Thoracic Trauma in Earthquakes

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Abstract

Major earthquakes continue to be one of the most devastating disasters for mankind. Severe thoracic injuries seen in earthquake victims frequently lead to high mortality rates and significant multisystem trauma, with approximately 10% of casualties from severe earthquakes suffering from chest and lung injuries. Blunt trauma is the main cause of these injuries, which can be treated with vital but straightforward interventions if the victim is assessed promptly. After the initial assessment and securing of the airway, breathing, and circulation, it is crucial to identify any life-threatening injuries through a thorough physical examination. A comprehensive understanding of the primary pathophysiology behind lethal thoracic injuries is crucial for their effective treatment.

Keywords: Thoracic injuries, trauma, earthquakes

Introduction

Thoracic traumas are responsible for a quarter of all trauma-related deaths and account for 10% of mortality after hospital admission.[1] Earthquakes are a notable cause of thoracic trauma, and it is estimated that nearly 10% of casualties from severe earthquakes suffer from chest and lung injuries.[2] Most of these injuries are caused by blunt trauma and can be treated with vital but relatively simple maneuvers, provided that the victim is accessed in a timely manner. After the initial assessment and securing of the airway, breathing, and circulation, it is crucial to identify any life-threatening injuries through a physical examination. This examination should include special attention to the inspection of the neck veins and chest wall motion as well as palpation and auscultation of the lungs. Understanding the main pathophysiology behind lethal thoracic injuries is critical in treating them effectively.

Bleeding

Hemothorax is a prevalent finding in patients with thoracic trauma, affecting almost 25% of patients.[3] Bleeding may occur from various sources, including the lung parenchyma, chest wall, major thoracic vessels, heart, and diaphragm. In cases of hemodynamic instability, chest tube insertion can be a rapid solution for diagnosing and treating air leaks and bleeding. During chest tube insertion, initial hemorrhagic drainage of more than 1500 mL or continued drainage of 250 mL/h over the next 4 hours is generally accepted as an indication for exploration with urgent thoracotomy.[4] However, conservative management is typically appropriate for small or moderate bleeding. For most patients, conservative follow-up is appropriate.

Cardiovascular Collapse

Only a small percentage of patients with thoracic trauma require emergency department thoracotomy to address pericardial tamponade, control hemorrhage, perform an open cardiac massage, and cross-clamp the descending aorta to help redistribute blood flow to more critical organs. Current indications for performing an emergency department thoracotomy include acute pericardial tamponade with impending loss of vital signs, exsanguinating intrathoracic hemorrhage, and witnessed arrest unresponsive to resuscitation.[5] While these situations are often fatal, patients may still be potentially salvageable, depending on their prehospital physiological status. In such cases, it is essential to release cardiac tamponade and to keep in mind that massive pneumomediastinum can also cause tamponade.[6] Massive bleeding should be controlled using staplers, clamps, or manual compression, and any cardiac injuries should be repaired.

Massive Air Leak

In 2.5%-8% of patients with blunt trauma, a massive air leak may be present.[3] Major tracheobronchial injury (TBI) should be suspected if the air leak persists after tube thoracostomy or if there is subcutaneous emphysema and reexpansion failure.[7,8] While multidetector computed tomography (CT) can typically detect most TBI, an undiagnosed injury can result in long-term disability or death due to inadequate ventilation and hypoxemia. Pneumoderma, which occurs when air dissects along the bronchi and vessels through the mediastinum and subcutaneous tissue, can also occur in patients with air leaks.[9] The severity of pneumoderma is typically proportional to the severity of the airway injury.

If there is a rapid progression of mediastinal or subcutaneous emphysema, signs of mediastinitis, or mechanical ventilation failure, urgent thoracotomy on the suspected side of the injury should be considered.[10] Alternatively, lung separation can be achieved by selectively bypassing the TBI with a single- or double-lumen endotracheal tube as a temporary solution to maintain oxygenation. However, major TBI should be surgically repaired once the patient has been stabilized.

Traumatic Asphyxia

Traumatic asphyxia, also known as Perthes syndrome, can occur as a result of a sudden or severe compression injury to the thorax or upper abdomen.[11] This condition is often associated with severe blunt trauma, such as being trapped under heavy rubble during an earthquake. Traumatic asphyxia is characterized by increased venous pressures, resulting in clinical manifestations such as bulbar

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conjunctival hemorrhage, facial cyanosis, temporary loss of vision due to retinal edema, and petechiae on the face or upper chest (Figure 1). Neurologic sequelae are also common due to anoxic brain injury.[12] The underlying mechanism of Perthes syndrome is believed to involve high-pressure retrograde blood flow from the right atrium to the valveless innominate and jugular venous system caused by crushing injury to the mediastinum.

