Chest Injuries in Polytrauma

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Abstract

Background and Purpose: Blunt chest injuries are commonly seen in polytrauma patients and are known to be associated with higher mortality and morbidity. The objectives of the present study are to assess the effect of blunt chest injury concerning morbidity, mortality as well as clinical courses and outcome of multiply injured patients with chest trauma.

Patients and Methods: This study includes all polytrauma patients with chest injury treated between 1992 and 2002 at a major urban trauma center. Parameters examined included injury pattern, injury severity, mortality, hemodynamics at admission, duration of ventilation, length of stay in intensive care unit (ICU), and outcome.

Results: 332 out of 501 polytrauma patients, 228 males and 104 females, had a coexisting chest injury. Mean age at the time of injury was 37.7 years, and 258 patients were intubated before admission. Average period on ICU was 15.4 days, and 35.9 days for total hospital stay. Regarding the injury pattern in 143 patients a combined hemo-/pneumothorax was seen, 109 patients had either a hemothorax or a pneumothorax, in 155 patients a unilateral and in 52 patients a bilateral serial rib fracture was diagnosed, in 28 patients either sternal or singular rib fractures were determined, in a total of 23 patients an unstable thorax or a flail chest was seen, 105 patients had a unilateral pulmonary contusion, and in 79 patients a bilateral pulmonary contusion was diagnosed. Finally, a total of eleven patients with a traumatic aortic disruption were identified.

Conclusion: The present study shows that chest injuries in polytrauma patients are common coexisting injuries and contribute significantly to the morbidity and outcome of these patients. Early intubation and ventilation in combination with an adequate circulatory stabilization are crucial to avoid complications and deleterious outcome.

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Key Words

Chest injuries · Polytrauma · AIS · Injury pattern · Mortality

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Introduction and Epidemiology

In Austria trauma is known to be the leading cause of death in the population aged between 26–35 years. In 2004, for 23 patients in this age group polytrauma was lethal [1]. During the period of 2000 to 2004, 120 patients between 26–35 years of age died in Austria of the consequences of polytrauma, and in nearly 50% of the cases injuries of the thorax were associated [1]. In the European Union (15 countries) 1,216 multiply injured patients died in 2002 [1]. Blunt chest injuries are common injuries in the polytraumatized patient, especially the entities of unstable thorax and pulmonary contusion [2]. Furthermore, these injuries have a higher mortality in the multiply injured patients than isolated penetrating injuries of the same region [3]. The lower mortality rates of penetrating injuries may be due to the fact that they tend to be less massive and less likely to include multiorgan injury. The leading cause of blunt chest injuries is motor vehicle accidents [3–5]. Seat belt protection is considered to provide a significant reduction in the incidence of thoracic injuries. Aggressive management of the pulmonary system along with prompt treatment of associated injuries is essential for optimal patient outcome. The aim of this study was to report our experience in the management of chest injuries in the polytrauma population.

Patients and Methods

Since September 1992, all medical data of polytrauma patients seen at the Department of Trauma Surgery,

Medical University of Vienna, Austria, have been entered into a computerized trauma database. The present study includes patients up to September 2002 as seen in Figure 1. We collected data on all polytrauma patients admitted to the hospital for at least 1 day, as well as all patients declared dead in the emergency department. Defined under the term of "polytrauma" the criteria for inclusion are injuries of two or more body cavities, or injury of one body cavity and two long-bone fractures [6]. All patients have been treated following the general principles of the polytrauma algorithm presented by Schweiberer et al. [7]. The initial management of the trauma patients has been carried out in the trauma emergency room. According to common ATLS® (Advanced Trauma Life Support) principles the airway and ventilation were assessed and established first. All patients had an initial chest X-ray, followed by a routine X-ray trauma series, including C-spine, pelvis and head. A computed tomography (CT) scanning of the head, chest and abdomen was indicated according to the suspected injury pattern. This diagnostic algorithm has been changed substantially in 2002 since a new multislice tomograph was installed at our emergency room. Nowadays, we just perform an initial chest X-ray, and after stabilization the patient undergoes a whole-body CT.

The major diagnoses of all chest injuries were classified into six diagnostic groups: traumatic aortic disruption (TAD), sternal and rib fracture (SARF), flail chest (FC), pulmonary contusion (PC) and pneumo- and hemothorax (PT/HT), either singular or in combination. Diagnosis of flail chest includes the unstable thorax (UT). Sternal and rib fracture was subdivided in those patients who had either a singular rib fracture or sternal fracture, and those with multiple rib fractures on one side or on both sides of the thorax. Pulmonary contusion was also subdivided, either in unilateral or bilateral.

