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The thorax trauma severity score and the trauma and injury severity score: Do they predict in-hospital mortality in patients with severe thoracic trauma?

A retrospective cohort study

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Abstract

Several scoring systems are commonly used to evaluate severity in patients with traumatic injuries. However, there is no generally accepted standard scoring system to assess the severity of thoracic trauma, specifically in patients who have sustained severe injuries. The present study aimed to evaluate the validity of the trauma and injury severity score (TRISS) and the thorax trauma severity score (TTSS) as predictors of in-hospital mortality in patients with severe thoracic trauma.

We conducted a retrospective, consecutive review of the medical records of patients with severe thoracic trauma who were managed at our institution between January 2005 and December 2015. Inclusion criteria were patients with severe thoracic injury (injury severity score > 18) who required intensive care therapy and who had no local or systemic infection. We analyzed the association between the trauma severity scores (TTSS and TRISS) and in-hospital mortality in these patients. We also determined the predictive value of the scores using receiver-operating characteristic (ROC) curves.

A total of 228 patients with severe thoracic trauma were included in this study. The in-hospital mortality rate was 21.9%. There was a statistically significant association between the TRISS and in-hospital mortality ($P < .001$), but the association between the TTSS and in-hospital mortality was not statistically significant ($P = .547$). The ROC curve demonstrated adequate discrimination, as demonstrated by an area under the curve value of 0.787 for the TRISS. At a cut-off value of 25.9%, the TRISS had a sensitivity of 83.6% and specificity of 73.5% to predict in-hospital mortality.

The present study demonstrated that the TRISS, but not the TTSS, can be used to predict in-hospital mortality in patients with severe thoracic trauma; hence, additional prospective studies are required.

Abbreviations: AUC = area under the curve, GCS = Glasgow coma scale, IQR = interquartile range, ISS = injury severity score, ROC = receiver-operating characteristic, RR = respiratory rate, RTS = revised trauma score, SBP = systolic blood pressure, TRISS = trauma and injury severity score, TTSS = thorax trauma severity score.

Keywords: injury severity score, mortality, thorax, wounds and injuries

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1. Introduction

Severe thoracic injury is a major cause of trauma-related death. Various scores have been developed to determine the severity of traumatic injury. Accurate evaluation of the level of severity of thoracic trauma is important for instituting correct treatment, predicting the need for intensive care, and predicting mortality.[1] Several trauma scoring systems exist; of these, the trauma and injury severity score (TRISS) is most commonly used to predict mortality.[2,3] The TRISS system was developed in 1980s to improve the prediction of patient outcomes following trauma through the use of physiological and anatomical criteria.[3] It used a weighted combination of a patient's age, injury severity score (ISS), and revised trauma score (RTS) to predict a patient's probability of death following trauma.[3–6] Despite the TRISS being widely used, it is not a specific scoring system for isolated thoracic trauma, the severity of which it seems to underestimate.[1] Furthermore, it may take several hours from emergency department admission until a complete diagnosis of all injuries is possible, limiting the usefulness of the score in clinical decision making.[1,3,6] To overcome these shortcomings, Pape et al[6] developed the thorax trauma severity score (TTSS), a score that includes both anatomical and functional parameters of thoracic trauma. Hence, the aim of our study was to identify the validity of the TRISS and TTSS as predictors of in-hospital mortality in patients with severe thoracic trauma.

2. Methods

2.1. Study population

This retrospective study was approved by the Institutional Review Board of the Gyeongsang National University Hospital. We retrospectively and consecutively evaluated patients with severe thoracic trauma (ISS > 18) who were treated in our institution between January 2005 and December 2015. We identified 357 patients with severe thoracic injury who received intensive care therapy, had a Glasgow coma scale (GCS) score >8 points, survived for >2 days after sustaining trauma, were artificially ventilated for >2 days, and had no local or systemic infection (eg, pneumonia or sepsis) at the time of sustaining a traumatic injury. Based on these criteria, 129 patients were excluded, and 228 patients were finally included in our study. Data on the patients' demographics, mechanism of injury, TRISS and TTSS values, thoracic trauma characteristics, clinical course, and in-hospital mortality were extracted from the medical records.

