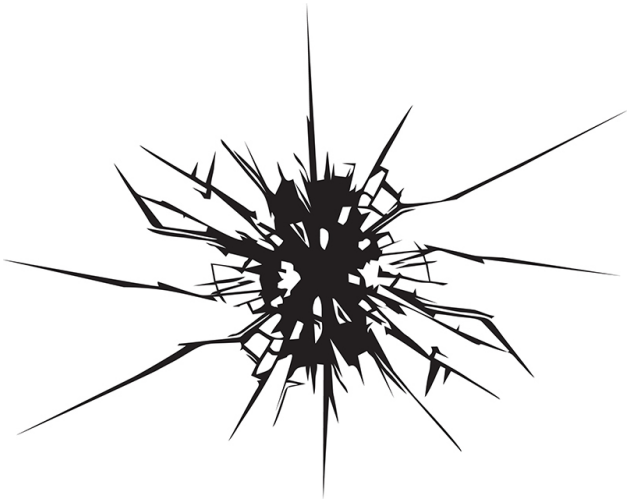
Acute Trauma



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 (e.g., seizure, drug or alcohol toxicity, cardiac arrhythmia or ischaemia) that may have contributed to the accident or if unrecognised may cause serious illness (e.g., 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/videos and clinical resources relevant to each of the 11 sections in the ABCDs of Emergency Medicine may be found on the LearnEM website as part of the *EDGE21* course, the *RESP High Risk Emergencies* (Online) Workshop and the 30 specialised *CPD courses.*

The CPD Courses relevant to trauma include :

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

Chapter 21

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, stabilisation of the cervical spine, 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 before the age of 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 major 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 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 (i.e., 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 the 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

Preparing for a Trauma Patient

Resuscitating a seriously injured patient is stressful and requires many hands. The moment it is apparent that a patient is seriously injured a call for assistance should be activated. Move the patient to a resuscitation area with appropriate monitoring and equipment and drugs for managing the airway, assisting ventilation, and treating shock.

If there is warning given that a seriously injured patient is in transit to the hospital use this time to take a few moments to set up IV fluids, prepare monitoring, drugs and equipment that may aid the resuscitation and have the team apply personal protective equipment (PPE). Use the opportunity to prepare staff and allocate roles.

The Zero Point survey described previously provides a useful framework for considering how to prepare for a Resuscitation.

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.

Primary Survey

On arrival of the patient to hospital a primary survey is performed. Begin by assessing for danger and ensuring staff are wearing appropriate PPE including gown, gloves, and eye protection.

The Primary Survey ensures that a structured approach to the patient with major trauma is followed and immediate priorities such as severe external bleeding, airway obstruction, severe respiratory compromise, circulatory shock, hypoglycaemia, raised intracranial pressure and hypothermia are recognised and treatment commenced to stabilise the patient.

Haemorrhage Control

Recent approaches to the management of the critically injured patient, emphasise the importance of initiating measures to limit severe bleeding. Begin the Primary Survey by searching for the signs of severe bleeding and attempt to limit blood loss by applying direct compression to an external bleeding site (s), application of a limb arterial torniquet (such as a CAT device) or by stabilisation of a pelvic fracture with a pelvic binder.

Haemorrhage control should be given immediate priority in managing the trauma patient as research has highlighted that even a short delay in identifying and limiting severe bleeding is associated with a significant increase in mortality and places the patient at risk of later complications including multiorgan organ failure.

Identifying severe bleeding will prompt the need (in addition to stabilising the airway and breathing), to obtain urgent vascular access and initiate fluid resuscitation. Blood transfusion (red for red) should be commenced as soon as possible with the aim of restoring oxygen carrying capacity and organ perfusion. In such cases consideration will also need to be given to the initiation of the local massive transfusion protocol and urgent retrieval of the patient to a trauma centre for definitive care.

Resuscitation

In the seriously injured patient intervention will be required to stabilise the patient's condition.

Examples include compression of external bleeding, application of a limb torniquet or pelvic binder, the use of basic airway manoeuvres to clear an obstructed airway, assisted ventilation with a bag and mask and IV fluids and bloods in the patient with shock from blood loss. As a problem is identified during the primary survey, treatment is instituted to stabilise the patient before proceeding to the next step in the survey. This is discussed in detail in the following chapter.

Priorities in Continuing Care of the Seriously Injured Patient

It is important to recognise that the Primary Survey provides the structure for the continued monitoring and resuscitation of the patient with major trauma and should be repeated regularly.

In the critically ill unstable patient and in the initial stages of the resuscitation after running through the primary survey, return back to "A" and reassess the patient's airway (obstructed? unprotected?), breathing (distress? hypoxia?), circulation (shock?), disability (altered conscious state, raised intracranial pressure) and environment (hypothermia ?).

Primary Survey in the Seriously Injured Patient

Danger - **Response** - **Send for Help**

	Assessment	Routine Action
Airway + Haemorrhage	**Look, Listen, Feel** Look for external bleeding Look in mouth / check breathing Listen for obstructive noises Feel air movement at the lips	**Routine Action** Apply High Flow O_2 Limit severe bleeding C-spine stabilisation
Breathing	**Look, Listen, Feel** Look : Resp Rate / Distress Listen : Auscultate / Percuss Feel for Trachea midline	**Routine Action** Attach Oximetry to monitor O2 saturation
Circulation	**Begin at hands, work up arm** Assess hands for Colour / Temp Assess Capillary Refill Pulse Rate, Rhythm, Volume Check Blood pressure	**Routine Action** Obtain vascular access Collect bloods Commence IV fluids Attach ECG and Blood pressure monitoring
Disability	**Check CNS function** Conscious state (AVPU scale) Check Pupils : Reaction to light, Size and Equality Look for limb movement	**Routine Action** Check Blood Glucose
Exposure	**Patient environment** Undress patient for examination Check the Temperature	**Routine Action** **Temperature** Keep patient warm Reassess ABCDs

Secondary Survey

After completing the Primary Survey and initiating Resuscitation, a Secondary survey is commenced to examine the patient from head to toe with the aim of identifying the extent of their injuries. As you begin the Secondary Survey briefly review the patient's ABCDE's to confirm that the patient's condition has been stabilised before continuing.

