Management of Warfare Chest Injuries

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Abstract

About 15% of war injuries involve the chest. Fortunately 85% of patients sustaining chest injuries that reach medical facility will require clinical observation or a simple procedure like tube thoracostomy. Only one in six patients has life-threatening injuries that necessitate urgent operative repair. Early deaths are caused by airway obstruction, major respiratory problems such as tension pneumothorax or massive hemothorax, and cardiac tamponade. These conditions are easily managed if recognized promptly. Diagnosis and management of various components of chest injury requires clear judgment and indepth knowledge of pathophysiological mechanisms involved. The therapeutic goal in the war scenario is to restore normal physiology and thereby to restore cardiac and pulmonary function and evacuate the patient after stabilization.

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Introduction

Chest injury occurs in about 15% cases of war injuries in conventional warfare. Majority have penetrating trauma, blunt chest trauma occurs in war in about 5% of patients. Blast injuries can result in the rupture of the lung as well as penetrating injuries from fragments. Combat injuries to the chest may involve the chest wall, heart, lungs, thoracic spine, thoracic aorta and great vessels, and rarely the esophagus. Injuries involving the central column of the chest (heart, great vessels, and pulmonary hilum) which constitute about 9% of war casualties are generally fatal on the battlefield. Other casualties with wounds of the lung and chest wall usually survive to reach medical setup and can be managed effectively and definitively, by relatively simple maneuvers like observation / chest tube insertion. Approximately one in six patients has life-threatening injuries like cardiac tamponade, a massive hemothorax, or uncontrolled massive air leaks that necessitate thoracotomy. With the advent of body armor and bullet proof jackets, it is hoped that the majority of thoracic injuries can be avoided. Unfortunately, many soldiers may not have such protection, and there will be others who will sustain chest injuries despite protection. With the development of improved modalities of treatment for chest wounds mortality from thoracic injury which was more than 50% before World War I, about 25% during World War I came down to 10% in World War II and was about 5% during the Korean War. It improved further during the Vietnam War to about 2-4% [1].

Clinical features and Evaluation

A complete and accurate diagnosis is usually not possible because of the limited diagnostic tools available in the setting of combat trauma. On evaluation the casualty will often be found to be dyspneic or in frank respiratory distress, the less severely injured will cough up bloody sputum. The key to effective trauma management is to minimize the time to definitive treatment of life-threatening conditions. Primary survey begins with the identification and treatment of conditions that constitute an immediate threat to life. Any life-threatening problem identified must be treated before advancing to the next step. Injuries that are not immediately obvious, but require urgent treatment are tension pneumothorax, massive hemothorax, and cardiac tamponade.

Examination of chest begins with looking for symmetrical movement of chest wall bilaterally and assessment of wounds. One should carefully look for intercostal and supraclavicular retractions suggesting airway obstruction, subcutaneous emphysema, crepitus and abnormal mobility of segments of chest wall and sternum. Examination of the patient's back is crucial. This may requires "logrolling" the patient, after assessing airway security when spinal injury cannot be ruled out. In the setting of multiple trauma auscultation of the chest is always suboptimal. Abnormal findings like absence or asymmetric breath sounds warrant an intervention. However normal breath sounds should never be assumed to confirm the absence of significant intrathoracic injury.

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It should be remembered that penetrating thoracic injuries below the T4 level (nipple line) have a high chance of involving abdominal organs.

Diagnosis

The diagnosis of life-threatening chest injuries is clinical. These conditions may not give enough time for diagnostic evaluation. In stable patients chest radiograph plays a crucial role in the management of chest trauma. The chest radiograph can identify rib fractures, hemothorax, pneumothorax, a widened mediastinum, and pneumomediastinum. An ultrasound (US) performed by the surgeon can help in detecting pericardial tamponade or hemothorax in the combat scenario. In places where it is available (higher levels of chain of evacuation) helical CT scan is becoming the choice of investigation. CT is more specific to detect pulmonary contusions, thoracic spinal injury, cardiac and aortic injury. Other diagnostic modalities like esophagography, esophagoscopy, bronchoscopy, and angiography are more organ specific and are generally not available in combat situations.

Rib Fractures

Simple Rib Fractures are the most common chest wall injuries. The main consequences of rib fractures are pain and prevention of cough. Diagnosis is possible by careful physical examination and antero-posterior chest radiographs. Clinical presentation of costochondral or costosternal separation is same as that of rib fractures, usually detected during physical examination but is not seen on routine chest radiographs. Isolated rib fractures are managed with oral analgesics and chest physiotherapy. Poor pain control contributes significantly to complications like atelectasis and pneumonia. For patients with multiple rib fractures or bilateral fractures epidural analgesia for pain control and pulmonary toilette are necessary to decrease complications. In these patients aggressive pain control with IV analgesics and intercostal nerve blocks with bupivacaine are effective. The presence of greater than three rib fractures on chest radiograph is a marker for associated solid visceral trauma and mortality, and thus has been used as a marker for transfer to higher level [2]. Fractures of the first or second rib require a significant force and in about 20-30% of these patients there is a possibility of major thoracic vascular injury.

