Chapter 7: Trauma

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Introduction

The treatment of trauma is well documented in the ATLS guidelines. This chapter will provide a brief summary of management of trauma and highlight the important aspects of management from an ICU prospective.

The key components in management include:

1. Preparation
2. Triage
3. Primary survey (ABCDE)
4. Resuscitation
5. Adjuncts to primary survey and resuscitation
6. Secondary survey
7. Adjuncts to the secondary survey
8. Continued post resuscitation monitoring and re-evaluation
9. Definitive care

We will focus on preparation, primary survey, resuscitation, secondary survey, post resuscitation care and monitoring for the purposes of ICU.

Preparation

The ingredient to the successful treatment of trauma is not just good clinical assessment and treatment decisions, but also team management. Preparation doesn't just involve fluids, drugs, equipment and monitoring, but also personnel and team organisation. Team roles should be assigned and can include:

1. A team leader
2. Airway and ventilation
3. IV access and circulation
4. Drug drawers
5. Physical examiner/s

Each role usually require more than one person. Other support services that you may need to inform outside of the emergency department include theatre, laboratory, blood bank, and diagnostic and intervention radiology.

Primary survey

This is the ABCDE assessment. This stands for:

- Airway
- Breathing
- Circulation
- Disability
- Exposure/environment

Airway

Please refer to chapter 1 for details of airway management. Common indications for intubation in terms of trauma includes:

1. Reduced level of consciousness (Traditionally taught GCS<9)
2. Airway patency
3. Airway injury
4. Respiratory failure
5. Uncooperative patient where assessment and management cannot be safely administered. Patients are at risk of aspiration if they are merely given sedation in this group of patients.

Assessment also need to be made with regards to whether there are injuries to the head/neck/airway that may affect airway management. The C-spine should be assumed to be unstable until radiological/clinical clearance. This means patients should be in a rigid neck collar and for intubation, inline immobilization (1) should be administered during the period when the collar is removed. In this hospital, a CT-c spine that has been reviewed by a consultant radiologist and deemed to have no acute injury is adequate clearance.

Breathing

Please refer to chapter 2 and 3 for details of ventilation assessment and management. Specific pathologies that are possible in the chest that can affect ventilation include:

- Pneumothorax, open and closed +/- tension
- Haemothorax
- Tracheal or bronchial injury
- Rib/sternal fractures
- Diaphragmatic rupture
- Aspiration
- Pulmonary contusions
- Cervical spine injury (not in the chest, but can compromise ventilation)

In haemothorax and pneumothorax, insertion of an intercostal drain will need to be inserted expediently, particularly if it is causing tension. This should occur before the application of positive pressure ventilation. The important signs for this includes unilateral chest movements and breath sounds, reduced air entry, and deviated trachea as well as signs of respiratory distress and hypoxia. Otherwise, ventilation assessments and therapies are as per chapter 2 and 3.

Circulation

This will be the main concern in trauma. Haemorrhage shock (2) is common in severe trauma and principles of assessment and management is described in the chapter 4 circulatory shock, under the second hypovolaemic shock. The key points to highlight is:

- 2x Large bore IV access should be obtained. Failure after 2 attempts should be followed by insertion of the intraosseous line (3).
- Group and screen to be performed
- Hypotension is a late sign of shock (4). Assess globally for shock, including mental state, capillary refill, peripheral perfusion, heart rate and urine output as well.
- After the first 2-3L of crystalloid or colloid start giving blood.

