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Using Scoring Systems to Predict Thoracic Trauma Mortality in Emergency Department Management

Acil Servis Yönetiminde Torasik Travma Mortalitesini Tahmin Etmek için Puanlama Sistemlerinin Kullanılması

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ABSTRACT

Background: Thoracic trauma accounts for approximately one-third of trauma cases admitted to the hospital, and approximately 20–25% of trauma-related deaths can be attributed to this type of injury. Given the significant morbidity and mortality associated with thoracic trauma, this study investigates the predictive value of trauma scoring systems for complications and mortality in affected patients.

Materials and Methods: This was a single-center, retrospective study. Patients who presented to the emergency department of a tertiary care hospital in Türkiye between January 1, 2021 and December 31, 2022 with trauma were consulted by the thoracic surgery clinic, and those who did not meet the exclusion criteria were included in the study. The diagnostic value of trauma scoring systems for predicting complications and mortality associated with thoracic trauma has been evaluated.

Results: A total of 329 patients were enrolled: 226 males (68.7%) and 103 females (31.3%); median age was 59 years (interquartile range: 48–70). Compared with the non-complication group, patients with complications had significantly higher Abbreviated Injury Scale (AIS), American Association for the Surgery of Trauma (AAST) score, Rib Fracture Scoring System, Chest Trauma Score (CTS), and Rib Score values, and lower Revised Trauma Score (RTS) values (all $p < 0.001$). In the mortality analysis, decedents demonstrated significantly lower RTS and higher AIS and AAST scores (all $p < 0.001$).

Conclusion: Our findings suggest that the AIS and the RTS may be more appropriate for predicting mortality, whereas the CTS may be more suitable for predicting complications.

Keywords: Thoracic trauma, trauma scoring systems, emergency department, mortality

ÖZ

Amaç: Göğüs travması, hastaneye yatırılan travma vakalarının yaklaşık üçte birini oluşturur ve travma ile ilişkili ölümlerin yaklaşık %20–25'i bu tür yaralanmalara atfedilebilir. Göğüs travması ile ilişkili önemli morbidite ve mortalite göz önüne alındığında, bu çalışma göğüs travması olan hastalarda komplikasyonları ve mortaliteyi öngörmede travma skorlama sistemlerinin öngörü değerini araştırmayı amaçlamaktadır.

Gereç ve Yöntemler: Bu çalışma tek merkezli ve retrospektif bir çalışmadır. 1 Ocak 2021 ile 31 Aralık 2022 tarihleri arasında Türkiye'deki bir üçüncü basamak hastanenin acil servisine travma ile başvuran, daha sonra göğüs cerrahisi kliniğine sevk edilen ve dışlama kriterlerine uymayan hastalar çalışmaya dahil edilmiştir. Göğüs travmasında komplikasyonları ve mortaliteyi öngörmede travma skorlama sistemlerinin tanısal değeri hesaplanmıştır.

Bulgular: Toplam 329 hasta çalışmaya dahil edildi; bunların 226'sı erkek (%68,7) ve 103'ü kadın (%31,3) idi ve yaş ortalaması 59 idi (çeyrekler arası aralık: 48–70). Komplikasyon olmayan grupla karşılaştırıldığında, komplikasyonlu hastalar önemli ölçüde daha yüksek Kısaltılmış Yaralanma Ölçeği (AIS), Amerikan Travma Cerrahisi Derneği Puanlama Sistemi (AAST), Kaburga Kırığı Puanlama Sistemi, Göğüs Travması Puanlama Sistemi (CTS) ve Kaburga Puanı (RS) değerlerine ve daha düşük Revize Travma Puanı (RTS) değerlerine sahipti (tümü $p < 0,001$). Mortalite analizinde, ölen hastalar önemli ölçüde daha düşük RTS ve daha yüksek AIS ve AAST skorları gösterdi (tümü $p < 0,001$).

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ÖZ

Sonuç: Bulgularımız, AIS ve RTS'nin mortaliteyi tahmin etmek için daha uygun olabileceğini, CTS'nin ise komplikasyonları tahmin etmek için daha uygun olabileceğini göstermektedir.

Anahtar Kelimeler: Torasik travma, travma skorlarma sistemleri, acil servis, mortalite

Introduction

Trauma patients present with a wide range of symptoms in the emergency department (ED) (1). Trauma is the leading cause of death among young adults (2). Thoracic trauma accounts for one-third of hospitalized trauma cases, and approximately 20–25% of trauma-related deaths are due to thoracic injuries (3,4). Rib fractures are the most common thoracic injury; they typically result from blunt chest trauma and most often involve four to nine ribs. Other common injuries include pneumothorax, hemothorax, and lung contusion (5,6). Early detection of thoracic injuries, which can cause significant morbidity and death, is crucial in the ED.

Emergency management of trauma patients depends on a comprehensive assessment of their medical history, physical examination, vital signs, laboratory results, and imaging findings. Advanced Trauma Life Support guidelines serve as the foundation of this patient's care (7). Evaluating vital signs, certain laboratory parameters, scoring systems, and imaging results helps guide management and inform prognosis in trauma patients (8,9). Likewise, the presence of concomitant thoracic trauma in a multi-trauma patient is important for both ED management and follow-up and treatment strategies. Trauma patients should undergo rapid, thorough triage beginning at the initial assessment, and trauma scoring systems should be used to determine injury severity. Prompt and appropriate initial interventions can reduce mortality and morbidity (10,11).

