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ORIGINAL RESEARCH

Validation of the Thorax Trauma Severity Score for mortality and its value for the development of acute respiratory distress syndrome

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Background: The aim of the present study was to evaluate and to validate the Thorax Trauma Severity Score (TTSS) for mortality.

Methods: By database analysis 712 patients with an injury to the chest admitted to the Universal Medical Center Utrecht between 2000 and 2004 were studied. All patients with a score of ≥1 on the AIS_{thorax} were included in the study. The patients' file was evaluated for: TTSS, intensive care unit stay, days on ventilation, thorax trauma-related complications (eg, acute respiratory distress syndrome [ARDS]), total hospital stay, and mortality.

Results: Of the 516 patients included in the study, 140 (27%) developed thorax-related complications. The overall in-hospital mortality rate was 10%. The receiver operating characteristic curve for predicting mortality demonstrated an adequate discrimination by a value of 0.844. The TTSS was statistically significant higher in patients who died of thorax-related complications than in patients who died because of nonthorax-related complications and survivors ($P < 0.001$, confidence interval [CI] 95%). In patients who developed ARDS the TTSS was significant higher ($P = 0.005$, CI 95%).

Conclusion: This study supports the use of the TTSS for predicting mortality in thoracic injury patients. Furthermore, the TTSS appears capable of predicting ARDS.

Keywords: wounds and injuries, thorax, trauma severity indices, acute respiratory distress syndrome, mortality

Introduction

Rapid and accurate assessment of the chest in blunt trauma patients is important to direct life-saving and definitive management. Solid risk stratification of thoracic trauma is needed for individual management of ventilation, intensive care support, and surgical strategy selection to reduce morbidity and mortality. If patients are not treated properly they can suffer from major disabilities.[1,2]

The present standards for assessing thoracic trauma vary widely.[3–5] A scoring system that can help predict thorax related complications in thoracic trauma patients is needed. For this in 2000 Pape et al[6] developed the Thorax Trauma Severity Score (TTSS). As demonstrated in Table 1, the TTSS combines the patient's age, resuscitation parameters, and radiological assessment of the thorax. After the first publication in 2000 the score has never been validated by any other independent study, and the association of the score with thoracic related death and mortality has not been explored. This makes it more difficult to add it to other widely used scorings systems, such as the Glasgow Coma Score[7] or the Injury Severity Score.[8]

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Table 1 The TTSS developed by Pape et al[6] to predict mortality in thoracic trauma patients

Grade	PaO_2/FiO_2	Rib fracture	Contusion	Pleural involvement	Age	Points
0	>400	0	None	None	<30	0
I	300–400	1–3	1 lobe, unilateral	PT	30–41	1
II	200–300	3–6	1 lobe, bilateral or 2 lobes unilateral	HT/HPT unilateral	42–54	2
II	150–200	>3 bilateral	<2 lobes bilateral	HT/HPT bilateral	55–70	3
IV	<150	Flail chest	≥2 lobes bilateral	TPT	>70	5

Notes: For calculation of the total score, all categories are summed. A minimum value of 0 points and a maximum value of 25 points can be achieved.
Abbreviations: PT, pneumothorax; HT, hemothorax; HPT, hemopneumothorax; TPT, tension pneumothorax; TTSS, Thorax Trauma Severity Score.

The aim of the present study was to evaluate and to validate the TTSS for mortality and evaluate the correlation between the TTSS and thorax-related complications such as acute respiratory distress syndrome (ARDS).

Materials and methods

All patients admitted to the University Medical Center Utrecht level-1 emergency department (ED) from January 1, 2000 until January 1, 2005 were evaluated. We searched the trauma database for patients with any injury to the chest and performed a retrospective analysis. Written informed consent was not required because of the retrospective nature of the investigation.

The TTSS employs 5 specific parameters: rib fractures, lung contusion, PaO_2/FiO_2 ratio, age, and pleural involvement. These parameters are coded from 0 to 5. The TTSS is calculated by adding the coded values for each of these five parameters; minimum score is 0 and maximum score is 25. The individual TTSS was calculated for every patient (see Figure 1).

Patients were included in this study if they scored ≥1 on the Abbreviated Injury Score$_{thorax}$ (AIS$_{thorax}$).[9] Patients referred from other hospitals were included if the referral was within 8 hours and if major surgical procedures were done in our institution.

