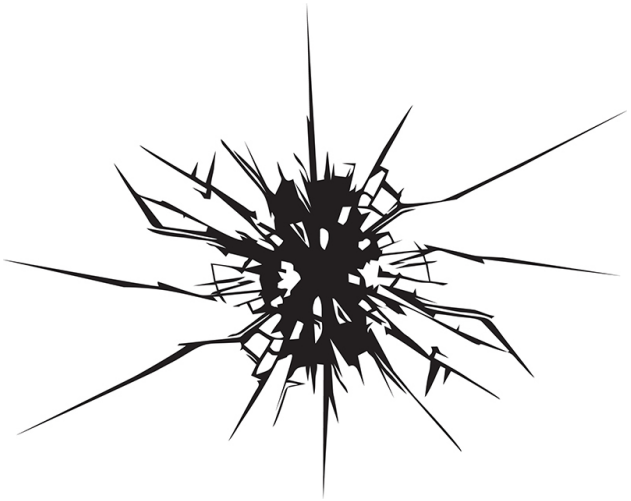
Acute Trauma



In the patient with major trauma we begin management "in the dark", often faced only with a patient with a life threatening clinical condition such as altered consciousness or shock and an uncertain number of injuries. In contrast to the acute medical patient where the focus is on identifying a single diagnosis, the patient with major trauma will have multiple diagnoses (injuries). In addition it is important to always consider the possibility and search for concomitant medical disease (eg seizure, drug or alcohol toxicity, cardiac arrhythmia or ischaemia) that may have contributed to the accident or if unrecognised may cause serious illness (eg type 1 diabetes).

A useful principle to keep in mind when assessing a victim of major trauma is that where one serious injury is identified, there is, in all probability, one or more other serious injuries yet to be discovered. It is common to miss significant injuries during the initial examination and reassessment and ongoing observation of the patient is essential - we should never let our guard down when managing the patient with major trauma, they will constantly surprise and unnerve us !

While "minor" trauma (in contrast to major trauma) can often seem straight forward, there remains the risk of missing a significant injury that may later cause long term disability or trigger life or limb threatening complications. Common examples include an unrecognised nerve or tendon injury in the hand following a "minor" laceration or missed scaphoid fracture diagnosed as a wrist sprain or even dislocation of the knee (that may have spontaneously relocated at the time of injury) causing injury to the popliteal artery. It is best to assume that with respect to injury "nothing is ever minor". Approach each case with a careful and considered initial assessment and ensure adequate follow up to allow for early identification of complications or missed injury.

On-line Resources @ www.learnem.com.au

Clinical case studies, e-tutorials, procedural videos and clinical resources relevant to each of the 10 sections in the ABCDs of Emergency Medicine may be found on the LearnEM website and listed under headings of "Crit Care", "Emerg Med 1", "Emerg Med 2" and "Prim Care" in the top nav bar.

The CPD accredited Courses relevant to trauma include :

1. ABCDs of Resuscitation
2. Advanced Airway Management
3. Procedural Sedation
4. Orthopaedic Trauma (1) and (2)
5. Bedside Emergency Ultrasound (1) and (2)

Chapter 17
Major Trauma : Patient Assessment

Key Points

1. **In major trauma the first priority is to identify and treat life-threatening problems. The Primary Survey is summarised by the mnemonic ABCDE.**
2. **Routine interventions include oxygen, oximetry, cervical immobilisation, intravenous access, cardiac and blood pressure monitoring and BGL.**
3. **Additional interventions may be required if problems are identified and may include basic airway manoeuvres, bag and mask ventilation, IV fluids and compression of an external bleeding site.**
4. **During the secondary survey an assessment is made to determine the extent of the patient's injuries. This involves an AMPLE (T) history, an examination of all body regions and the ordering of laboratory investigations and imaging.**
5. **During the assessment the patient should be continually re-evaluated for signs of instability.**
6. **Trauma "Flags" may be used to identify at-risk patients and "signal" the need for a trauma survey.**

Introduction

Trauma is the leading cause of death in children and adults < 44 years old and the third most common cause of death overall. Road trauma is responsible for 60% of those killed. Other common causes include falls, burns, assaults and sporting accidents.

Death from trauma typically occurs in one of three distinguishable time periods.

- Within secs / mins of injury (50% of deaths) : These are usually due to disruption of the CNS, Heart, Aorta, or other major blood vessels. These patients are essentially unsalvageable.
- Within 1 - 2 hours of injury (35% of deaths) : These are usually due to major head injuries (subdural and extradural haematomas), chest injuries (haemothorax), abdominal injuries (ruptured spleen, lacerated liver), fractured femur and pelvis or multiple injuries associated with major blood loss. These deaths occur in what is often termed the 'Golden Hour' and many of these are preventable with the delivery of acute medical care. The primary focus for trauma care is to provide rapid assessment and resuscitation to patients to reduce the morbidity and mortality associated with injury.
- Days / weeks following injury (15% of deaths) : These are usually due to organ failure, brain death or overwhelming sepsis and may be prevented by appropriate resuscitation during the golden hour.

Approach to Major Trauma

In the patient with major trauma the first priority is to identify and treat life threatening problems (ie stabilise the patient). After completing the primary survey and resuscitation phase, the next step is to undertake a thorough evaluation of the patient (termed secondary survey) and arrange definitive care.

The 4 phases in management of multiple trauma are classified as the Primary Survey, Resuscitation, Secondary Survey and Definitive Care :

- The Primary Survey — Aims to identify life threatening injuries
- The Resuscitation Phase — Aims to resuscitate and stabilise the patient
- The Secondary Survey — Aims to determine the extent of injuries
- The Definitive Care Phase — Aims to set management priorities / arrange definitive care

Primary Survey and Resuscitation Phase

On arrival of the patient to hospital a primary survey is performed.

This begins by first assessing for danger and in the trauma patient will include initiating universal precautions such as putting on a gown, gloves and eye protection. Next the patient is assessed to identify immediate risks to life and measures taken to commence resuscitation when a threat to vital organ function is identified.

The trauma primary survey is summarised by the mnemonic ABCDE. Often critical details on the nature of the accident, patient's condition at the scene and other clinical details may be obtained from the paramedics or witnesses and it is important that these are not lost in the process of receiving the patient.

