Trauma pre-course reading

Trauma is the leading cause of death in the western world for people aged 1-44. It can affect any body system, so a structured approach to assessment and management is important. The Advanced Trauma Life Support (ATLS) system was set up in America in the 1970’s and has been adopted across the world as the standard of care for trauma patients. It emphasises assessing and treating the system which has the greatest threat to life first, before moving on to the next most important system. The basic structure of ATLS has been adapted through the years, with slightly different priorities given by different agencies – most notably the military. However, the basic premise of structured assessment and treatment remains true.

Primary Survey

The primary survey refers to the approach that should be taken to the management of any new trauma patient. Its purpose is to identify any immediately life-threatening problems with the patient and rapidly treat these. In the course of the primary survey, you should also pick up any other significant problems, which may not be immediately life-threatening, but could potentially become so if not managed. Interventions should be instituted to treat any significant abnormalities as they are identified. Some basic, early investigations may also be performed. The primary survey follows the CABCDE framework, with some minor modifications. This stands for:

C – Catastrophic haemorrhage
A – Airway (with cervical spine control)
B – Breathing
C – Circulation (with haemorrhage control)
D – Disability
E – Exposure.

By the end of the primary survey, the patient should be in a stable condition, a few initial baseline investigations should have been organised and you should have some idea of the extent of their injuries.

What can cause problems in each system?

There are many different potential problems that can lead to abnormalities being identified in each of your assessment stations. It is worth having an idea of what you may be looking for when assessing ABCD and E.

Catastrophic haemorrhage: this just refers to any obvious, major bleeding points such as stab wounds where pressure can be applied to try and stem the flow of blood.

Airway: There could be foreign bodies in the airway, from blood, saliva or broken teeth.
There could be external compression or damage to the airway from facial or anterior neck trauma.

If a patient has suffered from burns, then the airway can become oedematous and swollen which can lead to obstruction.

Low conscious level – anyone with a head injury and a subsequent low GCS can develop airway obstruction. This is because they lose tone in the muscles of their pharynx and face, so when they lie flat on their back, the mandible can fall backwards and the tongue can rest against the posterior wall of the pharynx.

An obstructed airway needs to be cleared rapidly – this will kill a patient before a problem in any other system, which is why it is assessed and managed first.

Cervical spine: all trauma patients are assumed to have a cervical spine (C-spine) injury until proven otherwise. If the C-spine is damaged – either the bones or the ligaments – then these can move and cause compression of the spinal cord, which can potentially lead to infarction of the cord and a partial or complete loss of neurological function below that level of the cord. This can have devastating implications to the long-term life of the patient. Injuries may have occurred to the spinal cord before the patient is assessed – there’s nothing you can do about that. However, patients may have a bony or ligamentous injury to the C-spine with no or minimal underlying spinal cord injury, and the best way to stop them developing a spinal cord injury is to prevent the neck from moving – either flexion/extension, lateral flexion or rotation. The process for doing this is described below.

**Breathing:** There can be a loss of ventilator drive or neurological control in patients with severe head injury or a high cervical spine lesion (the phrenic nerve, which controls the diaphragm, has its cervical roots at C3, C4 and C5).

The ribs can be fractured. This can either cause problems due to pain limiting respiratory effort on that side, or due to the sharp, broken rib ends causing further trauma. Additionally, if a rib is broken in two places, then the free-floating section will no longer be able to support the underlying lung or move with the usual expansion of the ribs. This means the underlying lung will not expand or contract, and therefore not take part in gas exchange – this is called a flail segment.

The pleura can be damaged, leading to either air (pneumothorax) or blood (haemothorax) entering the pleural space. This compromises expansion of the lung on that side. A tension pneumothorax can develop, with high pressures in that hemi-thorax, which can lead to cardio-vascular collapse. In penetrating trauma (eg. stab wounds), patients can have an open pneumothorax – this is where there is a direct communication between the pleura and the atmosphere and air is sucked in and out of the hole during the respiratory cycle, instead of in and out of the lungs – again, compromising gas exchange.

The lung tissue itself can be bruised, with bleeding into the alveoli which again leads to loss of gas exchange potential. This is called a lung contusion.
Very rarely, other parts of the respiratory system can be damaged, such as the trachea, bronchi or diaphragm.

