ORIGINAL ARTICLES

Predictors of Outcome in Blunt Chest Trauma

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INTRODUCTION: Thoracic trauma is often associated with polytrauma. Because mortality is high, the search for prognostic tools is useful.

PATIENTS AND METHODS: A total of 108 patients with blunt thoracic trauma, 73 of whom had multiple injuries, were studied in an intensive care unit (ICU). The variables named as potential predictors of outcome were the need for mechanical ventilation, duration of ventilation, and high positive end-expiratory pressure (PEEP); the presence of rib fractures, pulmonary contusion, pleural involvement (hemo- and/or pneumothorax), or lung infection; the need for emergency surgery; mean duration of ICU stay, and age. We also studied whether or not the mortality rate was higher in polytrauma patients. Student *t* and χ^2 tests (95% confidence level) and multiple regression analysis (Hosmer-Lemeshow goodness of fit) were used to analyze the results.

RESULTS: The need for mechanical ventilation, radiographic evidence of pulmonary contusion, emergency surgery, and hemodynamic instability were risk factors for increased mortality. Higher risk of mortality was not demonstrated for patients with multiple injuries. For patients in need of mechanical ventilation, high PEEP was a predictor of poor prognosis.

CONCLUSIONS: The presence of the aforementioned predictors (mechanical ventilation, high PEEP, pulmonary contusion, emergency surgery, and hemodynamic instability) indicate serious injury to the lung parenchyma, which is the main determinant of outcome for patients with thoracic trauma.

Key words: *Thoracic trauma. Multiple injuries. Prognosis. Mortality. Mechanical ventilation.*

Marcadores pronósticos en los pacientes con traumatismo torácico cerrado

INTRODUCCIÓN: El traumatismo torácico suele producirse en el contexto de un politraumatismo. La mortalidad elevada de esta patología hace lógica la investigación de marcadores pronósticos.

PACIENTES Y MÉTODOS: Estudio sobre 108 pacientes ingresados en una unidad de cuidados intensivos, con traumatismo torácico cerrado, de los cuales 73 fueron politraumatizados. Analizamos, como marcadores pronósticos, la necesidad de ventilación mecánica, su duración, la presión positiva máxima final de la espiración, las fracturas costales, la contusión pulmonar, las alteraciones pleurales (hemo y/o neumotórax), la sobreinfección respiratoria, la inestabilidad hemodinámica, la necesidad de cirugía urgente, así como la estancia media y la edad. Estudiamos si fue mayor la mortalidad en los politraumatizados. Se emplearon como herramientas estadísticas las pruebas de la t de Student y de la χ^2 (intervalo mínimo de confianza del 95%), y se realizó un análisis de regresión logística (bondad de ajuste test de Hosmer-Lemeshow).

RESULTADOS: La necesidad de ventilación mecánica, la presencia radiológica de contusión pulmonar, la cirugía urgente y la inestabilidad hemodinámica comportan mayor mortalidad. No se demuestra mayor mortalidad en los enfermos politraumatizados. En los pacientes con ventilación mecánica, la presión positiva máxima final de la espiración requerida es un indicador de mayor mortalidad.

CONCLUSIONES: Los marcadores positivos indican una mayor lesión en el parénquima pulmonar, lesión que es el determinante principal de la evolución de los pacientes con traumatismo torácico.

Palabras clave: *Traumatismo torácico. Politraumatismo. Pronóstico. Mortalidad. Ventilación mecánica.*

Introduction

Blunt chest trauma is understood to be injury to the thoracic cage affecting the rib cage itself, the lung parenchyma, the heart, great vessels and/or mediastinal structures, although the bony structures are the ones that are usually the most damaged. Such trauma is potentially life threatening, with a direct mortality rate around 25% and it is related indirectly to mortality in polytrauma patients in another 25% of cases. Most closed chest injuries in Spain are caused by traffic accidents and it is not unusual for them to occur in a context of multiple injuries, a pattern that differs from that of countries in which thoracic injuries caused by fire arms are common.[1-4]