The secondary survey is outlined in detail below and involves the key elements :

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

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 the 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, pelvic 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
- ROTEM[1] where available enables the early identification of coagulopathy following trauma
- 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.

[1] ROTEM (rotational thromboelastometry) is a bedside point of care test for measuring hemostasis quality via the viscoelastic properties of a blood clot and is designed for patient blood management. It provides a rapid assessment of clot development from secondary hemostasis to clot lysis by evaluating clot formation, clot firmness, and clot fibrinolysis.

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 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 (e.g., 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 22
Major Trauma : Resuscitation

Key Points

1. **Haemorrhage control should be given immediate priority in managing the trauma patient. Blood loss should be limited by applying direct compression and /or application of a limb arterial torniquet or pelvic binder.**
2. **It is critical to assess and continually monitor the airway. Signs of airway compromise may be extremely subtle. Be particularly vigilant in the patient with altered conscious state.**
3. **Indications for intubation include altered conscious state, inability to maintain a patent airway, respiratory failure and severe agitation.**
4. **The use of the semi-rigid (hard) neck collar is no longer recommended and a variety of approaches are used to stabilise the C-spine.**
5. **In respiratory distress assess for airway obstruction, tension pneumothorax, open pneumothorax, massive haemothorax and flail chest / lung contusion.**
6. **Haemorrhage is the most common cause of shock. Treatment includes resuscitation with IV normal saline and blood and surgery to control bleeding.**
7. **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.**

In the seriously injured patient, resuscitation interventions will be required to stabilise the patient. As a problem is identified during the primary survey, treatment is commenced before proceeding to the next step in the survey. These are discussed below.

Haemorrhage Control

Haemorrhage control should be given immediate priority in managing the trauma patient. Attempt to limit blood loss by applying direct compression to an external bleeding site (s), application of a limb arterial torniquet (such as a CAT device) or by stabilisation of a pelvic fracture with a pelvic binder.

Identifying severe bleeding will prompt the need to obtain urgent vascular access and initiate fluid resuscitation. Blood transfusion (red for red) should be commenced as soon as possible with the aim of restoring oxygen carrying capacity and organ perfusion. In such cases consideration will also need to be given to the initiation of the local massive transfusion protocol and urgent retrieval of the patient to a trauma centre for definitive care.

Airway : Obstruction[2]

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.

[2] See chapters 5 - 7, "Acute Airway Obstruction", "Advanced Airway Management" and "Rapid Sequence Intubation" for a detailed discussion of this topic.

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 (Avoid the head-tilt technique in the trauma patient)
- If tolerated gently insert an oropharyngeal airway
- Definitive management involves the insertion of an endotracheal tube (or LMA in some cases)

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 (e.g., facial fractures, airway burns)
- Where respiratory assistance is required
- Severely agitated patient where c-spine immobilisation or resuscitation is compromised

Emergency airway management in trauma can be difficult. Whilst intubation may be indicated, it may not be possible in some circumstances and alternate techniques to secure the airway need to be planned and communicated. Ideally this planning should be conducted in advance.

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 that the 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 hyper-resonant 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 Angio catheter 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 Angio catheter 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 chest wall 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. This is referred to as an Open or Finger Thoracostomy.

After the tension pneumothorax has been decompressed a thoracostomy tube should be placed.

Open Pneumothorax

Open pneumothorax occurs following penetrating chest trauma (e.g., 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.

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. Noninvasive ventilation is useful and in severe cases intubation and ventilation will be required.

Practice Point

Significant underlying lung contusion can occur from trauma with or without associated flail chest. A useful rule of thumb is that if extensive lung contusion is apparent on the initial chest x ray, subsequent respiratory deterioration leading to respiratory arrest will be highly likely to occur within the next 1 - 2 hours. This holds true even if there is little or no respiratory compromise or increased work of breathing initially.

Therefore, in the presence of extensive lung contusion secondary to chest trauma on the initial chest x-ray, very strong consideration should be given to urgent intubation and mechanical ventilation even of the patient does not appear to have significant respiratory compromise at the time of examination.

Circulation : Shock[3]

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, obstructive, and distributive shock.

[3] See chapters 11, 12 and 16 on Circulatory Shock, Critical Bleeding and Bedside Emergency Ultrasound for a discussion of this topic.

Rarer Causes of Shock in Trauma

Cardiogenic / Obstructive shock may be caused by myocardial contusion, tension pneumothorax and cardiac tamponade. Clinical signs include raised central venous or jugular venous pressure.

Distributive 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 with the aim of securing 2 large bore cannulas. If required use ultrasound guided vascular access, IO access or a dilator (such as rapid infuser set).
- 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 commence immediate IV fluid resuscitation and administer tranexaminc acid. Consider applying a pelvic binder, femoral leg traction (e.g.CT6) etc.
- When feasible arrange insertion an indwelling urinary catheter (urine output is a sensitive indicator for the adequacy of fluid resuscitation and reflects organ perfusion)

Replace "Red with Red"!

While the fluid resuscitation will often begin with a Normal Saline bolus (10 – 20 ml/kg), it is critical that blood should be commenced as soon as possible to continue the fluid resuscitation of the patient with major bleeding. Replacing "red with red" improves patient outcomes by reducing the complications associated with the use of excessive crystalloids causing dilution of red blood cells and clotting factors and hypothermia.

Assess the response to Fluid Resuscitation

- If the patient's condition stabilises management involves continuing close observation, completion of the Primary and Secondary survey and arrangements for definitive management.
- If the patient shows signs of continuing blood loss, blood transfusion should be continued, and the local massive transfusion protocol activated. Urgent arrangements should be made for definitive management to control the bleeding.

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.

Cardiac Tamponade

Although haemorrhage is the most common cause of shock in trauma, shock 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 ultrasound to guide the needle using a subxyphoid or parasternal long axis (PLAX) approach. 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

In the patient with altered conscious state following trauma, management focuses on the 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 including hypoglycaemia, narcotic, alcohol or other drug poisoning and postictal states.

