CHEST INJURY MODULE

Introduction

Chest trauma accounts for 25% of the mortality of severely injured multi-trauma patient, second only to mortality from CNS injury.\(^1\) It can account for significant morbidity given the chest houses the majority of the cardiovascular and respiratory systems. As with other systems, the vast majority of trauma is of a blunt mechanism with motor vehicle accidents being primarily responsible. Less than 10% of blunt chest injuries require operative intervention.\(^2\)

Penetrating chest injuries, in particular cardiac injuries, can be highly lethal with death resulting from tamponade or exsanguination.\(^1\) Due to its anterior location injuries occur most commonly to the right ventricle followed by the left ventricle. Atrial injuries are less common and usually less severe.\(^1\)

Injury patterns

**AIRWAY**

**Tracheobronchial injury**

Tracheobronchial injury is relatively rare occurring in <1.5% of blunt chest trauma presentations\(^3\) and can be difficult to identify. Extensive subcutaneous emphysema, persistent pneumothorax or air leak after placement of an ICC should alert to the possibility of a tracheobronchial injury (TBI).\(^1\) Subtle presentations may only be appreciated by mediastinal air on CT imaging. Most blunt tracheobronchial injury occur within 2 cm of the carina, with a predominance for the right main bronchus, followed by the lower trachea.\(^1\) In penetrating trauma relatively exposed trachea at the level of the neck is more vulnerable. Bronchoscopy is the investigative modality of choice to identify site and extent of injury. It can also be used to safely place an ETT beyond the lesion.

![Diagram depicting the location of tracheobronchial injuries](image)

**BREATHEING**

**Pulmonary contusion**

Pulmonary contusion is the most common pulmonary lesion, present in 30-70% of patients with blunt chest trauma.\(^3\) Pulmonary contusion results from
high energy trauma with rapid deceleration, compression or shear forces.\textsuperscript{1} Damage occurs to the parenchyma with alveolar laceration and haemorrhage with progression to oedema, loss of compliance and V/Q mismatch.\textsuperscript{1} Clinical features of pulmonary contusion often progress over many hours, typically peaking 72 hours post injury.\textsuperscript{1} Similarly investigative features evolve with time; 50\% of patients with pulmonary contusions will have a normal CXR on arrival – however most contusions are identifiable on CXR at 24 hours. CT is very sensitive for pulmonary contusion in its early stages.\textsuperscript{1,3}

**Lung Laceration**

Lung laceration refers to the traumatic disruption of alveolar spaces with cavity formation filled with blood (haematoma), air (pneumatocele) or a combination of the two. Previously thought to be rare, these injuries are seen more commonly on CT.

**Pneumothorax**

Pneumothorax commonly occurs in chest injury from direct lung laceration from rib fractures or indirectly with deceleration injury or barotrauma. They are common and seen in approximately 40\% of blunt chest trauma patients. Respiratory compromise depends on the size, associated injuries (eg lung contusions, haemothorax), communications status and the patient’s premorbid respiratory status.\textsuperscript{1} If under tension, circulatory compromise may occur through increased intrathoracic pressure or compression of the vena cava resulting in decreased venous return.

**Rib Fractures**

Rib fractures are the very common, with the 4\textsuperscript{th} – 8\textsuperscript{th} arches most frequently affected.\textsuperscript{3} Fractures involving the 1-3\textsuperscript{rd} ribs suggest high energy trauma as they are protected by the clavicle, scapula and upper chest wall musculature.\textsuperscript{3}

**Flail chest**

Flail chest refers to the presence of 3 or more contiguous ribs which are fractured at 2 sites. It is associated with increased mortality compared to an injury with the same number of rib fractures but without a flail segment.\textsuperscript{1} The lateral chest wall – because of its bony anatomy and relatively limited musculature – is most susceptible to flail injuries.\textsuperscript{1} There is a strong association with pulmonary contusion and pneumothorax. Respiratory insufficiency in flail chest results from the underlying pulmonary contusion rather than the paradoxical movement of the chest.\textsuperscript{1} Pain is particularly problematic in this population, impairing ventilation and adequate cough to clear secretions. It is important to consider regional anaesthetic techniques in this group.

