When a patient presents following trauma, it is important to assess them in a logical manner and that injuries are managed in order of priority. It is often the case that musculoskeletal injuries are less significant than others!

The most recognised framework for managing trauma patients is that taught on the Advanced Trauma Life Support (ATLS®) course. This chapter will discuss management according to these principles. There will be some additional recommendations to traditional ATLS® teaching based on guidelines used in UK major trauma centres.

The Primary Survey and Resuscitation
The primary survey can easily be broken down into the mnemonic ABCDE, which outlines the sequence of management priorities. They are as follows:

- **A**irway and C-spine Protection
- **B**reathing
- **C**irculation and Haemorrhage Control
- **D**isability and Glucose
- **E**xposure / Environment

Whilst this is the sequence in order of importance when a full resuscitation team is present, they tend to occur in parallel. However, if a patient is not responding to resuscitation then the team needs to start again and go back over the interventions in sequence, to ensure that each has been adequately addressed and the situation has not evolved.

Airway Management
The best initial check for the airway is to ask the patient a question. If they can answer normally then they must have an adequate airway at that point. Remember that in the presence of a soft tissue injury or with burns the airway may become gradually occluded over time.

When the patient is hoarse, this implies that they have a laryngeal injury. This may need expeditious intubation or a surgical airway.

If the patient does not respond and their GCS is below 9 then you should assume that the airway is obstructed. This is similarly the case when the patient is snoring, gurgling or when there are no airway sounds at all. Airway obstruction usually occurs due to:

- the patients’ own tongue
- presence of a foreign body
- aspiration of vomit
- head or neck trauma

Briefly inspect the airway for the presence of a foreign body and/or perform a gentle finger sweep to feel for and remove one. Suction should be used to clear any liquid such as vomit. There are two simple maneuvers to try and regain an airway; the jaw thrust and the chin lift. The chin lift is rarely appropriate in the trauma setting as it does not allow for protection of the c-spine as it required the head to be tilted backwards as the chin is lifted up. The jaw thrust is therefore the option of choice. To perform a jaw thrust use your fingers to push the posterior aspect of the mandible forwards, which should lift the tongue out of the airway, as shown in the image below.

If simple airway maneuvers do not restore an adequate airway, then a number of airway adjuncts can be used. Remember the patient should receive supplemental oxygen at all times.

A Guedel airway, also known as an oropharyngeal airway, helps prevent the tongue from occluding the epiglottis. They come in a range of sizes and the most appropriate size should be selected for the patient, by measuring the length of the device against the patient from the incisors to the angle of the mandible.

If the patient still does not have an adequate airway a laryngeal mask airway (LMA) can be used. This is much easier to insert than an endotracheal tube but it is important to remember...
that it is not a protected airway. The patient can still vomit and aspirate with an LMA in place. The following image shows a typical laryngeal mask airway.

The only definitive airway is an endotracheal tube (ET tube), with the cuff inflated to prevent aspiration of gastric contents. In the trauma setting patients who are likely to need theatre, very agitated patients and those in whom other methods of securing an airway have failed, should all be intubated. An endotracheal tube is shown below with the cuff inflated.

Once an endotracheal tube has been inserted its correct positioning must be confirmed by auscultation (hearing equal bilateral chest sounds) and confirmation of exhaled CO\textsubscript{2} on a capnograph.

C-spine Protection
As well as securing the airway, a concurrent management priority is to protect the c-spine. In the trauma setting it should always be assumed that the patient has an unstable cervical spine injury until proven otherwise.

The c-spine should be immobilised using manual inline stabilisation until a hard collar and spinal board can be applied. Manual inline stabilisation involves placing your hands either side of the patients’ head and using them in conjunction with your forearms to prevent any movement of the neck.

The following image shows a typical rigid c-spine collar. They can be adjusted to fit the patient. The oval ratchets on the middle of the collar allow the chin support to be raised and lowered as appropriate.

X-rays of the c-spine are no longer part of a trauma series, as they miss far too many injuries and have largely been replaced by CT scanning. When the patient shows signs of neurological involvement, MRI may be used in addition to CT to better examine the spinal cord and canal. The following MRI scan is of a patient involved in a road traffic collision at high speed. It shows a C6-7 bilateral facet joint fracture dislocation, with critical narrowing of the spinal canal and compression of the spinal cord.

