Blunt chest trauma: soft tissue injury in the thorax

The management of blunt chest trauma is evolving. This article discusses the soft tissue injuries associated with blunt chest trauma.

Blunt chest trauma results in bony and soft tissue injuries and is associated with significant morbidity and mortality. A previous review discussed bony injuries (see p. 72). This second review of blunt chest trauma concentrates on soft tissue injuries and visceral injuries within the bony thorax and their management.

Any intrathoracic structure may be affected, although the most common soft tissue injuries are pulmonary contusion, haemothorax and pneumothorax (Allen and Coates, 1996).

Thoracic anatomy

The bony thorax protects vital structures. The mediastinum is the central part of the thoracic cavity and contains the heart, pericardium, primary bronchi, great vessels and the oesophagus.

The lungs lay either side of the mediastinum covered by two layers of pleura (visceral and parietal). The visceral pleura cover the surface of the lung and reflect at the hilum to form the parietal pleura. Between these is the pleural space.

The lungs are asymmetrically divided into lobes: the right having superior, middle and inferior lobes separated by horizontal and oblique fissures and the left has superior and inferior lobes separated by an oblique fissure. At the hilum, the root of the lung can be found, which contains a bronchus, two pulmonary veins, bronchial vessels, nerves and lymph nodes.

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The bronchial tree commences at the trachea, dividing into the left and right primary bronchi. Each primary bronchus enters the lung via its root and splits to become lobar bronchi and carry on dividing to become bronchioles and finally alveoli.

The diaphragm is a dome-shaped skeletal muscle innervated by the phrenic nerve (C3–C5). It attaches to lumbar vertebrae, ribs 7–12 and the xiphoid process of the sternum. The muscle fibres fuse centrally to form a tendon attached to the undersurface of the pericardium. Its main function is to assist with respiration and allows the passage of structures to the abdominal cavity:

- Inferior vena cava – T8
- Oesophagus – T10
- Aorta – T12.

Pathophysiology

Blunt chest trauma is the result of sudden deceleration causing the mobile intrathoracic viscera to impact upon the bony structures of the chest wall. This is usually caused by road traffic accidents or falling from a height. A range of bony and soft tissue injuries may ensue (*Table 1*).

Table 1. Common soft tissue and visceral thoracic injuries

Soft tissues of the chest wall	Laceration Haematoma
Pleura	Puncture by bony fragments Haemothorax Pneumothorax (simple or tension)
Lungs	Puncture Contusion Collapse
Tracheobronchial tree, oesophagus and diaphragm	Puncture Rupture
Heart and great vessels	Tear or transection of the vessels Contusion Cardiac tamponade Blunt cardiac injury

Table 2. Common signs, what they may mean and how to proceed

Sign	Suspect	Investigate (or immediate management)
Tracheal deviation	Tension pneumothorax	Cannula 2nd intercostal space, mid-clavicular line
Reduced breath sounds	Atelectasis, simple pneumothorax or haemothorax	Chest X-ray or computed tomography
Absent breath sounds	Atelectasis simple pneumothorax or haemothorax	Chest X-ray or computed tomography
Muffled heart sounds	Tamponade	Focused assessment with sonography in trauma (FAST) scan, pericardiocentesis
Paradoxical chest movement	Flail segment	Chest X-ray or computed tomography
Tachypnoea	Pulmonary contusion Pain or anxiety	Arterial blood gas, computed tomography
Hypoxia	Pulmonary contusion	Oxygen saturation, arterial blood gas, computed tomography
Tachycardia	Shock Pain or anxiety	Intravenous access, examine to determine source

The management of blunt chest trauma

Advanced trauma life support (ATLS) guided primary and secondary surveys are imperative. Assessment for blunt chest trauma-related injuries usually falls under the breathing and circulation categories. Careful examination and baseline observational measurements should guide further investigation and management. Indicative signs are given in *Table 2*.