Flail Chest

Flail chest is the most serious of the blunt chest wall injuries, occurs in 10-15% of patients sustaining major chest trauma, and is usually associated with other significant injuries [3]. By definition, a flail chest occurs in the presence of two or more fractures in three or more consecutive ribs and causes instability of the chest

wall; however, it can also occur after costochondral separation. In flail chest there is disruption of the stability and normal respiratory mechanics of the rib cage, characterized by paradoxical motion of the chest wall (inward with inspiration and outward with expiration). Fractures can be located in the anterior, lateral, or posterior chest wall. The diagnosis is suspected on the basis of presence of a paradoxical motion and presence of numerous adjacent rib fractures in a chest radiograph. Presence of underlying pulmonary contusion and pain during inspiration are the main components in the development of the respiratory failure. Isolated flail chest carries a low mortality rate and these injuries won't require immediate intubation. Early and aggressive pain management with thoracic epidural anesthesia is ideal in these patients. If respiratory distress develops, endotracheal intubation and mechanical ventilation with peak end-expiratory pressure are usually indicated. Open reduction plus internal fixation of sternal or rib fractures is rarely needed.

Pulmonary Injuries

Lung injury that requires operative intervention is more common after penetrating rather than blunt injury [4]. Penetrating injuries cause lung lacerations and results in hemopneumothoraces. Lung injuries due to blunt trauma are less common and are due to displaced rib fractures. The diagnosis is confirmed by low PaO₂ and presence of well-defined infiltrate in chest radiograph, but radiologic findings may take 24 to 48 hours to develop. Respiratory failure may occur in patients with large contusions, and in those with underlying chronic lung disease. Insertion of a chest tube and evacuation of the pleural space usually control hemorrhage and air leaks from the lung. Other supportive management is directed toward maintaining good oxygenation and adequate pulmonary toilette. Patients who do not respond to above treatment are intubated and mechanically ventilated. Pneumonia is the most frequent complication and significantly contributes to mortality. High velocity gunshot wounds are associated with larger area devitalization of lung parenchyma leading to higher incidence of empyema.

Operative indications for lung injury are mainly for hemorrhage or persistent air leak impairing ventilation. Studies have shown that about 40% of patients with penetrating trauma and 17% of those with blunt trauma to lungs require thoracotomy and procedures like pulmonary tractotomy or stapled nonanatomic resections or some form of lung resection [4,5]. Posterolateral thoracotomy is preferred for isolated lung injuries. Simple bleeding points are controlled with absorbable sutures; staples (TA-90) may be used for large bleeding lung tears. Penetrating tracts in the lung are managed by

performing tractotomy and ligation of bleeding points. The penetrating tracts are never to be managed by simple closure of entrance and exit points as this can lead to air embolism. Severe parenchymal injury with bleeding is managed with non anatomical wedge excisions. For uncontrolled parenchymal / hilar bleeding, complex hilar injuries pneumonectomy is done as a last resort and it carries high mortality. In blast injuries sudden rise in intrathoracic pressure causes alveolar disruption and parenchymal bleeding. When these patients are placed on mechanical ventilation pneumothorax and, air embolism can occur as complications [6].

Tracheobronchial injuries

Injuries to the trachea or main stem bronchi are rare in patients who survive, with an estimated incidence of 0.2-8% [7]. These injuries are suspected when pneumothorax persists even after chest tube placement or there is a continuous air leak. The “*fallen lung sign*” is a radiographic feature that is highly specific for tracheobronchial injury. On chest radiographs, the lung is falling away from rather than toward the hilum, as is the case with a simple pneumothorax [8]. It has been reported that as many as two thirds of tracheobronchial injuries go unrecognized initially and approximately 10% of patients may present weeks or months later with strictures [9]. Diagnosis is made based on clinical findings and chest radiography, CT Scan and rigid or flexible bronchoscopy. Median sternotomy is the best approach. Most tracheobronchial injuries occur within 2 cm of the carina, right thoracotomy approach is ideally suited in all of these injuries. Injuries are primarily repaired using interrupted or running monofilament suture with the knots placed on the outside of the lumen. In cases where tracheal resection is indicated, up to 2 cm of trachea can be excised and primary repair performed. Repairs are usually buttressed with viable vascularized intercostal muscle flap or pericardium or pleura.

Pleural Cavity - Pneumothorax

The most common life-threatening complications from both blunt and penetrating thoracic injury are hemothorax, pneumothorax, or a combination of both. Pneumothorax is one of the most common injuries sustained in chest trauma, occurring in about 20% of patients [10]. It is caused by penetrating or blunt mechanisms leading to injury to the lung and leak of air from the lung injury into the pleural space. The three subtypes of pneumothorax are: simple, open, and tension. A simple pneumothorax is of air in the pleural space. Open pneumothorax (also known as a *sucking chest wound*) occurs when air enters the pleural space from outside through wounds of the chest wall. A tension pneumothorax occurs when air collects in the pleural

space under pressures more than atmospheric pressure. This pressure results in shifting of the heart and great vessels to the opposite side. Tension pneumothorax is characterized by respiratory distress, lung collapse, tracheal deviation, mediastinal shift and hypotension. Immediate recognition and treatment of tension pneumothorax is the most important and lifesaving intervention in the treatment of chest injuries in battle field. A patient with a known chest injury presenting with an open airway and difficulty in breathing has a tension pneumothorax until proven otherwise. The definitive diagnosis of pneumothorax is made by CXR although it can often be suspected from physical examination. Pneumothorax is classified as small when the volume loss is less than a third of the normal lung volume.