The treatment of traumatic asphyxia is generally supportive, as the injury tends to resolve itself in nonfatal cases. Measures such as reducing intracranial pressure through head elevation or oxygen therapy can help to decrease the neurological impact. Traumatic asphyxia often occurs in conjunction with other specific conditions such as head injuries, pulmonary contusions, hemothorax, pneumothorax, or rib fractures, and it is typically the complications from these injuries that lead to fatalities.[13] Therefore, treating these associated conditions is often given priority.

Mediastinal Emphysema or Pneumoderma

The incidence of mediastinal emphysema or pneumoderma is high in blunt trauma patients, and it can be an indication of injury to the upper airway, tracheobronchial tree, esophagus, or lung parenchyma[3] (Figure 2). A thorough physical examination, plain chest radiograph, or chest CT can aid in the diagnosis of these injuries.[14] A bronchoscopy or esophagoscopy should also be performed to detect any endoluminal signs. Air usually dissects along the bronchi and pulmonary vessels through the mediastinum and subcutaneous tissue, and in some cases, it can extend from the face and neck down to the inguinal ligament and external genitalia. The primary treatment is directed toward managing the underlying conditions, and decompression incisions to the neck through the paratracheal fascia may be necessary in cases of massive emphysema.

Pneumothorax

A pneumothorax occurs when air accumulates between the visceral and parietal pleura (Figure 3). This can be caused by a defect in the pleura resulting from stab wounds, rib fractures, or projectile injuries. In penetrating traumas, air can enter the pleural cavity externally through the chest wall or internally through the tracheobronchial tree. In blunt trauma, a pneumothorax can only occur if the visceral pleura is lacerated, causing the alveoli to rupture. In earthquake victims, pneumothorax is usually expected due to rib fractures. It is important to perform auscultation of breath sounds during the initial assessment to detect pneumothorax. A plain chest radiograph should be obtained as soon as possible, and chest tube insertion is recommended even in small traumatic

Figure 1. A patient suffered from traumatic asphyxia has diffuse petechiae on the face, neck, and upper extremity.

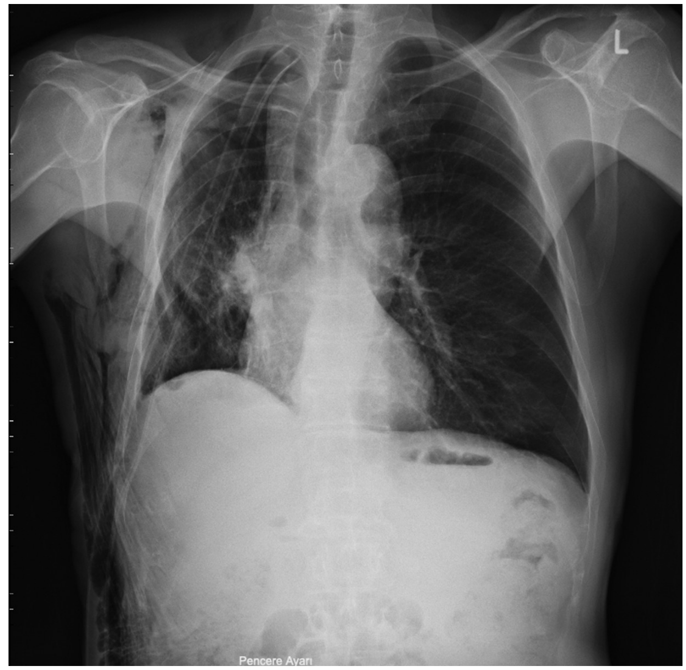

Figure 2. Right-sided pneumoderma in a patient with tube thoracostomy.