Five life-threatening thoracic conditions that should be identified in the primary survey are:

1. Tension pneumothorax
2. Open pneumothorax
3. Massive haemothorax
4. Flail chest
5. Cardiac tamponade.

Visceral injuries associated with blunt chest trauma

Soft tissues and intrathoracic viscera may be injured by several methods in blunt chest trauma:

- Sudden deceleration and impact on adjacent bony structure
- Puncture by a sharp bony fracture fragment
- Tear or transection as a result of tethering of the structure.

This section considers some of the most common injuries, their investigation (*Table 3*) and management.

Lung and pleura

Pulmonary contusion

Pulmonary contusion occurs in 30–75% of blunt chest trauma cases (Allen and Coates, 1996). It is an injury to the lung tissue that may cause pulmonary and systemic physiological changes in response to oedema and the pooling of blood in alveolar spaces. This reduces pulmonary function and complications such as adult respiratory distress syndrome or pneumonia may develop. Around 50% of patients with pulmonary contusions develop one or both of these (Miller et al, 2002).

Early diagnosis is essential to plan management and avoid complications. A high index of suspicion, arterial blood gas analysis and appropriate imaging can reduce the risks significantly. Computed tomography may illustrate the extent of lung tissue involvement. There may be a time lag of 24–48 hours before the contusion fully declares itself (Dehghan et al, 2014).

Management of pulmonary contusion is supportive. This includes close monitoring of vital observations, supplemental oxygen and adequate analgesia. Large contusions impeding gas exchange and resulting in hypoxaemia may warrant tracheal intubation and mechanical ventilation.

Any concomitant chest wall injury needs to be managed with adequate analgesia. This avoids splinting of the chest wall secondary to pain or deformity and resultant ventilation–perfusion mismatch causing type II respiratory failure (hypercapnic). Pulmonary contusions usually result in type I (hypoxaemic) respiratory failure as a result of oedema. A mixed picture can develop depending on the injuries present.

Table 3. Investigations used in blunt chest trauma and their indications

Investigation	Indication
Plain radiograph	Bony injury Pneumothorax or haemothorax Mediastinal injuries Tube or line positioning
Computed tomography	Pulmonary contusion Pneumothorax or haemothorax Traumatic aortic injury
Focus abdominal sonography for trauma (FAST)	Suspicion of free fluid in the abdomen, pericardial collection
Contrast studies	Diaphragmatic rupture Vessel injury

Pneumothorax and haemothorax

Pneumothorax is a collection of air in the pleural space. This may result from injury to the lung tissue, bronchi or chest wall.

Figure 1. Right-sided pneumothorax.

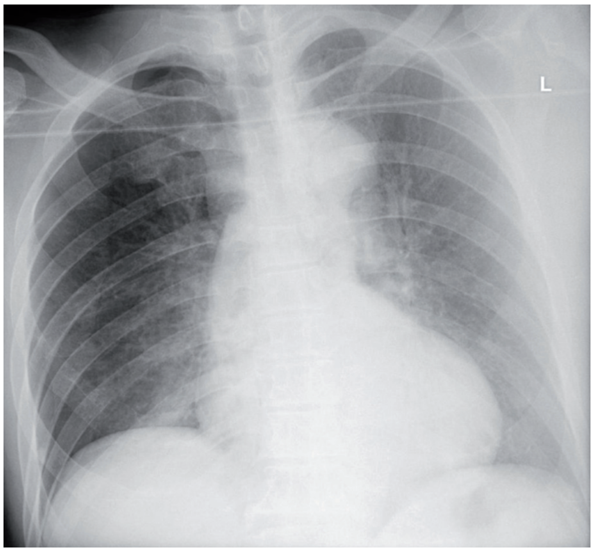
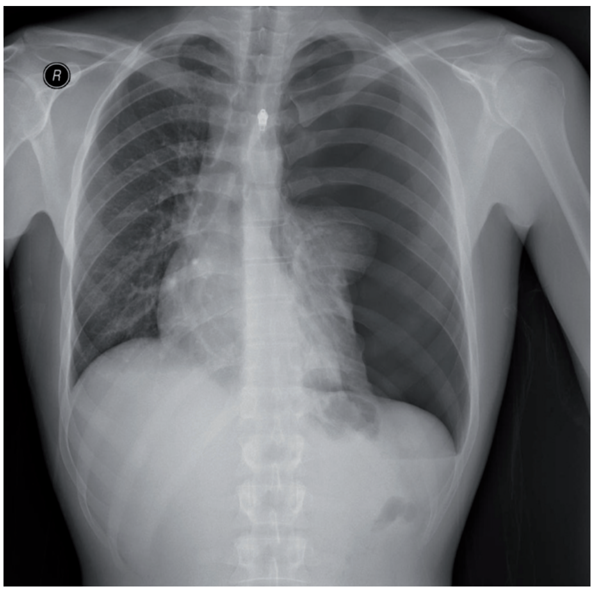