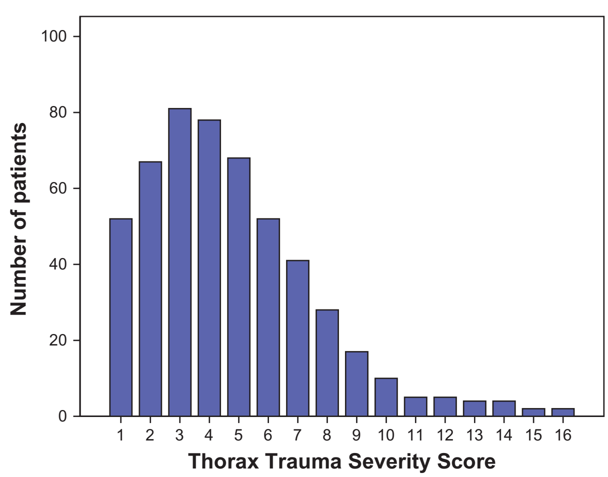

Figure 1 Distribution of the number of patients and the Thorax Trauma Severity Score in 516 thorax trauma patients.

The following factors were retrieved from the original patients' files: TTSS parameters as mentioned above, patients' age, sex, base excess at admission, total hospital stay, intensive care unit stay, resuscitation length, thorax-related complications, and mortality. The admission day chest X-rays of every patient were independently evaluated by a trauma radiologist (LB). The following thorax-related complications were registered: pneumonia, second pneumothorax, persistent hematothorax, ARDS,[10] and empyema.

Statistical analysis

Statistical analyses were performed by using SPSS 15 (v 15, for Windows, SPSS, Inc, Chicago, IL). The association between various parameters was evaluated using unvaried analysis. Statistical analysis was performed with the nonparametric Mann–Whitney *U* test to compare two groups and Kruskall–Wallis *H* test to compare multiple groups. Predictive values were calculated using a receiver operating characteristic curve (ROC) analysis. Statistical significance was defined as $P < 0.05$.

Results

Demographics

Of the 712 patients in total registered in the study period with an injury to the chest, 189 did not score any point on the AIS$_{thorax}$ and were excluded. This excluded group harbored for example patients with a minor laceration to the chest wall. So, in total 516 patients (73%) were included in the study. Demographic data are presented in Table 2.

Admission severity and events

Of TTSS characteristics, 70% of the 516 included patients at least one rib fracture (Table 3). Lung contusion was diagnosed in 44%, pneumothorax in 26%, hemothorax in 13%, and tension pneumothorax in 2%.

The distribution patten in our study cohort among the different TTSS scores was almost normal (Figure 1).

Table 2 Patient demographics

Number of patients	516
Mean age (years)	43
Sex of patient, n (%)	
Male	375 (73%)
Female	141 (29%)
Days of hospital stay (median)	23
Patients in ICU, n (%)	271 (53%)
Length of ICU stay (median)	8
Ventilated patients, n (%)	233 (45%)
Length of ventilation (median days)	7
TR complications, n (%):	140 (27)
Pneumonia	102 (20%)
Second pneumothorax	23 (5%)
Second hematothorax	9 (2%)
Empyema	8 (2%)
ARDS	29 (6%)
Total patients	140 (27%)
Mortality	52 (10%)

Abbreviations: ICU, intensive care unit; n, number; TR, thorax-related; ARDS, acute respiratory distress syndrome.

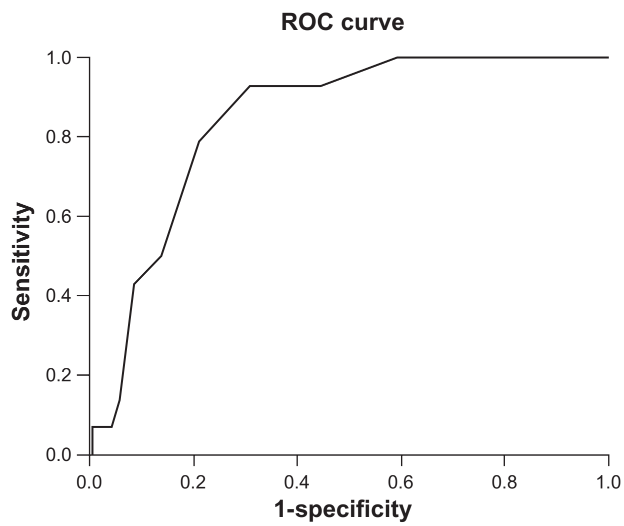

Figure 2 Receiver operating characteristic curve (ROC) analysis of the Thorax Trauma Severity Score, designed to predict mortality. The area under the curve shows a value of 0.844.