There are five steps to the primary survey and at each step there are clinical signs to check and routine action (s) required. This is outlined in detail below.

Airway : Look for signs of Airway Compromise

- Check Airway — Listen and feel for air movement/obstructive sounds.
  Look for chest rise with inspiration
- Routine action — Apply high flow oxygen
  Immobilise the cervical spine

Breathing : Look for signs of Hypoxia / Ineffective ventilation

- Check Breathing — Assess respiratory rate and look for signs of distress
  Auscultate and percuss the lungs
- Routine action — Attach oximetry and monitor oxygen saturation

Circulation : Look for signs of Shock

- Check Circulation — Assess pulse rate, rhythm and volume. Measure blood pressure
  Examine capillary refill and perfusion of extremities
- Routine action — Obtain IV access with 2 large cannulas. Collect bloods. Start IV fluids
  Attach ECG and BP monitors

Disability : Look for immediate threats to the Brain

- Check CNS function — Assess conscious state (AVPU)
  Examine pupils and check pupillary reaction and equality
  Assess limb movements / posturing / jerking
- Routine action — Check BGL

Exposure : Prepare the patient for further assessment

- Undress the patient — Cover the patient with blankets to avoid hypothermia
- Routine action — Check patient temperature

Resuscitation

Additional actions (ie Resuscitation) may be required if problems are identified during the Primary Survey. These may include basic airway manoeuvres such as suction of the airway, jaw thrust and insertion of a guedel airway, bag and mask ventilation, commencement of a rapid fluid bolus or compression of external bleeding. Resuscitation is initiated concurrent to performing the primary survey.

As a problem is identified in the primary survey an intervention to address the problem should be initiated before proceeding to the next step in the survey.

Secondary Survey

After completing the primary survey quickly review the patient's ABCDE's to confirm that the patient remains stable and then proceed to a thorough assessment of the patient to identify all injuries. This is termed the secondary survey and involves

- Patient history and a comprehensive head to toe examination (see below)
- Investigations : Laboratory tests, Urinalysis, Imaging
- Initiating/coordinating treatment of injuries

The secondary survey is summarised below. During the secondary survey continue to re-evaluate the patient to check for signs of instability and monitor vital signs. Stay with the patient and seek assistance early.

1. Begin with an AMPLE (T) history

- Check the patient's Allergies, Medications, Past medical history, Last Ate, Event History,
- Check Tetanus status : Give ADT and Tetanus Immunoglobulin as indicated

2. Next examine all body regions systematically

- Head — Perform a Glasgow Coma score, check ears and scalp
  Look for signs of base of skull / open / depressed fractures
- Face — Check pupils, eyes and orbits, mouth, nose. Look for facial fractures, eye injury
- Neck — Look but don't explore open wounds penetrating platysma.
  Check for subcutaneous emphysema and tracheal deviation
- Thorax — Palpate / Listen / Percuss / Ultrasound (Perform an eFAST exam if feasible)
  Look for fractures / flail chest, haemo / open / pneumothorax / penetrating injury
- Abdo — Palpate tenderness / guarding. Do a PR. Check perineum. Check pulses.
  Ultrasound (Perform an eFAST exam if feasible). Re-evaluate patient frequently.
- Spine — Examine the Cervical, Thoracic, Lumbo-sacral (log roll) spine.
  Arrange clinical or radiological clearance of the C-spine
- Limbs — Look for fractures, lacerations, neurovascular injury, amputations
  Assess for and document adequacy of distal neuro-vascular supply
- External — Look for lacerations, contusions, abrasions, burns

3. Arrange Imaging

- Trauma X-rays : A chest X-ray and radiological clearance of the C-spine is required routinely
- Other imaging will frequently be required and depend on the pattern of injury

4. Tests / Procedures

- Routine urinalysis and laboratory testing (CBP, G&S, EUC, Lactate, Coags) should be performed
- Depending on the severity of injury an IDC, Nasogastric tube or Splinting may be required

Definitive Care

Arrange definitive care of the patient once the secondary survey has been completed, all x-rays checked and all IV lines and other tubes inserted. Ensure all documentation has been completed. Summarise injuries and set priorities for management. Arrange transfer / retrieval as required.

Trauma Flags

Identifying the Patient with Severe Trauma

A patient with serious trauma may present to the emergency department in a variety of ways. The ambulance/paramedics may have notified the hospital in advance allowing mobilisation of the medical and nursing team (trauma team) to receive the patient. In other situations, the patient may arrive without notification but be quickly identified as unstable or seriously injured during the triage assessment resulting in a trauma team response.

In a few patients, the severity of their injuries may not be obvious or they may arrive by private vehicle without pre-hospital assessment. There is the potential for delayed diagnosis and treatment and as a consequence these patients are at risk for higher morbidity and mortality.

One approach to reducing the possibility of missing serious injury is to identify at-risk patients on arrival and arrange for a senior clinician (eg ED registrar / consultant or the On call rural practitioner in a rural hospital) to perform a trauma survey with the aim of identifying occult or potentially serious injury.

Trauma "Flags" may be used to identify at-risk patients and "signal" the need for a trauma survey. The table below provides an example of a procedure and a set of "Trauma Flags" for an emergency department and trauma centre.

Triage - Trauma Flags

Procedure

- The following are indications for an internal "Trauma Alert".
- The patient should be triaged as priority one or two and taken to the resuscitation room immediately.
- The ED Resuscitation Nurse and Senior Medical Officer will jointly assess the patient and notify a trauma team call if required.

