INJURY TO THE CHEST, COMPLICATIONS AND MANAGEMENT: EXPERIENCE AT A LEVEL I TRAUMA CENTER

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SUMMARY

The experience over a four year period with 2072 patients is presented. Blunt injury mechanism was the predominant pattern: 1720 (83%) vs. 336 with penetrating trauma. The mortality for both groups was comparable: 19% for the blunt chest injury group and 18% for the penetrating chest injury group. However the causes of death were very different: In the blunt chest trauma group, head injury was the most frequent cause listed, followed by exangunation and cardiac injury. In contrast, the overwhelming cause of death in penetrating chest injury was due to exanguination, identified in more than a half of those succumbing to their injury. Among the survivors, pulmonary compli-cations occurred with the highest frequency. However there were only 9 empyemas documented among these 1661 patients for an overall incidence of 0.5%. The chest Abbreviated Injury Scale (AIS) and mortality for both penetrating and blunt trauma was also recorded.

Key words. Chest trauma, Complications. Empyema, Tube thoracostomy.

INTRODUCTION

Injury to the chest, whether by blunt or penetrating mechanism, creates a set of circumstances which must be addressed in an organized fashion in order to restore optimal function promptly and to prevent complication from occurring subsequently. The goals of treatment are to address injury and any loss of function sustained, restore function and to do so in such a manner that further adverse sequelae are minimized.

The patient who sustains a chest injury is treated in a standardized manner after arrival at the trauma center. Initially, al patients are assessed for the adequacy of the airway. Without an adequate airmay, further treatment is hampered. Therefore, this is accomplished by whatever means in necessary. Our preferred method for patients who require a definitive airway is orotracheal intubation using a rapid sequence induction method. With an adequate airway in place, attention turns to the chest injury itself. Assessment of the chest entails a visual isnpection of all aspects, including the back and both flanks. The nature of the chest wall excursion in noted. External signs of injury are documented and open wounds are characterized and treated as necessary. Although rare in our experience, the open, sucking chest wound should be controlled with Vaseline gauze or suture. Breath sounds are evaluated to determine if any abnormality is present. Parenchymal lung injury may be difficult to detect by auscultation and a high index of suspicion in necessary, especially in patients who are being ventilated through an orotracheal tube with positive pressure. In the patient with diminished, abnormal or absent breath sounds, chest percussion may indicate the nature of the intrathoracic condition: pneumothorax, hemothorax or a combined hemopneumothorax. It is important to remember that a traumatic rupture of the diaphragm can cause similar abnormalities of respiration and clinical findings on examination of the chest. Heart sounds and cardiac rate are assessed. Neck veins status is evaluated. This is particularly important when the patient is in shock, for tamponade and tension pneumothorax can mimic the hypovolemia from exsanguination. For all patients, intravenous access and

volume restoration is begun. A Foley catheter is placed to monitor the results of resuscitation. A chest radiograph is obtained initially to assit in the exact determination of the chest injury. An arterial blood gas determination is obtained as part of the routine trauma laboratory panel. Results are usually rapidly available in the trauma room to help direct care. Electrocardiography is performed routinely.

Immediate treatment for some chest injury should be instituted on clinical grounds because any delay in usually fatal. Shock associated with tension pneumothorax or cardiac tamponade is usually addressed by performing needle chest decompression for tension and pericardiocentesis for tamponade. Of the two, pericardiocentesis is the more difficult to perform technically and is often associated with mixed results, leading some surgeons to discourage its use in the emergency setting. An alternative procedure is a subxiphoid pericardial window. The bedside focused ultrasound is a useful alternative for the diagnosis of tamponade. When cardiac arrest occurs in patients with chest injury, a resuscitative thoracotomy should usually be performed. It is well established that external chest compression is of little use in these circumstances and that exposure of the injury for correction and control requires direct access. Our preference is for a clamshell type thoracotomy incision starting in the left chest, extending across the sternum and entering the right chest. Cardiac exposure is superior with this approach and resuscitative maneuvers can be performed expeditiously.