As expected, the peak number of patients was within the lower TTSS scores, most patients scoring three points (modus). The maximum score of patients admitted alive to our ED was 16.

The overall in-hospital mortality rate was 10% (53 patients). Mortality was correlated with high TTSS. The ROC was used to demonstrate the sensitivity and specificity of the TTSS for predicting mortality during hospital stay. The area under the curve (AUC) shows a value of 0.844 (Figure 2). Patients who died of thoracic-related complications had a higher TTSS than patients who survived ($P \leq 0.001$, CI 95%) (Figure 3). Patients who died of thorax-related complications scored higher than patients who died of nonthorax-related complications ($P = 0.014$, confidence interval 95% [CI 95%]). No significant difference was found between the group of patients who died of nonthorax-related causes and the surviving patients ($P = 0.114$, CI 95%).

The total number of thorax trauma-related complications was 140 (27%): 102 patients suffered from hospital-acquired pneumonia, 23 patients developed a secondary pneumothorax, nine patients developed a persistent hematothorax, empyema was seen in eight patients, and 29 patients were diagnosed with ARDS (Table 2).

Patients who developed ARDS scored a higher TTSS than non-ARDS patients ($P = 0.005$, CI 95%) (Figure 4). Of note, four patients who scored 15 or 16 points did not

Table 3 Patients chest-wall injuries of the TTSS

Chest-wall injuries	Incidence n (%)
Rib fractures	363 (70%)
Unilateral	325 (90%)
Bilateral	38 (10%)
Lung contusion	230 (44%)
Unilateral	145 (63%)
Bilateral	85 (37%)
Pneumothorax	137 (26%)
Unilateral	126 (92%)
Bilateral	11 (8%)
Hemothorax	68 (13)
Unilateral	65 (96%)
Bilateral	3 (4%)
Tension pneumothorax	12 (2%)
Hemopneumothorax	19 (4%)
Unilateral	17 (89%)
Bilateral	2 (11%)

Abbreviations: n, number; TTSS, Thorax Trauma Severity Score.

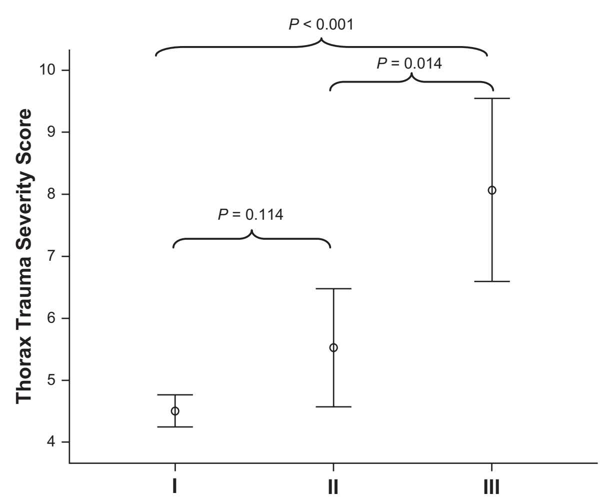

Figure 3 A standard error of mean figure of the Thorax Trauma Severity Score and patients who survived (**I**), patients who died of nonthorax-related complications (**II**), and patients who died of thorax-related complications (**III**).

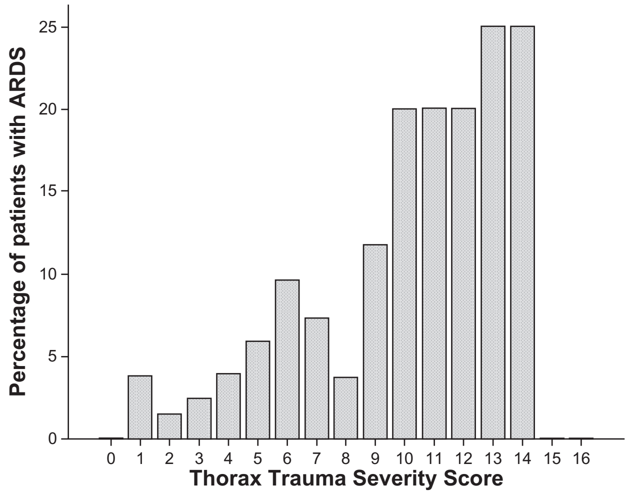

Figure 4 Percentage of patients with acute respiratory distress syndrome (ARDS) and Thorax Trauma Severity Score.

develop ARDS as they died earlier in the process and did not have the time to develop it.