Indications

- MVA at speed > 60 km/hour
- MVA where there has been a fatality
- Burn to > 10% of the body surface
- MVA – patient ejected from the vehicle
- Pedestrian or cyclist hit by a car travelling > 30 km/hr
- Fall from height $\geq$ 2 metres
- Other major impact
- Ambulance notification
- Penetrating trauma to head, neck or torso

Chapter 18

Major Trauma : Resuscitation

Key Points

1. **It is critical to assess and continually monitor the airway. Signs of aiway compromise may be extremely subtle. Be particularly vigilant in the patient with altered conscious state.**
2. **Indications for intubation include altered conscious state, inability to maintain a patent airway, respiratory failure and severe agitation.**
3. **Use of the semi-rigid (hard) neck collar for immobilisation of the C-spine is controversial. Research studies have failed to demonstrate clinical benefit and clinical practice is changing in relation to their role in trauma.**
4. **In respiratory distress assess for airway obstruction, tension pneumothorax, open pneumothorax, massive haemothorax and flail chest / lung contusion.**
5. **Haemorrhage is the most common cause of shock. Treatment includes resuscitation with IV normal saline, blood transfusion and if required surgery.**
6. **Signs of raised intracranial pressure include altered conscious state, unilateral dilated unreactive pupil and hyperventilation. Management involves endotracheal intubation and ventilation and mannitol or hypertonic saline.**

Airway : Obstruction[1]

Signs of airway compromise may be overt or extremely subtle. It is critical to assess the airway carefully on arrival and reassess the patient to identify the early signs of airway compromise. Be particularly suspicious in the agitated (hypoxic?), sleepy or unconscious (hypercarbic?) patient.

Listen for gurgling, snoring, gargling or other airway noises and feel for air movement with expiration. Determine if the trachea is midline and auscultate the chest. Ensure the C-spine is immobilised in a neutral position. The aim of this process is to ensure a clear airway and provide adequate oxygenation.

The procedure for managing the compromised airway in trauma is summarised below :

- Clear any secretions / vomitus / blood by suction of the oropharynx
- Apply a jaw thrust technique to open the airway (The head-tilt technique should be avoided in the trauma patient)
- If tolerated gently insert a guedel airway
- Definitive management involves the insertion of an endotracheal tube
- A laryngeal mask airway or surgical airway may be required in patients with failed endotracheal intubation.

Indications for endotracheal intubation in the trauma patient include :

- Deeply unconscious patient. Consider intubation in the patient with GCS < 9/15
- Inability to maintain a clear airway (eg facial fractures, airway burns)
- Where respiratory assistance is required
- Severely agitated patient where c-spine immobilisation or resuscitation is compromised

[1] See chapters 3 - 5, "Acute Airway Obstruction", "Advanced Airway Management" and "Rapid Sequence Intubation" for a detailed discussion of this topic.

Breathing : Chest Injury

There are four conditions that significantly compromise ventilation if not detected and managed early : tension pneumothorax, open pneumothorax, massive haemothorax and flail chest with lung contusion. These are identified by assessing respiratory rate, palpating for a flail segment, checking trachea is midline, percussing and auscultating the chest and examining for penetrating injuries and distended neck veins. Cardiac injuries include myocardial contusion, pericardial tamponade and cardiac valve rupture or leak.

Tension Pneumothorax

Air under pressure within the thoracic cavity results in compression of the contralateral lung and great vessels resulting in respiratory failure, shock and acidosis. It presents dramatically with severe respiratory distress.

The clinical findings in a patient with tension pneumothorax include :

- Marked tachycardia and tachypnoea
- Ipsilateral absent breath sounds and hyperresonant percussion note
- Raised jugular venous pressure (JVP) and Tracheal deviation (away from the pneumothorax)
- Hypotension occurs shortly before cardiac arrest

In the patient with suspected tension pneumothorax immediate needle or finger thoracostomy is required. Traditionally the advice has been to insert a large bore IV cannula or 5 cm angiocatheter into the second intercostal space in the mid clavicular line. In about 50% of patients however the chest wall thickness exceeds the length of the standard IV cannula and angiocatheter resulting in a high failure rate.

Currently suggested approaches to the management of tension pneumothorax include :

1. *Placement of the needle or open thoracostomy laterally* in the 5th intercostal space, midaxillary line. Laterally the chestwall is thinner with a decreased risk of injury to the great vessels or the heart.
2. *Using small bore catheters designed for aspiration of spontaneous pneumothorax* such as available in the Cook or Arrow pneumothorax kits. These are easily placed and use the seldinger technique or catheter over the needle approach to insertion, are wider in diameter and less likely to kink or obstruct.

Where this equipment is not available, a surgical incision and blunt dissection using forceps or a finger may be used to create a surgical opening in the lateral chest wall. After the tension pneumothorax has been decompressed a thoracostomy tube should be placed.

Open Pneumothorax

Open pneumothorax occurs following penetrating chest trauma (eg knife wound). Small defects usually seal spontaneously, however larger defects may remain open causing a sucking chest wound impairing ventilation. Manage patients by promptly closing the defect with a sterile occlusive dressing such as plastic wrap or Vaseline gauze. The dressing should be large enough to overlap wound edges. Tape the dressing securely on **three** sides to provide a flutter type valve effect. Once the patient is stabilised a chest tube should be placed in an area remote from the open wound. Definitive closure of the defect is usually required.

Massive Haemothorax

Massive haemothorax is defined as > 1500 ml of blood in the chest cavity. It is most commonly due to penetrating injury involving the systemic or pulmonary vessels but may on occasion be caused by blunt trauma. It results in shock (due to blood loss) and hypoxia (due to compression of the lung). Signs include hypotension, ipsilateral absent breath sounds and dull percussion note. Management involves IV fluids to correct hypovolaemia and decompression of the chest cavity with a large bore chest tube. Patients may need thoracotomy if blood loss continues at > 200 ml / hour.

Flail Chest

A Flail chest occurs where a segment of the chest wall does not have bony continuity with the rest of the thoracic cage. The major problem associated with flail chest is the underlying lung injury (contusion), which results in loss of lung compliance, respiratory dysfunction and hypoxia. Diagnosis is clinical. Signs include decreased air movement, asymmetrical and uncoordinated movement of the thorax and palpation of abnormal respiratory motion and bony crepitus. Flail chest may not be initially apparent because of splinting of the chest wall and the diagnosis is often delayed. Management includes adequate ventilation and oxygenation, careful control of IV solutions to prevent under or over hydration and provision of analgesia. Frequent assessment of ventilation status is required by close monitoring of the respiratory rate, oxygen saturation, work of breathing and blood gases. In severe cases intubation and ventilation will be required.

Circulation : Shock[2]

Shock is a clinical diagnosis and is defined as an abnormality of the circulatory system that results in inadequate organ perfusion.

