begin to grow longer, hence the lower pitch of the adult male voice.
- Volume of the voice depends upon *the force* with which the cords vibrate. The greater the force of expired air the more the cords vibrate and the louder the sound emitted.
- Resonance, or tone, is dependent upon the shape of the mouth, the position of the tongue and the lips, the facial muscles and the air in the para-nasal sinuses.

Speech

This occurs during expiration when the sounds produced by the vocal cords are manipulated by the tongue, cheeks and lips.

Protection Of The Lower Respiratory Tract

During swallowing (deglutition) the larynx moves upwards, occluding the opening into it from the pharynx and the hinged epiglottis closes over the larynx. This ensures that food passes into the oesophagus and not into the lower respiratory passages.

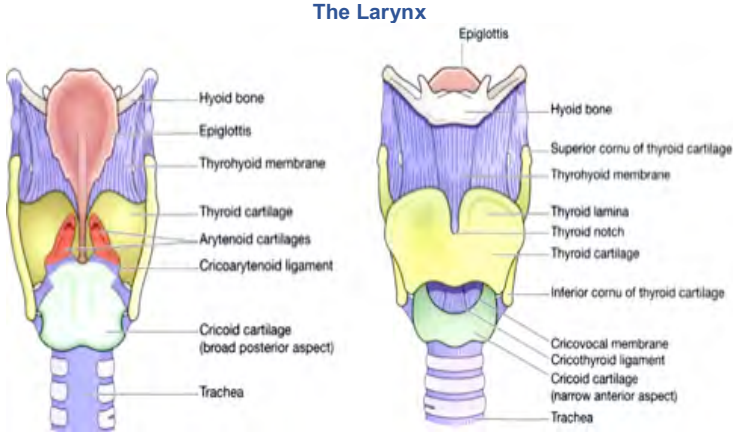
Passageway for Air

This is between the pharynx and trachea.

Humidifying, Filtering and Warming

These continue as inspired air travels through the larynx.

The Larynx



The Trachea

The trachea is composed of from 16 to 20 incomplete (C-shaped) rings of hyaline cartilages lying one above the other. The cartilages are incomplete posteriorly. Connective tissue and involuntary muscle join the cartilages and form the posterior wall where they are incomplete. The soft tissue posterior wall is in contact with the oesophagus.

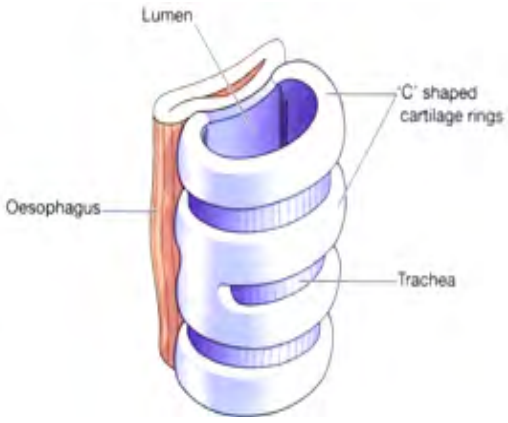
There are three layers of tissue, which 'clothe' the cartilages of the trachea.

The outer layer. This consists of fibrous and elastic tissue and encloses the cartilages.

The middle layer. This consists of cartilages and bands of smooth muscle that wind round the trachea in a helical arrangement. There is some areolar tissue, containing blood and lymph vessels and autonomic nerves.

The inner lining. This consists of ciliated columnar epithelium, containing mucus-secreting goblet cells.

The Trachea



Functions of the Trachea

Support and Patency

The arrangement of cartilage and elastic tissue prevents kinking and obstruction of the airway as the head and neck move. The absence of cartilage posteriorly allows the trachea to dilate and constrict in response to nerve stimulation, and for indentation as the oesophagus distends during swallowing. The cartilages prevent collapse of the tube when the internal pressure is less than intrathoracic pressure, i.e. at the end of forced expiration.

Mucociliary Escalator

This is the synchronous and regular beating of the cilia of the mucous membrane lining that wafts mucus with adherent particles upwards towards the larynx where it is swallowed or expectorated.

Cough Reflex

Nerve endings in the larynx, trachea and bronchi are sensitive to irritation that generates nerve impulses, which are conducted by the vagus nerves to the respiratory centre in the brain stem. The reflex motor response is deep inspiration followed by closure of the glottis. The abdominal and respiratory muscles then contract and suddenly the air is released under pressure expelling mucus and/or foreign material from the mouth.

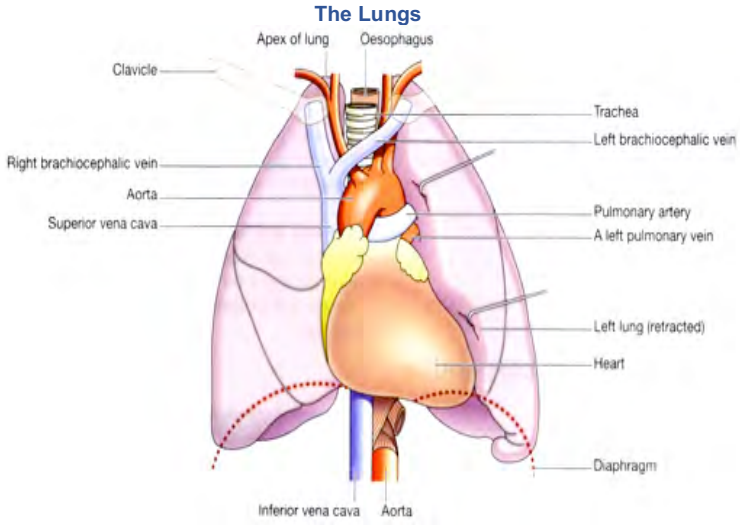
The Lungs 8.1.2

Bronchus

The two primary bronchi are formed when the trachea divides, i.e. about the level of the 5th thoracic vertebra.
The right bronchus. This is wider, shorter and more vertical than the left bronchus and is therefore the more likely of the two to become obstructed by an inhaled foreign body. It is approximately 2.5cm long. After entering the right lung at the hilum it divides into three branches, one to each lobe. Each branch then subdivides into numerous smaller branches.
The left bronchus. This is about 5 cm long and is narrower than the right. After entering the lung at the hilum it divides into two branches, one to each lobe. Each branch then subdivides into progressively smaller tubes within the lung substance.

Bronchi and Bronchioles Structure

The bronchi are composed of the same tissues as the trachea. They are lined with ciliated columnar epithelium. The bronchi progressively subdivide into *bronchioles*, *terminal bronchioles, respiratory bronchioles, alveolar ducts* and finally, *alveoli.* Towards the distal end of the bronchi the cartilages become irregular in shape and are absent at bronchiolar level. In the absence of cartilage the smooth muscle in the walls of the bronchioles becomes thicker and is responsive to autonomic nerve stimulation and irritation. Ciliated columnar mucous membrane changes gradually to non-ciliated cuboidal shaped cells in the distal bronchioles.



Respiratory Bronchioles And Alveoli

Lobules are the blind ends of the respiratory tract distal to the terminal bronchioles, consisting of: *respiratory bronchioles, alveolar ducts* and *alveoli* (tiny air sacs). It is in these structures that the process of gas exchange occurs. The walls gradually become thinner until muscle and connective tissue fade out leaving a single layer of simple squamous epithelial cells in the alveolar ducts and alveoli. These distal respiratory passages are supported by a loose network of elastic connective tissue in which macrophages, fibroblasts, nerves and blood and lymph vessels are embedded. The alveoli are surrounded by a network of capillaries. The exchange of gases during respiration takes place across two membranes, the alveolar and capillary membranes.

Functions Of Respiratory Bronchioles And Alveoli

Defence Against Microbes

At this level, ciliated epithelium, goblet cells and mucus are no longer present.
Defence relies on protective cells present within the lung tissue. These include lymphocytes and plasma cells, which produce antibodies in the presence of antigens, and macrophages and polymorphonuclear lymphocytes, which are phagocytic. These cells are most active in the distal air passages where ciliated epithelium has been replaced by flattened cells.

Lungs

There are two lungs, one lying on each side of the midline in the thoracic cavity. They are cone-shaped and are described as having an *apex, a base, costal surface* and *medial surface.*

The Apex

This is rounded and rises into the root of the neck, about 25 mm (1 inch) above the level of the middle third of the clavicle. The structures associated with it are the first rib and the blood vessels and nerves in the root of the neck.

The Base

This is concave and semilunar in shape and is closely associated with the thoracic surface of the diaphragm.

The Costal Surface

This surface is convex and is closely associated with the costal cartilages, the ribs and the intercostal muscles.

The Medial Surface

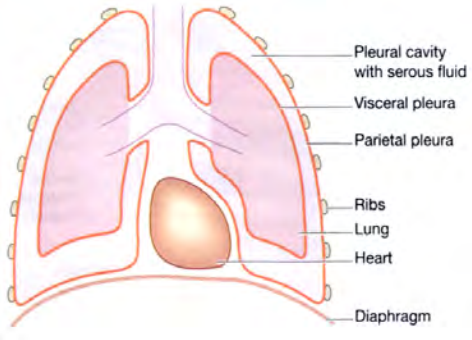
This surface is concave and has a roughly triangular-shaped area, called the *hilum,*at the level of the 5th, 6th and 7th thoracic vertebrae. Structures which form the *root of the lung* enter and leave at the hilum. These include the primary bronchus, the pulmonary artery supplying the lung and the two pulmonary veins draining it, the bronchial artery and veins, and the lymphatic and nerve supply.
The area between the lungs is the *mediastinum.* The heart, great vessels, trachea, right and left bronchi, oesophagus, lymph nodes, lymph vessels and nerves occupy it.

Organisation of the Lungs

The *right lung* is divided into three distinct lobes: superior, middle and inferior.
The *left lung* is smaller as the heart is situated left of the midline. It is divided into only two lobes: superior and inferior.

Pleura and Pleural Cavity

The pleura consists of a closed sac of serous membrane (one for each lung) which contains a small amount of serous fluid. The lung is invaginated into this sac so that it forms two layers: one adheres to the lung and the other to the wall of the thoracic cavity.



The Visceral Pleura

This is adherent to the lung, covering each lobe and passing into the fissures which separate them.

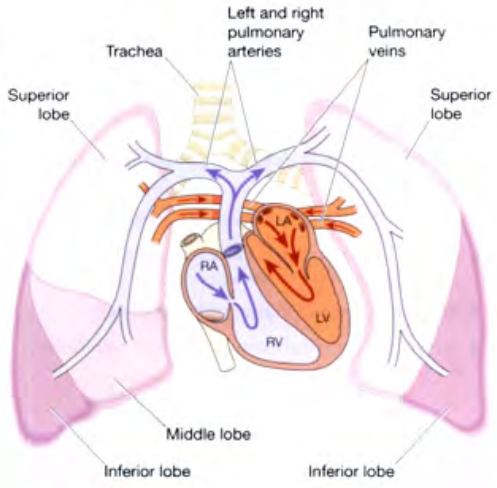
The Parietal Pleura

This is adherent to the inside of the chest wall and the thoracic surface of the diaphragm. It remains detached from the adjacent structures in the mediastinum and is continuous with the visceral pleura round the edges of the hilum.

The Pleural Cavity

This is only a potential space. In health, the two layers of pleura are separated by only a thin film of serous fluid, which allows them to glide over each other, preventing friction between them during breathing.
The two layers of pleura, with serous fluid between them, behave in the same way as two pieces of glass separated by a thin film of water. They glide over each other easily but can be pulled apart only with difficulty, because of the surface tension between the membranes and the fluid. If either layer of pleura is punctured, the underlying lung collapses due to its inherent property of elastic recoil.

The Lungs



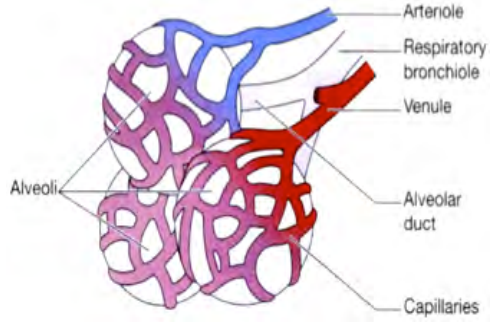
Interior of the Lungs

The lungs are composed of the bronchi and smaller air passages, alveoli, connective tissue, blood vessels, lymph vessels and nerves. The left lung is divided into two lobes and the right, into three. Each lobe is made up of a large number of lobules.

Pulmonary Blood Supply

The *pulmonary artery* divides into two, one branch conveying *deoxygenated blood* to each lung. Within the lungs each pulmonary artery divides into many branches, which eventually end in a dense capillary network around the walls of the alveoli. The walls of the alveoli and those of the capillaries each consist of only one layer of flattened epithelial cells. The exchange of gases between air in the alveoli and blood in the capillaries takes place across these two very fine membranes. The pulmonary capillaries join up, eventually becoming *two pulmonary veins* in each lung. They leave the lungs at the hilum and convey *oxygenated blood* to the left atrium of the heart. The innumerable blood capillaries and blood vessels in the lungs are supported by connective tissue.

The Alveolar



Muscles of Respiration

The expansion of the chest during inspiration occurs as a result of muscular activity, partly voluntary and partly involuntary. The main muscles of respiration in normal quiet breathing are the *inter-costal muscles* and the *diaphragm.* During difficult or deep breathing they are assisted by the muscles of the neck, shoulders and abdomen.

Intercostal Muscles

There are 11 pairs of intercostal muscles that occupy the spaces between the 12 pairs of ribs. They are arranged in two layers, the external and internal inter-costal muscles.

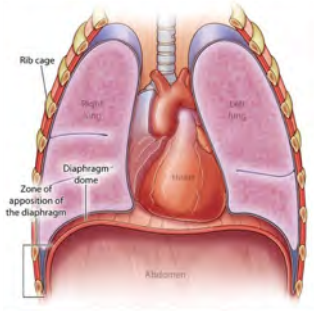
The External Inter-Costal Muscle Fibres.

These extend in a downwards and forwards direction from the lower border of the rib above to the upper border of the rib below.

The Internal Inter-Costal Muscle Fibres

These extend in a downwards and backwards direction from the lower border of the rib above to the upper border of the rib below, crossing the external inter-costal muscle fibres at right angles.
The first rib is fixed. Therefore, when the inter-costal muscles contract they pull all the other ribs towards the first rib. Because of the shape of the ribs they move outwards when pulled upwards. In this way the thoracic cavity is enlarged anteroposteriorly and laterally. The inter-costal muscles are stimulated to contract by the *inter-costal nerves.*

The Diaphragm



Diaphragm

The diaphragm is a dome-shaped structure separating the thoracic and abdominal cavities. It forms the floor of the thoracic cavity and the roof of the abdominal cavity and consists of a central tendon from which muscle fibres radiate to be attached to the lower ribs and sternum and to the vertebral column by two crura. When the muscle of the diaphragm is relaxed, the central tendon is at the level of the 8th thoracic vertebra. When it contracts, its muscle fibres shorten and the central tendon is pulled downwards to the level of the 9th thoracic vertebra, enlarging the thoracic cavity in length. This decreases pressure in the thoracic cavity and increases it in the abdominal and pelvic cavities.

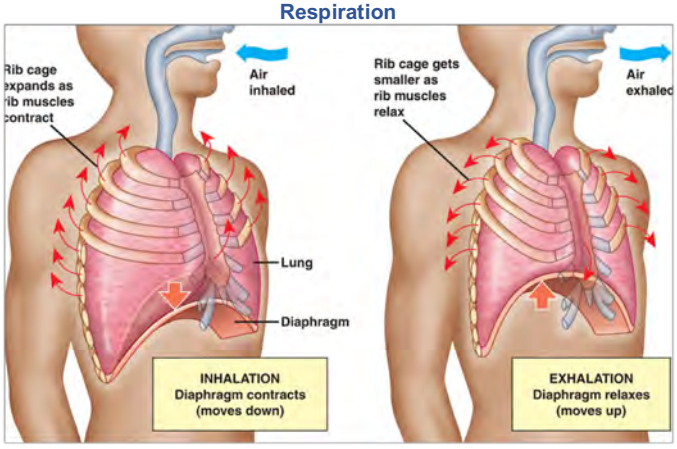
Respiration 8.1.3

Cycle of Respiration

This Occurs 12 To 16 Times Per Minute And Consists Of Three Phases:

- Inspiration
- Expiration
- Pause.

Respiration



Inspiration

When the capacity of the thoracic cavity is increased by simultaneous contraction of the inter-costal muscles and the diaphragm, the parietal pleura moves with the walls of the thorax and the diaphragm. This reduces the pressure in the pleural cavity to a level considerably lower than atmospheric pressure. The visceral pleura follows the parietal pleura pulling the lung with it. This stretches the lungs and the pressure within the alveoli and in the air passages falls, drawing air into the lungs in an attempt to equalise the atmospheric and alveolar air pressures.
The process of inspiration is *active,* as it requires expenditure of energy for muscle contraction. The negative pressure created in the thoracic cavity aids venous return to the heart and is known as the *respiratory pump.*

Expiration

Relaxation of the inter-costal muscles and the diaphragm results in downward and inward movement of the rib cage and elastic recoil of the lungs. As this occurs, pressure inside the lungs exceeds that in the atmosphere and therefore air is expelled from the respiratory tract. The lungs still contain some air and are prevented from complete collapse by the intact pleura. This process is *passive* as it does not require the expenditure of energy. After expiration, there is a *pause* before the next cycle begins.

Physiological Variables Affecting Respiration

Elasticity

Elasticity is the term used to describe the ability of the lung to return to its normal shape after each breath. Loss of elasticity of the connective tissue in the lungs necessitates forced expiration and increased effort on inspiration.

Compliance

This is a measure of the distensibility of the lungs, i.e. the effort required to inflate the alveoli. When compliance is low the effort needed to inflate the lungs is greater than normal, e.g. in some diseases where elasticity is reduced or when insufficient surfactant is present. It should be noted that compliance and elasticity are opposing forces.

Airflow Resistance

When this is increased, e.g. in broncho-constriction, more respiratory effort is required to inflate the lungs. Lung volumes and capacities In normal quiet breathing there are about 15 complete respiratory cycles per minute. The lungs and the air passages are never empty and, as the exchange of gases takes place only across the walls of the alveolar ducts and alveoli, the remaining capacity of the respiratory passages is called the *anatomical dead space* (about 150 ml).

Tidal Volume (TV)

This is the amount of air, which passes into and out of the lungs during each cycle of quiet breathing (about 500ml).

Inspiratory Reserve Volume (IRV)

This is the extra volume of air that can be inhaled into the lungs during maximal inspiration.

Inspiratory Capacity (IC)

This is the amount of air that can be inspired with maximum effort. It consists of the tidal volume (500ml) plus the inspiratory reserve volume.

Functional Residual Capacity (FRC)

This is the amount of air remaining in the air passages and alveoli at the end of quiet expiration.

Expiratory Reserve Volume (ERV)

This is the largest volume of air, which can be expelled from the lungs during maximal expiration.

Residual Volume (RV)

This cannot be directly measured but is the volume of air remaining in the lungs after forced expiration.

Vital Capacity (VC)

This is the maximum volume of air, which can be moved into and out of the lungs:

VC = Tidal volume + IRV + ERV

Alveolar Ventilation

This is the volume of air that moves into and out of the alveoli per minute. It is equal to the tidal volume minus the anatomical dead space, multiplied by the respiratory rate:

Alveolar Ventilation =

= (TV - anatomical dead space) x respiratory rate
= (500-150) ml x 15 per minute
= 5.25 litres per minute

Composition of Air

Atmospheric pressure at sea level is 101.3 kilopascals (kPa) or 760mmHg. With the increase in height above sea level, atmospheric pressure is progressively reduced and at 5500 m, about two-thirds the height of Mount Everest (8850 m), it is about half that at sea level. Under water, pressure increases by approximately 1 atmosphere per 10 m below sea level.

Air is a mixture of gases: nitrogen, oxygen, carbon dioxide, water vapour and small quantities of inert gases. Each gas in the mixture exerts a part of the total pressure proportional to its concentration, i.e . the *partial pressure*. This is denoted as, e.g. PO_2, PCO_2.

Alveolar Air

The composition of alveolar air remains fairly constant and is different from atmospheric air. It is saturated with water vapour and contains more carbon dioxide, and less oxygen. Saturation with water vapour provides 6.3kPa (47 mmHg) thus reducing the partial pressure of all the other gases present. Gaseous exchange between the alveoli and the bloodstream *(external respiration)* is a continuous process, as the alveoli are never empty, so it is independent of the respiratory cycle. During each inspiration only some of the alveolar gases are exchanged.

Expired Air

This is a mixture of alveolar air and atmospheric air in the dead space.

The Composition Of Inspired And Expired Air		
	Inspired Air %	Expired Air %
Oxygen	21	16
Carbon Dioxide	0.04	4
Nitrogen And Rare Gases	78	78
Water Vapour	Variable	Saturated

Diffusion of Gases

Exchange of gases occurs when a difference in partial pressure exists across semi-permeable membranes. Gases move by diffusion from the higher concentration to the lower until equilibrium is established. Atmospheric nitrogen is not used by the body so its partial pressure remains unchanged and is the same in inspired and expired air, alveolar air and in the blood.

External Respiration

This is exchange of gases by diffusion between the alveoli and the blood. Each alveolar wall is one cell thick and is surrounded by a network of tiny capillaries (the walls of which are also only one cell thick). The total area for gas exchange in the lungs is 70 to 80 square metres. Venous blood arriving at the lungs has travelled from all the active tissues of the body, and contains high levels of CO_2 and low levels of O_2.

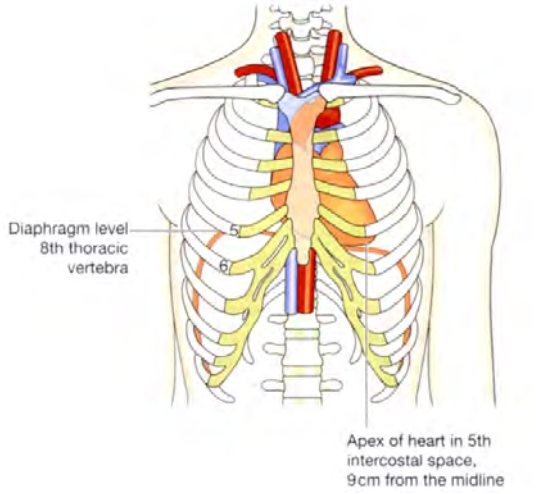
Carbon dioxide diffuses from venous blood down its concentration gradient into the alveoli until equilibrium with alveolar air is reached. By the same process, oxygen diffuses from the alveoli into the blood. The slow flow of blood through the capillaries increases the time available for diffusion to occur. When blood leaves the alveolar capillaries, the oxygen and carbon dioxide concentrations are in equilibrium with those of alveolar air.

CARDIO-VASCULAR SYSTEM 8.2

Heart 8.2.1

The heart is a roughly cone-shaped hollow muscular organ. It is about 10 cm long and is about the size of the owner's fist. It weighs about 225g in women 310g and men in.

The heart lies in the thoracic cavity in the mediastinum between the lungs. It lies obliquely, a little more to the left than the right, and presents a *base* above, and an *apex* below. The apex is about 9 cm to the left of the midline at the level of the 5th inter-costal space, i.e. a little below the nipple and slightly nearer the midline. The base extends to the level of the 2nd rib.



Structure

The heart is composed of three layers of tissue: pericardium, myocardium and endocardium.

Pericardium

The pericardium is made up of two sacs. The outer sac consists of fibrous tissue and the inner of a continuous double layer of serous membrane.

The outer fibrous sac is continuous with the tunica adventitia of the great blood vessels above and is adherent to the diaphragm below. Its inelastic, fibrous nature prevents overdistension of the heart.

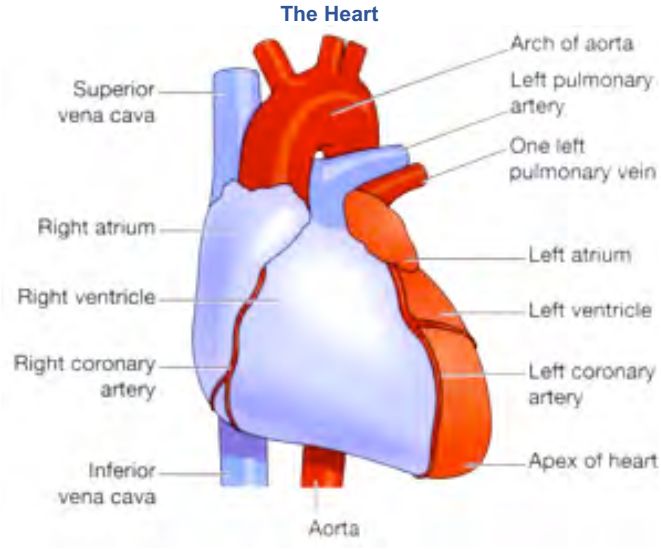
Myocardium

The myocardium is composed of specialised cardiac muscle found only in the heart.

It is not under voluntary control but, like skeletal muscle, cross-stripes are seen on microscopic examination. Each fibre (cell) has a nucleus and one or more branches. The ends of the cells and their branches are in very close contact with the ends and branches of adjacent cells.

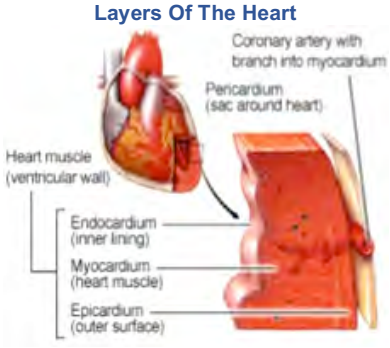
This arrangement gives cardiac muscle the appearance of being a sheet of muscle rather than a very large number of individual cells.

Because of the end-to-end continuity of the fibres, each one does not need to have a separate nerve supply. When an impulse is initiated it spreads from cell to cell via the branches and intercalated discs over the whole 'sheet' of muscle, causing contraction. The 'sheet' arrangement of the myocardium enables the atria and ventricles to contract in a coordinated and efficient manner.



The myocardium is thickest at the apex and thins out towards the base. This reflects the amount of work each chamber contributes to the pumping of blood. It is thickest in the left ventricle.

A ring of fibrous tissue that does not conduct electrical impulses separates the atria and the ventricles. Consequently, when a wave of electrical activity passes over the atrial muscle, it can only spread to the ventricles through the conducting system, which bridges the fibrous ring from atria to ventricles.



Endocardium

This forms the lining of the myocardium and the heart valves. It is a thin, smooth, glistening membrane, which permits smooth flow of blood inside the heart. It consists of flattened epithelial cells, continuous with the endothelium that lines the blood vessels.

Interior of the Heart

The heart is divided into a right and left side by the *septum*, a partition consisting of myocardium covered by endocardium.

After birth, blood cannot cross the septum from one side to the other. An atrioventricular valve into an upper chamber, the atrium, and a lower chamber, the ventricle divides each side.

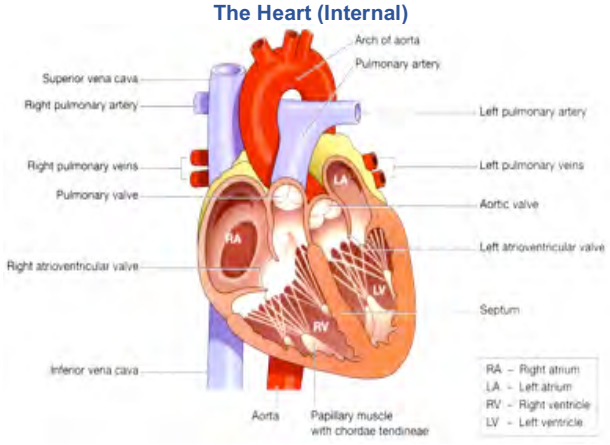
Double folds of endocardium strengthened by a little fibrous tissue form the atrioventricular valves. The *right atrioventricular valve* (tricuspid valve) has three flaps or *cusps* and the *left atrioventricular valve* (mitral valve) has two cusps.

The valves between the atria and ventricles open and close passively, according to changes in pressure in the chambers. They open when the pressure in the atria is greater than that in the ventricles.

During *ventricular systole* (contraction) the pressure in the ventricles rises above that in the atria and the valves snap shut preventing backward flow of blood.

The valves are prevented from opening upwards into the atria by tendinous cords, called *chordae tendineae.*

The Heart (Internal)



Flow Of Blood Through The Heart

The two largest veins of the body, the *superior* and *inferior venae cavae,* empty their contents into the right atrium.