During the primary survey the patient's conscious state is initially assessed using the AVPU system. A formal GCS should be documented when possible. The pupils should be assessed for possible raised intracranial pressure and the limbs assessed for movement. Reflexes should be evaluated as the finding of absent/asymmetric reflexes is suggestive of spinal cord or intracranial trauma.

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

Head Injury with Raised Intracranial Pressure

In the patient with altered conscious state following trauma, a careful search for signs of raised intracranial pressure is required. In many patients only one or two signs may be present to alert the clinician to the possibility of life threatening raised intracranial pressure requiring urgent intervention.

The cardinal sign of acutely raised intracranial pressure is altered conscious state. In these circumstances check the pupils, breathing and cardiovascular system for any of the following :

- Unilateral dilated pupil, unreactive to light
- Abnormal respiration (hyperventilation, irregular breathing pattern, hypoventilation)
- Bradycardia and Hypertension (Cushing reflex)

When raised intracranial pressure 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

- Raising the end of the bed to 30^{o}
- Protecting the airway with an endotracheal tube (or LMA)
- Initiating assisted ventilation aiming for an end tidal pCO_2 of 35 to 40 mmHg
- Cautious use of Mannitol 20% or Hypertonic Saline*[4]

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 (e.g., 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.

[4] Neurosurgical advice should be sought before administering Mannitol 20% or Hypertonic Saline. This is because the timing of administration needs to be synchronised with surgery. If there are significant delays with surgical access, the ICP relieving effects of Mannitol 20% and Hypertonic Saline can wear off as these drugs are excreted, leading to a possible rebound increase in ICP.

Management of Specific Injuries

Thoracic Injury

Look for tension pneumothorax, open pneumothorax, haemothorax and flail chest/lung contusion. Where available an eFAST examination will assist to identify pneumothorax, haemothorax and cardiac tamponade. Be on guard for 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.

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

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.

Bedside ultrasound with the FAST/eFAST protocol has significantly altered the diagnosis of abdominal injury in trauma, facilitating the early recognition of intra-abdominal injury. The eFAST examination is now a routine part of the assessment of the patient with major trauma and may be used to monitor a stable patient for the possibility of occult abdominal injury. In the patient with suspected abdominal trauma CT scan is 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[5]

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

The use of the semi-rigid (hard) neck collar for immobilisation of the C-spine is no longer recommended[6]. A variety of approaches are now used including the use of soft foam collars, rolled towels applied to the side of the head and use of a vacmat for transport. The local protocol should be followed with respect to managing the cervical spine in the patient with major 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 vasopressor support (e.g., 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 with the use of imaging (Radiological clearance). These are described in the following chapter.

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[5] See chapter 23 for a detailed discussion on clearance of the cervical spine in trauma.
[6] Research studies have not demonstrated a clinical benefit from the routine use of semi-rigid (hard) neck collars.

Burns[7]

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 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). Hartman's solution is the preferred fluid for resuscitation in the patient with major burns.

Trauma in Pregnancy[8]

Specific anatomic/physiologic changes occur in pregnancy altering the response to injury. Assessment and management follow the routine procedure for Primary Survey / Resuscitation.

Diagnosis and treatment follow the same principles as the non-pregnant trauma patient with several critical differences due to the altered maternal physiology and presence of the fetus. Physiological changes make the pregnant patient more vulnerable to hypoxia (due to decreased respiratory reserve), severe blood loss (from uterine injury) and failure to recognise abdominal injury (due to diminished peritoneal signs).

Aggressive fluid replacement is required in shock (50% above non-pregnant requirements) because the physiological hypervolaemia of pregnancy and ability to shut down the uteroplacental 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
- Pelvic examination may be required 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.

[7] See chapter 26, "Burns" for a detailed discussion of this topic.
[8] See chapter 99, "Trauma in Pregnancy" for a detailed discussion of this topic.

Paediatric Trauma[9]

Significant anatomical, developmental and physiological differences in children impact upon the nature of injuries, prognosis for recovery and clinical management of children with 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 or disease and may pose a significant challenge to the clinician attempting to secure the airway with an endotracheal tube. Vascular access may also be difficult and require the use of the IO drill or bone injection gun (BIG).

Child abuse needs to be considered in all children presenting as a consequence of trauma. The most common presenting features for child abuse are the 3 B's : bruising, burns and bony injuries. In infants, a sudden unexplained change in neurological status may suggest neurological injury from abuse.

Continuing management needs 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). Clinical assessment may be severely compromised by the emotional state of the child while crying may increase the risk of the child for air swallowing and result in gastric distension increasing risk for aspiration and ventilatory compromise from reduced diaphragmatic excursion.

The interpretation of vital signs needs to be considered in the context of the "normal range" for vital signs in the child while 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. Standard formulae, charts and other resources are essential to tailor IV fluid resuscitation and drug doses based on the weight of the child.

[9] See chapters 55 - 57, "Paediatric trauma", Closed head Injury" and "Child Abuse / NAI" for a detailed discussion of this topic.

Chapter 27
Orthopaedic Injury : Upper Arm

Key Points

1. **Fractures of the clavicle most commonly involve the middle third and are generally treated with a sling.**
2. **Proximal Humeral fractures are common and rarely require urgent intervention. Most can be managed with a collar and cuff sling.**
3. **Humeral shaft fractures may be complicated by radial nerve injury and are managed initially using a splint followed by a functional brace.**
4. **Anterior dislocation of the shoulder is the most common major joint dislocation. Injury to the axillary nerve is a common complication.**
5. **Displaced supracondylar fractures may cause brachial artery injury and require urgent reduction to avoid limb ischaemia.**
6. **Posterior elbow dislocation is common and often associated with fractures of the radial head and coronoid process. Ulnar nerve injury may occur.**
7. **Forearm fractures include concomitant ulna / radial fractures, nightstick fracture, monteggia fracture and galeazzi fracture.**

Clavicle Fractures

Fractures of the clavicle are common injuries. In neonates and children, these fractures generally heal well. In adults, the force required to fracture the clavicle is greater, healing occurs at a slower rate, and risk of potential complications is higher.

The injury is caused by a fall onto an outstretched upper extremity, a fall onto a shoulder, or direct clavicular trauma. The patient reports pain, especially with upper extremity movement and examination reveals local swelling, tenderness and deformity.