Hypovolaemic shock due to haemorrhage is the most common cause of shock in trauma. Tachycardia and cutaneous vasoconstriction are the earliest signs. Blood pressure is generally maintained by compensatory mechanisms until approximately 30% of the blood volume is lost.

Possible sites for bleeding include:

- Thoracic (Massive haemothorax, Aortic Disruption)
- Abdomen (Ruptured spleen, liver, kidney. IVC injury)
- Pelvis (Fractured pelvis)
- Limb (Fractured femur)
- External (Vascular injury to limb, scalp wound)

Less common causes of shock include cardiogenic and neurogenic shock. Cardiogenic shock may be caused by myocardial contusion, tension pneumothorax and cardiac tamponade. Clinical signs of cardiogenic shock are raised central venous or jugular venous pressure.

Neurogenic shock occurs in the context of spinal injury and is due to the loss of sympathetic vascular tone. Clinical features include bradycardia and warm extremities. Head injury alone virtually never causes shock except in very young children and in terminal brain injury with failure of medullary cardiac centres.

Immediate Management

- Begin by obtaining some form of vascular access.
- In difficult cases consider using ultrasound (to identify veins and guide placement) or intraosseous access or using a dilator (such as the rapid infusor set). Work toward obtaining 2 large bore IV catheters as soon as feasible.
- Collect Blood for haematology (CBP), biochemistry (EUC/LFTs), Lactate, Coags, Group and Match
- Assess the degree of shock (Pulse rate / volume, Capillary refill, BP, Mental status).
- If shock is present administer an immediate IV fluid bolus (20 ml/kg) of normal saline and monitor carefully to assess response to the fluid bolus :
- When feasible arrange insertion an indwelling urinary catheter (urine output is a sensitive indicator for the adequacy of fluid resuscitation and reflects organ perfusion)

Assess response to Fluid Bolus

- If the patient's condition stabilises this indicates a loss of < 20% of the blood volume. Management involves continuing fluid resuscitation with maintenance fluids and close observation.
- If the patient shows a transient improvement but later deteriorates this indicates a 20% - 40% blood volume loss. A second fluid bolus (20 ml/kg) should be given and blood transfusion commenced when blood is available. An inadequate response to blood administration identifies the patient with continued bleeding and in need of surgical intervention.
- In the patient with minimal or no response to the initial fluid bolus, fluid resuscitation and blood should continue and arrangements made for immediate surgery to control exsanguinating haemorrhage

Ultrasound, where available, may be used to identify the cause of shock and assess the fluid status of the patient. The RUSH protocol (Rapid Ultrasound in Shock) assesses cardiac function, the pericardial, pleural and intraabdominal spaces, the abdominal aorta and evaluates the IVC to determine fluid loading / hypovolaemia.

[2] See chapters 9 - 10 and 13 - 14, "Circulatory Shock"," Critical Bleeding" and "Bedside Emergency Ultrasound" for a detailed discussion of this topic.

Cardiac Tamponade

Although haemorrhage is the most common cause of shock in trauma it may rarely be caused by pump failure due to myocardial contusion or cardiac tamponade. In cardiac tamponade the pericardium fills with blood impairing cardiac filling and resulting in shock. It most commonly results from penetrating trauma. Diagnosis may be made using bedside ultrasound as part of the FAST examination and RUSH protocol.

Clinical features of pericardial tamponade include :

- Hypotension with raised jugular venous pressure. This is the characteristic clinical finding in cardiac tamponade but may be absent in the patient with severe hypovolaemia.
- Pulsus paradoxus : this describes a decrease in systolic BP > 10 mmHg with inspiration
- Kussmaul's sign : this is a rise in jugular venous pressure with inspiration

Management involves the administration of a 250 - 500 ml IV fluid bolus followed by pericardiocentesis using subxyphoid approach. Where available ultrasound may be used to guide the pericardiocentesis needle. Aspiration of only a few mls of blood may have a dramatic effect. All patients with a positive pericardiocentesis will require open thoracotomy and inspection of the heart.

Disability : Altered Conscious State

During the primary survey assess the patient's conscious state using the AVPU system

- A = Alert
- V = Eyes closed but responds to Verbal stimuli
- P = Responds only to Painful stimuli
- U = Unresponsive

Examine the pupils to assess for raised intracranial pressure and assess the limbs for movement or absent or asymmetric reflexes suggestive of spinal cord or intracranial trauma. Document the Glasgow Coma Score.

Glasgow Coma Score (GCS)

Eye opening (tests brainstem function)	
Spontaneously	4
To verbal command	3
To pain	2
No response	1

Talking (tests cerebral function)	
Orientated and converses	5
Disorientated and converses	4
Inappropriate words	3
Incomprehensible sounds	2
No response	1

Motor (tests cortical / brainstem function)	
Obeys verbal command	6
Localises painful stimulus	5
Flexion - withdrawal to pain	4
Abnormal flexion (decorticate)	3
Extension (decerebrate rigidity)	2
No response	1

Maximum Glasgow Coma score = 15

Management involves assessment and stabilisation of the ABCs, identification and treatment of raised intracranial pressure and the exclusion of non-traumatic causes for altered mental state. It is vital to consider other causes for a depressed conscious state beside those due to trauma. In particular, consider hypoglycaemia, narcotic, alcohol or other drug poisoning and postictal states.

When head injury is suspected, management includes securing the airway (to prevent aspiration / airway obstruction), ensuring adequate oxygenation and ventilation, rapidly correcting circulatory compromise and controlling seizure(s). Raised intracranial pressure should be managed with normo-ventilation (aiming for an end tidal pCO2 of 35 to 40 mmHg) and cautious use of Mannitol 20% or Hypertonic Saline.

Most patients with GCS < 9 will require intubation. Patients with a GCS between 9 - 12 will frequently require intubation particularly if there is a poor or absent gag reflex, difficulty in maintaining a clear airway (eg facial fracture, bleeding), associated shock or respiratory compromise.

Severely agitated patients should be assumed in the first instance to have cerebral irritation due to head trauma. They may need to be managed using rapid sequence intubation to protect the C-spine, facilitate examination and permit CT scan of the head.