Given the high morbidity and mortality rates associated with thoracic trauma, it is crucial to determine the severity of thoracic injuries in the ED. To this end, we aimed to evaluate the ability of the Revised Trauma Score (RTS), Abbreviated Injury Scale (AIS), American Association for the Surgery of Trauma (AAST), Rib Fracture Scoring System (RFS), Chest Trauma Score (CTS), and Rib Score (RS) to predict mortality in patients with thoracic trauma.

Materials and Methods

Study Design and Population

This study was single-center, cross-sectional, and retrospective. Approval was obtained from the Recep Tayyip Erdoğan University Non-Interventional Clinical Research Ethics Committee before data collection (decision number: 2023/177, dated: 03.08.2023).

Historically, morbidity and mortality rates associated with different thoracic trauma scores have been observed to range from 10 to 20 per cent (4,12). Similarly, different trauma scores have acceptable accuracy in predicting morbidity and mortality (area under the curve [AUC]: 0.600–0.900) (10,12,13). Based on these studies, we estimated that a sample size of 200–400 patients would be required to use thoracic trauma scores to predict morbidity and mortality, assuming an expected AUC of at least 0.60, an outcome prevalence of 10–20%, and 80% power. After estimating a 10% dropout rate, the final sample size was 223–445 participants.

Patients who presented with trauma to the ED of a tertiary care hospital in Türkiye between January 1, 2021, and December 31, 2022, were evaluated by the thoracic surgery clinic. Those who did not meet any exclusion criteria were included in the study.

Patients under the age of 18, patients aged 90 years and older (excluded because of high comorbidity), patients with chest trauma who did not undergo advanced imaging by computed tomography, patients with minor trauma who did not require consultation with a thoracic surgery clinic, and patients with terminal-stage cancer were excluded from the study.

The study population (n = 329) was selected based on the inclusion and exclusion criteria.

Study Protocol

The study population was defined after applying the inclusion and exclusion criteria.

Demographic data, anamnesis and background information, vital parameters at admission, trauma mechanisms, thoracic examination findings, additional trauma, rib fractures (presence, number, and locations), pneumothorax, hemothorax, pulmonary contusion, sternal fracture, scapular fracture, ED outcome, complications (pneumonia, pulmonary embolism, deep vein thrombosis, acute respiratory failure, tracheostomy, and atelectasis), and hospital outcome were analyzed. All patient data were obtained from the hospital information management system.

Furthermore, RTS, AIS, AAST, RFS, CTS, and RS for the patients included in the study were calculated and analyzed.

Endpoints

The primary endpoint of the study was the diagnostic value of thoracic scoring systems for predicting mortality. The secondary endpoints were defined as the diagnostic values of thoracic scoring systems for predicting complications.

Statistical Analysis

All analyses were performed using Jamovi statistical software (The Jamovi Project [2021] Computer Software, version 1.6. Sidney, Australia). Categorical data were expressed as frequencies (n) and percentages. Normally distributed continuous variables were presented as mean and standard deviation and non-normally distributed continuous variables were presented as median and interquartile range (IQR). The normality of the distribution was evaluated using the Shapiro-Wilk test.

When comparing continuous variables, groups with a normal distribution were compared using the t-test, and those lacking a normal distribution were compared using the Mann-Whitney U test. The chi-square and Fisher's exact tests were used to compare the categorical variables between groups. A receiver operating characteristic (ROC) curve was created to determine the cut-off levels of RTS, AIS, AAST, RFS, CTS, and RS for predicting complications and mortality. In ROC analysis, the maximum value of Youden's index was used to select the cut-off value. Finally, sensitivity, specificity, likelihood ratios (+LR and -LR), and positive and negative predictive values were calculated for the RTS, AIS, AAST, RFS, CTS, and RS. Logistic regression was used for univariate analysis to estimate odds ratios (ORs) and p-values for associations with complications and mortality.

Results

A total of 329 patients were enrolled, comprising 226 males (68.7%) and 103 females (31.3%), with a median age of 59 years (IQR: 48–70). The most common comorbidities were hypertension (34.7%), diabetes mellitus (15.2%), and coronary artery disease (14.0%), whereas congestive heart failure (2.1%), chronic obstructive pulmonary disease (3.0%), atrial fibrillation (3.6%), and prior stroke (2.1%) were less prevalent. At presentation, median systolic and diastolic blood pressures were 120 mmHg (IQR: 120–130) and 80 mmHg (IQR: 80–80), respectively; the median pulse rate was 77/min (IQR: 69–87), the respiratory rate was 15/min (IQR: 14–16), and the oxygen saturation (SO_2) was 97% (IQR: 96–98). Falls and roll-type injuries were the leading trauma mechanisms (66.6%), followed by in-vehicle traffic accidents (19.8%), non-vehicle traffic accidents (4.0%), and gunshot wounds (2.4%). Extra-thoracic injuries were most commonly localized to the head and neck (25.5%) and the extremities (30.0%), with smaller proportions affecting the abdomen (7.9%) and pelvis (4.2%); no cardiac injuries were reported. The median number of rib fractures was 3 (IQR: 0–15). Overall, 47 patients (14.3%) developed complications, and 12 (3.6%) died. There was no statistically significant difference in gender between participants who developed complications and those who did not; however, age differed significantly between the two groups (p = 0.109 for gender, p = 0.038 for age). Furthermore, there were no statistically significant differences in gender or age between the mortality and non-mortality groups (p = 0.265 for gender, p = 0.419 for age). The demographic data and other baseline characteristics of the patients are presented in Tables 1 and 2.