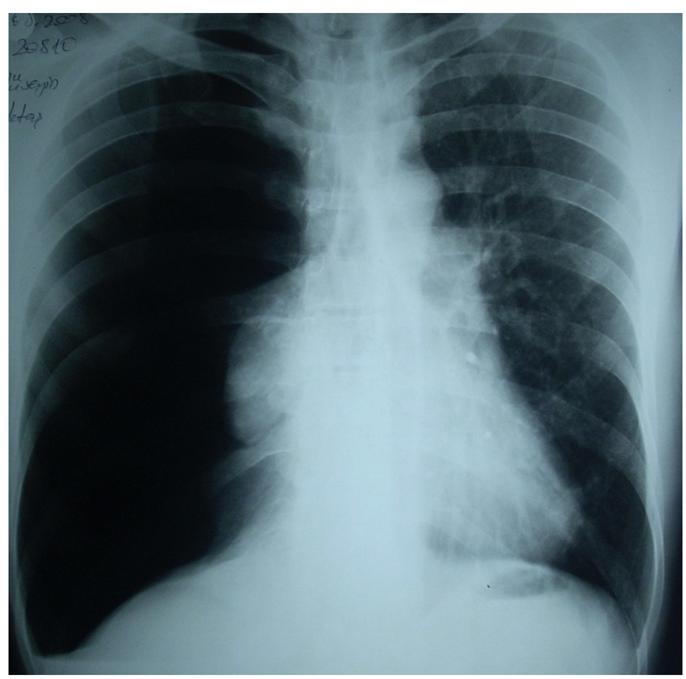

Figure 3. Total pneumothorax on the right side.

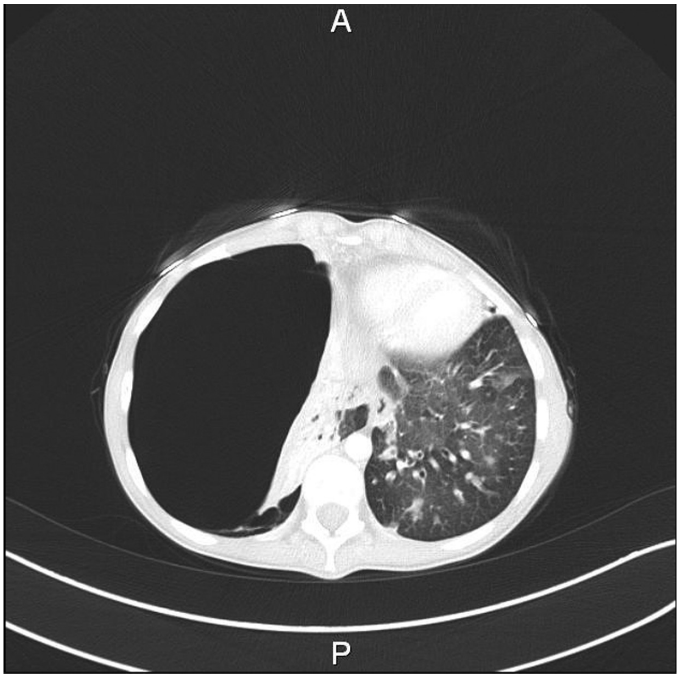

Figure 4. Tension pneumothorax on the right side. Mediastinal shift has emerged.

pneumothoraces, particularly in patients who may need positive-pressure mechanical ventilation.[15] The incidence of progression to tension physiology is 1%-3% in spontaneous pneumothoraces, but it may progress faster in traumatic conditions.[3] In the presence of pneumothorax, the increased pressure causes the mediastinum to shift toward the contralateral side, compressing the contralateral lung and impairing venous return to the right atrium (Figure 4). This can lead to severe respiratory distress, deviated trachea, distended neck veins, decreased blood pressure, and the absence of breath sounds. Tension pneumothorax needs to be diagnosed clinically and converted to an open pneumothorax immediately by placing a needle into the pleural cavity to prevent cardiovascular collapse.[16]

Hemothorax

Hemothorax is a condition that affects almost a quarter of patients with chest trauma and is usually caused by penetrating or blunt trauma with rib fractures.[17]. Symptoms of hemothorax may include decreased breath sounds, dyspnea, tachypnea, low blood pressure, or hemodynamic shock, depending on the amount of blood loss. Bleeding usually originates from the lung parenchyma, intercostal arteries/veins, or internal thoracic artery. Ultrasound imaging is an effective tool for rapid detection of hemothorax during initial assessment. Once the patient is stabilized, a chest x-ray (CXR) and a CT scan can be performed. While CXR may not detect less than 300 mL of fluid, a CT scan is useful for detecting the amount of blood and the cause of hemothorax (Figure 5).