Careful examination is required to exclude the rare complications of brachial plexus compression and intrathoracic injury. Open fractures require urgent treatment with prophylactic antibiotics (Cephazolin 2g IV 8 hourly), tetanus immunisation and local irrigation. A sterile dressing should be placed over the fracture and urgent referral arranged.

Classification

Fractures are divided according to the location of the fracture : middle third of the clavicle (the most common), distal third and proximal third of the clavicle

Middle third fracture

Treat with sling immobilisation. There is no advantage to using a figure eight bandage and this increases discomfort to the patient. No orthopaedic referral required. Ensure adequate pain relief and GP follow up.

Distal third fracture

Treat non-displaced fractures of the distal third of the clavicle and fractures involving the articular surface with sling immobilisation. Immobilise displaced fractures in a sling.

Proximal third fracture

Treat non-displaced fractures with sling immobilisation. Displaced injuries may require orthopaedic referral for surgical reduction but this is rare.

Fractures of the Humerus

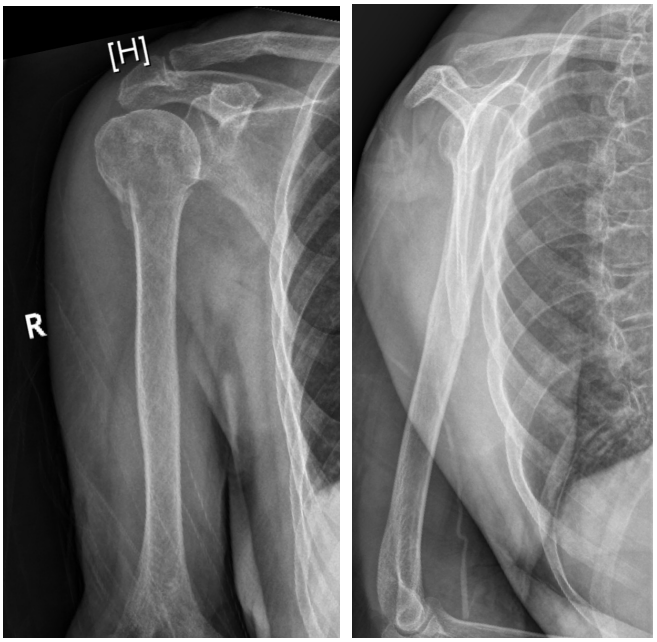
Humeral fractures are common and rarely require urgent intervention. A humeral fracture in a child with an inconsistent injury mechanism should raise suspicion for abuse. Pathologic fractures of the humerus may occur with minimal trauma.

Proximal humerus fracture

Proximal fracture of the humerus is common. It is typically caused by direct trauma to the arm or shoulder or axial loading transmitted through the elbow.

On examination there is pain and tenderness with palpation or movement of the shoulder. Local bruising and swelling are present.

Proximal fracture of the humerus



Management

Most fractures are displaced minimally and treated conservatively with a collar and cuff sling and early ROM exercises. Displaced (>10 mm) 3 or 4 part fractures often require surgical fixation.

Most isolated proximal and diaphyseal humeral fractures can be managed in an outpatient setting if the fracture is otherwise uncomplicated. Complete union is expected at 6 - 8 weeks. Older patients often exhibit functional decrease in shoulder ROM.

Humerus shaft fracture

These are commonly caused by a fall on an outstretched and abducted arm. On examination there is pain and tenderness with palpation or movement of shoulder or elbow. Local bruising and swelling are present.

A careful neurovascular exam should be performed, as radial nerve injury following humeral shaft fracture is relatively common.

To assess radial nerve function, the easiest test is to assess wrist extension (dorsiflexion). Have the patient attempt to straighten the wrist and then flex backwards (dorsiflexion) and test the strength by comparing it with the normal side.

Humerus shaft fracture

Management

Most patients are managed non-operatively with an expected union rate of 90 - 100%, though surgical fixation is necessary if the fracture is segmental or vasculature is compromised.

The fracture is best stabilised using a coaptation splint. This is made by creating a stirrup around elbow by wrapping the splinting material snugly from axilla, along the inner arm, around the elbow and then up along the outer aspect of the arm to the nape of neck.

Fracture reduction is unnecessary because maintaining a reduction is difficult once achieved. Because of the shoulder's ability to compensate, 30 - 45° of angulation is acceptable.

Use the coaptation splint until immediate post fracture pain has subsided, usually within 3 - 7 days. Then place patient in a functional brace. Residual angulation is well tolerated because of compensation by the shoulder and elbow ROM.

Shoulder Dislocation

Anterior shoulder dislocation

The shoulder (or glenohumeral) joint, although having the most extensive range of motion of any joint in the body, is unfortunately an inherently unstable joint. Dislocation of the shoulder is the most common major joint dislocation seen in the emergency department (accounting for about 50% of all major joint dislocations).

The vast majority of shoulder dislocations (95 - 98%) are anterior with the humeral head displaced anteriorly in relation to the glenoid. This is due to relatively weak anterior support when compared to the more robust posterior support provided by the rotator cuff and scapula.

Anterior dislocation most commonly results from abduction of the arm combined with external rotation (imagine the position when waving goodbye). Approximately 70% of cases occur in patients < 30 years old with a 60% chance of recurrence in this age group. In older patients the risk for recurrence is much lower decreasing to 10 - 15 % after the age of 40 years.

Management

Management should begin with a primary survey followed by the provision of analgesia. Careful neurovascular examination should be performed as injury to the axillary nerve is a common complication of anterior shoulder dislocation. X-ray confirms dislocation and identifies any associated fractures.

Injury to the axillary nerve is assessed by testing motor strength and pinprick sensation over the lateral aspect of the arm (the badge area) and comparing it to the unaffected arm. Always assess pinprick sensation before attempting reduction (and again after the procedure) to document function of the axillary nerve. Motor testing assesses the function of the Deltoid muscle and is tested by having the patient attempt to abduct the arm against resistance. This is not practical before reduction of the shoulder (due to the associated pain of the procedure) but should be assessed after reduction of the shoulder.