Trauma scores were analyzed: median RTS, 12 (IQR: 12–12); AIS, 3 (IQR: 2–5); AAST, 2 (IQR: 1–2); RFS, 5 (IQR: 3–7); CTS, 4 (IQR: 3–6); RS, 0 (IQR: 0–1). The median RTS, AIS, AAST, RFS, CTS, and RS values measured in the included groups showed a statistically significant difference between the complication and non-complication groups (p = 0.001 for RTS, p = 0.001 for AIS, p = 0.001 for AAST, p = 0.001 for RFS, p = 0.001 for CTS, and p = 0.001 for RS). The median RTS, AIS, and AAST values measured in the included groups differed significantly between the mortality and non-mortality groups (p = 0.001 for RTS, AIS, and AAST). The trauma scores and statistical analyses are presented in Table 3.

ROC analysis identified CTS (AUC: 0.702 ± 0.036; cut-off: 6) as the most accurate predictor of complications, followed closely by AIS (AUC: 0.694 ± 0.040; cut-off: 6) and RFS (AUC: 0.672 ± 0.044; cut-off: 8). AAST demonstrated the highest sensitivity (89.4%) but poor specificity (31.0%), whereas RS achieved the highest specificity (90.6%) but low sensitivity (21.2%). RTS, despite its widespread use, showed limited discriminatory power (AUC: 0.577 ± 0.049). For mortality prediction, AIS outperformed other scores with the highest AUC (0.774 ± 0.075; cut-off: 6) and a balanced sensitivity–specificity profile (66.7% and 79.5%, respectively). RTS ranked second (AUC: 0.742 ± 0.094; cut-off: 7), offering excellent specificity (97.8%) but moderate sensitivity (50.0%). AAST achieved 100% sensitivity but only 29.1% specificity. CTS, RFS, and RS demonstrated modest predictive value, with AUCs ranging from 0.527 to 0.604. ROC curve analyses for complications and mortality are presented in Tables 4 and 5 and Figures 1 and 2.

Of the 329 patients analyzed, 47 developed complications (14.3%) and 12 died (3.6%). All trauma scores were significant predictors of complications. Similarly, RTS, AIS, and AAST scores were statistically significant predictors of mortality. The AAST score was identified as the best score for predicting both complications and mortality (OR for complications: 2.304, 95% confidence interval [CI]: 1.524–3.483, p = 0.001; OR for mortality: 2.329, 95% CI: 1.160–4.677, p = 0.017). The summary of the logistic regression analysis is shown in Table 6.

Discussion

In the present study, we evaluated the prognostic utility of scoring systems in predicting complications and mortality among patients presenting to the ED with thoracic trauma. This study contributes to the literature by simultaneously evaluating multiple scoring systems and assessing their predictive value for both complications and mortality. Our findings suggest that the CTS provides superior predictive value for complications compared with other trauma scoring systems, while the AIS and RTS demonstrate greater suitability for predicting mortality. This observation is consistent with previous reports in the literature (13–15).

In the study by Harde et al. (16), conducted at a tertiary care trauma center in India, the CTS was evaluated for its ability to predict outcomes in patients with chest trauma. Patients with a CTS ≥5 were found to have significantly higher rates of complications and mortality. ROC analysis demonstrated that CTS had acceptable accuracy in predicting mortality (AUC: 0.75). Consequently, a CTS ≥5 was interpreted as an indicator of poor prognosis and may be utilized to identify patients who require early, intensive, and focused management (16). In the study by Elsaied Hussein et al. (17), patients with chest trauma were evaluated using the CTS. The CTS demonstrated a significant association with the need for mechanical ventilation, the development of pneumonia, intensive care unit stay, and mortality. ROC analysis showed that a CTS score ≥6.5 predicted mortality with high sensitivity (100%) and acceptable specificity (62.2%), whereas a CTS score ≥5.5 predicted pneumonia with 80% accuracy. Consequently, CTS was concluded to be a valuable prognostic tool to assess the risk of complications and mortality in patients with blunt chest trauma (17). In our

Table 1. The patients' demographic data and baseline characteristics (according to develop complications).