Figure 2. Left tension pneumothorax.



Pneumothorax is usually diagnosed on routine chest X-ray and with no associated symptoms. Occult or simple pneumothoraces (*Figure 1*) occur in 2–16% of patients with blunt chest trauma (Guerrero-López et al, 2000). Studies have demonstrated no benefit in surgical intervention for these compared to observation and so they are managed expectantly (Moore et al, 2011).

A tension pneumothorax (*Figure 2*) is a life-threatening event where a one-way valve is created allowing air to enter the pleural space with no exit. Insertion of a cannula into the second intercostal space in the mid-clavicular line may be life-saving. This may give some time until an appropriately skilled physician can insert a surgical chest drain (definitive treatment). This is inserted into the fifth intercostal space in the anterior axillary line. Signs of pneumothoraces are shown in *Table 4*.

Haemothorax is a collection of blood in the pleural space, usually identified on chest X-ray. It may be traumatic or occult. Occult haemothoraces are usually detected on computed tomography and reported in 20–30% of cases with blunt chest trauma (Stafford et al, 2006).

Management is expectant with review for progression. Large haemothoraces are managed with a chest drain. A chest drain inserted for a haemothorax is aimed down towards the lung base, as this is where blood will collect. For a pneumothorax it is aimed towards the apex of the lung.

Haemodynamically stable patients with unresolved haemo- or pneumothoraces at 72 hours after chest drain may benefit from video-assisted thoracic surgery. Video-assisted thoracic surgery may also be considered in the management of retained haemothorax. Video-assisted thoracic surgery decreases the length of chest drainage use, overall hospital stay and costs (DuBose et al, 2012).

Tracheobronchial tree

Injury to the tracheobronchial region occurs in 0.8–2.8% of cases of blunt chest trauma, but the pre-hospital mortality rate is up to 80% (Granetzny et al, 2005; Karmy-Jones and Wood, 2007). It can be missed in 25–68% of patients (Kiser et al, 2001).

Three common mechanisms result in tracheobronchial injury:

Table 4. Signs and symptoms of simple and tension pneumothorax and haemothorax

Simple pneumothorax	Tension pneumothorax	Haemothorax
Shortness of breath – may be none	Absent breath sounds	Shortness of breath may be present
Normal-resonant percussion note	Hyper-resonant percussion	Dull percussion note
Trachea central	Tracheal deviation away from the affected side	Trachea central
Hypoxia	Hypoxia	Hypoxia
Signs of shock absent. If present they are unlikely to be related to the simple pneumothorax	Signs of shock	Signs of shock may or may not be present

1. Sudden or forceful anterior-posterior compression of the chest, which distracts the lungs at the carina (most common)
2. Compression of the chest and trachea with a closed glottis. This increases pressure in the airways and when this exceeds the capacity of the tracheobronchial tree, the airway ruptures at the membranous portion
3. Rapid deceleration causing shearing forces at fixation points such as the carina.