Injury severity was classified according to the Abbreviated Injury Scale (AIS) and the Injury Severity Score (ISS) [8]. Systemic hemodynamics at admission were scored as unstable, defined as systolic blood pressure < 90 mmHg, or were found stable, systolic blood pressure ≥ 90 mmHg. In addition to demographic data, the preclinical intubation rate, hemodynamics at admission, duration of ventilation and ICU (intensive care unit) stay, complications, and outcome were analyzed. Multiorgan failure syndrome (MOF) was defined as ≥ 2 points for two or more organ systems (pulmonary, cardiovascular, hepatic, renal, central nervous, hematologic and renal systems) over a period of ≥ 3 days, according to Goris et al. [9]. Adult respiratory distress syndrome (ARDS) was defined as a PaO_2/FiO_2 ratio of < 200 for at least 5 consecutive days and bilateral diffuse infiltrates seen on the chest X-ray in the absence of pneumonia and cardiogenic pulmonary edema [10].

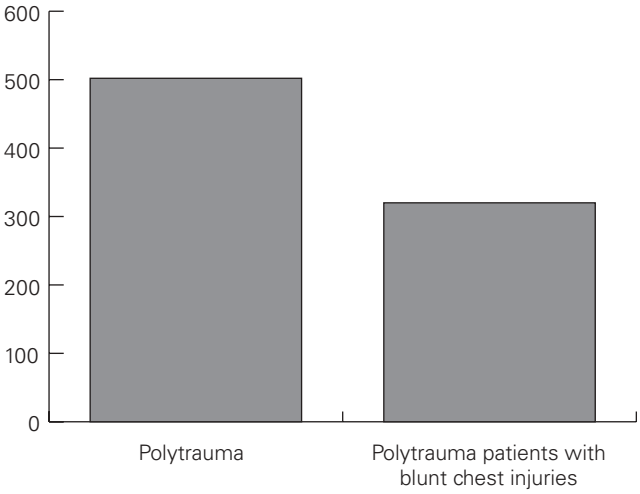

Figure 1. Number of polytrauma patients.
The number of all polytrauma patients (n = 501) in comparison to the number of polytrauma patients with chest injuries (n = 332).

Results

Out of 501 consecutive polytrauma patients (ISS 34.3), there were a total of 332 cases (66.3%) with blunt chest injuries, 228 males (68.7%) and 104 females (31.3%), with a mean ISS of 38.4. The mean age at the time of injury was 37.7 years. 258 patients (78%) had been intubated and ventilated before admission. Compared to that, 169 polytrauma patients (33.7%) without a chest injury were seen in the observation period. Their mean age at the time of injury was 37.1 years and their mean ISS 26.2. In this group without chest injury 107 patients (63%) had been intubated and ventilated before admission.

Altogether, 705 diagnoses of thoracic injury were found. A combined hemothorax and pneumothorax was seen 143 times (20.3%). In 109 patients (15.5%) we found either a hemothorax or a pneumothorax. Unilateral serial rib fractures were diagnosed in 155 cases (21.9%), and in 52 (7.4%) these were bilateral. 28 times (3.9%) we determined either sternal or singular rib fractures. In a total of 23 patients (3.3%) an unstable thorax was recognized, in 105 (14.9%) a pulmonary contusion and in 79 (11.2%) a bilateral pulmonary contusion were found. Finally, we identified a total of eleven (1.6%) traumatic aortic disruptions. An overview is shown in

Figure 2. Regarding the regional injury severity, the AIS-chest revealed 6 points in eight patients, 51 patients scored 5 points, 119 patients scored 4 points, and another 154 patients had 3 points.

74 patients had a chest tube placed at admission in the emergency room. In 22 cases an emergency thoracotomy had to be performed. Out of these 16 patients died because of the ongoing and uncontrollable hemorrhage, and in six cases the bleeding could be controlled and the patients survived. Regarding the patients who sustained an aortic disruption, 7/11 patients died in the emergency room before the aorta could be surgically addressed. The remaining four patients, who were all hemodynamically stable at admission, had an aortic graft done by the attending cardiothoracic surgeon and recovered from their injuries.

The average period of ventilation of the polytrauma patients with chest injuries was 11.7 days and the mean ICU stay was 15.4 days, and 35.9 days for total hospital stay. In regard to the complications, 55 patients (16.5%) developed an ARDS, and in 24 patients (7.2%) an MOF was seen. The overall mortality was 34.3% (114/332 patients). In this group we identified 19/114 patients (17%) with an ARDS compared to 36/218 patients (16%) who survived. Considering the patients who survived (group A) and those who died (group B) with respect to the AIS, we identified 114 patients (52.3%) in group A and 40 patients (35.1%) in group B with an AIS of 3. An AIS 4 injury was found in 74 patients (33.9%) of group A and in 45 patients (39.5%) of group B. AIS 5 injuries were seen in 30 patients (13.8%) of group A and in 21 patients (18.4%) of group B. Finally, we determined eight patients (7%) with an AIS 6 injury in group B. An overview is given in Figure 3.