	Analysis of groups with and without complications			
Characteristics	**All patients (n = 329)**	**Complication group (n = 47)**	**Non-complication group (n = 282)**	**p-value**
Gender				
Male, n (%)	226 (68.7)	37 (78.7)	189 (67.0)	0.109
Female, n (%)	103 (31.3)	10 (21.3)	93 (33.0)	
Age (years), median (IQR)	59 (IQR: 48–70)	65 (IQR: 54–74)	58 (IQR: 47–68)	**0.038**
Comorbidities				
Hypertension, n (%)	114 (34.7)	23 (48.9)	91 (32.3)	**0.026**
Diabetes, n (%)	50 (15.2)	10 (21.3)	40 (14.2)	0.210
CAD, n (%)	46 (14.0)	9 (19.1)	37 (13.1)	0.270
CHF, n (%)	7 (2.1)	1 (2.1)	6 (2.1)	1.000
COPD, n (%)	10 (3.0)	3 (6.4)	7 (2.5)	0.159
Atrial fibrillation, n (%)	12 (3.6)	3 (6.4)	9 (3.2)	0.390
Stroke, n (%)	7 (2.1)	2 (4.3)	5 (1.8)	0.263
Vital signs				
SBP (mmHg), median (IQR)	120 (IQR: 120–130)	120 (IQR: 110–130)	120 (IQR: 120–130)	0.058
DBP (mmHg), median (IQR)	80 (IQR: 80–80)	80 (IQR: 70–80)	80 (IQR: 80–90)	**0.020**
Pulse (/min), median (IQR)	77 (IQR: 69–87)	80 (IQR: 74–95)	77 (IQR: 69–85)	**0.010**
RR (/min), median (IQR)	15 (IQR: 14–16)	16 (IQR: 14–18)	15 (IQR: 14–16)	**0.043**
SO_2 (%), median (IQR)	97 (IQR: 96–98)	96 (IQR: 94–98)	97 (IQR: 96–99)	**0.001**
Trauma Mechanisms				
In-vehicle traffic accident, n (%)	65 (19.8)	8 (17.9)	57 (20.2)	**0.043**
Non-vehicle traffic accident, n (%)	13 (4.0)	2 (4.3)	11 (3.9)	
Fall and roll, n (%)	219 (66.6)	33 (70.2)	210 (74.5)	
Gunshot wound, n (%)	8 (2.4)	4 (8.6)	4 (1.4)	
Presence of extra-thoracic trauma				
Head-neck, n (%)	84 (25.5)	19 (40.4)	65 (23.0)	**0.011**
Abdominal, n (%)	26 (7.9)	8 (17.0)	18 (6.4)	**0.012**
Pelvic, n (%)	14 (4.2)	4 (8.5)	10 (3.6)	0.124
Cardiac, n (%)	0 (0)	0 (0.0)	0 (0.0)	-
Extremity, n (%)	69 (30.0)	12 (25.5)	57 (20.2)	0.407
Number of hip fractures (number), median (IQR)	3 (IQR: 0–15)	4 (IQR: 3–8)	3 (IQR: 1–5)	**0.001**

CAD, coronary artery disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; DBP, diastolic blood pressure; IQR, interquartile range (25p, 75p); RR, respiratory rate; SBP, systolic blood pressure.

study, the CTS demonstrated a sensitivity of 78.7% and a specificity of 56.0% at a cut-off value of ⩾ 6 for predicting complications in patients with thoracic trauma. Similarly, CTS showed a sensitivity of 75.0% and a specificity of 53.0% at the same cut-off value for predicting mortality. Based on our findings, CTS may be superior to other scoring systems in forecasting complications among thoracic trauma patients. The variability in reported cut-off values, sensitivities, and specificities in the literature may be attributed to differences in study populations, including sex distribution, comorbidities, and mechanisms of trauma.

In the study by Bayer et al. (18), greater severity of thoracic trauma was associated with a higher incidence of thoracic injuries and an increased need for prehospital intubation (58%), chest tube placement (22%), cardiopulmonary resuscitation (11%), massive transfusion (12%), and emergency surgery (17%). Patients with an AIS-thorax score ⩾4 required more complex early management and had higher mortality and complication rates (18). Similarly, in the study by Benhamed et al. (19), AIS ⩾3 was strongly associated with mortality. In another study by Besra et al. (20), the effectiveness of different trauma scoring systems in predicting mortality among patients with chest and abdominal trauma was evaluated. The authors concluded that, in particular, the RTS and several comprehensive trauma-scoring systems are reliable prognostic methods for chest and abdominal trauma (20). In our study, the AIS demonstrated a sensitivity of 66.7% and a specificity of 79.5% at a cut-off value of ⩾6 for predicting mortality in thoracic trauma patients. Similarly, the RTS showed a sensitivity of 50.0% and a specificity of 97.8% at a cut-off value of less than 7 for predicting mortality. Based on our findings, AIS and RTS may be superior to other scoring

Table 2. The patients' demographic data and baseline characteristics (according to mortality).

