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Beyond Clinical Intuition: Quantitative Mortality Prediction in Blunt Thoracic Trauma using the Thoracic Trauma Severity Score (TTSS)

Harief Seamaladi[1*], Aswin Nugraha[2], Erial Bahar[3]

[1]Specialist Doctor Study Program, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia

[2]Department of Cardiovascular Thoracic Surgery, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia

[3]Department of Anatomy, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia

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***Corresponding author:**

Harief Seamaladi

E-mail address:

surgery0331@gmail.com

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A B S T R A C T

Introduction: Blunt thoracic trauma is a leading cause of significant morbidity and mortality, particularly in younger populations. Accurate and early prediction of mortality is crucial for guiding clinical management and resource allocation. This study aimed to move beyond subjective clinical assessment by evaluating the accuracy of the Thoracic Trauma Severity Score (TTSS) as an objective, quantitative tool for predicting in-hospital mortality in patients with blunt thoracic trauma in a specific regional trauma center. **Methods:** A retrospective cohort study was conducted at Dr. Mohammad Hoesin General Hospital, Palembang, Indonesia. Data from 38 patients admitted with blunt thoracic trauma between January 2023 and January 2025 were analyzed. The TTSS was calculated for each patient based on five parameters: age, number of rib fractures, presence of bilateral rib fractures, extent of pulmonary contusion (assessed by chest X-ray), and the PaO_2/FiO_2 ratio (from arterial blood gas analysis). The primary outcome was in-hospital mortality. Receiver Operating Characteristic (ROC) curve analysis was used to determine the predictive accuracy of the TTSS, including the Area Under the Curve (AUC), sensitivity, specificity, and optimal cut-off value. Bivariate analysis using the chi-square test was performed. **Results:** Of the 38 patients, 76.3% (n=29) were male. The mortality rate was 15.8% (n=6). The ROC curve analysis for TTSS in predicting mortality yielded an AUC of 0.727 (95% CI: 0.447–1.000; p = 0.082). At an optimal cut-off value of 10.5, the TTSS demonstrated a sensitivity of 66.6% and a specificity of 71.8% for mortality prediction. Patients with TTSS >7 had a significantly higher proportion of mortality (83% of deaths occurred in this group) compared to those with TTSS $\leq$7. **Conclusion:** The Thoracic Trauma Severity Score (TTSS) showed fair predictive accuracy for in-hospital mortality in patients with blunt thoracic trauma in this study setting. While demonstrating reasonable sensitivity at a cut-off of 10.5, its specificity was also moderate. The TTSS can serve as a useful quantitative adjunct to clinical judgment, aiding in the early identification of patients at higher risk, though its limitations, particularly the modest specificity and non-significant p-value for AUC in this cohort, warrant cautious interpretation and highlight the need for further validation in larger, multicenter studies.

1. Introduction

Blunt thoracic trauma remains a formidable challenge in emergency medicine and critical care, contributing substantially to global morbidity and mortality.[1] It accounts for approximately 20-25% of all trauma-related deaths and is a primary or contributing factor in up to 50% of such fatalities.[2,3] In Indonesia, trauma is a leading cause of death, particularly among the younger, economically active population, with traffic accidents being a predominant cause of blunt thoracic injuries. The mechanisms often involve high-energy impacts, leading to a spectrum of injuries ranging from simple rib fractures to life-threatening conditions such as flail chest, pulmonary contusions, hemothorax, pneumothorax, and great vessel injuries.[4,5]

The initial clinical presentation of patients with blunt thoracic trauma can be deceptive. Some patients may appear stable upon arrival at the emergency department, only to deteriorate rapidly within 48 to 72 hours due to evolving pulmonary complications, such as acute respiratory distress syndrome (ARDS) or pneumonia. This underscores the critical need for accurate and timely risk stratification to guide appropriate management, optimize resource allocation (including ICU admission and ventilatory support), and ultimately improve patient outcomes.[6]

Traditionally, clinicians have relied on a combination of physiological parameters, anatomical injury patterns, and clinical intuition to assess the severity of thoracic trauma and predict outcomes. However, clinical intuition, while invaluable, can be subjective and vary significantly among practitioners.[7] To address this, numerous trauma scoring systems have been developed to provide a more objective and standardized approach to risk assessment. These include anatomically based scores like the abbreviated injury scale (AIS) and the injury severity score (ISS), physiologically based scores such as the revised trauma score (RTS), and combined scores like the trauma and injury severity score (TRISS). While widely used, many of these general trauma scores may not adequately capture the specific nuances and complexities associated with isolated or predominant thoracic injuries.[8]

