Thoracic Trauma: Diagnosis and Management

Traumatic injuries are one of major causes of high morbidity and mortality nowadays. Traffic accidents, sports-related and violence-induced traumas often include thoracic trauma. Different classification and scoring systems are available, all made with the same goal: recognition of signs and symptoms, rapid primary assessment, timely and to the point diagnostic procedures, proper treatment and all leading to the same point which is a lesser time to recover and a favorable outcome.

Definition of Thoracic Trauma

A traumatic thoracic injury can be defined as any form of injury to the chest, including the ribs, heart, lungs, and major blood vessels. An injury can be generally classified as blunt or penetrating.

The specific types of chest injuries include injuries to the chest wall, pulmonary injury, airway injury, cardiac injury, blood vessel injury, and esophageal injury.

Classification of Thoracic Trauma

By the mechanism of injury

Blunt

Blunt traumatic thoracic injuries are caused by a blunt force trauma to the chest. Blunt trauma can cause contusions, abrasions, lacerations, and/or bone fractures.

Penetrating

Penetrating injuries to the thorax happen when an object pierces the skin and enters the chest, creating an open wound. The mortality rate of chest-penetrating injuries is reportedly less than 10%. Penetrating injuries might involve the heart or the major blood vessels within the mediastinum. Lung laceration, pulmonary contusion, hemothorax, pneumothorax, and hemopneumothorax are all more common with penetrating thoracic injuries.

The specific types of chest injuries include:

Injuries to the chest wall
- Rib fractures
- Flail chest
- Sternal fractures
- Chest wall contusions and hematomas

**Injuries to the lung**
- Pulmonary contusion
- Pulmonary laceration
- Pneumothorax
- Hemothorax
- Hemopneumothorax

**Injury to the airway**
- Tracheobronchial tear

**Cardiac injuries**
- Pericardial tamponade
- Myocardial contusion
- Traumatic cardiac arrest
- Hemopericardium

**Blood vessel injuries**
- Traumatic aortic rupture
- Thoracic aorta injury
- Aortic dissection

**Injuries to the esophagus or the diaphragm**

By the time of required treatment and injury severity

**Major or LETHAL SIX should be recognized in the primary assessment:**
- Airway obstruction
- Tension pneumothorax
- Cardiac tamponade
- Open pneumothorax
- Massive hemothorax
- Flail chest

**Minor or HIDDEN SIX can be unrecognized in the primary assessment, but is absolutely necessary not to miss the following:**
- Thoracic aortic disruption
- Tracheobronchial disruption
- Myocardial contusion
- Traumatic diaphragmatic tear
- Esophageal disruption
- Pulmonary contusion

The American Association for the Surgery of
Trauma (AAST) Injury Scoring Scale for Chest and Heart Injuries

AAST Injury Scoring Scale for Chest Wall Injury

Grade I
- Any size of a chest wall contusion
- Skin and subcutaneous lacerations
- Closed fracture of fewer than 3 ribs or a non-displaced closed fracture of the clavicle

Grade II
- Any chest wall laceration that involves the skin, subcutaneous and muscle
- Fracture of three or more adjacent ribs that is closed
- An open or a displaced fracture of the clavicle
- A non-displaced closed fracture of the sternum
- A closed or open fracture of the scapular body

Grade III
- Full-thickness laceration with penetration of the pleura
- An open or displaced fracture of the sternum
- A flail sternum
- Unilateral flail chest of fewer than 3 ribs

Grade IV
- An avulsion laceration of the chest wall tissues with underlying rib fractures
- Unilateral flail chest of three ribs or more

Grade V
- Bilateral flail chest of three ribs or more on both sides

AAST Injury Scoring Scale for Lung Injury

Grade I
- A unilateral lung contusion that involves less than one lobe

Grade II
- A unilateral lung contusion that involves a single lobe
- A lung laceration that is associated with simple pneumothorax

Grade III
- A unilateral lung contusion that involves more than one lobe
- A lung laceration that is associated with persistent air leak for more than 72 hours
- A non-expanding lung hematoma

Grade IV
- Major segmental or lobar air leak
- An expanding lung hematoma
- Vascular injuries involving the primary branches of the intrapulmonary vessels

**Grade V**
- Disruption of the blood vessels at the lung hilum

**Grade VI**
- A total transection of the pulmonary hilum

**AST Injury Scoring Scale for Heart Injury**

**Grade I**
- Blunt cardiac injury – minor EKG abnormality (nonspecific ST of T wave changes, premature atrial or ventricular contractions, or persistent sinus tachycardia)
- Blunt and/or penetrating pericardial trauma without cardiac injury, including tamponade and/or cardiac herniation

**Grade II**
- Blunt cardiac injury without cardiac failure with heart block or ischemic changes
- Penetrating tangential cardiac wound, not extending through endocardium, no tamponade present