Prognostic scales for chest injury patients include the Injury Severity Score, the Hannover Polytrauma Score,

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the Revised Trauma Score, and the Abbreviated Injury Scale-Thorax. Some of these scales are fairly complicated to apply. Clinical features usually assessed in prognostic scales intended for use with patients with acute lung injury or acute respiratory distress syndrome are hypoxemia (the ratio of PaO_2 to fraction of inspired oxygen), positive end-expiratory pressure (PEEP), lung distensibility, and radiographic evidence of alveolar infiltrates.[5-10]

In the present study of patients admitted to an intensive care unit (ICU) with blunt chest trauma, we investigated the prognostic utility of clinical, radiographic, and therapeutic variables that could be assessed quickly and easily even in unstable patients who must remain immobile and even in settings in which complete assessments cannot be carried out.

Patients and Methods

We studied 108 patients admitted with blunt chest trauma to a multi-purpose, 17-bed ICU. Patients with lower limb long bone fractures were excluded, such that the only polytrauma patients included were those with head and brain injuries and/or abdominal injuries.

Patients with chest injuries were admitted to the ICU if they fulfilled at least one of the following criteria: initial presence of hypoxemia, hemodynamic instability, increased work of breathing, or significant thoracic instability. Patients were also admitted if they had evidence of initial pulmonary contusion on a simple chest x-ray and/or significant pneumothorax. Multiple-injury patients meeting these conditions were also admitted.

Hemodynamic instability was defined by the sustained need for inotropic or vasoactive drugs (mainly dopamine and noradrenalin) unrelated to sepsis and after adequate volume replacement confirmed by central venous pressure.

Increased work of breathing was defined by the presence of any of the accepted signs or symptoms (tachypnea, recruitment of accessory muscles, or abdominal breathing) or by signs of imminent respiratory claudication (cyanosis, mental confusion, hemodynamic alterations, etc).

Simple chest radiographs were available for all patients so that a diagnosis of pleural and pulmonary parenchymal involvement could be established. We did not analyze images obtained by computed tomography (CT), as scans were not available for all patients. Multiple rib fracture was defined as breakage of 3 or more ribs.

Complementary tests were ordered during a patient's ICU stay as needed based on clinical course. The frequency of arterial blood gas analysis depended on clinical criteria. Monitoring by pulse oximetry and electrocardiography was continuous for all patients.

As possible prognostic factors of greater risk of death in the ICU, we studied information that could be gathered and interpreted quickly: need for mechanical ventilation, duration of ventilation, maximum PEEP required, initial presence of more than 3 fractured ribs, initial pulmonary contusion or its appearance within 24 hours, alterations in the pleural space (hemo- or pneumothorax), concurrent respiratory infection, hemodynamic instability, and the need for emergency surgery. Also analyzed as factors related to mortality were age, mean duration of ICU stay, and a history of chronic bronchial disease (as evidenced by clinical signs).

The need for mechanical ventilation was usually assessed clinically. Not included were patients who required ventilation briefly after surgery. The maximum PEEP value recorded was the one needed to keep arterial oxygen saturation greater than 95% when the inspired oxygen fraction had risen above 60%. Given that it is difficult to interpret chest radiographs for signs of concomitant respiratory infection in mechanically ventilated patients, we took respiratory samples for immediate laboratory testing, using a protected specimen brush in a telescoping catheter. We also took into consideration fever, worsening arterial blood gases, or radiographic signs of worsening.

We compared patients with and without mechanical ventilation and patients who died in the ICU to those who survived. Univariate analysis was performed using Z tests and Student *t* tests for normally distributed findings or the Wilcoxon test for non-normally distributed results. A χ^2 test was applied to qualitative variables. A 95% confidence interval was calculated in all cases. A stepwise multiple regression analysis and the Hosmer-Lemeshow test was used to assess goodness of fit. The MiniTab® statistical package, version 13, was used.