Some injury, small, stable pneumothoraces for example, can be treated by observation but the patient should be monitored closely for evidence of clinical deterioration. Other conditions require prophylactic treatment with tube thoracostomy to prevent clinical deterioration at an inopportune time: penetrating injury with an urgent need for laparotomy is one such indication. Other injury, with thoracoabdominal trajectory, will require tube thoracostomy and laparotomy for correction. The vast majority of chest injury can be treated with tube thoracostomy. This technique has envolved over the past thirty years to become the mainstay for the treatment of conditions causing pneumothorax, hemothorax or both.

Tube thoracostomy is the preferred method for obtaining rapid re-expansion of injured lung, complete evacuation of the pleural space and monitoring the injured chest for the nature and extent of continued bleeding when present following insertion. Our experience attests to its importance in this regard[1]. Tube thoracostomy is a surgical procedure performed by a variety of physicians with differing skill levels, often under less than optimal surgical conditions. The goal of drainage of the chest with tube thoracostomy is coaptation of two pleural surfaces: that of the chest wall and that of the lung parenchyma. Only a correctly placed, properly positioned thoracostomy tube achieves this goal. Meticulous attention to the technique of chest tube insertion is the singlemost important factor in accomplishing this goal. Additionally, many of the various complications which can occur in the patient with chest injury are actually also diminished as a consequence of optimal technique. Proper position of the chest tube is always documented with a radiograph of the chest. In general, our rule is that tubes “pointing at the apex” are properly positiones, while tube “pointing at the mediastinum” are not properly positioned. At our institution, we are very aggressive at correcting tube position errors when recognized since we feel that this decreases the incidence of tubre related complications such as post-traumatic empyema.

Complications following chest injury can occur early or late[2]. Most complications relate to the circumstances of wounding, the treatment choices made and the procedures performed. Technical problems with tube thoracostomy placement, position and function, delay in placement of the chest tube, the presence of a large hemothorax, incomplete re-explansion of injured lung, incomplete obliteration of the space between the pleural surfaces, delayed recognition of a diaphragmatic injury, pulmonary parenchymal contusion, extrathoracic hematoma, unstable chest wall injury with multiple rib fractures, all predispose a patient to complications with the chest injury[1,2]. Associated injury may well increase risks of complications with chest injury as well. Patterns of thoracoabdominal wounding with contamination from the gastrointestinal tract will increase infection risks. Head, spine and pelvic fractures associated with chest injury will result in less than optimal mobilization of the patient and predispone to a host of pulmonary problems[3].

Our work on empyema prevention and antibiotic prophylaxis for tube thoracostomy demonstrated value in antibiotic use for a small subset of those with chest injury: isolated chest injury[1,4] (AIS 3, the Abbreviated Injury Scale[5]), however, the research also revealed that the singlemost important risk factor within the control of the trauma team was the procedure of tube thoracostomy. We have become compulsive in our technique, fanatic about the proper placement of the chest tube, aggressive regarding repositioning of improperly placed tubes and meticulous regarding complete clearance of the pleural space and complete reexpansion of the lung. In concert with this vigorous management approach, we have also become increasingly aggressive about pursuing problems associated with incomplete drainage of the chest. Chest computerized tomographic imaging has been the mainstay of our approach in this regard. In contrast to the portable AP chest radiograph, often obtained as part of the workup of such patients, and which if often only suggestive of intrapleural pathology, the CT image details precisely the nature and location of the pathologic process. This affords us the opportunity to determine the best additional treatment required. In keeping with our philosophy of complete evacuation, this often entails percutaneous drainage at the same time as the CT imaging study. Antibiotic therapy is adjunctive in these settings since it is axiomatic that the treatment of a localized site of infection is incision and drainage. Many of the cases of chest injury will, additionally, require antibiotic therapy for other conditions associated with infection, and therefore, not meet the criteria established for antibiotic prophylaxis for tube thoracostomy. Finally, risk of empyema occurrence in the setting of patient care must be considered in arriving at the decision to use antibiotic prophylaxis. Our work shows that risks for empyema > 5% would support antibiotic prophylaxis as a means of decreasing this complication[6].

