ORIGINAL ARTICLES

Indicators of Severity in Chest Trauma

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OBJECTIVE: We undertook a review of patients with chest trauma attended between January 1992 and June 2005 in order to establish severity criteria in these cases.

PATIENTS AND METHODS: During the study period, 1772 cases (1346 [76%] males) were treated, with ages ranging from 7 to 98 years (mean, 46.4 years). The Revised Trauma Score (RTS) was calculated and the following variables were also studied as potential indicators of severity: age, extent of the injury, number of rib fractures, presence of lung contusion, hemothorax, cardiorespiratory repercussions, and need for mechanical ventilation.

RESULTS: At the time of admission, 84.4% of patients presented only symptoms related to the injury, with no general repercussions, and 66.7% had an RTS of 12. The number of rib fractures was a reliable indicator of severity, as was the presence of multiple injuries, lung contusion, need for mechanical ventilation, and cardiorespiratory repercussions. Neither age nor presence of hemothorax was found to be an indicator of severity. Pleural drainage was performed in 756 cases and was effective in 670 (88.6%).

CONCLUSIONS: There are a number of indicators of severity in chest trauma, related more closely to the type and repercussions of the trauma than to the age of the patient. There is a high incidence of fluid or gas accumulation in the pleural space, though this can be easily managed by pleural drainage, which constitutes the main therapeutic procedure in chest trauma.

Key words: *Chest trauma. Rib fractures. Hemothorax. Traumatic pneumothorax.*

Indicadores de gravedad en los traumatismos torácicos

OBJETIVO: Revisamos la experiencia en traumatismos torácicos (TT) atendidos entre enero de 1992 y junio de 2005 con la intención de establecer criterios de gravedad en ellos.

PACIENTES Y MÉTODOS: Durante dicho período se atendieron 1.772 casos con edades comprendidas entre los 7 y 98 años (1.346 varones; 76%) y con una media de edad de 46,4 años. Se aplicó la escala Revised Trauma Score (RTS) y se tuvieron en cuenta, como indicadores, la edad, el grado de traumatismo, el número de fracturas costales, la presencia de contusión pulmonar, hemotórax, la repercusión cardiorrespiratoria y la necesidad de ventilación mecánica.

RESULTADOS: En el momento del ingreso el 84,4% tenía únicamente síntomas relacionados con el traumatismo, sin repercusión general, y el 66,7% presentaba un índice RTS de 12. El número de fracturas costales fue un marcador eficaz de gravedad, al igual que la presencia de politraumatismo, contusión pulmonar, necesidad de ventilación mecánica y repercusión cardiorrespiratoria. La edad no se reveló como un índice de gravedad, y tampoco la presencia de hemotórax. En 756 ocasiones se realizó drenaje pleural, que fue resolutivo en 670 (88,6%).

CONCLUSIONES: Los TT tienen una serie de indicadores de gravedad, más relacionados con el tipo e impacto del traumatismo que con la edad del paciente. El síndrome de ocupación pleural es un problema de mucha incidencia, aunque de resolución fácil con un drenaje pleural. Éste constituye la principal arma terapéutica en los TT.

Palabras clave: *Traumatismos torácicos. Fracturas costales. Hemotórax. Neumotórax traumático.*

Introduction

Trauma constitutes a common problem in Spain, particularly due to the high incidence of road traffic accidents and other causes such as the persistence of a considerable level of social conflict and increasing life expectancy, which has meant that a larger elderly population is exposed to home and leisure accidents. Trauma is the first cause of death among young people. In the United States, it is calculated that around 3.5 million cases require hospital admission each year.[1]

Chest trauma is a specific type of trauma that is suitable for individual study. Present in around 50% of cases of multiple trauma and the direct cause of death in 25% of such cases, chest trauma is quite common.[2]

We analyzed our experience between 1992 and 2005 in order to evaluate the utility of certain indicators for predicting the clinical course in patients with chest trauma.