2.2. Definitions

The ISS is an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury is assigned an abbreviated injury scale score and is allocated to one of the following 6 body regions: head, face, chest, abdomen, extremities (including the pelvis), and external. Only the highest abbreviated injury scale score for each body region is used. The 3 most severely injured body regions have their scores squared and summed to produce the ISS score.[7]

The RTS is a physiological scoring system that has high inter-rater reliability and demonstrates accuracy in predicting death. It is scored from the first set of data obtained on the patient and uses 3 physiological parameters – the GCS, systolic blood pressure (SBP), and respiratory rate (RR) – to score injuries. The minimum and maximum scores are 0 and 7.8408, respectively.[8]

The TRISS calculation uses the ISS and RTS and considers the patient's age and type of trauma (blunt or penetrating). This index is calculated by summing the results of these 3 components and multiplying them by their respective weights. It retrospectively applies a logistic regression model to compute the probability (range: 0–1) using the following equation:

$$\text{Probability of Survival} = 1/(1 + e^{-b})$$

where $b = \alpha + \beta_{Age} \times age + \beta_{RR} \times RR + \beta_{SBP} \times SBP + \beta_{GCS} \times GCS + \beta_{ISS} \times ISS$

In the equation, α, β_{AGE}, β_{RR}, β_{SBP}, β_{GCS}, and β_{ISS} are constants defined differently for patients with blunt trauma and those with penetrating trauma.[3,9]

The TTSS combines the patient's age, resuscitation parameters, and radiological assessment of thoracic trauma. It is calculated by adding each of the values. The minimum and maximum scores are 0 and 25, respectively (Table 1).[6]

In this study, all injuries were classified by the trauma physician, who routinely scores injury severity. In-hospital mortality was defined as all-cause mortality directly related to the trauma event, based on review of the medical records. We did not evaluate either the timing or specific cause of death.

2.3. Data analysis

Missing data were not replaced or imputed. Data are presented as the median and interquartile range (IQR) or number and percentage, as appropriate. The Wilcoxon signed-rank test was used to analyze associations between the trauma scoring systems (TRISS and TTSS) and in-hospital mortality. The diagnostic test characteristics for in-hospital mortality were calculated from receiver-operating characteristic (ROC) curves, using the area under the curve (AUC); specifically, the AUC and 95% confidence intervals were computed. Additionally, the cut-off values associated with the highest sensitivity and specificity values of each scoring system to predict in-hospital mortality were estimated, and the corresponding accuracy, positive predictive values, and negative predictive values were obtained. A 2-sided P-value of <.05 was considered statistically significant. The statistical analyses were performed using R version 3.3.3 for Windows (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

Between January 2005 and December 2015, our hospital managed 228 patients with severe thoracic trauma who met the inclusion criteria. Most were men (n = 187 [82%]), the median age was 67 years (IQR 51–74), and 50 (21.9%) were died. The most common causes of trauma were car accidents (23.7%), cultivator accidents (21.1%), pedestrian accidents (18.8%), falls (18.4%), and motorcycle accidents (18%). A total of 123 (53.9%) patients were smokers or ex-smokers (the latter had not smoked within the last 1 year), and 15 patients had a history of lung disease: 8 (3.5%) had chronic obstructive pulmonary disease, 5 (2.2%) had asthma, and 1 had pulmonary tuberculosis. The median durations of intensive care unit stay and

Table 1

The thorax trauma severity score (Pape et al)[6].

Grade	S*	Rib fractures	Contusion	Pleural involvement	Age, y	Points
0	$400 \le S$	0	None	None	<30	0
I	$300 \le S < 400$	1–3	1 Lobe, unilateral	PTX	30–41	1
II	$200 \le S < 300$	>3	Unilobar bilateral or bilobar Unilateral	HTX/HPTX unilateral	42–54	2
II	$150 \le S < 200$	>3 Bilateral	<2 Lobes bilateral	HTX/HPTX bilateral	55–70	3
IV	$S < 150$	Flail chest	≥2 Lobes bilateral	TPTX	>70	5

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. HPTX = hemopneumothorax, HTX = hemothorax, PTX = pneumothorax, TPTX = tension pneumothorax.