**Grade III**
- Blunt cardiac injury with sustained/multifocal ventricular contractions
- Blunt or penetrating cardiac injury, combined with rupture of the septum, pulmonary or tricuspid incompetence, dysfunction of papillary muscle and/or distal coronary artery occlusion not joined with cardiac failure
- Blunt pericardial laceration combined with cardiac herniation
- Blunt cardiac injury and cardiac failure
- Penetrating tangential myocardial wound, not through endocardium combined with tamponade of the heart

"Malignant cardiac tamponade from non-small cell lung cancer" Image created by Lecturio
Grade IV

- Blunt or penetrating cardiac injury including rupture of the septum, pulmonary or tricuspid incompetence, dysfunction of papillary muscle, distal coronary artery occlusion leading to cardiac failure
- Blunt or penetrating cardiac injury and aortic or mitral incompetence
- Blunt or penetrating cardiac injury of the right ventricle, right /left atrium

Grade V

- Blunt or penetrating cardiac injury and proximal coronary artery occlusion
- Blunt or penetrating left ventricular perforation
- Stellate injuries, with no more than 50% tissue loss of the right ventricle, right or left atrium

Grade VI

- Blunt avulsion of the heart
- Penetrating wound with more than 50% tissue loss of chambers

Pathophysiology of Thoracic Trauma

Fractured bones

Ribs, clavicle, and sternum, thoracic vertebrae leading to pain, inadequate ventilation, and subsequent complications:

- **Clavicle** – necessary to exclude trauma of the lung apices and subclavian vessels (chest X-Ray/CT)
- **Sternum** – potential myocardial contusion and internal thoracic vessels trauma (cardiac echo/CT)
- **1st rib** – necessary to exclude trauma of the lung apices, subclavian vessels (chest X-Ray/CT)
- **2nd rib** – may be joined with ascending aorta and superior vena cava trauma (CT)
- **10th rib** – necessary to exclude diaphragmatic, liver, splenic injury (US/CT)
- **11th rib** – necessary to exclude diaphragmatic, liver, splenic injury (US/CT)
- **12th rib** – necessary to exclude renal injury (US/CT)

Flail chest

It is a segment of the thoracic cage separated from the rest of the chest wall, usually represented by a free segment (at least two fractures per rib in at least two ribs) that does not contribute to lung expansion, leading to inadequate ventilation. If the free segment is large enough, the patient requires mechanical ventilation.

The chest wall expands during inspiration. Still, the flail chest segment moves inwards because of the sucking effect of negative intrathoracic pressure, leading to limited lung expansion and thus ineffective ventilation and hypoxia.

Since force is needed to fracture ribs at multiple sites, these injuries are often associated with an extensive lung contusion, complicated by hemothorax and/or pneumothorax. It is an underlying injury that causes respiratory dysfunction rather than the flail segment itself. If analgesia is inadequate, pain makes breathing shallow and
worsens the ventilation, leading to airway collapse and pneumonia.

Hemothorax

Hemothorax refers to the collection of blood in the pleural space. If it is a result of rib fracture, lung, and minor venous injuries, then it is a self-limiting disease. In a few cases, an arterial injury is the underlying cause and requires surgical repair.

Aortic injury

The most serious aortic injury is aortic transection, with imminent death. Other options are tearing with dissection or pseudoaneurysm formation with potential recovery if cases of adequate management. These scenarios happen due to deceleration injury when aortic arch and aorta move suddenly within the chest cavity, and tear occurs most frequently distal to left subclavian artery origin.

Cardiac trauma

Various injuries of heart that are roughly divided into:

- Penetrating trauma presenting as cardiac tamponade: blood or other fluid collects rapidly in the pericardial space, restricting cardiac motion, lowering output, and leading to cardiac arrest and death if not managed promptly
- Blunt cardiac trauma: Difficult to diagnose due to the absence of laboratory testing and clear definition

Myocardial contusion is a common injury in blunt cardiac trauma. Usually, it includes trauma to the left anterior descending artery. Rare injuries include trauma to valves and tendinous chords, rupture of papillary muscle, and blunt pericardial rupture.

Clinical Features of Thoracic Trauma

Thoracic trauma may present itself in a vast spectrum of clinical scenarios. Patients who present with what appear to be minor injuries may experience rapid deterioration and fatal outcome. Therefore, one must very thoughtfully and carefully evaluate every trauma patient.

The primary assessment is roughly based on excluding the Lethal Six, whereas the secondary assessment is focused on including the Hidden Six.