Results

The group was composed of 84 men and 24 women with a mean age of 44.3 years. Relevant medical history included chronic bronchial disease in 22 and ischemic heart disease in 16; 7 patients had a history of both. Thirty-five of the 108 patients had blunt chest trauma only and 73 had multiple injuries.

Thirty-six (33%) died in the ICU. Nine were patients with blunt chest trauma only (26% of such patients) and 27 had multiple injuries (37% of all polytrauma patients). The difference in mortality between chest-only and multiple-injury patients was not statistically significant and the presence of craniocerebral injury did not affect the rate. Seventeen patients (16%) needed major surgery (7 neurosurgery and 10 abdominal surgery); all such patients had multiple injuries and 9 died (53% of those needing surgery).

Twenty patients did not need mechanical ventilation (Table 1), 10 of them had multiple injuries (50%). Seven of them (35%) had head and brain injuries. The mean (SD) hospital stay was 5(2.6) days and the mean age was 48.4(18) years. Thirteen were men (65%) and 7 women (35%). Multiple rib fractures were present in 19 (95%) and 4 of those patients (20%) had thoracic instability. Pulmonary contusion was evident radiographically in 9 (45%) and was bilateral in 2 cases (10%). Pleural alterations were observed in 7 (35%), among them 6 cases of pneumothorax (30%), 3 of hemothorax (15%), and 2 of hemopneumothorax (10%). Three (15%) were treated surgically by exploratory laparotomy and mechanical ventilation was needed only during the early postoperative period. None of the patients who did not require ventilation died.

The remaining 88 patients required mechanical ventilation, as indicated in Table 1. Sixty-three of them

TABLE 1
Patient Characteristics and Univariate Comparisons*

	No Mechanical Ventilation (n=20)	Mechanical Ventilation (n=88)	*P*
Polytraumatized	50% (n=20)	72% (n=63)	NS
Head/brain injury	35% (n=7)	58% (n=51)	NS
ICU stay, days†	5(2.6)	16.1(15.8)	.0016‡
Age, years†	48.4(18)	43.4(20.4)	NS
Men	65% (n=13)	81% (n=71)	NS
Multiple rib fractures	95% (n=19)	82% (n=72)	NS
Thoracic instability	20% (n=4)	36% (n=32)	NS
Pulmonary contusion	45% (n=9)	100% (n=88)	.0001§
Bilateral pulmonary contusion	10% (n=2)	59% (n=52)	.03§
Pleural alterations	35% (n=7)	74% (n=65)	.002§
Pneumothorax	30% (n=6)	56% (n=49)	NS
Hemothorax	15% (n=3)	41% (n=36)	.03§
Hemopneumothorax	10% (n=2)	30% (n=26)	.01§
Hemodynamic instability	5% (n=1)	43% (n=38)	.003§
Emergency surgery	15% (n=3)	16% (n=14)	NS
Death	0% (n=0)	41% (n=36)	.0001§

*NS indicates not significant.
†Results expressed as means (SD).
‡Wilcoxon test.
§χ^2 test.

TABLE 2
Death Versus Survival in Patients With Mechanical Ventilation: Univariate Comparison*

	Died (n=36)	Survived (n=52)	*P*
Polytraumatized	75% (n=27)	69% (n=36)	NS
Head/brain injury	64% (n=23)	77% (n=40)	NS
ICU stay, days†	11.6(16.2)	19.3(14.8)	.002‡
Age, years†	46.08(22.4)	41.6(19.8)	NS
Duration of ventilation, days†	8.5(9.5)	10.2(6.9)	.001§
PEEP, mbar†	12.4(4)	6.2 (5.5)	.0001‡
Concurrent respiratory infection	44% (n=16)	52% (n=27)	NS
Thoracic instability	61% (n=22)	44% (n=23)	.03‖
Pulmonary contusion	100% (n=36)	85% (n=44)	.03‖
Bilateral contusion	86% (n=31)	40% (n=21)	.0001‖
Pneumothorax	75% (n=27)	42% (n=22)	.004‖
Hemothorax	69% (n=25)	56% (n=29)	NS
Hemodynamic instability	100% (n=36)	44% (n=23)	.0001‖
Emergency surgery	25% (n=9)	9% (n=5)	NS

*NS indicates not significant; PEEP, positive end-expiratory pressure.
†Results expressed as means (SD).
‡Wilcoxon test.
§Student *t* test.
‖χ^2 test.