By comparison, the average period of ventilation of the polytrauma patients without chest injuries was 13.1 days and their mean ICU stay 17.3 days. An ARDS was seen in 16 cases (9.4%), and 13 patients (7.7%) developed an MOF. Mortality was 21.3% in this group (36/169 patients).

To complete this overview, the entire polytrauma population had an average ventilation of 12.2 days and a mean ICU stay of of 16.0 days. The overall ARDS rate was 14.2%, and an MOF was seen in 7.4%. The overall mortality was 29.9% (150/501 patients; Table 1).

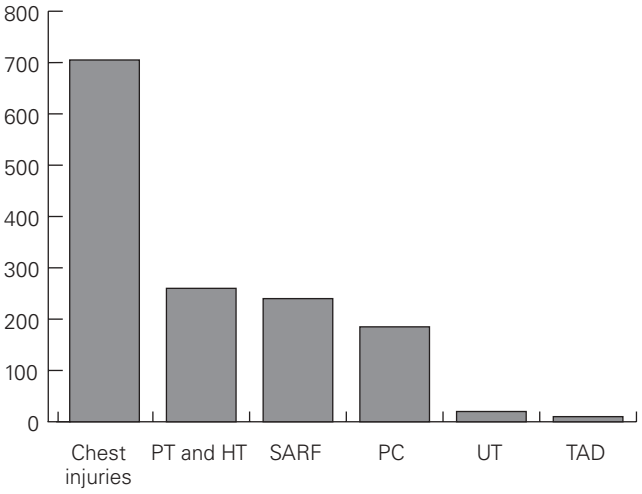

Figure 2. 332 polytrauma patients with 705 chest injury diagnoses. The number of the polytrauma patients with different thoracic injury pattern. HT: hemothorax; PC: pulmonary contusion; PT: pneumothorax; SARF: sternal and rib fracture; TAD: traumatic aortic disruption; UT: unstable thorax.

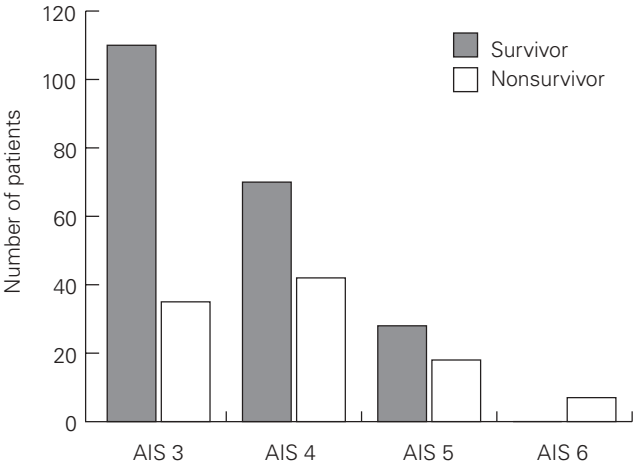

Figure 3. Number of patients and AIS distribution. The AIS distribution in the surviving and nonsurviving patients demonstrates the correlation of chest injury severity with overall mortality.

Discussion

As our retrospective analysis shows, chest injuries are seen in about two thirds of all blunt polytrauma patients and contribute significantly to the morbidity, mortality and outcome of these patients. As clearly seen in Figure 3, with increasing severity of the chest injury, the mortality is continuously increasing as well. This has also been shown by other authors [11–13]. In comparison to the polytrauma patients without chest injuries, we saw a higher mortality in the presence of a chest trauma. This can be explained by the entity of a chest injury itself and the resulting higher injury severity, seen by difference in the ISS between the two groups. Not surprisingly, also the ARDS rate was higher in the group of patients with a chest injury. On the other hand, it was interesting to

Table 1. Overview of important parameters to compare polytrauma patients with and without a chest injury. ARDS: adult respiratory distress syndrome; ICU: intensive care unit; ISS: Injury Severity Score; MOF: multiorgan failure syndrome.

	All polytrauma patients	With chest injury	Without chest injury
Number	501	332	169
ISS	34.3	38.4	26.2
Ventilation days	12.2	11.7	13.1
ICU stay (days)	16.0	15.4	17.3
ARDS rate (%)	14.2	16.5	9.4
MOF rate (%)	7.4	7.2	7.7
Mortality (%)	29.9	34.3	21.3

see that there were no big differences in the ventilation days and ICU stay between the two groups. Ventilation days and ICU stay were even slightly shorter in the group with chest trauma. Though not directly evaluated in this review, this might be due to the fact that a higher early mortality in the group of patients with chest injury, that reduces the total duration of ventilation and ICU stay, resulted, on average, in shorter ventilation days as well as in a shorter ICU stay.