Management of Specific Injuries

Thoracic Injury

Look for tension pneumothorax, open pneumothorax, haemothorax and flail chest/lung contusion. Be aware of lung contusion/flail chest, as respiratory failure is often insidious and develops in the period after the medical team may have left the patient and only intermittent observations are being performed. Where available an eFAST examination will assist to identify pneumothorax, haemothorax and cardiac tamponade.

Blood gases should be performed in all patients with significant chest trauma and will show a gradual deterioration in patients developing lung contusion. Check the CXR for evidence of traumatic aortic rupture, lung contusion, fractures, pneumo / haemothorax. Perform an ECG and assess for signs of possible myocardial contusion (tachycardia, AF, non-specific ST changes). Consider the possibility of pericardial tamponade.

Abdominal Injury

The abdominal cavity extends between nipples and scapulae superiorly and inguinal creases and gluteal folds inferiorly. Clinical signs in the patient with significant abdominal injury may be subtle and a high index of suspicion should be maintained particularly in patients reporting abdominal pain, chest or pelvic injury or other painful distracting injury and in the elderly patient.

Serial clinical examination and bedside ultrasound (FAST scan) play an important role. CT scan is frequently required and surgical consultation should be requested early.

Pelvic injury

Pelvic injuries may be complicated by severe hidden blood loss into the retroperitoneal space and difficulties in controlling the haemorrhage. X-ray of the pelvis is required in patients with suspected pelvic trauma.

A careful examination of the inguinal region and perineum including a PR should be performed. Look for evidence of urethral injury (perineal bruising, blood at the urethral meatus, high riding prostate). Where clinical signs of injury to the urethra are present do not attempt to pass an IDC until a retrograde urethrogram has been performed. Vaginal laceration is common in female patients with pelvic fractures and will be evident on vaginal examination. A PR exam is essential to identify rectal injury as this serious injury is easily missed.

In the presence of significant pelvic fractures stabilise the pelvis using a pelvic binder or a firm compressive bandage tied around the pelvis and strapping the legs firmly together. CT of the pelvis with contrast will be required to evaluate the extent of injury.

Cervical Spine Injury[3]

Cervical Spine injury has the potential to be associated with catastrophic cord injury. Although cervical spine immobilisation is placed with airway at the top of the trauma hierarchy, the only intervention required during the primary survey and resuscitation phase is immobilisation. and attention to ensuring an adequate airway, oxygenation and circulation.

Although traditionally placed on all patients with major trauma, the use of the semi-rigid (hard) neck collar for immobilisation of the C-spine has been challenged recently and clinical practice is changing with respect to their role in trauma[4].

Patients with cervical cord injury may develop a type of shock, referred to as "Neurogenic shock", due to loss of sympathetic tone resulting in vasodilation (warm peripheries), hypotension and bradycardia. Management involves the use of 250 - 500 ml fluid boluses, atropine and in some cases inotropic support (eg Noradrenaline).

After the primary survey is completed a formal neurological assessment of the patient is performed. This should include an examination of the power, reflexes and sensation in the limbs and an assessment of anal tone and perianal sensation.

In a patient with a normal neurological examination, the final step in assessment is cervical spine clearance. This may be performed clinically (Clinical Clearance) or require the use of imaging (Radiological clearance).

[3] See chapter 19, "Clearance of the Cervical Spine" for a detailed discussion on the NEXUS rules and Canadian C-spine rules for clearance of the cervical spine in trauma.

[4] Research studies have not demonstrated a clinical benefit from the routine use of semi-rigid (hard) neck collars and have identified significant adverse effects with their use. See Chapter 19 for a detailed discussion on this issue.

Burns[5]

The principles of management for the patient with major burn injury are identical to those for managing patients with other types of severe trauma. Completion of the primary survey and institution of resuscitation should always take priority. It is easy to be distracted by the burn injury and degree of patient distress with the result that the clinician fails to adequately assess the patient's vital organ functions.

Particular attention should be placed on assessing the airway for evidence of inhalational burn injury as this may lead to severe life threatening airway obstruction. Clinical findings suggesting upper airway burns include altered voice / hoarseness, extensive facial burns, singed nasal hairs, oropharyngeal burns, stridor, dysphonia, dysphagia and drooling. Patients with clinical symptoms/signs of airway burns and those requiring transfer who have a high potential for airway burns should be intubated early as delayed swelling may rapidly cause obstruction which is very difficult to manage once it has developed.

Careful attention should be given to identifying shock and ensuring effective fluid resuscitation. As large amounts of fluid are sequestered from partial and full thickness burns it is important that account is taken of this in deciding fluid management for the following 24-hour period. All adults with > 15% burn surface area (BSA) and children with > 10% BSA require IV fluid replacement. To determine IV fluid requirements in burns use the Parkland Burn formula : Fluid replacement = 4 ml / kg / % burn over 24 hours (Half given over 8 hours from the time of injury and half over remaining 16 hrs). Use Hartmans solution or Normal saline.

Paediatric Trauma[6]

Significant anatomical, developmental and physiological differences in children impact upon the nature of injuries, prognosis for recovery and clinical management of paediatric trauma. A disproportionately larger head predisposes children to head and upper cervical spinal injury, while a more pliable chest wall increases the risk for serious intrathoracic injury without clinical signs of significant chest wall injury. The altered airway anatomy in the child increases their risk for airway obstruction from local injury and may pose a significant challenge to the clinician attempting to secure the airway with an endotracheal tube.

Clinical assessment may be compromised by the emotional state of the child. The interpretation of vital signs needs to be considered in the context of the "normal range" for vital signs in the child and the importance of assessing the BGL is emphasised by the susceptibility of the infant to hypoglycaemia. A modification to the standard Glasgow Coma Scale is required to assess GCS in the infant or very young child.

Clinical assessment and ongoing management need to take into consideration the heightened physiological compensatory mechanisms in the child that paradoxically predispose them to sudden and rapid deterioration (once these extraordinary physiological compensatory mechanisms are exceeded).

Trauma in Pregnancy[7]

Specific anatomic/physiologic changes occur in pregnancy altering the response to injury. Assessment and management follow the routine procedure for Primary Survey / Resuscitation. Aggressive fluid replacement is required in shock (50% above non-pregnant requirements) because the physiological hypervolaemia of pregnancy and ability to shut down the ureteroplacental circulation allow a blood loss of 30% - 35% before maternal hypotension develops. To avoid aortocaval compression patients greater than 20 weeks gestation should be placed in the left lateral position.