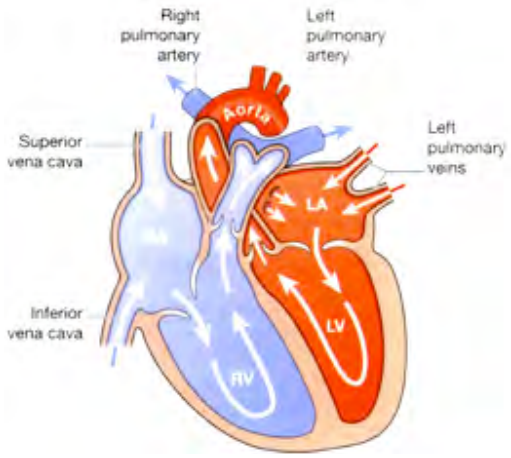
This blood passes via the right atrio-ventricular valve into the right ventricle, and from there it is pumped into the *pulmonary artery* or *trunk* (the only artery in the body which carries deoxygenated blood).

The pulmonary valve, formed by three semilunar cusps, guards the opening of the pulmonary artery.

This valve prevents the back flow of blood into the right ventricle when the ventricular muscle relaxes. After leaving the heart the pulmonary artery divides into *left* and *right pulmonary arteries,* which carry the venous blood to the lungs where exchange of gases takes place: carbon dioxide is excreted and oxygen is absorbed.

Two *pulmonary veins* from each lung carry *oxygenated blood* back to the *left atrium.* Blood then passes through the left atrio-ventricular valve into the left ventricle, and from there it is pumped into the aorta, the first artery of the general circulation. The aortic valve, formed by three semilunar cusps, guards the opening of the aorta.

The Heart (Blood-Flow)



From this sequence of events it can be seen that the blood passes from the right to the left side of the heart via the lungs, or pulmonary circulation. However, it should be noted that both atria contract at the same time and this is followed by the simultaneous contraction of both ventricles.

The muscle layer of the walls of the atria is very thin in comparison with that of the ventricles. This is consistent with the amount of work it does. The atria, usually assisted by gravity, only propel the blood through the atrio-ventricular valves into the ventricles, whereas the ventricles actively pump the blood to the lungs and round the whole body. The muscle layer is thickest in the wall of the left ventricle.

The pulmonary trunk leaves the heart from the upper part of the right ventricle, and the aorta leaves from the upper part of the left ventricle.

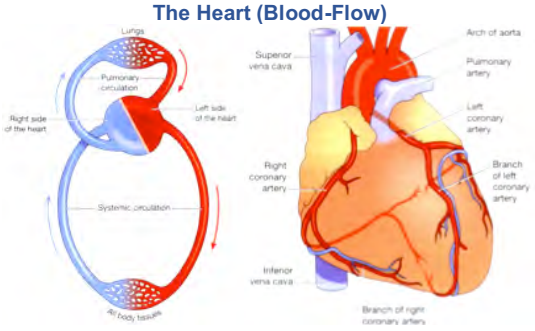
Blood Supply To The Heart

Arterial supply

The heart is supplied with arterial blood by the *right and left coronary arteries,* which branch from the aorta immediately distal to the aortic valve.

The coronary arteries receive about 5% of the blood pumped from the heart. The coronary arteries traverse the heart, eventually forming a vast network of capillaries.

The Heart (Blood-Flow)



Venous Drainage

Most of the venous blood is collected into several small veins that

join to form the *coronary sinus,* which opens into the right atrium.
The remainder passes directly into the heart chambers through little venous channels.

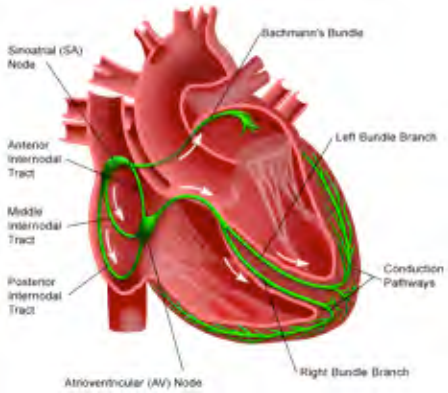
Electrical Conducting System Of The Heart

The heart has an intrinsic system whereby the cardiac muscle is automatically stimulated to contract without the need for a nerve supply from the brain. However, the intrinsic system can be stimulated or depressed by nerve impulses initiated in the brain and by circulating chemicals including hormones.
There are small groups of specialised neuromuscular cells in the myocardium, which initiate and conduct impulses causing coordinated and synchronised contraction of the heart muscle.

Sinoatrial Node (SA node)

This small mass of specialised cells is in the wall of the right atrium near the opening of the superior vena cava. The SA node is the *'pace-maker'* of the heart because it normally initiates impulses more rapidly than other groups of neuromuscular cells.

The Heart (Electrical Pathway)



Atrioventricular Node (AV node)

This small mass of neuromuscular tissue is situated in the wall of the atrial septum near the atrio-ventricular valves. Normally the AV node is stimulated by impulses that sweep over the atrial myocardium.

Atrioventricular Bundle (AV bundle or bundle of His)

This is a mass of specialised fibres that originate from the AV node. The A V bundle crosses the fibrous ring that separates atria and ventricles then, at the upper end of the ventricular septum, it divides into *right and left bundle branches.* Within the ventricular myocardium the branches break up into fine fibres, called the *Purkinje fibres.*

The AV bundle, bundle branches and Purkinje fibres convey electrical impulses from the AV node to the apex of the myocardium where the wave of ventricular contraction begins, then sweeps upwards and outwards, pumping blood into the pulmonary artery and the aorta.

The Cardiac Cycle

The function of the heart is to maintain a constant circulation of blood throughout the body. The heart acts as a pump and its action consists of a series of events known as the *cardiac cycle*.

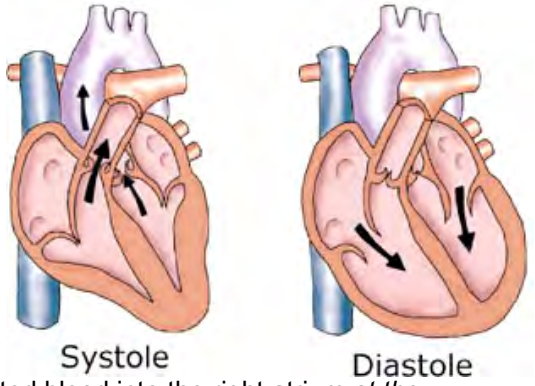
During each heartbeat, or cardiac cycle, the heart contracts and then relaxes. The period of contraction is called *systole* and that of relaxation, *diastole.*

Stages of the Cardiac Cycle

The normal number of cardiac cycles per minute ranges from 60 to 80. Taking 74 as an example each cycle lasts about *0.8 of a second* and consists of:

- Atrial systole (contraction of the atria).
- Ventricular systole (contraction of the ventricles).
- Cardiac diastole (relaxation of the atria and ventricles).

It does not matter at which stage of the cardiac cycle a description starts. For convenience the period when the atria are filling has been chosen.



The superior vena cava and the inferior vena cava transport deoxygenated blood into the right atrium *at the same time* as the four pulmonary veins convey oxygenated blood into the left atrium.

The atrio-ventricular valves are open and blood flows through to the ventricles. The SA node triggers a wave of contraction that spreads over the myocardium of both atria, emptying the atria and completing ventricular filling (atrial systole 0.1s). When the wave of contraction reaches the AV node it is stimulated to emit an impulse which quickly spreads to the ventricular muscle via the AV bundle, the bundle branches and Purkinje fibres. This results in a wave of contraction, which sweeps upwards from the apex of the heart and across the walls of both ventricles pumping the blood into the pulmonary artery and the aorta (ventricular systole 0.3s). The high pressure generated during ventricular contraction is greater than that in the aorta and forces the atrioventricularvalves to close, preventing backflow of blood into the atria.

After contraction of the ventricles there is *complete cardiac diastole,* a period of *0.4 seconds,* when atria and ventricles are relaxed. During this time the myocardium recovers until it is able to contract again, and the atria refill in preparation for the next cycle.

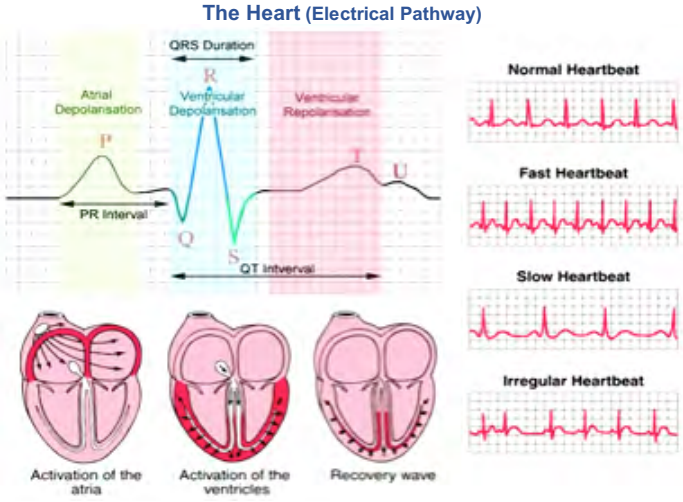
The valves of the heart and of the great vessels open and close according to the pressure within the chambers of the heart. The AV valves are open while the ventricular muscle is relaxed during atrial filling and systole. When the ventricles contract there is a gradual increase in the pressure in these chambers, and when it rises above atrial pressure the atrio-ventricular valves close.

When the ventricular pressure rises above that in the pulmonary artery and in the aorta, the pulmonary and

aortic valves open and blood flows into these vessels. When the ventricles relax and the pressure within them falls, the reverse process occurs. First the pulmonary and aortic valves close, then the atrio-ventricular valves open and the cycle begins again. This sequence of opening and closing valves ensures that the blood flows in only one direction. This figure also shows how the walls of the aorta and other elastic arteries stretch and recoil in response to blood pumped into them.

Electrical Changes in the Heart

As the body fluids and tissues are good conductors of electricity, the electrical activity within the heart can be detected by attaching electrodes to the surface of the body. The apparatus used is an *electrocardiograph* and the tracing is an *electrocardiogram* (ECG).



The normal ECG tracing shows five waves which, by convention, have been named P,Q, R, S and T. The P wave arises when the impulse from the SA node sweeps over the atria. The QRS complex represents the very rapid spread of the impulse from the A V node through the A V bundle and the Purkinje fibres and the electrical activity of the ventricular muscle. The T wave represents the relaxation of the ventricular muscle.

The ECG described above originates from the SA node and is known as *sinus rhythm.* The rate of sinus rhythm is 60 to 100 beats per minute. A faster heart rate is called *tachycardia* and a slower heart rate, *bradycardia.*

By examining the pattern of waves and the time interval between cycles and parts of cycles, information about the state of the myocardium and the cardiac conduction system is obtained.

Cardiac Output

The cardiac output is the amount of blood ejected from the heart. The amount expelled by each contraction of the ventricles is the *stroke volume.* Cardiac output is expressed in litres per minute (1/min) and is calculated by multiplying the stroke volume by the heart rate (measured in beats per minute):

Cardiac output = Stroke volume x Heart rate

In a healthy adult at rest, the stroke volume is approximately 70ml and if the heart rate is 72 per minute, the cardiac output is 5L/minute. This can be greatly increased to meet the demands of exercise to around 25L/minute, and in athletes up to 35L/minute. This increase during exercise is called the *cardiac reserve.*

Stroke Volume

The volume of blood in the ventricles determines the stroke volume immediately before they contract, i.e. the ventricular end-diastolic volume (VEDV), sometimes called *preload.* This depends on the amount of blood returning to the heart through the superior and inferior venae cavae (the *venous return).*

Increased VEDV leads to stronger myocardial contraction, and more blood is expelled. In turn the stroke volume and cardiac output rise. This capacity to increase the stroke volume with increasing VEDV is finite, and when the limit is reached.

Other Factors That Increase Myocardial Contraction Include:

- Increased stimulation of the sympathetic nerves innervating the heart
- Hormones, e.g. adrenaline, noradrenaline, thyroxine.

Arterial Blood Pressure

This affects the stroke volume as it creates resistance to blood being pumped from the ventricles into the great arteries. This resistance (sometimes called *afterload)* is determined by the distensibility, or *elasticity,* of the large arteries and the *peripheral resistance* of arterioles.

Blood Volume

This is normally kept constant by the kidneys and if deficient the stroke volume, cardiac output and venous return decrease.

Venous Return

Venous return is the major determinant of cardiac output and, normally, the heart pumps out all blood returned to it. The force of contraction of the left ventricle ejecting blood into the aorta is not sufficient to return the blood through the veins and back to the heart. Other factors are involved.

The position of the body. Gravity assists the venous return from the head and neck when standing or sitting and offers less resistance to venous return from the lower parts of the body when an individual is lying flat.

Muscular Contraction

Valves, especially when standing, prevent this causes back flow of blood in veins of the limbs. The contraction of skeletal muscles surrounding the deep veins puts pressure on them, pushing blood towards the heart. In the lower limbs, this is called the *skeletal muscle pump.*

The Respiratory Pump

During inspiration the expansion of the chest creates a negative pressure within the thorax, assisting flow of blood towards the heart. In addition, when the diaphragm descends during inspiration, the increased intra-abdominal pressure pushes blood towards the heart.

Blood Pressure

Blood pressure is the force or pressure, which the blood exerts on the walls of the blood vessels.
The systemic arterial blood pressure, usually called simply arterial blood pressure, is the result of the discharge of blood from the left ventricle into the already full aorta.

When the left ventricle contracts and pushes blood into the aorta the pressure produced within the arterial system is called the *systolic blood pressure.* In adults it is about 120 mmHg (millimeters of mercury).

When *complete cardiac diastole* occurs and the heart is resting following the ejection of blood, the pressure within the arteries is called *diastolic blood pressure.* In an adult this is about 80mmHg. The difference between systolic and diastolic blood pressures is the *pulse pressure.*

These figures vary according to the time of day, the posture, gender and age of the individual. During bed rest at night the blood pressure tends to be lower. It increases with age and is usually higher in women than in men. Arterial blood pressure is measured with a *sphyg-momanometer.*

It Is Usually Expressed In The Following Manner:

$$BP = {}^{120}/_{70}\ mmHg$$

Pulse

The pulse is a wave of distension and elongation felt in an artery wall due to the contraction of the left ventricle forcing about 60 to 80 millilitres of blood through the already full aorta and into the arterial system.

When the aorta is distended, a wave passes along the walls of the arteries and can be felt at any point where a superficial artery can be pressed gently against a bone. The number of pulse beats per minute normally represents the heart rate and varies considerably in different people and in the same person at different times. An average of 60 to 80 is common at rest.

Information That May Be Obtained From The Pulse Includes:

- The rate at which the heart is beating.
- The regularity with which the heartbeats occur (i.e. the length of time between beats should be the same).
- The volume or strength of the beat (it should be possible to compress the artery with moderate pressure, stopping the flow of blood; the compressibility of the blood vessel gives some indication of the blood pressure and the state of the blood vessel wall).
- The tension (the artery wall should feel soft and pliant under the fingers).

Circulation Of Blood 8.2.2

Blood Vessels

The right side of the heart pumps blood to the lungs (the pulmonary circulation) where gas exchange occurs; i.e. CO_2 leaves the blood and enters the lungs, and O_2 leaves the lungs and enters the blood. The left side of the heart pumps blood into the systemic circulation, which supplies the rest of the body.

Here, tissue wastes are passed into the blood for excretion, and body cells extract nutrients and O_2.

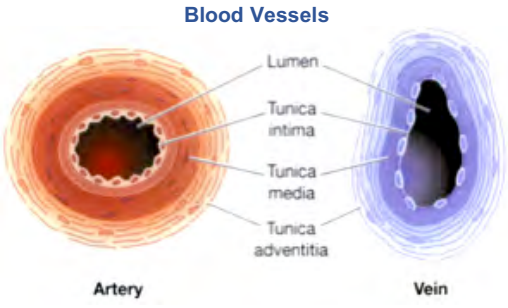
Arteries and Arterioles

These are the blood vessels that transport blood away from the heart.

They Vary Considerably In Size And Their Walls Consist Of Three Layers Of Tissue:

- *Tunica adventitia* or outer layer of fibrous tissue.
- *Tunica media* or middle layer of smooth muscle and elastic tissue.
- *Tunica intima* or inner lining of squamous epithelium called *endothelium.*

The amount of muscular and elastic tissue varies in the arteries depending upon their size. In the large arteries, sometimes called elastic arteries, the tunica media consists of more elastic tissue and less smooth muscle. These proportions gradually change as the arteries branch many times and become smaller until in the *arterioles* (the smallest arteries) the tunica media consists almost entirely of smooth muscle. Arteries have thicker walls than veins and this enables them to withstand the high pressure of arterial blood.



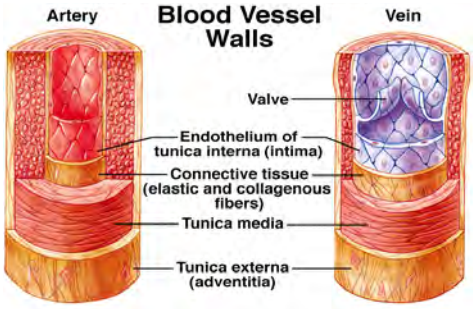
Veins and Venules

The veins are the blood vessels that return blood at low pressure to the heart. The walls of the veins are thinner than those of arteries but have the same three layers of tissue. They are thinner because there is less muscle and elastic tissue in the tunica media. When cut, the veins collapse while the thicker-walled arteries remain open.

When an artery is cut blood spurts at high pressure while a slower, steady flow of blood escapes from a vein.

Some veins possess *valves,* which prevent backflow of blood, ensuring that it flows towards the heart. Valves are abundant in the veins of the limbs, especially the lower limbs where blood must travel a considerable distance against gravity when the individual is standing.

Valves are absent in very small and very large veins in the thorax and abdomen.



They are formed by a fold of tunica intima strengthened by connective tissue. The cusps are *semilunar* in shape with the concavity towards the heart.

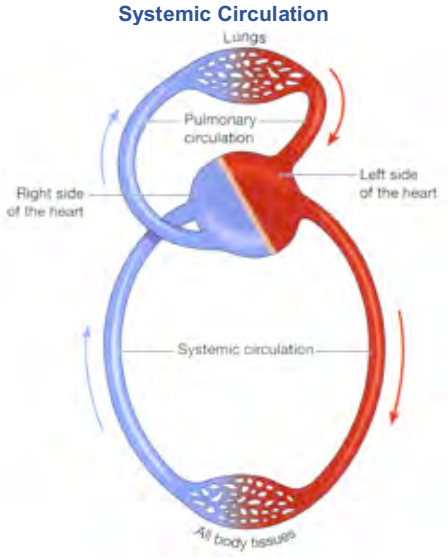
The smallest veins are called *venules.*

Systemic or General Circulation

The blood pumped out from the left ventricle is carried by the *branches of the aorta* around the body and is returned to the right atrium of the heart by the *superior* and *inferior venae cavae.*

Pulmonary Circulation

This consists of the circulation of blood from the right ventricle of the heart to the lungs and back to the left atrium. In the lungs, CO_2 is excreted and O_2 absorbed.



The pulmonary artery or trunk, carrying *deoxygenated blood,* leaves the upper part of the right ventricle of the heart. It passes upwards and divides into left and right pulmonary arteries at the level of the 5th thoracic vertebra.

The left pulmonary artery runs to the root of the left lung where it divides into two branches, one passing into each lobe.

The right pulmonary artery passes to the root of the right lung and divides into two branches. The larger branch carries blood to the middle and lower lobes, and the smaller branch to the upper lobe.

Within the lung these arteries divide and subdivide into smaller arteries, arterioles and capillaries. The inter- change of gases takes place between capillary blood and air in the alveoli of the lungs. In each lung the capillaries containing oxygenated blood join up and eventually form two veins.

Two pulmonary veins leave each lung, returning oxygenated blood to the left atrium of the heart. During atrial systole this blood passes into the left ventricle, and during ventricular systole it is forced into the aorta, the first artery of the general circulation.

Venous Circulation Of Blood To The Upper Limb

The veins of the upper limb are divided into two groups: deep and superficial veins.

The *Deep Veins* Follow The Course Of The Arteries And Have The Same Names:

- Palmar metacarpal veins
- Deep palmar venous arch
- Ulnar and radial veins
- Brachial vein
- Axillary vein
- Subclavian vein.

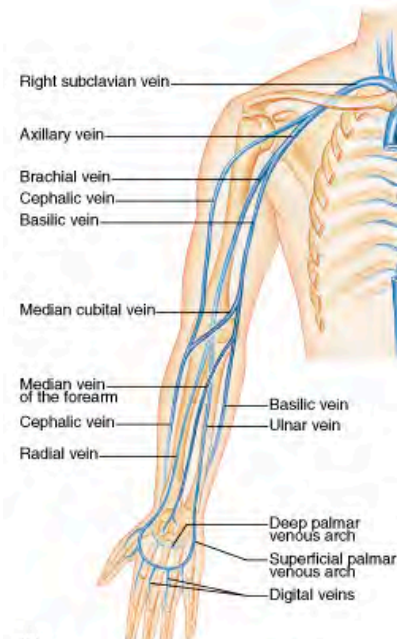
The *Superficial Veins* Begin In The Hand And Consist Of The Following:

- Cephalic vein

- Basilic vein
- Median vein
- Median cubital vein.

The *cephalic vein* begins at the back of the hand where it collects blood from a complex of superficial veins, many of which can be easily seen. It then winds round the radial side to the anterior aspect of the forearm.

Veins Of The Arm



In front of the elbow it gives off a large branch, the *median cubital vein,* which slants upwards and medially to join the *basilic vein.* After crossing the elbow joint the cephalic vein passes up the lateral aspect of the arm and in front of the shoulder joint to end in the axillary vein. Throughout its length it receives blood from the superficial tissues on the lateral aspects of the hand, forearm and arm.

The *basilic vein* begins at the back of the hand on the ulnar aspect. It ascends on the medial side of the forearm and upper arm then joins the axillary vein. It receives blood from the medial aspect of the hand, forearm and arm. There are many small veins, which link the cephalic and basilic veins.

The *median vein* is a small vein that is not always present. It begins at the palmar surface of the hand, ascends on the front of the forearm and ends in the basilic vein or the median cubital vein.

The *brachiocephalic vein* is formed when the subclavian and internal jugular veins unite. There is one on each side.

The *superior vena cava* is formed when the two brachio-cephalic veins unite. It drains all the venous blood from the head, neck and upper limbs and terminates in the right atrium. It is about 7 cm long and passes downwards along the right border of the sternum.

Blood Composition 8.2.3

The total body water in adults of average build is about 60% of body weight. This proportion is higher in young people and in adults below average weight. It is lower in the elderly and in obesity in all age groups.

About 22% of body weight is extracellular water and about 38% is intracellular water.

Extracellular Fluid

The extracellular fluid (ECF) consists of blood, plasma, lymph, cerebrospinal fluid and fluid in the interstitial spaces of the body. Interstitial or intercellular fluid (tissue fluid) bathes all the cells of the body except the outer layers of skin. It is the medium through which substances pass from blood to the body cells, and from the cells to blood. Every body cell in contact with the ECF is directly dependent upon the composition of that fluid for its wellbeing.

Fluid Distribution

Total Body Water 40 Litres	Extracellular Fluid (ECF) 12 Litres (Plasma 2.5 Litres / Interstitial Fluid 9.5 Litres)
	Intracellular Fluid 28 Litres

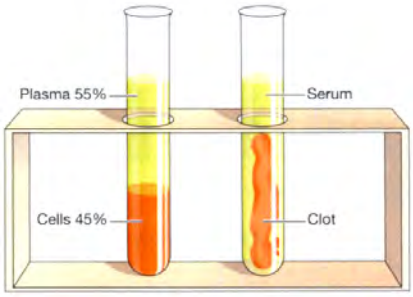
Intracellular Fluid

The composition of intracellular fluid (ICF) is largely controlled by the cell itself, because there are selective uptake and discharge mechanisms present in the cell membrane. The composition of ICF can therefore be very different from ECF. Thus, sodium levels are nearly ten times higher in the ECF than in the ICF. Conversely, many substances are found inside the cell in significantly higher amounts than outside, e.g. ATP, protein and potassium.

Blood is a connective tissue. It provides one of the means of communication between the cells of different parts of the body and the external environment.

Blood Transports:

- Oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs for excretion
- Nutrients from the gut to the tissues and cell wastes to the excretory organs, principally the kidneys.
- Hormones secreted by endocrine glands to their target glands and tissues heat produced in active tissues to other less active tissues.
- Protective substances, e.g. antibodies, to areas of infection.
- Clotting factors that coagulate blood, minimising its loss from ruptured blood vessels.



Blood makes up about 7% of body weight (about 5.6 litres in a 70 kg man). This proportion is less in women and considerably greater in children, gradually decreasing until the adult level is reached.

Blood in the blood vessels is always in motion. The continual flow maintains a fairly constant environment for the body cells.

Blood volume and the concentration of its many constituents are kept within narrow limits by homeostatic mechanisms.

Blood Composition

Blood is composed of a straw-coloured transparent fluid, *plasma,* in which different types of cells are suspended. Plasma constitutes about 55% and cells about 45% of blood volume.

Plasma

The constituents of plasma are water (90 to 92%) and dissolved substances.

These Include:

- Plasma proteins: albumins, globulins (including *antibodies),* fibrinogen, clotting factors.
- Inorganic salts (mineral salts): sodium chloride, sodium bicarbonate, potassium, magnesium, phosphate, iron, calcium, copper, iodine & cobalt.
- Nutrients, principally from digested foods, e.g. monosaccharides (mainly glucose), amino acids, fatty acids, glycerol and vitamins.
- Organic waste materials, e.g. urea, uric acid, creatinine.
- Hormones enzymes, e.g. certain clotting factors.
- Gases, e.g. oxygen, carbon dioxide, nitrogen.

Plasma Proteins

Plasma proteins, which make up about 7% of plasma, are normally retained within the blood, because they are too big to escape through the capillary pores into the tissues.

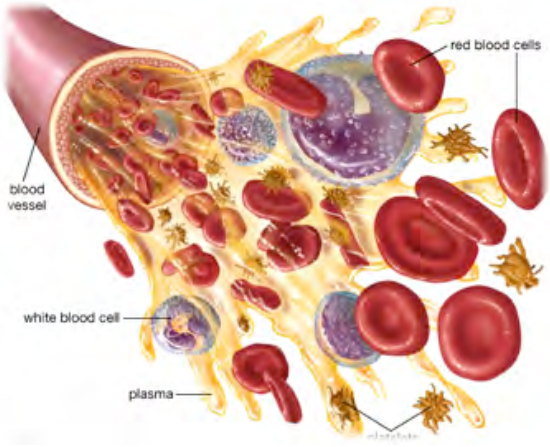
They are largely responsible for creating the osmotic pressure of blood, which keeps plasma fluid within the circulation.

If plasma protein levels fall, because of either reduced production or loss from the blood vessels, osmotic pressure is also reduced, and fluid moves into the tissues (oedema) and body cavities.

Albumins

These are formed in the liver. They are the most abundant plasma proteins and their main function is to maintain a normal plasma osmotic pressure. Albumins also act as carrier molecules for lipids and steroid hormones.

Blood Composition



Globulins

Most are formed in the liver and the remainder in lymphoid tissue.

Their Main Functions Are:

- As antibodies (immunoglobulins), which are complex proteins produced by lymphocytes that play an important part in immunity. They bind to, and neutralise, foreign materials (antigens) such as micro-organisms.
- Transportation of some hormones and mineral salts; e.g. thyroglobulin carries the hormone thyroxine and transferrin carries the mineral iron.
- Inhibition of some proteolytic enzymes.

Clotting Factors

These are substances essential for coagulation of blood. *Serum* is plasma from which clotting factors have been removed.

Fibrinogen

This is synthesised in the liver and is essential for blood coagulation.
Plasma viscosity (thickness) is due to plasma proteins, mainly albumin and fibrinogen. Viscosity is used as a measure of the body's response to some diseases.

Inorganic salts (mineral salts or Electrolytes)

The amounts of intracellular and extracellular fluids contained in a person's body are extremely important to his healthy physiology. Losses of body fluids by vomiting, diorrhea, or excessive perspiration can produce illness or even death. Whenever body fluids are lost, the substances dissolved in the fluids are also lost. Certain inorganic substances are found in the body's fluids. These are called "electrolytes." Examples of electrolytes are potassium and chloride. These electrolytes exist in their "ion" state in the body fluids.

This means that each ion can combine with one or more ions to form needed body compounds or can produce electro-chemical equilibrium (or balance). One example of this is the osmotic pressure that causes water to flow across a cell membrane. The relationship between the concentrations of sodium and potassium electrolytes in the cells and the extracellular fluid causes the water to flow into and out from the cells. There is usually a low level of sodium in the cells and a high concentration of potassium. Alkalinity and acidity are expressed in terms

of pH, which is a measure of hydrogen ion concentration, or [H^+].

The pH of blood is maintained between 7.35 and 7.45 by an ongoing complicated series of chemical activities, involving buffering systems.