	Analysis of groups with and without mortality			
Characteristics	**All patients (n = 329)**	**Mortality group (n = 12)**	**Non-mortality group (317)**	**p-value**
Gender				
Male, n (%)	226 (68.7)	10 (83.3)	216 (68.1)	0.265
Female, n (%)	103 (31.3)	2 (16.7)	101 (31.9)	
Age (years), median (IQR)	59 (IQR: 48–70)	68 (IQR: 39–76)	59 (IQR: 48–70)	0.419
Comorbidities				
Hypertension, n (%)	114 (34.7)	7 (58.3)	107 (33.8)	0.079
Diabetes, n (%)	50 (15.2)	3 (25.0)	47 (14.8)	0.403
CAD, n (%)	46 (14.0)	3 (25.0)	43 (13.6)	0.227
CHF, n (%)	7 (2.1)	1 (8.3)	6 (1.9)	0.231
COPD, n (%)	10 (3.0)	2 (16.7)	8 (2.5)	**0.047**
Atrial fibrillation, n (%)	12 (3.6)	1 (8.3)	11 (3.5)	0.365
Stroke, n (%)	7 (2.1)	0 (0.0)	7 (2.2)	1.000
Vital signs				
SBP (mmHg), median (IQR)	120 (IQR: 120–130)	93 (IQR: 80–120)	120 (IQR: 120-130)	**0.001**
DBP (mmHg), median (IQR)	80 (IQR: 80–80)	63 (IQR: 50–80)	80 (IQR: 80–80)	**0.001**
Pulse (/min), median (IQR)	77 (IQR: 69–87)	93 (IQR: 82–104)	77 (IQR: 60–85)	**0.019**
RR (/min), median (IQR)	15 (IQR: 14–16)	18 (IQR: 16–21)	15 (IQR: 14–16)	**0.013**
SO_2 (%), median (IQR)	97 (IQR: 96–98)	92 (IQR: 68–96)	97 (IQR: 96–99)	**0.001**
Trauma mechanisms				
In-vehicle traffic accident, n (%)	65 (19.8)	3 (25.0)	62 (19.6)	
Non-vehicle traffic accident, n (%)	13 (4.0)	1 (8.3)	12 (3.8)	**0.023**
Fall and roll, n (%)	219 (66.6)	6 (50.0)	213 (67.2)	
Gunshot wound, n (%)	8 (2.4)	3 (25.0)	5 (1.6)	
Presence of extra-thoracic trauma				
Head-neck, n (%)	84 (25.5)	5 (41.7)	79 (25.0)	0.192
Abdominal, n (%)	26 (7.9)	4 (33.4)	22 (6.9)	**0.010**
Pelvic, n (%)	14 (4.2)	2 (16.7)	12 (3.8)	0.087
Cardiac, n (%)	0 (0)	0 (0.0)	0 (0.0)	-
Extremity, n (%)	69 (30.0)	5 (41.7)	64 (20.2)	0.073
Number of hip fractures (number), median (IQR)	3 (IQR: 0–15)	4 (IQR: 2–4)	3 (IQR: 2–5)	0.998

CAD, coronary artery disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; DBP, diastolic blood pressure; IQR, interquartile range (25p, 75p); RR, respiratory rate; SBP, systolic blood pressure.

systems in predicting mortality among thoracic trauma patients. Furthermore, our results suggest that general trauma scoring systems may outperform specific scoring systems in predicting mortality.

In our study, RFS demonstrated 50.0% sensitivity and 67.5% specificity in predicting mortality in patients with thoracic trauma at a cut-off value of ≥8. Similarly, RS demonstrated a sensitivity of 50.0% and a specificity of 58.8% in predicting mortality in patients with ≥2 cut-off values. However, RFS demonstrated a sensitivity of 59.6% and a specificity of 71.3% in predicting complications in patients with ≥8 cut-off values in thoracic trauma. Similarly, RS demonstrated 21.2% sensitivity and 90.6% specificity in predicting complications at a cut-off value of ≥2. Our

Table 3. Statistical analysis of trauma scores.

	Analysis of groups with and without complications			
Trauma scoring	**All patients (n= 329)**	**Complication group (n = 47)**	**Non-complication group (n = 282)**	**p-value**
RTS, median (IQR)	12 (12–12)	12 (12–12)	12 (12–12)	**0.001**
AIS, median (IQR)	3 (2–5)	5 (3–8)	3 (2–5)	**0.001**
AAST, median (IQR)	2 (1–2)	2 (2–3)	2 (1–2)	**0.001**
RFS, median (IQR)	5 (3–7)	7 (5–10)	5 (3–7)	**0.001**
CTS, median (IQR)	4 (3–6)	5 (5–7)	4 (3–6)	**0.001**
RS, median (IQR)	0 (0–1)	1 (0–2)	0 (0–1)	**0.001**
	Analysis of groups with and without mortality			
Trauma scoring	**All patients (n = 329)**	**Mortality group (n = 12)**	**Non-mortality group (317)**	**p-value**
RTS, median (IQR)	12 (12–12)	12 (7–12)	12 (12–12)	**0.001**
AIS, median (IQR)	3 (2–5)	7 (5–10)	3 (2–5)	**0.001**
AAST, median (IQR)	2 (1–2)	2 (2–3)	2 (1–2)	**0.001**
RFS, median (IQR)	5 (3–7)	7 (2–7)	5 (3–7)	0.752
CTS, median (IQR)	4 (3–6)	5 (5–5)	4 (3–6)	0.215
RS, median (IQR)	0 (0–1)	1 (0–1)	0 (0–1)	0.572

AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale; CTS, chest trauma scoring; IQR, interquartile range (25p, 75p); RFS, Rib Fracture Scoring System; RS, Rib Score; RTS, Revised Trauma Score.

Table 4. The cut-off values for complication of ROC curve analysis.