**CIRCULATION**

**Aortic transaction**

While most thoracic great vessel injuries are caused by penetrating trauma, blunt aortic injury remains an important albeit uncommon consequence of thoracic trauma. Rapid deceleration injuries accounts for the majority of blunt aortic injury and should be suspected in any patient with a concerning mechanism;\textsuperscript{1}  
- High speed MVA with front or side impact  
- Falls from great height
The patient suffering a complete aortic transection typically exsanguinates at scene. Other less disruptive lesions can produce variable haemodynamic instability. It is important to recognise the group with a stable aortic injury early before the lesion progresses to rupture. The proximal descending aorta is most at risk given the transition point between the fixed descending and mobile aortic arch at the ligamentum arteriosum.

![Diagram depicting the location of blunt aortic transection](image)

**Haemothorax**
Intrathoracic haemorrhage can result from injury to the chest wall (particularly intercostals or mammary arteries) lung parenchyma, great vessels or the heart. In the event of diaphragmatic injury, intra-abdominal haemorrhage can also result in haemothorax.

While patient physiology should always be the primary indicator for need for surgical intervention – rather than absolute numbers – in general drainage of > 1500mL immediately or > 200mL/hour for 2 hours should prompt consideration for surgical intervention. ICC placement is indicated for any haemothorax greater than 500 mL.

**Blunt cardiac injury**
Blunt cardiac injury encompasses a spectrum of manifestations from an asymptomatic myocardial contusion through to cardiac rupture. Because of its anterior location, most blunt cardiac injuries involve the right heart. Mechanisms of injury include direct praecordial impact, deceleration and crush injuries. In those patients with a high index of suspicion an ECG should be performed to detect any conduction abnormalities. Patients do not require further diagnostic imaging if they have only mild symptoms, a normal ECG and are haemodynamically stable. This group have a benign course. If there are any abnormalities of cardiac monitoring, biomarkers and echocardiography are generally performed.

**OTHER**

**Pneumomediastinum**
Pneumomediastinum refers to the collection of free air surrounding the mediastinal structures, dissecting along the mediastinal fat plane. It should raise suspicion for tracheobronchial or oesophageal injury. It may originate from alveolar rupture and dissect along the bronchoalveolar sheath.
Digestive tract
Injuries to the oesophagus are rare in chest trauma as it is well protected in the posterior mediastinum. These injuries are difficult to diagnose. Mediastinal air on CT imaging with no clear origin should raise suspicion of an oesophageal injury.1

Diaphragmatic Injuries
Occurs in 1-7% of patients with blunt trauma as a consequence of raised intrathoracic or intraabdominal pressure by a crushing force.3 It is more common on the left (up to 90%) due to the liver protecting the right hemidiaphragm. Consequently the stomach is the most commonly herniated abdominal organ.3

Assessment

HISTORY
- Handover from QAS with particular consideration of mechanism
- Evidence of airway injury
- Evidence of ventilatory impairment
- Evidence of circulatory impairment

EXAMINATION
Immediate priority is to identify life threats:

AIRWAY  tracheobronchial injury: subcutaneous emphysema, neck swelling, stridor

BREATHING  flail segment: chest wall asymmetry, paradoxical movement, hypoxia, crepitus

CIRCULATION  tension haemo/pneumothorax**: tachycardia, hypotension, hypoxia, decreased AE, hyper(PTX) or hypo(HTX)resonant, hyperinflation, subcutaneous emphysema, tracheal deviation

massive haemothorax: tachycardia, hypotension, decreased AE, hyporesonant,

cardiac tamponade: tachycardia, hypotension, elevated JVP, muffled heart sounds

In the context of penetrating trauma, the risk of cardiac injury is possible with any injury located within the ‘cardiac box’ delineated by the clavicles superiorly, the midclavicular lines laterally and the costal margin inferiorly.
*** Tracheal deviation, hypoxaemia and hypotension are inconsistent findings (<25% each) in the spontaneously ventilating patients with tension pneumothorax.