There are a range of approaches for reducing a shoulder dislocation. No clear evidence supports one technique over another and the choice is often based on previous experience. Useful approaches to consider that have a high rate of success (80%- 90%), are safe to perform and do not require procedural sedation include : Scapular Manipulation, Modified Milch Technique, Cunningham Technique and the Oxford Chair Technique. The Scapular Manipulation technique is described here.

Scapular Manipulation

With the patient seated and the back exposed, the dislocated arm is gently lifted by an assistant so that it reaches a position of 90° of forward flexion at the shoulder. The clinician performing the procedure faces the back of the patient and identifies the lateral border and inferior tip of the scapula. The clinician then stabilises the scapula by placing the palm of one hand on the lateral aspect of the shoulder with the thumb securely on the superior lateral border of the scapula. The palm of the second hand is placed over the inferior tip of the scapula positioning the thumb on the inferior lateral border of the scapula. The clinician then uses both hands to rotate the inferior tip of the scapula medially and the superior aspect laterally with slight dorsal displacement. The goal is to move the glenoid fossa back into the correct anatomic position. To facilitate reduction, the assistant may apply, along with traction, slight external rotation of the humerus, elbow flexion in 90°, or both. Success rates of > 80 - 90% have been reported using this technique.

Post-reduction Management

Management of the shoulder post reduction involves immobilisation in a sling and swathe or shoulder immobiliser. The duration of immobilisation is unclear however with most authorities recommending 3 weeks followed by gentle active range of motion exercises. Research has shown equivalent results with a period of three weeks of immobilisation when compared to longer periods. It is important though to avoid any external rotation and abduction for a further 3 weeks after the immobiliser is removed. In patients > 30 years the period of immobilisation should be a little shorter (7 - 10 days) followed by early range of movement exercises (avoiding external rotation and abduction) to reduce the risk for joint stiffness.

Elbow Fractures

Elbow fractures are common and result from direct trauma or a fall onto an outstretched hand. Fracture patterns vary markedly among different age groups.

Supracondylar fracture of the humerus is most common in children aged 4 - 10 years because of the relative strength of surrounding ligaments in comparison to bone. Injuries to the proximal radius often manifest as *radial neck fractures* in children and *radial head fractures* in adults. *Intra-articular condyle fractures* are seen in children and adults.

Patients commonly report pain, swelling and decreased range of motion. On examination the patient is unable to fully extend elbow, and pain is present with pronation and supination of the forearm.

Serious Complications

Fractures around the elbow, most notably, displaced supracondylar fractures, may damage vital structures and cause serious (limb threatening) complications. Careful neurovascular examination is essential to avoid missing complications.

Displaced supracondylar fractures may cause limb ischaemia due to direct brachial artery injury or later development of a compartment syndrome. The first step in assessment of any patient with suspected displaced supracondylar fracture of the humerus should be to check for the presence of a radial pulse. The absence of a radial pulse or clinical features indicating the presence of limb ischaemia requires urgent orthopaedic intervention. Assistance should be sought immediately if the pulse is absent or there are clinical features indicating distal limb ischaemia - this is a limb threatening complication !

In addition to direct injury to the brachial artery these patients are also at high risk for later developing a compartment syndrome - severe swelling in the forearm muscle compartment resulting in compression of the venous and arterial blood supply leading to limb ischaemia. Continuing assessment of these patients should always involve close observation for the development of the symptoms / signs indicating compartment syndrome.

Clinical features of developing compartment syndrome include severe pain with attempted passive extension of the fingers, patient refusal to open the hand and localised forearm tenderness. Urgent decompression of the muscle compartment is required to avoid muscle ischaemic injury and permanent contracture.

The median nerve may also be injured (again most often due to displaced supracondylar humerus fracture). Rarely however does this result in complete nerve transection, and full return of function is common. Rarely the ulnar nerve may be injured in displaced olecranon fracture.

Elbow X-ray

The lateral elbow X-ray best demonstrates most fractures whilst the AP view may not always reveal the fracture.

Examine the lateral film carefully for the anterior and posterior fat pads.

The *posterior fat pad* is a soft-tissue finding that is appreciated on the lateral radiograph and appears as a radiolucency in the posterior aspect of the distal humerus.

The presence of a posterior fat pad is always abnormal and usually represents haemarthrosis displacing a posterior fat pad, signifying an occult fracture.

Anterior fat pad : Anteriorly, a fat pad adjacent to the distal humerus is usually a normal finding. In radial head fractures, however, haemarthrosis can displace the fat pad anteriorly, resulting in the sail sign.

Elbow X-ray with anterior and posterior fat pads due to occult elbow fracture

Supracondylar fracture

Displaced supracondylar fracture

Supracondylar fracture of the humerus is a common fracture in children. They occur most often in children aged 4 - 10 years because of the relative strength of surrounding ligaments in comparison to bone. The fracture is caused generally by a fall on an outstretched hand. The child reports pain, swelling and decreased range of motion.

Nondisplaced fractures are the most common type of supracondylar fracture and are often difficult to diagnose. The fracture may be missed unless a careful check of the X-ray is made looking for the indirect signs of elbow fracture - the presence of an anterior and posterior fat pad indicating elbow effusion and/or displacement of the anterior humeral line. Once diagnosed the treatment of non-displaced, non-angulated fractures is straight forward requiring either a broad arm sling or application of u shaped plaster.

Significantly angulated or displaced fractures such as the one shown here require reduction and fixation urgently and should be referred immediately for orthopaedic review. A careful neurovascular examination is critical to check the presence of a radial artery pulse. If neurovascular structures are compromised apply forearm traction to re-establish distal pulses. If the pulse is not restored with traction, emergent operative intervention for brachial artery exploration or fasciotomy is indicated. Emergency transfer is required in these circumstances.

Radial head and neck fractures

Radial head fracture is a common injury in adults caused by a falling on an outstretched hand. It can generally be diagnosed on clinical examination and is characterised by point tenderness at the radial head (located along lateral aspect of elbow) with pain most associated with pronation and supination.

Occult or small radial head fractures are treated symptomatically with early range of motion exercises. Patients can be placed in a posterior long arm splint with the elbow in 90° of flexion and forearm in full supination and then given a sling for comfort. For displaced or comminuted fractures mechanically blocking joint motion, surgical intervention may be necessary with referral to an orthopaedic surgeon.

