

Chest Trauma; Significant Source of Morbidity and Mortality

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Background

Despite advances in trauma management and critical care, chest trauma still continues to be a significant source of morbidity, mortality and hospitalization especially in otherwise healthy young adults.¹⁻³ In the developed countries, chest trauma directly accounts for 20%-25% of all trauma related deaths and is recognized as a major contributor in another 25% of trauma related deaths. The mortality and morbidity depends on factors such as severity of chest injury, condition of the underlying lungs, associated extra-thoracic injuries especially to head, abdomen and long bones.^{4,5} Road traffic accidents (RTAs), firearm injuries (FAIs), falls from heights, blasts, stabs and other acts of violence are the causative mechanisms involved.^{1,4-6}

The clinical presentation varies from case to case, however there is more frequent involvement of the relatively young males, which further amplifies the grave implications of this serious problem.^{1, 7-9} In urban areas the problem stems largely from blunt mechanisms such as RTAs, falls from heights and accidents at construction sites. Stabs and FAIs are relatively more common in rural set ups.

RELEVANT ANATOMY AND PHYSIOLOGY: Chest trauma implies trauma to different structures of the chest wall and the chest cavity. The chest is arbitrarily divided into four components including chest wall, pleural space, lung parenchyma and mediastinum. The chest wall includes the bony thorax and associated musculature. The pleural space lies between visceral and parietal pleura and can become filled with blood or air following chest trauma. The lung parenchyma includes the lungs

and associated airways and may sustain contusions, lacerations, hematoma and pneumatocele. The mediastinum includes the heart, aorta/ great vessels of chest, tracheobronchial tree and esophagus.⁴⁻⁶

Normally the chest is responsible for the vital cardiopulmonary physiology of delivering oxygenated blood to the metabolically active tissues of the body. Derangements in the flow of air or blood, either alone or in combination are responsible for the pathologic consequences of chest injury. Clinical consequences of chest trauma depend on factors such as the mechanism of injury, the extent and location of injury, associated injuries and underlying co-morbidities. Chest trauma patients are likely to deteriorate due to effects on respiratory function with secondary associated cardiac dysfunction. Chest trauma treatment aims to restore cardiorespiratory function to normal, control of bleeding and prevention of sepsis.¹⁰⁻¹²

INJURY MECHANISM: Chest trauma may be caused by blunt or penetrating mechanisms.^{4, 5}

Blunt Chest Trauma: Blunt chest trauma accounts for about 75%-80% of all chest trauma cases and significant percentage of the patients have associated extra-thoracic injuries as well. RTAs are the leading cause and account for up to 80 % of cases in our country. Falls from heights, assaults and blast injuries are the other causative mechanisms. The victims are usually young to middle aged men as they are more frequently in outdoor activities in road traffic, construction sites and other hazardous occupations.^{1, 4} Blunt trauma to the chest causes injury by one of the three mechanisms; a direct blow to the chest, deceleration injury, and compression injury.⁴

Penetrating chest trauma: Stab injuries, firearm injuries and blasts are the common causative mechanisms of penetrating chest trauma. These are further classified on the basis of the velocities of the penetrating missiles:⁵

- Low velocity injuries include knife cuts and impalements.
- Medium velocity injuries resulting from handgun and air gun.
- High velocity injuries typically caused by rifles and military weapons. These missiles produce their effects by causing temporary and permanent cavitation and shock wave effects.
- Very high velocity injuries are caused by weapons of antipersonnel effects e.g. mines, blast fragments, grenades and bombs. The fragments may have a velocity of 4500 ft/sec.

Easy availability and indiscriminate use of weapons is a recognized cause of increasing penetrating trauma in our country.⁸ Stab injuries and firearm injuries are often due to enmity and murder attempts.

Initial Resuscitation: The initial management of chest trauma patients is no different than that of any other trauma patient and includes ABCDE i.e. A: Airway patency with care of cervical spine, B: Breathing adequacy, C: Circulatory support, D: Disability assessment and E: Exposure without causing hypothermia.¹³

Primary chest survey with thorough examination of the chest should be undertaken. The aim is to identify and treat any immediately life threatening conditions including airway obstruction, tension pneumothorax, massive open pneumothorax, massive hemothorax, pericardial tamponade and large flail segment.¹⁴⁻¹⁶

Once the immediately life threatening conditions have been addressed, a second more detailed head to toe examination along with secondary chest survey is undertaken. The secondary chest survey would focus on the detection of the following conditions: pulmonary contusion, myocardial contusion, aortic disruption, traumatic diaphragmatic rupture, tracheobronchial disruption and esophageal disruption.¹⁷⁻¹⁹

Apnea, profound shock and inadequate ventilation are the leading indications for emergency endotracheal intubation. Intravenous fluid resuscitation constitutes the cornerstone of treating hemorrhagic shock. Effective pain control is one of the most crucial measures in chest trauma patients. Ventilatory support should be instituted in patients with significant hypoxemia, hypercarbia and tachypnea or impending respiratory failure. It is also indicated in patients with severe lung contusion, hemothorax or pneumothorax,

and flail chest accompanied by hemodynamic compromise. Initially, manual ventilation is sometimes beneficial in these patients.^{4, 5, 10}