(72%) had multiple injuries and 51 (58%) had head and brain injuries. The mean duration of ICU stay was 16.1(15.8) days and they were ventilated for a mean 9.5(8.08) days. The mean age of these patients was 43.4(20.4) years and 71 (81%) were men and 17 women (19%). In 72 (82%) multiple rib fractures were demonstrated and 32 (36%) had thoracic instability. Pulmonary contusion was evident on the chest x-rays of all patients (100%) studied and bilateral contusions were observed in 52 (59%). Pleural alterations were seen in 65 (73.8%): pneumothorax in 49 (56%), hemothorax in 36 (41%), and hemopneumothorax in 26 (30%). Vasoactive agents were required for 38 (43%) to achieve hemodynamic stability. Fourteen of these patients (16%) underwent surgery and 9 of them died (65%). The 36 patients who died in this group all needed ventilation (41%).

Statistically significant differences between ventilated and non-ventilated patients were found for mean duration of ICU stay, evidence of pulmonary contusion on x-rays, bilateral pulmonary contusion, pleural alterations overall (both hemo- and hemopneumothorax) (Table 1).

Among mechanically ventilated patients (Table 2), survivors had a longer mean stay in the ICU and a longer duration of ventilation, at lower levels of PEEP. Among patients who died, the rates of thoracic instability, pulmonary contusion, bilateral pulmonary contusion, hemothorax, pneumothorax, and hemodynamic instability were higher.

The PEEP levels for patients with pneumothorax were higher than those without that complication (10.3[4.9] mbar vs 6.7[6.3] mbar, respectively; Wilcoxon test, *P*=.004).

We then performed multivariate analysis, initially including data for all 108 patients in the series and proceeding to stepwise logistic regression, with death in the ICU as the dependent variable and the following parameters as independent variables: history of bronchial disease, history of heart disease, head and brain injury, abdominal trauma, radiographic signs of pulmonary contusion, bilateral pulmonary contusion, pneumothorax, hemothorax, thoracic instability, concurrent infection, the need for mechanical ventilation, PEEP over 10 mbar, hemodynamic instability, and the need for emergency surgery. Variables that were statistically significant in the model were history of bronchial disease (*P*=.049; odds ratio [OR], 19.1), the presence of bilateral pulmonary contusion (*P*=.033; OR, 12.9), and the need for emergency surgery (*P*=.041; OR, 20.3) (Hosmer-Lemeshow goodness of fit, *P*=1).

Finally, stepwise logistic regression was used again to study mortality in patients requiring ventilation. Death in the ICU was again the dependent variable. The same independent variables were used, except for the need for ventilation, which was replaced by duration of ventilation. After Hosmer-Lemeshow analysis (*P*=1) the factors found to be statistically significant were a history of chronic bronchial disease (*P*=.05; OR, 23.15), bilateral pulmonary contusion (*P*=.041; OR, 12.7), maximum PEEP level over 10 mbar (*P*=.01; OR, 71.3), and the need for emergency surgery (*P*=.043; OR, 22).

Discussion

The exclusion of patients with pelvic and/or lower limb injuries might cause bias in the analysis of mortality in our study. However, one of the complications patients with such injuries suffer is the formation of fat embolisms, a phenomenon that can lead to radiographic signs similar to those seen in patients with chest injuries who have refractory hypoxemia. We therefore excluded such patients, as it would have been difficult to differentiate pulmonary alterations caused by a fat embolism from those caused by chest trauma.