The most common sites of injury are 2 inches above or below the carina (80%) or at the laryngotracheal junction (20%) (Altinok and Can, 2014).

The clinical findings of tracheobronchial injury include:

- Respiratory distress
- Dysphonia
- Subcutaneous emphysema
- Failure of lung re-expansion after chest drain for pneumothorax.

Plain radiography may reveal mediastinal widening or separation in the tracheobronchial air column. Computed tomography can define the extent of the injury, but bronchoscopy is the definitive diagnostic study (Jones and Athanasiou, 2005).

The first-line management is to secure the airway by bronchoscopic-guided intubation (Gómez-Caro et al, 2006).

Minor tracheobronchial injuries heal without secondary problems. Surgical repair is indicated if the tear is greater than 2 cm or there is accompanying oesophageal prolapse or mediastinitis (Granetzny et al, 2005). Complications include dehiscence of the anastomosis and fistula formation.

Diaphragm

Blunt trauma is a major cause of diaphragmatic ruptures occurring in 0.2–4% of trauma admissions (Granetzny et al, 2005). About 70% of these occur on the left (Granetzny et al, 2005) because the liver cushions the right side of the diaphragm.

The mechanism of injury is commonly an anterior blow to the abdomen, transmitting force through the abdominal viscera. This leads to a sudden significant increase in intra-abdominal pressure and therefore disruption of the diaphragm. Diaphragmatic injury is associated with vascular tears in the adjacent inferior vena cava and hepatic vein, which increase pre-hospital mortality (Scharff and Naunheim, 2007). The clinical symptoms and signs include:

- Epigastric or shoulder tip pain
- Respiratory distress
- Reduced chest wall expansion
- Displacement of cardiac sounds
- Intrathoracic bowel sounds.

Intrathoracic bowel loops may be noted on chest X-ray. This sign is missed on 30% of primary surveys (Shanmuganathan et al, 2000). Focused assessment with sonography in trauma (FAST) scanning may also be helpful, but computed tomography is the gold standard diagnostic test. If this remains inconclusive, T1-weighted sagittal and coronal magnetic resonance imaging may also be useful (Mirvis and Shanmuganathan, 2007).

Management entails surgical repair, usually through an abdominal approach. Repair should be considered as soon as possible, although this is dependent on the respiratory and haemodynamic status of the patient. Video-assisted thoracic surgery can be considered if patients are unsuitable for open repair. Small lacerations may be repaired using suture, but larger perforations may require the use of a mesh.

Heart and the great vessels

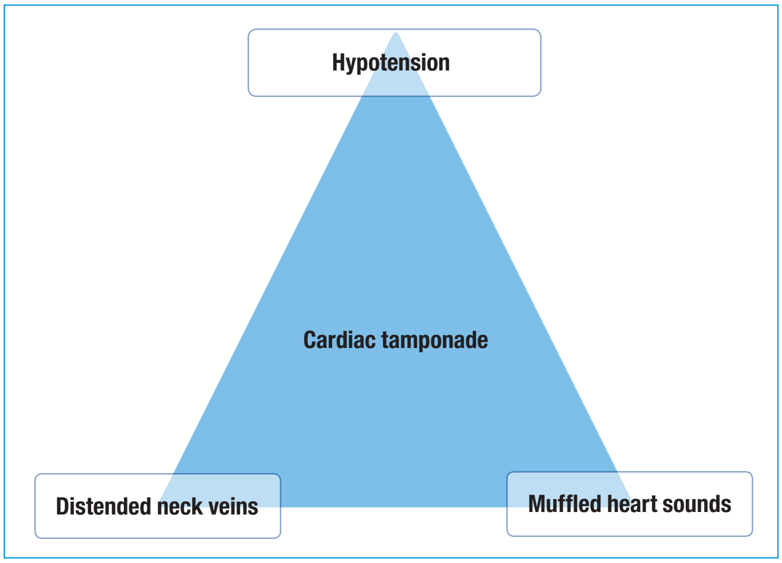
Blunt cardiac injury

Cardiac contusion is the most common cardiac injury seen in blunt chest trauma. It has an incidence between 20 and 70% (Schultz and Trunkey, 2004; Elie, 2006). It includes both injury to the heart (valve, septal or wall rupture) or dysfunction of the heart (diminished contractility in absence of arrhythmia or haemorrhage) (Mattox et al, 1992).