Discussion

This is the first study to validate the TTSS for mortality and describe an association between the score and the development of ARDS.

We analyzed the collected data from original patients' files of a total number of 516 chest trauma patients. All radiological findings were reviewed by the same dedicated trauma radiologist, which ensured a consistent way of reviewing every chest X-ray and ruled out inter-observer variability occurring in radiological documentation reports.

We used the results from the admission chest X-ray, as originally described by Pape.[6] This type of radiological diagnostics will probably still be used for an extensive time in the advanced trauma life support.[11] This modality is easily available in every hospital. By using the chest X-ray, the TTSS can also be used in hospitals where early chest computed tomography (CT) scan is not yet fully integrated in the early care. Moreover, the chest X-ray is a quick modality with a specific diagnostic yield and still is of importance in the early work up of trauma patients. To put it in perspective, however, chest X-ray can miss rib fractures more than 50% of the time compared to the CT scan.

The predictive value of the TTSS could not be demonstrated in this study since the method was not set up to calculate the predictive value of the TTSS. Nevertheless, we did demonstrate a clear association between the TTSS and several outcome parameters.

Several general scorings systems for trauma patients have shown excellent values for predicting outcome.[12,13] In concordance with trauma scores such as the New Injury Severity Score (AUC of 0.827)[14] the TTSS demonstrated a high AUC of 0.844 which makes it a sensitive and specific scoring system for predicting mortality. In addition our study was able to demonstrate an association between the TTSS and thorax-related death. The score was significantly higher than in patients who died of other complications and even more so in all patients who survived. This extra characteristic of the score could be of added value in trauma evaluation.

The thorax trauma-related complication rate has been shown to be high (27%) and can be severe.[15] Although the mortality of ARDS has declined during the last decade, ARDS is still is one of the most serious thorax trauma-related complications, with a mortality rate of 20%–43%,[16,17] and accounts for about 7%–9% of intensive care unit admissions per year.[18] However, Davidson et al concluded that there was no difference in the long-term mortality rate for ARDS patients.[19] Miller et al[20] published several independent risk factors for developing ARDS, but the maximum AUC was 0.72. We showed that the TTSS is significantly higher in patients who develop ARDS after thorax trauma. To our knowledge no other scoring system has demonstrated an association with the development of ARDS. This may lead to a different clinical policy on blood transfusion in patients with a high TTSS. Restrictive transfusion policies and ventilation strategies are advised for these patients because these measures are associated with a decreased incidence of ARDS.[21,22]

Some limitations of our study should be acknowledged. First, the design of the study was retrospective. Although it had an advantage that every chest X-ray was assessed by the same radiologist, this is also a limitation, because we were therefore unable to calculate inter-observer variability for interpretation of the chest X-rays with kappa statistics. The interpretation of the chest X-ray by the radiologist could not be compared with a gold standard because not all patients received a subsequent chest CT-scan in the ED, yet this is the way the original score was constructed.

In future an increasing number of EDs will be equipped with a CT scanner for quick radiological diagnosis. The CT scan is more sensitive and specific than the conventional chest X-ray for diagnosing the radiological items used in the TTSS (rib fracture and lung contusion).[23–25] In future studies, radiological results of the CT scan may be used for the TTSS to further improve the sensitivity and specificity of the scoring system.

In conclusion this study supports the use of the TTSS for predicting mortality in thoracic injury patients. Furthermore, the TTSS appears capable of predicting ARDS.

Prior publication

This paper was first presented in part at the Annual Congress of the Dutch Society of Surgery [Nederlandse Vereniging voor Heelkunde], May 11, 2007, Veldhoven, The Netherlands.

Disclosure

The authors declare no conflicts of interest in relation to this paper.

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