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Patients and Methods

The overall sample included 1772 cases (1346 men; 75.9%) treated between January 1992 and June 2005 and aged between 7 and 98 years (mean, 48.4 years). The study was performed using a prospective data collection protocol that included the cause of the accident, type of injury, clinical manifestations, severity of the injury, and treatment. Patients who died at the scene of the accident or during transfer to the hospital were excluded. The Advanced Trauma Life Support protocol is applied in treatment of chest trauma at our center.[1,2]

The patients were divided into groups according to the extent of the injury: *a)* chest injury only; *b)* chest injury associated with a major extrathoracic injury (bone fracture, abdominal visceral lesion, head injury) in patients who did not enter the category of multiple trauma; and *c)* multiple trauma, that is, patients with 2 or more major traumatic injuries in addition to chest injury.

For comparisons, the population was divided into the following age groups: *a)* young (<40 years); *b)* middle age (from 40 to 69 years); and *c)* elderly (>70 years).

The criteria for the insertion of a chest tube were the presence of a clinically or radiologically significant pleural effusion (hemothorax) and/or pneumothorax or significant or increasing subcutaneous emphysema. Emergency surgery was indicated in patients with hemodynamic instability that could not be attributed to other injuries, hemothorax greater than 1000 mL or with a drainage greater than 200 mL per hour for 3 hours, and in the presence of cardiac tamponade. Significant air leakage and a lack of lung expansion, leading to a suspicion of a lesion of the main airway or a large tear of the lung parenchyma, were also criteria for surgery. Lung contusion was defined radiologically as the presence of an alveolar-interstitial pulmonary condensation at the time of admission or within the first 72 hours. Suspected rupture of the diaphragm and complications in the clinical course (persistent pneumothorax, clotted hemothorax, and pleural empyema) were also considered as indications for surgical treatment. In cases with marked rib destruction or paradoxical respiration associated with concomitant lesions that could be treated surgically, rib fixation was performed with Judet struts.

For analysis, complications were classified as respiratory (atelectasis, retained secretions, pneumonia, respiratory distress, pleural complications, pulmonary thromboembolism) and general (extrathoracic). Death was always attributed to an immediate cause: type of injury (due to associated injuries or to the chest injury itself), and a main cause (due to a complication in the clinical course or to the injury itself).

The following variables, assessed at the time of the patient's admission to the hospital, were studied as prognostic markers: age, number of rib fractures, hemothorax, presence of lung contusion, presence of multiple injuries, cardiorespiratory repercussions, need for mechanical ventilation, and the Revised Trauma Score (RTS) as the index of severity (Table 1).[3]

TABLE 1
Revised Trauma Scoring

Glasgow Coma Scale	Systolic Blood Pressure, mm Hg	Respiratory Rate, Breaths/Min	Revised Trauma Score
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

FR: frecuencia respiratoria; GSC: escala de Glasgow; PAS: presión arterial sistólica.

TABLE 2
Results of the Application of the Revised Trauma Score at the Time of Admission, and the Related Mortality

Revised Trauma Score	No. of Patients	Mortality, %
12	1183	0.4
11	213	4.2
10	98	10.7
9	65	18.5
8	47	36.1
7	43	37.2
6	36	38.8
5	31	54.8
4	24	79.2
3	18	83.3
2	9	77.7
1	5	80

Statistical Analysis

The statistical analysis was performed using contingency tables and the χ^2 test. A P value less than .05 was considered significant.

Results

The site of the injury was on the right hemithorax in 738 cases (41.6%), left hemithorax in 689 (38.9%), central (sternal) region in 147 (8.3%), and in more than 1 site on the chest in 198 (11.2%). Particularly important causes of injury were road traffic accidents (n=771, 43.5%) and home and leisure accidents (n=639, 36.1%). Other causes were physical aggression in 181 cases (10.2%), work-related accidents in 101 cases (5.7%), sports injuries in 29 (1.6%), and attempted suicide in 51 (2.9%). In the young population (<40 years, n=646), road traffic accidents were very common and accounted for 63.3% of all injuries (n=409) in this age group. There was a high incidence of multiple trauma due to high impact accidents in this age group (n=232, 35.9%). Physical aggression was also common at younger ages, with 102 cases (56.3% of the total of 181). In the elderly population (>70 years, n=356), home and leisure accidents were very common (n=286, 80.3%) and were almost always due to accidental falls with a single, low impact chest injury (n=225, 78.7%). There was a statistically significant relationship between the type of accident and age (P<.00001).

The injuries were recorded as exclusively chest trauma in 980 cases (55.3%), associated with an extrathoracic injury in 338 (19.1%), and multiple trauma in 454 (25.6%).