- Consider massive blood transfusion protocol
- Assess for source of bleeding and obtain source control with temporizing measures if possible and definitive methods. This includes applying external pressure to external bleeding sites, reduction of long limb fractures, and use of pelvic binders.
- Manage the consequence of massive blood transfusion (5):
    - Maintain core body temperature by giving warmed fluids
    - Watch for hypocalcaemia and hyperkalaemia in the context of massive transfusion
- Set an appropriate blood pressure target. You need to consider:
    - Patient's normal BP. Young patients can tolerate a SBP of 80, whereas patients with pre-existing hypertension may need more
    - In penetrative injuries, permissive hypotension can be considered to reduce blood loss until source control can be achieved
    - Presence of traumatic brain injury (TBI) will mean a higher mean arterial blood pressure (MAP) is needed to maintain cerebral perfusion pressure (traditionally taught SBP of 120 if bleeding is an issue, otherwise MAP >80-90 should be maintained if TBI is suspected)

Disability

Assess level of conscious with Glasgow Coma Scale (GCS), although this is often done as part of an airway assessment to assess the patients' to protect their airway. It consists of 3 component: Eyes, motor and verbal. The most important component is the Motor score. GCS is used as a surrogate marker for the ability to protect airway, and ATLS guidelines recommends intubation with GCS <9. It is also used to grade the severity of head injury, although the initial GCS maybe confounded by other factors (e.g. other drugs present, including iatrogenic and recreational). Pupil size and reactivity of light is also an important part of the assessment, particularly if the patient is sedated and paralyzed. A fixed and dilated pupil in this context is likely to signify herniation and compression of the brain stem and urgent intervention is required (see section under "Head" below).

Component	Response	Score
Eye	Opens spontaneously	4
	Opens to voice	3
	Opens to pain	2
	No response	1
Motor	Obeys commands	6
	Localizes to pain	5
	Withdrawals to pain	4
	Abnormal flexion to pain	3
	Extension to pain	2
	No response	1
Verbal	Orientated	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sound	2
	No response	1

Exposure/environment

Exposure means that the patient is well exposed for assessment for possible injuries and sources of bleeding. Subsequent to a comprehensive assessment, attention needs to be given to minimize heat loss and maintain core temperature as hypothermia causes coagulopathy (the environment).

Secondary survey

The primary survey and management is to ensure that the patient stays alive and buys time for a more comprehensive assessment of the patient. It is important to remember that the ABCs needs to be continually monitored as the patient's condition can rapidly deteriorated at any stage. The purpose of the secondary survey is to identify injuries and sources of bleeding. Consideration will also need to be given to patient's comorbidities. There are 4 main components of the secondary survey:

1. Physical examination: Head to toe exam
2. History: AMPLE
3. Bedside investigations
4. Radiological investigations

Physical examination

This is a head to toe examination looking for injuries and sources of bleeding. In this section, we will not discuss every single injury that is possible, but rather focus on life or limb threatening injuries that have intensive care implications.

Sites of significant injuries

Head

Traumatic brain injury should be suspected in patients with reduced level of consciousness, high energy mechanism, and external evidence of trauma to the head. By definition, severe traumatic head injury is defined as GCS<9 (6), however, in the initial assessment of this might be clouded by confounding factors such as recreational or administered drugs. Pupils should be checked regularly if there is LOC or patient is sedated or paralysed. If there is reduced level of consciousness, than a CT-head and CT-spine should be performed. If there is high energy mechanism and altered mental state, then a pan scan (CT head, neck, chest, abdomen, pelvis) should be performed.

If severe head injury is suspected, then initial cerebral protection therapy needs to be commenced (see neurosurgical chapter). This includes good ABC cares as well as:

- Head up. As the C-spine is not cleared, the whole bed will need to be tilted
- Keep cerebral perfusion by maintaining mean arterial pressure >80-90. This may need to balanced against the risk of bleeding of high blood pressure.
- Maintain normal CO2, 35-45mmHg

The principles of the above therapy is that the skull is a fixed volume space (7) (8). In trauma, the injured brain is swollen, but because the skull cannot expand to accommodate this, the pressure builds. This means that higher blood pressure is needed to overcome the pressure inside the cranium in order for blood flow to occur. In addition, the injured brain loses its ability to autoregulate, which means it does not increase its blood flow in the presence of low blood pressure.