Furthermore, it may be that the decision to study only ICU mortality has led to the loss of information related to overall mortality. We did not consider it necessary to prolong the study period to that of the full time of hospitalization, however, under the assumption that the ICU stay comprised the period of greatest threat to life, such that mortality on other wards would be minor except in cases in which only palliative care was being provided.

The parameters chosen for this study involved certain inconveniences that might pose a limitation. One of them is that of not having performed a CT scan of the thorax on all patients. Although the diagnostic yield of CT is lower than that of simple radiography for detecting rib fractures, scans would have allowed us to diagnose parenchymal lesions and pleural alterations not visible on x-rays. CT would also have provided information on the condition of the great vessels of the thorax.[11,12] CT is not available 24 hours a day in some hospitals, however, and it involves moving the patients, possibly endangering those whose condition is not stable. Moreoever, great vessel lesions cause significant hemodynamic instability and many patients so-injured die in transfer,[13] meaning their exclusion would cause only slight bias.

As echocardiography was not available for all patients, we were unable to analyze the effect of the presence of myocardial contusion on outcome in this patient series. Echocardiography provides information about dyskinesia and hypokinesia in the regions where there is myocardial contusion. However, it is also a technique that is not available 24 hours a day in some hospitals, and its usefulness, particularly in the thoracic window, is limited in the presence of hemo- or pneumothorax. Bearing in mind that myocardial contusion is usually accompanied by electrocardiographic alterations as well as tachycardia and hemodynamic instability, the inclusion of those variables in our study would mean that the possible bias from failing to detect myocardial contusion would be minor.[14-17]

Assessment of vascular refilling by way of central venous pressure, rather than systematic use of a Swan-Ganz catheter, might suggest suboptimal management of hemodynamics. Although it can be argued that using a pulmonary artery catheter has advantages, it is also true that most information provided by them is of minor practical importance in the absence of serious cardiac injury and/or signs of sepsis. Thus, not quantifying the precise volume of blood products or fluid therapy used is a limitation for this study, given that these parameters are related to the development of certain complications (coagulopathy, acute respiratory distress syndrome).

Although it might seem that using the maximum PEEP value, designated based on clinical criteria, implies a lack of systematic use of ventilation levels, it is widely accepted that PEEP should be set at the lowest possible level able to provide adequate oxygenation with the least possible hemodynamic repercussion.[18-20]

Finally, objection might be made as to the admission criteria for our ICU patients, as they were wide-ranging and possibly subjective. This is particularly evident in the comparison between patients who required mechanical ventilation and those who did not, and in the decision to include the latter in the study. In this sense we must bear in mind that it is often at first impossible to distinguish patients who will need ventilation from those who will not. Moreover, if we consider that it is the ICU's duty to treat not only critically ill patients but also to provide adequate monitoring of patients who are potentially critical, provided the resources are available, the admission criteria, while wide-ranging, are acceptable. We believe that it is preferable to accept more patients into the ICU to provide stricter initial monitoring, and thereby avoid seeing a patient's condition worsen on the ward, where resources are not ideal for careful monitoring.

We did not see a higher mortality rate among polytrauma patients, even those with head and brain injury in our series, a finding that differs from reports in the literature.[2,21-23] This seems to imply that blunt chest trauma is per se an independent predictor of mortality, although it is not easy to compare our study with others. One explanation would be that the condition of our subgroup of patients with head and brain injury was less severe than that of patients described by other authors. However, the rate of pulmonary lesions in our patients was similar to the rates reported by Segers et al.[22]