The predominant clinical manifestations involved a combination of pain and dyspnea in more than half of the cases (n=921, 52%). Chest pain alone was found in 671 cases (37.8%), and in a small number of cases other manifestations such as hemoptysis (n=22, 0.1%). The majority of patients (n=1495, 84.4%) presented no hemodynamic or respiratory repercussions. Respiratory insufficiency based on blood gas criteria was detected in 143 cases (8.1%) and hypotension or hypovolemic shock in 132 (7.4%). Cardiac tamponade was only observed on 2 occasions. The results of the RTS classification and the associated mortality are presented in Table 2, where

TABLE 3
Traumatic Chest Conditions

	No. of Cases	%
Chest wall		
Rib fractures 1-3	598	33.7
Rib fractures 4-6	412	23.2
>6 rib fractures	104	5.8
Flail chest	73	4.1
Sternal fracture	156	8.8
Chest wounds	161	9.1
Pleura		
Right pneumothorax	140	7.9
Left pneumothorax	152	8.6
Bilateral pneumothorax	24	1.3
Right hemothorax	81	4.6
Left hemothorax	76	4.3
Bilateral hemothorax	5	0.3
Right hemopneumothorax	90	5.1
Left hemopneumothorax	101	5.7
Bilateral hemopneumothorax	67	3.8
Chylothorax	5	0.3
Subcutaneous emphysema	47	2.7
No pleural alterations	984	55.5
Lung		
Contusion	480	23.7
Laceration	49	2.8
Others		
Rupture of the diaphragm	22	1.2
Tracheal or bronchial lesion	15	0.9
Cardiac or great vessel lesion	25	1.4
Thoracic vascular lesion	30	1.7

mortality may be observed to rise as RTS values indicate greater cardiac, respiratory, or neurological involvement. On admission, 67.7% of patients had a score of 12.

Chest wall injury was the most common, with rib and/or sternal fractures in 1343 cases (75.8%), and chest wounds in 161 (9.1%) (Table 3). Paradoxical respiration was diagnosed in 73 cases (4.1%) and the fractures were bilateral in 73 cases (4.1%). No chest wall injury was detected in 268 cases (15.1%). Considering the number of rib fractures as a prognostic factor (Table 4), a greater number of fractures was associated with a higher rate of pleural fluid or gas accumulation, which was of particular importance in patients with paradoxical respiration (flail chest). General and respiratory complications and mortality increased in direct proportion to the number of fractures present. Flail chest was associated with a marked increase in morbidity and mortality. There was a statistically significant relationship between these parameters.

The accumulation of fluid or gas in the pleural space was the second most common traumatic condition (n=741, 41.8%). Pneumothorax was diagnosed on 316 occasions (42.6% of all cases of pleural collections), and blood was found in 420 patients (56.6%), as a hemopneumothorax in 258 cases and hemothorax in 162. In patients with hemothorax or hemopneumothorax, pleural drainage alone was sufficient for resolution in 350 cases (83.3%), and surgical exploration was required in 70 cases (16.6%; thoracotomy in 57 and thoracoscopy in 13). In 16 cases the surgery was performed to evacuate a clotted hemothorax and in the remainder to achieve hemostasis. The indication for surgery was based on the pleural drainage in 54 patients (12.8%). Hemothorax was not found to be clinically significant as an indicator of poor prognosis (Table 5). Pneumothorax occurred in 316 cases; pleural drainage was curative in 300 (94.9%) of these patients and the remainder required surgery. Chylothorax occurred in 5 cases (0.6%). Subcutaneous emphysema without gas or fluid accumulation in the pleural space was found in 47 cases (2.7% of all injuries). It was necessary to insert a chest tube in 15 of these cases and the condition resolved spontaneously in the remainder.

Lung contusion was diagnosed clinically and radiologically in 420 cases (23.7%). Of these, 336 (80%) were due to road traffic accidents and 178 (42.4%) were found in the context of multiple trauma. The other injuries found in patients with lung contusion included cardiac lesions (n=23, 1.3%), with 14 myocardial contusions and 9 cardiac wounds.

Mechanical ventilation was required in 122 patients (6.9%) and was found to be a factor associated with increased mortality. As observed with lung contusion, multiple injury, and cardiorespiratory repercussions, mechanical ventilation was an indicator of poor prognosis; this was also reflected by the RTS. In contrast, age and the presence of hemothorax were not prognostic indicators (Table 5).