* S is PaO_2/FiO_2.

Table 2

Patient characteristics and outcome (n=228).

Characteristic	n, % or median (IQR)
Age, y	67 (51–74)
Male	187 (82)
Smoking	123 (53.9)
Mechanism of trauma	
Pedestrian	43 (18.8)
Car accident	54 (23.7)
Motorcycle	41 (18)
Cultivator	48 (21.1)
Falls	42 (18.4)
Comorbidity	
COPD	8 (3.5)
Asthma	5 (2.2)
Tuberculosis	2 (0.9)
Length of ICU stay, d	17.0 (8.8–25.0)
Duration of ventilation, d	14.0 (8.0–23.3)
Length of hospital stay, d	50 (21–87)
TRISS	49.4 (24.5–75.5)
TTSS	17 (14–19)
Death	50 (21.9)

COPD=chronic obstructive pulmonary disease, ICU=intensive care unit, IQR=interquartile range, ISS=injury severity score, TTSS=thorax trauma severity score, TRISS=Trauma and Injury Severity Score.

Table 3

Characteristics of the thoracic injuries (n=228).

Characteristic	Number of patients (%)
Number of rib fractures	10 (6–14)[*]
Bilateral rib fractures	146 (64)
Sternal fracture	49 (21.5)
Pulmonary contusion	200 (96.5)
Pneumothorax	181 (79.4)
Bilateral pneumothorax	60 (26.3)
Tension pneumothorax	82 (36)
Hemothorax	213 (93.4)
Bilateral hemothorax	70 (30.7)
Hemopneumothorax	169 (74.1)
Bilateral hemopneumothorax	45 (19.7)
Flail chest	203 (90.2)
Injury to thoracic vessels[†]	12 (5.3)
Diaphragmatic rupture	7 (3.1)
Cardiac injuries[§]	3 (1.3)

[*] Median (interquartile range).
[†] Includes the pulmonary vessels, intercostal artery, internal thoracic artery, and aorta.
[§] Includes tricuspid valve (1) and aortic valve (1) injury, and left atrium rupture (2).

hospital stay were 17.0 days (IQR 8.8–25.0) and 50 days (IQR 21–87), respectively, and patients were artificially ventilated for a median of 14.0 days (IQR 8.0–23.3). Trauma severity was calculated using the TTSS and TRISS. The median TRISS was 49.4 (24.5–75.5); the median TTSS was 17 (14–19) (Table 2). Figure 1 shows the distributions of patients according to TRISS and TTSS values.

Table 3 shows the characteristics of the thoracic injuries managed. The median number of rib fractures was 10 (IQR 6–14), and 146 (64%) patients sustained bilateral rib fractures. Sternal fractures were noted in 49 (21.5%) patients, flail chest in 203 (90.2%), and pulmonary contusion in 220 (96.5%). Seventeen patients (7.5%) underwent surgical treatment to control massive bleeding due to pulmonary laceration. Seven (3.1%) patients sustained a diaphragmatic injury, all of whom underwent surgical repair. Of the 12 (5.3%) patients with traumatic injury to the thoracic vessels, 7 had traumatic aortic dissection, 3 of these patients underwent thoracic endovascular aortic repair once their condition was suitable (1–2 weeks' postinjury). Four (1.3%) patients sustained traumatic heart injuries: 1 had a traumatic tricuspid valve injury, 1 had a traumatic aortic valve injury, and one had a ruptured left atrium. Traumatic pneumothorax was observed in 181 (79.4%) patients, 60 (26.3%) of whom had bilateral pneumothorax and 82 (36%) had tension pneumothorax. Traumatic hemothorax was observed in 213 (93.4%) patients, which was bilateral in 70 (30.7%) patients. Of the 169 (74.1%) patients with hemopneumothorax, 45 (19.7%) had bilateral hemopneumothorax.