Exsanguinating External Haemorrhage
This is rare in civilian practice and is seen more often in military settings. However, when a patient is exsanguinating this takes equal priority to the airway. In the limb, direct pressure should be applied until a military tourniquet can be
applied proximal to the site of bleeding. A tourniquet is not for prolonged use and when it is used the patient needs to be transferred to theatre as soon as is practical. The tourniquet should ideally stay in place for only 30 minutes. It is good practice to write the time the tourniquet was applied on the patient in indelible marker pen.

Breathing
As with the airway, a good initial check of ventilation is to see if the patient is able to talk to you and if so, whether this is in full sentences, short phrases or single words. Look at the patient to see what their respiratory rate is and whether they are using accessory muscles to help them breathe. Look at the lips and periphery for signs of cyanosis (blue tinge). The image below shows peripheral cyanosis in a patient with a low oxygen saturation.

Also observe the chest for any asymmetry in excursion; a patient with multiple rib fractures will exhibit inwards movement of the chest on inspiration and outwards movement on expiration (the opposite of normal).

Palpate the chest and neck for crepitus which is a sign of subcutaneous emphysema. It is seen in cases of penetrating or blunt chest trauma and pneumothorax where gas is allowed to enter the pleural space. Also look for local tenderness which may indicate a rib fracture.

Percuss across the chest. A normal percussion note is resonant. A dull percussion note may indicate a haemothorax (blood in the thoracic cavity) and a hyper-resonant note may indicate tension pneumothorax.

Auscultate the chest, first checking whether breath sounds are present on both sides of the chest. Also listen for noisy breath sounds which can be a sign of aspiration.

The most common method of monitoring respiratory function is to place an O₂ saturation probe on the patient’s finger. This gives a rough guide and is useful for monitoring trends in saturation. However, there is no substitute for an early arterial blood gas with repeated samples to assess the adequacy of ventilation.

Pneumothorax
A common cause of ventilatory impairment in trauma is the presence of a pneumothorax. There are two types. The first is a simple pneumothorax, where a rib fracture or penetrating trauma causes a variable degree of collapse of the lung. The wound acts as a two way valve so there is no significant increase in intrathoracic pressure. The trachea will deviate towards the side of the collapse and there will be an absence of breath sounds. The x-ray below shows a patient with a simple pneumothorax.

The second type is a tension pneumothorax. In this circumstance the wound acts as a one way valve, sucking air in but not letting it back out. This quickly increases the intrathoracic pressure on the side of the collapse pushing the mediastinal structures away and compressing the other lung. The trachea is therefore deviated away from the side of the collapse and the affected side has absent breath sounds and a very hyper-resonant percussion note. The following x-ray below shows a patient with a tension pneumothorax.

Note the complete absence of lung markings on the left and the way the midline structures are beginning to be pushed to
the right. In practice an x-ray should never be taken as the diagnosis is a clinical one and the patient should immediately have the affected side decompressed with a needle thoracotomy (a large bore needle inserted into the chest in the second intercostal space in the midclavicular line).

The definitive treatment for a pneumothorax is the insertion of a chest drain, where a large bore tube is inserted into the 5th intercostal space in the mid-axillary line. This is then connected to an underwater chest drain which usually remains in place for two or three days.

Circulation and Haemorrhage Control

The next step in resuscitation is to assess and manage any circulatory compromise. Traumatised patients may have blood loss due to any number of injuries and the blood loss is usually hidden. A patient can lose their entire circulating blood volume into the abdomen and pelvis.

The patients’ response to questions is again an excellent initial assessment of circulation but for different reasons than for airway and breathing assessment. A patient who can give appropriate answers must have an adequately perfused brain. Also assess the patients’ pulse and blood pressure. Look at their skin colour for pallor and temperature (cool peripheries implies vasoconstriction). Also make note of their respiratory rate as in the absence of respiratory compromise this is also affected by haemorrhagic shock.

<table>
<thead>
<tr>
<th>Blood Loss (ml)</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP</td>
<td>Normal</td>
<td>Normal</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Pulse (bpm)</td>
<td>&lt; 100</td>
<td>100 - 120</td>
<td>120 - 140</td>
<td>&gt; 140</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>14 - 20</td>
<td>20 - 30</td>
<td>30 - 40</td>
<td>&gt; 40</td>
</tr>
</tbody>
</table>

Haemorrhagic shock is divided into four classes depending on the degree of blood loss. The table above shows the physiological responses to each class with the corresponding degree of blood loss. The first sign of shock developing is an increase in respiratory rate. Then the patient becomes tachycardic, hypotensive and then goes into circulatory collapse potentially with cardiac arrest.