The movement of electrolytes is governed by their electrical charge. Some are positively charged and are called "cations." Others are negatively charged and called "anions." Below are the major electrolytes, their chemical abbreviations, and the amount of each contained in a litre of extracellular fluid.

Sodium (Na^+) 135 – 145 mmol/L

The most abundant positive electrolyte (or cation) in the extracellular fluid and is also present in intracellular fluid. The main function of sodium is in maintaining normal osmotic pressure.

Chloride (Cl^-) 95 -110 mmol/L

The most abundant negative electrolyte (or anion) in extracellular fluid and is present in intracellular fluid as well. Chloride is essential to maintain normal osmotic pressure and is found in the stomach fluid.

Potassium (K^+) 3.5-5.0 mmol/L

Potassium is the most abundant electrolyte in the intracellular fluid. Potassium is also required for osmotic pressure but has other vital functions. Potassium is required to convert dextrose (a sugar) into body energy and is vital in transmitting electrical impulses within the heart.

Bicarbonate (HCO_3^-) 19 – 25 mmol/L

Bicarbonate helps to maintain the acid-base balance within the body.

Phosphate (PO_4) 0.5 – 1.6 mmol/L

Phosphate is required for the formation of bones, teeth, and body enzymes.

Magnesium (Mg^{++}) 0.6 – 1.0 mmol/L

Magnesium is essential for the formation of enzymes within the body.

Calcium (Ca^{++}) 2.1 – 2.8 mmol/L

Calcium is essential for the formation of bones and teeth. Calcium is needed to help in blood clotting and in maintaining the rhythm of the heartbeat.

Acid Base Ballance

For proper body functions to continue normally, this internal environment must be kept constant (homeostasis) and within a very narrow limit.

The acid-base balance of the blood is maintained by the chemical balance between the cations and the anions, which must be there in a very delicate balance. The cations are sodium (Na+), potassium (K+), calcium (Ca+) and magnesium (Mg+). The anions are chloride (Cl–), bicarbonate (HCO_3-) and phosphate (PO_4). The acid-base balance is normally expressed as the "pH." The normal range of the blood pH is 7.35 to 7.45.

The body is always slightly alkaline. The body's acid-base balance is effectively maintained under normal circumstances by the various buffer processes, which neutralize strong acids or strong bases (alkalines) using the body's various buffer systems (chemical, organic, and so forth) to help excrete excess body system products.

Nutrients

Food is digested in the alimentary tract and the resultant nutrients are absorbed, e.g. monosaccharides, amino acids, fatty acids, glycerol and vitamins. Together with mineral salts they are required by all body cells to provide energy, heat, materials for repair and replacement, and for the synthesis of other blood components and body secretions.

Organic Waste Products

Urea, creatinine and uric acid are the waste products of protein metabolism. They are formed in the liver and conveyed in blood to the kidneys for excretion. Carbon dioxide, released by all cells, is conveyed to the lungs for excretion.

Hormones

These are chemical compounds synthesised by endocrine glands. Hormones pass directly from the cells of the glands into the blood, which transports them to their target tissues and organs elsewhere in the body, where they influence cellular activity.

Gases

Oxygen (approximately 15% of the circulating volume), carbon dioxide and nitrogen are transported round the body in solution in plasma. Oxygen and carbon dioxide are also transported in combination with haemoglobin in red blood cells. Most oxygen is carried in combination with haemoglobin and most carbon dioxide as bicarbonate ions dissolved in plasma. Atmospheric nitrogen enters the body in the same way as other gases and is present in plasma but it has no physiological function.

Cellular Content of Blood

There Are Three Types Of Blood Cells:

- Erythrocytes or red cells
- Thrombocytes or platelets
- Leukocytes or white cells

All blood cells originate from *pluripotent stem cells* and go through several developmental stages before entering the blood. Different types of blood cells follow separate lines of development. The process of blood cell formation is called *haemopoiesis* and takes place within red bone marrow.

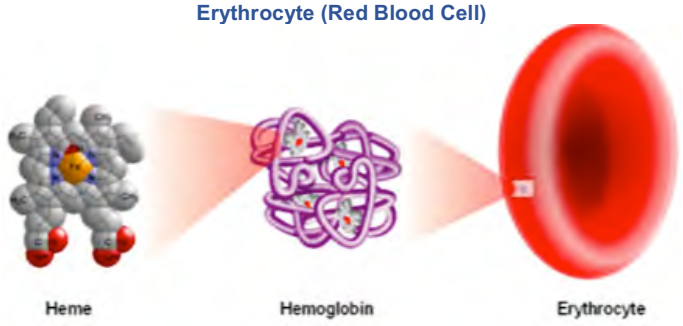
Erythrocytes (red blood cells / R.B.C.)

Red blood cells (also referred to as erythrocytes) are the most common type of blood cell and the principal means of delivering oxygen (O_2) to the body tissues via the blood flow through the circulatory system.

These cells are rich in hemoglobin, an iron-containing bio-molecule that can bind oxygen and is responsible for the blood's red color.

Mature red blood cells are flexible biconcave disks that lack a cell nucleus and most organelles. 2.4 million new erythrocytes are produced *per* second. The cells develop in the bone marrow and circulate for about 100–120 days in the body before their components are recycled by macrophages. Each circulation takes about 20 seconds. Approximately a quarter of the cells in the human body are red blood cells.

Erythrocyte (Red Blood Cell)



Packed red blood cells, which are made from whole blood with the plasma removed, are used in transfusion medicine.

Erythrocyte count (Male: 4.5 x 10^{12}/l to 6.5 x 10^{12}/l (4.5 to 6.5 million/mm^3). Female: 4.5 x 10^{12}/l to 5 x 10^{12}/l (4.5 to 5 million/mm^3))

This is the number of erythrocytes per litre or per cubic millimetre (mm^3) of blood.

Packed Cell Volume (PCV) or haematocrit (0.4 to 0.5 l/l (40 to 50/mm3))

This is the volume of red cells in 1 litre or 1 mm3 of whole blood.

Mean Cell Volume (MCV) 80 to 96 fl

This is the average volume of cells, measured in femtolitres (fl =10L-15L).

Haemoglobin Male: (13 to 18g/100ml Female: 11.5 to16.5 g/100 ml)

This is the weight of haemoglobin in whole blood, measured in grams per 100ml.

Leukocytes (white blood cells)

These cells have an important function in defending the body against microbes and other foreign materials. Leukocytes are the largest blood cells and they account for about 1% of the blood volume. They contain nuclei and some have granules in their cytoplasm. There are two main types:

- Granulocytes (polymorphonuclear leukocytes) — neutrophils, eosinophils and basophils
- Agranulocytes — monocytes and lymphocytes.

Granulocytes (polymorphonuclear leukocytes)

During their formation, *granulopoiesis,* they follow a common line of development through *myeloblast* to *myelocyte* before differentiating into the three types.

- Neutrophils
- Eosinophils
- Basophils

All granulocytes have multilobed nuclei in their cytoplasm. Their names represent the dyes they take up when stained in the laboratory. Eosinophils take up the red acid dye, eosin; basophils take up alkaline methylene blue; and neutrophils are purple because they take up both dyes.

Neutrophil (white blood cell)

Neutrophils 2.5 to 7.5 x 10^9/l

Their main function is to protect against any foreign material that gains entry to the body mainly microbes, and to remove waste materials, e.g. cell debris. They are attracted in large numbers to any area of infection by chemical substances, released by damaged cells, called *chemotaxins.* Neutrophils pass through the capillary walls in the affected area by *amoeboid movement*. Thereafter they engulf and kill the microbes by *phagocytosis*. Their granules are *lysosomes* that contain enzymes that digest the engulfed material. The pus that may form in the affected area consists of dead tissue cells, dead and live microbes, and phagocytes killed by microbes.

There is a physiological increase in circulating neutrophils following strenuous exercise and in the later stages of normal pregnancy.

Numbers Are Also Increased In:

- Microbial infection.
- Tissue damage, e.g. inflammation, myocardial infarction, burns, crush injuries.
- Metabolic disorders, e.g.diabetic ketoacidosis, acute gout.
- Leukaemia.
- Heavy smoking.
- Use of oral contraceptives.

Eosinophils 0.04 to 0.44 x 10^9/l

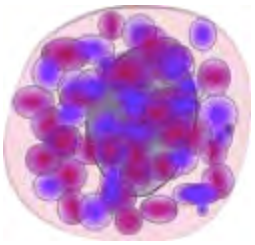
Eosinophil (white blood cell)

Eosinophils, although capable of phagocytosis, are less active in this than neutrophils; their specialised role appears to be in the elimination of parasites, such as worms, which are too big to be phagocytosed. They are equipped with certain toxic chemicals, stored in their granules, which they release when the eosinophil binds an infecting organism.

Eosinophils are often found at sites of allergic inflammation, such as the asthmatic airway and skin allergies. There, they promote tissue inflammation by releasing their array of toxic chemicals, but they may also dampen down the inflammatory process through the release of other chemicals, such as an enzyme that breaks down histamine.

Basophils 0.015 to 0.1 –x 10^9/l

Basophil (white blood cell)



Basophils, which are closely associated with allergic reactions, contain cytoplasmic granules packed with *heparin* (an anticoagulant), *histamine* (an inflammatory agent) and other substances that promote inflammation.

Usually the stimulus that causes basophils to release the contents of their granules is an *allergen* (an antigen that causes allergy) of some type. This binds to antibody-type receptors on the basophil membrane. A cell type very similar to basophils, except that it is found in the tissues, not in the circulation, is the *mast cell.* Mast cells release their granule contents within seconds of binding an allergen, which accounts for the rapid onset of allergic symptoms following exposure to, for example, pollen in hay fever.

Agranulocytes

The types of leukocyte with a large nucleus and no granules in their cytoplasm are *monocytes* and *lymphocytes* and they make up 25% to 50% of all leukocytes.

Monocytes

Monocyte (white blood cell)

These are large mononuclear cells that originate in red bone marrow. Some circulate in the blood and are actively motile and phagocytic while others migrate into the tissues where they develop into *macrophages.* Both types of cell produce *interleukin 1* which:

- Acts on the hypothalamus, causing the rise in body temperature associated with microbial infections
- Stimulates the production of some globulins by the liver
- Enhances the production of activated T-lymphocytes.

Macrophages have important functions in inflammation and immunity.
Macrophages function in close association with monocytes in the blood and with lymphocytes, which influence their activity. They are actively phagocytic and if they encounter large amounts of foreign or waste material, they tend to multiply at the site and wall off the area, isolating the material, e.g. in the lungs when foreign material has been inhaled. Their numbers are increased in microbial infections, collagen diseases and some non-infective bowel conditions.

Lymphocytes

Lymphocytes are smaller than monocytes and have large nuclei. They circulate in the blood and are present in great numbers in lymphatic tissue such as lymph nodes and the spleen. Lymphocytes develop from pluripotent stem cells in red bone marrow, then travel in the blood to lymphoid tissue elsewhere in the body where they are *activated,* i.e. they become immuno-competent which means they are able to respond to *antigens* (foreign material).

Examples Of Antigens Include:

- Cells regarded by lymphocytes as abnormal, e.g. those that have been invaded by viruses, cancer cells, tissue transplant cells.
- Pollen from flowers and plants.
- Fungi.
- Bacteria.
- Some large molecule drugs, e.g. penicillin, aspirin.

Although all lymphocytes originate from one type of stem cell, when they are activated in lymphatic tissue, two distinct types of lymphocyte are produced— *T-lymphocytes* and *B-lymphocytes.*

Thrombocytes (Platelets) 200 - 350 x 10^9/l

These are very small non-nucleated discs, 2 to 4 um in diameter, derived from the cytoplasm of megakaryocytes in red bone marrow. They contain a variety of substances that promote blood clotting, which causes *haemostasis* (cessation of bleeding).

The normal blood platelet count is between 200 000 to 350 000/mm^3. The control of platelet production is not yet entirely clear but it is believed that one stimulus is a fall in platelet count and that a substance called *thrombopoietin* is involved. The life span of platelets is between 8 and 11 days and those not used in haemostasis are destroyed by macrophages, mainly in the spleen.

Platlets

Haemostasis (Blood Clotting) 8.2.4

When a blood vessel is damaged, loss of blood is stopped and healing occurs in a series of overlapping processes, in which platelets play a vital part.

Vasoconstriction

When platelets come in contact with a damaged blood vessel, their surface becomes sticky and they adhere to the damaged wall. They then release *serotonin* (5-hydroxytryptamine), which constricts (narrows) the vessel, reducing blood flow through it. The damaged vessel itself releases other chemicals that cause vasoconstriction, e.g. thromboxanes.

Platelet Plug Formation

The adherent platelets clump to each other and release other substances, including *adenosine diphosphate* (ADP), which attract more platelets to the site. Passing platelets stick to those already at the damaged vessel and they too release their chemicals. This is a positive feedback system by which many platelets rapidly arrive at the site of vascular damage and quickly form a temporary seal the *platelet plug.*

Coagulation (blood clotting)

This is a complex process that also involves a positive feedback system and only a few stages are included here. Their numbers represent the order in which they were discovered and not the order of participation in the clotting process.

Blood clotting results in formation of an insoluble thread-like mesh of *fibrin,* which traps blood cells and is much stronger than the rapidly formed platelet plug. In the final stages of this process *prothrombin activator* acts on the plasma protein *prothrombin* converting it to thrombin.

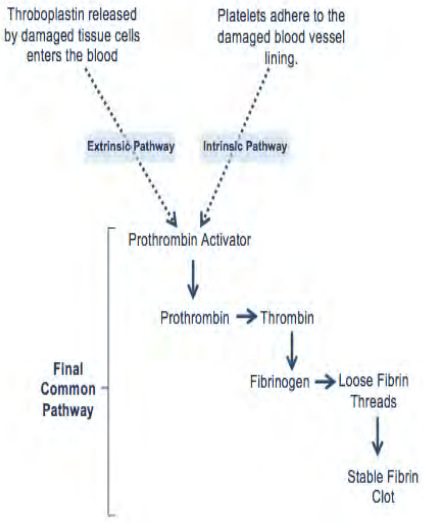
Thrombin then acts on another plasma protein *fibrinogen* and converts it to fibrin.

Two processes, which often occur together, can form prothrombin activator: the extrinsic and intrinsic pathways. The *extrinsic pathway* occurs rapidly (within seconds) when there is tissue damage outside the circulation.

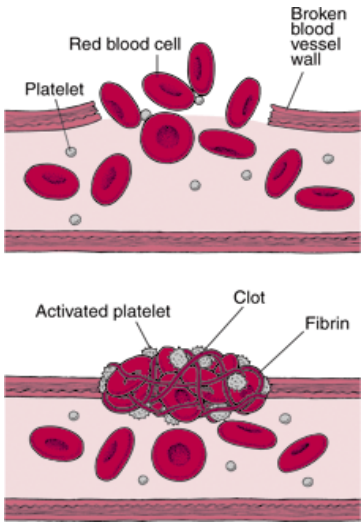
Damaged tissue releases a complex of chemicals called *thromboplastin* or tissue factor, which initiates coagulation. The *intrinsic pathway* is slower (3-6 minutes) and is confined to the circulation. It is triggered by damage to a blood vessel lining (endothelium) and the effects of platelets adhering to it.

After a time the clot shrinks, squeezing out *serum,* a clear sticky fluid that consists of plasma from which clotting factors have been removed.

Clotting Cascade



Clot Formation



Fibrinolysis

After the clot has formed the process of removing it and healing the damaged blood vessel begins. The breakdown of the clot, or fibrinolysis, is the first stage. An inactive substance called *plasminogen* is present in the clot and is converted to the enzyme *plasmin* by activators released from the damaged endothelial cells.

Plasmin initiates the breakdown of fibrin to soluble products that are treated as waste material and removed by phagocytosis.

As the clot is removed, the healing process restores the integrity of the blood vessel wall.

Control of Coagulation

The process of blood clotting relies heavily on several processes that are self-perpetuating that is,once started, a positive feedback mechanism promotes their continuation. For example, thrombin is a powerful stimulator of

its own production. The body therefore possesses several mechanisms to control and limit the coagulation cascade; otherwise once started the clotting process would spread throughout the circulatory system, far beyond requirements.

The Main Controls Are:

- The perfect smoothness of normal blood vessel lining; platelets do not adhere to this surface
- The binding of thrombin to a special thrombin receptor on the cells lining blood vessels; once bound, thrombin is inactivated.
- The presence of natural anticoagulants, e.g. heparin, in the blood, which inactivate clotting factors.

CENTRAL NERVOUS SYSTEM 8.3

The nervous system detects and responds to changes inside and outside the body. Together with the endocrine system it controls important aspects of body function and maintains homeostasis. Nervous system stimulation provides an immediate response while endocrine activity is, in the main, slower and more prolonged.

The nervous system consists of the brain, the spinal cord and peripheral nerves. Organisation of nervous tissue within the body enables rapid communication between different parts of the body.

Response to changes in the internal environment maintains homeostasis and regulates involuntary functions, e.g. blood pressure and digestive activity. Response to changes in the external environment maintains posture and other voluntary activities.

For Descriptive Purposes The Parts Of The Nervous System Are Grouped As Follows:

- *The central nervous system* (CNS), consisting of the brain and the spinal cord
- *The peripheral nervous system* (PNS) consisting of all the nerves outside the brain and spinal cord.

The PNS comprises paired cranial and sacral nerves, some of these are sensory (afferent), some are motor (efferent) and some mixed.

It Is Useful To Consider Two Functional Parts Within The PNS:

- The sensory division
- The motor division

Nerves 8.3.1

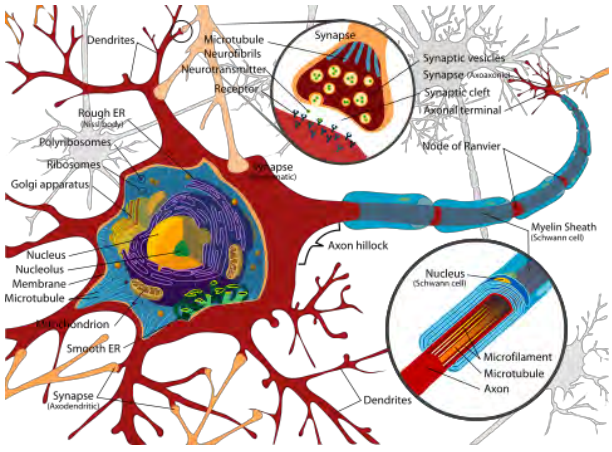
Neurones

The nervous system consists of a vast number of cells called *neurones*, supported by a special type of connective tissue, *neuroglia.* Each neurone consists of a *cell body* and its processes, one *axon* and many *dendrites.* Neurones are commonly referred to simply as nerve cells. Bundles of axons bound together are called *nerves.* Neurones cannot divide and for survival they need a continuous supply of oxygen and glucose. Unlike many other cells, neurones can synthesise chemical energy (ATP) only from glucose.

The physiological 'units' of the nervous system are *nerve impulses,* or *action potentials,* which are akin to tiny electrical charges. However, unlike ordinary electrical wires, the neurones are actively involved in conducting nerve impulses. In effect the strength of the impulse is maintained throughout the length of the neurone.

Some neurones initiate nerve impulses while others act as 'relay stations' where impulses are passed on and sometimes redirected.

Neurone



Properties of Neurones

Neurones have the characteristics of *irritability* and *conductivity.*

Irritability is the ability to initiate nerve impulses in response to stimuli from:

- Outside the body, e.g. touch, light waves
- Inside the body, e.g. a change in the concentration of carbon dioxide in the blood alters respiration; a thought may result in voluntary movement.

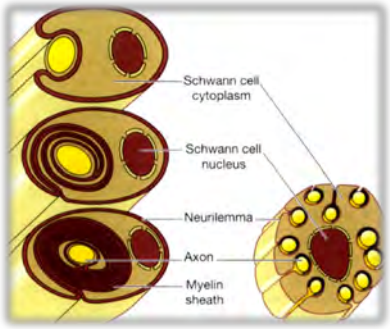
In the body this stimulation may be described as partly electrical and partly chemical-electrical in that motor neurones and sensory nerve endings initiate nerve impulses, and chemical in the transmission of impulses between one neurone and the next or between a neurone and an effector organ.

Conductivity means the ability to transmit an impulse.

Cell Bodies

Nerve cells vary considerably in size and shape but they are all too small to be seen by the naked eye.

Cell bodies form the *grey matter* of the nervous system and are found at the periphery of the brain and in the centre of the spinal cord. Groups of cell bodies are called *nuclei* in the central nervous system and *ganglia* in the peripheral nervous system.



Axons and Dendrites

Axons and dendrites are extensions of cell bodies and form the *white matter* of the nervous system. Axons are found deep in the brain and in groups, called *tracts,* at the periphery of the spinal cord. They are referred to as *nerves* or *nerve fibres* outside the brain and spinal cord.

Axons

Each nerve cell has only one axon, carrying nerve impulses away from the cell body. They are usually longer than the dendrites, sometimes as long as 100cm.

Structure of an Axon

The membrane of the axon is called *axolemma* and it encloses the cytoplasmic extension of the cell body.

Large axons and those of peripheral nerves are surrounded by a *myelin sheath*. This consists of a series of *Schwann cells* arranged along the length of the axon. Each one is wrapped around the axon so that it is covered by a number of concentric layers of Schwann cell plasma membrane.

Between the layers of plasma membrane there is a small amount of fatty substance called *myelin.* The outermost layer of Schwann cell plasma membrane is sometimes called *neurilemma.* There are tiny areas of exposed axolemma between adjacent Schwann cells, called *nodes of Ranvier,* which assist the rapid transmission of nerve impulses.

Postganglionic fibres and some small fibres in the central nervous system are *non-myelinated.* In this type a number of axons are embedded in Schwann cell plasma membranes. The adjacent Schwann cells are in close association and there is no exposed axolemma. The speed of transmission of nerve impulses is significantly slower in non-myelinated fibres.

Dendrites

The dendrites are the many short processes that receive and carry incoming impulses towards cell bodies.

They have the same structure as axons but they are usually shorter and branching. In motor neurones they form part of synapses and in sensory neurones they form the sensory receptors that respond to stimuli.

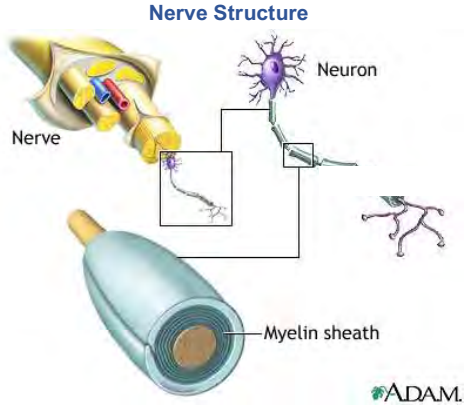
The Nerve Impulse (action potential)

An impulse is initiated by stimulation of sensory nerve endings or by the passage of an impulse from another nerve. Transmission of the impulse, or action potential, is due to movement of ions across the nerve cell membrane. In the resting state the nerve cell membrane is *polarised* due to differences in the concentrations of ions across the plasma membrane.

This means that there is a different electrical charge on each side of the membrane that is called the *resting membrane potential.* At rest the charge on the outside is positive and inside it is negative.

The Principal Ions Involved Are:

- Sodium (Na^+) the main extracellular cation
- Potassium (K^+) the main intracellular cation.



In the *resting state* there is a continual tendency for these ions to diffuse along their concentration gradients, i.e. K^+ outwards and Na^+ into cells. When stimulated, the permeability of the nerve cell membrane to these ions changes. Initially Na^+ floods into the neurone from the ECF causing *depolarisation,* creating a *nerve impulse* or *action potential.*

Depolarisation is very rapid, enabling the conduction of a nerve impulse along the entire length of a neurone in a few milliseconds (ms). It passes from the point of stimulation in one direction only, i.e. away from the point of stimulation towards the area of resting potential.

During this process K^+ floods out of the neurone and the movement of these ions returns the membrane potential to its resting state. This is called the *refractory period* during which restimulation is not possible. As the neurone returns to its original resting state, the action of the *sodium pump* expels Na^+ from the cell in exchange for K^+.

In myelinated neurones, the insulating properties of the myelin sheath prevent the movement of ions. Therefore electrical changes across the membrane can only occur at the gaps in the myelin sheath, i.e. at the nodes of Ranvier. When an impulse occurs at one node, depolarisation passes along the myelin sheath to the next node so that the flow of current appears to 'leap' from one node to the next. This is called *saltatory conduction*.

The speed of conduction depends on the diameter of the neurone: the larger the diameter, the faster the conduction. Myelinated fibres conduct impulses faster than unmyelinated fibres because saltatory conduction is faster than the complete conduction, or *simple propagation*.

The fastest fibres can conduct impulses to, e.g., skeletal muscles at a rate of 130 metres per second while the

slowest impulses travel at 0.5 metres per second.

Types of Nerves

Sensory or Afferent Nerves

When action potentials are generated by sensory receptors on the dendrites of these neurones, they are transmitted to the spinal cord by the sensory nerve fibres. The impulses may then pass to the brain or to connector neurones of reflex arcs in the spinal cord.

Sensory Receptors

Specialised endings of sensory neurones respond to different stimuli (changes) inside and outside the body. *Somatic, cutaneous* or *common senses.*

These originate in the skin. They are: pain, touch, heat and cold. Sensory nerve endings in the skin are fine branching filaments without myelin sheaths.

When stimulated, an impulse is generated and transmitted by the sensory nerves to the brain where the sensation is perceived.

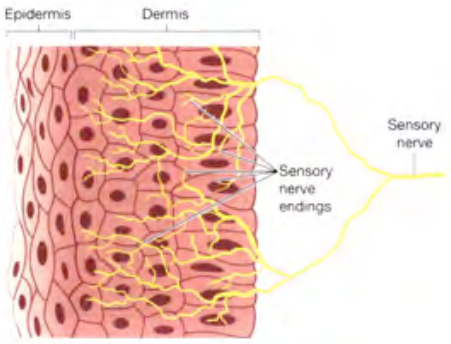
Proprioceptor Senses

These originate in muscles and joints and contribute to the maintenance of balance and posture.
Special senses. These are sight, hearing, smell, touch and taste.

Autonomic Afferent Nerves

These originate in internal organs, glands and tissues, e.g. baroreceptors, chemoreceptors, and are associated with reflex regulation of involuntary activity and visceral pain.

Sensory Nerve



Motor or Efferent Nerves

Motor nerves originate in the brain, spinal cord and autonomic ganglia. They transmit impulses to the effector organs: muscles and glands.

There Are Two Types:

- *Somatic nerves* - Voluntary and reflex skeletal muscle contraction.
- *Autonomic nerves* (sympathetic and parasympathetic) - involved in cardiac and smooth muscle contraction and glandular secretion.

Mixed Nerves

In the spinal cord, sensory and motor nerves are arranged in separate groups, or *tracts.*

Outside the spinal cord, when sensory and motor nerves are within the same sheath of connective tissue they are called *mixed nerves.*

The Synapse And Neurotransmitters

There is always more than one neurone involved in the transmission of a nerve impulse from its origin to its destination, whether it is sensory or motor. There is no physical contact between these neurones. The point at which the nerve impulse passes from one to another is the *synapse.* At its free end the axon of the *presynaptic neurone* breaks up into minute branches, which terminate in small swellings called *synaptic knobs,* or terminal boutons. These are in close proximity to the dendrites and the cell body of the *postsynaptic neurone.*

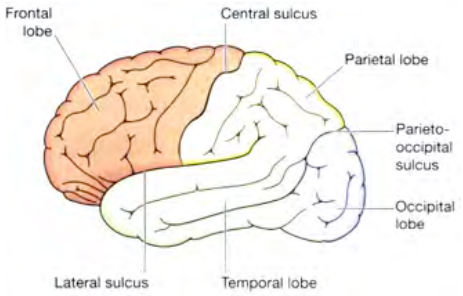
The space between them is the *synaptic cleft.* In the ends of synaptic knobs there are spherical *synaptic vesicles,* containing a chemical, the *neurotransmitter,* which is released into synaptic clefts. Neurotransmitters are synthesised by nerve cells, actively transported along the axons and stored in the synaptic vesicles.

They are released by exocytosis in response to the action potential and diffuse across the synaptic cleft. They act on specific receptor sites on the postsynaptic membranes. Their action is short lived as immediately they have stimulated the post-synaptic neurone or effector organ, such as a muscle fibre; they are either inactivated by enzymes or taken back into the synaptic knob.

The Brain 8.3.2

The brain constitutes about one-fiftieth of the body weight and lies within the cranial cavity.

The Brain



The Parts Are:

- Cerebrum
- Midbrain (the brain stem)
- Pons (the brain stem)
- Medulla oblongata (the brain stem)
- Cerebellum

Blood Supply To The Brain

The circulus arteriosus and its contributing arteries play a vital role in maintaining a constant supply of oxygen and glucose to the brain even when a contributing artery is narrowed or the head is moved. The brain receives about 15% of the cardiac output, approximately 750ml of blood per minute.