**Circulation:** By far the most common reason for a trauma patient’s circulation to be compromised is due to haemorrhage. The source of haemorrhage is often described as “on the floor, plus four more” – which means you may see obvious external bleeding, or the patient may be bleeding internally. The places that patients can bleed internally are the thorax, the abdomen, the pelvis and the long bones. It is perfectly possible to exsanguinate from haemorrhage into one of these cavities, so just because bleeding is not visible, does not mean that it is not happening. You therefore have to trust your vital signs (heart rate, respiratory rate, capillary refill time, blood pressure, mental status, urine output) as well as indicators of oxygen delivery to tissues (lactate, base excess) to indicate if bleeding is happening. The earliest signs to change are usually respiratory rate and heart rate. The last sign to change is usually blood pressure, particularly amongst young, healthy people – do not be fooled by a relatively normal blood pressure, as this usually will not drop until the patient is peri-arrest.

There are rare alternative causes for a compromised circulation in trauma – these include cardiac tamponade, tension pneumothorax or neurogenic shock. These won’t be considered in more detail here as they occur relatively rarely.

**Disability:** This refers to the neurological status of the patient. Reduced conscious level can be due to a head injury, and this will always need excluded in the trauma patient with a reduced Glasgow Coma Scale (GCS). However there are a number of other potentials – remember that the patient may have suffered trauma because they had an altered conscious level – which can obviously happen for many reasons. Examples would be drug intoxication (especially alcohol); hypoglycaemia; other electrolyte abnormalities; seizure activity.

Additionally, the peripheral nervous system should be assessed – injuries to the spinal cord can manifest as weakness or numbness in the peripheries.

**Exposure:** This refers to an assessment of the rest of the body (including the back) to identify any other injuries. The temperature should also be checked, as patients can easily become cold, especially if they have been lying outside.

At this point, you may wish to provide analgesia. This will usually be in the form of intravenous morphine.

**Performance of the primary survey**

The CABCDE assessment should be worked through, assessing for abnormalities in each system and instituting basic interventions to stabilise any problems as you go. You should not move on from A to B or B to C until you have dealt with any potentially life-threatening problems that you have identified. If, however, you have identified an abnormality, but it is not
immediately life-threatening, then as long as you have instituted appropriate initial therapy and investigations, then you may progress through the survey.

Firstly: Safe to approach? Check for any obvious danger to yourself before approaching the patient. This includes the risk of contamination, so protective clothing should be worn – ie. gloves, plastic apron, sometimes eye protection.

C is for Catastrophic haemorrhage – fairly obvious in real life. If identified, pressure should be applied, in an attempt to stem the flow of blood.

A is for Airway with Cervical spine control.

All trauma patients should be assumed to have a potential cervical spine injury. The cervical spine is not actually assessed in the primary survey, as an injury here is unlikely to be immediately life threatening, and in any case, you cannot fix a cervical spine problem acutely. It should, however, be immobilised. The quickest way to do this is for someone to hold the patients head and neck in a neutral position – ie. Facing forwards, not flexed or extended. The airway should then be assessed and managed whilst the neck is immobilised like this, with more definitive control deferred until the airway is secure.

**Airway** - The quickest way to check for patency is to talk to the patient. If they can talk back to you with a normal sounding voice, then their airway is likely to be patent. If not, the airway should be assessed more fully.

Inspect – are there foreign bodies in the mouth? Is there obvious deformity, swelling, burns or trauma to the mouth, face or front of the neck?

Listen and feel for breath sounds – best done by leaning down with your cheek above the patient’s mouth and looking at the chest for movement. Signs of partial airway obstruction would include gurgling or stridor, and signs of see-saw chest movement – this is where the chest is sucked in and the abdomen moves out during attempted inspiration.

Basic management – any obvious foreign bodies can be removed by suction or using magills forceps.

Basic airway manoeuvres such as the jaw-thrust can be used to open the airway. A head-tilt should be avoided in all trauma patients, due to the risk of cervical spine injury. If these fail, basic airway adjuncts such as an oropharyngeal airway can be inserted. Further airway management is a more specialised process which should be handled by the ED senior or an anaesthetist.