If the pupils are unilaterally or bilaterally are dilated, this signals coning, or compression of the brainstem. This is a surgical emergency and in addition to above you will also need to:

- Hyperventilate
- Commence Mannitol or hyperosmolar salt (9)
- Urgent Neurosurgical referral, CT head and theatre preparation

Hyperventilation is not done prior to dilated pupils because hyperventilation can reduce blood flow to the brain and that chronic hyperventilation will reduce the setpoint of CO2 at which vasoconstriction will occur (10). Mannitol is only administered after pupil dilatation because of a theoretical risk of reducing brain mass will increase space for venous bleeding. Both of these are temporizing measures and the definitive therapy is surgery.

Once in ICU the care of TBI includes standard medical therapy of intracranial pressure (ICP) (11):

- Monitoring with ICP. The insertion of an ICP is decided by the neurosurgeons with input of the duty ICU consultant. It is based on the likelihood of the brain to swell. Where there is high ICP an external ventricular drain (EVD) may be inserted.
- Aim cerebral perfusion pressure (CPP) of 60mmHg. Cerebral perfusion pressure is the difference between the MAP and the intracerebral pressure (ICP)

CPP=MAP-ICP

This is a surrogate marker for the cerebral blood flow. CPP of less than 60mmHg can result in cerebral ischaemia and further brain injury (secondary brain injury)

- Keep good venous drainage. This means make sure the neck veins are not constricted (commonly happens with tight neck collar application) and head up. If there is poor venous drainage, the venous blood volume within the brain increases and therefore increases ICP.
- Keep higher osmolarity. This means keeping the Na high, with a usual target of 145-150mmol/L. This reduces cell volume and therefore swelling of the brain.
- Avoid hyperthermia. Hyperthermia increases metabolic activity of the brain and can raise ICP as well as increasing brain ischaemia. Common temperature target is 35-37C.
- Avoid hypoxia which can worsen ischaemia.
- Maintain normocarbia, CO2 35-45mmHg.
- Keep well sedated and sometimes relaxants may help. In refractory high ICP, additional agents such as barbiturates (12) may be added, but this should only be in consultation with the intensivist.

An ICP that is not responding to the above therapies should be discussed with the neurosurgical service and consultant. Often, further imaging and intervention may be required, rather than just persisting with more medical therapy.

Spine

In patients with significant trauma, the C-spine is considered unstable until cleared, and should be stabilized externally until such time. Clinical clearance will unlikely to be possible in the group that is referred to ICU because patients often have LOC, under the influence of sedative or drugs, and often have distraction injuries. CT C-spine is now the investigation of choice for the clearance of C-spine. A normal CT C-spine reported by a consultant radiologist is adequate for the removal of external stabilization, provided in the absence of other evidence or risk of C-spine injury. There is a very small chance of missing soft tissue injuries, however the risk of harm of keeping the collar outweighs the benefits in this instance. There is evidence that soft tissue injuries missed by a modern multidetector CT is unlikely to have neurological significance (13). Presence of other risk factors/evidence (e.g. neck pain, tendering, neurological signs and symptoms) will warrant MRI and this should be in consultation with the spinal surgeons.

Assessment of spinal injuries

Ensure ABCs. Patients with high cervical spine injuries will have ventilation problems, as the phrenic nerve is innervated by C3-5 nerve roots. Even if the phrenic nerve is spared, they may not be able to cough and clear secretions due to loss of abdominal muscle innervation. Note the use of accessory muscles in breathing, which are supplied by the 11th cranial nerve.

If it is possible, get a neurological assessment looking at a sensory and motor level as well as anal tone. Log roll of the patient and a careful look for steps and gentle feel for tenderness and a PR is also required.

Spinal shock

This presents as flaccidity and arreflexia of the affected limbs due to spinal injury

Neurological shock

This is due to the involvement of the sympathetic chain from spinal injury. The sympathetic system which cause peripheral vasoconstriction and tachycardia are affected. This is presented as hypotension and if the cardiac fibres are involved, bradycardia.

Management

In patients with severe multitrauma, ABC management and cervical spine stabilization and log rolls will suffice in the initial phase. Priority will still be given to life saving procedures i.e. interventions for source control of bleeding, then urgent intracranial pathologies if required and then consideration of spinal interventions if one is possible. Consult orthopaedics/neurosurgeons early. In isolated spinal injury, the same principles apply, beginning with ABCs. An urgent MRI is likely to be required as early surgical intervention may improve neurological outcomes. Manage the neurological shock with inotropes and vasopressors, but always exclude bleeding as a cause of hypotension.