Small hemothoraces can resolve within a few days. Massive hemothorax is defined as blood accumulation of more than 1500 mL in one hemithorax, usually caused by major vessel injury, and can lead to hemodynamic instability, including hypotension and cardiovascular collapse. Hemothorax should be treated by completely evacuating the blood with a tube thoracostomy. A 28-Fr chest tube is generally placed on the midaxillary line at the fifth intercostal space. A CXR is necessary after tube thoracostomy placement to ensure the pleural space is adequately drained and

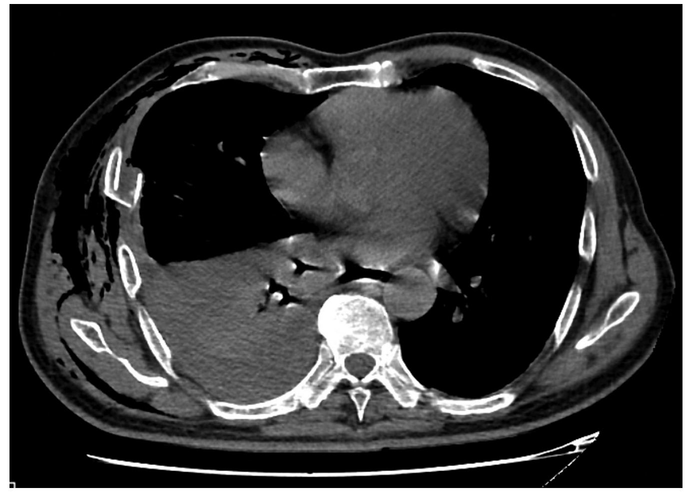

Figure 5. Right-sided hemothorax with rib fracture and pneumoderma on a computed tomography scan.

the lung is reexpanded. If initial drainage is greater than 1500 mL or drainage exceeds 250 mL/h for 4 hours, exploratory thoracotomy should be considered.[4]

Ineffective evacuation increases the risk of developing empyema and pneumonia. Therefore, exploration and drainage via video-assisted thoracoscopic surgery in stable patients or thoracotomy should be considered to prevent the development of a cortex (thickened visceral pleura and trapped lung).

Rib Fractures and Flail Chest

Rib fractures are a common occurrence in chest trauma patients, particularly those with crush injuries and are often associated with other injuries. While rib fractures themselves do not typically cause major problems, they can indicate the severity of trauma. As the number of fractured ribs increases, the risk of associated complications such as pneumothorax, pneumonia, acute respiratory distress syndrome (ARDS), empyema, and mortality rates increases significantly.[18]

Treatment of rib fractures is primarily supportive care with management of related conditions. Effective pain management is crucial, as uncontrolled pain can cause hypoventilation, suppression of cough, and deep inspiratory efforts, resulting in the retention of carbon dioxide and mucus. Pulmonary physiotherapy, bronchial toilet, and aggressive pain control are essential in preventing complications such as pneumonia, empyema, or ARDS. Nasotracheal suctioning or fiberoptic bronchoscopy should be considered if the patient is unable to clear secretions. In elderly patients, blunt chest trauma with rib fractures is associated with significantly higher morbidity and mortality rates, with an increased risk of developing pneumonia.[19]

In patients with blunt chest trauma and suspected rib fractures, caution should be taken to examine for concomitant organ injuries. Fractures on the lower ribs may be associated with liver injury on the right side and spleen injury on the left. Fractures of the first and second ribs are at risk for accompanying aortic injury, and patients should be monitored closely for widened mediastinum, expanding hematoma on CT scan, and upper extremity pulse deficit.

In cases where at least 4 consecutive ribs are fractured in 2 or more places, flail chest deformity may occur, defined as an incompetent segment of the chest wall that impairs respiratory dynamics. The free chest wall segment can cause paradoxical chest wall motion, resulting in the flail segment moving inward during inspiration, leading to a reduction in vital capacity and ineffective ventilation. Early mechanical ventilatory support is crucial in patients with flail chest, along with aggressive pain control and bronchopulmonary toilet. Mechanical ventilation provides "internal pneumatic stabilization" via positive pressure ventilation that helps the flail segment move synchronously with the remainder of the chest wall.[20] However, prolonged mechanical ventilation is associated with higher complication rates. In patients unable to wean from the ventilator or with severe chest wall instability, progressive decline in pulmonary functions, or persistent pain, surgical repair should be considered. Surgical stabilization is associated with faster weaning from the ventilator, recovery of pulmonary functions, shorter intensive care unit stays, and lower hospital costs.[21]

Lung Contusion

Pulmonary contusion is defined as hemorrhage and interstitial edema resulting from parenchymal injury. It usually occurs after blunt chest trauma and can lead to ventilation/perfusion mismatch and left-to-right shunting. The underlying mechanism is believed to be a combination of alveolar stretching, parenchymal tearing, and concussion. The clinical picture generally appears 12 to 24 hours after injury and mainly consists of respiratory distress with hypoxemia and hypercarbia. Focal or diffuse consolidative processes are expected to be visible in a CT scan almost immediately after injury[22] (Figure 6). Pulmonary contusion is associated with prolonged mechanical ventilation.[23] Therefore, treatment is mostly supportive and based on providing aggressive pulmonary physiotherapy and adequate pain control, fluid restriction, and management of concomitant rib fractures. Limited fluid administration is essential in these patients, as hypervolemia can worsen fluid extravasation into the alveolar spaces and lead to ARDS. Steroids and prophylactic antibiotics are not indicated in uncomplicated cases. Close respiratory monitoring is important, as respiratory failure generally occurs within a few hours after injury.