There was a statistically significant association between the TRISS and in-hospital mortality ($P<.001$), whereas the

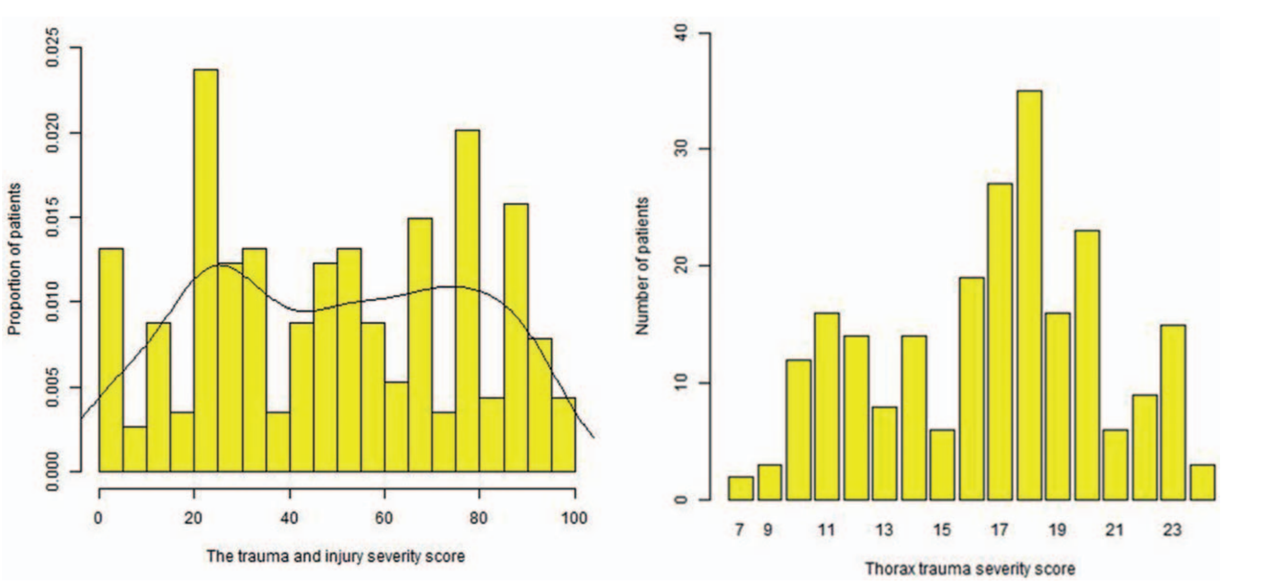

Figure 1. The distribution of scores obtained using the TRISS and TTSS in patients with severe thoracic trauma. TRISS=trauma and injury severity score, TTSS=thorax trauma severity score.

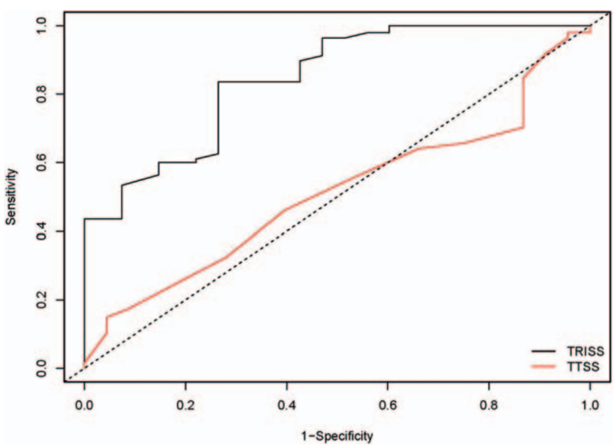

Figure 2. The ROC curve analysis of the TRISS and TTSS designed to predict in-hospital mortality. The TRISS has an AUC value of 0.787; the TTSS has an AUC value of 0.472. AUC=area under the curve, ROC=receiver-operating characteristic, TRISS=trauma and injury severity score, TTSS=thorax trauma severity score.

association between the TTSS and in-hospital mortality was not statistically significant ($P=.547$). ROC curves were used to estimate the sensitivity and specificity of the TRISS for predicting in-hospital mortality: the AUC was 0.787 ($P<.001$) (Fig. 2). Using a cut-off value of 25.9%, the TRISS had a sensitivity of 83.6% and a specificity of 73.5%. The corresponding accuracy was 82.3%. The positive predictive value was higher than expected at 90.1%, but the negative predictive value was lower than expected at 61%.