The univariate comparison of patients who needed ventilation and those who did not (Table 1) shows that none of the unventilated patients died. Above, we have discussed the implications of our inclusion of patients not requiring ventilation. The factors most directly related to the presence of pulmonary lesions (uni- or bilateral pulmonary contusion, pleural space alterations) were present more often in patients needing mechanical ventilation. Looking only at the results for ventilated patients (Table 2), we see that those who died had higher rates of pulmonary contusion and of more severe (bilateral) contusion, higher levels of PEEP, and a higher rate of more severe hemodynamic instability. These observations are consistent with the study of Dimopoulou et al,[23] who found a higher mortality rate in patients with such lesions. Similarly, Pape et al[24] reported a higher mortality rate in patients with pulmonary contusion and hemopneumothorax in a large retrospective study and they confirmed that isolated rib cage lesions are not associated with higher mortality. Our findings differ from those of Sirmali et al[25] and Liman et al,[26] however. The former concluded that more rib fractures lead to higher morbidity and mortality and that other lesions found (hemo- or pneumothorax, contusion, etc) are less predictive of poor prognosis. Liman et al saw patterns more similar to those of our study, observing higher mortality among patients with high injury severity scores. Many of the items on their injury severity score referring to blunt chest trauma were included in our study. This suggests that our results partially overlap those of Liman et al.[26]

The shorter ICU stay of patients who did not require ventilation is unsurprising. If we start with the assumption that the admission criteria are acceptable, surely they were patients who were admitted for monitoring of clinical course, and they were also seen to have less severe injuries. The shorter mean stay of patients who died is attributable to early death, which also meant fewer days of ventilation.

The multivariate analysis offered interesting results. In spite of the relatively small number of patients studied, significant differences were found for certain variables, namely those that were most closely related to the presence of pulmonary parenchymal injury, particularly bilateral pulmonary contusion and, in patients on mechanical ventilation, high PEEP levels. Furthermore, by including aspects of medical history in the multivariate analysis, we found that patients with pre-existing respiratory problems (bronchial disease) were at greater risk of death. Once again our findings are consistent with those of other authors, who identified pulmonary contusion to be a risk factor for mortality.[21-24,26] Patients who underwent emergency surgery were also at greater risk, an observation that is attributable to the severity of their injuries in addition to the risk from surgery itself.

Finally, patients with blunt chest trauma who have bilateral pulmonary contusion and who also require mechanical ventilation and PEEP levels exceeding 10 mbar have a higher risk of death. Patients with chest trauma who do not require mechanical ventilation have negligible risk of death whether they also have other injuries or not, particularly if no radiographic signs of contusion are present. Most of those patients can be discharged from the ICU within 24 to 48 hours, or could be initially admitted to an intermediate care ward. The absence of a higher mortality rate among polytrauma patients in our series in comparison with patients with only chest trauma has not been observed by other authors. It may be that the blunt chest trauma cases in our study were more serious or that the polytrauma patients we studied were less seriously injured. Our findings, given the characteristics of our study, do not allow us to assert that blunt chest trauma-only and multiple-injury patients have identical risk.

We conclude that, in spite of the limitations of this study, the results indicate that greater severity of initial pulmonary lesion (bilateral contusion, the need for mechanical ventilation, higher PEEP required) and the need for emergency surgery in polytrauma patients, lead to greater risk of death.

REFERENCES

1. LoCicero JI, Mattox KL. Epidemiology of chest trauma. Surg Clin North Am 1989;69:15-9.
2. Baker CC, Oppenheimer L, Stephens B, Lewis FR, Trunkey DD. Epidemiology of trauma deaths. Am J Surg 1980;140:144-50.
3. Shorr RM, Crittenden M, Indeck M, Hartunian SL, Rodríguez A. Blunt thoracic trauma. Analysis of 515 patients. Ann Surg 1987; 206:200-5.
4. Tonge JI, O'eilly MJ, Davison A, Johnston NG, Wilkey IS. Traffic crash fatalities (1968-73). Injury and other factors. Med Sci Law 1977;17:9-24.
5. Murray JF, Matthay MA, Luce M, Flick MR. An expanded definition of the adult respiratory distress syndrome. Am Rev Respir Dis 1988;138:720-3.
6. Morel DR, Dargent F, Bachman M, Suter PM, Junod AF. Pulmonary extraction of serotonin and propranolol in patients with adult respiratory distress syndrome. Am Rev Respir Dis 1985;132:479-84.
7. Artigas A, Carlet J, McGall JR. Clinical presentation prognostic factors and outcome of ARDS in the European collaborative study (1985-1987). In: Zapol W, Lemare F, editors. Adult respiratory distress syndrome. New York: Dekker, 1991; p. 37-63.
8. Zapol WM, Frikke MJ, Pontoppidian H. The adult respiratory distress syndrome at Massachusets General Hospital. In: Zapol W, Lemare F, editors. Adult respiratory distress syndrome. New York: Dekker, 1991; p. 367-80.
9. Richter M, Krettek C, Otte D, Wiesse B, Stalp M, Ernts S, et al. Correlation between crash severity, injury severity, and clinical course in car occupants with thoracic trauma: a technical and

