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Original article

Prognostic factors in chest traumas: A prospective study of 500 patients

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A B S T R A C T

Objective: Identify the factors of greatest impact in patients with chest trauma.
Patients and methods: A prospective study of 500 patients (425 men and 75 women) with chest trauma treated between January 2006 and December 2008. The parameters assessed include the degree of trauma, the abbreviated injury scale (AIS), the injury severity score (ISS), prehospital intubation, duration of mechanical ventilation, length of stay in the intensive care unit (ICU), number of rib fractures, presence of pulmonary contusion, haemothorax and cardio-pulmonary effects.
Results: The presence of polytrauma, the number of rib fractures, the presence of flail chest, pulmonary contusion, the delay in mechanical ventilation and age were shown to be effective markers of severity.
Conclusions: Thoracic injuries have a number of markers of severity. The mortality risk is associated with an ISS >25, the presence of 3 or more rib fractures with flail chest, pulmonary contusion, the development of ARDS, and with age >55.

Factores pronóstico del traumatismo torácico: estudio prospectivo de 500 pacientes

Palabras clave:
Traumatismos torácicos
Traumatismo cerrado
Fractura costal
Politrauma

R E S U M E N

Objetivo: Identificar los factores pronóstico de mayor impacto en el paciente con traumatismo torácico.
Método: Estudio prospectivo de 500 pacientes (425 hombres y 75 mujeres) con traumatismo torácico atendidos entre enero de 2006 y diciembre de 2008. Los parámetros valorados incluyen el grado del traumatismo, la *abbreviate injury scale*, el *injury severity score*, la intubación prehospitalaria, la duración de la ventilación mecánica, la estancia en unidad de cuidados intensivos, el número de fracturas costales, la presencia de contusión pulmonar, hemotórax y repercusión cardiopulmonar.

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Resultados: La presencia de politraumatismo, el número de fracturas costales, la presencia de volet, la contusión pulmonar, el retraso en la ventilación mecánica y la edad se han demostrado marcadores eficaces de gravedad.

Conclusiones: Los traumatismos torácicos tienen una serie de indicadores de gravedad: el riesgo de mortalidad se asocia con un *injury severity score* > 25, la presencia de 3 o más fracturas costales con volet costal, contusión pulmonar, el desarrollo de ARDS y con una edad > 55 años.

Introduction

Chest traumas represent 50% of all traumas.

They are the cause of 25% of trauma deaths[1]; 70% are blunt traumas and the rest are penetrating injuries.[2]

Identifying high-risk patients is essential for the efficacy of a triage system in a trauma unit.

In this paper, we present our experiences between 2006 and 2008, in order to identify the factors with the highest prognostic impact in patients with chest trauma, treated using the most modern diagnostic and therapeutic techniques.

Patients and methods

Between January 2006 and December 2008, 500 patients with chest trauma were admitted to the emergency room at the Asepeyo-Sant Cugat Hospital, a specialist trauma hospital.

The study followed a prospective data-collection protocol that included: accident dynamics, type of trauma (polytrauma/pure chest trauma), clinical manifestations, and diagnostic and therapeutic techniques.

The advanced trauma life support system[2] (ATLS) was applied and all the patients underwent a chest x-ray, followed by a series of x-rays which always included the cervical column, the pelvis and skull. The following tests were performed depending on the suspected diagnosis: abdominal ultrasound; echocardiography; abdominal, cranial and chest CT scans; and intravenous digital subtraction arteriography/angiography.

The main prognostic factors were classified into 11 groups: fracture of clavicle, fracture of scapula, fracture of sternum, fracture of ribs, flail chest, pulmonary contusion, haemothorax, pneumothorax, injury of thoracic aorta and injury of pulmonary blood vessels.

The criteria for performing pleural drainage were: the presence of haemothorax, complete or incomplete pneumothorax in patients on mechanical ventilation or with severe subcutaneous emphysema.

Indications for emergency surgery: haemodynamic instability unrelated with other traumas; haemothorax with initial drainage ≥ 1,000 ml or > 200 ml/h during the first 3 h.