Radial neck fractures are most commonly seen in children and are generally managed with a sling however angulation greater than 15° may require closed reduction and should be referred for orthopaedic review.

Olecranon fracture

Olecranon fracture presents with pain, swelling and decreased range of motion. On examination the patient is unable to fully extend elbow and local tenderness is present over the olecranon (point of the elbow).

Patients can be placed in a well-padded, long-arm posterior splint with the elbow in 70° of flexion and forearm neutral with respect to pronation and supination. Refer these patients to an orthopaedic surgeon. Loss of active extension or intra-articular displacement of greater than 1 mm are indications for surgical treatment.

Elbow Dislocation

Elbow dislocation is generally caused by a fall on the outstretched arm. It is the second most common major joint dislocation with posterior dislocation occurring in 90% of cases. Patients present with the elbow held in flexion at 45º with obvious deformity of the joint due to the prominent posterior olecranon process.

Dislocations may be classified as simple (no associated fracture) or complex (associated fracture present). Fractures of the radial head and coronoid process are the most commonly associated fracture in elbow dislocation and occur in up to 50% of dislocations. Less commonly the medial epicondyle may be fractured and can sometimes become entrapped in the joint preventing closed reduction.

It is important in patients with elbow dislocation to perform a careful neurovascular examination of the limb due to the close proximity of nerves and blood vessels to the elbow joint. Ulnar nerve injury occurs in 8% - 21% of patients with posterior elbow dislocation. In most cases the injury is due to entrapment and the nerve recovers with conservative treatment. Injury to the brachial artery occurs rarely but requires urgent intervention to save the limb. Median nerve entrapment may also occur but is less common than ulnar nerve injury.

Management

It is important to reduce elbow dislocations as soon as possible as delay in reduction results in damage to the articular cartilage, increased risk for circulatory compromise from associated swelling and increases the risk for long term disability due to reduced range of movement, chronic stiffness and joint instability.

In most cases procedural sedation will be required to facilitate reduction. Several techniques are described including Traction / Counter traction, Leverage technique, Stimson Technique and the Kumar Technique. Irrespective of the technique chosen for reduction, it is important that slow, continuous and gentle forces are used to minimise the risk of causing further associated soft tissue injury.

In the Traction / Countertraction technique the arm is supinated (palm up), elbow is held in slight flexion (aim for about 30 degrees). The clinician stabilises the lower humerus with one hand while using their second hand to distract (pull down) on the forearm and apply a slow, continuous, gentle longitudinal traction to the forearm while gradually flexing the elbow. Reduction may be aided by applying downward and forward pressure directly to the olecranon.

Another useful approach is the Leverage technique. This performed by giving the patient an arm wrestle ! Hold the patient's arm up in moderate flexion (with the patient lying supine). Place your elbow onto the distal biceps while interlocking your fingers with the patient's (like an Indian arm wrestle). Gently flex the patient's elbow while your elbow acts as a lever to disimpact the olecranon.

Never extend the elbow as it can cause neurovascular injury and increase the risk of damage to muscle and articular surfaces leading to long term disability for the patient.

Forearm Shaft Fractures

Forearm shaft fractures are commonly the result of a direct blow and usually fit one of four patterns : Isolated ulna fracture (Nightstick fracture), Monteggia or Galeazzi fracture or involve fractures of both the radius and ulna. Most patients will require ORIF and orthopaedic referral is required in all cases.

Patients usually present with localised pain, tenderness, and swelling at the fracture site. Complications are rare. Compartment syndrome is less common than in the lower limb but may rarely occur with closed shaft fractures of radius or ulna and due to a tight cast.

Nightstick fracture

Nightstick fracture

This is an isolated midshaft ulna fracture caused by a blow to the ulna aspect of the forearm when the person has the arm raised in defense. These fractures require orthopaedic referral and can be immobilised with a long-arm splint. Open reduction and internal fixation (ORIF) becomes necessary when displacement greater than 5 mm or angulation greater than 10° persists.

Monteggia fracture

This is a fracture of the ulna (usually proximal one third) with dislocation of the radial head. Anterior radial head dislocation is most common, yet medial, lateral, and posterior dislocations also occur. Isolated proximal ulna fractures are rare. Always suspect a Monteggia fracture/dislocation and closely examine the radial head for dislocation or other evidence of injury. Immobilise with a long-arm splint (with elbow flexed 90° and forearm neutral). Children may be treated by reduction and casting, while adults require admission for ORIF.

Galeazzi fracture

Galeazzi fracture, also known as a Reverse Monteggia fracture, is a fracture of the distal one third of the radius with dislocation of the distal radioulnar joint (DRUJ). Immobilise with a long-arm splint (with elbow flexed 90° and forearm pronated). Treatment requires admission for an ORIF.

Concomitant radius and ulna fractures

Concomitant mid-shaft fractures of the radius and ulna are usually the result of a significant force applied directly to the forearm or occur in the context of major trauma. Swelling and deformity indicate the diagnosis, and radiographic confirmation is usually straightforward. Compartment syndrome is a potential complication. Treatment requires admission for an urgent ORIF.

Chapter 28

Orthopaedic Injury : Wrist

Key Points

1. **Colles fracture is common and describes any fracture of the distal radius that has dorsal displacement of the fracture fragments.**
2. **Management of suspected Colles fracture involves IV / IN analgesia, temporary immobilisation and reduction of displaced / angulated fractures**
3. **Scaphoid fracture is the most frequently missed wrist injury. X-ray fails to demonstrate 15% of fractures. Avascular necrosis is a serious complication.**
4. **Patients with wrist injury and snuff box tenderness should be assumed to have a scaphoid fracture and managed either with a scaphoid cast for 10 days followed by X-ray or early CT scan to confirm / exclude fracture**
5. **Although lunate and perilunate fracture / dislocations are rare they are associated with substantial morbidity if missed.**
6. **Always consider lunate / perilunate dislocation in the patient with a markedly swollen wrist and severely restricted range of movements especially in the context of a "normal appearing" X-ray or isolated fractured scaphoid.**

Wrist Fractures

The wrist is the most commonly injured region of the upper extremity. Fractures of the distal radius and ulna account for the majority of wrist injuries. The carpal bones themselves are injured much less frequently. The mobility and delicate functional requirements of the hand make accurate diagnosis and treatment crucial to avoiding long-term loss of function and disability.