Remember there are other causes of shock which should be considered. The non-haemorrhagic causes include:

- tension pneumothorax
- tamponade
- cardiogenic
- septic
- neurogenic

All traumatised patients should have two wide bore cannulae inserted, ideally into each antecubital fossa. This allows for the rapid administration of fluid.

There is some degree of controversy over the resuscitation fluid of choice. For initial resuscitation, 0.9% Saline should be given. Any trauma patient who presents with a systolic blood pressure under 80mmHg should trigger a ‘massive transfusion protocol’. Blood should rapidly be available and then becomes the resuscitation fluid of choice. Trauma patients often rapidly become coagulopathic and so with every two units of blood transfused the patient should also receive one unit of platelets and one of fresh frozen plasma.

Another recent development in managing haemorrhage is the increasing use of Tranexamic acid. This stabilises any clot which forms and can reduce the amount of overall blood loss. Any trauma patient who presents with a systolic blood pressure under 110mmHg should receive 1g of Tranexamic acid IV as soon as possible, but at least within 3 hours of injury.

Pelvic Fractures

Significant pelvic fractures are a high risk injury for exsanguination and are often associated with intra-abdominal visceral injuries. They are particularly seen in cases of high energy or blunt trauma. Any patient who is at risk should have a pelvic binder applied to splint the pelvis, tamponading bleeding and protecting any blood clots which have already formed. A pelvic x-ray should be performed as an initial screening x-ray (the only other x-ray being a chest x-ray). A clear AP film is 97% sensitive at picking up significant pelvic fractures. The x-ray below shows a significant pelvic fracture. The artifact is due to a spinal board.

It is no longer part of trauma management of examine the pelvis for stability (‘spring the pelvis’) as it risks disturbing blood clots formed. The patient should not be log rolled or catheterised until the pelvis has been cleared by x-ray or CT scan. If a pelvic binder is in place when the x-ray or CT is done, further imaging should also be performed when the binder is removed as it can perfectly reduce an open book fracture which will re-open when the binder is removed.
Response to Resuscitation

Once fluid resuscitation has begun the response to this must be monitored. There are three categories of response to resuscitation:

1) Patients with initial blood loss but minimal active bleeding will be rapid responders. This means that once the normal circulating volume is restored the patient’s observations will return to normal and remain normal.

2) Patients with active bleeding at a rate which is exceeded by administration of fluid will be transient responders. Observations will improve with fluid but deteriorate if it is stopped.

3) Patients with catastrophic haemorrhage, usually from abdominal or pelvic injuries will be non-responders. They are bleeding faster than fluid can be given. These patients need transfer to the operating room immediately.

The response can also be evaluated by looking at other clinical signs. As hypovolaemia is reversed, signs of end organ perfusion will improve. Patients will improve their level of consciousness and the peripheries will become warmer and pink. Unless contraindicated trauma patients should also be catheterised. This allows close monitoring of urinary output, a sign of adequate renal perfusion and circulating volume. As cerebral perfusion improves conscious level will normalise.

Disability and Glucose

As has been discussed, hypoxia and poor cerebral perfusion due to hypovolaemia are possible causes of a reduced level of consciousness. Once you have reached the fourth stage of resuscitation, these variables should have been corrected but the conscious level may remain impaired. There may be a number of reasons for this, including intracranial haemorrhage and traumatic brain injury.

There are two ways that consciousness can be measured and assessed. The first simple method is the acronym AVPU.

- A Alert : the patient it fully awake though may be confused.
- V Voice : the patient makes some response to voice.
- P Pain : the patient only makes a response to pain such as a sternal rub.
- U Unresponsive : the patient does not respond to any stimulus.

The second and more accurate method of assessing consciousness is the modified Glasgow Coma Scale or GCS. This looks at the patients’ response to various stimuli using three criteria: eyes, voice and motor. Eye response is graded from 1 - 4, verbal from 1 - 5 and motor from 1 - 6 with 15 being the highest score (fully conscious). The lowest score is 3, signifying a completely unresponsive patient.

Eye response is broken down into:
(4) Spontaneous : the patient has their eyes open requiring no stimulus.
(3) To Command : the patient opens their eyes when asked to or in response to their name being called.
(2) To Pain : the patient opens their eyes to painful stimuli.
(1) None : the patient does not open their eyes to any stimulus.