INVESTIGATION

- Standard baseline trauma bloods including:
  - Blood gas will reveal ventilation inadequacy and evidence of hypoperfusion
  - Troponin is a sensitive biomarker for blunt cardiac injury, but can be elevated in reperfusion injury, catecholamine release, microcirculatory dysfunction or oxidative injury. Should be performed in patients with a high suspicion of a blunt cardiac injury who have an abnormal ECG

- ECG – initial investigation for suspected blunt cardiac injury and should be performed routinely in patient with significant blunt thoracic trauma

- Extended FAST can be performed in traumatic chest injuries to identify haemothorax, pneumothorax or traumatic pericardial effusion.

- CXR is performed routinely in significant chest trauma.
  - Erect CXRs are more sensitive in detecting haemopneumothoraces, but are often inappropriate in the acute trauma patient. Approximately 200mL of blood can be detected on an upright CXR, while a supine film only has a 40%-60% sensitivity in detecting haemothorax. Remember the sensitivity for rib # is poor (approx 50%) on plain film.
  - beware pneumothorax mimics including lobar collapse, right main stem intubation and diaphragmatic herniation.

CXR demonstrating R sided collapse with mediastinal shift to the right, note the absence of a PTX on the L with lung markings visible in the peripheries

CXR signs of blunt aortic injury:
1. Widened mediastinum
2. Loss of aortopulmonary window
3. Deviation of trachea to R
4. Deviation of NGT to R
5. thickened paratracheal stripe
6. L haemothorax
7. L pleural cap
8. # 1st or 2nd rib
Wide mediastinum, loss of aortopulmonary window, deviated trachea – consistent with aortic transection

Left sided tension pneumothorax with mediastinal deviation

Tension haemopneumothorax with simultaneous placement of bilateral ICCs
R sided haemothorax, L sided pneumothorax, extensive subcutaneous emphysema with bilateral open thoracostomies

Rupture of the left hemidiaphragm
CT imaging (with or without angiography) allows for better delineation of injuries particularly to lung parenchyma and vasculature. Up to 59% of patients with blunt chest trauma have additional findings on CT compared with CXR, with change in clinical management occurring in up to 70% cases.\(^3\) In general, the decision to perform CT should be guided by history and examination. Drawbacks of CT include radiation and contrast exposure.

Axial CT demonstrating bilateral pulmonary contusion and L sided traumatic pneumatocele

**SCRAP decision rule for CT chest in blunt chest trauma**

The Canadians – clever as they are – have come up with a clinical decision rule to guide CT imaging in blunt thoracic trauma.

Patients with penetrating injuries and children were excluded. Also excluded were patients with a GCS < 9 or any paralysis as there is a general consensus that this group should be imaged.

SCRAP variables:
- Saturations < 95% RA or <98% on O\(_2\)
- CXR abnormality
- RR > 28
- Auscultation abnormality
- Palpation abnormality

When the SCRAP rule is normal (ie no variables present), no patients had a major thoracic injury in 434 patient included in the study. Major thoracic trauma was defined as any thoracic injury that could potentially change clinical management in that it needed a specific therapy or in-hospital observation. They further defined injuries to include great vessels, diaphragmatic, flail segments, oesophageal, haemo/pneumothorax, mediastinal/paravertebral haematoma, pneumomediastinum, cardiac injury, scapula fracture and thoracic spine fracture (excluding spinous/transverse process fracture). Non-major injuries included clavicle #, rib # without a flail segment, pulmonary contusions and transverse/spinous process #. The study quotes 100% sensitivity for major thoracic trauma when the variables are present. The rule still needs to be prospectively validated.

- **Bronchoscopy** should be performed if there is suspicion of a tracheobronchial injury as it can determine location and size of injury
Echocardiography should be performed if there is suspicion clinically for cardiac contusion

Management

Goals of management:

1. Integrated Trauma team approach
2. Address Life threatening injuries
3. Expedite definitive therapy
   - Initiate trauma activation system: ALERT or RESPOND depending on mechanism and physiological parameters
   - Notify Trauma/CTS/Vascular teams as appropriate
   - Manage in a trauma resuscitation bay with comprehensive non-invasive monitoring