Colles fracture

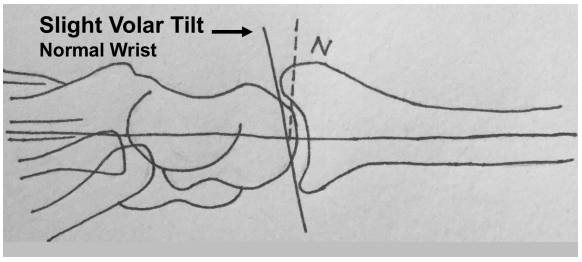
Colles fracture is the most common injury caused by falling on the outstretched hand. Although classically described as a fracture through the distal metaphysis approximately 4 centimetres proximal to the articular surface of the radius, the term is now used to describe any fracture of the distal radius that has *dorsal* displacement +/- *dorsal* angulation of the fracture fragments.

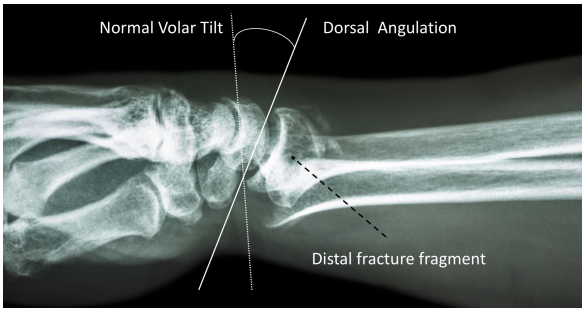
Colles fracture occurs in all age groups. In the elderly, because of the relatively weaker cortex, the fracture is more often extra-articular.

Younger individuals tend to require a relatively higher energy force to cause the fracture and are more likely to have complex intra-articular fractures.

In children with epiphyseal plates, an equivalent fracture is the epiphyseal slip. This is a Salter I or II fracture with the deforming forces directed through the weaker epiphyseal plate.

Angulation. The top illustration shows a normal wrist with slight volar angulation. The lower image shows dorsal angulation in a colles fracture.





Emergency Management : Colles fracture

Immediate management of Colles fracture includes :

- Examination of the patient to exclude other injuries (Primary/Secondary Survey)
- Neurovascular examination with assessment of the median, radial and ulnar nerves
- Provision of analgesia usually with IV or Intranasal Fentanyl, titrated to achieve pain relief
- Immobilisation of the wrist to reduce pain and prevent further injury. A cardboard splint, pillow or temporary backslab may be used
- X-ray examination to determine the type of fracture and assess angulation / displacement

Orthopaedic Management : Colles fracture

Undisplaced fractures or fractures with minimal displacement/angulation may be managed with application of a dorsal cast (plaster backslab) to immobilise the fracture and the provision of outpatient analgesia. Early orthopaedic follow up should arranged.

Displaced fracture

Fractures associated with significant dorsal displacement and angulation require orthopaedic review to determine the need for closed reduction.

Uncomplicated fractures requiring reduction may often be reduced in the emergency department (subject to local resources and expertise) using procedural sedation, ischaemic arm block and/or fracture block to assist the procedure.

Colles fracture with marked dorsal angulation and dorsal displacement with the dinner fork deformity

Smith fracture

Smith fracture is relatively uncommon and refers to any fracture of the distal radius that has *volar* displacement of the distal fragments.

It is typically caused by a fall onto a supinated forearm or hand with generation of a hyperflexion force. A direct blow to the dorsum of the wrist with the hand in flexion and forearm pronated can produce a similar fracture pattern.

Emergency management is the same as Colles fracture however splint the fracture using a volar cast. Orthopaedic referral is required for reduction.

Smith fracture with marked volar displacement of the distal fracture fragment

Barton fracture

The Barton fracture is an *intra-articular injury* involving either the dorsal or volar articular surface of the radius.

Barton fracture is uncommon and usually results from extreme dorsiflexion of the wrist with concomitant pronating force.

Emergency management is the same as Colles fracture. Orthopaedic referral is required for operative reduction and fixation.

Barton (intra-articular) fracture

Carpal fractures

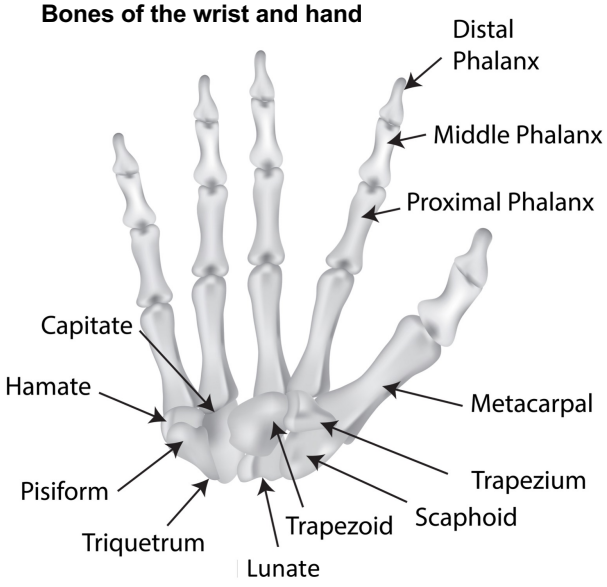
Scaphoid Fracture

The scaphoid bone is based in the proximal row of carpal bones but extends into the distal row, making it more vulnerable to injury than the other carpal bones.

It is the most frequently injured carpal bone, accounting for 70% of all carpal fractures. It has the distinction of being the most frequently missed injury, with approximately15% of fractures not demonstrated on the initial X-ray.

More than three fourths of all fractures occur at the narrow mid-portion or waist of the scaphoid. Because blood is supplied to the scaphoid along its dorsal surface near its waist, fractures at this location potentially compromise flow to the proximal portion of the bone. As a consequence avascular necrosis is a serious complication of this injury.