Voice response is broken down into:
(5) Oriented : the patient makes appropriate response to any questions asked such as their name and age.
(4) Confused : the patient responds coherently to questions but shows some confusion.
(3) Inappropriate : the patient says words but they are random and are incoherent.
(2) Incomprehensible : the patient does not form words but just makes sounds.
(1) None : the patient is silent.

Motor response is broken down into:
(6) Obeys Commands : the patient can complete simple tasks.
(5) Localises pain : the patient will directly reach to stop a painful stimulus.
(4) Withdraws : will pull away hand in response to pressure on nailbed.
(3) Flexion : will flex elbow and wrist and abduct arm in response to pressure on nailbed (decorticate response).
(2) Extension : will extend elbow and wrist and abduct arm in response to pressure on nailbed (decerebrate response).
(1) None : the patient does not respond to pain.

Once the assessment has been carried out this will give an overall score which is recorded as follows;

\[ GCS \ 15/15 \quad E_6 \ V_5 \ M_6 \]

The pupillary response should also be checked. Shine a light into each eye looking for a contraction both in the pupil the light is shone into and the other pupil. Look at the pupils to check they are equal and one is not ‘blown’ which is a sign of raised intracranial pressure. Remember that 20% of the population have the condition anisocoria where the pupils are normally a different size. In these patients the pupils will still constrict to light.

Glucose

It is important to check the patients’ glucose as even in the non-diabetic patient there can be a significant rise due to the hypermetabolic response to trauma. There is some evidence to show that if hyperglycaemia is well controlled there is a reduction in mortality, though it is equally important for the patient not to become hypoglycaemic.
Exposure
The final step in the primary survey is to completely undress the patient. This ensures that all visible significant injuries can be seen and that something important is not missed. It is critical that the patient does not become hypothermic and warm blankets and warmed intravenous fluids should be used to aid this.

Secondary Survey
Once the patient has been adequately resuscitated and stabilised you can go on to perform a secondary survey. This should be an exhaustive head to toe assessment of the patient to document each and every injury. A hand injury may seen inconsequential in the context of the acute trauma but should the patient survive could cause significant long term morbidity if missed.

AMPLE History
Begin the secondary survey with a focussed history using the acronym AMPLE. This stands for:

- A Allergies
- M Medications
- P Past Medical History
- L Last Meal
- E Events of Trauma / Environment eg mechanism and location of injury.

Head
Begin looking at the patients head. Assess the conscious level with a GCS again to see if there is a persisting deficit after adequate resuscitation. This could indicate raised intracranial pressure. Look for any depressed skull fractures. Look at the eyes and examine for a fracture of the orbit. Look in the ears for blood in the auditory canal. Examine all the maxillofacial bones for fracture.

Cervical Spine
Examine the midline of the cervical spine for pain and any palpable steps. A complete upper limb neurological examination should be undertaken from C4 - T1 checking sensation and motor function. Look for biceps, triceps and supinator reflexes.

X-ray is not an appropriate imaging study for the cervical spine and is no longer part of the assessment of the trauma patient. When there is any doubt a CT scan should be performed, likely as part of a whole body vertex to symphysis scan.

It is also important to remember that the cervical spine cannot be clinically cleared if there is any impaired consciousness or another significant ‘distracting’ injury elsewhere in the body.

Neck
The soft tissues of the neck should be examined for signs of blunt or penetrating trauma. Subcutaneous emphysema may be felt in the neck if the patient has a pneumothorax. If the patient is hoarse this can indicate blunt laryngeal trauma and this could lead to delayed airway obstruction. These patients may need intubation, despite the airway being patent at the initial assessment.

Chest
The chest is assessed in the same way as you will have been taught from the early years of medical school; inspect, palpate, percuss then auscultate.
- Inspect : look for penetrating trauma and bruising. Don’t forget to look at the back as well as the front if this is possible (a log roll should not be performed in the presence of unstable pelvic injuries). Watch the rise and fall of the chest wall for symmetry.
- Palpate : feel the chest wall for subcutaneous emphysema and the trachea (which should be in the midline) both of which may indicate a pneumothorax.
- Percuss : The chest should normally have a resonant percussion note. You should percuss the upper, middle and lower zones of each lung. A dull note may indicate a haemothorax and a hyper-resonant note a tension pneumothorax.
- Auscultate : listen for the presence of breath sounds bilaterally. Also auscultate the heart. Muffled heart sounds could indicate pericardial tamponade from bleeding within the pericardial sac.