Once airway control has been achieved, equipment can be attached to control the C-spine. It is immobilised in three ways – the 3-point immobilisation. Firstly, a rigid collar is applied. This primarily helps by stopping the patient flex or extend their neck. Secondly, sand-bags are placed either side of the patients head – this stops the patient turning their head. Thirdly, the patients forehead and chin are immobilised by attaching secure tape over their heads and to the bed.
B is for Breathing.

Look: Respiratory rate; breathing pattern; chest expansion – equal or unequal. Any signs of bruising or injury

Feel: tracheal position. You can also feel the chest for surgical emphysema – which is a crunchy feeling under the skin, indicative of air in the subcutaneous tissues.

Monitor – check the saturations

Percuss – percuss the chest, listening for dullness or hyper-resonance

Auscultate – listen for breath sounds.

Investigations/interventions – chest x-ray. May consider an ABG. Apply oxygen if the saturations are below 94%.

C is for Circulation.

Look: patient colour – nice and pink, or pale. Look at the JVP – is it raised or not?

Feel: the peripheries, are they warm or cool? Feel the peripheral pulse – what is the rate, is it a good volume or weak and thready.

Monitor: ECG monitoring, non-invasive blood pressure cuff.

Auscultate: listen to the heart sounds – are they audible or muffled? Any murmurs?

Investigations/interventions: Insert a wide-bore IV cannula. Take of bloods for FBC, U&E, coagulation and cross-match as a minimum. May need IV fluids and/or blood products depending upon your findings.

Some practitioners would advocate feeling the abdomen during the “C” part of your assessment. This is because it is a common site of blood loss in trauma, and identifying tenderness or bruising here can help to guide your assessment. Some others may suggest leaving the abdominal exam until the “E” part of your assessment.

D is for Disability

Check their conscious level. The easier format is the AVPU – this assesses what the patient responds to. They are either A – alert; V – respond to voice; P – respond to pain; or U – unresponsive. A more detailed assessment is the Glasgow Coma Scale (GCS). Pupils should also be assessed for their size and reactivity.

The peripheral nervous system should also be checked – this is not a detailed assessment, you are just looking for any gross abnormality. Check that power and sensation in the limbs are normal.

Check the blood glucose. Remember, ABC...Don’t Ever Forget Glucose
E is for Exposure and Environment.

This means you have a look over the rest of the patient who must be completely exposed, often by cutting the clothes off. You are looking for any signs of injury to the rest of the body – so abrasions, bruising, deformities, tenderness. This will include the back.

You should also check the patient’s temperature. The patient should then be covered up and kept warm.

Once the primary survey is finished, you should have some idea of how unwell the patient is and can make some decisions about what further investigations should be performed. Potentially useful investigations would include:

- ECG – quick and easy, useful as a baseline and occasionally helps with diagnosis
- X-rays – most trauma patients would get a chest x-ray. Decisions on further body parts to x-ray depends upon your findings, and also if you have plans to proceed to CT
- FAST scan – this stands for Focussed Assessment with Sonography in Trauma. This is a rapid ultrasound assessment which looks to identify free fluid in the abdomen, pelvis or pericardial space. It can be extended to include assessment for free fluid or air in the pleural space. Any free fluid identified is assumed to be blood. This test is quite specific, but not particularly sensitive – put another way, if free fluid is found (ie. the test is positive) then it is very likely that there is internal bleeding. However, lots of patients with internal bleeding will not have any free fluid identified on FAST scan (ie. the test is negative): therefore the FAST scan is a useful “rule-in” test, but not good as a “rule-out” test. It can be repeated serially.
- CT. This is being used increasingly to assess internal injuries. It is very specific and sensitive, but has the disadvantage of requiring the patient to be transferred out of the Emergency Department. Common areas to scan would be the head, the cervical spine, the thorax, abdomen or pelvis. Often these are combined.