Rapid deceleration compresses the heart against the sternum, thus the right heart is more commonly affected. Clinical diagnosis may be difficult as a result of other injuries. Common signs include cardiac tamponade (*Figure 3*), evidence of cardiac failure and abnormal heart sounds.

FAST scanning during the primary survey is useful to determine the presence of haemopericardium and tamponade. Electrocardiography and echocardiography are necessary to assess for aberrant electrical activity, valvular and septal damage. Electrocardiography may reveal persistent arrhythmias, bundle–branch block or ST depression or elevation (Sybrandy et al, 2003). Cardiac markers alone are non-specific and should be interpreted with caution (Bertinchant et al, 2000).

Figure 3. Beck's triad.



The management of blunt cardiac injury is dependent on the extent and location of injury. Early input from cardiology should be sought. Injuries affecting the valve, septum or ventricles require surgical assessment. Significant cardiac tamponade is drained by pericardiocentesis and the catheter left in situ. If acute coronary syndrome is suspected, transfer to the cardiac care unit for catheterization and stenting is indicated (Dahle et al, 2005). Thrombolytics require careful consideration as bleeding can complicate other injuries.

Pericardial rupture is rare in blunt chest trauma and has a high pre-hospital mortality (Granetzny et al, 2005).

Blunt aortic injuries

Injury to the aorta is the second most common cause of death from blunt chest trauma with a pre-hospital mortality rate of 85% (Yamane et al, 2008). These injuries occur where tethering is present, such as by the ligamentum arteriosum. The clinical presentation varies from non-specific symptoms to hypovolaemic shock. If aortic injury is suspected then emergency computed tomography should be performed. If this is not possible then transoesophageal echocardiogram should be considered (Erbel et al, 2014).

Minor injuries with limited disruption of the aorta and intact intima can be managed expectantly with observation and serial imaging (Erbel et al, 2014; Challoumas and Dimitrakakis, 2015). The definitive management of larger blunt aortic injuries is surgery by open repair techniques or thoracic endovascular aortic repair. The Society of Vascular Surgery advocates the use of thoracic endovascular aortic repair over open repair within 24 hours of injury for patients with complete transection of aortic wall and mediastinal haemorrhage or those with pseudocoarctation syndrome (Challoumas and Dimitrakakis, 2015).

Complications of blunt aortic injury repair include paraplegia which is more common after open repair and stent endoleaks (Challoumas and Dimitrakakis, 2015). Thoracic endovascular aortic repair is also more favoured as a result of its lower post-procedure mortality rates.

There has been a transition in management from immediate to delayed repair (>24 hours) provided the patient is stable (Holmes et al, 2002). Delayed repair allows optimization of patients and reduces the risk of complications, but may result in prolonged periods of ventilation and time on the intensive care unit (Hemmila et al, 2004).

Oesophageal injury

Oesophageal perforation following blunt chest trauma is rare. The clinical symptoms of perforation include chest pain, dysphagia, dyspnoea and epigastric pain. These symptoms mimic those of other injuries such as myocardial infarction, aortic dissection or pneumothorax.

A perforation in the cervical oesophagus is least problematic and can present with neck pain, cervical dysphagia, dysphonia or bloody regurgitation. An intrathoracic perforation is more severe as it can contaminate the mediastinum causing sepsis and shock. The same applies to intra-abdominal perforations that can contaminate the peritoneal cavity. The distinguishing symptoms of intraperitoneal soiling include back pain and inability to lie in the supine position.