	RTS	**AIS**	**AAST**
AUC ± SD	0.577 ± 0.049	0.694 ± 0.040	0.648 ± 0.042
Cutoff	7	6	3
Sensitivity (%), (95% CI)	17.0 (7.6–30.8)	44.7 (30.2–59.9)	89.4 (76.9–96.4)
Specificity (%), (95% CI)	98.2 (95.9–99.4)	81.5 (76.5–85.9)	31.0 (25.6–36.7)
+LR, (95% CI)	9.6 (3.3–28.1)	2.83 (1.62–3.62)	1.29 (1.1–1.5)
-LR, (95% CI)	0.84 (0.7–1.0)	0.79 (0.5–0.9)	0.34 (0.2–0.8)
PPV (%), (95% CI)	61.5 (35.3–82.4)	28.8 (21.3–37.6)	17.8 (16.0–19.7)
NPV (%), (95% CI)	87.7 (86.2–89.0)	89.9 (87.2–92.0)	94.6 (88.2–97.6)
Accuracy (%), (95% CI)	86.6 (82.5–90.1)	76.2 (71.3–80.8)	39.3 (34.0–44.9)
	RFS	**CTS**	**RS**
AUC ± SD	0.672 ± 0.044	0.702 ± 0.036	0.630 ± 0.045
Cutoff	8	6	2
Sensitivity (%), (95% CI)	59.6 (44.3–73.6)	78.7 (64.3–89.3)	21.2 (14.7–29.0)
Specificity (%), (95% CI)	71.3 (65.6–76.5)	56.0 (50.0–61.9)	90.6 (85.6–94.4)
+LR, (95% CI)	2.07 (1.5–2.8)	1.79 (1.5–2.9)	2.26 (1.3–3.9)
-LR, (95% CI)	0.57 (0.4–0.8)	0.38 (0.2–0.7)	0.87 (0.8–1.0)
PPV (%), (95% CI)	25.7 (20.4–31.8)	23.0 (19.7–26.7)	61.7 (48.3–73.6)
NPV (%), (95% CI)	91.4 (88.1–93.8)	94.0 (90.0–96.5)	61.7 (59.4–64.0)
Accuracy (%), (95% CI)	69.6 (64.3–74.5)	59.2 (53.7–64.6)	61.7 (56.2–67.0)

AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale; AUC, area under the curve; CI, confidence interval; CTS, chest trauma scoring; LR, likelihood ratio; NPV, negative predictive value; PPV, positive predictive value; RFS, Rib Fracture Scoring System; ROC, receiver operating curve; RS, Rib Score; RTS, Revised Trauma Score; SD, standard deviation.

Table 5. The cut-off values for mortality of ROC curve analysis.

	RTS	AIS	AAST
AUC ± SD	0.742 ± 0.094	0.774 ± 0.075	0.686 ± 0.065
Cutoff	7	6	3
Sensitivity (%), (95% CI)	50.0 (21.1–78.9)	66.7 (34.9–90.1)	100.0 (73.5–100.0)
Specificity (%), (95% CI)	97.8 (95.5–99.1)	79.5 (74.6–83.8)	29.1 (24.2–34.5)
+LR, (95% CI)	22.6 (9.0–57.1)	3.3 (2.1–5.1)	1.4 (1.3–1.5)
-LR, (95% CI)	0.51 (0.3–0.9)	0.42 (0.2–0.9)	0 (0.0–0.0)
PPV (%), (95% CI)	46.2 (25.4–68.4)	11.0 (7.2–16.3)	5.1 (4.7–5.4)
NPV (%), (95% CI)	98.1 (96.7–98.9)	98.4 (96.6–99.3)	100.0 (100.0-100.0)
Accuracy (%), (95% CI)	96.1 (93.3–97.8)	79.0 (74.2–83.3)	31.7 (26.7–37.0)
	RFS	**CTS**	**RS**
AUC ± SD	0.527 ± 0.094	0.604 ± 0.063	0.543 ± 0.085
Cutoff	8	6	2
Sensitivity (%), (95% CI)	50.0 (21.1–78.9)	75.0 (42.8–94.5)	50.0 (21.1–78.9)
Specificity (%), (95% CI)	67.5 (62.1–72.6)	52.0 (46.4–57.7)	58.7 (53.0–64.2)
+LR, (95% CI)	1.5 (0.9–2.8)	1.6 (1.1–2.2)	1.2 (0.7–2.2)
-LR, (95% CI)	0.7 (0.4–1.3)	0.5 (0.2–1.3)	0.9 (0.5–1.5)
PPV (%), (95% CI)	5.5 (3.1–9.5)	5.6 (4.0–7.7)	4.4 (2.5–7.6)
NPV (%), (95% CI)	97.3 (95.3–98.4)	98.2 (95.4–99.3)	96.9 (94.6–98.2)
Accuracy (%), (95% CI)	66.8 (61.5–71.9)	52.9 (47.3–58.4)	58.4 (52.8–63.2)

AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale; AUC, area under the curve; CI, confidence interval; CTS, chest trauma scoring; LR, likelihood ratio; NPV, negative predictive value; PPV, positive predictive value; RFS, Rib Fracture Scoring System; ROC, receiver operating curve; RS, Rib Score; RTS, Revised Trauma Score; SD, standard deviation.