CLINICAL EXPERIENCE

Over a four year period (1993-1996) we have managed 2,072 patient with chest injury at our institution. The overall mortality for this group was 19%; 1,433 were men and 693 were women. Blunt injury mechanism was the predominant pattern: 1,720 (83%) vs. 336 with penetrating trauma. The mortality for both groups was comparable: 19% for the blunt chest injury group and 18% for the penetrating chest injury group. The principle causes of death were very different in both groups however. In the blunt chest trauma group, multiple causes of death were recorded. Death from head injury was the most frequent cause listed, followed by exsanguination and cardiac injury. Late deaths were due to multiple organ failure or adult respiratory distress syndrome (MOF/ARDS), pulmonary embolus and hypoxia or pneumonia. Only one death from empyema was recorded in this group. In contrast, the overwhelming cause of death in penetrating chest injury was due to exanguination, identified in more than half of those succumbing to their injury.

Table 1 displays the intrathoracic diagnoses recorded in these patients. As would be expected with the preponderance of blunt chest injury, lung contusions were the most frequent finding.

Table 1
Intrathoracic Injury

Injury	Nº patients
Lung contusion	470
Pneumothorax	439
Hemopneumo	155
Hemothorax	93
Cardiac injury	91
Total	1,248

Table 2 lists the associated injuries identified in these patients. The pattern of multisystem injury observed in patients with blunt chest trauma is evident from this data. In the abdomen, the most frequent organ injured was the liver, followed by the spleen. Injury to the diaphragm was relatively infrequently recorded.

Table 2
Major Injuries

Major injury	Nº patients
Extremity	1,138
Head/neck/spine	803
Torso (Abd/vasc)	631
Total	2,572

Laparotomy was the most frequent procedure performed and procedures on the spleen: splenectomy and splenorrhaphy, the most frequent procedures performed at the tima of laparotomy. In contrast, thoracotomy was infrequently performed in both blunt and penetrating chest trauma. Cardiac procedures, also infrequently performed, were similar in frequency in both groups. Tube thoracostomy was commonly used in both groups and with a similar degree of frequency.

Among survivors, the complications identified are described in Table 3. Pulmonary complications occurred with the highest frequency. Interestingly, there were only nine empyemas documented among these patients for an overall incidence of 9 cases in 1,661 survivors (0.5%).

Table 3
Complications/Survivors

Pulmonary	680 (9 empyema)
Cardiac	90
GI tract	72
Infections	67
Hepatobiliary	55
Total	964

Table 4 describes the injury frequency, severity and mortality for blunt and penetrating chest trauma using AIS: the Abbreviated Injury Scale[5]. For this display, all chest injuries were tabulated. Some patients had more than one chest injury scored by this system. This was the case more frequently in the blunt chest trauma population than in those with penetrating injury. The numerical score for the chest injury increases with increasing injury severity. The ISS or injury severity score[7,8] is the sum of the squares of the three most severe scores in three major areas. Rising chest AIS scores, while not totally predictive, presume increasing ISS, with increasing risk of death. By convention, an AIS=6, equates to an ISS of 75 which predicts mortality risk of virtually 100%. Not everyone with an ISS of 75 will die. This is seen from the data in this series. Patient salvage with an ISS 75 is often associated with spectacular care on the part of the trauma team and should be analyzed for its impact on the entire trauma care continuum.