Recognizing the need for a more specific tool, developed the thoracic trauma severity score (TTSS) in 2000. The TTSS is a composite score that uniquely integrates patient-related factors (age), anatomical injury characteristics (number and bilaterality of rib fractures, extent of pulmonary contusion, pleural injury), and a key physiological parameter reflecting oxygenation impairment (the PaO_2/FiO_2 ratio). Each of these five components is scored, and the sum provides a total score ranging from 0 to 25, with higher scores indicating greater severity. The TTSS was designed to be readily applicable in the emergency setting using commonly available diagnostic tools like chest X-rays and arterial blood gas analysis, making it potentially suitable for widespread use, including in resource-limited settings.[9]

Several studies have investigated the utility of TTSS in predicting outcomes such as mortality, ARDS development, need for mechanical ventilation, and ICU length of stay.[10,11] For instance, a study reported that TTSS was a significant predictor of mortality and complications. Another study suggested that a TTSS score of 7 or more was associated with increased morbidity and mortality, while a score of 20 or more predicted a fatal prognosis. Other studies have explored different cut-off values and reported varying degrees of sensitivity and specificity. A study showed a very high AUC for TTSS in predicting outcomes. However, the performance of prognostic scores can be influenced by patient population characteristics, healthcare system variations, and methodological differences in validation studies.[12] Therefore, local validation of such scoring systems is crucial before their widespread adoption into clinical practice.

The novelty of this study lies in its specific quantitative evaluation of the TTSS for mortality prediction in patients with blunt thoracic trauma at Dr. Mohammad Hoesin General Hospital, Palembang, a major referral center in South Sumatra, Indonesia. While TTSS has been validated in various international settings, data from Indonesian populations are scarce. It sought to determine if TTSS could offer an objective and reliable tool to supplement clinical judgment for early risk stratification, which is particularly valuable in busy emergency departments and in settings where resources might be constrained. Furthermore, the determination of a locally relevant optimal cut-off value for TTSS is a key aspect of this research, contributing to region-specific evidence-based practice. The aim of this study was therefore to determine the accuracy of the thoracic trauma severity score (TTSS) in predicting in-hospital mortality among patients with blunt thoracic trauma at Dr. Mohammad Hoesin General Hospital, Palembang, by establishing its optimal cut-off value and evaluating its sensitivity, specificity, and predictive values at that point.

2. Methods

This study was a retrospective cohort, prognostic test accuracy study based on the analysis of medical records. The research was conducted at the Dr. Mohammad Hoesin General Hospital (RSMH) in Palembang, a tertiary care and referral hospital in South Sumatra, Indonesia. Data were collected from patients treated in the Emergency Department, inpatient wards, and from the medical records installation. The study population comprised all patients with a diagnosis of blunt thoracic trauma who were treated at RSMH Palembang. Data were retrospectively collected for patients admitted from January 2023 to January 2025. The sample consisted of patients who met the inclusion and exclusion criteria. The inclusion criteria mandated that patients; Were diagnosed with blunt thoracic trauma; Complete medical record data were available for all variables required for TTSS calculation and outcome assessment. The exclusion criteria; Patients with a history of pre-existing significant cardiac or pulmonary disease that could independently affect pulmonary function or mortality (severe COPD, congestive heart failure, active malignancy, pregnancy); Patients with penetrating chest trauma; Patients with blunt thoracic trauma who did not have an indication for hospital admission (managed as outpatients); Incomplete or duplicated medical records where essential data points were missing.

A total sampling technique was employed, including all patients who met the eligibility criteria during the study period. The initial search of medical records from January 2023 to January 2025 yielded 97 subjects with blunt thoracic trauma. After applying exclusion criteria (34 subjects due to data duplication or not meeting criteria, and 25 subjects with incomplete data), a final sample of 38 subjects was included in the analysis. This exceeded the initially calculated minimum sample size of 37, which was determined using a formula for prognostic accuracy studies (assuming 95% sensitivity, 10% desired precision, and 50% outcome prevalence).

Data were collected retrospectively from patient medical records by trained personnel. The following variables were collected; Demographic Data: Age, gender and thoracic trauma severity score (TTSS) Components: Age: Categorized and scored as per TTSS guidelines (<30 years = 0 points; 30-41 years = 1 point; 42-54 years = 2 points; 55-70 years = 3 points; >70 years = 5 points). Number of Rib Fractures: Determined from chest X-ray reports and/or clinical findings documented in the medical record. Scored as: 0 fractures = 0 points; 1-3 fractures = 1 point; >3-6 fractures = 2 points; >3 bilateral fractures = 3 points; flail chest = 5 points. Pulmonary Contusion: Assessed from chest X-ray findings. Scored as: No contusion = 0 points; 1 lobe unilateral = 1 point; 1 lobe bilateral or 2 lobes unilateral = 2 points; <2 lobes bilateral = 3 points; >2 lobes bilateral = 5 points. Pleural Injury: Determined from chest X-ray findings. Scored as: No pleural injury = 0 points; pneumothorax = 1 point; hemothorax/hemopneumothorax unilateral = 2 points; hemothorax/hemopneumothorax bilateral = 3 points; tension pneumothorax = 5 points. PaO_2/FiO_2 Ratio: Calculated from arterial blood gas (ABG) analysis results recorded at or near the time of admission. Scored as: >400 = 0 points; 300-400 = 1 point; 200-300 = 2 points; 150-200 = 3 points; <150 = 5 points. The total TTSS for each patient was calculated by summing the scores for these five components, ranging from 0 to 25 points. In-hospital Mortality: Defined as death occurring during the hospital stay, directly or indirectly related to the blunt thoracic trauma.