Pathophysiologically, the key to organ integrity is the endothelial cell, which normally maintains a dynamic process of vasoconstriction and dilatation and further governs permeability of the capillary wall [3]. In trauma patients there is a complex cellular and molecular generic response leading to multiorgan failure. This response has sometimes been referred to as the systemic inflammatory response syndrome (SIRS). The interaction of the neutrophils and the endothelial cells, governed by inflammatory cytokines, adhesion molecules and the generation of free radicals, has generally been implicated in the development of SIRS. This process is diagnosed in the lung as the ARDS. The lung is a very delicate and unforgiving organ and during this process free radicals injure autogenous tissues and lead to relative ischemia due to hypovolemia, arterial thrombosis, followed by necrosis [14, 15]. Following major trauma, there is an increase in capillary permeability, both systemic and pulmonary. Endothelial damage is most severe with leukocyte migration. This exposes the basement membrane of the capillaries, leading to an increased thrombogenicity and permeability with subsequent generalized organ and tissue dysfunction. The relationship of the neutrophil and endothelial cell is therefore paramount in generating the molecular response to trauma. Endothelial dysfunction is the critical early event in the body's molecular response after trauma and leads to dysfunction of alveolar capillary exchange and also to arterial hypoxemia. In the lung this process leads to an interrupted gas exchange and, clinically, to a declined pCO_2, tachypnea and hyperventilation.

In the acute management, starting already in the preclinical setting, a secure airway and oxygenation together with the optimal fluid administration are crucial for severely injured patients and even more for those with an additional chest injury. Early intubation and ventilation, as suggested by numerous authors, are therefore very important, as it has been shown that polytrauma patients with delayed ventilation are more prone to develop complications such as ARDS and MOF. In the present series, 78% of the patients had been intubated and ventilated already in the preclinical setting before admission. In the Central European countries, like Germany and Austria, we have a very good rescue system, by air as well as on the ground, staffed with specially trained emergency physicians. This stays in contrast to the paramedic-based rescue systems in the Anglo-American countries. To our knowledge, a direct comparison of both systems by means of a multicenter study has not been undertaken yet.

In the emergency room, a well-trained staff is crucial for the optimal management of the polytrauma victim. The installation of standardized protocols for every possible situation has proven to be very effective in numerous studies. In case of a chest injury the criteria for early intubation and ventilation have been suggested by Richardson et al. [16]: hypoxia with a $pO_2 < 55$ mmHg or a $pCO_2 > 55$ mmHg, dyspnea, tachypnea > 30/min or bradypnea < 10/min. Although these criteria may be helpful in isolated chest injuries, the entity "polytrauma", in our opinion, represents an indication for early intubation. In the present series we had a preclinical intubation rate of 78%; the remaining patients were all intubated right after their admission in the emergency room.

The indication for chest tube insertion in the severely injured patient is also somewhat controversially discussed. Westaby & Brayley recommended chest tube insertion for all pneumothoraces > 1.5 cm visible on chest X-ray [17]. If there is just a small pneumothorax visible (< 1.5 cm), a chest tube is only indicated in case of bilaterality or if longer mechanical ventilation is expected. However, in the polytrauma patient, we think that every visible pneumothorax should be drained, especially as the

majority of these patients have to undergo longer surgeries and ventilation. With the introduction of modern CT devices in the trauma setting, even very small pneumothoraces, not visible on the plain X-ray, are detectable. It has always been our policy to also drain these occult pneumothoraces in the multitrauma patient who requires longer mechanical ventilation.

An emergency thoracotomy is performed, if the initial blood loss after chest tube insertion exceeds 1,500 ml or if there is a continuous blood loss of > 250 ml/h for 3 h. This concept is based on the findings of McNamara et al., who demonstrated during the Vietnam war, that an early thoracotomy in patients with penetrating injuries resulted in a decreased mortality [18]. In our series 6/22 patients could be saved by emergency thoracotomy. 16/22 patients that had an emergency thoracotomy died.

During the last decades there has been an ongoing debate on the optimal timing and procedures of fracture fixation in severely injured patients with chest injuries. In this series we did not focus especially on this topic, and therefore an extended discussion about fracture fixation in polytrauma patients is beyond the scope of this article. However, it should be mentioned that this discussion has still not come to an end, with all kinds of studies, clinical and experimental, that support different treatment strategies and philosophies [19, 20].

Conclusion

In this study we aimed to report our results on polytrauma patients with combined chest injuries and to give an overview of evidenced-based management. We conclude that the severity of a chest injury in polytrauma directly correlates with the overall outcome of these patients. Like others we state that early intubation and ventilation are crucial in the management of polytrauma patients with chest injury.

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