Pulmonary contusions were defined radiologically as the presence of alveolar/interstitial pulmonary condensation 24 h after admission and during the first 72 h, in order to differentiate them from post-traumatic pulmonary plethora.

The Abbreviated Injury Scale (AIS) and the Injury Severity Score (ISS)[3] were used to assess the severity of the injury and these patients were classified into 4 groups.

The following were established as prognostic factors: age, number of fractured ribs, flail chest, pulmonary contusion, in need of mechanical ventilation, and AIS and ISS scores. The following information was also analysed: demographic data, prehospital intubation, length of stay in the intensive care unit (ICU), and complications coded by the ICD-10 index.

Multiorgan failure syndrome (MOF) was defined as ≥ 2 points for 2 or more apparatus during ≥ 3 days, following Goris et al.[4]

ARDS was defined as the quotient PaO_2/FiO_2 < 200 for at least 5 consecutive days and the presence of bilateral diffuse infiltrates in the chest x-ray in the absence of pneumonia and cardiogenic pulmonary oedema.[5]

Statistical analysis

The SPSS 12.0 program for Windows was used, in accordance with a descriptive methodology by analysing the frequency allocation for the qualitative variables, which were expressed as an absolute frequency or percentage, with a confidence interval of 95%; centralizing measures such as the mean, and dispersion measures such as the range were used with quantitative variables.

In addition, a bivariate analysis was performed using the chi-squared test. The level of statistical significance was $P<.05$.

Results

The sample was composed of 425 men (85%) and 75 women (25%).

The average age was 44.0 (range: 18-95 years old).

Road traffic accidents (n=385, 77%) and accidents of chance (n=80, 16%) were the most common causes of the trauma injuries. Other causes were assaults (n=20, 4%), workplace accidents (n=10, 2%) and autolytic attempts (n=5, 1%).

The median hospital stay was 25 days (range: 1-400 days).

Two hundred and thirty-five patients (47%) received prehospital intubation. Early intubation had a positive

Table 1 – Distribution of patients with chest trauma by prehospital intubation and mortality

Prehospital intubation	Deaths		Total
	Yes	No	
Yes	2	233	235
% deaths	6.5	49.5	
No	28	237	265
% deaths	93.5	50.5	
Total	30	470	500

Table 2 – Distribution of patients with chest trauma by prehospital intubation and development of ARDS

Prehospital intubation	ARDS		Total
	Yes	No	
Yes	25	215	235
% ARDS	20	57.5	
No	100	160	265
% ARDS	80	42.5	
Total	125	375	500

ARDS: acute respiratory distress syndrome.

Table 3 – Distribution of patients with chest trauma by prehospital intubation and development of multiorgan failure syndrome

Prehospital intubation	MOF		Total
	Yes	No	
Yes	1	234	235
% MOF	0.1	47.5	
No	10	255	265
% MOF	99.9	52.5	
Total	11	489	500

MOF: multiorgan failure syndrome.

influence on mortality and complications (ARDS, MOF) compared with hospital intubation ($P>.05$) (Table 1, Table 2 and Table 3).

Abdominal ultrasound was performed on 155 patients (31%), echocardiography on 40 (8%), CT scans (cranial, chest, abdominal) on 350 (70%), arteriography on 18 (3.6%) and intravenous digital subtraction arteriography/angiography on 20 (4%).

1,273 prognostic factors of thoracic injury were identified:

