Blunt Thoracic Trauma

Analysis of 515 Patients

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A retrospective analysis of 515 cases of blunt chest trauma is presented. The overall thoracic morbidity rate was 36% and mortality rate was 15.5%. Atelectasis was the most common complication. Severe chest trauma can be present in the absence of rib or other thoracic bony fractures. Emergency thoracotomies for resuscitation of the patient with blunt chest trauma with absent vital signs proved unsuccessful in 39 of 39 patients. A high index of suspicion for blunt chest injury occurring in blunt trauma, coupled with an aggressive diagnostic and therapeutic approach, remains the cornerstone of treatment to minimize the morbidity and mortality of such injuries.

TRAUMA IS THE THIRD leading cause of death in the United States and the leading cause of death in persons under the age of 40. Twenty-five per cent of the 100,000 annual civilian traumatic deaths result from chest trauma.[1] Blunt thoracic injuries are more common than penetrating chest trauma, with the most frequent causes being motor vehicle accidents, falls, and crush injuries.[2]

The Shock Trauma Center of the Maryland Institute for Emergency Medical Services Systems (MIEMSS) is a 107-bed trauma referral center for the State of Maryland, serving a large population of patients with multisystem injuries, both acutely injured patients and traumatized patients referred from regional trauma centers. Seventy-five per cent of the admissions arrive by helicopter and 25% arrive by land transportation.

Between January 1982 and December 1984, 5378 patients were admitted to the MIEMSS Shock Trauma Center. We present a retrospective report on the MIEMSS experience with 515 patients who sustained blunt thoracic trauma within this 3-year period, including an analysis of the injury patterns, complications, and mortality for this group.

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Materials and Methods

Five hundred fifteen patients were admitted to the MIEMSS Shock Trauma Center with blunt chest trauma between January 1982 and December 1984. The mean age was 36.9 years, with a range of 14–86 years. There were 374 males and 141 females admitted, constituting a male to female ratio of 2.7 to 1. The causes of these injuries encompassed automobile (70.9%), pedestrian (9.5%), and motorcycle accidents (7.8%); falls (7.6%); and miscellaneous causes (4.2%) (Table 1). Our miscellaneous category included injuries such as waterskiing accidents, assaults, farm accidents, a plane crash, and one person kicked by a horse.

Of the 515 patients, admission vital signs were available for 512 patients. Three hundred thirty-nine patients (66.2%) arrived with stable vital signs (defined as systolic blood pressure greater than 90 mmHg). One hundred forty-three patients (27.5%) had hypotension (defined as systolic blood pressure less than 90 mmHg). Thirty patients (5.7%) arrived with no pulse or blood pressure and with cardiopulmonary resuscitation in progress. The three patients whose admission vital signs were not available all died within 48 hours.

Results

The majority of patients with blunt chest trauma had an array of associated injuries. Although only 84 patients (16.3%) had isolated thoracic injuries, 431 patients (83.7%) had extrathoracic injuries. The magnitude of injury is further highlighted by the fact that nearly half (245) of these patients (47.5%) had two or more systems involved besides the thoracic injuries. The asso-

ciated injuries included head trauma in 222 patients, extremity fractures in 205 patients, intra-abdominal injuries in 147 patients, and miscellaneous injuries in 181 patients. The miscellaneous category included spine injuries, pelvic fractures, facial trauma, and significant soft tissue injury.

Fractures of the Bony Thorax

Blunt thoracic trauma is often heralded by fractures of the bony thorax. These fractures reflect the large amount of energy that has been imparted to the chest wall and thoracic viscera (especially when the scapulae and sternum are involved). Recognition of these injuries is critical in the management of these patients. Rib fractures interfere with ventilation and may lacerate underlying lung parenchyma. Sternal and rib fractures may contribute to paradoxic chest wall motion and impair ventilation in that manner. If a scapula is fractured, high energy transfer has occurred to the thorax, and one must suspect that deeper structures have been injured.

Fractures comprised the largest single group of thoracic injuries in our series. There were 451 fractures of the ribs, scapulae, sternum, and clavicles either alone or in combination in 388 patients. Of these, rib fractures predominated (368), with nearly half of these involving three or more ribs. There was an 8% incidence of bilateral rib fractures. The remaining injuries comprised 14 sternal fractures, 43 clavicular fractures, and 25 scapular fractures. One hundred twenty-seven patients had no radiographic or clinical manifestations of bony thorax fractures despite the presence of other thoracic injuries.