Resuscitation

AIRWAY & BREATHING

- Apply O₂ titrating to Sats ≥ 94%
- Perform chest decompression if tension H/PTX
  - Consider needle decompression
  - Urgent thoracostomy and ICC insertion
- Perform RSI and mechanically ventilate with lung protective strategy if respiratory failure evident or imminent – particularly if significant lung contusion or flail segment

CIRCULATION

- Resuscitate patient with principles of damage control resuscitation if evidence of uncontrolled haemorrhage while expediting surgical control of bleeding
  - Activate massive transfusion protocol
  - 1:1:1 red cells:FFP: platelets
  - Aim to restore radial pulse or SBP ~ 80
  - Correct Coagulopathy
  - Tranexamic Acid 1g bolus & 1g infusion over 8h if within 3 hours of injury
- Indications for operative thoracotomy
  - Massive HTX
    - >1500mL on ICC insertion
    - > 200mL/hr for 3 hr following ICC insertion
Classic indication refers to an absolute volume of blood, however the clinical status of the patient is a more important indicator for thoracotomy.¹
- cardiac injury +/- haemopericardium
- Vascular injury at the thoracic outlet
- Massive air leak

Indications for ED thoracotomy See Additional Information
- Penetrating chest/epigastric trauma with cardiac arrest with loss of output < 10 minutes

Specific therapy

- Bronchoscopy is indicated in all cases of suspected tracheobronchial injury. In severe injury it can guide the ETT distal to the air leak.
- Place ICC for H/PTX
  - Small asymptomatic PTX identified on CT do not mandate ICC insertion. However any traumatic PTX visualised on CXR should be drained by an ICC.¹
  - HPTX greater than 500 ml to avoid retained haemothorax and reduce requirement for VAT²
  - Consider prophylactic antibiotic cover for ICC insertion²
- Surgical fixation of ribs is considered in significant chest injuries – particularly if the chest is stoved in. There is limited evidence that fixation reduces the duration of mechanical ventilation and its associated complications.
- TEVAR for aortic transaction
- Operative intervention is indicated in blunt oesophageal injury

Supportive therapy

- Keep NBM if awaiting surgical intervention or at risk of ventilatory compromise
- IV fluid maintenance 100mL N/Saline
- Adequate analgesia is paramount in the event of multiple rib #s. PCA (with parenteral opioid) should be provided and anaesthetic input for regional blocks considered.
- Chart antiemetics
- Chest physiotherapy
- Keep warm
- Ensure normoglycaemia
- Ensure documentation completed
**Disposition**

Patients with significant chest injury should be managed in a HDU or ICU environment.

**Additional Information**

- Doubts surround the usefulness of needle decompression for decompressing pneumothorax. Needle decompression can fail for multiple reasons including misplacement in the chest wall, placement in a subcutaneous emphysematous pocket or in a vascular structure. Studies reviewing CT imaging has suggested that a standard 5cm cannula would not reach the pleural space in 33% of patients if placed anteriorly.

- **Indications for Thoracotomy**

  Emergency clamshell thoracotomy is well described in Wise et al. “Emergency thoracotomy: how to do it” EMJ 2005;22:22-4 and is well worth the read. This approach is favoured by non-surgeons and is used in the pre-hospital environment in the London HEMS system. In general neurological survival for this procedure in penetrating trauma is low. Overall survival rates are quoted as approximately 9-12%. Survival is more likely if on thoracotomy it is found there is tamponade secondary to a single cardiac wound. In contrast, the survival rate in blunt trauma is quoted as 1-2% - as such most clinicians would consider blunt trauma a contra-indication to emergency thoracotomy.

- The ‘cardiac box’ is not absolute. Although unlikely, it is possible for injuries outside of this demarcation to result in a cardiac injury.

- Bickell’s landmark paper (Bickell et al. ‘Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating trauma’ NEJM 1994; 331:1105-9) on minimum volume resuscitation in hypotensive patients with penetrating torso injuries is compulsory reading. This study demonstrated an 8% absolute survival advantage in the group who received fluids only once they reached the operating theatre opposed to the group who received fluids in the field and in ED.
Further reading

- Bickell et al. ‘Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating trauma’ NEJM 1994; 331(17) 1105-9

References

5. http://www.jvascbr.com.br/03-02-03/03-02-03-197/03-02-03-197.htm