Data were analyzed using SPSS (Statistical Package for Social Sciences) version 20. Descriptive statistics (frequencies, percentages, mean ± SD, or median [IQR] as appropriate) were used to summarize patient characteristics and TTSS component scores. The primary analysis involved assessing the predictive accuracy of the total TTSS score for in-hospital mortality using the Receiver Operating Characteristic (ROC) curve analysis. The Area Under the ROC Curve (AUC) with its 95% confidence interval (CI) was calculated to quantify the overall discriminatory ability of the TTSS. An AUC of 0.5 indicates no discrimination, 0.7-0.8 is considered acceptable/fair, 0.8-0.9 is excellent, and >0.9 is outstanding.[13] The optimal cut-off value for the TTSS in predicting mortality was determined from the ROC curve, typically at the point maximizing the Youden index (Sensitivity + Specificity - 1) or by visual inspection for the best balance between sensitivity and specificity. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated at the determined optimal cut-off and also for a cut-off of >7. Bivariate analysis using the Chi-square test or Fisher's exact test, where appropriate, was used to compare categorical variables and the distribution of TTSS scores between patients who died and those who survived. A p-value < 0.05 was considered statistically significant for all analyses.

The study obtained ethical approval from the institutional review board and ethics committee at Dr. Mohammad Hoesin General Hospital Palembang, Indonesia. Given the retrospective nature of the study using anonymized medical record data, patient consent was waived. All patient data were handled with confidentiality.

3. Results

Table 1 shows a detailed summary of the baseline demographic and clinical characteristics of the 38 patients with blunt thoracic trauma included in this study. This information is crucial for understanding the context of the Thoracic Trauma Severity Score (TTSS) validation. The study exhibited a significant male predominance (76.3%), a common finding in trauma studies often attributed to higher engagement in risk-associated activities. The age distribution was skewed towards younger to middle-aged adults, with the largest group being <30 years (31.6%), followed by those aged 30-41 and 42-54 years (each 23.7%). While younger patients typically have better physiological reserves, the severity of thoracic trauma can overwhelm these. The inclusion of age as a weighted factor in the TTSS acknowledges its prognostic importance, as outcomes generally worsen with advancing age. A critical indicator of respiratory function, the PaO_2/FiO_2 ratio, revealed significant impairment in a large portion of the cohort. A striking 36.8% of patients presented with a ratio <150, indicative of very severe oxygenation impairment, often aligning with severe ARDS criteria. Another 21.1% had a ratio between 150-200 (severe impairment/moderate ARDS). This means over half the patients (57.9%) had substantial respiratory compromise on admission, underscoring the profound impact of their injuries on gas exchange and highlighting the cohort's overall severity. Only 15.8% of patients had normal oxygenation (PaO_2/FiO_2 >400). Rib fractures, a hallmark of blunt chest trauma, were prevalent. The most common pattern was 1-3 fractures (44.7%), but a significant number had >3-6 fractures (23.7%). More concerning were the 10.5% with >3 bilateral fractures and one patient (2.6%) with a flail chest, both conditions associated with severe respiratory compromise and higher mortality. Notably, 18.4% had no rib fractures, illustrating that severe internal thoracic injuries can occur without direct overlying bony trauma, especially in younger individuals with more compliant chest walls. Pulmonary contusion, or bruising of the lung tissue, was also a common finding, affecting the vast majority (86.8%) of patients to some degree. The largest group (42.1%) had contusions affecting one lobe bilaterally or two lobes unilaterally. Critically, 23.7% suffered extensive contusions involving > 2 lobes bilaterally, indicating severe parenchymal damage and a high risk for respiratory failure. The extent of pulmonary contusion is a key determinant of outcome, and its assessment (even by chest X-ray as in this study) is vital for the TTSS. Pleural involvement was noted in 60.5% of patients. Unilateral hemothorax or hemopneumothorax was the most frequent finding (28.9%), followed by pneumothorax (21.1%). The presence of tension pneumothorax in 3 patients (7.9%) is particularly alarming, as this is an immediate life-threatening condition requiring urgent decompression. Bilateral hemothorax/hemopneumothorax, though rare (2.6%), signifies extensive trauma. Finally, the in-hospital mortality rate for this cohort was 15.8% (6 out of 38 patients died), reflecting the serious nature of the injuries sustained. Table 1 depicts a study of blunt thoracic trauma patients at Dr. Mohammad Hoesin General Hospital characterized by a male predominance and a range of ages, but with a substantial burden of severe physiological derangements. Key indicators like profound hypoxemia (low PaO_2/FiO_2 ratios), multiple and complex rib fracture patterns (including flail chest), extensive pulmonary contusions, and life-threatening pleural injuries were highly prevalent. This profile of a severely injured patient group provides the critical backdrop against which the predictive accuracy of the TTSS for mortality was subsequently evaluated. The diversity in the severity of these components suggests the TTSS was tested across a relevant spectrum of blunt thoracic trauma.