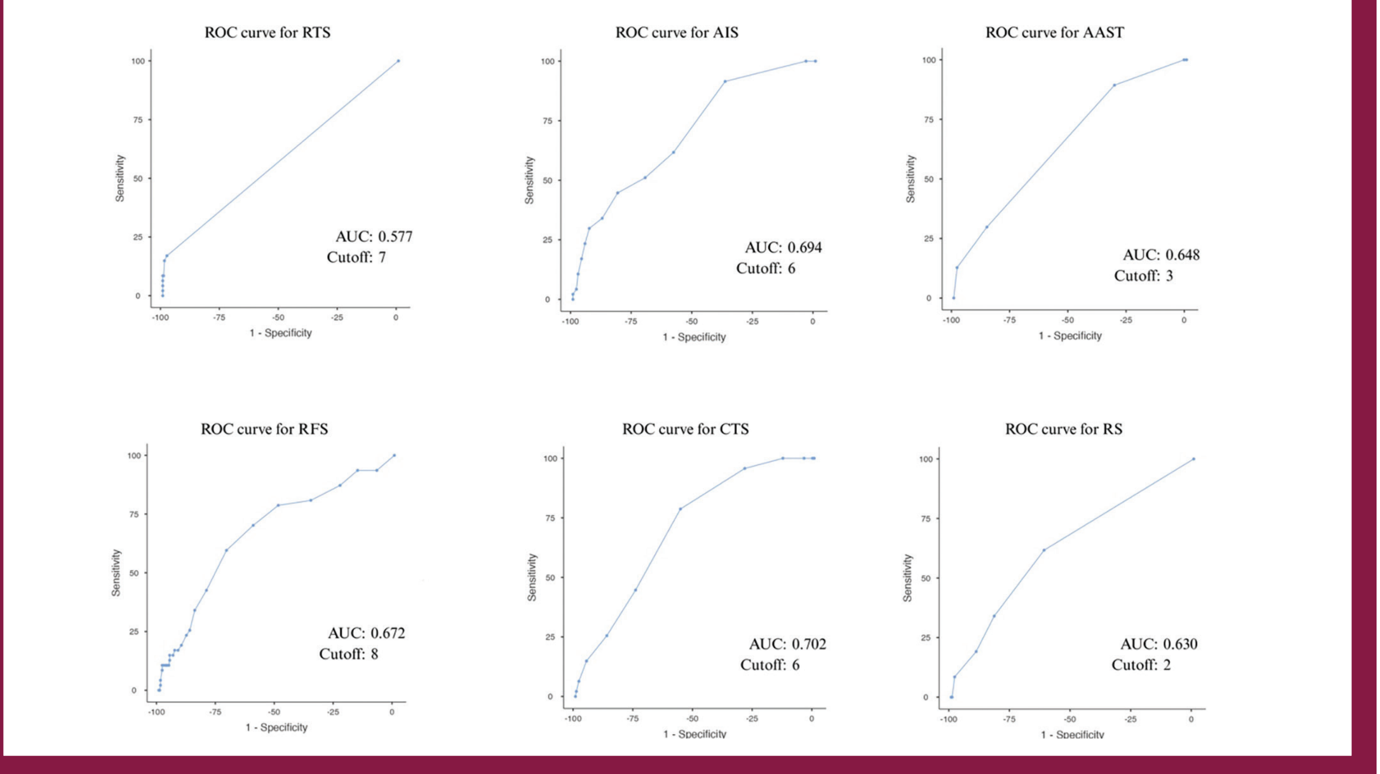

Figure 1. ROC analysis for complications.
AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale; AUC, area under the curve; CTS, chest trauma scoring; RFS, Rib Fracture Scoring System; ROC, receiver operating curve; RS, Rib Score; RTS, Revised Trauma Score.