Patients with clinical signs of a tension pneumothorax should undergo immediate chest decompression with needle thoracocentesis and subsequently with tube thoracostomy. Chest X-ray should be avoided in these patients as the diagnosis is clinical and Chest X-ray will unnecessarily delay the immediately needed management. A sucking chest wound must be adequately covered with an occlusive dressing to prevent the development of open tension pneumothorax.²⁰⁻²²

Measures such as tube thoracostomy, thoracotomy and other interventions are instituted as dictated by the patient's condition.^{23, 24}

Essential Diagnostic Work: Chest X-ray is the initial radiographic study of choice, however spiral CT scans are rapidly evolving as a primary diagnostic tool.²⁵⁻²⁷

Hematocrit value, hemoglobin and arterial blood gases (ABGs) determination offer the most useful information for treating these patients. Blood grouping and cross matching is also important in patients with blood loss. Other basic essential tests such as blood sugar, renal and liver function tests help to rule out underlying medical conditions especially diabetes mellitus, renal and hepatic insufficiency.

The need for such specialized investigations such as cervical spine X-rays, CT scans head and abdomen, focused assessment with sonography for trauma (FAST) and angiography, will be dictated by the special circumstances of individual patients.²⁸

Common life threatening chest conditions are elucidated in the following:

1) Pneumothorax and Tension Pneumothorax:

Simple pneumothorax refers to collection of air in the pleural cavity without mediastinal shift. Tension pneumothorax occurs when a flap valve leak allows air accumulation in the pleural space and intrapleural pressure rises above atmospheric pressure. With each inspiration air enters into the pleural space with no escape during expiration, resulting in progressively increasing air accumulation. This causes mediastinal shift and circulatory collapse. Respiratory distress, shock, hyper-expanded hemithorax, absent breath sounds and hyper-resonant percussion notes, engorged neck veins, tracheal shift to the opposite side etc. indicate tension pneumothorax. The diagnosis is clinical without chest X-ray. Management includes rapid decompression with needle thoracocentesis followed by expeditious tube thoracostomy.²⁹ Needle thoracocentesis is performed by inserting a wide bore needle (14-16 G) with a syringe partially filled with 0.9% saline into 2nd intercostal space in midclavicular line on the

affected side. The plunger is removed to allow escape of the trapped air that bubbles through the syringe with saline as water seal, until tube thoracostomy is done. Alternatively a wide bore venflon can be inserted in the same location.^{30, 31}



Figure I: X-Ray chest showing pneumothorax with collapsed lung border on left side.

2) Massive Hemothorax: It is characterized by accumulation of >1500 cc of blood in the pleural space. It is often attended by hemodynamic instability. The sources of the bleeding include



Figure II: X-Ray chest showing Hemothorax with multiple rib fractures on right lower lung.



Figure III: X-Ray chest showing multiple rib fractures and contusion injury on right lung predominantly middle lobe.



Figure IV: A check X-Ray chest showing kinked chest tube which was corrected subsequently. A check X-Ray chest helps to confirm proper placement of the tube.

intercostals vessels, internal mammary vessels, lung parenchyma and major vessels. Initial treatment

includes a tube thoracostomy, which re-expands the lung and serves to tamponade bleeding by bringing the lung surface up against the thoracic wall. The tube must be large (> 28 Fr) and should be aimed posteriorly. The chest tube output is monitored closely as massive initial output (i.e.>1500cc) and continued high hourly output (i.e. > 200cc / hr for consecutive 3 or more hours) are frequently associated with thoracic vascular injuries that require thoracotomy. Nevertheless most cases of hemothorax do not require operation unless bleeding continues and there is hemodynamic instability.⁴⁻⁶

Large clotted hemothorax results in dense fibrothorax with the possibility of added empyema. This can be managed with thoracoscopy or open approach.³²

3) Pericardial Tamponade: It is most frequently caused by penetrating cardiac injuries but occasionally it is observed in blunt thoracic trauma from myocardial rupture, coronary arterial laceration or ascending dissection of an aortic tear. Hemopericardium of as little as 150 cc blood in pericardial cavity is sufficient to cause cardiac tamponade.^{4, 5, 33}

The classic Beck's triad of hypotension, venous distension and muffled heart sounds is documented only in 10-30 % of patients with proven cardiac tamponade. There may be associated pulses paradoxus as well.