1. *Chest wall injuries:* 92 cases (17.7%) of fracture of clavicle (S42.0); 69 cases (13.2%) of fracture of scapula (S42.1); 78 cases (15%) of fracture of sternum (S22.2), complete in 47.4%, incomplete in 52.6%; 315 cases (90.5%) of multiple fractures of ribs (S22.4), unilateral in 315 cases (90.5%), and bilateral in 33 (9.5%); and 60 cases (17.2%) of flail chest (S22.5), anterior in 61.7% of cases and lateral in 38.3%.
2. *Pulmonary and pleural parenchymal injuries:* 152 cases (64.2%) of unilateral and 85 cases (35.9%) of bilateral pulmonary contusion (S27.3); haemothorax (S27.1): 138 unilateral cases (74.2%) and 48 bilateral (25.8%); pneumothorax (S27.0): 166 unilateral cases (93.3%), 12 bilateral cases (6.7%), 163 simple cases (91.6%), 12 cases of tension pneumothorax (6.7%), and 3 cases of open pneumothorax (1.7%).
3. *Heart and large vessel injuries:* 17 cases (3.3%) of heart injury with haemopericardium (S26.0); one case (0.2%) of injury of pulmonary blood vessels (S25.4); and 7 cases (1.3%) of injury of thoracic aorta (S25.0).

Table 4 – Markers of severity

	Complications		Mortality
	General	Respiratory	
MV	85.5%	87.2 %	19.5%
Haemothorax	30.2%	34.4%	12%
Pulmonary contusion	47.2%	45.8%	15.2%

MV: mechanical ventilation.

The AIS-chest revealed 4 patients (0.8%) scored 6 points, 249 patients (49.8%) scored 5 points, 185 patients (37%) scored 3 points and 28 patients (5.7%) scored 2 points.

Action taken and procedure: in 183 cases (36.7%) pleural drainage was performed, of decisive importance in 163 cases (89.5%); in 13 cases (2.7%) an emergency thoracotomy was performed. Seven patients died due to uncontrollable bleeding; 6 patients underwent an emergency thoracotomy (4 cases in under 48 h after trauma; 2 cases over 48 h after trauma): all survived. In one case of multiple fractures of the ribs, stabilisation was performed with Judet plates.

Among the patients with injury of the thoracic aorta, 3/7 died in the emergency room.

232 patients (46.4%) received mechanical ventilation; the median ventilation time was 12 days (range: 1-59 days). The need for mechanical ventilation proved to be a determinant factor in increased mortality, as were suffering from haemothorax and pulmonary contusions (Table 4).

Complications: The median stay in the ICU was 15 days (range: 1-107 days); 28 patients (5.6%) developed subcutaneous emphysema, in 23 cases associated with pneumothorax; 125 patients (25%) developed ARDS; 11 patients (2.1%) developed MOF; 69 patients (13.8%) developed pneumonia (33 unilateral cases and 39 bilateral); and one patient (0.2%) had pleural empyema.

Associated injuries: focal brain injury (S06.3) in 249 cases (49.9%): mild in 123 cases (49.6%), moderate in 44 cases (17.7%), severe in 81 cases (32.7%); 163 cases (32.6%) of fractures of

Table 5 – Markers of severity

Rib injury	n	Haemothorax		MV		Mortality	
		n	%	n	%	n	%
1–3	182	51	28	1	1	0	0
4–6	100	57	57	6	6	2	2
>6	66	49	75.6	11	16	5	8
Flail chest	60	56	92.5	18	30.5	8	13.5
P		<.00001		<.00001		<.00001	

MV: mechanical ventilation.

Table 6 – Distribution of patients with chest trauma by Injury Severity Score and mortality

	Deaths		Total
	Yes	No	
ISS category			260
< 25	0	260	
n			
Mortality			
P			
≥ 25 < 50			90
n	8	82	
Mortality	27%	17.5%	
P	<.05		
≥ 50 < 70			116
n	10	106	
Mortality	35%	22.5%	
P	<.05		
> 70			34
n	12	22	
Mortality	40%	4.5%	
P	<.05		
Total	30	470	500

ISS: Injury Severity Score.

limbs (S42.8-S72-S82.7); 100 cases (20%) of fracture of the pelvis (S32.1-S32.2-S32.3-S32.4-S32.5); 65 cases (13.1%) of fracture of vertebra (S22.1); 37 cases (7.5%) of injury of liver or gallbladder (S36.1); 30 cases (6.0%) of injury of spleen (S36.0); 13 cases (2.7%) of kidney injury (S37.0); 11 cases (2.3%) of injury of multiple internal organs (S36.7); and 6 cases (1.3%) of injury of the diaphragm (S27.8).