Secondary survey includes an Obstetric evaluation. Uterine size (fundal height) is evaluated to assess gestation and abdominal examination performed to assess for uterine tenderness / irritation / tetanic contraction. The fetal heart rate should be checked if the fetus is > 16 weeks and pelvic examination performed to assess cervical dilatation and presence of amniotic fluid. All pregnant patients > 23 – 24 weeks require a minimum of 4 hours of CTG monitoring (even in minor trauma). Where the patient is symptomatic or CTG trace is abnormal, admission for continuous CTG monitoring is indicated.

Urgent obstetric consultation is indicated in patients with vaginal bleeding, abdominal tenderness, pain or cramping, evidence of maternal hypovolaemia, absence of fetal heart tones and suspected leakage of amniotic fluid. Important injuries / complications to consider include placental abruption, preterm labour and uterine rupture. The presence of any of these complications poses a serious threat to fetal survival. If the mother is Rhesus negative, Anti-D should be administered.

[5] See chapter 22, "Burns" for a detailed discussion of this topic.
[6] See chapters 48 - 50, "Paediatric trauma", Closed head Injury" and "Child Abuse / NAI" for a detailed discussion of this topic.
[7] See chapter 90, "Trauma in Pregnancy" for a detailed discussion of this topic.

Chapter 19

Cervical Spine Clearance / Imaging

Key Points

1. **The best treatment for a cervical spine injury is immobilisation and ensuring an adequate airway, oxygenation and circulation. Immobilisation must be continued until clinical or radiological clearance has been completed.**
2. **Clinical practice is changing in relation to use of semi-rigid collars in trauma. Some prehospital providers have replaced semi-rigid collars with soft collars. Local policies and protocols should be applied to their use in clinical practice.**
3. **An evidence based approach suggested to management of the cervical spine applies the NEXUS criteria to identify high risk patients and application of a soft foam collar to indicate that the C-spine has not been cleared.**
4. **Clinical clearance is suitable for the asymptomatic cooperative alert patient with no obvious serious or painful injuries.**
5. **Radiological clearance is required in the patient with midline (neck) pain / tenderness, serious / painful injury, altered conscious state, alcohol intoxication or high-risk trauma.**
6. **Indications for CT scan include abnormal or inadequate X-ray, neurological symptoms or signs, altered mental state (GCS < 15) and the symptomatic high-risk patient.**

Approach to Cervical Spine Injury

Primary Survey

Cervical Spine injury is relatively common after major trauma and has the potential to be associated with catastrophic cord injury. Up to 15% in patients suffering multiple trauma involving injury above the clavicles have cervical spine injury. Accurate assessment and management is critical to prevent deterioration due to cord ischaemia or cord compression.

Although cervical spine immobilisation is placed with airway at the top of the trauma hierarchy, the only intervention required during the primary survey and resuscitation phase is immobilisation. The best treatment for a cervical spine injury is immobilisation and attention to ensuring an adequate airway, oxygenation and circulation. Immobilisation should be continued until clinical or radiological clearance of the cervical spine has been completed. Although traditionally placed on all patients with major trauma, the use of the semi-rigid (hard) neck collar for immobilisation of the C-spine has been challenged recently and clinical practice is changing with respect to their role in trauma.

Patients with cervical cord injury may develop a type of shock, referred to as "Neurogenic shock", due to loss of sympathetic tone resulting in vasodilation (warm peripheries), hypotension and bradycardia. Management involves the use of 250 - 500 ml fluid boluses, atropine and in some cases inotropic support (eg Noradrenaline).

Secondary Survey

After the primary survey is completed a formal neurological assessment of the patient is performed. This should include an examination of the power, reflexes and sensation in the limbs and an assessment of anal tone and perianal sensation. In a patient with a normal neurological examination, the final step in assessment is cervical spine clearance. This may be performed clinically (Clinical Clearance) or require the use of imaging (Radiological clearance).

Cervical Spine Immobilisation

Traditionally 2 methods for immobilisation of the cervical spine have been used :

- *In-line cervical spine immobilisation* : This refers to manual positioning of the neck in the neutral position, without traction, using 2 hands (the ATLS handshake). It remains a useful approach for the initial stabilisation of the c-spine and for stabilisation of the cervical spine during rapid sequence intubation.
- *Semi-rigid collars* : Placement of a semi-rigid collar has been the standard of clinical care in major trauma for many years. However, the use of semi-rigid collars has been recently challenged.

Although previously the "gold standard" in clinical care of the trauma patient, research has not demonstrated a clinical benefit from the routine use of semi-rigid (hard) neck collars and has identified significant adverse effects with their use including impaired ventilation, raised intracranial pressure and prolonged cervical pain. In fact the use of any collar (or any form of immobilisation) has been challenged with research indicating that there appears to be no evidence that movement of the C-spine after the accident causes further injury[8,9].

It is now increasingly accepted that alert patients stabilise their C-spine due to the muscle spasm and pain associated with injury and do not require immobilisation. The use of rigid cervical collars does not appear to be justified in this patient group based on current evidence.

Discussion is now focused on the management of the unconscious, intoxicated and/or intubated patient. Some prehospital providers have introduced protocols that replace the rigid collar with the use of soft foam collars in high-risk patients. Others have developed protocols that transport these patients in the left lateral position aiming to keep the spine straight with blankets and a standard pillow to keep the neck in a neutral position.

In some services the only indications left for the use of a rigid collar are in difficult extrications of unconscious patients where the paramedic cannot physically stabilise the head during the extraction or for stabilising the neck in a patient being carried over rough terrain.

Toward an Evidenced Based Approach to Management

With research indicating that the use of rigid cervical collars may be detrimental to patient care, a reassessment of the clinical approach to immobilisation in trauma is indicated with development of an evidence based approach to managing the cervical spine in trauma.

In Australia the protocol developed by the Queensland Ambulance Service appears to be a practical and evidence based approach to this issue[10] and provides an example of an approach that has been developed based on extensive reviews of the literature.