medical study. J Trauma 2001;51:10-6.
10. Yates DW. Índices de gravedad en el paciente politraumático. In: Net A, Marruecos-Sant L, editors. El paciente politraumatizado. Barcelona: Springer-Verlag, 2000; p. 40-6.
11. Kunisch Hoppe M, Bachmann G, Hoppe M, Weimar B, Bauer T, Zickmann B, et al. CT quantification of pleuropulmonary lesions in severe thoracic trauma. Rofo Fortschr Geb Rontgenstr Neuen Bildgeb Verfhar 1998;167:453-7.
12. Poole GV, Morgan DB, Cranston PE, Muakkassa FF, Griswold JA. Computed tomography in the management of blunt thoracic trauma. J Trauma 1993;35:296-300.
13. Martínez JC. Asistencia prehospitalaria al paciente politraumatizado. In: Net A, Marruecos-Sant L, editors. El paciente politraumatizado. Barcelona: Springer-Verlag, 2000; p. 47-66.
14. Cinella G. Use of CT scan and transesophageal echocardiography in blunt thoracic trauma. Intensive Care Med 1999;24:986-7.
15. Jhonsonn SB, Kearny PA, Smith MD. Echocardiography in the evaluation of thoracic trauma. Surg Clin North Am 1995;75:193-205.
16. Chan D. Echocardiography in thoracic trauma. Emerg Med Clin North Am 1998;16:191-207.
17. Potkin RT, Werner JA, Trobaugh GB, Chestnut CH, Carrico CJ, Hallstrom A, et al. Evaluation of non invasive test of cardiac damage in suspected cardiac contusion. Circulation 1982;66:627-31.
18. Suter P, Fairley H, Isemberg M. Optimum end expiratory airway pressure in patients with acute pulmonary failure, N Engl J Med 1975;292:2984-9.
19. Gattini L, Pelosi P, Crotti S, D'Andrea L. Effect of positive end expiratory pressure on tidal volume and recruitment in adult respiratory distress syndrome. Am J Respirat Cri Care Med 1995;151: 1807-14.
20. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. N Engl J Med 2000;342:1301-8.
21. Sonnerborn R, Espinoza R, Geni R, Rodríguez A, Power E, Plaza de los Reyes M. Resultados del tratamiento en 588 pacientes politraumatizados. Rev Med Chil 1999;126:1478-82.
22. Segers P, van Schil P, Jorens P, van den Brande F. Thoracic trauma: an analysis of 187 patients. Acta Chir Belg 2002;101: 277-82.
23. Dimopoulou I, Anthi A, Lignos M, Boukouvalas E, Evangelou E, Routso C, et al. Predicition of prolonged ventilatory support in blunt thoracic trauma patients. Intensive Care Med 2002;29:1010-105.
24. Pape HC, Remmers D, Rice J, Ebisch M, Krettek C, Tschern H. Appraisal of early evaluation of blunt chest trauma: development of a standarized scorinf system for initial clinical decision making. J Trauma 2000;49:496-504.
25. Sirmali M, Türüt H, Topcu S, Gülhan E, Yazici U, Kaya S, et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg 2003;24:133-8.
26. Liman ST, Kuzucu A, Tastepe AI, Ulasan GN, Topcu S. Chest injury due to blunt trauma. Eur J Cardiothorac Surg 2003;23:374-8.