Forty-three patients (8.6%) underwent an emergency laparotomy.

One hundred and one patients (20.2%) received a blood transfusion; the average pretransfusion haemoglobin value was 7.9g/dl (9.8g/dl in those not receiving a transfusion). They all received heterologous blood. The average volume of red blood cell concentrate transfused was 2,898 ± 2,456 ml. Despite not reaching statistical significance, it was observed that the patients who survived received less blood (2,671 ± 2,109 ml; n=89) than those who did not (3,739 ± 3,401 ml; n=12) (*P*=.4).

The overall mortality was 30 cases (6%).

Of these 30 cases there were 21 (70%) with ARDS, compared with 104/470 of the surviving patients: the difference reached statistical significance ($p < 0.05$). Furthermore, we identified that 15/30 patients (50%) had 3 or more rib fractures with flail chest, compared with 45 (9.5%) of the 470 who survived: the difference reached statistical significance (*P*<.05) (Table 5).

In accordance with the ISS, mortality between the groups was statistically significant (*P*<.05) (Table 6).

The average age of the patients who died was 55; the average age of those who survived was 40 (*P*<.05).

Discussion

Fractures of ribs are considered the most common injury associated with chest trauma (35-40%).[6] In our series, the incidence was over 90%.

Having 3 or more fractured ribs is a marker of severe injury[7,8]; furthermore, flail chest has a positive influence on mortality, probably because of its association with pulmonary contusion.

Pleural drainage is of great diagnostic and therapeutic value and our study has demonstrated its importance. In 89.5% of the times it was used it was decisive for controlling haemothorax or pneumothorax, while in the rest it was a determinant factor in the indication for surgery. These data have even more value if we consider that haemothorax is a marker of a negative prognosis.

If conservative treatment is not enough and intrathoracic injuries are detected, an emergency thoracotomy must be performed. Less than 5% of patients with blunt chest trauma have the necessary symptoms to undergo a thoracotomy.[9] In our series the surgical intervention rate was 4%.

There were no cases of laryngotracheal fracture; these are uncommon injuries affecting only 7-8% of all cases of chest trauma[10,11]; guided by the high-resolution TC scan, we did not perform a flexible laryngoscopy or bronchoscopy in any patients with signs of maxillofacial or neck trauma. Different studies[12-14] have shown that, in polytrauma patients, TC scan images can show artefacts which make the diagnosis of laryngeal or tracheobronchial injury difficult; thus, direct examination of the laryngotracheobronchial tree is considered essential.

In our series, ARDS positively influenced mortality.

In recent years, study of the treatment of ARDS in the ICU has intensified to try to identify prognostic factors. In polytrauma patients with associated chest trauma, the almost constant presence of pulmonary contusions makes it necessary to combine volume depletion and antibiotic treatment with the standard treatment of IMV and high doses of corticoids.[5]

The most unfavourable prognostic factors on admission to the ICU are haematocrit < 26%, bilirubin ≥ 2 mg/dl, positive fluid balance > 2.51, and age ≥ 65.[15] The duration of IMV is related to deterioration in respiration function parameters due to the loss of thoracic muscle mass.[16] As a result, it is essential to set up forms of ventilation which do not modify the patients breathing mechanisms irreversibly, and allow for early disconnection, such as releasing pressure on the airway, which does not limit the possibility the patient has to breath spontaneously,[17] or lung protective ventilation, which makes it possible to improve the oxygenation index (prognostic factor of mortality in patients with ARDS[18,19]) and maintain tidal volumes < 7.4 ml/kg, following the recommendations of the ARDS Network.[20,21]

It has not been proven that early intubation in the prehospital phase improves survival and reduces the rate of complications in the short, medium and long term in severe trauma patients with additional chest injury. Some studies have shown an increase in survival when following the ATLS in the prehospital phase; others show that there are no differences between ATLS and basic life support.[22,23]

In this series, 47% of the patients received prehospital intubation and ventilation; contrary to the data in the medical literature mentioned, a reduction in the complication rate (ARDS, MOF) and mortality were observed in this group.