The following steps should be undertaken:

ABC

- Airway (be careful to examine C-spine first) assessment with intubation if required
- Breathing: Inspection, palpation, percussion, and auscultation
- Circulation: Blood pressure, gas exchange tests

Secondary survey

- Lung contusion: The presence of multiple rib fractures or a flail chest should warn the emergency doctor about the possibility of a lung contusion. Moreover, a patient with a lung contusion is likely to show difficulties with maintaining good peripheral oxygen saturation despite optimum oxygen
supplementation therapy

- **Cardiac tamponade:** Be aware of Beck’s triad: distended neck veins, hypotension, heart sounds muffled < other signs such as a rise in jugular vein pressure on inspiration, paradox pulse, and PEA arrest may be present

- **Cardiac contusion:** Non-specific clinical presentation ranging from asymptomatic to complaints of chest pain and shock. Overlap with other thoracic injuries is common and should be kept in mind

- **Rib fractures and flail segment:** Pain and tachypnea, paradoxical movement in patients who are not intubated, crepitation on palpation of broken rib ends, as well as moderate to severe respiratory distress in proportion to injury extent

- **Blunt aortic injury:** Interscapular murmur on auscultation, low blood pressure

- **Esophageal injury:** Pain when swallowing, crepitus in the neck

- **Diaphragmatic rupture:** May present as auscultated bowel sounds in the chest or dullness on percussion of the chest

- **Thoracic vertebral fractures:** Could be presented by ‘step’ deformity or spinous process tenderness on palpation in the secondary survey. It’s important to include lateral thoracic spine X-ray or to evaluate the thoracic spine on a CT scan done for general evaluation. The integrity of vertebral bodies and the integrity of conceptual columns of the spinal column is evaluated

### Investigations for Thoracic Trauma

#### Chest X-ray

This simple and fast method can be used initially to evaluate different thoracic structures. It is used to evaluate the chest wall fracture, pneumothorax, hemothorax, lung contusion areas, widening of aortic arch shadow, diaphragmatic contour.

#### CT scan

A CT scan of the chest is the imaging diagnostic tool of choice for assessing thoracic injuries as it has high sensitivity and specificity. Different thoracic structures can be evaluated with high accuracy to make decisions in the management of the patient.

It is used to examine bone fractures, small pneumothorax, cardiac, aortic, pulmonary vessel injuries, pneumo- and hemato-mediastinum, diaphragmatic rupture, and lung contusions.

#### Echocardiography

Transthoracic echocardiography (TTE) is a very important diagnostic tool for assessing cardiac injuries since it can show pericardial effusion and reveal whether the patient is in echocardiographic findings of cardiac tamponade.

Echocardiography-guided pericardiocentesis is both diagnostic and therapeutic in cases of hemorrhagic pericardial effusion.

Injuries associated with cardiac tamponade include cardiac contusion and coronary artery injury, which may have a delayed presentation that presented with ventricular septal
Management of Thoracic Trauma

Management of thoracic trauma requires a multidisciplinary team effort. Depending on injury severity, the patient might be treated and discharged home from the emergency department or might be admitted to the intensive care unit.

Life-threatening conditions are assessed and treated first; therefore, imaging should not delay treatment.

The most frequent injuries are treated as follows.

**Tension pneumothorax**

*Needle decompression* is done by inserting a 14 gauge, 5 cm long needle in the second intercostal space in the mid-clavicle line. After the needle decompression, the pleural space is decompressed. Further diagnostic exams and definitive management, such as the insertion of a formal chest drain, can then be completed.

**Open pneumothorax**

Immediate management – supplemental (100%) oxygen, flap-valve dressing, insertion of a chest drain, and applying an occlusive dressing to the wound.

**Hemothorax**

The patient should receive 100% oxygen, followed by the insertion of an intercostal chest drain and maintenance of the circulating volume.

**Cardiac contusion**

Urgent intervention may be mandatory and life-saving. A resuscitation procedure, combined with 100% oxygen and intravenous fluid or blood product administration, should increase cardiac input pressure, temporarily buying time and improving the situation. The sole aim of therapy is to maintain cerebral perfusion.

Systolic pressure should not be elevated because it will increase the cardiac rate and potentially the volume of blood in the pericardial sac.

*If needed, a needle pericardiocentesis* can be performed by insertion of a large-bore needle between the xiphisternum and left subcostal margin. Evacuating even a small amount of blood (such as 50 ml) could improve the situation.

*Note:* To distinguish whether the evacuated blood is from the heart or from the pericardial sac, one should remember that blood drawn from the heart clots, but blood from the pericardium does not.

If pericardiocentesis fails, *urgent surgery and decompression are necessary*. When pericardiocentesis is done, there is a risk of severe damage to coronary vessels.

**Lung contusion**

3 – 5 days supportive period is required to follow up the resolution of contusion, involving supplemental oxygen, and analgesia in order to avoid complications.
Pneumonia is one of the most frequent ones. ARDS and respiratory failure are potential complications of severe contusion.

Simple rib fracture

It is treated by analgesia and targeted physiotherapy in order to prevent complications due to inadequate respiration. Special focus should be on underlying conditions.

Complications of Thoracic Trauma

Common complications of thoracic trauma include:

- Respiratory failure
- Pneumonia
- Pleural sepsis (in cases of retained hemothorax by external contamination of thoracostomy tube)

Complications of management of cardiac trauma include:

- Internal mammary and coronary artery injury
- Ventricular puncture and aspiration
- Introduction of infection and pericarditis
- Phrenic nerve injury during surgical approach through the pericardial sac

References

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