The standard treatment for a traumatic pneumothorax is tube thoracostomy to allow re-expansion of the lung. In a case of tension pneumothorax initially chest decompression is done with a large-bore needle inserted in the second intercostal space in the midclavicular line and subsequent tube thoracostomy. Re-expansion of the lung and reapproximation of the pleural surfaces usually seals the lung defect. Open pneumothorax is managed by application of an occlusive dressing and insertion of a chest tube before closure of the chest wall defect to avoid the development of tension pneumothorax.

Hemothorax

Accumulation blood in the pleural cavity is called hemothorax. This can occur after blunt or penetrating injuries to chest. Common sources of blood in thoracic cavity include lung parenchyma, intercostal or internal mammary arteries, heart and great vessels. Hemothoraces can occur following injury to intra-abdominal organs like liver and spleen, in the setting of diaphragmatic laceration. Bleeding may be minor to massive. Massive hemothorax generally occurs following a major pulmonary vascular or major arterial injury, whereas minor lung injuries cause small hemothorax. Physical examination shows decreased breath sounds on the side of the injury. A chest radiograph reveals accumulations of blood more than 200 mL. A massive hemothorax is defined as the presence of one liter or more blood in the pleural cavity. Main goal in the management of hemothoraces is to evacuate the pleural space completely. This decreases bleeding from the lung and in most cases leads to definitive control of bleeding. Approximately 85% of cases of hemothorax can be treated by chest tube placement (36-French tube). If one tube fails to completely evacuate the hemothorax, a second tube may be placed. Indications for thoracotomy in the management of hemothorax are caked hemothorax, drainage of more than 1500 mL of blood

when chest tube is first inserted, continuous hemorrhage of more than 200 mL/h for 3 consecutive hours.

Esophageal Injuries

Esophageal injuries are rare and are difficult to treat. Morbidity and mortality associated with esophageal injury is high because of injury to several other intrathoracic organs along with it. Spillage from the esophagus leads to mediastinitis, causing sepsis, and this results in increased morbidity and mortality as is seen with delayed diagnosis and treatment of esophageal injuries [11]. Most esophageal injuries are secondary to penetrating trauma and may occur at any level. Intrathoracic esophageal injuries following blunt trauma occur just proximal to the esophagogastric junction on the left side because esophagus is less well protected in this area. Pain, fever, subcutaneous emphysema, abdominal tenderness, and mediastinal crunching sounds (*Hamman sign*) are common physical findings. Diagnosis is confirmed by esophagography and esophagoscopy. Treatment is early wound excision (débridement) primary repair, and drainage if these injuries are identified within 24 hours after injury. Injuries diagnosed after 24 hours have mediastinal contamination and are treated by cervical esophagostomy and feeding jejunostomy. Esophageal resection is indicated rarely in patients with esophageal necrosis or severe mediastinitis. The preferred approach for intrathoracic esophageal injuries is posterolateral thoracotomy; right for upper esophagus and left for lower esophagus. Primary repair is done with a single layer of 3-0 absorbable suture and is covered with pleural or intercostal muscle flap. Postoperative drainage with chest tubes - one apical, one posterior is indicated in all the patients.

Diaphragmatic Injuries

Diaphragmatic injuries are often caused by penetrating injuries and are rare following blunt chest trauma - diagnosis is suspected when respiratory distress develops or when an upright chest film demonstrates herniation of viscera into chest. Incidence of diaphragmatic injuries range from 0.8-8% of all abdominal injuries. The fact that one must remember is - *diaphragm is rarely injured alone*. Acute diaphragmatic rupture is generally repaired after exploratory laparotomy, and in fact in most cases the diagnosis of a diaphragmatic injury made intraoperatively. Simple small lacerations less than 2 cm are repaired with interrupted 0 or 1-0 nonabsorbable horizontal mattress sutures. For lacerations larger than 2 cm, repair is done as above and then the repair is reinforced with a running suture for an airtight closure. While repairing

injuries in the central tendon area of diaphragm one should be careful to avoid inadvertent cardiac injury during the repair. Diaphragmatic defects discovered months or years after the initial injury can be treated through a transthoracic, abdominal, or a combined approach.

Conclusion

Combat surgeon is expected to manage war casualties with minimum available resources. Survival of at least 90% of the chest casualties that reach him is expected and is possible with simple measures like tube thoracostomy and careful observation. In the postoperative period, attention to analgesia, prevention of fluid overload, maintenance of adequate pulmonary ventilation and the removal of tracheobronchial secretions lessen the incidence of complications. Due care should be taken in air evacuation of these patients in unpressurised aircrafts.

Conflicts of Interest

None identified

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