In stable patients diagnosis can be confirmed by echocardiography, needle pericardiocentesis or subxiphoid pericardial window.^{4, 5}

Definitive management is thoracotomy and opening of pericardial sac. Tamponade is relieved, bleeding can be controlled by digital pressure while preparation for definitive repair are made. Small lacerations can be repaired using pledgetted sutures on the beating heart, while large or complex be repaired on cardiopulmonary bypass.^{33, 34}

4) Large Flail Segment: When three or more consecutive ribs are fractured at two or more places either on one side of the chest or on either side of the sternum, a free floating unstable segment of chest wall is produced. This is called flail chest. This flail segment moves paradoxically with breathing, i.e. inwards during inspiration and outwards during expiration. Severe pulmonary contusions often accompany and result in subtle respiratory failure. Patients with significant arterial hypoxemia, or ventilatory insufficiency would need ventilatory support. Some authorities also advocate elective ventilation for up to 3 weeks in flail chest patients. Intravenous fluids should be used cautiously in these patients as their excess has detrimental effects in these patients.^{4, 5, 35-37}

Conservative management of flail chest is superior to operative fixation, however the later is indicated if there is large flail segment in the context of borderline premorbid pulmonary status or if there severe instability, intolerable pain and failure to wean from the ventilator. Additionally operative fixation is carried out if the patient is undergoing thoracotomy for other reasons and in the event of secondary infections.⁵

5) Open Pneumothorax: An open chest wound often results from penetrating mechanisms but may rarely occur in association with blunt trauma as well. A defect in chest wall provides a direct communication of the pleural space with the environment. A wound large enough to exceed the laryngeal cross-sectional area provides an alternative air pathway with less resistance than that of the normal tracheobronchial tree. Small wounds can thus form a one way valve, allowing air to be sucked into chest with inspiration leading to pneumothorax.^{4, 5}

The treatment consists of covering the wound with occlusive dressing such as Vaseline soaked gauzes and taping the dressing on three sides so it can act as a valve allowing air to exit the chest with expiration but preventing sucking in during inspiration. A tube thoracostomy is performed at another place. The wound is managed with debridement and closure. Large chest wall defects may need reconstruction and closure with prosthetic devices such as Mesh or tissue flaps.^{4, 5}

A special situation arises when the thoracic wall defect is sufficiently large, intrapleural pressure remains equal to atmospheric pressure. Spontaneous breathing will cause only movement of air in and out of the body wall defect. There is ineffective breathing and respiratory compromise is severe. Simple occlusion of the defect will result in dramatic improvement, creating a closed pneumothorax that can be well managed with tube thoracostomy.^{4, 5}

6) Injuries to Great Vessels and Tracheobronchial Tree: Such injuries are relatively rarely seen in hospital as the patients rarely survive the severe insult leading to major vascular or airway disruption. The prevalence of great vessel injuries is 0.3-10 %. More than 90% of these are caused by penetrating trauma. Traumatic aortic rupture accounts for 10-15% of automobile crash fatalities. Up to 90 % of these victims die within minutes at the scene or when en route to the hospital. Rapid deceleration is the most common mechanism causing major blunt bronchial injuries.^{4, 5}

Emergency thoracotomy for rapid descending aortic cross-clamping and manual control of bleeding is required in patients who arrive alive to hospital. Specific operative measures are instituted according to the individual needs of the patients.^{4, 5}

Tube Thoracostomy: Tube thoracostomy is the most frequent intervention undertaken among chest trauma patients.³⁸ It effectively drains the pleural space and provides the definitive treatment in the great majority of patients. It is effective for obtaining rapid re-expansion of injured the lung, complete evacuation of the pleural space and monitoring the injured chest for any continued heavy blood loss following insertion. It as a safe procedure, however there is 2%-10 % reported incidence of complications which often result from poor technique.³⁹⁻⁴¹

Thoracotomy: Thoracotomy has a role in certain emergency situations as well as in some late complications of chest trauma. It may be indicated in emergency room or on urgent basis or in chronic basis. Internationally the rate of thoracotomy is approximately 10% in blunt and 30% in penetrating thoracic trauma.⁴²⁻⁴⁵

In our published local studies the rate of emergency thoracotomy or elective one is not in conformity with what is reported from the developed countries.¹ The low rate of thoracotomy in our local studies is probably a reflection of our living circumstances. Due to lack of public awareness, non availability of on-scene emergency services infrastructure and legal anomalies, victims of RTAs are either left alone on roads or there is considerable time lag in their arrival to the health care facility. Hence seriously injured patients who are potential candidates for thoracotomy either die on the spot or when en route to the hospital.

Room For Future Developments: There is enormous scope for improvement, both in the diagnosis as well as management of chest trauma.^{4, 5} More accurate diagnostic tools and less invasive procedures should emerge in future. Spiral CT scans should be used more frequently for definitive diagnosis of different chest injuries including major vascular injuries. Video assisted thoracoscopy should be increasingly employed for the diagnosis and management of chest injuries. Endovascular techniques for the repair of great vessel injuries may also be developed. With increasing awareness and understanding, urgent as well as emergency resuscitative thoracotomy should be more frequently employed.

Closing Thoughts: Generally speaking, certain aspects of trauma management, have not yet gained adequate attention in Pakistan. Chest trauma is fairly common in our set, however it has been the subject of only a few published local studies. Dedicated trauma care centers are not yet established. Emergency facilities are not well developed at our highways and motorways. There exists no satisfactory mechanism for communication between hospitals and accident scene. There is also an intense

need to evolve trauma registry in order to have accurate trauma statistics of our own.

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