Surgery was indicated in 143 cases (8.1%). This was performed based on pleural drainage in the 70 cases mentioned above (54 for persistent hemothorax and 16 for clotted hemothorax) and in 16 cases for massive or persistent air leakage. Twenty-two patients underwent surgery for suspected diaphragmatic lesions and 9 for suspected cardiac lesions (cardiac tamponade or hypovolemic shock). Cervicotomy was performed in 8 patients for tracheal lesions and in 1 case for an esophageal lesion. Thoracotomy was required in 5 patients for aortic lesions, and 4 rib fixations were performed (2 with an indication exclusively for rib injury and the other 2 for associated lesions). Surgical intervention was indicated

TABLE 4
Indicators of Severity of Rib Fractures

Rib Fractures	No.	Pleural Collection		Respiratory Complications		General Complications		Mortality	
		No.	%	No.	%	No.	%	No.	%
1-3	598	167	27.9	22	3.7	81	13.5	35	5.8
4-6	412	231	56.1	29	7	69	16.7	25	5.7
>6	104	78	75	17	16.3	27	26	24	23.4
Flail chest	73	68	93	22	30.1	29	39.7	25	33.8
P			<.00001		<.00001		<.00001		<.00001

TABLE 5
Other Indicators of Severity[a]

	Complications		Mortality
	General	Respiratory	
Hemothorax[b]	15.6	17.2	6
Lung contusion	45.9	40.8	16.2
Mechanical ventilation	83.9	85.7	17.6
Cardiorespiratory repercussion	79.9	87.1	31.8
Multiple trauma	60.8	71.8	26

[a]Numbers are percentages of the study sample.
[b]*P* not significant

in 10 patients for hemodynamic instability and suspected thoracic lesion.

The overall morbidity rate after chest injury was 35.5% (n=629). Respiratory complications occurred in 20.3% of cases (n=360) and general complications in 15.2% (n=269); more than 1 complication developed in 6.5% (n=115). Complications occurred particularly in cases of multiple trauma, with 218 respiratory complications (48.1%) and 121 general complications (26.7%).

Associated lesions were very common. Particularly affected were the limbs (n=509, 28.7%), head (n=255, 14.4%), and abdomen (n=179, 10.1%). There were fewer injuries affecting the face (n=115, 6.5%), spinal cord (n=112, 6.3%), and kidneys (n=48, 2.7%). These injuries were almost always seen in the context of multiple trauma due to road traffic accidents and considerably worsened the patient's situation. Death occurred in 145 cases (8.2%), mainly in patients with multiple trauma (n=118, 26% of such cases). Death was due to the associated injury in 44 cases of multiple trauma (9.7%), almost always to a head injury (n=33); 58 deaths (36.5%) were due to complications during the clinical course (38 occurring in patients with multiple trauma), and 47 (32.6%) were due directly to the chest injury.

Discussion

Although the fundamental objective of this investigation was not to perform an epidemiological study, it does provide a close approximation to the epidemiology of chest trauma in our practice setting. Because the study's duration was long and it included cases from a thoracic surgery reference center, it has provided a very reliable appraisal of the causes of chest injury and of the most susceptible populations. Almost half of the cases were due to road traffic accidents, occurring mainly in the employed population, and the rate of multiple trauma was high. Home and leisure accidents occurred in a similar proportion, mainly in elderly individuals with significantly limited mobility. Chest trauma in these cases represents a significant social and economic burden, and morbidity and mortality are considerable.[4,5] Aggressions are the result of the level of conflict present in our society, making this type of injury a constant feature in other reports in the literature.[6-9]

In the traditional division of chest trauma into open and closed lesions, the group of open injuries generally includes stab and bullet wounds. Firearms are less common in Spain[6-8] than in other countries.[9] Open chest trauma can be classified as penetrating the pleural cavity or not. Penetrating open trauma usually gives rise to a pleural collection (hemothorax or pneumothorax). Serious hemodynamic repercussions (shock or cardiac tamponade) develop in a small number of cases, usually due to cardiac injuries that require emergency thoracotomy.[9,10]