In the Queensland Ambulance protocol, the NEXUS criteria are used to identify high risk patients

- Patients who do not fulfill all 5 of the NEXUS criteria are considered high risk. In these patients, a soft foam collar is applied and provides a signal to clinicians that the C-spine has not been cleared.
- In patients who fulfill all 5 the NEXUS criteria no immobilisation is required. The C-spine is cleared.

Nexus Rules

- No posterior midline cervical-spine tenderness
- No evidence of intoxication
- A normal level of alertness
- No focal neurological deficit.
- No painful distracting injuries

Conclusion

Clinical practice is changing in relation to the use of the semi-rigid collar in trauma with a number of prehospital care providers introducing protocols that replace semi-rigid collars with the application of soft collars (for high risk patients) or no collar at all (in low risk patients). Local policies and protocols should be applied to their use in clinical practice[11].

[8] https://prehospitalandretrievalmedicine.files.wordpress.com/2015/05/spinal-immobilisation_evidence-review_170314_v3_eem.pdf
[9] Hauswald, M. et al. (2002) Out of hospital spinal immobilisation in trauma patients: is it really necessary? *Curr Opin Crit Care,* vol. 8, pp. 566-570. Hauswald, M. et al. (1998) Out of hospital spinal immobilisation: its effect on neurologic injury, *Acad Emer Med,* vol. 5, pp. 214-221.
[10] https://www.ambulance.qld.gov.au/docs/clinical/cpg/CPG_Spinal cord injury.pdf
[11] A useful discussion on this topic can be found on the NSW Emergency Clinical Institute (ECI) website under clinical tools. https://www.aci.health.nsw.gov.au/networks/eci/clinical/clinical-resources/clinical-tools/orthopaedic-and-musculoskeletal/cspine-collars

Clearance of the Cervical Spine

In a patient with a normal neurological examination the procedure of cervical spine clearance is undertaken. This may be done clinically or where this is not possible will require imaging.

Clinical Clearance

Clinical clearance is suitable only in the asymptomatic cooperative alert patient with no obvious serious or painful injuries. It should not be attempted in the patient with altered conscious state, serious injuries or with alcohol intoxication.

Clinical clearance refers to the procedure of clinical assessment that rules out cervical spine injury on the basis of history and examination without the need for an X-ray. It is most commonly used in the patient who has presented for a "checkup" after an MVA or has been involved in low speed MVA with minor injuries and may have been walking around after the accident. The procedure for clinical clearance is outlined in the table below.

Procedure for Clinical Clearance of the Cervical spine

History : Answer the following questions

- Is GCS <15 ?
- Are there ANY distracting injuries ? (injuries that may impede patient's ability to report reliably)
- Is there any other reason to suspect the patient may not reliably report ? (eg intoxication)
- Are there any abnormalities to neurological examination below the neck ?
  (test for power, reflexes and sensation – fine touch and vibration – all limbs, trunk and peri-anal)
- Is there any neck pain ?

Examination

If answer to ALL of the above is NO, undo cervical collar (if in situ). Ask patient to keep neck still and check

- Is there ANY midline tenderness on palpation of the neck ?
- Is there ANY midline pain or lack of control on rotating the neck 45^{o} both ways ?
- Is there any midline pain, or evidence of lack of control, on active flexion of the neck ?

Intervention

If the answer to all three is NO, remove collar if present. Ask the patient to sit up and actively move the neck.

- Is there any pain, or any evidence of lack of control, on sitting up ?

If the answer is NO to all of the above the cervical spine has been clinically cleared

If the answer is YES, or UNCERTAIN to any of the above questions, continued immobilisation is required and radiological clearance should be arranged.

Radiological clearance

Radiological clearance is required in most trauma patients and indicated in patients with :

- Midline (neck) pain and / or tenderness
- Associated serious / painful injury
- Altered conscious state
- Alcohol intoxication
- High-risk trauma (high speed MVA, fall from > 2 metres)

Radiological clearance may be undertaken using X-ray or CT scan. The choice between C-spine X-ray and CT scan will be determined by the index of clinical suspicion, presence of neurological findings, associated injuries (that may require CT scan) and availability of CT imaging.

Cervical Spine X-ray

For patients in whom the C-spine cannot be clinically cleared, plain radiography may be considered to radiologically clear the C-spine however where available CT scan is now the method of choice for radiological clearance of the C-spine in trauma

A minimum of three views are required for plain X-ray imaging of the C-spine :

- Lateral view - the most useful view detecting up to 85% of fractures
- Odontoid peg view - of value in visualising injury to C1 or C2
- AP view - the least useful of the three views

If the C7-T1 junction is not clearly visualised, additional films such as an oblique or swimmers view or a CT scan will be required to exclude injury. The ABCS approach to X-ray interpretation is outlined below.

Even when adequate views are obtained the three view series (lateral, odontoid peg and AP) misses at least 7% of all cervical spine fractures. For high risk patients CT scan of the cervical spine will be required for radiological clearance.

Approach to Interpreting the C-spine X-ray

1. Adequacy of the film

- Begin by checking film adequacy - look for overlying shadows, rotation and check to see if the C7/T1 junction is visualised on the lateral film

2. Check lower and upper cervical spine

- Consider the spine from two perspectives - upper cervical spine (C1 and C2) and lower cervical spine (C3 - C7) and examine the films looking at these two areas of the spine deliberately to identify fractures or indirect evidence of injury (eg soft tissue oedema)

3. Use the ABCS approach

A = Alignment, B = Bones, C = Cartilage, S = Soft tissues

Alignment

- Consistent, smooth lordotic curves should be able to be traced in 4 lines from C1 - T1 :

  = Supraspinous line, Spinolaminar line, Posterior vertebral line, Anterior vertebral line

- Look for discontinuity in the lines.