Airway injuries

Injuries of the head and neck may involve airway injuries. This can have two important effects: the airway becomes difficult, becomes obstructed, or both can occur. For details on the assessment of airway please refer to the airway chapter. In essence if there are injury to the airway suspected, help should be sought for early. This is in the form of anaesthetists +/- ENT surgeon.

Chest

Injuries to the chest can cause the following life threatening injuries:

- Pneumothorax +/-tension
- Massive haemothorax
- Tracheobronchial tree injury
- Pericardial tamponade/cardiac contusion
- Aortic injury
- Diaphragmatic rupture
- Pulmonary contusion (aspiration can also relate to trauma)
- Penetrating mediastinal wounds

Pneumothorax

Tension pneumothorax requires urgent decompression and chest drain(s). Needle decompression mid-clavicular line 2nd intercostal drain is a rapid method of achieving decompression, but always needs to be followed by insertion of intercostal drains (ICD). Simple pneumothorax detected by CXR should be treated with ICD as well. Occult pneumothorax is where pneumothorax is present on CT chest but not CXR. This does not necessarily need a chest drain even if positive pressure ventilation is required, unless it is >8mm in size. However the patient needs to be closely monitored as there is still potential for progression.

Haemothorax

Pleural fluid in the context of trauma is likely to be blood and an intercostal drain needs to be inserted. Blood can be from a variety of sources including chest wall, great vessels, and lung.

Indications for thoracotomy

- Shock and drainage of 1500ml of blood initially
- Ongoing bleeding of around 200ml/hr is also an indication.

Tracheobronchial tree injury

Most patients with significant injury to the tracheobronchial tree die at scene due to loss of airway and ventilation. For those who survive, tracheobronchial injury may present as persistent subcutaneous emphysema, pneumomediastinum and pneumothorax despite insertion of chest drain. The injury can be diagnosed with a fine slice CT of the airway and lung with bronchoscopy.

Pericardial tamponade

Look for distended neck vein to give you a clue. This can be diagnosed by a focussed assessment with sonography for trauma (FAST) scan or an echocardiogram. The presence of tamponade will mean urgent sternotomy/thoracotomy. If the patient is too unstable to go to theatre, than an emergency thoracotomy maybe required. Percardiocentesis maybe an alternative if the above options are not feasible.

Aortic injury

High energy trauma with signs and symptoms of chest trauma should prompt suspicion. CXR changes such as widened mediastinum, pleural effusion, pleural cap, 1st or 2nd left rib fracture, a deviated nasogastric tube, obscured aortic knob can suggest an aortic injury, although they are not specific. History, exam or CXR abnormalities that suggests suspicion should warrant a contrast CT of the chest. Treatment requires discussion with cardiothoracic and vascular surgery on whether open or endovascular repair is required.

Diaphragmatic rupture

This relatively uncommon and characterised by upper abdominal pain. Herniation of bowel contents into the thorax may be present on CXR, but often in the ICU where patients are positively ventilated this will not be apparent. Sometimes can be diagnosed in multislice CT but definitive diagnosis and treatment is laparotomy particularly where the patient is unstable.

Pulmonary contusion

This can present as hypoxia and haemophytsis, with CXR showing opacity in the lung. Although mild contusion can be treated with could chest physio and simple oxygen therapy, in the ICU setting, it is treated with mechanical ventilation and good tracheal toileting.

Penetrating chest injury

This has potential for significant structures to be injured. Immediate life threatening complications include tension pneumothorax, pericardial tamponade, great vessel injury, and massive bleeding. Patient with shock and penetrating chest injury needs to have urgent sternotomy/thoracotomy. Remember that abdominal injuries can occur as a result of penetrating chest injuries.