Autoregulation keeps blood flow to the brain constant by adjusting the diameter of the arterioles across a wide range of arterial blood pressure (about 65-140 mmHg) with changes occurring only outside these limits.

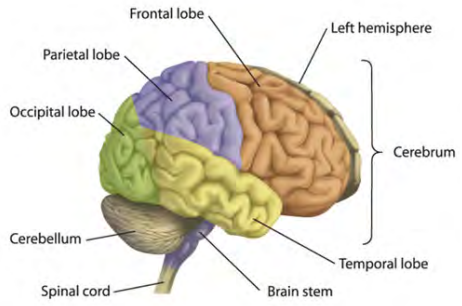
Cerebrum

This is the largest part of the brain and it occupies the anterior and middle cranial fossae. It is divided by a deep cleft, the *longitudinal cerebral fissure,* into *right* and *left cerebral hemispheres,* each containing one of the lateral ventricles. Deep within the brain the hemispheres are connected by a mass of white matter (nerve fibres) called the *corpus callosum.* The falx cerebri is formed by the dura mater. It separates the two hemispheres and penetrates to the depth of the corpus callosum. The superficial (peripheral) part of the cerebrum is composed of nerve cell bodies or grey matter, forming the *cerebral cortex,* and the deeper layers consist of nerve fibres or white matter.

The cerebral cortex shows many infoldings or furrows of varying depth. The exposed areas of the folds are the *gyri* or *convolutions* and these are separated by *sulci* or *fissures.* These convolutions greatly increase the surface area of the cerebrum.

Each hemisphere of the cerebrum is divided into *lobes,* which take the names of the bones of the cranium under which they lie.

The Brain



They Are:

- Frontal
- Parietal
- Temporal
- Occipital.

Interior of the Cerebrum

The surface of the cerebral cortex is composed of grey matter (nerve cell bodies). Within the cerebrum the lobes are connected by masses of nerve fibres, or tracts, which make up the white matter of the brain.

Functions of the Cerebrum

There are three main varieties of activity associated with the cerebral cortex:

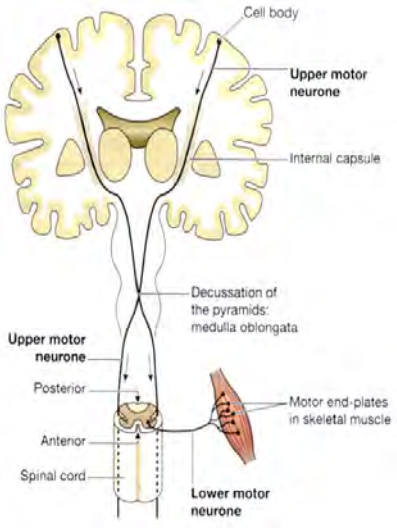
- Mental activities involved in memory, intelligence, sense of responsibility, thinking, reasoning, moral sense and learning are attributed to the *higher centres*
- Sensory perception, including the perception of pain, temperature, touch, sight, hearing, taste and smell
- Initiation and control of skeletal (voluntary) muscle contraction.

Functional Areas of the Cerebrum

The main areas of the cerebrum associated with sensory perception and voluntary motor activity are known but it is unlikely that any area is associated exclusively with only one function. Except where specially mentioned, the different areas are active in both hemispheres.

The Precentral (motor) Area

This lies in the frontal lobe immediately anterior to the *central sulcus.* The cell bodies are pyramid shaped (Betz's cells) and they initiate the contraction of skeletal muscles. A nerve fibre from a Betz's cell passes downwards through the internal capsule to the medulla oblongata where it crosses to the opposite side then descends in the spinal cord. At the appropriate level in the spinal cord the nerve impulse crosses a synapse to stimulate a second neurone, which terminates at the motor endplate of a muscle fibre. This means that the motor area of the *right hemisphere* of the cerebrum controls voluntary muscle movement on the left side of the body and vice versa. The neurone with its cell body in the cerebrum is the *upper motor neurone* and the other, with its cell body in the spinal cord, is the *lower motor neurone*. Damage to either of these neurones may result in paralysis.



In the motor area of the cerebrum the body is represented upside down, i.e. the cells nearest the vertex control the feet and those in the lowest part control the head, neck, face and fingers. The sizes of the areas of cortex representing different parts of the body are proportional to the *complexity of movement* of the body part, not to its size.

The Premotor Area

This lies in the frontal lobe immediately anterior to the motor area. The cells are thought to exert a controlling influence over the motor area, ensuring an orderly series of movements. For example, in tying a shoe lace or writing, many muscles contract but the movements must be coordinated and carried out in a particular sequence. Such a pattern of movement, when established, is described as *manual dexterity.*

In the lower part of this area just above the lateral sulcus there is a group of nerve cells known as the *motor*

speech (Broca's) area, which controls the movements necessary for speech. It is dominant in the *left hemisphere* in *right-handed people* and vice versa.

The Frontal Area

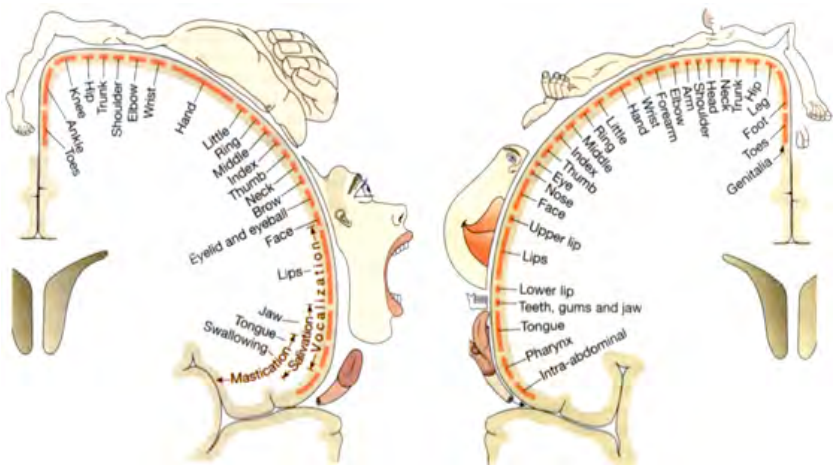
This extends anteriorly from the premotor area to include the remainder of the frontal lobe. It is a large area and is more highly developed in humans than in other animals. It is thought that communications between this and the other regions in the cerebrum are responsible for the behaviour, character and emotional state of the individual. No particular behaviour, character or intellectual trait has, so far, been attributed to the activity of any one group of cells.

The Postcentral (sensory) Area

This is the area behind the central sulcus. Here sensations of pain, temperature, pressure and touch, knowledge of muscular movement and the position of joints are perceived.

The sensory area of the *right hemisphere* receives impulses from the *left side of the body* and vice versa. The size of the areas representing different parts of the body is proportional to the *extent of sensory innervation,* e.g. the large area for the face is consistent with the extensive sensory nerve supply by the three branches of the trigeminal nerves (5th cranial nerves).

Sensory Centres



The Parietal Area

This lies behind the postcentral area and includes the greater part of the parietal lobe of the cerebrum. Its functions are believed to be associated with obtaining and retaining accurate knowledge of objects.

It has been suggested that objects can be recognised by touch alone because of the knowledge from past experience (memory) retained in this area.

The Sensory Speech Area

Situated in the lower part of the parietal lobe and extends into the temporal lobe. It is here that the spoken word is perceived. There is a dominant area in the *left hemisphere* in *right-handed* people and vice versa.

The Auditory (hearing) Area

This lies immediately below the lateral sulcus within the temporal lobe. The cells receive and interpret impulses transmitted from the inner ear by the cochlear (auditory) part of the vestibulo-cochlear nerves (8th cranial nerves).

The Olfactory (smell) Area

This lies deep within the temporal lobe where impulses from the nose via the olfactory nerves (1st cranial nerves) are received and interpreted.

The Taste Area

This is thought to lie just above the lateral sulcus in the deep layers of the sensory area. This is the area where impulses from special nerve endings in taste buds in the tongue and in the lining of the cheeks, palate and pharynx are perceived as taste.

The Visual Area

This lies behind the parieto-occipital sulcus and includes the greater part of the occipital lobe. The optic nerves (2nd cranial nerves) pass from the eye to this area, which receives and interprets the impulses as visual impressions.

Other Areas Of The Cerebrum

Deep within the cerebral hemispheres there are groups of cell bodies called *nuclei* (previously called ganglia), which act as relay stations where impulses are passed from one neurone to the next in a chain.

Important Masses Of Grey Matter Include:

- Basal nuclei
- Thalamus
- Hypothalamus.

Basal Nuclei

These are areas of grey matter, lying deep within the cerebral hemispheres, with connections to the cerebral cortex and thalamus. The basal nuclei form part of the extrapyramidal tracts and are thought to be involved in initiating muscle tone in slow and coordinated activities. If control is inadequate or absent, movements are jerky,

clumsy and uncoordinated.

Thalamus

The thalamus consists of two masses of nerve cells and fibres situated within the cerebral hemispheres just below the corpus callosum, one on each side of the third ventricle. Sensory input from the skin, viscera and special sense organs is transmitted to the thalamus before redistribution to the cerebrum.

Hypothalamus

The hypothalamus is composed of a number of groups of nerve cells. It is situated below and in front of the thalamus, immediately above the *pituitary gland.* The hypothalamus is linked to the posterior lobe of the pituitary gland by nerve fibres and to the anterior lobe by a complex system of blood vessels. Through these connections, the hypothalamus controls the output of hormones from both lobes of the gland.

Other Functions With Which The Hypothalamus Is Concerned Include Control Of:

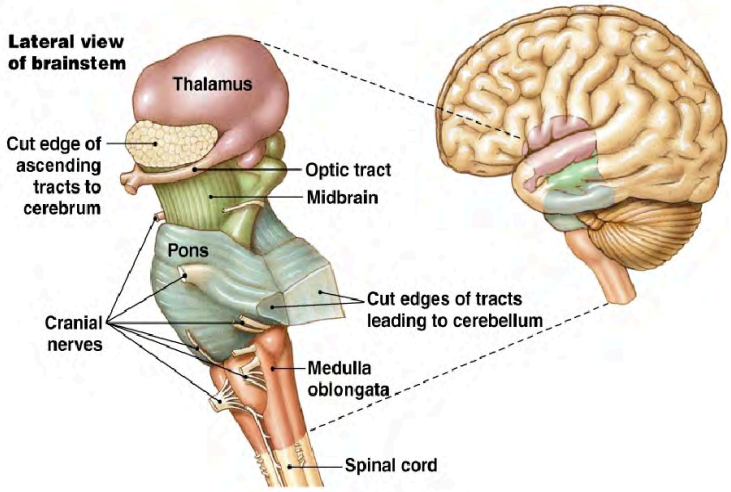
- The autonomic nervous system.
- Appetite and satiety.
- Thirst and water balance.
- Body temperature.
- Emotional reactions, (e.g. pleasure, fear, rage).
- Sexual behaviour (including mating and child rearing).
- Biological clocks or circadian rhythms, (e.g. sleeping and waking cycles, temperature and secretion of some hormones).

Brain Stem

Midbrain

The midbrain is the area of the brain situated around the cerebral aqueduct between the cerebrum above and the *pons* below. It consists of groups of cell bodies and nerve fibres (tracts), which connect the cerebrum with lower parts of the brain and with the spinal cord. The cell bodies act as relay stations for the ascending and descending nerve fibres.

The Brain Stem



Pons

The pons is situated in front of the cerebellum, below the midbrain and above the medulla oblongata. It consists mainly of nerve fibres, which form a bridge between the two hemispheres of the cerebellum, and of fibres passing between the higher levels of the brain and the spinal cord. There are groups of cells within the pons which act as relay stations and some of these are associated with the cranial nerves.

Medulla Oblongata

The medulla oblongata extends from the pons above and is continuous with the spinal cord below. It is about 2.5 cm long and it lies just within the cranium above the foramen magnum. Central fissures mark its anterior and posterior surfaces. The outer aspect is composed of *white matter,* which passes between the brain and the spinal cord, and *grey matter* lies centrally. Some cells constitute relay stations for sensory nerves passing from the spinal cord to the cerebrum.

The vital centres, consisting of groups of cells associated with autonomic reflex activity, lie in its deeper structure.

These Are The:

- Cardiac centre
- Respiratory centre
- Vasomotor centre
- Reflex centres of vomiting, coughing, sneezing and swallowing.

The Medulla Oblongata Has Several Special Features:

- *Decussation (crossing) of the pyramids.* In the medulla *motor nerves* descending from the motor area in the cerebrum to the spinal cord in the pyramidal (corticospinal) tracts cross from one side to the other. This means that the left hemisphere of the cerebrum controls the right half of the body, and vice versa. These tracts are the main pathways for impulses to skeletal (voluntary) muscles.
- *Sensory decussation.* Some of the *sensory nerves* ascending to the cerebrum from the spinal cord cross from one side to the other in the medulla. Others decussate at lower levels, i.e. in the spinal cord.
- *The cardiovascular centre* controls the rate and force of cardiac contraction. Sympathetic and

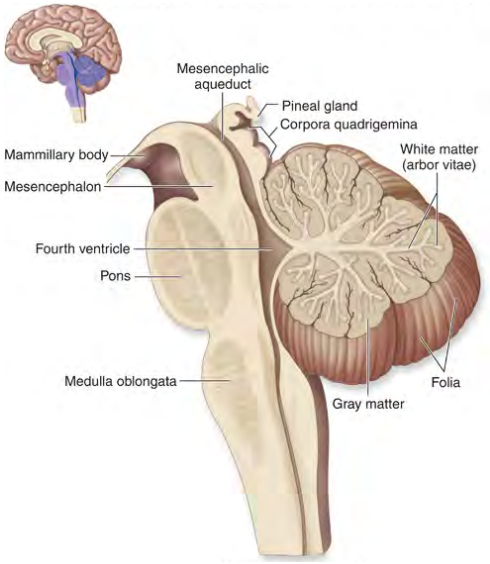
parasympathetic nerve fibres originating in the medulla pass to the heart. Sympathetic stimulation increases the rate and force of the heartbeat and parasympathetic stimulation has the opposite effect.

- *The respiratory centre* controls the rate and depth of respiration. From this centre, nerve impulses pass to the phrenic and intercostal nerves, which stimulate contraction of the diaphragm and intercostal muscles, thus initiating inspiration. The respiratory centre is stimulated by excess carbon dioxide and, to a lesser extent, by deficiency of oxygen in its blood supply and by nerve impulses from the chemoreceptors in the carotid bodies.
- *The vasomotor centre* controls the diameter of the blood vessels, especially the small arteries and arterioles, which have a large proportion of smooth muscle fibres in their walls. Vasomotor impulses reach the blood vessels through the autonomic nervous system. Stimulation may cause either constriction or dilatation of blood vessels depending on the site.
- The sources of stimulation of the vasomotor centre are the arterial baroreceptors, body temperature and emotions such as sexual excitement and anger. Pain usually causes vasoconstriction although severe pain may cause vasodilatation, a fall in blood pressure and fainting.
- *Reflex centres.* When irritating substances are present in the stomach or respiratory tract, nerve impulses pass to the medulla oblongata, stimulating the reflex centres, which initiate the reflex actions of vomiting, coughing and sneezing to expel the irritant.

Reticular Formation

The reticular formation is a collection of neurones in the core of the brain stem, surrounded by neural pathways, which conduct ascending and descending nerve impulses between the brain and the spinal cord. It has a vast number of synaptic links with other parts of the brain and is therefore constantly receiving 'information' being transmitted in ascending and descending tracts.

The Cerebellum



The Reticular Formation Is Involved In:

- Coordination of skeletal muscle activity associated with voluntary motor movement and the maintenance of balance.
- Coordination of activity controlled by the autonomic nervous system, e.g. cardiovascular, respiratory and gastrointestinal activity.
- Selective awareness that functions through the *reticular activating system* (RAS), which selectively blocks or passes sensory information to the cerebral cortex, (e.g. the slight sound made by a sick child moving in bed may arouse his mother but the noise of regularly passing trains may be suppressed).

Cerebellum

The cerebellum is situated behind the pons and immediately below the posterior portion of the cerebrum occupying the posterior cranial fossa. It is ovoid in shape and has two hemispheres, separated by a narrow median strip called the *vermis.* Grey matter forms the surface of the cerebellum, and the white matter lies deeply.

The cerebellum is concerned with the coordination of voluntary muscular movement, posture and balance. Cerebellar activities are not under voluntary control. The cerebellum controls and coordinates the movements of various groups of muscles ensuring smooth, even, precise actions. It coordinates activities associated with the *maintenance of the balance and equilibrium* of the body.

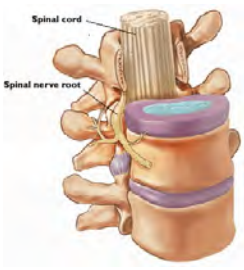
The sensory input for these functions is derived from the muscles and joints, the eyes and the ears. *Proprioceptor impulses* from the muscles and joints indicate their position in relation to the body as a whole and those impulses from the eyes and the semicircular canals in the ears pro- vide information about the position of the head in space. Impulses from the cerebellum influence the contraction of skeletal muscle so that balance and posture are maintained.

Damage to the cerebellum results in clumsy uncoordinated muscular movement, staggering gait and inability to carry out smooth, steady, precise movements.

The Spinal Cord 8.3.3

The spinal cord is the elongated, almost cylindrical part of the central nervous system, which is suspended in the vertebral canal surrounded by the meninges and cerebroespinal fluid. It is continuous above with the medulla oblongata and extends from the *upper border of the atlas* to the lower border of the 1st *lumbar vertebra*. It is approximately 45 cm long, and is about the thickness of the little finger.

The Verterbrae



Except for the cranial nerves, the spinal cord is the nervous tissue link between the brain and the rest of the body.

Nerves conveying impulses from the brain to the various organs and tissues descend through the spinal cord. At the appropriate level they leave the cord and pass to the structure they supply. Similarly, sensory nerves from organs and tissues enter and pass upwards in

the spinal cord to the brain.

Some activities of the spinal cord are independent of the brain, i.e. *spinal reflexes.* To facilitate these there are extensive neurone connections between sensory and motor neurones at the same or different levels in the cord.

The spinal cord is incompletely divided into two equal parts, anteriorly by a short, shallow *median fissure* and posteriorly by a deep narrow septum, the *posteriormedian septum.*

A cross-section of the spinal cord shows that it is composed of grey matter in the centre surrounded by white matter supported by neuroglia.
The other side is the same.

Grey Matter

The arrangement of grey matter in the spinal cord resembles the shape of the letter H, having *two posterior, two anterior* and *two lateral columns.*

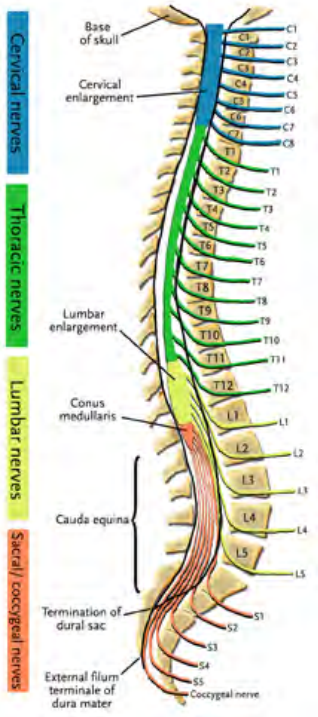
The area of grey matter lying transversely is the *transverse commissure* and the central canal, an extension from the fourth ventricle, containing cerebrospinal fluid, pierces it.

The Cell Bodies May Be:

- *Sensory cells,* which receive impulses from the periphery of the body
- *Lower motor neurones,* which transmit impulses to the skeletal muscles
- *Connector neurones,* linking sensory and motor neurones, at the same or different levels, which form spinal reflex arcs.

At each point where nerve impulses are passed from one neurone to another there is a synaptic cleft and a neurotransmitter.

The Spinal Cord



Posterior Columns Of Grey Matter

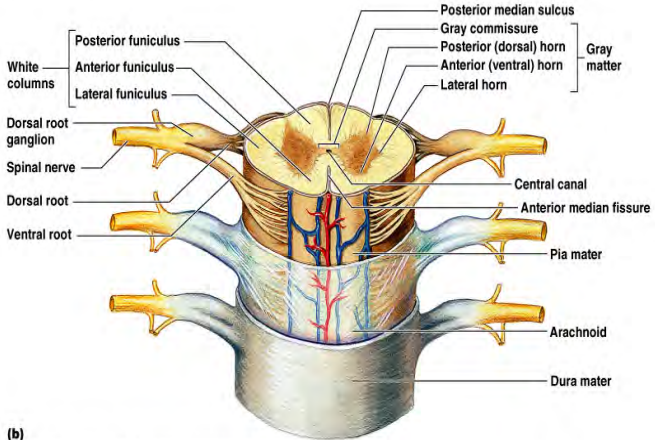
These are composed of cell bodies, which are stimulated by *sensory impulses* from the periphery of the body. The nerve fibres of these cells contribute to the formation of the white matter of the cord and transmit the sensory impulses upwards to the brain.

Anterior Columns Of Grey Matter

These are composed of the *cell bodies of the lower motor neurons,* which are stimulated by the axons of the upper motor neurones or by the *cell bodies of connector neurones* linking the anterior and posterior columns to form reflex arcs.

The posterior root (spinal) ganglia are composed of cell bodies, which lie just outside the spinal cord on the path-way of the sensory nerves. All sensory nerve fibres pass through these ganglia. The only function of the cells is to promote the onward movement of nerve impulses.

The Spinal Cord



White Matter

The white matter of the spinal cord is arranged in three *columns* or *tracts;* anterior, posterior and lateral. These tracts are formed by *sensory nervefibres* ascending to the brain, *motor nerve fibres* descending from the brain and fibres of *connector neurones.*
Tracts are often named according to their points of origin and destination, e.g. spinothalamic, corticospinal.

Sensory Nerve Tracts (Afferent Or Ascending) In The Spinal Cord

There are two main sources of sensation transmitted to the brain via the spinal cord.

The Skin

Sensory receptors (nerve endings) in the skin, called *cutaneous receptors,* are stimulated by pain, heat, cold and touch, including pressure. Nerve impulses generated are conducted by three neurones to the sensory area in the *opposite hemisphere of the cerebrum* where the sensation and its location are perceived. Crossing to the other side, or *decussation,* occurs either at the level of entry into the cord or in the medulla.

The Tendons, Muscles and Joints

Sensory receptors are nerve endings in these structures, called *proprioceptors,* and they are stimulated by stretch. Together with impulses from the eyes and the ears they are associated with the maintenance of balance and posture and with perception of the position of the body in space.

These Nerve Impulses Have Two Destinations:

- By a three-neurone system the impulses reach the sensory area of the *opposite hemisphere of the cerebrum*

- By a two-neurone system the nerve impulses reach the *cerebellar hemisphere on the same side.*

Motor Nerve Tracts (Efferent Or Descending) In The Spinal Cord

Neurones, which transmit nerve impulses away from the brain, are motor (efferent or descending) neurones.

Motor Neurone Stimulation Results In:

- Contraction of skeletal (striated, voluntary) muscle.
- Contraction of smooth (involuntary) muscle, cardiac muscle and the secretion by glands controlled by the *autonomic nervous system*.

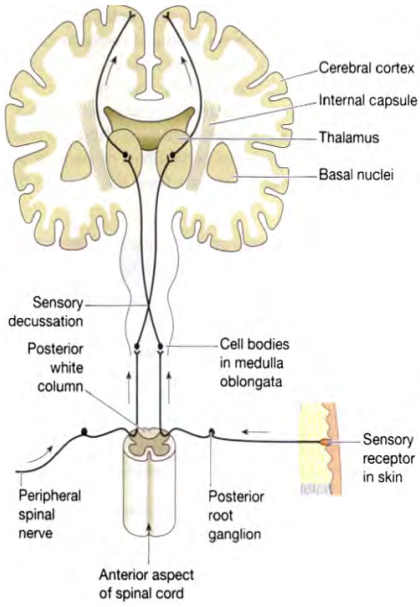
Voluntary Muscle Movement

The contraction of the muscles, which move the joints, is, in the main, under conscious (voluntary) control, which means that the stimulus to contract originates at the level of consciousness in the cerebrum.

However, some nerve impulses, which affect skeletal muscle contraction, are initiated in the midbrain, brain stem and cerebellum. This involuntary activity is associated with coordination of muscle activity, e.g. when very fine movement is required and in the maintenance of posture and balance.

Efferent nerve impulses are transmitted from the brain to the body via bundles of nerve fibres or *tracts* in the spinal cord.

The *motor pathways* from the brain to the muscles are made up of two *neurones*.



These Tracts Are Either:

- Pyramidal (corticospinal).
- Extrapyramidal.

The motor fibres that form the pyramidal tracts travel through the internal capsule and are the main pathway for impulses to voluntary (skeletal) muscles. Those motor fibres that do not pass through the internal capsule form the extrapyramidal tracts and have connections with multiple parts of the brain (including the basal nuclei and the thalamus).

The Upper Motor Neurone

This has its cell body (Betz's cell) in the *precentral sulcus area* of the cerebrum. The axons pass through the internal capsule, pons and medulla. In the spinal cord they form the *lateral corti-cospinal tracts* of white matter and the fibres terminate in close association with the cell bodies of the *lower motor neurones* in the anterior columns of grey matter.

The axons of these upper motor neurones make up the pyramidal tracts and decussate in the medulla oblongata, forming the pyramids.

The Lower Motor Neurone

This has its cell body in the *anterior horn of grey matter* in the spinal cord. Its axon emerges from the spinal cord by the *anterior root,* joins with the incoming sensory fibres and forms the *mixed spinal nerve* which passes through the *intervertebral foramen.* Near its termination in muscle the axon branches into a variable number of tiny fibres, which form *motor endplates,* each of which is in close association with a sensitive area on the wall of a muscle fibre. The motor endplates of each nerve and the muscle fibres they supply form a *motor unit*.

The neurotransmitter that conveys the nerve impulse across the synapse to stimulate the muscle fibre is *acetylcholine.* Motor units contract as a whole and the strength of contraction of a muscle depends on the number of motor units in action at a time.

The lower motor neurone has been described as the *final common pathway* for the transmission of nerve impulses to skeletal muscles. The cell body of this neurone is influenced by a number of upper motor neurones originating from various sites in the brain and by some neurons, which begin and end in the spinal cord.

Some of these neurones stimulate the cell bodies of the lower motor neurone while others have an inhibiting effect. The outcome of these influences is smooth, coordinated muscle movement, some of which is voluntary and some involuntary.

Involuntary Muscle Movement

Upper Motor Neurones.

These have their cell bodies in the brain at a level *below* the cerebrum, i.e. in the midbrain, brain stem, cerebellum or spinal cord. They influence muscle activity in relation to the maintenance of posture and balance, the coordination of muscle movement and the control of muscle tone.

Spinal Reflexes

These Consist Of Three Elements:

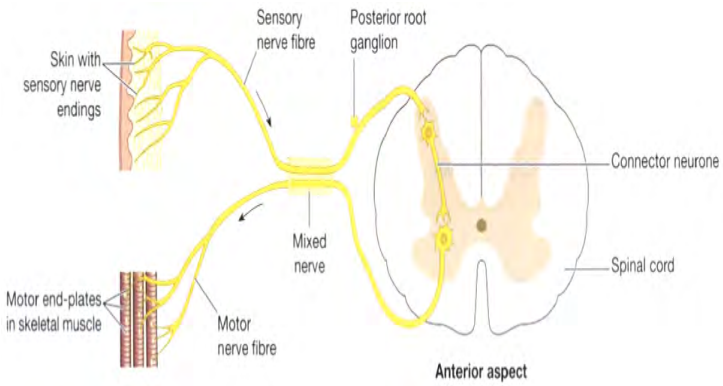
- Sensory neurons.
- Connector neurones in the spinal cord.

- Lower motor neurones.

In the simplest *reflex arc* there is only one of each. A *reflex action* is an immediate motor response to a sensory stimulus. Many connector and motor neurones may be stimulated by afferent impulses from a small area of skin, e.g. the pain impulses initiated by touching a very hot surface with the finger are transmitted to the spinal cord by sensory nerves. These stimulate many connector and lower motor neurones in the cord, which results in the contraction of many skeletal muscles of the hand, arm and shoulder, and the removal of the finger.

Reflex action takes place very quickly, in fact, the motor response may have occurred simultaneously with the perception of the pain in the cerebrum. Reflexes of this type are invariably protective but they can on occasion be inhibited.