Burns

These are considered under the trauma banner, as the two may co-exist. There are a few issues to consider with burns

- Airway burns
- Smoke inhalation
- Surface area and depth of burn
- Fluid requirements

Airway: If a patient has suffered airway burns, there is a risk that the airway can become swollen and oedematous. This can develop rapidly over a relatively short period of time and lead to
complete airway obstruction. It is more likely if the patient was in an enclosed space when the burn occurred. Signs of an airway burn can include:

- A change in the patients voice (particularly hoarseness)
- Burns to the face and/or neck
- Black soot in the sputum
- Acute inflammatory changes in the oropharynx
- Cough

None of these signs are particularly sensitive or specific, but should be considered in conjunction. Where there is any concern of an airway burn, the patient should be seen urgently by an ED senior or an anaesthetist as they may need to have their trachea intubated early before oedema develops.

**Smoke inhalation:** There are two potential concerns with inhalation of fumes. The patients lungs may have been damaged directly by toxic fumes. Additionally, they may have inhaled carbon monoxide. Carbon monoxide is toxic because it binds much more avidly to haemoglobin than oxygen does (forming carboxy-haemoglobin). This blocks the haemoglobin molecule, and means that oxygen delivery to the tissues is impaired. An oxygen saturation monitor will interpret carboxy-haemoglobin as being oxygenated haemoglobin, and will therefore usually read as oxygen saturations of 100% - this can therefore not be used as a screening tool to exclude carbon monoxide poisoning. If suspected, an arterial blood gas should be taken, which will identify the levels of carboxy-haemoglobin present. The treatment for this is to give a high concentration of inspired oxygen, which helps to dissociate the carbon monoxide from haemoglobin.

**Surface area and depth of burn:** A burn can penetrate the skin to various depths. They are classified as either superficial (first degree); partial thickness (second degree) or full thickness (third degree).

Superficial: These are red, painful and usually have no blistering – eg. Sunburn. They are not life threatening and generally do not require any intravenous fluid therapy. They are usually mildly painful.

Partial: These are red or mottled, with blistering and swelling. The surface is usually moist and weeping and they are extremely painful and hypersensitive.

Full thickness: These are leathery with a dry surface. They can be white or red in colour and are painless, as the nerves will have been destroyed.

The surface area can be assessed according to the rule of 9s. This states that each body surface accounts for the approximate proportions of total body surface area:

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Head (front and back)</td>
<td>9%</td>
</tr>
<tr>
<td>Chest/abdomen</td>
<td>18%</td>
</tr>
<tr>
<td>Back</td>
<td>18%</td>
</tr>
</tbody>
</table>
Left arm 9%
Right arm 9%
Left leg (front and back) 18%
Right leg (front and back) 18%
Perineum 1%

(NB. This only applies to adults – different proportions exist for children).

Using this, the proportion of body surface involved can be estimated. Patients lose a lot of fluid through burned tissue, so anyone with significant burns will need IV fluid replacement. For patients with over 15% body surface area burns (or 10% with smoke inhalation), the Parkland formula can be used to calculate fluid requirements over the first 24 hours post-burn. Crystalloid fluids such as Hartmanns solution should be used. The formula states that, for every 1% body surface burn and every 1kg of body weight, 4mls of fluid are required.

Put another way:

Fluid requirement in ml = (%age body surface burned) X (body weight in kg) X 4

This volume should be given over 24 hours. The first half should be given over the first 8 hours from the time of the burn (i.e. not from the time of presentation). The second half should be given over the subsequent 16 hours. Any fluids the patient has already received should be subtracted from the volume to be delivered. A urinary catheter should be inserted and hourly urine output should be measured – a minimum of 0.5ml/kg/hour is considered acceptable.

**Example**

A 42 year old man weighing 70kg with a 30% body surface area burn is admitted at 21:00. The burn occurred at 20:00. He has already received 1000ml of IV hartmanns solution.

Fluid requirements over the first 24 hours are:

(%age body surface burned) X (body weight in kg) X 4

= 30 X 70 X 4

= 8400ml

He is to receive the first half (i.e. 4200ml) over the first 8 hours from the time of the burn, and the second half over the subsequent 16 hours.

He has already had 1000ml, so he needs (4200-1000) = 3200ml over the first 8 hours from the burn (which happened at 20:00) – therefore he needs to have this fluid in by 04:00. It is now 21:00, so there are 7 hours to go. He needs to receive 3200/7 = 457ml/hr.