Chest Injuries in the Absence of Fractures of the Bony Thorax

Bony fractures of the thorax (including ribs, clavicle, scapula, and sternum) are the most common injuries in blunt thoracic trauma and often are a hallmark of severe underlying injury. However, we have identified a group of patients with significant thoracic injuries in the absence of bony fractures. From our total group, we identified 127 (24.7%) such patients (Table 2); the majority of these injuries represented hemothoraces or pneumothoraces (62.2%). Nine of 19 ruptured thoracic aortas and 10 of 23 ruptured diaphragms were included in this group. Because the energy of forces is not dissipated by the fracturing of bones, other structures within the chest may become more vulnerable to injury. It is evident from this series that major thoracic blunt trauma cannot be ruled out in the absence of bony injuries.

Pneumothorax–Hemothorax

Pneumothorax is a frequent finding in blunt chest trauma. It is usually due to a rib fracture that is driven inward and damages the pulmonary parenchyma or to chest decelerating injuries, causing an abrupt increase in intra-alveolar pressure. Other causes of pneumothorax include a tear in the tracheobronchial tree or esophagus.[3]

Hemothorax often accompanies pneumothorax, with similar etiologies causing a tear in the blood vessels of the lung parenchyma, injury to intercostal vessels, or injury to the heart and great vessels.

Pneumomediastinum and pneumopericardium in the adult trauma patient are often incidental findings of air that has tracked along the bronchial or vascular sheaths of the thorax into the mediastinum and pericardium. Occasionally, this can be a grave sign of a ruptured bronchus or esophagus, uncontrolled pneumothorax, or ventilator barotrauma. Air within the pericardial space can develop into cardiac tamponade.[4]

In our series, 287 patients had complications of pneumothorax, hemothorax, or a combination of the two injuries. Of the 95 patients with pneumothoraces, 54 had simple pneumothoraces, 15 had bilateral pneumothoraces, eight had a tension pneumothorax, and one had an open pneumothorax. There were 17 patients in whom delayed pneumothoraces developed (defined as a pneumothorax occurring 24 hours after injury). Of the hemothorax group (193 patients), 54 patients had unilateral hemothoraces, 17 had bilateral hemothoraces, and 11 had delayed hemothoraces. One hundred eleven patients had various combinations of hemopneumothoraces.

In three of the six patients in whom pneumomediastinum developed, the condition was associated with car-

TABLE 1. *Mechanism of Injury*

	No. of Patients	%
Automobile	365	70.9
Pedestrian	49	9.5
Motorcycle	40	7.8
Falls	39	7.6
Miscellaneous	22	4.2

TABLE 2. *Chest Injuries in the Absence of Bony Thoracic Injury (N = 127)*

	N
Hemopneumothorax (unilateral, bilateral)	44
Pulmonary contusion (unilateral, bilateral)	35
Cardiac contusions	20
Ruptured diaphragms	10
Ruptured aortas	9
Cardiac rupture	4
Tracheobronchial injury	2
Pulmonary laceration	2
Great vessel injury	1

diac compromise due to tension pneumopericardium. Two patients had pneumomediastinum without pneumopericardium, and one patient had asymptomatic combination pneumomediastinum pneumopericardium.

Ruptured Diaphragm

Traumatic rupture of the diaphragm is a relatively rare finding in patients with blunt trauma. It is most commonly the result of motor vehicle accidents and is secondary to abrupt increases in intra-abdominal pressure. The injury usually occurs through the weakest points of the diaphragm, which are in the posterolateral positions along the embryonic fusion lines. However, diaphragmatic rupture has occurred in all areas of the diaphragm.[5] In previous series, right-sided diaphragmatic ruptures have been reported only rarely.[6] However, as this entity is more aggressively identified, right-sided lesions are being more frequently recognized.[7] Mortality is directly related to associated injuries.

We report on 23 cases of ruptured diaphragms: 16 (69.5%) were left sided and seven (30.5%) were right sided. Motor vehicle accidents were responsible for 78.0% of the injuries. Other causes included motorcycle accidents, pedestrian accidents, and a kick from a horse. In two cases (1 right and 1 left), diagnosis was delayed more than 1 week after injury. Of the patients with ruptured diaphragms, 14 (60.9%) had two or more systems involved, and the mortality rate was 26.9% (6 deaths). All injuries were repaired *via* abdominal incisions.