Chest X-ray or computed tomography may demonstrate pneumomediastinum, pneumothorax and pleural effusion. Contrast oesophagography, using a water-soluble contrast agent such as gastrograffin, is the gold standard in the diagnosis of oesophageal perforation (Brinster el al, 2004).

The primary goals in oesophageal perforation are prevention of contamination and infection. Perforation contained to the cervical oesophagus can be managed non-operatively by keeping patients nil-by-mouth for 48–72 hours then slowly initiating clear fluids. Broad-spectrum antibiotics are indicated for 7–14 days with total parenteral nutrition (Altorjay et al, 1997). Fluid collections may require a chest drain.

The surgical management of oesophageal perforation includes debridement and closure of the perforation. The options include primary or reinforced primary closure, oesophageal resection, drainage and diversion (Brinster el al, 2004). Tissue grafts using pleural flaps, omental onlay and rhomboid muscles can be used to reinforce the primary repair.

Other injuries

While the above injuries are more common, it is also important to remember that the thorax also protects the spleen and liver. Splenic or hepatic laceration may be fatal and a high index of suspicion and good abdominal examination will help avoid missing these injuries. During the primary survey, a FAST scan may prove useful, although sometimes the patient's body habitus makes this difficult and an abdominal computed tomography should reveal these injuries.

Other injuries include ecchymosis, haematoma and trauma to the soft tissues and skin, and while rare, subcutaneous degloving may occur. It is important to check the tissues carefully and monitor these for evidence of necrosis. Other injuries such as lung herniation are very rare in blunt chest trauma. Clinical findings include chest tenderness, respiratory distress and the presence of a parasternal hernia.

It is also important to remember that significant trauma is not only a physical injury but may also have a significant impact on a patient's psychological wellbeing and that appropriate support and input should be sought. The metaphorical psychological scars may long outlast the physical injuries to the patient.

Conclusions

The management of blunt chest trauma is evolving and close interdepartmental and trauma team collaboration is essential for the successful management of these patients.

Understanding the common injuries, having a high index of suspicion and aggressive investigation will reduce morbidity and mortality in this cohort.

British Orthopaedic Association Standards for Trauma (BOAST) guidelines have helped clarify the management of complex orthopaedic conditions. The authors suggest that the management of blunt chest trauma would be aided by similar national best practice guidelines for the teams involved (emergency, intensivist, vascular, orthopaedic, cardiac, cardiothoracic and gastroenterological). **BJHM**

Figure 1 *is reproduced from Radiopaedia.org, case courtesy of Dr Henry Knipe, rID: 27794, and* Figure 2 *is reproduced from Radiopaedia.org, case courtesy of Dr Hani Al Salam, rID: 31180.*
Conflict of interest: none.

KEY POINTS

- Visceral and soft tissue injuries may be life threatening and include pulmonary contusion, tracheobronchial injury, oesophageal rupture or perforation and blunt cardiac injury. Having a high index of suspicion reduces the risk of missing these.
- Up to 75% of cases will present with pulmonary contusion although it may take 24–48 hours before the full extent of the injury declares itself. Appropriate monitoring and management can reduce the risk of acute respiratory distress syndrome.
- Occult pneumothoraces and haemothoraces may be managed expectantly. A surgical chest drain directed towards the lung apex will be required for a larger pneumothorax and one directed down to the base will be required for a larger haemothorax.
- Tracheobronchial injuries have a high pre-hospital mortality but a low incidence. They may be missed in up to 68% of patients if they are more subtle.
- Simple pneumothoraces are managed expectantly with regular examination and chest radiography.
- Collaborative guidelines on blunt chest trauma management (perhaps through British Orthopaedic Association Standards for Trauma; BOAST) may help to reduce mortality and morbidity in this cohort.

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