Stretch Reflexes



Only two neurones are involved. The cell body of the lower motor neurone is stimulated by the sensory neurone. There is no connector neurone involved. The *knee jerk* is one example, but this type of reflex can be demonstrated at any point where a stretched tendon crosses a joint. By tapping the tendon just below the knee when it is bent, the sensory nerve endings in the tendon and in the thigh muscles are stretched. This initiates a nerve impulse, which passes into the spinal cord to the cell body of the lower motor neurone in the anterior column of grey matter on the same side. As a result the thigh muscles suddenly contract and the foot kicks forward. This is used as a test of the integrity of the reflex arc. This type of reflex has a protective function it prevents excessive joint movement that may damage tendons, ligaments and muscles.

Peripheral Nervous System 8.3.4

This Part Of The Nervous System Consists Of:

- 31 pairs of spinal nerves.
- 12 pairs of cranial nerves.
- The autonomic part of the nervous system.

Most of the nerves of the peripheral nervous system are composed of *sensory nerve fibres* conveying afferent impulses from sensory end organs to the brain, and *motor nerve fibres* conveying efferent impulses from the brain through the spinal cord to the effector organs, e.g. skeletal muscles, smooth muscle and glands.

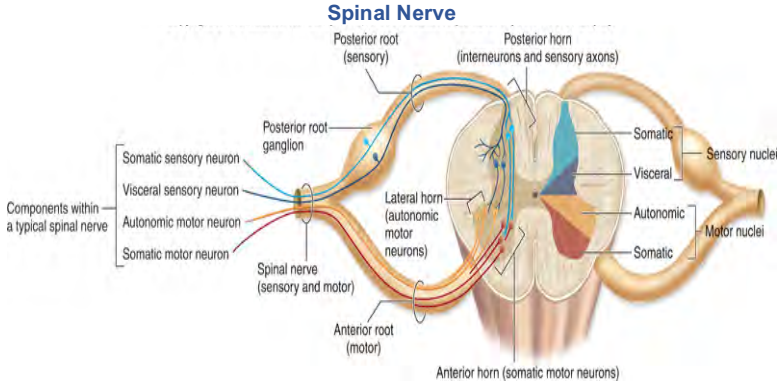
Each nerve consists of numerous nerve fibres collected into bundles. Each bundle has several coverings of protective connective tissue.

There Structure Includes:

- *Endoneurium* is a delicate tissue, surrounding each individual fibre, which is continuous with the septa that pass inwards from the perineurium.
- *Perineurium* is a smooth connective tissue, surrounding each *bundle* of fibres.
- *Epineurium* is the fibrous tissue, which surrounds and encloses a number of bundles of nerve fibres. Most large nerves are covered by epineurium.

Spinal Nerves

There are *31 pairs of spinal nerves* that leave the vertebral canal by passing through the intervertebral foramina formed by adjacent vertebrae. They are named and grouped according to the vertebrae they are associated with.



These Are:

- 8 cervical
- 12 thoracic
- 5 lumbar
- 5 sacral
- 1 coccygeal.

Although there are only seven cervical vertebrae, there are eight nerves because the first pair leaves the vertebral canal between the occipital bone and the atlas and the eighth pair leaves below the last cervical vertebra. Thereafter the nerves are given the name and number of the vertebra immediately *above.*

The lumbar, sacral and coccygeal nerves leave the *spinal cord* near its termination at the level of the first lumbar vertebra, and extend downwards inside the vertebral canal in the subarachnoid space, forming a sheaf of

nerves, which resembles a horse's tail, the *cauda equina.* These nerves leave the vertebral canal at the appropriate lumbar, sacral or coccygeal level, depending on their destination.

The spinal nerves arise from both sides of the spinal cord and emerge through the inter-vertebral foramina. Each nerve is formed by the union of a *motor and a sensory nerve root* and is, therefore, a *mixed nerve.* Each spinal nerve has a contribution from the sympathetic part of the autonomic nervous system in the form of a *preganglionic fibre*.

Nerve Roots

The anterior nerve root consists of *motor nerve fibres,* which are the axons of the nerve cells in the anterior column of grey matter in the spinal cord and, in the thoracic and lumbar regions, *sympathetic nerve fibres,* which are the axons of cells in the lateral columns of grey matter.

The posterior nerve root consists of *sensory nerve fibres.* Just outside the spinal cord there is a *spinal ganglion* (posterior root ganglion), consisting of a little cluster of cell bodies. Sensory nerve fibres pass through these ganglia before entering the spinal cord. The area of skin supplied by each nerve is called a *dermatome*.

For a very short distance after leaving the spinal cord the nerve roots have a covering of *dura* and *arachnoid maters.* These terminate before the two roots join to form the mixed spinal nerve. The nerve roots have no covering of pia mater.

Immediately after emerging from the intervertebral foramen each spinal nerve divides into a ramus commu- nicans, a posterior ramus and an anterior ramus.

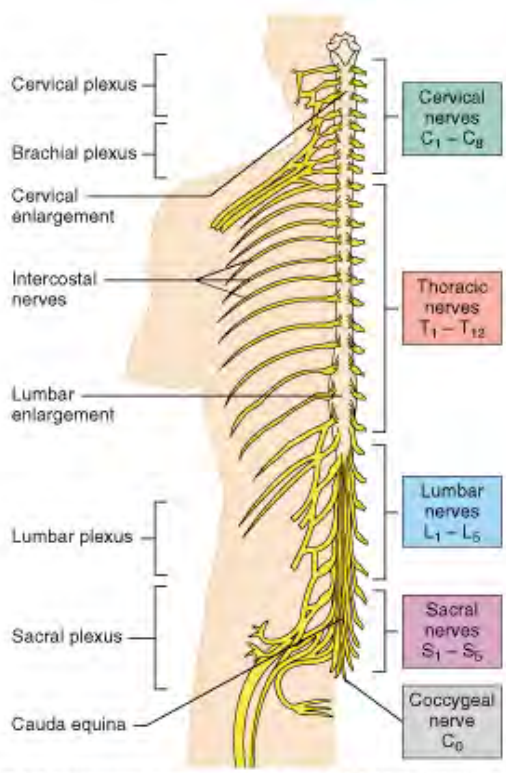
The rami communicans are part of preganglionic sympathetic neurones of the autonomic nervous system. *The posterior rami* pass backwards and divide into medial and lateral branches to supply skin and muscles of relatively small areas of the posterior aspect of the head, neck and trunk. *The anterior rami* supply the anterior and lateral aspects of the neck, trunk and the upper and lower limbs.

In the cervical, lumbar and sacral regions the anterior rami unite near their origins to form large masses of nerves, or *plexuses,* where nerve fibres are regrouped and rearranged before proceeding to supply skin, bones, muscles and joints of a particular area. This means that these structures have a nerve supply from more than one spinal nerve and therefore damage to one spinal nerve does not cause loss of function of a region.

In the thoracic region the anterior rami do not form plexuses.

There are five large plexuses of mixed nerves formed on each side of the vertebral column.

Spinal Nerve Roots



They Are The:

- Cervical plexuses.
- Brachial plexuses.
- Lumbar plexuses.
- Sacral plexuses.
- Coccygeal plexuses.

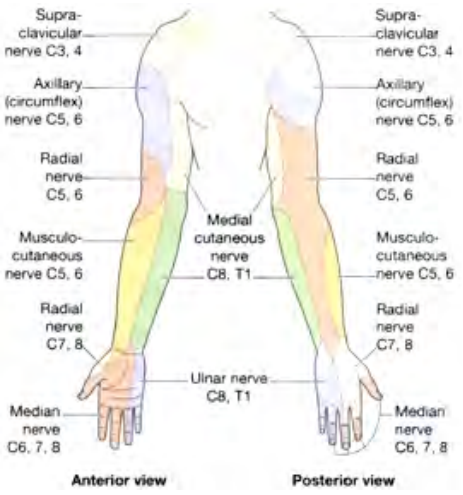
Cervical Plexus

This is formed by the anterior rami of the first four cervical nerves. It lies opposite the 1st, 2nd, 3rd and 4th cervical vertebrae under the protection of the sterno-cleidomastoid muscle.

The superficial branches supply the structures at the back and side of the head and the skin of the front of the neck to the level of the sternum. *The deep branches* supply muscles of the neck, e.g. the sternocleidomastoid and the trapezius.

The phrenic nerve originates from cervical roots 3,4 and 5 and passes downwards through the thoracic cavity in front of the root of the lung to supply the muscle of the diaphragm with impulses, which stimulate contraction.

Nerve Sensations Of The Arms



Brachial Plexus

The anterior rami of the lower four cervical nerves and a large part of the first thoracic nerve form the brachial plexus. The plexus is situated in the neck and shoulder above and behind the subclavian vessels and in the axilla.

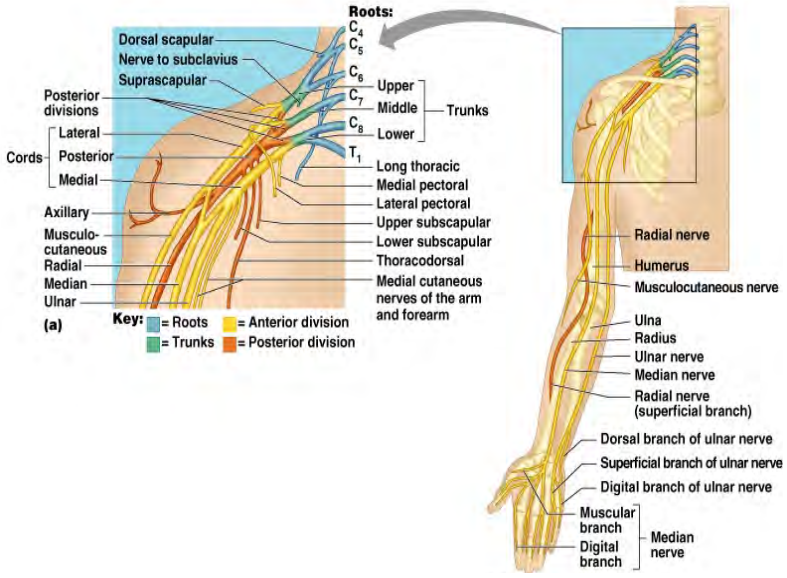
The branches of the brachial plexus supply the skin and muscles of the upper limbs and some of the chest muscles. Five large nerves and a number of smaller ones emerge from this

plexus, each with a contribution from more than one nerve root, containing sensory, motor and autonomic fibres.

These Are:

- Axillary (circumflex) nerve: C5, C6.
- Radial nerve: C5, C6, C7, C8, T1.
- Musculo-cutaneous nerve: C5, C6, C7.
- Median nerve: C5, C6, C7, C8, T1.
- Ulnar nerve: C7, C8, T1.
- Medial cutaneous nerve: C8, T1.

Nerve Roots Of The Arm



The Axillary (Circumflex) Nerve

Winds round the humerus at the level of the surgical neck. It then breaks up into minute branches to supply the deltoid muscle, shoulder joint and overlying skin.

The Radial Nerve

The largest branch of the brachial plexus. It supplies the triceps muscle behind the humerus, crosses in front of the elbow joint then winds round to the back of the forearm to supply extensors of the wrist and finger joints.

It continues into the back of the hand to supply the skin of the thumb, the first two fingers and the lateral half of the third finger.

The Musculo-Cutaneous Nerve

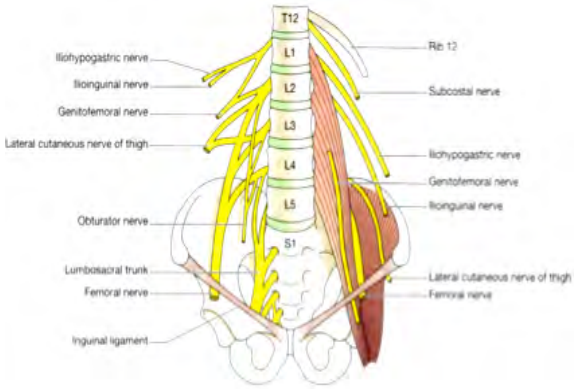
Passes downwards to the lateral aspect of the forearm. It supplies the muscles of the upper arm and the skin of the forearm.

The Median Nerve

Passes down the midline of the arm in close association with the brachial artery. It passes in front of the elbow joint then down to supply the muscles of the front of the forearm. It continues into the hand where it supplies small muscles and the skin of the front of the thumb, the first two fingers and the lateral half of the third finger. It gives off no branches above the elbow.

The ulnar nerve descends through the upper arm lying medial to the brachial artery. It passes behind the medial epicondyle of the humerus to supply the muscles on the ulnar aspect of the forearm. It continues downwards to supply the muscles in the palm of the hand and the skin of the whole of the little finger and the medial half of the third finger. It gives off no branches above the elbow.

Lumbar Plexus



Lumbar Plexus

The lumbar plexus is formed by the anterior rami of the first three and part of the fourth lumbar nerves. The plexus is situated in front of the transverse processes of the lumbar vertebrae and behind the psoas muscle.

The Main Branches, And Their Nerve Roots Are:

- Iliohypogastric nerve: L1.
- Ilioinguinal nerve: L1.
- Genitofemoral: L1, L2.
- Lateral cutaneous nerve of thigh: L2, L3.
- Femoral nerve: L2, L3, L4.
- Obturator nerve: L2, L3, L4.
- Lumbosacral trunk: L4, L5.

Iliohypogastric, Ilioinguinal And Genito-Femoral Nerves

Supply muscles and the skin in the area of the lower abdomen, upper and medial aspects of the thigh and the inguinal region.

The Lateral Cutaneous Nerve Of The Thigh

Supplies the skin of the lateral aspect of the thigh including part of the anterior and posterior surfaces.

The Femoral Nerve

One of the larger branches. It passes behind the inguinal ligament to enter the thigh in close association with the femoral artery. It divides into cutaneous and muscular branches to supply the skin and the muscles of the front of the thigh. One branch, the *saphenous nerve,* supplies the medial aspect of the leg, ankle and foot.

The Obturator Nerve

Supplies the adductor muscles of the thigh and skin of the medial aspect of the thigh. It ends just above the level of the knee joint.

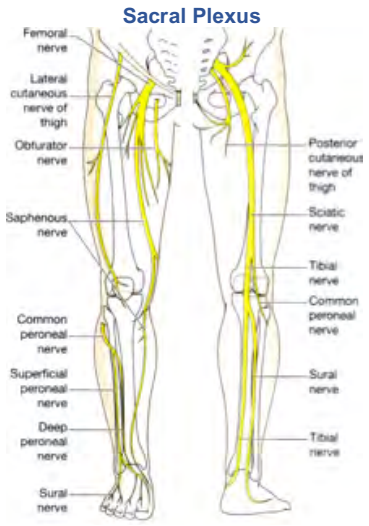
The Lumbo-Sacral Trunk

Descends into the pelvis and makes a contribution to the sacral plexus.

Sacral Plexus

The sacral plexus is formed by the anterior rami of the lumbosacral trunk and the first, second and third sacral nerves. The lumbosacral trunk is formed by the fifth and part of the fourth lumbar nerves. It lies in the posterior wall of the pelvic cavity.

It divides into a number of branches, supplying the muscles and skin of the pelvic floor, muscles around the hip joint and the pelvic organs. In addition to these it provides the *sciatic nerve* which contains fibres from L4, 5, S1, 2, 3.

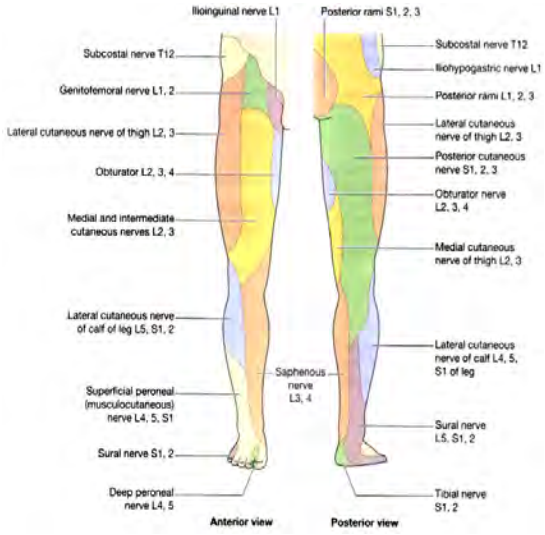


Sciatic Nerve

The largest nerve in the body. It is about 2 cm wide at its origin. It passes through the greater sciatic foramen into the buttock then descends through the posterior aspect of the thigh supplying the hamstring muscles. At the level of the middle of the femur it divides to form the *tibial* and the *common-peroneal nerves.*

The tibial nerve descends through the popliteal fossa to the posterior aspect of the leg where it supplies muscles and skin. It passes under the medial malleolus to supply muscles and skin of the sole of the foot and toes.

One of the main branches is the *sural nerve,* which supplies the tissues in the area of the heel, the lateral aspect of the ankle and a part of the dorsum of the foot.



Common Peroneal Nerve

Descends obliquely along the lateral aspect of the popliteal fossa, winds round the neck of the fibula into the front of the leg where it divides into the *deep peroneal* (anterior tibial) and the *superficial peroneal* (musculocutaneous) nerves. These nerves supply the skin and muscles of the anterior aspect of the leg and the dorsum of the foot and toes.

Pudendal Nerve (S2, S3, S4)

The perineal branch supplies the external anal sphincter, the external urethral sphincter and adjacent skin

Coccygeal Plexus

The coccygeal plexus is a very small plexus formed by part of the fourth and fifth sacral and the coccygeal nerves. The nerves from this plexus supply the skin in the area of the coccyx and the levators ani and coccygeus muscles of the pelvic floor and the external anal sphincter.

Thoracic Nerves

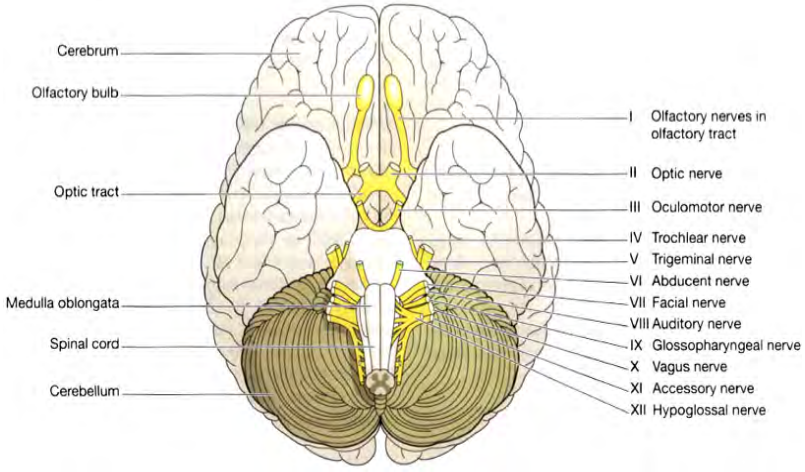
The thoracic nerves *do not* intermingle to form plexuses. There are 12 pairs and the first 11 are the *inter-costal nerves.* They pass between the ribs supplying them, the inter- costal muscles and overlying skin. The 12th pair are the *sub-costal nerves.* The 7th to the 12th thoracic nerves also supply the muscles and the skin of the posterior and anterior abdominal walls.

The Cranial Nerves 8.3.5

There are 12 pairs of cranial nerves originating from nuclei in the inferior surface of the brain, some sensory, some motor and some mixed.

Their Names And Numbers Are:

I. Olfactory: sensory
II. Optic: sensory
III. Oculomotor: motor
IV. Trochlear: motor
V. Trigeminal: mixed
VI. Abducent: motor
VII. Facial: mixed
VIII. Vestibulocochlear (auditory): sensory
IX. Glossopharyngeal: mixed
X. Vagus: mixed
XI Accessory: motor
XII. Hypoglossal: motor.



I. Olfactory Nerves (Sensory)

i. Olfactory Nerve

These are the nerves of the *sense of smell.* Their nerve endings and fibres originate in the upper part of the mucous membrane of the nasal cavity, pass upwards through the cribriform plate of the ethmoid bone and then go to the *olfactory bulb*.

The nerves then proceed backwards as the olfactory tract, to the area for the perception of smell in the temporal lobe of the cerebrum.

II. Optic Nerves (Sensory)

II. Optic Nerve

These are the nerves of the *sense of sight.* The fibres originate in the retinae of the eyes and they combine to form the optic nerves. They are directed backwards and medially through the posterior part of the orbital cavity. They then pass through the *optic foramina* of the sphenoid bone into the cranial cavity and join at the *optic chiasma.*

The nerves proceed backwards as the *optic tracts* to the *lateral geniculate bodies* of the thalamus. Impulses pass from these to the centre for sight in the occipital lobes of the cerebrum and to the cerebellum. In the occipital lobe sight is perceived, and in the cerebellum the impulses from the eyes contribute to the maintenance of balance, posture and orientation of the head in space.

The central retinal artery and vein enter the eye enveloped by the fibres of the optic nerve.

III. Oculomotor Nerve

III. Oculomotor Nerves (Motor)

These nerves arise from nerve cells near the cerebral aqueduct. They supply:

- Four extraocular muscles, which move the eyeball, i.e. the *superior, medial* and *inferior recti* and the *inferior oblique muscle.*
- Intraocular muscles:
  - *Ciliary muscles,* which alter the shape of the lens, changing its refractive power.
  - *Circular muscles of the iris,* which constrict the pupil
- The *levator palpebrae* muscle, which raises the upper eyelid.

IV. Trochler Nerve

IV. Trochlear Nerves (Motor)

These nerves arise from nerve cells near the cerebral aqueduct. They supply the *superior oblique muscles* of the eyes.

V. Trigeminal Nerves (Mixed)

V. Trigeminal Nerve

These nerves contain motor and sensory fibres and are among the largest of the cranial nerves. They are the chief sensory nerves for the face and head (including the oral and nasal cavities and teeth), receiving impulses of pain, temperature and touch. The motor fibres stimulate the muscles of mastication.

There are three main branches of the trigeminal nerves. *The ophthalmic nerves* are sensory only and supply the lacrimal glands, conjunctiva of the eyes, forehead, eyelids, anterior aspect of the scalp and mucous membrane of the nose.

The maxillary nerves are sensory only and supply the cheeks, upper gums, upper teeth and lower eyelids.

The mandibular nerves contain both sensory and motor fibres. These are the largest of the three divisions and they supply the teeth and gums of the lower jaw, pinnae of the ears, lower lip and tongue. The motor fibres supply the muscles of mastication.

VI. Abducent Nerve

VI. Abducent Nerves (Motor)

These nerves arise from a group of nerve cells lying under the floor of the fourth ventricle. They supply the *lateral rectus muscles* of the eyeballs.

VII. Facial Nerve

VII. Facial Nerves (Mixed)

These nerves are composed of both motor and sensory nerve fibres, arising from nerve cells in the lower part of the pons. The motor fibres supply the muscles of facial expression.

The sensory fibres convey impulses from the taste buds in the anterior two-thirds of the tongue to the taste perception area in the cerebral cortex.

VIII. Vestibulochlear Nerve

VIII. Vestibulocochlear (Auditory) Nerves (Sensory)

These nerves are composed of two distinct sets of fibres, vestibular nerves and cochlear nerves.

The vestibular nerves arise from the semicircular canals of the inner ear and convey impulses to the cerebellum. They are associated with the maintenance of posture and balance.

The cochlear nerves originate in the organ of Corti in the inner ear and convey impulses to the hearing areas in the cerebral cortex where sound is perceived.

IX. Glossopharyngeal Nerves (Mixed)

IX. Glossopharyngeal Nerve

These nerves arise from nuclei in the medulla oblongata. The motor fibres stimulate the muscles of the tongue and pharynx and the secretory cells of the parotid (salivary) glands.

The sensory fibres convey impulses to the cerebral cortex from the posterior third of the tongue, the tonsils and pharynx and from taste buds in the tongue and pharynx.

These nerves are essential for the swallowing and gag reflexes.

X. Vagus Nerves (Mixed)

X. Vagus Nerve

These nerves have a more extensive distribution than any other cranial nerves. They arise from nerve cells in the medulla oblongata and other nuclei, and pass down through the neck into the thorax and the abdomen. These nerves form an important part of the parasympathetic nervous system.

The motor fibres supply the smooth muscles and secretory glands of the pharynx, larynx, trachea, heart, oesophagus, stomach, intestines, pancreas, gall bladder, bile ducts, spleen, kidneys, ureter and blood vessels in the thoracic and abdominal cavities.

The sensory fibres convey impulses from the lining membranes of the same structures to the brain.

XI. Accessory Nerves (Motor)

XI. Accessory Nerve

These nerves arise from cell bodies in the medulla oblongata and in the spinal cord. The fibres supply the *sternocleidomastoid* and *trapezius muscles.*

Branches join the vagus nerves and supply the *pharyngeal* and *laryngeal muscles.*

XII. Hypoglossal Nerves (Motor)

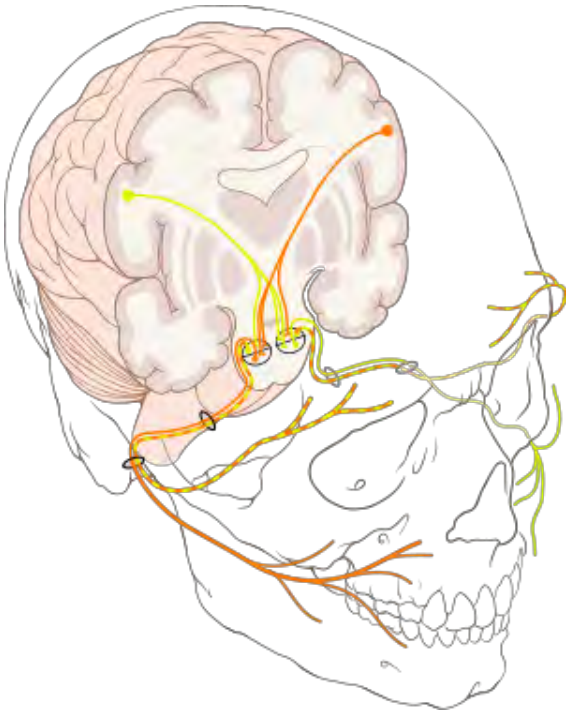
XII. Hypoglossal Nerve

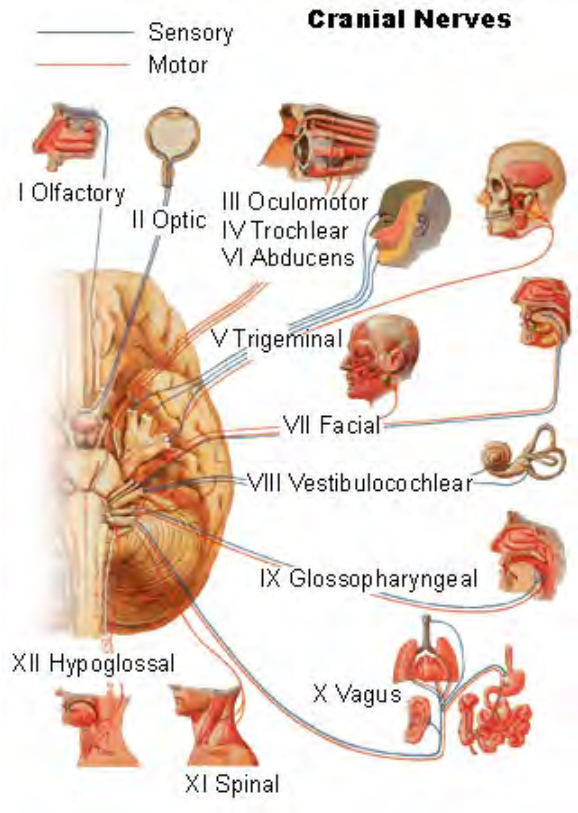
These nerves arise from cells in the medulla oblongata.

They supply the muscles of the tongue and muscles surrounding the hyoid bone and contribute to swallowing and speech.

Summary of the cranial nerves

Name *and* no.	Central connection	Peripheral connection	Function
I. Olfactory (sensory)	Smell area in temporal lobe of cerebrum through olfactory bulb	Mucous membrane in roof of nose	Sense of smell
II. Optic (sensory)	Sight area in occipital lobe of cerebrum Cerebellum	Retina of the eye	Sense of sight Balance
III. Oculomotor (motor)	Nerve cells near floor of aqueduct of midbrain	Superior, inferior and medial rectus muscles of the eye Ciliary muscles of the eye Circular muscle fibres of the iris	Moving the eyeball. Focusing Regulating the size of the pupil
IV. Trochlear (motor)	Nerve cells near floor of aqueduct of midbrain	Superior oblique muscles of the eye	Movement of the eyeball
V. Trigeminal (mixed)	Motor fibres from the pons Sensory fibres from the trigeminal ganglion	Muscles of mastication Sensory to gums, cheek, lower jaw, iris, cornea	Chewing Sensation from the face
VI. Abducent (motor)	Floor of fourth ventricle	Lateral rectus muscle of the eye	Movement of the eye
VII. Facial (mixed)	Pons	Sensory fibres to the tongue Motor fibres to the muscles of the face	Sense of taste Movements of facial expression
VIII. Vestibulocochlear (sensory) (a) Vestibular (b) Cochlear	Cerebellum Hearing area of cerebrum	Semicircular canals in the inner ear Organ of Corti in cochlea	Maintenance of balance Sense of hearing
IX. Glossopharyngeal (mixed)	Medulla oblongata	Parotid gland Back of tongue and pharynx	Secretion of saliva Sense of taste Movement of pharynx
X. Vagus (mixed)	Medulla oblongata	Pharynx, larynx; organs, glands ducts, blood vessels in the thorax and abdomen	Movement and secretion
XI. Accessory (motor)	Medulla oblongata	Sternocleidomastoid, trapezius, laryngeal and pharyngeal muscles	Movement of the head, shoulders, pharynx and larynx
XII. Hypoglossal (motor)	Medulla oblongata	Tongue	Movement of tongue





THE AUDITORY SYSTEM 8.4

The Ear

The ear is the organ of hearing. It is supplied by the 8th *cranial nerve,* i.e. the *cochlear part* of the *vestibulocochlear* nerve, which is stimulated by vibrations caused by sound waves.