Bones of the wrist and hand



Clinical Presentation

Hyperextension of the wrist is the most common mechanism for the fracture and may occur due to fall on an outstretched hand or by a direct blow to the palm. Often the wrist has some degree of radial deviation. Hyperextension causes the radial styloid to impinge on the waist of the scaphoid as it crosses between the two rows of carpal bones.

Scaphoid fractures are often associated with other injuries of the wrist, including dislocation of the radiocarpal joint, dislocation between the 2 rows of carpal bones, fracture-dislocation of the distal end of the radius, fracture at the base of the thumb metacarpal, and dislocation of the lunate.

Fracture through the waist of Scaphoid

Management

Management of scaphoid fractures is evolving.

The traditional approach has been to apply a plaster cast on the wrist in a patient with snuff box tenderness suggesting possible scaphoid fracture and then re-X-ray in 10 days to confirm / exclude the fracture.

In the past decade imaging using CT and more recently MRI has been used to rule out injury avoiding the need for immobilisation.

The approach taken to management will depend on local resources and protocols. Patients with scaphoid or suspected fracture require orthopaedic review.

Patients with a history of wrist injury and the examination finding of snuff box tenderness should be assumed to have a scaphoid fracture even when the fracture is not seen on the initial X-ray.

- *They should be managed with a scaphoid cast for 10 days and then referred for X-ray (which if positive shows a white line across the fracture site due to healing of the fracture).*
- *An alternative approach is to arrange a CT scan (where this available) to identify / rule out fracture.*

Lunate Fracture

Although a relatively uncommon injury, fracture of the lunate is the third most frequent carpal bone fracture. The lunate is located in the centre of the proximal carpal row and articulates with the radius. Fractures can occur in any orientation, and diagnosis often requires a high degree of clinical suspicion. Fractures of the lunate often result from hyperextension of the wrist or impact of the heel of the hand on a hard surface. This injury also can occur from a fall on the outstretched hand. Patients usually present with weakness of the wrist and pain aggravated with compression along the middle finger. Orthopaedic referral is required.

Lunate and Perilunate dislocation

Lunate and perilunate dislocation injuries may have a poor outcome if not recognised in a timely fashion.

The injury is commonly missed. Always consider lunate / perilunate dislocation in the patient with a markedly swollen wrist and severely restricted ROM especially in the context of a "normal appearing" X-ray or an isolated fractured scaphoid.

Dislocation usually results from extreme flexion or extension of the wrist. The type of dislocation or fracture-dislocation produced depends upon the direction and intensity of the injuring force and the position of the hand in relation to the forearm at the moment of impact. Three patterns are described :

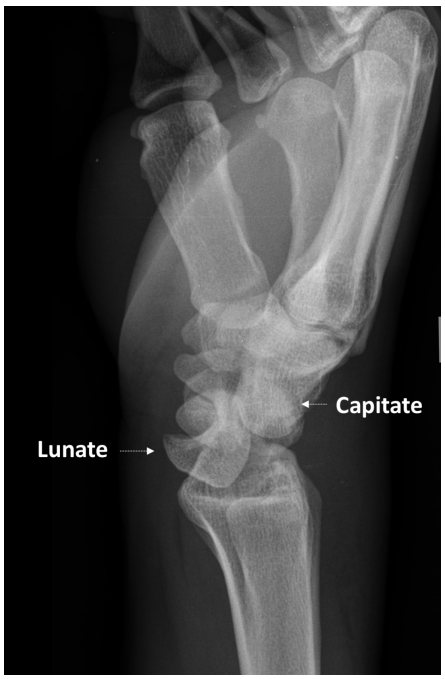
1. **Volar dislocation** is caused when the hand is forced into extension (eg fall on outstretched hand). The injury is commonly associated with fracture of the scaphoid.

2. **Dorsal dislocation** occurs when the hand is hyperflexed (eg fall onto the back of the hand). The upward force generated when the hand contacts the ground, together with the downward force acting through the radius, forces the capitate to rotate anteriorly and drive the lunate backward.

3. **Perilunate dislocation**. In this injury the lunate remains in its normal position relative to the radius and the carpus dislocates. This often is associated with scaphoid fracture.

Perilunate Dislocation : Lateral View

In the X-ray below examine the three Cs - the capitate (the last C) is displaced backwards and lies dorsal to the C of the lunate - a perilunate dislocation.



Radiological findings

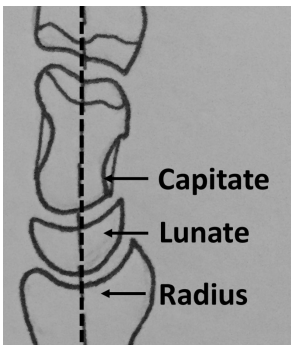
The X-ray findings of lunate or perilunate dislocation are easily missed. The diagnosis relies on assessing the lateral X-ray for the "Three C's". The three bones, the distal radius, lunate and capitate align to form a series of "C's" (lying on their side). The three bones should line up as if holding each other.

In lunate dislocation it will appear that one bone shaped like a crescent moon (ie the lunate) is pushed forward of the wrist and rotated 90 degrees.

In perilunate dislocation, the lunate remains in its normal position and the capitate (and other carpal bones) are dislocated and lie in a position either volar or dorsal to the lunate. This is illustrated in the X-ray shown above.

Lunate and Perilunate dislocations require urgent orthopaedic intervention.

The Three "C" s



Triquetrum fracture

The triquetrum is one of the more commonly injured carpal bones. It lies on the ulnar aspect of the proximal row of carpal bones. Strong ligaments attach the triquetrum to the lunate, which adjoins its radial aspect. In addition, the triquetrum is connected to the distal ulna by a triangular fibrocartilage complex. The most common mechanism of injury is forced hyperextension of the wrist with ulnar deviation. In this position the triquetrum is forced against the ulnar styloid, generating a shearing force that results in avulsion of ligaments and a dorsal chip fracture of the triquetrum. Treatment involves a plaster cast and orthopaedic referral.

A second, less common, mechanism is a direct blow to the dorsum of the hand, which causes a transverse fracture through the body of the triquetrum. This is a high-energy injury and frequently is associated with injury to other carpal bones. Treatment depends on associated injuries.