The clinical presentation of closed chest trauma varies according to the intensity of the impact, and this is demonstrated in the indices of severity that we have used in this study. A large number of our cases presented only chest pain and dyspnea related to the injury, with no evaluable hemodynamic or respiratory repercussions. These injuries are usually due to low impact trauma and have an RTS of 12. In general, they are isolated chest injuries or are associated with a single extrathoracic lesion. Prognosis is good and morbidity and mortality low. Multiple trauma, mostly due to road traffic accidents, is generally caused by a direct high-impact trauma or deceleration.[11] This type of trauma is associated with a high rate of lung damage in the form of contusions and lacerations and other chest injuries affecting the heart and great vessels,[12-14] airways,[15,16] and diaphragm,[15] as well as a large number of rib fractures and concomitant extrathoracic lesions. On many occasions, death occurs at the scene of the accident or during transfer.[17,18] The clinical course in the patients that survive is often prolonged, with a high incidence of complications and high mortality, which is usually due to these complications and frequently occurs more than 2 weeks after the injury.[11,14,19] The clinical course of chest trauma therefore depends more on the severity and mechanism of the injury than on the age of the patient, as has been found in previous studies.[20] Mortality in the group of patients over 70 years of age was lower than in the younger age groups, as elderly patients presented trauma from a lower intensity of impact and without associated lesions (falls due to home or leisure accidents).[5] The number of rib fractures constitutes a good indicator of the severity of the trauma and is directly related to higher rates of pleural involvement, complications, and mortality. More than 3 rib fractures is an indicator of severity,[21-27] and paradoxical respiration is particularly serious.[28,29] Other indicators of severity used in this study (mechanical ventilation, lung contusion, and cardiorespiratory repercussions) have also demonstrated their prognostic value, confirming the findings of previous studies.[30]

The value of pleural drainage for the treatment of both pneumothorax and hemothorax, and for the diagnosis of cases of persistent hemothorax that will require emergency surgery has been demonstrated repeatedly over many years.[31,32] Drainage is now even used in the prehospital setting.[33] In our study, pleural drainage was found to be of great utility, as it was sufficient to control a hemothorax or pneumothorax in 95% of cases, and in the remainder it was the determining factor of the surgical indication. It was also an indicator for surgery in cases of pneumothorax with massive air leakage due to a suspected tracheal or bronchial lesion, and in cases of persistent pneumothorax.[15] The percentage of surgical interventions required was low, which is also consistent with traditional concepts of chest trauma and with reports of other patient series of similar sizes[34,35] and in similar settings.[14,35] The majority of operations were performed for blood loss and, on some occasions, for the presence of cardiac tamponade or massive air leakage. In a very small percentage, surgery was performed for the presence of paradoxical respiration; in this situation, surgical intervention is reserved for highly specific cases in which there is a marked destruction of the thoracic cage, when surgery is required for another indication (such as hemothorax), or when this was the only reason for keeping the patient on mechanical ventilation. Although some authors report good results with rib fixation,[36] the present tendency is towards conservative management in this type of lesion, as is also our practice, as we only operated in 4 cases.

The complications recorded in our series depended to a large extent on the impact and the intrinsic severity of the injury. Respiratory complications, especially pneumonia, are very common in multiple trauma[37,38] and are of particular importance because of their frequency and severity. The presence of associated lesions represented a highly significant risk factor for morbidity and mortality. Isolated chest injuries presented much lower rates of mortality and complications, as found in previous studies, in which it was reported that serious chest injury without associated lesions carried a very high probability of survival.[39-41]

In conclusion, from an epidemiological point of view, our study confirms the importance of chest injury due to road traffic accidents and corroborates the high frequency of home and leisure accidents among the elderly. The number of rib fractures is a good indicator of the severity of the injury, and more than 3 is the number associated with the greatest prognostic difference. Other parameters that we have analyzed (multiple trauma, need for mechanical ventilation, cardiorespiratory repercussions, RTS, and presence of pulmonary contusion) have also been found to be good indicators. From a clinical point of view, pleural drainage is a diagnostic procedure of great interest and the most useful tool from a therapeutic perspective, as it achieves resolution in more than 90% of patients in whom it is used, significantly reducing the number of cases requiring surgical treatment. Mortality depends to a large extent on the type of injury. It is high in road traffic accidents, due to both the intrinsic severity of the lesions and to the presence of associated injuries and complications in the clinical course.

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