With the exception of the auricle (pinna), the structures that form the ear are encased within the petrous portion of the temporal bone.

The Ear Is Divided Into Three Distinct Parts:

- Outer ear.
- Middle ear (tympanic cavity).
- Inner ear.

Outer Ear

The outer ear consists of the auricle (pinna) and the external acoustic meatus.

The Auricle (pinna)

The auricle is the expanded portion projecting from the side of the head. It is composed of *fibroelastic cartilage* covered with skin. It is deeply grooved and ridged and the most prominent outer ridge is the *helix.*

The lobule (earlobe) is the soft pliable part at the lower extremity, composed of fibrous and adipose tissue richly supplied with blood.

External Acoustic Meatus (Auditory Canal)

Tympanic Membrane

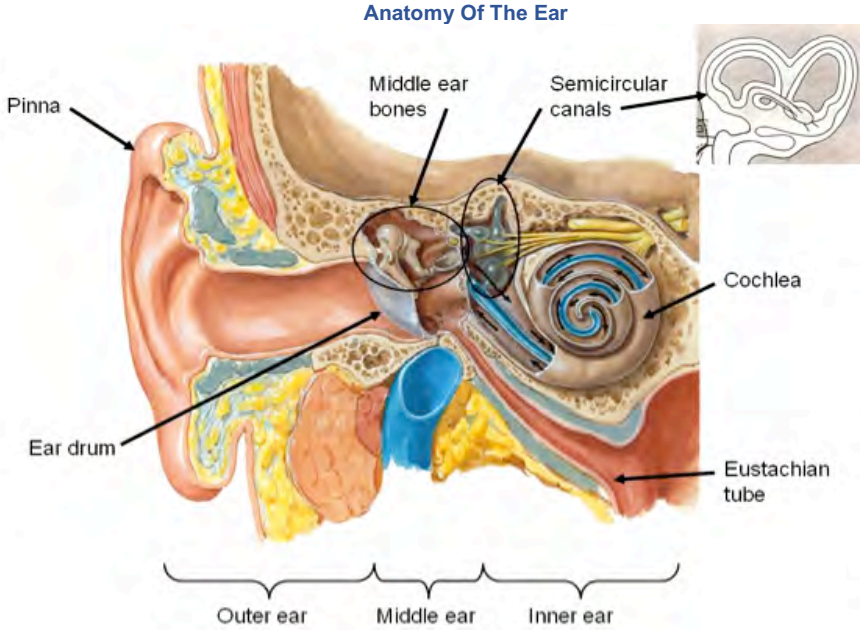
This is a slightly 'S'-shaped tube about 2.5cm long extending from the auricle to the *tympanic membrane* (eardrum). The lateral third is cartilaginous and the remainder is a canal in the temporal bone. The meatus is lined with skin containing hairs continuous with that of the auricle. There are numerous *sebaceous* and *ceruminous glands* in the skin of the lateral third.

Ceruminous glands are modified sweat glands that secrete *cerumen* (wax), a sticky material containing lysozyme and immunoglobulins. Foreign materials, e.g. dust, insects and microbes, are prevented from reaching the tympanic membrane by wax, hairs and the curvature of the meatus. Movements of the temporomandibular joint during chewing and speaking 'massage' the cartilaginous meatus, moving the wax towards the exterior.

The tympanic membrane (eardrum) completely separates the external acoustic meatus from the middle ear. It is

oval-shaped with the slightly broader edge upwards and is formed by three types of tissue: the outer covering of *hairless skin,* the middle layer of *fibrous tissue* and the inner lining of *mucous membrane* continuous with that of the middle ear.

Anatomy Of The Ear



Middle Ear (Tympanic Cavity)

This is an irregular-shaped *air-filled* cavity within the petrous portion of the temporal bone. The cavity, its contents and the air sacs, which open out of it are lined with either simple squamous or cuboidal epithelium.

The lateral wall of the middle ear is formed by the tympanic membrane.

The roof and floor are formed by the temporal bone.

The posterior wall is formed by the temporal bone with openings leading to the *mastoid antrum* through which air passes to the air cells within the mastoid process.

The medial wall is a thin layer of temporal bone in which there are two openings:

- Oval window.
- Round window.

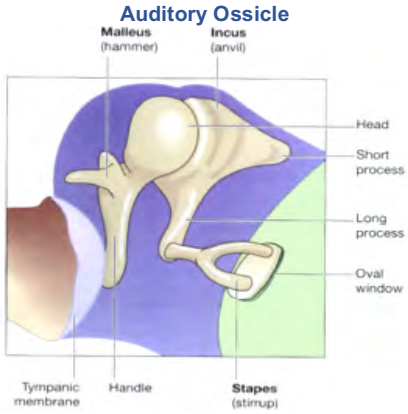
Middle Ear

The oval window is occluded by part of a small bone called the *stapes* and the round window, by a fine sheet *of fibrous tissue.*

Air reaches the cavity through the *pharyngotympanic (auditory or Eustachian)* tube, which extends from the nasopharynx. It is about 4 cm long and is lined with ciliated epithelium. The presence of air at atmospheric pressure on both sides of the tympanic membrane is maintained by the pharyngotympanic tube and enables the membrane to vibrate when sound waves strike it. The pharyngotympanic tube is normally closed but when there is unequal pressure across the tympanic membrane, e.g. at high altitude, swallowing opens it or yawning and the ears 'pop', equalising the pressure again.

Auditory Ossicles

Auditory Ossicle



These are three very small bones that extend across the middle ear from the tympanic membrane to the oval window. They form a series of movable joints with each other and with the medial wall of the cavity at the oval window. They are named according to their shapes. *The malleus.* This is the lateral hammer-shaped bone.

The handle is in contact with the tympanic membrane and the head forms a movable joint with the incus.

The incus. This is the middle anvil-shaped bone. Its body articulates with the malleus, the long process with the stapes, and it is stabilised by the short process, fixed by fibrous tissue to the posterior wall of the tympanic cavity.

The stapes. This is the medial stirrup-shaped bone. Its head articulates with the incus and its footplate fits into the oval window.

The three ossicles are held in position by fine ligaments.

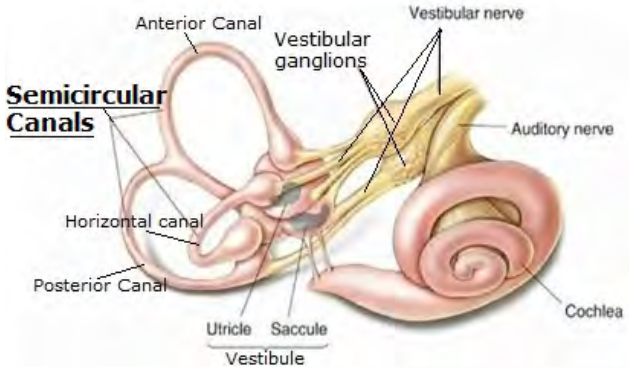
Inner Ear

The inner (internal) ear or labyrinth (meaning 'maze') ear contains the organs of hearing and balance. It is generally described in two parts, the *bony labyrinth* and the *membranous labyrinth.*

Bony Labyrinth

This is a cavity within the temporal bone lined with periosteum. It is larger than, and encloses, the membranous labyrinth of the same shape, which fits into it, like a tube within a tube. Between the bony and membranous labyrinth there is a layer of watery fluid called *perilymph* and within the membranous labyrinth there is a similarly watery fluid, *endolymph.*

Bony Labrynth



The Bony Labyrinth Consists Of:

- 1 vestibule.
- 1 cochlea.
- Semicircular canals.

The Vestibule

This is the expanded part nearest the middle ear. It contains the oval and round windows in its lateral wall.

The Cochlea

This resembles a snail's shell. It has a broad base where it is continuous with the vestibule and a narrow apex, and it spirals round a central bony column.

The Semicircular Canals

These are three tubes arranged so that one is situated in each of the three planes of space. They are continuous with the vestibule.

Membranous Labyrinth

This contains endolymph and lies within its bony counterpart.

The Cochlea

It Comprises:

- The vestibule, which contains the *utricle* and *saccule*
- The cochlea
- Three semicircular canals.

The Cochlea

A Cross-Section Of The Cochlea Contains Three Compartments:

- The Scala vestibule.
- The scala media, or *cochlear duct.*
- The scala tympani.

In cross-section the bony cochlea has two compartments containing perilymph: the scala vestibuli, which originates at the oval window, and the scala tympani, which ends at the round window. The two compartments are continuous with each other.

The cochlear duct is part of the membranous labyrinth and is triangular in shape. On the *basilar membrane,* or base of the triangle, there are *supporting cells* and specialised *cochlear hair cells* containing auditory receptors. These cells form the *spiral organ* (of Corti), the sensory organ that responds to vibration by initiating nerve impulses that are then perceived as hearing by the brain.

The *auditory receptors* are dendrites of efferent nerves that combine forming the cochlear (auditory) part of the vestibul-ocochlear nerve (8th cranial nerve), which passes through a foramen in the temporal bone to reach the hearing area in the temporal lobe of the cerebrum

The Semicircular Canals and Vestibule

The semicircular canals have no auditory function although they are closely associated with the cochlea. They provide information about the position of the head in space, contributing to maintenance of posture and balance. There are three semicircular canals, one lying in each of the three planes of space. They are situated above and behind the vestibule of the inner ear and open into it.

The semicircular canals, like the cochlea, are composed of an outer bony wall and inner membranous tubes or *ducts.* The membranous ducts contain endolymph and are separated from the bony wall by perilymph.
The utricle is a membranous sac, which is part of the vestibule and the three membranous ducts open into it at their dilated ends, the *ampullae.* The *saccule* is a part of the vestibule and communicates with the utricle and the cochlea.

In the walls of the utricle, saccule and ampullae there are fine specialised epithelial cells with minute projections, called *hair cells.* Amongst the hair cells there are sensory nerve endings, which combine forming the *vestibular part* of the vestibulocochlear nerve.

Physiology of Balance

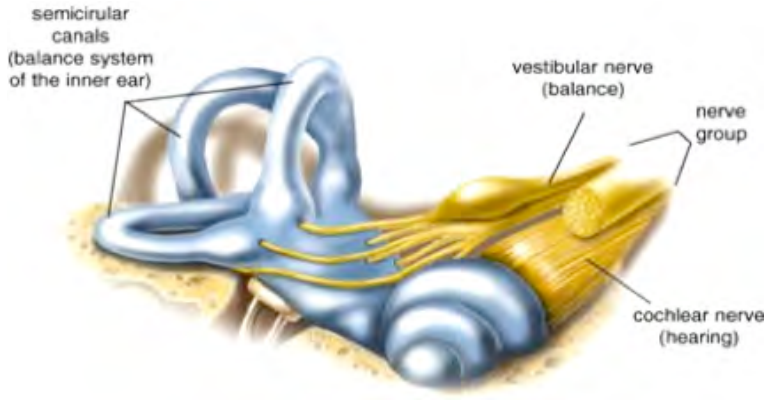
The semicircular canals and the vestibule (utricle and saccule) are concerned with balance. Any change of position of the head causes movement in the perilymph and endolymph, which bends the hair cells and stimulates the sensory nerve endings in the utricle, saccule and ampullae.

The resultant nerve impulses are transmitted by the vestibular nerve, which joins the cochlear nerve to form the

vestibulocochlear nerve. The vestibular branch passes first to the *vestibular nucleus,* then to the *cerebellum.*

The cerebellum also receives nerve impulses from the eyes and proprioceptors (sensory receptors) in the skeletal muscles and joints. Impulses from these three sources are coordinated and efferent nerve impulses pass to the cerebrum and to skeletal muscles. This results in awareness of body position, maintenance of upright posture and fixing of the eyes on the same point, independently of head movements.

The Organ Of Ballance



THE URINARY SYSTEM 8.5

The urinary system is one of the excretory systems of the body.

It Consists Of The Following Structures:

- 2 kidneys (which secrete urine).
- 2 ureters (which convey the urine from the kidneys to the urinary bladder).
- 1 urinary bladder (where urine collectsand is temporarily stored).
- 1 urethra (through which the urine is discharged from the urinary bladder to the exterior).

The urinary system plays a vital part in maintaining homeostasis of water and electrolyte concentrations within the body. The kidneys produce urine that contains metabolic waste products, including water, the nitrogenous compounds urea and uric acid, excess ions and some drugs.

The Main Functions Of The Kidneys Are:

- Formation and secretion of urine.
- Production and secretion of erythropoietin (the hormone responsible for controlling the rate of formation of red blood cells).
- Production and secretion of renin (an important enzyme in the control of blood pressure).
- Assisting in acid base balance.

Urine is stored in the bladder and excreted by the process of *micturition.*

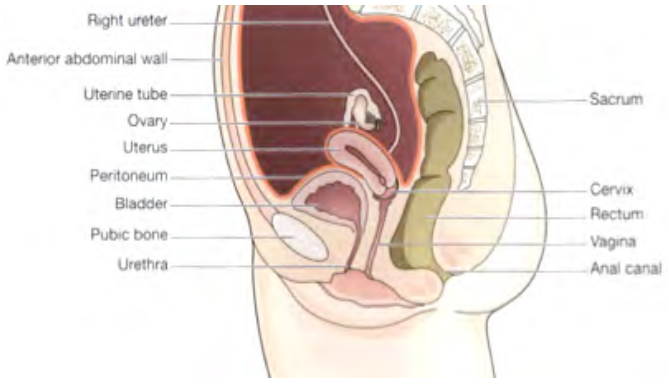
The urinary bladder is a reservoir for urine. It lies in the pelvic cavity and its size and position vary, depending on the amount of urine it contains. When distended, the bladder rises into the abdominal cavity.

The bladder is roughly pear-shaped, but becomes more oval as it fills with urine. It has anterior, superior and posterior surfaces. The posterior surface is the *base.*

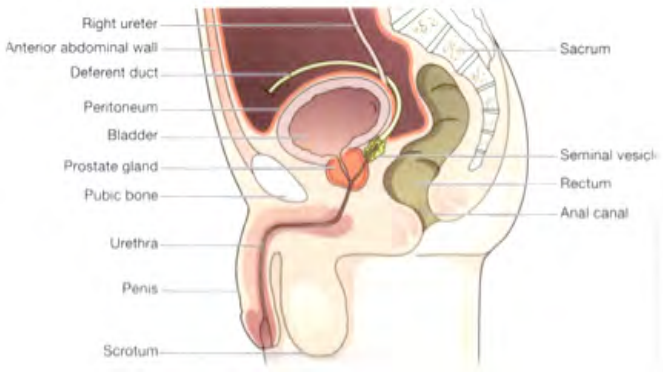
The bladder opens into the urethra at its lowest point, *the neck.*

The *peritoneum* covers only the superior surface before it turns upwards as the parietal peritoneum, lining the anterior abdominal wall. Posteriorly it surrounds the uterus in the female and the rectum in the male.

The Female Urinary System



The Male Urinary System



The Bladder

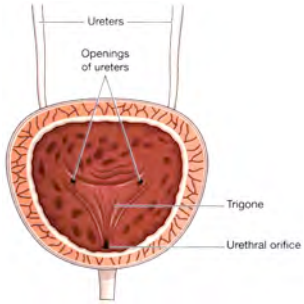
The Bladder Wall Is Composed Of Three Layers:

- The outer layer of loose connective tissue, containing blood and lymphatic vessels and nerves, covered on

the upper surface by the peritoneum.

- The middle layer, consisting of a mass of interlacing smooth muscle fibres and elastic tissue loosely arranged in three layers. This is called the *detrusor muscle* and it empties the bladder when it contracts.
- The mucosa, lined with transitional epithelium.

The Bladder



When the bladder is empty the inner lining is arranged in folds, or rugae, and these gradually disappear as the bladder fills. The bladder is distensible but when it contains 300 to 400 ml the awareness of the desire to urinate is initiated. The total capacity is rarely more than about 600 ml.

The three orifices in the bladder wall form a triangle or *trigone*. The upper two orifices on the posterior wall are the openings of the ureters. The lower orifice is the point of origin of the urethra. Where the urethra commences is a thickening of the smooth muscle layer forming the *internal urethml sphincter.* This sphincter is not under voluntary control.

Urethra

The urethra is a canal extending from the neck of the bladder to the exterior, at the external urethral orifice. Its length differs in the male and in the female.

The female urethra is approximately 4 cm long. It runs downwards and forwards behind the symphysis pubis and opens at the *external urethral orifice,* which is under voluntary control. Except during the passage of urine, the walls of the urethra are in close apposition.

The male urethra provides a common pathway for the flow of urine and semen, the combined secretions of the male reproductive organs. It is about 19 to 20 cm long and consists of three parts. The *prostatic urethra* originates at the urethral orifice of the bladder and passes through the prostate gland. The *membranous urethra* is the shortest and narrowest part and extends from the prostate gland to the bulb of the penis, after passing through the perineal membrane. The *spongiose* or *penile urethra* lies within the corpus spongiosum of the penis and terminates at the external urethral orifice in the *glans penis.*

There are two urethral sphincters. The *internal sphincter* consists of smooth muscle fibres at the neck of the bladder above the prostate gland. The *external sphincter* consists of skeletal muscle fibres surrounding the membranous part.

Prostate Gland (Males)

The prostate gland lies in the pelvic cavity in front of the rectum and behind the symphysis pubis, surrounding the first part of the urethra. It consists of an outer fibrous covering, a layer of smooth muscle and glandular substance composed of columnar epithelial cells.

The prostate gland secretes a thin, milky fluid that makes up about 30% of *semen,* and gives it its milky appearance. It is slightly alkaline, which provides a protective local environment for sperm arriving in the acidic vagina. It also contains a clotting enzyme, which thickens the semen in the vagina, increasing the likelihood of semen being retained in the vicinity of the cervix.

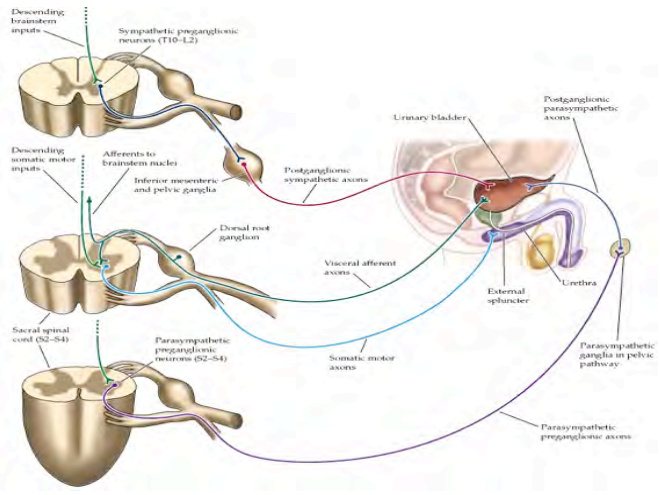
Penis (Males)

The penis has a *root* and a *body.* The root lies in the perineum and the body surrounds the urethra. It is formed by three cylindrical masses of *erectile tissue* and involuntary muscle. The erectile tissue is supported by fibrous tissue and covered with skin and has a rich blood supply.

The two lateral columns are called the *corpora caver-nosa* and the column between them, containing the urethra, is the *corpus spongiosum.* At its tip it is expanded into a triangular structure known as the *glans penis.* Just above the glans the skin is folded upon itself and forms a movable double layer, t*he foreskin* or *prepuce.*

Arterial blood is supplied by deep, dorsal and bulbar arteries of the penis, which are branches from the internal pudendal arteries. A series of veins drain blood to the internal pudendal and internal iliac veins. Autonomic and somatic nerves supply the penis. Parasympathetic stimulation leads to filling of the spongy erectile tissue with blood, caused by arteriolar dilatation and venoconstriction, which increases blood flow into the penis and obstructs outflow. The penis therefore becomes engorged and erect, an essential prerequisite for coitus.

Urinary Micturition



Micturition

The urinary bladder acts as a reservoir for urine. When 300 to 400 ml of urine has accumulated, afferent autonomic nerve fibres in the bladder wall sensitive to stretch are stimulated. In the infant this initiates a *spinal reflex action* and micturition occurs.

Micturition occurs when autonomic efferent fibres convey impulses to the bladder causing contraction of the detrusor muscle and relaxation of the internal urethral sphincter.

When the nervous system is fully developed the micturition reflex is stimulated but sensory impulses pass upwards to the brain and there is an awareness of the desire to pass urine. By conscious effort, reflex contraction of the bladder wall and relaxation of the internal sphincter can be inhibited for a limited period of time.

In adults, micturition occurs when the detrusor muscle contracts, and there is reflex relaxation of the internal sphincter and voluntary relaxation of the external sphincter. It can be assisted by increasing the pressure within the pelvic cavity, achieved by lowering the diaphragm and contracting the abdominal muscles (Valsalva's manoeuvre).

Over-distension of the bladder is extremely painful, and when this stage is reached there is a tendency for involuntary relaxation of the external sphincter to occur and a small amount of urine to escape, provided there is no mechanical obstruction.

THE SKIN 8.6

The skin completely covers the body and is continuous with the membranes lining the body orifices.

It Provides:

- Protects the underlying structures from injury and from invasion by microbes.
- Contains sensory *(somatic)* nerve endings of pain, temperature and touch.
- Is involved in the regulation of body temperature.

The skin has a surface area of about 1.5 to 2 m^2 in adults and it contains glands, hair and nails.

There Are Two Main Layers:

- Epidermis
- Dermis.

Between the skin and underlying structures there is a layer of subcutaneous fat.

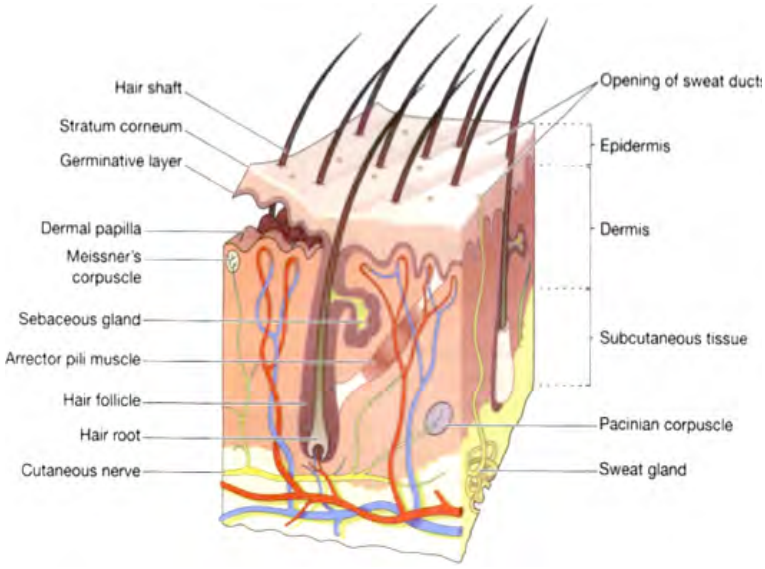
Epidermis

The epidermis is the most superficial layer of the skin and is composed of *stratified keratinised squamous epithelium,* which varies in thickness in different parts of the body. It is thickest on the palms of the hands and soles of the feet. There are no blood vessels or nerve endings in the epidermis, but its deeper layers are bathed in interstitial fluid from the dermis, which provides oxygen and nutrients, and is drained away as lymph.

There are several layers (strata) of cells in the epidermis, which extend from the deepest *germinative layer* to the surface *stratum corneum* (a thick horny layer). The cells on the surface are flat, thin, non-nucleated, dead cells

These cells are constantly being rubbed off and replaced by cells. Complete replacement of the epidermis takes about 40 days.

Skin Anatomy



The Maintenance Of Healthy Epidermis Depends Upon Three Processes Being Synchronised:

- Desquamation (shedding) of the keratinised cells from the surface.
- Effective keratinisation of the cells approaching the surface.
- Continual cell division in the deeper layers with newly formed cells being pushed to the surface.

Hairs, secretions from sebaceous glands and ducts of sweat glands pass through the epidermis to reach the surface.

The surface of the epidermis is ridged by projections of cells in the dermis called the *papillae.* The pattern of ridges is different in every individual and the impression made by them is the 'fingerprint'.

The downward projections of the germinative layer between the papillae are believed to aid nutrition of epidermal cells and stabilise the two layers, preventing damage due to shearing forces.

Blisters develop when acute trauma causes separation of the dermis and epidermis and serous fluid collects between the two layers.

The Colour Of The Skin Is Affected By Three Main Factors:

- *Melanin,* (A dark pigment derived from the amino acid tyrosine and secreted by *melanocytes* in the deep germinative layer). The amount is genetically determined and varies between different parts of the body, between members of the same race and between races. Exposure to sunlight promotes synthesis of increased amounts of melanin.

- *The level of oxygenation of haemoglobin* and the amount of blood circulating in the dermis give the skin its pink colour.
- *Bile pigments* in blood and *carotenes* in subcutaneous fat give the skin a yellowish colour.

Dermis

The dermis is tough and elastic. It is formed from connective tissue and the matrix contains *collagen fibres* interlaced with *elastic fibres.* Rupture of elastic fibres occurs when the skin is overstretched, resulting in permanent *striae,* or stretch marks, that may be found in pregnancy and obesity.

Collagen fibres bind water and give the skin its tensile strength, but as this ability declines with age, wrinkles develop. Fibroblasts, macrophages and mast cells are the main cells found in the dermis. Underlying its deepest layer there is areolar tissue and varying amounts of adipose tissue (fat).

The Structures In The Dermis Are:

- Blood vessels.
- Lymph vessels.
- Sensory (somatic) nerve endings.
- Sweat glands and their ducts.
- Hairs, arrector pili muscles and sebaceous glands.

Blood Vessels

Arterioles form a fine network with capillary branches supplying sweat glands, sebaceous glands, hair follicles and the dermis. The epidermis has no blood supply. It obtains nutrients and oxygen from interstitial fluid derived from blood vessels in the papillae of the dermis.

Lymph Vessels

These form a network throughout the dermis.

Sensory Nerve Endings

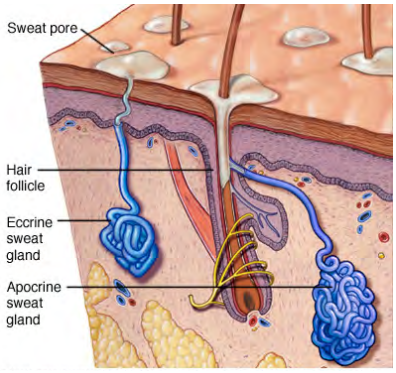
Sensory receptors (specialised nerve endings), which are sensitive to *touch, change in temperature, pressure* and *pain* are widely distributed in the dermis. Incoming stimuli activate different types of sensory receptors. The skin is an important sensory organ through which individuals receive information about their environment.

Nerve impulses, generated in the sensory receptors in the dermis, are conveyed to the spinal cord by sensory *(somatic cutaneous)* nerves, then to the sensory area of the cerebrum where the sensations are perceived.

Sweat Glands

Sweat glands are found widely distributed throughout the skin and are most numerous in the palms of the hands, soles of the feet, axillae and groins. They are composed of epithelial cells. The bodies of the glands lie coiled in the subcutaneous tissue. Some ducts open onto the skin surface at tiny depressions, or pores, and others open into hair follicles.

Sweat Glands



Glands opening into hair follicles do not become active until puberty. In the axilla they secrete an odourless milky fluid, which if decomposed by surface microbes, causes an unpleasant odour.

Sympathetic nerves in response to raised body temperature and fear stimulate sweat glands.

The most important function of sweat secreted by glands opening on to the skin surface is in the regulation of body temperature. Evaporation of sweat from body surfaces takes heat from the body and the temperature-regulating centre in the hypothalamus governs the amount of sweat produced.

Excessive sweating may lead to dehydration and serious depletion of body sodium chloride unless intake of water and salt is appropriately increased. After 7 to 10 days' exposure to high environmental temperatures the amount of salt lost is substantially reduced but water loss remains high.

Functions Of The Skin

Protection

The skin forms a relatively waterproof layer that protects the deeper and more delicate structures. As an important non-specific defence mechanism.