Aortic Ruptures

Traumatic thoracic aortic tears are one of the most catastrophic injuries seen in blunt chest trauma. The severity of such an event is appreciated when survival statistics are examined. A large, widely quoted study by Parmley has shown that only 20% of patients with aortic rupture survive for more than 1 hour after injury; 80% of patients die at the scene.[8] In initial survivors, if the injury is not surgically addressed, 40% die within 24 hours and 90% are dead by 10 weeks.

Nineteen patients presented to the MIEMSS Shock Trauma Center with a traumatic ruptured thoracic aorta; there were seven long-term survivors. As with the rest of the MIEMSS population, motor vehicle accidents were the predominant cause of injury and multiple injuries were present. Forty-four per cent of the patients had two or more extrathoracic systems involved. The mean age of this group was 42 years, with a range of 16–82 years.

Twelve patients with ruptured aortas died. Three of these patients presented in cardiac arrest. Two patients were in profound shock and had emergent thoracotomies, which disclosed free rupture of the aorta. Of these five deaths, aortic reconstruction was not attempted because of cardiac arrest. There were three late deaths not related to the aortic injury or perioperative course. One death was due to a presumed pulmonary embolus, and one was due to acute respiratory distress syndrome (ARDS) and sepsis. One patient died of an aortic esophageal fistula.[9] Four patients died of factors directly related to their aortic injury and repair. One of the seven survivors had a postoperative paraplegia develop. The total survival rate was 37% and the mortality rate directly related to aortic repair was 21%.

Tracheobronchial Injuries

Rupture of the thoracic tracheobronchial tree is a rare but serious injury in blunt trauma.[10] Kirsh and Sloan[6] have proposed three theories as to the cause of the injury. The first theory states that forceful compression to the thorax pulls each lung apart, with the resulting traction on the trachea and carina producing a tear. A second theory states that high intrabronchial pressure secondary to a closed glottis makes the tracheobronchial tree vulnerable to injury with sudden impact to the chest. A third theory is based on shearing forces on the tracheobronchial tree between the relative stationary areas of the cricoid cartilage and carina with decelerating forces.

Because many persons with disruption of the tracheobronchial tree do not survive, a true incidence of this injury is difficult to determine. In our series, we limited our reporting to the tracheobronchial injuries confined to the thorax and had four such patients. Of these patients, three had tracheal injuries within 2 cm of the carina and one had a mainstem bronchial tear. Three tears were primarily repaired, and one injury consisting of a small carinal tear was treated with expectant observation. Three of the four patients had injury of two or more extrathoracic systems. Two deaths occurred during initial resuscitation (within 6 hours of injury) and were due to multiple injuries. One survivor subsequently had bilateral pleural empyemas develop and the other patient had tension pneumopericardium develop that was treated by open pericardial drainage.

Flail Chest: Pulmonary Contusion

Crushing chest wall injuries resulting in flail chest most commonly occur from motor vehicle accidents; however, they are also associated with compression injuries, falls, and direct blows. The injury causes multiple fractured ribs, creating a segment of chest wall that has lost its continuity with the remainder of the thorax. This produces the paradoxic respirations that are frequently present with flail chest. Flail chest constitutes a serious

chest wall injury, and its high morbidity and mortality are mainly due to underlying pulmonary injury and associated injuries.

Pulmonary contusion, defined as injury to lung parenchyma resulting in edema and interstitial hemorrhage, usually is the result of acceleration–deceleration forces. Although often subtle and overlooked when more dramatic injuries are present, its potential to be progressive and develop into respiratory insufficiency underlines its serious nature.[11]

In our series, there were 63 (10.3%) flail chests. The majority of these injuries occurred in patients with multiple injuries. In patients with flail chests, 53.9% had two or more extrathoracic systems injured; only 14.3% of patients had injuries confined to the chest. We report a mortality rate of 28.6%. There were 39 major pulmonary complications within the group, the most common being prolonged intubation (greater than 1 week), pneumonia, and ARDS. Of these 63 patients, 31 (49%) sustained pulmonary contusions and bilateral pulmonary contusion developed in three patients. In the general group, there were 113 unilateral pulmonary contusions and 21 bilateral contusions or 30%.

Cardiac Contusions

Cardiac contusion from blunt chest trauma occurs frequently, ranging from 16% in autopsy studies[12] to 76% in clinical studies.[13] The clinical presentations of such injuries are extremely variable and are frequently unnoticed in the multitraumatized patient. The spectrum of symptoms and signs ranges from the asymptomatic patient to the patient with severe cardiac compromise. Arrhythmias and conduction defects are the most common complications of cardiac contusions.