The result obtained for ARDS could be explained by considering the physiopathology of the gaseous interchange in these conditions. Patients have symptoms of pulmonary oedema due to increased permeability; alveolar occupation reduces the surface available for the gas exchange, increasing the pulmonary areas with poor or null ventilation/perfusion (V/Q) ratio. As ARDS progresses, vascular phenomena occur that affect the gas exchange differently. On the one hand, the poorly ventilated areas react to local hypoxia with vasoconstriction, reducing the blood flow and redirecting it to well-ventilated areas. Shortly afterwards, pulmonary microthrombosis occurs in small blood vessels, producing patchy areas of dead space and increasing the V/Q imbalance. An added factor is the formation of atelectasis in areas of low V/Q. Patients being supine for long periods, deep sedation with/without muscle paralysis and the absence of active diaphragm contraction can all contribute to this. Prehospital intubation enables the evolution of ARDS to be slowed down, limits atelectasis due to the early use of positive telespiratory pressure, and allows sedation without muscular paralysis to be used, which consequently helps patients to adapt to the ventilator and makes it possible to use methods to reduce pressure on the airway or to use lung protective ventilation.

We consider that the reduction in the rate of MOF in this same group of patients is not an independent phenomenon, but is related to lung protection strategies. In recent years mortality from MOF in polytrauma patients has gone down from 80% to 25-36%. Different factors are responsible for these results, with the most important being the maintenance of lung function in cases of acute lung injury or ARDS.[24]

In our casuistry, severe trauma is defined by an ISS ≥ 25.

Nowadays, the ISS is considered the gold standard of point systems used with polytrauma patients.

Calculating the ISS involves summing the squares of the highest AIS scores in the three body regions most seriously affected.

The ISS is usually used to control for patient case-mix, and has the following limitations: it cannot be adjusted precisely to differentiate the severity of injuries in different parts of the body; it has biased distribution, and has a non-linear relationship with mortality and other parameters; and it only considers one injury per body region.[25]

In 1997, Osler[26] proposed a revised ISS, the New Injury Severity Score (NISS) which is calculated as the sum of the squares of the 3 most severe injuries, regardless of the body area in which these occur.

The NISS has not been shown to be better than the ISS at predicting mortality in polytrauma patients. In 2004, a paper was published showing that it was more accurate at predicting admission to the ICU and hospital stay;[27] however, this result was brought into question by an article published in 2008 concluding exactly the opposite.[28] The accuracy of the two systems might vary depending on the characteristics of the population it is applied to.

In our series 20.2% of the patients received transfusions. Polytrauma patients are still given large quantities of blood despite evidence that this can have negative effects. It can: increase the risk of complications from infection/sepsis; lead to systemic inflammatory response syndrome; contribute to the emergence of ARDS (risks depend on dose; the cut is 4 red blood cell concentrates).[29] Despite not reaching statistical significance, the results seen in our series confirmed these data.

In recent years something very important has been evidenced. In the hospital phase, transfusion protocols are getting stricter, for the reasons mentioned above, while in the prehospital phase, very aggressive conduct results in an increase in survival. Massive replacement of volume in the minutes immediately after trauma occurs averts the emergence of acidosis, hypothermia and disseminated intravascular coagulation.[30]

The progress of chest trauma depends more on the severity and mechanism of the trauma than on the age of the patient[9]; despite this, we have observed that the risk of mortality is associated with being over 55 years of age.

Conclusions

Chest traumas have a series of markers of severity. The risk of mortality is associated with:

- having 3 or more fractured ribs with flail chest
- pulmonary contusion
- haemothorax

- mechanical ventilation
- developing ARDS
- ISS > 25
- and age > 55.

Early prehospital intubation and ventilation are associated with a reduction in the rate of complications (ARDS, MOF) and mortality.

Priority must be given to applying strict transfusion protocols in the hospital phase.

Conflict of interest

The authors affirm that they have no conflicts of interest.

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