It Acts As A Barrier Against:

- Invasion by microbes.
- Chemicals.
- Physical agents, e.g. mild trauma, ultraviolet light.
- Dehydration.

The dermis contains specialised immune cells called Langerhans cells. They phagocytose intruding antigens and travel to lymphoid tissue, where they present antigen to T-lymphocytes, thus stimulating an immune response.

Due to the presence of the sensory nerve endings in the skin the body reacts by reflex action to unpleasant or painful stimuli, protecting it from further injury.

Regulation of Body Temperature

The temperature of the body remains fairly constant at about 36.8°C across a wide range of environmental temperatures. In health, variations are usually limited to between 0.5 and 0.75°C, although it is raised slightly in the evening, during exercise and in women just after ovulation. When metabolic rate increases body temperature rises and when it decreases body temperature falls.

A constant temperature balance is maintained between heat produced in the body and heat lost to the elements.

Heat Production

Some of the energy released in the cells during metabolic activity is in the form of heat. The most active organs, chemically and physically, produce the most heat.

The Principal Organs Involved Are As Follows:

- *The muscles.* Contraction of skeletal muscles produces a large amount of heat and the more strenuous the muscular exercise the greater the heat produced. Shivering involves muscle contraction and produces heat when there is the risk of the body temperature falling below normal.
- *The liver* is very chemically active, and heat is produced as a by-product. Metabolic rate and heat production are increased after eating.
- *The digestive organs* produce heat during peristalsis and by the chemical reactions involved in digestion.

Heat Loss

Most of the heat loss from the body occurs through the skin. Small amounts are lost in expired air, urine and faeces.

Only the heat lost through the skin can be regulated to maintain a constant body temperature. There is no control over heat lost by the other routes.

Heat loss through the skin is affected by the difference between body and environmental temperatures, the amount of the body surface exposed to the air and the type of clothes worn. Air is a poor conductor of heat and when layers of air are trapped in clothing and between the skin and clothing they act as effective insulators against excessive heat loss.

A balance is maintained between heat production and heat loss. Control is achieved mainly by thermo-receptors in the hypothalamus.

Mechanisms of Heat Loss

- In *evaporation* (the body is cooled when sweat converts to water vapour).
- In *radiation* (exposed parts of the body radiate heat away from the body).
- In *conduction* (clothes and other objects in contact with the skin take up heat).
- In *convection* (air passing over the exposed parts of the body is heated and rises, cool air replaces it and convection currents are created).

Control of Body Temperature

Nervous Control

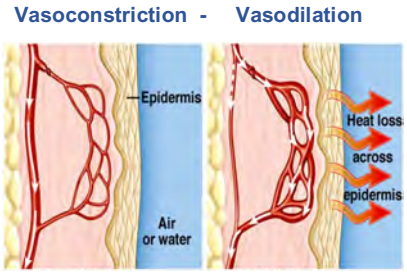
The *temperature regulating centre* in the hypothalamus is responsive to the temperature of circulating blood. This centre controls body temperature through autonomic nerve stimulation of the sweat glands.

The *vasomotor centre* in the medulla oblongata controls the diameter of the small arteries and arterioles, and therefore the amount of blood, which circulates in the capillaries in the dermis. The vasomotor centre is influenced by the temperature of its blood supply and by nerve impulses from the hypothalamus. When body temperature rises the skin capillaries dilate and the extra blood near the surface increases heat loss by radiation, conduction and convection. The skin is warm and pink in colour. When body temperature falls arteriolar constriction conserves heat and the skin is whiter and feels cool.

Activity of the Sweat Glands

When the temperature of the body is increased by 0.25 to 0.5°C the sweat glands are stimulated to secrete sweat, which is conveyed to the surface of the body by ducts. When sweat droplets can be seen on the skin the rate of production is exceeding the rate of evaporation. This is most likely to happen when the environmental air is humid and the temperature high.

Loss of heat from the body by unnoticeable evaporation of water through the skin and expired air occurs even when the environmental temperature is low. This is called *insensible water loss* (around 500 ml per day) and is accompanied by insensible heat loss.



Effects of Vasodilatation

The amount of heat lost from the skin depends to a great extent on the amount of blood in the vessels in the

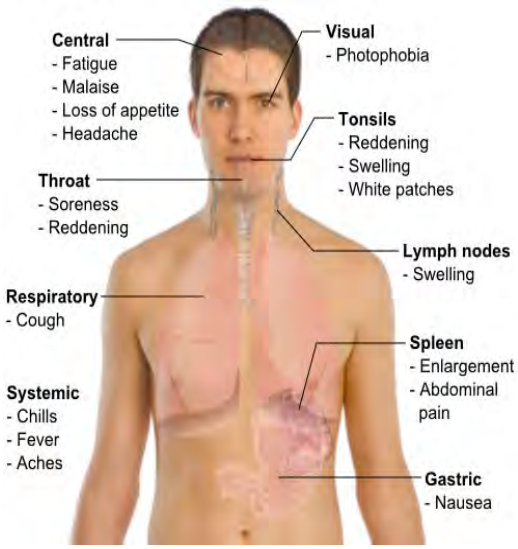
dermis. As heat production increases, the arterioles become dilated and more blood pours into the capillary network in the skin. In addition to increasing the amount of sweat produced the temperature of the skin is raised and there is an increase in the amount of heat lost by radiation, conduction and convection.

If the external environmental temperature is low or if heat production is decreased, vasoconstriction is stimulated by sympathetic nerves. This decreases the blood flow near the body surface, conserving heat.

Fever

This is often the result of infection and is caused by release of chemicals *(pyrogens)* from damaged tissue and the cells involved in inflammation. Pyrogens act on the hypothalamus, which releases prostaglandins that reset the hypothalamic thermostat to a higher temperature. The body responds by activating heat-promoting mechanisms, e.g. shivering and vasoconstriction until the new higher temperature is reached. When the thermostat is reset to the normal level, heat-loss mechanisms are activated. There is profuse sweating and vasodilatation accompanied by warm, pink (flushed) skin until body temperature falls to the normal range again.

Viral Fever



Hypothermia

This is present when core temperature, e.g. the rectal temperature, is below 35°C. At a rectal temperature below 32°C, compensatory mechanisms to restore body temperature usually fail, e.g. shivering is replaced by muscle rigidity and cramps, vasoconstriction fails to occur and there is lowered blood pressure, pulse and respiration rates. Mental confusion and disorientation occur.

Death usually occurs when the temperature falls below 25°C.

THE MUSCULO-SKELETAL SYSTEM 8.7

The Skeletal System 8.7.1

The skeletal system consists of bones and associated connective tissues, including cartilage, tendons and ligaments. The skeletal system provides a rigid framework for support and protection and provides a system of levers on which muscles act to produce body movements. The skeletal system contains 206 individual bones.

Bone Structure

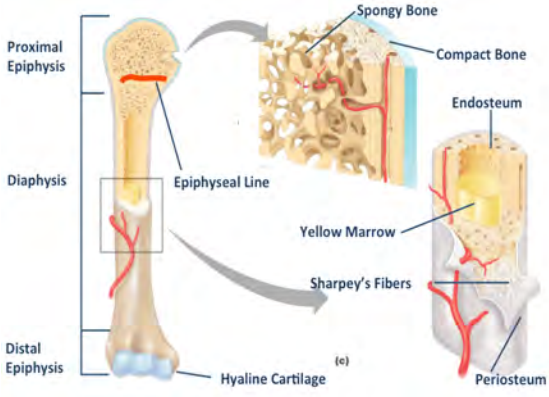
Bones are rigid organs that constitute part of the endoskeleton of vertebrates. They support and protect the various organs of the body, produce red and white blood cells and store minerals.

Bone tissue is a type of dense connective tissue. Bones come in a variety of shapes and have a complex internal and external structure, are lightweight yet strong and hard, and serve multiple functions.

One of the types of tissue that makes up bone is the mineralized osseous tissue, also called bone tissue that gives it rigidity and a coral-like three-dimensional internal structure.

Other types of tissue found in bones include marrow, endosteum, periosteum, nerves, blood vessels and cartilage.

Bone Structure



Bones Are Divided Into Two Categories:

- The axial skeleton.
- The appendicular skeleton.

Axial Skeleton

The Axial Skeleton Consists Of:

- The skull.
- The hyoid bone.
- The vertebral column.
- The thoracic cage.

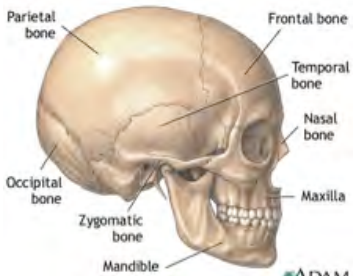
The Skull

The skull is composed of 28 separate bones divided into the following groups: the auditory ossicles, cranial vault, and facial bones. The 6 auditory ossicles (3 on each sides of the head) are located inside the cavity of the temporal bone. The auditory ossicles function in hearing.

The cranial vault consists of 6 bones that surround and protect the brain. They are the parietal, temporal, frontal, occipital, sphenoid, and ethmoid bones.

The 14 facials bones from the structure of the face in the anterior skull but do not contribute to the cranial vault. The bones include the maxilla, mandible, zygomatic, palatine, nasal, lacrimal, vomer, and inferior concha bones. The frontal and ethmoid bones contribute to both the cranial vault and the face.

The Skull



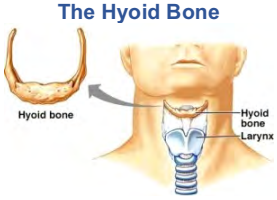
The Hyoid Bone

The hyoid bone is attached to the skull by muscles and ligaments and floats in the superior aspect of the neck, just below the mandible. The hyoid bone serves as the attachment point for several important neck and tongue muscles.

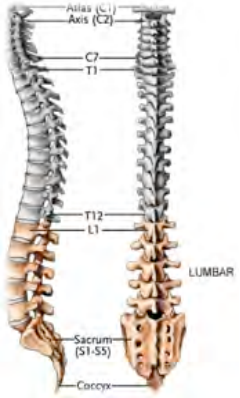
The Vertebrae

The vertebral column consists of 26 bones, which can be divided into five regions: 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, 1 sacral bone, and 1 coccygeal bone. A total of 34 vertebrae originally from during development, but the 5 sacral vertebrae fuse to form 1 bone, as do the 4 or 5 coccygeal bones.

The Hyoid Bone



The Vertebral Column



The weight-bearing portion of the vertebrae is a bony disk called the body. Intervertebral disks, located between the bodies of adjacent vertebrae, serve as shock absorbers for the vertebral column, provide additional support for the body, and prevent the vertebral bodies from rubbing against each other.

The vertebral arch and the dorsal portion of the body protect the spinal chord. A transverse process extends laterally from each side of the arch, and a single spinous process is present at the point of junction. Much vertebral movement is accomplished by the contraction of skeletal muscles attached to the transverse and the spinous processes.

The Thoracic Cage

The thoracic cage protects vital organs within the thorax and prevents the collapse of the thorax during respiration. It consists of the thoracic vertebrae, ribs with their associated costal cartilages, and sternum.

The 12 pairs of ribs can be divided into true or false ribs. The superior 7 (the true ribs) articulate with the thoracic vertebrae and attach directly through their costal cartilages to the sternum. The inferior 5 (the false ribs) articulate with the thoracic vertebrae but do not attach directly to the sternum. The eight, ninth, and tenth ribs are joined to a common cartilage, which is attached to the sternum. The eleventh and twelfth ribs are “floating” ribs that have no attachment to the sternum.

The Thoracic Cage

The sternum is divided into three parts: the manubrium, body, and xyphoid process. At the superior margin of the manubrium is the jugular notch, witch can easily be palpated at the anterior base of the neck. The point at which the manubrium joins the body of the sternum is the sternal angle. The second rib is found lateral to the sternal angle and is used clinically as starting point for counting the other ribs.

Appendicular Skeleton

The Appendicular Skeleton Consists Of The:

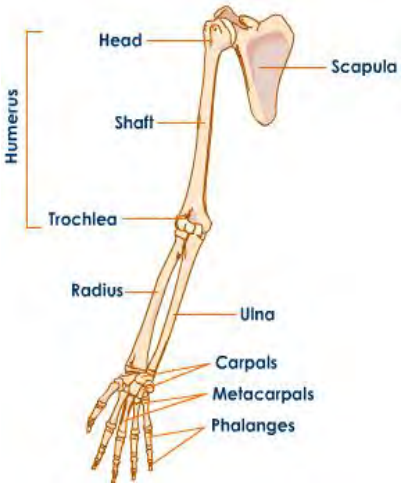
- Upper extremities.
- Lower extremities.
- And their girdles (by which they are attached to the body).

The Upper Extremities

The scapula and clavicle constitute the pectoral girdle, which attaches the upper limbs to the axial skeleton. The direct point of attachment between the bones of occurs at the sterno-clavicular joint between the clavicle and the sternum.

The humerus is the second longest bone in the body. The head of the humerus articulates with the scapula the greater and the lesser tubercles are on the lateral and anterior surfaces of the proximal end of the humerus, where they function as sites of muscles attachment. The humerus articulates with the radius and the ulna at its distal end. The capilatulum (lateral aspect of the humerus) articulates with the head of the radius, and the trochlea (medial aspect of the humerus)

The Upper Extremities



articulates with the ulna. Proximal to the trochlea and capitulum are the medial and lateral epicondyles, respectively, which function as muscles attachments for the muscles of the forearm.

The large bony process of the ulna (the olecranon process) can be felt at the point of the elbow. This process fits in a large depression on the posterior surface of the humerus known as the olecranon fossa. The structural relationship between these two processes makes movement of the joint possible. The distal end of the ulna has a small head that articulates with the radius and the wrist bones. The posterior medial side of the head has a small stilloid process to which the ligament of the wrist is attached. The proximal end of the radius articulates with the humerus, and the medial surface of the head constitutes a smooth cylinder where the radius rotates against the radial notch of the ulna. Major anterior arm muscles (biceps brachii) are attached to the radial tuberosity.

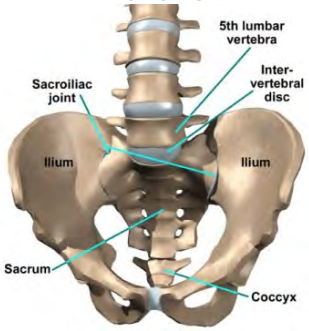
The wrist is composed of 8 carpal bones, which are arranged in two rows of 4 each. A total of 5 metacarpals are attached to the carpal bones and constitute the bony framework of the hand.

A total of 28 phalanges make up the 10 digits of the hands. There are two phalanges for each thumbs and 3 for each finger.

The Lower Extremities

The pelvic girdle attaches the leg to the trunk. The girdle consists of two coxa (hip bones), one located on each side of the pelvis. Each coxa surrounds a large obturator foramen, through which muscles, nerves and blood vessels pass to the leg. A fossa called the acetabulum is located on the lateral surface of each coxa and is the point of articulation of the lower limb with the girdle. During development, each coxa is formed by the fusion of 3 separate bones: the ilium, ischium and pubis. The superior portion of the ilium is the iliac crest. The crest ends anteriorly as the anterior-superior iliac spine and posteriorly as the superior-posterior spine.

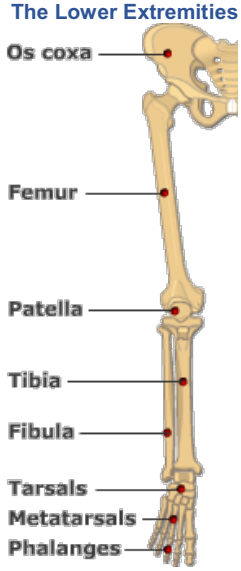
The Pelvis



The femur is the longest bone in the body. It has a well-defined neck and a prominent rounded head that articulates with the acetabulum. The proximal shaft has 2 tuberosities: a great trochenter lateral to the neck and a smaller or lesser trochenter inferior and posterior to the neck. Both trochenters are attachment sites for muscles that attach the hip to the thigh. The distal end of the femur has medial and lateral condyles that articulate with the tibia. Located laterally and proximally to the condyles are the medial and lateral epicondyles, which are sites of muscle and ligament attachment.

Distally, the femur also articulates with the patella, which is located in a major tendon of the thigh muscle. The patella allows the tendon to turn the corner over the knee.

The Lower Extremities



The 2 bones of the lower leg are the tibia and the fibula.

The tibia is the largest of the 2 and supports most of the weight of the leg. A tibial tuberosity can be seen and palpated just inferior to the patella. The proximal end of the tibia has flat medial and lateral condyles that articulate with the condyles of the femur. The distal end of the tibia forms the medial malleolus, which helps to form the medial side of the ankle joint.

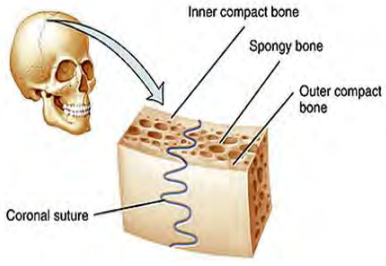
The foot consists of 7 bones. The talus articulates with the tibia and the fibula to form the ankle joint. The calcaneus is located inferior and jus lateral to the talus, supporting the bone. It protrudes posteriorly where the calf muscles attach to it and easily identified as the heel.

The foot consists of tarsals, metatarsals, and phalanges, which are arranged in a manner similar to the metacarpals and phalanges of the hand, the great toe being analogous to the thumb. The ball of the foot is the junction between the metatarsals and the phalanges. Strong ligaments and leg muscles tendons normally hold the foot bones firmly in their arched position.

Joints

With the exception of the hyoid bone, every bone in the body connects to at least 1 other bone. The connections or joints commonly are named according to the bones or portions of the bones that are united at the joint.

Fibrous Joints



The Three Major Classifications Of Joints Are:

- Fibrous.
- Cartilaginous.
- Synovial.

Fibrous Joints

Fibrous joints consists of 2 bones united by fibrous tissue that have little or no movement. The joints are further divided on the basis of structure into sutures, syndesmosomes, or gomphoses. Structures (seams between flat bones) are located in the skull bones and may be completely immobile in adults. In newborns, the sutures have gaps between them, called fontanelles; these gaps are fairly wide to allow give to the skull during birth and allow growth of the head during development.

A syndesmosis is a fibrous joint in which the bones are separated by a greater distance than in a suture and are joined by ligaments. These ligaments may provide some movement of the joint. An example of these joints is the radioulnar syndesmosis that binds the radius and the ulna together.

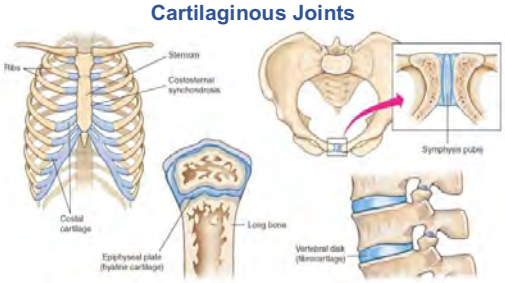
A gomphosis joint consists of a peg that fits into a socket. The peg is held in place by fine bundles of collagenous connective tissue. The joints between the teeth and the sockets along the processes of the mandible and maxillae are examples of gomphoses joints.

Cartilaginous Joints

Cartilaginous joints unit two bones by means of hyaline cartilage (synchondrose) or fibrocartilage (symphyses). A synchondrosis allows only slight movement at the joint. Common examples of this type of joint are epiphysial plate of a growing bone and the cartilage rod between most of the ribs and the sternum.

Symphyses joint are slightly moveable because of flexible nature of the fibrocartilage. Symphyses include the junction between the manubrium and the body of the sternum in adults, the symphisis pubis of the coxae, and the Intervertebral disks.

Cartilaginous Joints



Synovial Joints

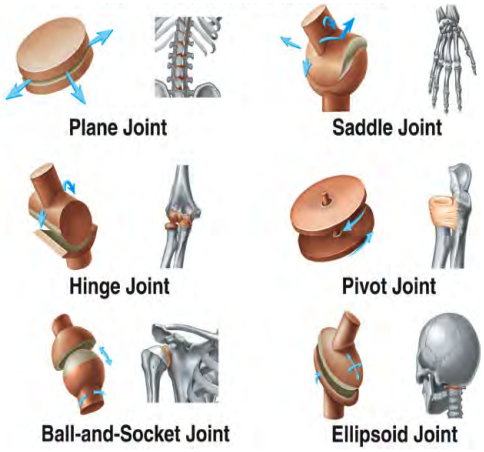
Synovial joints contain synovial fluid, a thin, lubrificating film that allows considerable movement between articulating bones. Most joints that unite the bones of the appendicular skeleton are synovial. The articular surfaces of bones within synovial joints are covered with a thin layer of hyaline cartilage, which provides a smooth surface where the bones meet. The joint is enclosed by a joint capsule, which consists of an outer fibrous capsule and an inner synovial membrane.

The synovial membrane lines the joint and produces synovial fluid.

Synovial Joints Are Classified Into Six Divisions According To The Shape Of The Adjoining Articular Surfaces:

- Plane or gliding joints (consist of two opposed flat surfaces that are about equal in size. Examples of these joints are the articular processes between vertebrae).
- Saddle joints (consist of two saddle-shaped articulating surfaces oriented at right angles to one another. Movement in these joints can occur in two planes. An example of saddle joint is the carometacarpal joint of the thumb).
- Hinge joints (consist of a convex cylinder in one bone applied to a corresponding concavity in another bone. These joints permit movement in one plane only. Examples of hinge joints are those of the elbow and the knee).
- Pivot joints (consist of a relatively cylindrical bony process that rotates within a ring composed partly of bone and partly of ligament. An example of pivot joint is the head of the radius articulating with the proximal end of the ulna).
- Ball-and-socket joints (consist of a ball (head) at the end of one bone and a socket into an adjacent bone into which a portion of the ball fits. These joints allow wide ranges of movement in almost any direction. Examples are the shoulder and the hip joints).
- Ellipsoid joints (modified ball-and-socket joint where the articular surfaces are ellipsoid. The shape of the joint limits the movement, making it similar to a hinge motion, but the motion occurs in two planes. The atlantooccipital joint is an ellipsoid joint).

Sinovial Joints

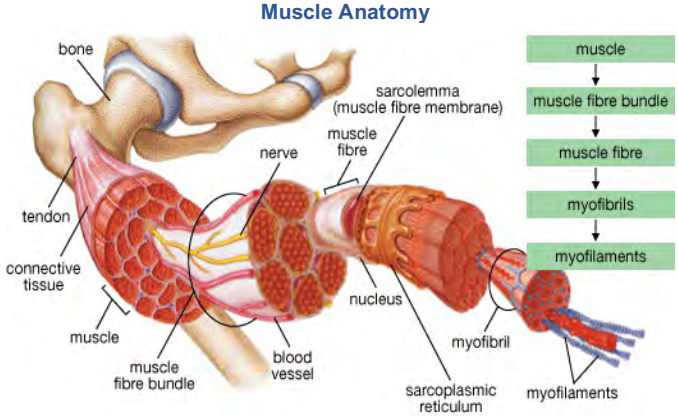


The Muscular System 8.7.2

Muscle comprises of approximately 40% of the bodys total bio-mass.

Muscle cells contain protein filaments that slide past one another, producing a contraction that changes both the length and the shape of the cell. Muscles function to produce force and cause motion. They are primarily responsible for maintenance of and changes in posture, locomotion of the organism itself, as well as movement of internal organs, such as the contraction of the heart and movement of food through the digestive system via peristalsis.

Muscle Anatomy



The Three Primary Functions Of The Muscular System Are:

- Movement.
- Postural maintenance.
- Heat production.

The major types of muscles are skeletal, cardiac, and smooth muscle. Skeletal muscle is far more common than other types of muscles in the body and is the focus of this section.

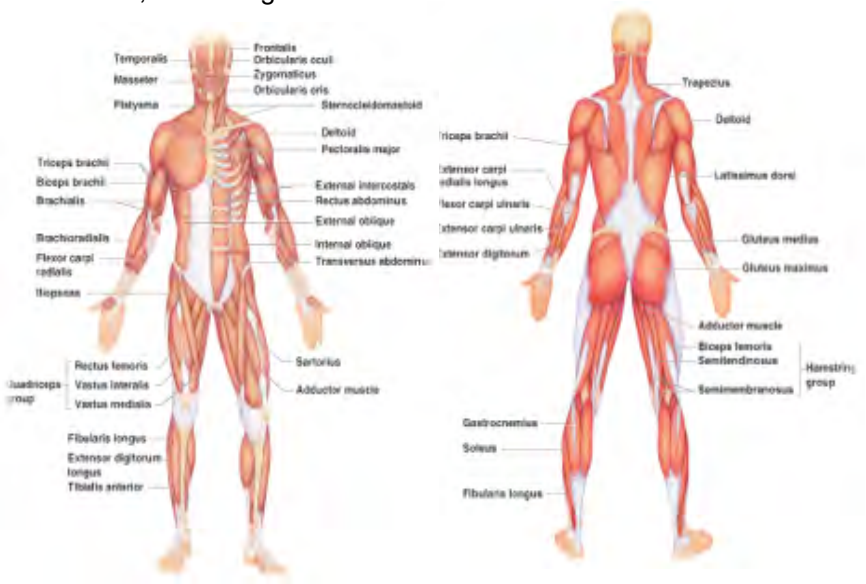
Physiology Of Skeletal Muscle

Muscle tissue consists of specialized contractile cells or muscle fibers. Skeletal muscle contracts in response to electrochemical stimuli. Nerve cells regulate the function of skeletal muscle fibres by controlling the series of events that result in muscle contraction.

Each skeletal muscle fiber is filled with thick and thin myofilaments, which are fine, threadlike structures. The thick myofilaments are formed from the protein myosin, and the thin myofilaments are composed of the protein actin.

The sarcomere is the contractile unit of skeletal muscle, containing thick and thin myofilaments.

During the contraction process, energy obtained from ATP molecules enables the two types of myofilaments to slide toward each other and shorten the sarcomere and eventually the entire muscle.



Neuromuscular Junction

A nervous impulse enters the muscle fiber through a specialized nerve known as the motoneuron. The point of contact between the nerve ending and the muscle fiber is the neuromuscular junction or synapse. Each muscle fiber receives a branch of an axon, and each axon innervates more than a single muscle fiber. When a nerve impulse passes through this junction, specialized chemicals are released, causing the muscle to contract.

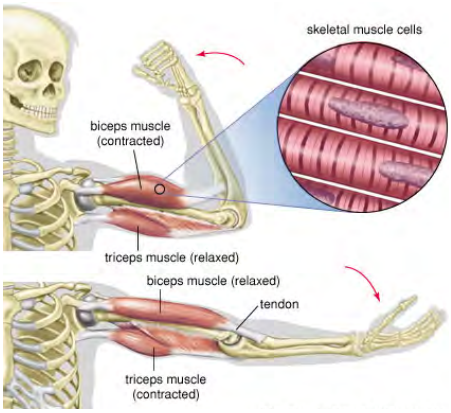
Skeletal Muscle Movement

Most muscles extend from one bone to another and cross at least one joint. Muscles contraction causes most body movement by pulling one of the bones toward the other across the moveable joint. The points of attachment of each muscle are the origin and insertion. The origin is the end of the muscle attached to the more stationary of the two bones. The insertion is the end of the muscle attached to the bone undergoing the greatest movement.

Some muscles of the face are not attached to bone at both ends but attach to the skin, which moves when muscles contract.

The contraction of some muscles with the simultaneous relaxation of others produces movement. Muscle that work in cooperation with one other to cause movement are called synergist, and a muscle working in opposition to another muscle (moving the structure to an opposite direction) is called an antagonist.

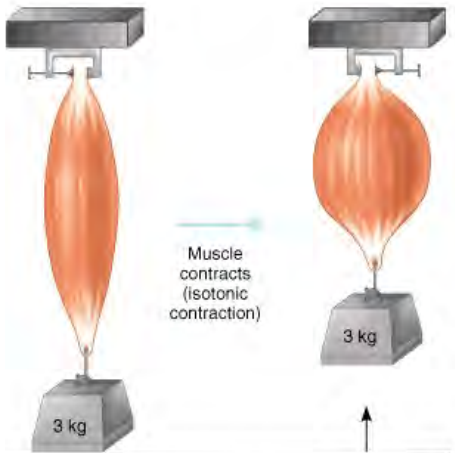
Muscle Movement



The muscle that is primarily responsible for a particular movement is called the prime mover. For example, the biceps brachii, brachialis, and triceps brachii muscles are all involved in flexion and extension of the forearm at the elbow joint. The biceps brachii is the prime mover during flexion, and the brachialis is the synergic muscle.

When the biceps brachii and the brachialis muscles flex the forearm, the triceps brachii relaxes (antagonistic muscle). During extension of the forearm, the triceps brachii becomes the prime mover, and the biceps and the brachialis become the antagonisic muscles. The coordinated activity of synergists and antagonists is what makes muscular movement smooth and gracefull.