Diaphragmatic Injuries

Diaphragmatic ruptures due to blunt trauma usually result from motor vehicle accidents, falls from great heights, and crushing injuries, such as being trapped under rubble in earthquakes.[24] The main mechanism behind diaphragmatic rupture is increased transdiaphragmatic pressure between the thorax and abdomen. The rupture is commonly located along the central tendon, and the large defect allows visceral organs to herniate into the pleural space. Left-sided ruptures are more common (65%-86%) than right-sided ruptures (14%-35%) due to the cushioning effect of the liver.[25] The most commonly herniated organs are the spleen, stomach, and intestines on the left side and the colon on the right.[26]

Only a small group of patients present with respiratory distress, a deviated trachea, or bowel sounds in the chest. Associated conditions such as traumatic brain injury, hypovolemic shock, or sepsis are likely to be seen in patients with forced diaphragmatic injury. In the emergency department, a Focused Assessment with Sonography in Trauma (FAST) exam may be helpful in diagnosing diaphragmatic rupture with immobility or abnormal motion. Chest x-ray has a sensitivity of up to 94% to detect diaphragmatic ruptures with hernia.[27]. Common findings of diaphragmatic injuries are abdominal contents or a nasogastric tube seen in the thorax, >4 cm elevated hemidiaphragm, and distortion of the diaphragmatic margin.[28] The hernia sac containing visceral gas and one or more air-fluid levels seen in the lower hemithorax and deviating the mediastinum to the contralateral side is pathognomonic. However, CT scan has a sensitivity of 50%-78% and a specificity of 100%.[29] Diaphragmatic discontinuity, thickened diaphragm, and stomach or colon passing through the tear (collar sign) are significant signs. When the diagnosis remains elusive, magnetic resonance imaging can be helpful in detailing the characteristics of the rupture.

Changes in pressure due to the now communicating thoracic and abdominal cavities increase the possibility of bowel obstruction, incarceration, or strangulation. Therefore, surgical repair is required for diaphragmatic ruptures. Small defects without hernia have the potential to enlarge and develop hernia over time. Therefore, they are also recommended for surgical repair. Laparoscopy, thoracoscopy, laparotomy, or thoracotomy can be used as a surgical approach depending on the location, size, progress of the rupture, and contents of the hernia. The diaphragm can be repaired with non-absorbable sutures and prosthetic materials when needed.

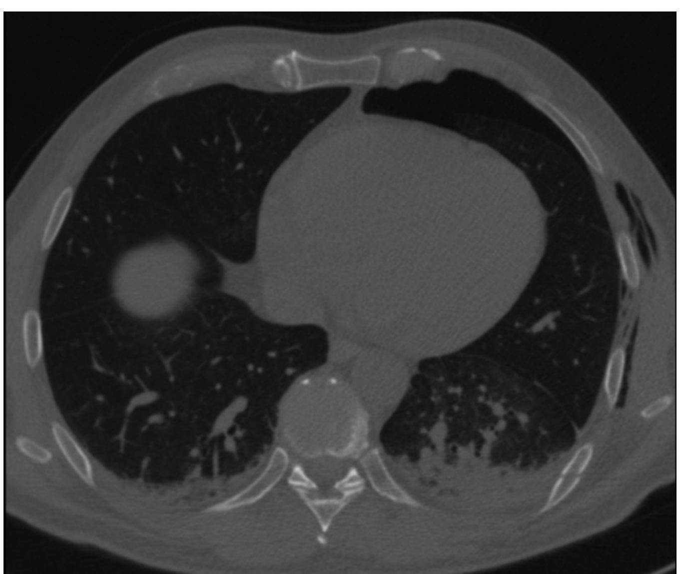

Figure 6. Bilateral lung contusion at the posterior, along with left-sided pneumothorax, rib fracture, and pneumoderma.

Conclusion

In major earthquakes, thoracic injuries mostly result from blunt traumas and include lethal clinical manifestations like pneumothorax, hemothorax, flail chest, or cardiovascular collapse emerged from injuries of the lung, heart, great vessels, musculoskeletal cage, diaphragm, and associated structures. Identifying these injuries in an expeditious manner and early intervention are of great importance in the treatment.

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