Abdomen

Abdomen is a source of major bleeding in trauma. Look for symptoms of abdominal pain, examine for external evidence of injury, abdominal distension and feel for abdominal tenderness or guarding which may suggest significant abdominal pathology. The bedside investigation that is useful is the FAST scan to look for free intra-abdominal fluid. If the patient is unstable, a positive FAST scan warrants an urgent laparotomy. If the patient is stable, then a CT-abdomen should be done.

Pelvis

A fractured pelvis may cause significant amounts of retroperitoneal bleeding causing shock. Important signs of pelvic fracture includes perineal ecchymosis, tenderness over the pelvis, lower body neurology, and haematuria of the rectum and vagina. Checking for pelvic stability should only be done once by the doctor with the most expertise. If pelvic instability and bleeding is suspected, the pelvis should be bound. Consultation with orthopaedics is vital, as the management is either pelvic packing for venous bleeds or angiography and embolization in arterial bleeds.

Limbs

The initial management of significant limb injuries are reduce/traction and immobilisation. These therapies are often enough to control significant bleeding. If the patient is stable, then they often have delayed definitive surgery, unless they need to wash out a contaminated open fracture, or there is neurovascular compromise.

History

A good pneumonic is the AMPLE history

- **A**llergies: Drug allergies
- **M**edications: Mediation history, in particular, antiplatelets or anticoagulants, anti-hypertensive drugs
- **P**ast history: Important comorbidities
- **L**ast meal: This is not as important. All patients are assumed to be an aspiration risk, but it keeps the pneumonic a nice word.
- **E**vents: Sequence of events. A good source is the ambulance reports

An important point to make is make sure anti-tetanus is administered.

Bedside investigations

There are important investigations that can be done without the patient leaving the relatively safe environment of the ED. This is particularly important when the patient is too unstable to go through a CT scan.

1. CXR: Can often be done reasonable rapidly. Can show many chest injuries, as well as tube position, in particular, the ETT.
2. Pelvic Xray: Done at the same time as the CXR. Can show pelvic and hip fractures.
3. FAST scan: This looks for intra-abdominal free fluid as well as pericardial tamponade (14). It is non-invasive and quick to do. The disadvantages is that it doesn't tell you what is injured (compared to a CT) (15) and does not distinguish between retroperitoneal blood and peritoneal blood. This is important as the management of pelvic artery bleeding (which produced retroperitoneal blood) is radiological intervention whereas peritoneal bleeding requires a laparotomy. This distinction may not be as important where hybrid theatres are available.

4. Diagnostic peritoneal lavage: Very rarely done and has largely been replaced by the FAST scan. It can distinguish between retroperitoneal and peritoneal bleeding, as well as potentially diagnosing bowel perforations, but is so rarely done that it is often not available.
5. Beta HCG in all females within the child bearing ages

Radiological investigations

CT scan is the mainstay of radiological investigations in trauma (16). It is important to note that it is not the option to take in a haemodynamically unstable patient. An unstable patient may need to go to the operating theatre or an angiography suite and stabilized before a complete set of CTs can be done.

On arrival to ICU

A complete ABCDE should be again reassessed. Check and document the secondary survey already done, but also do another careful head to toe (sometimes known as the tertiary survey). This is because hopeful, the patient should be in a stable condition and you have more time to do your assessment. If the patient is unstable, you will need to go through the full primary and secondary survey again as described in this chapter. This is the time to make sure that the less urgent surgical injuries are assessed and that a plan is made. Often, this includes the orthopaedic, ophthalmology, urology, maxillary facial services. Make sure tetanus is administered and that if there are open fractures or other surgical injury indications that antibiotics is administered. Significant vasopressor requirement out of keeping with sedation or known injury (such as a spinal cord injury) should be assumed to be hypovolaemia, and if ongoing resuscitation requirement, you need to assume bleeding.

Ensure that all lines and tubing are in the correct position. Patients should have oral or nasogastric tube placed (nasal is preferred, but oral if there is significant base of skull fracture) and arterial line. Most patients with severe trauma will also need a central venous line for vasopressor administration. A discussion with the family should be made to establish a history and also to update them with the patient's progress.

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