Muscle Contaction (Isometric)



Types Of Muscle Contraction.

Muscle contractions are classified as either isometric or isotonic, depending on the type of contraction that predominates. In isometric contractions, the length of the muscle does not change, but amount of tension increases during the contraction process. Isometric contractions are responsible for the constant length of the postural muscles of the body.

During isotonic contractions, the amount of tension produced by the muscle is constant during contraction, but the length of the muscle changes. An example of isotonic contraction is the movement of the arms or fingers. Most muscle contractions are a combination of isotonic and isometric contractions.

Section 9

Glossary

GLOSSARY 9

Abdomen
The portion of the body between the thorax and the pelvis containing the majority of the organs of digestion as well as the liver and spleen.

Abduction
Movement away from the midline of the body.

Acidosis
The condition of an excess concentration of hydrogen ions in the body. (This is the opposite of alkalosis.) This may be as a result of either a metabolic problem or a respiratory problem. Treatment relies on correcting the cause of the imbalance.

Actual Consent
Consent by the adult patient, usually in oral form, accepting emergency care. This must be informed consent.

Acute
To have a rapid onset. Sometimes used to mean severe.

Acute Myocardial Infarction (AMI)
Heart attack. The sudden death of heart muscle due to oxygen starvation. Usually caused by a narrowing or blockage of coronary artery supplying the myocardium.

Acute hypoxia
Sudden fall in oxygen concentration within the blood stream. It may be caused by airway obstruction, lung failure or cardiac failure. Signs may be subtle such as confusion or more obvious such as acute loss of consciousness

Adipose
Nature of fat.

Adduction
Movement toward to midline of the body.

Airway
The passage allowing free movement of air into and out of the lungs. The term is also used to describe clinical devices for maintenance of a patent airway; these may range from simple devices such as Guedel airways to endotracheal tubes.

Alveoli
Microscopic air sacs of the lungs where gas exchange takes place with the circulatory system.

Alkalosis
The condition of a decrease in the body's concentration of hydrogen ions or an increase in bicarbonate ions. Like acidosis, this may be caused by respiratory (hyperventilation) or metabolic causes (the ingestion of excess bicarbonate or loss of excess gastric acid following vomiting).

Allergy
Abnormal sensitivity to normally harmless antigens. In the severest form this may result in an anaphylactic reaction.

Amputation
The loss of a digit, limb or appendage, either deliberately (surgically) or as a result of trauma.

Anatomical Position
Standard reference position for the body in the study of anatomy. The body is erect, facing the observer. The arms are down at the sides and the palms of the hands face forward.

Aneurysm
Blood filled sac caused by the localised dilation of an artery or vein. The dilated or weakened section of an arterial wall.

Angina Pectoris
Chest pains often caused by an insufficient blood supply to the heart muscle.

Anoxia
Absence of oxygen. See Hypoxia.

Anorexia Loss of appetite.

Anterior
Front surface of the body or body part.

Antiseptic
Substance that will stop the growth of, or prevent the activities of germs (micro organisms).

Anaemia
An abnormally low haemoglobin concentration in the blood.

Analgesic
A pain-relieving drug.

Anaphylactic reaction
An extreme reaction to an allergen characterised by release of histamine from cells of the immune system and resulting in generalized itching, angi-oedema, collapse, tachycardia, bronchospasm and (in the worst cases) death.

Anterior
In front of or at the forward limits of the body.

Antibiotic
A drug with antibacterial actions.

Antigen
A substance, usually a protein, the body regards as foreign and against which it produces an antibody in an attempt to render the antigen harmless.

Aorta
Major artery of systemic circulation that carries blood from the heart.

Apnoea
Suspension of breathing.

Arrhythmia
Disturbance of heart rate and rhythm.

Artery
Blood vessel supplying tissues with oxygenated blood.

Aseptic
Clean, free of particles of dirt and debris, but not necessarily sterile.

Astringent
An agent causing contraction of organic tissue.

Asphyxia
Loss of consciousness caused by too little oxygen reaching the brain. The functions of the brain, heart, and lungs will cease.

Atrium
Superior chamber of the heart. (Plural-atria).

Avulsion
Piece of tissue or skin that is torn loose or pulled off by injury.

Auscultation
Listening and interpreting sounds as heard through the stethoscope.

Axilla
The armpit.

Bacteriostatic
Inhibiting the growth of bacteria.

Blanch
Become pale.

Blood pressure (BP)
The pressure exerted by the circulating blood on the arteries as it is pumped around the circulation.

Brachial Pulse
Pulse produced by compressing the major artery of the upper arm. Used to detect heart action and circulation in infants.

Bradycardia
Abnormal condition where the heart rate is very slow. The pulse rate will be below 50 beats per minute.

Bronchiole
Small branches of the airway that carry air to and from the alveoli.

Bronchus
The division of the trachea leading down to the alveoli; the two first divisions after the trachea are known as the right and left main bronchi.

Burn
An injury caused by extremes of temperature – hot or cold. Classified as full-thickness or partial-thickness, depending how deep is the extent of tissue damage. Other causes of burns include chemicals and electricity

Cannula
Hollow tube that can be inserted into a cavity to allow for fluid to be introduced or removed.

Capillary
Microscopic blood vessel where exchange takes place between bloodstream and body tissues.

Carbon Dioxide Retention
An increase in the concentration of carbon dioxide within the blood stream, often secondary to respiratory failure.

Carbon monoxide (CO)
A colourless, odourless gas. It has the ability to combine with haemoglobin in an almost irreversible manner, displacing oxygen and causing hypoxia of the tissues.

Cardiac
Refers to the heart.

Carotid arteries
The two major arteries that can be felt in the neck giving arterial supply to the face and brain.

Cardiac output
The volume of blood pumped out by the heart in one minute. It is derived from the stroke volume (the amount of blood pumped per heartbeat) multiplied by heart rate.

Cardiogenic Shock
Failure of the cardiovascular system brought about when the heart can no longer develop the pressure needed to circulate blood to all parts of the body.

Cardiopulmonary Resuscitation
The re-establishment of the heart and lung action, by artificial ventilation and external cardiac compression.

Cardiovascular
Concerning the heart & blood vessels.
Catheter - flexible tube passed through body channels to allow for the drainage or withdrawal of fluids.

Cephalic
Refers to the head.

Cerebral oedema
An increase in the fluid around the cells in brain tissue with resultant swelling. A number of causes include head injury (the most common). It may present with signs of raised intracranial pressure owing to the closed nature of the skull.

Cerebrospinal Fluid
Clear watery fluid that helps to protect the brain and spinal cord.

Cervical
Relating to the neck or to the interior end of the uterus.

Chin-lift
A manoeuvre to open the airway by pulling forward the point of the chin.

Chronic
Opposite of acute. It can be used to mean long and drawn out or recurring.

Clavicle
(The Collar bone) The supporting bone articulating between the scapula and the sternum.

Clonic Phase
Second phase of a convulsion seizure, with the patient exhibiting violent body jerks, drooling, and possible cyanosis. Most convulsions last 1 to 2 minutes

Coccyx
Lowermost bones of the vertebral column. They are fused into one bone in the adult.

Coagulopathy
An abnormal condition characterised by a decreased ability of the blood to clot. In trauma, this may be caused by continual bleeding and an inadequate replacement of coagulation factors after large blood loss.

Coma
Deep unconsciousness with no response to vocal or painful stimuli and absence of spontaneous eye movement.

Comminuted Fracture
Fracture where the bone is fragmented or turned to powder.

Concussion
State of stupor or temporary unconsciousness caused by a blow to the head. There is no laceration or bleeding in the brain.

Conjunctiva
The membrane that lines the eyelids and the sclera of the eye.

Contraindicated
Condition, sign, or symptom that makes a particular course of treatment or procedure inadvisable.

Contrecoup
The head injury sustained on the opposite side of the head to the site of the blow. It results from the movement of the soft brain against the cranium on the opposite side.

Contusion
Bruise. The simplest form of closed wound where blood flows between tissues causing a discolouration.

Convulsion
Uncontrolled muscle spasm, often violent.

Core Temperature
Body temperature measured at a central point, such as within the rectum.

Cornea
Transparent covering over the iris and pupil of the eye.

Coronary
Refers to the blood vessels that supply blood to the heart muscle. Many people use this term to mean heart attack.

Cranium
Braincase of the skull. Many people use the term skull when they mean cranium.

Crepitus
Grating noise or the sensation felt. Caused by the movement of broken bone ends rubbing together. Also a crackling sound.

Crowing
A typical sound made when a patient breathes. It usually indicates airway obstruction.

Cutaneous
Pertaining to the skin.

Cyanosis
The blue colour seen at the periphery or centrally caused by the inadequate oxygenation of blood, which thus contains too much deoxyhaemoglobin which has a bluish colour.

Dead space
The area of the lung that is in contact with oxygen but is not being perfused with blood; also applied to the volume of air that is contained within the trachea and the bronchi which never reaches the gas exchange surface.

Diaphragm
The musculotendinous sheet that separates the thoracic cavity from the abdominal cavity.

Diastole
The period of time during the cardiac cycle when the heart is relaxed and blood enters the atria or ventricles.

Diastolic Pressure
Pressure exerted on the internal walls of the arteries when the heart is relaxing.

Dilation
To enlarge, expanding in diameter.

Disinfect
To destroy harmful microorganisms, but not necessarily their resistant spores.

Dislocation
Displacement (pulling out) of a bone end that forms part of a joint.

Distal
Away from a point of reference, such as the shoulder or the hip joint. More distant to.

Distended
Inflated, swollen or stretched.

Dysphasia
Difficulty in speaking, due to a brain leasion.

Dyspnea
Difficult or laboured breathing.

Electrocardio-Gram (ECG)
A trace of the electrical activity of the heart normally taken as 12 differing views of the heart. Used to diagnose abnormalities of the heart such as arrhythmias and myocardial infarction.

Embolism
Movement and the lodgement of a blood clot or foreign body (fat or air bubble) inside a blood vessel. The foreign body is called an embolus.

Emergency Medical Technician (EMT)
Professional level provider of emergency care. This individual has received formal training and is state certified.

Emphysema
The abnormal presence of air in tissues or cavities of the body.

Epidermis
Protective structure that overhangs the larynx and hinges backwards during swallowing to prevent food entering the larynx.

Epiglottis
Flap of cartilage and other tissues that is the superior structure of the larynx. It closes off the airway and diverts solids and liquids down the esophagus.

Epistaxis
Nosebleed.

Eructation
Belching. The escape of gas from the stomach, through the mouth.

Erythema
A superficial redness of the skin.

Esophagus
Muscular tube leading from the pharynx to the stomach.

Eustachian Tube
The tube connecting the middle ear to the throat.
Fainting - simple form of shock, occurring when the patient has a temporary, self-correcting, loss of consciousness caused by a reduced supply of blood to the brain. Also called psychogenic (SI- ko-JEN-ic) shock.

Extradural
Literally, outside the dura; particularly refers to the cerebral bleed associated with a temporal fracture where the middle meningeal artery bleeds into the extradural space compressing the cerebral substance.

Femur
The thigh bone.

Fibrillation
Uncoordinated contractions of the myocardium resulting from independent individual muscle fibre activity.

Fibrin
Fibrous protein material formed and utilized to produce a blood clot.

Fibula
Lateral leg bone. Flexion - bending. To lessen the angle of a joint.

Flail chest
A chest wall that as a result of trauma has two rows of multiple rib fractures leading to paradoxical movement.

Flexion
Movement between two bones, generally in a direction to decrease the angle between them.

Fracture
An injury to the bone at which the continuity of the bone is broken. There are a variety of classifications, but one important feature of note is whether the skin has been broken over the fracture site (compound or open fracture) or not (closed).

Gastro
Used as a beginning of words in reference to the stomach.
Genitalia Uen-i-TA-le-ah) - external reproductive organs.

Greenstick Fracture
Split along the length of a bone, giving the appearance of a green stick bent to its breaking point.

Gag reflex
The reflex occurring in response to irritation of the pharynx.

Gangrene
Death of tissue, often due to inadequate blood supply as the main cause, though a variety of other conditions such as cold injury may also cause gangrenous changes. Often divided into wet or dry gangrene: typically, wet gangrene follows major tissue damage such as crush injury.

Glasgow Coma Scale (GCS)
A swift method for assessing and monitoring the conscious level of a patient. It is based on the eye response, the verbal response and motor response.

Guarding
The contraction of the abdominal muscles to protect a painful area from the pressure of an examining hand.

Haematuria
Passage of blood in the urine.

Haematoma
A collection of blood within the tissues; this may be as a direct result of trauma or of surgery.

Haemoglobin (HB)
The red pigment found in red blood cells that is responsible for the carriage of oxygen around the body.

Haemoptysis
Coughing up blood from the lung.

Haemorrhage
The loss of blood – a term normally referring to rapid loss of a large quantity of blood either internally or externally.

Haemothorax
The filling of a pleural cavity with blood, usually after trauma to the chest or following thoracic surgery.

Hemiparesis
Paralysis on one side of the body.

Hemiplegia
Paralysis of one half of the body. The lesion is on the side of the brain opposite to the side paralised.

Hepatic/hepato
Pertaining to the liver.

Hyper-
Prefix meaning increased.

Hyperthermia
Greatly increased body temperature.

Hyperventilation
Increased rate and depth of breathing.

Hypervolaemia
A larger than required circulating volume, generally the result of overtransfusion, though overdrinking (particularly in the presence of reduced renal function) may also give rise to it.

Humerus
Arm bone.

Hypercapnia
An increased amount of carbon dioxide in the blood.

Hyperglycaemia
Excess of sugar in the blood.

Hypertension
Above normal blood-pressure.

Hypo -
Prefix meaning low or inadequate.

Hypoglycaemia
The blood sugar level is less than normal.

Hypotension
A low blood pressure which is inadequate for perfusion of the vital organs. This may be as a result of abnormalities of the heart, side effects of drugs in excess or loss of circulating fluid (for example bleeding).

Hypothermia
A pathologically low body temperature (normally defined as below 35°C), most frequently due to exposure to cold conditions.

Hypovolaemic shock
The state of inadequate perfusion (and therefore oxygenation of the tissues) due to a fall in the circulating volume (usually due to blood loss) and a subsequent fall in blood pressure. Excessive loss of body fluids due to other causes (for example, diarrhoea) can also occasionally cause this.

Hypoxaemia
Low level of oxygen in the blood.

Hypoxia
A fall in the concentration of oxygen in cells. This may result from inadequate oxygenation due to a decrease in atmospheric oxygen, inadequate respiration (due to a reduction in the respiratory drive, an obstruction of the respiratory tract or lung injury) or inadequate circulation (for example, shock).

Infarction
Localized death of tissue resulting from the discontinuation of its blood supply.

Inferior
Away from the top of the body. Usually compared with another structure which is closer to the top (superior).

Infra -
Prefix meaning below or beneath.

Inter-
Prefix meaning between.

Intra -
Prefix meaning within.

Intravenous (IV)
Into a vein (administration of fluid or drugs.

Ischaemia
An inadequate flow of blood to part of the body, caused by constriction or blockage of the blood vessels supplying it.

Jaw-thrust
A manoeuvre to open the airway by pushing the mandible forward, normally with the fingers behind the angle of the mandible.

Joint
A junction between two bones. This may be classified in a number of ways, for example by its structure (for example, a ball and socket joint such as the hip) or by its type (for example, fibrous, cartilaginous or synovial).

Jugular
Pertaining to the neck (for example, jugular vein, the major vein running on the right and left of the neck alongside the carotid artery draining blood from the face and head).

Laceration
Jagged edged open wound. See cut.

Lactic acid
One of the waste products of protein and carbohydrate metabolism. It may accumulate in certain conditions to cause a metabolic acidosis.

Laparotomy
Surgical exploration of the abdominal cavity.

Larynx
Airway situated between the pharynx and the trachea. The voice box.

Laryngo-
Relating to the larynx.

Lateral
To the side, away from the midline of the body.

Ligament
Fibrous tissue that connects bone to bone.

Log roll
Manoeuvre to move a casualty to expose the back but maintaining in-line stability of the whole spine.

Lumbar
(Latin *lumbus*, the loin) General term referring to the lower back between the thorax and the pelvis, (for example, lumbar spine).

Lumbar Spine
Vertebrae of the lower back, consisting of 5 bones.

Malleolus
(Latin, a little hammer) Rounded, bony protuberances found on the inner (medial) and outer (lateral) aspect of the ankles.

Medial
Toward the vertical midline of the body.

Mediastinum
Central portion of the chest cavity (thoracic cavity) containing the heart, its greater vessels, part of the esophagus, and part of the trachea.

Meninges
Three membranes surrounding the brain and spinal cord.

Metabolic Shock
State of shock due to a loss of body fluids (dehydration) and a change in body chemistry.

Metacarpals
Hand bones.

Metatarsals
Foot bones.

Myocardium
Heart muscle.

Narcotic
A drug that has pain-relieving properties and causes sleep.

Necrosis
The death of tissue, often due to ischaemia.

Neurogenic Shock
Caused when the nervous system fails to control the diameter of the blood vessels. The vessels remain widely dilated, providing too great a volume to be filled by available blood.

Nystagmus
An involuntary, rapid movement of the eyeball.

Oedema
An abnormal collection of fluid around tissue and cells or within tissue spaces.

Oesophagus
The muscular structure that carries food from the oropharynx to the stomach, linking the two structures.

Open Pneumothorax
The collapse of a lung with entry of air into the pleural space and direct communication of the pleural space with the external environment. Also known as a 'sucking' chest wound.

Ophthalmo-
Relating to the eye.

Opiates / opioids
Morphine and related drugs which may be used for pain relief. They have a tendency to cause respiratory depression and nausea. They maybe administered subcutaneously, intramuscularly or intravenously.

Oropharyngeal Airway
Curved breathing tube inserted into the patient's mouth. It will hold the base of the tongue forward.

Osteo-
Relating to bone or bony.

Oxygen (O_2)
A colourless and odourless gas which is vital for cellular metabolism. In conditions of shock and respiratory deficiency its supplementation forms an important part of therapy.

Palpation
To examine a casualty by feeling with the hand(s).

Pancreas
A large glandular retroperitoneal structure lying across the posterior midline of the abdomen.

Paradoxical breathing
Generally associated with traumatic damage to the chest, resulting in instability of the chest wall such that on inspiration the chest wall collapses in and the lung fails to expand.

Paraesthesia
Disorder of sensation, e.g. a feeling of tingling or as of pins & needles.

Paraplegia
Spinal lesion. From lesion below total paralysis.

Paralysis
No power or sensation or movement of any part.

Patella
Kneecap.

Penetrating Wound
Puncture wound with only an entrance wound.

Perforating Wound
Puncture wound with an entrance and an exit.

Perfusion
The passage of blood through a tissue at a rate adequate to supply it with necessary nutrients and remove toxic metabolites.

Peri-
Prefix meaning around.

Pericardium
The sac that surrounds the heart.

Peritoneum
The lining membrane of the abdominal cavity, enfolding all the abdominal cavity. Organs in the abdomen may be within the peritoneal cavity or retroperitoneal (behind the peritoneal cavity): examples of the latter are the kidneys and pancreas.

Peritonitis
Inflammation of the abdominal cavity due to bacterial, chemical or other causes. The most common causes include appendicitis, perforation of an ulcer or perforation of the small or large bowel.

pH
The measure of acid and base balance within the body. It is a measure of the concentration of hydrogen ions present in the blood (the log of the reciprocal of the hydrogen ion concentration). Normal body pH is 7.4. In cases of acidosis (metabolic or respiratory) the pH falls. In alkalotic conditions (metabolic or respiratory alkalosis) the pH rises.

Pharynx
The throat. It is divided into the nasal cavity (nasopharynx), the oral cavity (oropharynx) and the larynx (laryngopharynx).

Plasma
Fluid portion of the blood. It is blood minus blood cells and other structures (formed elements).

Platelet
Formed elements of the blood that release factors needed for form blood clots.

Pleura
The lining tissue that coats the inside of the thoracic cavity, the mediastinal contents and the lungs, allowing movement of the lungs relative to the thoracic wall.

Pneumothorax
A collection of air within the pleural space leading to collapse of the lung. This may be caused by a spontaneous leak from the lung or from perforation of the thoracic wall, (for example, in stabbing). When a leak exists with a 'one-way valve' effect, the pressure of the pneumothorax may increase, leading to distortion of the mediastinum, decreased venous return and collapse: this is known as a tension pneumothorax.

Postero-
Prefix meaning back.

Posterior
Back.

Pre -
Prefix meaning in front of.

Pro-
Prefix meaning before.

Proximal
Usually referring to a point on a limb which is closer to the trunk than another point, (for example, the elbow is more proximal than the fingers).Close to a point of reference such as the shoulder or hip joint. Used with distal, meaning away from.

Prone
Lying face down.

Psychogenic Shock
See fainting.

Pulmonary
Pertaining to the lungs and respiratory system.

Pulmonary Circulation
Circuit of blood travelling from the right ventricle of the heart to the lungs and returning to the left atrium.

Pulmonary Oedema
The accumulation of excess fluid, firstly within the interstitial tissues of the lung and in severe cases within the actual alveoli of the lungs. Most commonly caused by congestive cardiac failure, though also associated with other acute conditions such as following acute head injury, near drowning and following inhalation injuries.

Pulse
The expansion and contraction of an artery as a result of the intermittent flow of arterial blood; can be detected by palpation or other means.

Pulse Pressure
The difference between the systolic and diastolic blood pressure. A reduction in the pulse pressure as a result of an increase in the diastolic pressure may be one of the first and subtle signs of shock.

Radial pulse
The pulse of the radial artery which can be felt in the wrist; because of the ease with which it can be felt, it is the most frequently palpated.

Rebound tenderness
The pain felt on sudden release of a hand palpating the abdomen. It is seen in conditions of inflammation of the peritoneum.

Rectum
Lower portion of the large intestine ending with the anus.

Referred pain
Pain felt at one site but caused by disease at another anatomical site, (for example, hip disease may present with knee pain).

Respiration
The process of inhaling oxygen-rich atmospheric air and exhaling carbon dioxide-enriched air.

Respiratory acidosis
The condition of increased carbon dioxide and carbonic acid (thus an increased hydrogen ion concentration) due to failure of excretion of carbon dioxide by the lungs. This may be due to suppression of the respiratory centre in the brain (for example, head injury, drugs, and so on) or lung disease.

Respiratory alkalosis
A condition characterised by a decrease in the concentration of carbon dioxide in the blood stream. Like respiratory acidosis it may be caused by lung disease, through hyperventilation and excess excretion of carbon dioxide (for example, asthma or pneumonia). Other causes may include drugs and a variety of medical conditions.

Respiratory Shock
State of shock caused by too little oxygen in the blood. Usually due to lung failure, where the patient is unable to adequately fill the lungs.

Retro-
Prefix meaning behind.

Retrosternal sternum.
Behind the Sacrum - fused vertebrae of the lower back, inferior to the lumbar spine.
At a cellular level, the process of cellular exchange of oxygen as a fuel, metabolising it into carbon dioxide and excreting it.

Rule of nines
An approximate formula that may be used to calculate the surface area of a burn: 9% is allocated to each arm and the head; 18% (2 x 9) to each leg and the front and back of the trunk; and 1% to the perineum.

Sacrum
Fused vertebrae of the lower back, inferior to the lumbar spine.

Scapula
Shoulder blade.

Semi-
Prefix meaning half.

Septic Shock
Form of shock caused by severe infection. Toxins from the infection cause the blood vessels to dilate and plasma to be lost through vessel walls.

Septum
A partition between two cavities.

Shock
Reduced perfusion of tissues inadequate to maintain their metabolic rate and oxygenation. It may have many causes, which fall into five main groups: hypovolaemic, septic, cardiogenic, spinal and anaphylactic.

Skin Traction
A method for attaching bandage or material (either adhesive or non-adhesive) to the skin of a limb in order to apply a corrective force reducing a fracture or orthopaedic deformity.

Spleen
Organ located to the left of the upper abdominal cavity, behind the stomach. It stores blood and destroys old blood cells.

Sphygmomanometer
A device for measuring the arterial blood pressure.

Spine
The collective term for the group of bones which articulate together to form the backbone. It contains the spinal cord.

Spinal Cord Injury
Traumatic damage of the spinal cord. The results depend on the level of the cord where the injury occurs and the severity of the cord damage. Cord damage below C5 and above T1 is associated with quadriplegia, while damage below T1 produces paraplegia. The effects depend on the severity of the damage and may range from temporary to permanent. Transection of the cord is associated with spinal shock characterised by warm peripheries, low blood pressure and absence of sensation and movement below the level of the injury.

Spleen
A vascular organ in the upper left quadrant of the abdomen. Its role is primarily producing cells for the lymphoreticular system. Traumatic damage may result in severe haemorrhage owing to its vascular nature.

Splint
Any device that may be used to immobilise an injured part of the body.

Sterile
Free of all life forms.

Sternum
Breastbone.

Stokes-Adams Syndrome
Attacks of syncope or fainting, due to cerebral anaemia in some cases of complete heart block. The heart stops, but breathing continues.

Strain
Injury to muscles or tendon, caused by overexertion.

Subcutaneous
Beneath the skin. Usually refers to the fatty and connective tissue layer found beneath the dermis.

Subconjunctival Haemorrhage
Bleeding which occurs under the membrane lining the outer side of the eyeball.

Superior
Toward the top of the body. Often used *in* reference with inferior, meaning away from the top of the body.

Sub-
Prefix meaning under.

Subarachnoid Haemorrhage
The presence of blood within the subarachnoid space.

Supine
Lying flat on the back.

Supra -
Prefix meaning above.

Surgical Emphysema
The presence of gas in the subcutaneous or deep tissues of the body that has been forced there due to a leak of air from the lungs or trachea (rarely the gut). It may indicate the presence of a penetrating neck wound or a pneumothorax, for example.

Symptom
Evidence of injury or illness told to you by the patient.

Systemic
Refers to the entire body.

Systole
The part of the cardiac cycle in which the heart contracts and blood is expelled into the aorta.

Systolic Blood Pressure
Force exerted by the blood on the artery walls when the heart is contracting.

Tachycardia
An abnormally fast pulse rate, generally defined as a pulse rate above 100 beats per minute.

Tarsals
Ankle bones.

Tendon
Fibrous tissue that connects muscle to bone.

Therapeutic
Science & art of healing and the treatment of a disease.

Thoracic Cavity
Anterior body cavity above the diaphragm. Protects heart and lungs.

Thoraco-
Relating to the chest.

Thorax
Chest.

Thready Pulse
A pulse that is weak or difficult to feel: may be related to a small pulse volume (pulse pressure) secondary to shock.

Tibia
The main weightbearing bone of the lower limb below the knee joint.

Tinnitus
A ringing or roaring sound in the ears.

Tonic Phase
First state of a convulsive seizure where the patient's body can become rigid for up to 30 seconds per episode. Can be longer in diving.

Tourniquet
Last resort used to control bleeding. A band or belt is used to constrict blood vessels to stop the flow of blood.

Trachea
The main air passage connecting the lungs to the oropharynx and nasopharynx.

Traction
The placement of a limb or body part under tension; often used in orthopaedics to correct deformity, realign broken bones and as a temporary method of pain relief at a fracture site.

Trans-
Prefix meaning across or over.

Transverse
At right angles to the long axis of the body (this plane is also at right angles to the coronal and sagittal planes).

Trauma
Injury caused by violence, shock or pressure.

Triage
The classification and sorting of casualties into groups based on the severity of injury and chance of survival. Successful triage aims to do the most for the most, even if resources are limited.

Ulna
The long bone of the forearm that runs on the inner aspect from the elbow to the wrist. At the elbow it forms the olecranon.

Unconsciousness
The inability to sense and respond to external stimuli, due to a variety of causes.

Valsalva manoeuvre
Breathing out against a closed glottis to increase intrathoracic pressure.

Vasoconstriction
The narrowing of the blood vessels, particularly the arterioles and veins. This may be accomplished by a variety of stimuli and is useful in the response to shock or to control blood pressure.

Vasodilatation
The widening of the various small vessels (see vasoconstriction) brought about by relaxation of the smooth muscle in the walls of the vessels.

Vein
Any blood vessel that returns blood to the heart.

Ventilation
The process of exchanging gases from within the lung to the atmosphere.

Ventral
Front of the body or body part. See Anterior.

Ventricle
Inferior chamber of the heart. Ventricles pump blood from the heart.

Vertebra
One of the constituent bones of the spinal column. It may be a cervical, thoracic, lumbar, sacral or coccygeal vertebra.

Viscera
Internal organs. Usually refers to the abdominal organs.

Vital Signs
In **DMT** care, pulse rate and character, breathing rate and character, blood pressure, and relative skin temperature. Pupil reaction.

Whiplash injury
Forced flexion/extension injury of the neck often seen following a road traffic accident.

Xiphoid
Inferior process of the sternum.

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