4. Discussion

Various systems are available for scoring trauma severity. The ideal trauma scoring system should provide an accurate, reliable, and reproducible description of injuries and prediction of morbidity and mortality outcomes in any setting.

The TRISS, developed by Champion et al[10] in 1983, has become the gold standard. Several studies have evaluated its accuracy.[2,3,7–11] Jung et al[9] reported that the TRISS is the best prediction model of trauma outcomes in the current Korean population (AUC=0.91, $P<.001$).[9] Recently, Valderrama-Molina et al[2] reported a study that validates the performance of the TRISS as a predictor of mortality in a population of trauma patients in a Latin American setting. They showed that the TRISS has adequate performance for the prediction of mortality in patients with trauma (AUC 0.86). Our study findings were similar; the AUC was 0.787 ($P<.001$) for in-hospital mortality. Moreover, at a cut-off value of 25.9%, the TRISS had a sensitivity of 83.6% and specificity of 73.5%.

However, the TRISS has several limitations, especially for patients with thoracic trauma.[1,4,6,12,13] As this scoring system was not developed for isolated thoracic trauma, it may underestimate the importance of thoracic trauma in terms of mortality.[1,13] The TRISS is difficult to calculate quickly, and there are limitations to using it as a decision-making tool in emergency situations.[1,4,6,13] Furthermore, the TRISS calculation uses the RTS, which considers the GCS, SBP, and RR variables upon admission. However, calculation of the RTS can be difficult because endotracheal intubation, sedation, and neuromuscular paralysis during prehospital care preclude determining either the GCS score or the spontaneous RR upon admission.[14–16]

To overcome the above-mentioned disadvantages of the TRISS, a scoring system that can help to predict outcomes in thoracic trauma patients is needed. Therefore, in 2000, Pape et al[6] at Hannover Medical School developed the TTSS, based on the results of a retrospective study of 4571 cases of blunt poly-trauma. Inclusion criteria were the treatment of the thoracic injury at their unit, an ISS$\geq$18, initial GCS$>$8 points, survival$>$2 days after sustaining trauma, artificial ventilation$>$4 days, and no local or systemic infection (eg, pneumonia, sepsis, soft tissue infection, acquired immune deficiency syndrome, or tuberculosis) at the time of trauma.[6] After the publication of the TTSS in 2000, some studies reported an association between the TTSS score and thoracic trauma-related outcomes. In 2011, Aukema et al[13]suggested that the TTSS was useful for predicting mortality and acute respiratory distress syndrome. In 2016, a study by Martinez Casas et al[1] concluded that the TTSS is an appropriate and feasible tool to predict the development of complications or mortality in patients with mild thoracic trauma. Our study established inclusion criteria (ISS$>$18, GCS score$>$8 points, survived for >2 days after sustaining trauma, were artificially ventilated for >2 days, and had no local or systemic infection) similar to Pape et al[6] to confirm the findings of the TTSS reported in that study. In our study, unlike previous reports, the Wilcoxon signed-rank test ($P=.547$) and ROC curve (AUC 0.472) showed no association between the TTSS value and trauma-related outcomes. However, considering the importance of TTSS as an instrument to improve the quality of care provided to thoracic trauma patients, further research is warranted.[1,6,13]

Some limitations of our study should be acknowledged. First, we only evaluated patients from a single hospital, which may have introduced selection bias and may limit the extrapolation of our findings to the entire population of patients with severe thoracic trauma. Second, our study evaluated a relatively small number of patients with severe thoracic trauma; thus, larger studies are needed to validate our findings. Third, our study was a retrospective evaluation, and, as with all trauma registries, the accuracy of the recorded data may vary.[17] Accurate prospective and larger population studies are needed to support our findings.

5. Conclusion

Since no complete trauma scoring system currently exists, continuous validation is needed. The present study demonstrates that the TRISS, but not the TTSS, can be used to predict in-hospital mortality in patients with severe thoracic trauma; hence, additional prospective studies are required. We believe that our study provides important information regarding validation of the trauma severity score and that our results play an important role in the accurate prediction of trauma outcomes.

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