The heterogeneity of cardiac contusions is related to the evolving method of diagnosis. The most sensitive method for diagnosis is probably an understanding of the mechanism of injury, awareness of possible associated injuries, and a high index of suspicion. Other methods include admitting and serial electrocardiograms (ECGs), assessment of cardiac isoenzymes, two-dimensional echocardiogram, multiple gated acquisition (MUGA) scan, and evaluation of Swan–Ganz thermodilation cardiac output.[14,15] The more compulsively the diagnosis is pursued, the more frequent is the reported incidence.

The usual clinical course is therefore one of resolution. However, in the acute injury phase, morbidity could be high. A small number of patients with high morbidity will develop a course of chronic arrhythmias or overt cardiac compromise. The incidence of morbidity is probably multifactorial, relating to size and location of contusion, premorbid cardiac status, and associated injuries.

In our series, we identified 33 patients with cardiac contusions. The diagnosis was made using ECG in two, MUGA scan in 11, echocardiogram in four, cardiac isoenzymes in two, thermodilution cardiac output in two, and gross inspection of the heart during thoracotomy in four. Eight patients carried the diagnosis of cardiac contusion without a specific diagnostic test listed. There were four deaths in this group: three patients died during the acute resuscitative phase, presenting with shock, and one (late) died of sepsis. In two patients, significant arrhythmia developed that was controlled medically (one with premature ventricular contractions [PVCs] controlled with lidocaine and one with bradycardia controlled with atropine and a temporary pacer). A persistent right bundle branch block developed in one patient. Although no late follow-up information was available, no patient had persistent symptoms of cardiac compromise on discharge.

Cardiac/Pericardial Injuries

Cardiac lacerations from blunt trauma are usually lethal injuries that are frequently diagnosed postmortem. There are scattered case reports in the literature of survival from this injury; however, the insult to the heart and concomitant associated injuries frequently result in death.[16] Pericardial injuries have also been reported as a cause of morbidity and mortality.[17]

In our series, there were 14 cases of cardiac lacerations and no survivors. Eight of the 14 patients arrived with no vital signs, five patients had severe hypotension (initial blood pressure <60 mmHg), and one patient had stable vital signs initially that rapidly changed to significant hemodynamic instability. Emergency thoracotomies were performed in the admitting area on all patients. The injury pattern to the heart involved all chambers, with four injuries involving the right ventricle, three injuries to the right atrium, two injuries to the left atrium, and one injury to the left ventricle. Four patients had injuries involving a combination of two injured chambers. Seven patients had two or more associated injuries. All patients had tamponade before thoracotomy, and a repair or attempt at primary repair using horizontal pledgetted sutures was done in all cases.

An additional four patients sustained pericardial tears that did not violate the cardiac chambers. Two of the four patients arrived with no vital signs; emergency thoracotomies were unsuccessful. One patient arrived in shock and quickly became asystolic; again, emergency thoracotomy was unsuccessful. The fourth patient arrived with stable vital signs and was taken to the operating room for repair of associated intra-abdominal injuries. A thoracotomy was performed because of ongoing hemothorax. Parenchymal injury to the lung was present, associated with a tear in the pericardium, which

TABLE 3. *Morbidity in 515 Cases of Blunt Trauma*

	N
Atelectasis	38
Pneumonia	35
ARDS	33
Empyema	20
Recurrent pneumothorax or persistent leak	24
Aspiration	9
Miscellaneous*	30

* Lung cyst, lung abscess, arrhythmias, pericarditis, pericardotomy syndrome, sternal dehiscence, pericardial herniation, chylothorax, thoracotomy wound infection, myocardial infarction, paraplegia, aortoesophageal fistula, barotrauma, bleeding.

ARDS = acute respiratory distress syndrome.

was repaired. There was no cardiac injury, and the patient had an unremarkable course.

Great Vessel Injuries

Like injuries to the aorta, an insult to the branches of the aortic arch, thoracic vena cava, or pulmonary hilar vessels connotes a life-threatening injury. A majority of patients with these injuries have severe concomitant injuries and die at the scene or are dead on arrival. A diagnosis of great vessel injury is made by having a high index of suspicion from the mechanism of injury, associated injuries, and physical examination and detection of an abnormal mediastinum by chest x-ray. A suspicion of such an injury mandates an aortic arch arteriogram.