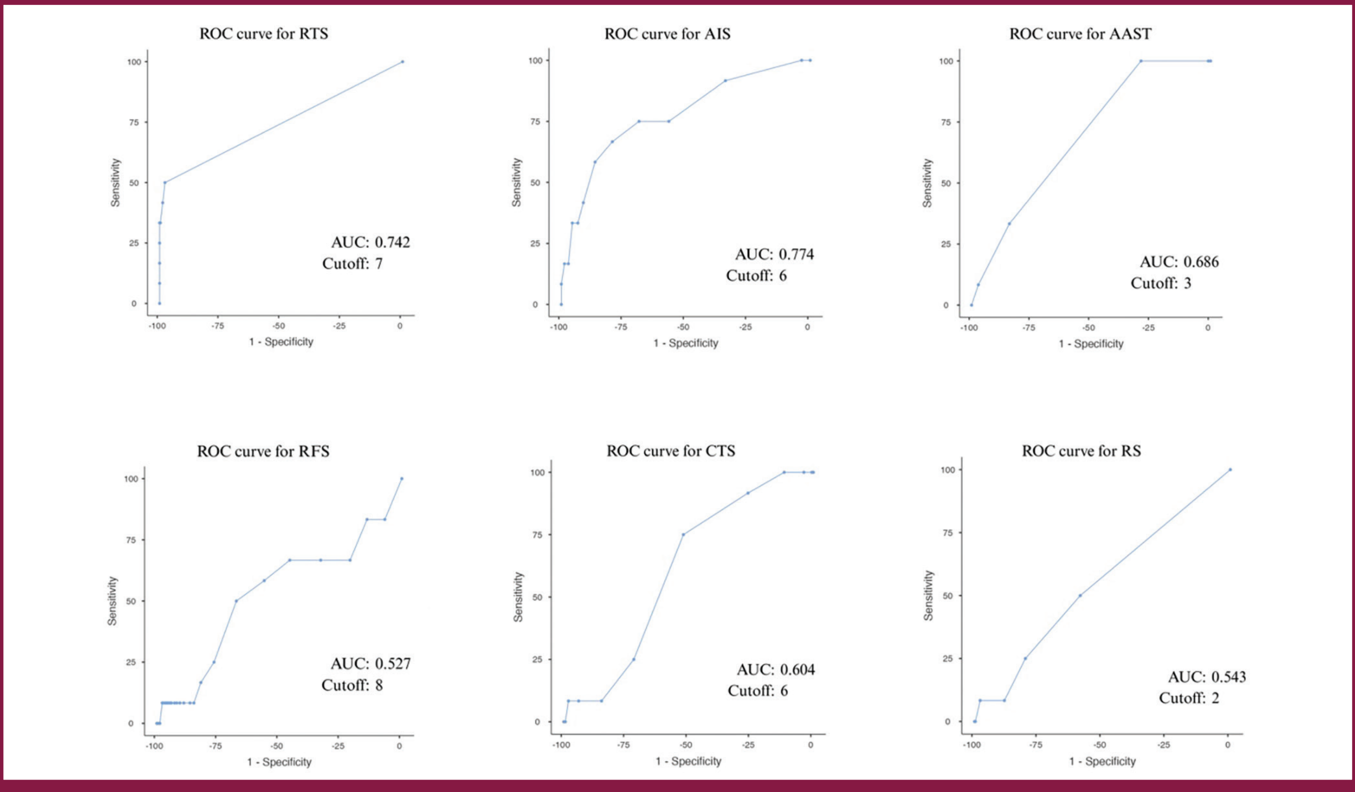

Figure 2. ROC analysis for mortality.
AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale; AUC, area under the curve; CTS, chest trauma scoring; RFS, Rib Fracture Scoring System; ROC, receiver operating curve; RS, Rib Score; RTS, Revised Trauma Score.

Table 6. Logistic regression analysis for trauma scores.

	Univariate analysis to predict complications			
Predictor	OR	95% CI		p-value
		Lower	Upper	
RTS, median (IQR)	0.371	0.186	0.739	**0.005**
AIS, median (IQR)	1.285	1.153	1.432	**0.001**
AAST, median (IQR)	2.304	1.524	3.483	**0.001**
RFS, median (IQR)	1.090	1.038	1.144	**0.001**
CTS, median (IQR)	1.487	1.241	1.781	**0.001**
RS, median (IQR)	1.450	1.139	1.846	**0.003**
	Univariate analysis to predict mortality			
Predictor	**OR**	**95% CI**		**p-value**
		Lower	**Upper**	
RTS, median (IQR)	0.276	0.129	0.590	**0.001**
AIS, median (IQR)	1.415	1.191	1.683	**0.001**
AAST, median (IQR)	2.329	1.160	4.677	**0.017**
RFS, median (IQR)	1.012	0.914	1.121	0.809
CTS, median (IQR)	1.194	0.874	1.632	0.263
RS, median (IQR)	1.124	0.700	1.805	0.628

AAST, American Association for the Surgery of Trauma; AIS, Abbreviated Injury Scale; CI, confidence interval; CTS, chest trauma scoring; OR, odds raito; RFS, Rib Fracture Scoring System; RS, Rib Score; RTS, Revised Trauma Score; SD, standard deviation.

findings support that the specific scoring systems RFS and RS are not sufficiently robust in predicting complications and mortality in thoracic trauma.

In our study, all trauma scores were statistically significant predictors of complications. Similarly, RTS, AIS, and AAST scores were statistically significant predictors of mortality. The lack of significance of thoracic-only trauma scores as predictors of mortality indicates that trauma scores incorporating a more general assessment would have better predictive value. This situation should be taken into account in mortality assessments.

In our study, gender was not associated with complications or mortality, whereas age was associated with complications. Among comorbid conditions, hypertension was found to be associated with complications, while chronic obstructive pulmonary disease was found to be associated with mortality. This finding is consistent with previous studies (21–24). In the literature, mortality rates associated with thoracic trauma have been reported to vary considerably (25,26). In our study, the mortality rate was 3.6%, and we believe that the differences observed in other studies may have also influenced the mortality outcomes in our cohort.

Study Limitations

This study has several limitations. In particular, it was conducted on a small scale, at a single center, and in a retrospective design. Due to its retrospective nature, patient data could not be comprehensively assessed, raising concerns about selection bias, as is common in other retrospective studies. However, the study population was designed to minimize this concern by excluding conditions that could potentially introduce bias. Another limitation is that, while some scoring systems (e.g., AIS) assess trauma comprehensively, others (e.g., RS) are restricted to thoracic evaluation. Regarding mortality, this makes holistic scoring systems more effective, whereas those focused only on the thorax seem less so. This situation could potentially bias approaches to comprehensive scoring systems when considering mortality. Finally, the sample size was calculated based on the morbidity and mortality rates in previous studies, whereas our study observed lower morbidity and mortality. This may have affected our results. Further studies with larger patient cohorts and the inclusion of multiple centers are necessary to validate our findings.

Conclusion

In thoracic trauma, general trauma scoring systems appear to be superior to specific trauma scoring systems in predicting both complications and mortality. Our findings suggest that the AIS and the RTS may be more appropriate for predicting mortality, whereas the CTS may be more suitable for predicting complications.

Ethics

Ethics Committee Approval: Approval was obtained from the Recep Tayyip Erdoğan University Non-Interventional Clinical Research Ethics Committee before data collection (decision number: 2023/177, dated: 03.08.2023).

Informed Consent: This study was single-center, cross-sectional, and retrospective.

Footnotes

Authorship Contributions

Concept: A.M.K., M.M.Y., G.E., Ö.B., Design: A.M.K., M.M.Y., Data Collection or Processing: A.M.K., Analysis or Interpretation: M.M.Y., G.E., Ö.B., Literature Search: A.M.K., Writing: A.M.K., M.M.Y.

Conflict of Interest: No conflict of interest was declared by the author(s).

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