Table 4
Chest Injury-AIS Distribution

Chest AIS	Trauma type	Total	%	% mortality	Death
1	B	113	70.2	18.5	21

	P	48	29.8	12.5	6
	Total	161	5.6*	16.7	27
2	B	312	89.1	21.4	67
	P	38	10.9	26.3	10
	Total	350	12.1*	22.0	77
3	B	1,387	84.0	24.0	334
	P	264	16.0	20.4	54
	Total	1,651	57.1*	23.5	388
4	B	482	92.9	39.6	191
	P	37	7.1	59.4	22
	Total	519	18.0*	41.0	213
5	B	121	76.1	58.7	71
	P	38	23.9	55.3	21
	Total	159	5.5*	57.8	92
6	B	16	53.3	87.5	14
	P	14	46.7	92.8	13
	Total	30	1.0*	90.0	27
	Total	2,870			

COMMENT

This review of the experience with chest injury from a large North American Level I trauma center demonstrates the results of a coordinated process of care for patients with chest injury, both blunt and penetrating, based on sound surgical management principles enumerated above. While there have been a number of different physicians who provided care for these pateints during the period of the review, the process of care has been remarkably consistent. The primary causes of death from head injury in the blunt trauma population and exsanguination in the penetrating injury population, as well as the mortality rates observed for both groups, speaks to the significant injury patterns sustained by the entire population. In the face of such significant injury, it would seem that the treatment of the chest injury and the technique of tube thoracostomy would be relegated a secondary role. The infrequent need for thoracotomy and the small number of empyemas encountered in the course of treatment is evidence that this is not the case. Patients with significant injury are at risk for significant complications. Our high incidence, particularly of pulmonary complications, is testimony to that fact. Physicians who care for the injured must have more than a little knowledge or passing interest in the care of chest injury. This knowledge will assure optimal treatment of the chest injury and help to minimize complications during the course of treatment.

RESUMEN

Se presenta la experiencia con 2,072 pacientes atendidos durante un período de cuatro años. El trauma cerrado fue el mecanismo predominante: 1,720 (83%) vs. 336 con trauma penetrante. La mortalidad para ambos grupos fue comparable: 19% para el trauma cerrado y 18% para el penetrante. Sin embargo, las causas de muerte fueron muy diferentes: en el grupo con trauma cerrado de tórax, el trauma craneoencefálico fue la causa más frecuente, seguida por la exanguinación y la lesión cardíaca. En contraste, en trauma penetrante la exanguinación fue abrumadora, encontrándose en más de la mitad de estos pacientes fallecidos por este mecanismo. Entre los sobrevivientes, ocurrieron con mayor frecuencia las complicaciones pulmonares . Sin embargo, entre estos 1,661 pacientes sólo hubo 9 empiemas documentados, para una incidencia de 0.5%. También se registró la escala abreviada de injuria (AIS) y la mortalidad para el trauma penetrante y para el trauma cerrado.

REFERENCES

1. Brunner RG, Vinsant GO, Alexander RH, Laneve L, Fallon WF. The role of antibiotic therapy in the prevention of empyema in patients with an isolated chest injury (ISS 9-10): a prospective study. *J Trauma* 1990; *30:* 1148-54.
2. Fallon WF. Analysis of the risk for empyema occurrence following tube thoracostomy for injury to the cest. Top Emerg Med 1990; 47-52.
3. FALLON WF. Post-traumatic empyema. *J Am Col Surg* 1994; *179*: 483-92.
4. Fallon WF, Wears RL. Prophylactic antibiotics for the prevention of infectious complications including empyema following tube thoracostomy for trauma: results of meta-analysis. *J Trauma* 1992; *33*: 110-17.
5. Association for the Advancement of Automotive Medicine. *The Abbreviated Injury, 1990 revision.* Arlington Heights, AAAM, 1990.
6. Wear RL, Fallon WF. At what risk of empyema is empiric antibiotic therapy justified in tube thoracostomy for trauma? *Theor Surg* 1994; *9*: 154-59.
7. Baker SP, O'Neill B, Haddon W, *et al.* The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974; *14*: 187-96.
8. Baker SP, O'Neill B. The Injury Severity Score: an update. *J Trauma* 1976; *16*: 882-85.