Nine patients presented to the MIEMSS Shock Trauma Center with great vessel injuries other than aortic tears. These included three patients with innominate artery injuries, two patients with subclavian artery avulsions, two patients with axillary artery injury, one patient with injury of the azygous vein, and one patient with an avulsed pulmonary artery and pulmonary vein. There were two deaths and three major complications. One death occurred 48 hours after injury and was secondary to significant preoperative hypotension and low flow state. The second death was late (>4 weeks) and due to sepsis. The complications included empyema, brachial plexus injury, and sternal dehiscence.

Discussion

Blunt thoracic trauma is responsible for one fourth of all traumatic deaths in the United States. In our analysis, we have identified several areas of interest.

The absence of rib fractures or other bony thoracic injuries does not preclude other serious chest injuries. Indeed, 47.4% of the ruptured aortas, 43.5% of the ruptured diaphragms, 50% of the tracheobronchial injuries, and 60.6% of the cardiac contusions presented in the absence of thoracic fractures. Whether this occurs because the energy of acceleration/deceleration forces is not dissipated through the fractures or because a specific type of kinetic force predisposes the patient to soft tissue injury instead of bony injury is unclear. Of importance is that a serious thoracic injury may be present without associated rib or other overt thoracic fractures. To identify these patients, an index of suspicion for blunt thoracic trauma must be maintained based on history, mechanism of injury, and physical examination, despite the absence of fractures.

Within our group of patients with ruptured diaphragms, we identified a high incidence of right-sided diaphragmatic injuries. Although the majority of ruptured diaphragms continued to predominate on the left side, 30% were right sided, a figure much higher than the 5–10% that is often cited. The right-sided lesions are often more subtle in presentation radiographically and can represent a missed injury if an index of suspicion is not raised.[7]

Emergency room thoracotomies continue to be controversial in blunt trauma. All patients in this study who had absent vital signs in the emergency room died despite aggressive resuscitative measures, which included emergency left thoracotomy (39 patients). Emergency thoracotomy might be effective in the treatment of a ruptured cardiac chamber or severe pulmonary parenchymal laceration. However, all patients with these injuries died despite emergency thoracotomy.

The dismal results of our emergency thoracotomies reflect the findings in other studies, which indicate that patients with absent vital signs at the scene, or for greater than 30 minutes after injury, cannot be resuscitated.[18] Nevertheless, because the decision to perform an emergency thoracotomy requires an immediate decision, often with incomplete and inaccurate data concerning the patient, we hesitate from making sweeping recommendations concerning emergency thoracotomies.

Our general philosophy remains that if there is any doubt about a patient's immediate or subsequent clinical status, it is better to err on the side of resuscitation rather than declaring the patient dead on arrival. However, if the patient has no vital signs at the scene or has been without vital signs for 30 minutes, this represents a nonsalvageable patient.

Morbidity

We identified 185 patients (36%) with a morbidity secondary to their chest trauma (Table 3). Atelectasis, confirmed radiographically and significant enough to cause fever and require bronchoscopy or vigorous physical therapy, was the most common complication. Pneumonia, ARDS, and recurrent pneumothoraces were other common complications. An unusual complication of a ruptured thoracic aorta was an aortoesophageal

TABLE 4. *Mortality in 515 Cases of Blunt Chest Trauma*

	No. of Patients	%
Early deaths	64	80
Late deaths	16	20
Total	80	15.5

TABLE 5. *Causes of Late Death Occurring >72 Hours After Injury*

	N
ARDS	8
ARDS/sepsis	3
ARDS/MSOF	2
Fatty embolus	1
Aortoesophageal fistula	1
Other	2

ARDS = acute respiratory distress syndrome.
MSOF = multiple system organ failure.

fistula that presented several months after successful repair and subsequently proved fatal.[9] In general, we believe that early mobilization, aggressive analgesia, vigorous physical and respiratory therapy, and bronchoscopy, if other measures fail, are essential in reducing the majority of pulmonary complications from chest trauma.

Mortality

The mortality rate in this study was 15.5%, representing 80 patients (Table 4). Fifty-nine of these patients arrived with absent vital signs or had cardiac arrest within 1 hour of their arrival. Eight patients died of a primary insult to their central nervous system. There were 16 late thoracic deaths (defined as deaths after 72 hours of hospitalization and primarily related to their thoracic trauma). The causes of death included ARDS, sepsis, heart failure, and multiple organ failure (Table 5).

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