Abdomen
As with the chest you should assess the abdomen methodically using the inspect, palpate, percuss and auscultate sequence.
- Inspect : look for penetrating trauma and bruising (particularly flank bruising which can be a sign of retroperitoneal haemorrhage). If the patient has peritonitis they will hold their abdomen rigid which indicates a likely visceral injury.
- Palpate : feel each of the nine quadrants methodically for pain, thinking of the underlying structures in each. Feel for masses, tenderness and deformities. For example, left upper quadrant pain could indicate a splenic injury. If the patient has peritonitis they will hold their abdomen rigid which indicates a likely visceral injury.
- Percuss : percuss across the same nine quadrants. Percussion tenderness indicates underlying pathology and should be investigated.
- Auscultate : listen for bowel sounds. When they are absent this may indicate peritonitis.

Pelvis and Perineum
The pelvis itself should not be examined for stability and when appropriate should already be stabilised by a pelvic binder. Closely inspect the perineum, particularly looking for evidence of an open pelvic fracture.

A digital rectal examination should be performed looking for sphincter tone (spinal injury), blood (gastrointestinal injury), rectal wall (rectal injury) and the prostate. A high riding prostate (the prostate feels ‘too far up’) is a sign of urethral injury.

Musculoskeletal
All four limbs should then be assessed carefully. Each joint and long bone should be assessed for dislocation, stability and fracture. All wounds including abrasions, lacerations and skin loss or degloving should be documented, particularly when
they are related to an open fracture. The neurological and vascular status should be documented. Careful examination for compartment syndrome should be made and if in doubt a pressure transducer can be used (see later chapters). Remember that in the hypotensive patient, compartment syndrome becomes more likely.

Provided the patient is stable, all suspected skeletal injuries should be x-rayed, though this should not delay a trauma CT scan if this is needed. All fractures should be splinted with traction or plaster.

If any open fractures are identified the patient should receive antibiotics. If the injury is aquatic or farmyard in origin broad spectrum cover is needed.

The wound should be cleaned with saline and covered with a betadine soaked gauze before splinting.

Damage Control Surgery / Early Definitive Care

The significantly traumatised patient will usually require surgery. The type of surgery related to fractures falls into two categories.

*Damage control surgery (DCS)* is rapid emergency surgery to save life or limb. It avoids any kind of time consuming reconstruction. It focusses on four key areas:

1. Control of haemorrhage including exsanguinating limb injuries.
2. Control of contamination of wounds, particularly farmyard or aquatic contamination, by debridement.
3. Decompression of the limb compartments in compartment syndrome.
4. Fracture splinting with traction, plaster or external fixators.

This is employed in patients who are unstable and so the aim is to create as little surgical trauma as possible and get the patient to the intensive care unit as quickly as possible. If the patient falls into this group, a devascularised limb may well need amputation as an extensive revascularisation procedure is unlikely to be appropriate.

*Early Total Care (ETC)* is employed when the patient is stable and its aim is to definitively fix all fractures within twenty-four hours.

When deciding between DCS and ETC there are four parameters which should be considered. The first three are known as the terrible triad – Hypothermia, Coagulopathy and Acidosis.

**Hypothermia:**
- Patients must be kept warm throughout resuscitation.
- If the core temperature is below 35°C do not perform ETC.

**Coagulopathy:**
- Platelets below 120 do not perform ETC.
- INR above 1.5 do not perform ETC.

**Acidosis:**
- If the pH is below 7.25 or the Base excess is below -5.0 do not perform ETC.

The fourth parameter is the patient’s lactate. The lactate should be measured serially throughout the resuscitation (usually from the arterial blood gas) as its trend as well as the absolute value is a good guide of the patient’s response. When deciding on DCS or ETC the guidelines below should be used:

- Lactate below 2.0 : ETC possible.
- Lactate above 2.5 : Continued resuscitation.
- Lactate between 2.0 and 2.5 but trending upwards : Continued resuscitation.
- Lactate between 2.0 and 2.5 but trending downwards : ETC possible.

These parameters should be monitored intraoperatively once the decision to go for ETC has been made, as if the patient deteriorates then there may be a need to revert to DCS.

Further Reading


2) Care of the Injured : trauma.org www.trauma.org