He then needs his second 4200ml of fluid over 16 hours, from 04:00 to 20:00. This should therefore run at 4200/16 = 262ml/hr.
**Fluids and blood in trauma**

When considering if a trauma patient needs some sort of IV fluid replacement, there are two competing priorities.

1) **Maintain the circulation.** This requires a reasonable blood pressure and volume to be within the circulation, and ensures perfusion of tissues and organs. If this were your only priority, you would give lots of fluids.

2) **Preserve activity of the coagulation system.** This can be impaired either by dilution of clotting factors (from eg. crystalloid or colloid fluids, or bags of red blood cells), by consumption of clotting factors (from the body attempting to clot, but bleeding continuing unabated) or from the patient becoming cold (which can be exacerbated by giving unwarmed fluids or blood). If this were your only priority, you would not give any fluids at all.

Modern management of fluids in the trauma patient is therefore a balance between these two factors.

Assessment of degree of blood loss can be tricky. Vital signs such as heart rate, respiratory rate, capillary refill time and blood pressure can be useful, although they are not always that sensitive – ie. some patients with quite considerable blood loss may have relatively normal vital signs. Assessment of oxygen delivery to the tissues is a more effective way – this means checking the serum lactate or base excess which can change if the patient's tissues are respiring anaerobically. The serum lactate may rise. The base excess (normal range -2 to +2) can become more negative, which reflects a developing metabolic acidosis.

In patients who do not have much evidence of blood loss, there is not likely to be much value in giving fluids. In these situations, IV fluids are generally not given at all, or in small volumes. Crystalloids such as hartmanns would be appropriate.

For patients with evidence of more severe bleeding, crystalloids and colloids are only given in small volumes. They are primarily used in small fluid boluses of about 250ml in order to acutely improve blood pressure and perfusion. There is good evidence that giving large volumes of IV fluids to bleeding trauma patients will increase their mortality – therefore, blood products are usually transfused early (once you are approaching 1litre of crystalloid/colloid fluids, you should definitely be giving some blood). The first type of blood product required are red blood cells - the oxygen carrying component of blood. If you anticipate giving a reasonable amount of blood – either because the patient is displaying signs of being unstable, or they have a bleeding source that you can’t immediately control (ie. Anything internal), then you should activate the major haemorrhage protocol. This is normally done by phoning switchboard.

There are 3 preparations of red blood cell available:
O negative – there will usually be 2 or 4 units immediately available in the Emergency Department fridge or the laboratory.

Type specific – this comes from the laboratory and will take about 15 minutes to prepare (from their receipt of the patients blood sample). This is a compatible ABO and rhesus group for the patient, but has not been tested against the patients blood so there is a risk of more minor incompatibilities.

Cross-matched – this also comes from the laboratory. It usually takes about 30-40 minutes to be prepared, and the patients blood has been tested with the donors so that you are very unlikely to experience any incompatibilities.

It is important to remember that bags of red cells contain just that – red blood cells, some water and electrolytes. They contain no clotting factors, fibrinogen or platelets. Therefore, if you give more than a few bags of red cells there is a risk that you will dilute the patients clotting factors. These, therefore, will also start to need replaced which is initially with fresh frozen plasma (FFP). There is no hard rule as to when to initiate this, but generally speaking, if a patient has had 4 units of red cells then they will need some FFP too. If you need to continue transfusing red blood cells, then they may need some more specialized blood products – these are platelets and cryoprecipitate. Cryoprecipitate is a bit like FFP, but contains much higher levels of fibrinogen. Remember to keep in touch with the haematologist and laboratory and send regular full blood count and coagulation samples to them.

NB: IV fluids and blood products should be warmed before being given to a patient – this is particularly true of blood products as many of them will have come from the fridge and be very cold.

**Tranexamic acid:** This is an anti-fibrinolytic drug, which means it inhibits the breakdown of clots. It is very cheap with an excellent side-effect profile. There is evidence that it reduces mortality in trauma patients who are bleeding, so you should give it to anyone who you are transfusing. The dose is 1gram over 10 minutes, followed by 1gram over 8 hours.