Bones

- Trace outline of the cortex for the body, pedicles, facet joints, lamina, and spinous processes of all seven cervical vertebrae.
- Look especially for small "avulsion" (teardrop) fractures indicating significant ligamentous injury and consequent instability of the vertebral column

Cartilage

- Examine the relationship between vertebrae with regard to the interspinous and intervertebral spaces.
- Check the anterior and posterior margins of the intervertebral disc spaces for evidence of inequality suggesting vertebral body fracture
- Check the interspinous spaces for widening - evidence of posterior ligamentous injury

Soft tissue (Use the 3 x 7 = 22 rule)

- Soft tissue width anterior to vertebral body of C1 should be < 3 mm wide (pre-dental space)
- Soft tissue width anterior to vertebral body of C2 should be < 7 mm wide.
- Soft tissue width anterior to vertebral body of C6 should be < 22 mm wide

CT scan of the Cervical Spine

The recent introduction of Spiral CT scan to clinical care has permitted reduced radiation doses and faster scans. In particular, it has enabled thin cut axial scans with sagittal reconstruction with reported sensitivity for C-spine injury of 99% and specificity greater than 93%. In practice the only injuries missed on CT scan are ligamentous injuries that require an MRI for diagnosis.

As with all new technology, the role of CT scan in clinical practice is evolving and a variety of guidelines have been suggested for patients requiring CT imaging of the C-spine. The major issue centres on which patients cannot be safely cleared with plain X-ray of the C-spine (assuming the films are adequate).

In clinical practice CT scan of the neck in the trauma patient will be required in following circumstances

- Abnormal or suspicious plain film
- Inadequate plain films in a patient who cannot be clinically cleared
- Neurological symptoms / signs suspicious for spinal cord injury
- Patients requiring CT Head for trauma
- Altered conscious state (GCS < 13)

Special populations - At risk for cervical spine injury

Research has identified two other groups of patients at high risk for C-spine injury and where CT scan is indicated for radiological clearance. These are

1. Symptomatic patients > 65 years

Age is an independent predictor for cervical spine injury. Elderly patients are at greater risk for cervical spine injury from apparent minor trauma (eg fall from standing position) and clinicians more commonly miss fractures on plain X-ray due to degenerative and arthritic changes.

Consider CT scan in the elderly patient with neck pain and / or midline tenderness even if the trauma has been minor and the plain X-rays are interpreted as normal.

2. Symptomatic patients with a high-risk mechanism of injury

Mechanisms of injury associated with a high risk for producing cervical spine injury include :

- Fall from > 1 metre (5 steps)
- Axial loading to neck (eg diving)
- MVA - High speed > 100 km/hr, rollover or ejection
- Motorised recreational vehicles
- Bicycle collision

These patients are at significantly higher risk for injury and CT scan is recommended in symptomatic patients even if the plain X-ray is "normal".

Chapter 20
Management of Pain in Trauma

With critically ill patients, a focus on resuscitation issues will often result in failure to consider analgesia. It is obviously the first priority in a patient to provide resuscitation, however, the next priority should be to relieve suffering and pain. Not only is it humane to provide analgesia and relieve suffering but unrelieved pain may have detrimental effects in the critically ill patient by contributing to increased myocardial load and oxygen consumption. Pain may also limit ventilation causing pulmonary dysfunction and hypoxaemia, and contribute to sodium and water retention, hyperglycaemia and increased coagulability.

One of the major questions when considering pain relief in the severely injured patient is how to minimise adverse effects of the analgesic drug(s) on the patient's haemodynamic status, respiration (and airway) and conscious state. This requires a thorough understanding of the analgesic agent(s) to permit their safe use in the seriously ill patient.

Intravenous analgesia[12]

The carefully monitored intravenous administration of morphine or fentanyl is the method of choice for the provision of analgesia in severe trauma and should follow immediately after resuscitation initiatives. The IM or SC routes are not suitable for analgesia in the seriously ill patient as the rate of absorption is variable and physiological changes occurring as resuscitation proceeds makes the time of onset unreliable and the effect unpredictable.

A cautious approach using small doses and titrating to relief of pain whilst monitoring the patient's physiological response is safe. This will avoid the possible detrimental effects of respiratory and CNS depression that result from excessive doses of narcotic agents. The maximum dose of morphine or fentanyl is that which is required to relieve the pain. As patients are under close observation, repeated small aliquots should be administered to maintain effective analgesia during the secondary survey.

An alternative agent that is increasingly used for the management of severe acute pain is low dose Ketamine. Used in subdissociative dose, Ketamine may be used as an adjunct to IV opioids, increasing their potency and decreasing the dose of opioids. Ketamine may be used in the haemodynamically unstable patient and has little effect on the airway or ventilation, making it a very useful agent in the seriously ill patient. One suggested approach for the use of Ketamine as an adjunct to IV opioids is to administer 0.2 - 0.3 mg/kg over 10 minutes followed by an infusion of 0.1 - 0.3 mg/kg/hour.

Altered conscious state

In many patients with altered conscious state, intubation will be required to protect the airway, ensure effective ventilation, control agitation or treat raised intracranial pressure. In trauma patients with altered conscious state who are not intubated, the use of analgesia is challenging and may often be withheld for fear of hiding pupillary changes and obscuring a deteriorating conscious state. Although opioids cause miosis, the pupils will dilate if there is an expanding intracranial haematoma. In patients with obvious pain, aliquots of IV morphine should be administered, until the patient settles. Neurological observations should be continued at 15-minute intervals. There is no evidence to support the use of codeine over morphine for analgesia in patients with head injuries.

Emotional Aspects of Trauma

An often overlooked area in trauma management is the emotional aspect. It is important to consider that most patients, in addition to the physical pain of injury, will experience feelings such as intense anxiety, fear, uncertainty, disbelief and anger. In lay terms this is what is often meant when a person is said to be in 'shock' after an accident. These emotions are often so intense that patients re-live these feelings for considerable periods after the initial trauma in the form of flashbacks, frequent dreams, panic attacks, generalised anxiety, insomnia, depressive illness, continued anger or guilt.

It is extremely important to provide reassurance and explain what is happening (and why) and where possible allay unreasonable fears or excessive guilt. For example a patient having a routine C spine X-ray may strongly believe they have broken their neck unless it is explained that this is routinely ordered in patients with significant trauma. Continuing to talk to patients throughout the process of assessment and allowing them to feel comfortable to raise concerns, will greatly assist co-operation and will help to minimise the serious emotional sequelae that may result from the accident and subsequent medical treatment.

[12] See Chapters 29 and 30 for a detailed discussion on acute pain management and pharmacology.