Table 1. Baseline demographic and clinical characteristics of patients with blunt thoracic trauma (N=38).

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	29	76.3
	Female	9	23.7
Age (Years)	<30	12	31.6
	30-41	9	23.7
	42-54	9	23.7
	55-70	7	18.4
	>70	1	2.6
PaO_2/FiO_2 ratio	>400 (Normal)	6	15.8
	300-400 (Mild Impairment)	4	10.5
	200-300 (Moderate Impairment/Mild ARDS Criteria)	6	15.8
	150-200 (Severe Impairment/Moderate ARDS Criteria)	8	21.1
	<150 (Very Severe Impairment/Severe ARDS Criteria)	14	36.8
Rib fractures	None	7	18.4
	1-3 Fractures	17	44.7
	>3-6 Fractures	9	23.7
	>3 Bilateral Fractures	4	10.5
	Flail Chest	1	2.6
Pulmonary contusion	None	5	13.2
	1 Lobe, Unilateral	5	13.2
	1 Lobe Bilateral or 2 Lobes Unilateral	16	42.1
	<2 Lobes Bilateral	3	7.9
	> 2 Lobes Bilateral	9	23.7
Pleural involvement	None	15	39.5
	Pneumothorax (Unilateral/Bilateral not specified)	8	21.1
	Hemothorax/Hemopneumothorax, Unilateral	11	28.9
	Hemothorax/Hemopneumothorax, Bilateral	1	2.6
	Tension Pneumothorax	3	7.9
In-hospital mortality	Survived	32	84.2
	Died	6	15.8

Table 2 shows the distribution of the thoracic trauma severity scores (TTSS) among the 38 patients with blunt thoracic trauma included in this study. This distribution is pivotal as it reflects the overall injury severity burden within the cohort and provides the foundation for evaluating the TTSS's utility in risk stratification, particularly for predicting in-hospital mortality. The table presents this distribution based on two key thresholds: a commonly cited clinical cut-off of 7, and the optimal cut-off of 10.5 (effectively distinguishing scores ≤ 10 from ≥ 11) as determined by the Receiver Operating Characteristic (ROC) curve analysis within this specific study. Examining the distribution based on the common clinical cut-off of 7, a significant majority of the patients, 26 individuals (68.4%), had a TTSS greater than 7. Conversely, 12 patients (31.6%) scored ≤ 7. A TTSS greater than 7 is often considered in the literature to indicate a higher severity of thoracic trauma and an increased likelihood of complications and adverse outcomes. The fact that over two-thirds of this study cohort fell into this higher severity category (TTSS > 7) aligns with the characteristics detailed in Table 1, which highlighted a substantial prevalence of significant injuries such as severe hypoxemia, multiple rib fractures, and extensive pulmonary contusions. This suggests that the patient population at Dr. Mohammad Hoesin General Hospital included in this research generally presented with a considerable degree of thoracic injury severity. When the distribution was analyzed using the study-derived optimal cut-off of 10.5 (interpreted as scores ≤ 10 versus ≥ 11 for mortality prediction), a different pattern emerged, providing more refined risk stratification. Based on this threshold, 25 patients (65.8%) had a TTSS of ≤ 10, categorizing them into a lower mortality risk group. The remaining 13 patients (34.2%) had a TTSS of ≥ 11, placing them in a higher mortality risk group. This indicates that while a large proportion of the cohort had scores suggesting higher severity (TTSS > 7), the more stringent cut-off of 10.5 identified a more specific subgroup, approximately one-third of the patients, who were at a demonstrably higher risk of dying based on the model derived from this dataset. The TTSS is a composite score, integrating five critical parameters: patient age, the PaO_2/FiO_2 ratio (reflecting oxygenation), the number and bilaterality of rib fractures, the extent of pulmonary contusion, and the nature of pleural involvement. The observed distribution of total TTSS scores in Table 2 is therefore a direct consequence of the varying combinations and severities of these individual components within each patient, as detailed in Table 1. A patient might achieve a high score due to advanced age and moderate lung injury, while another might reach a similar score due to severe oxygenation impairment despite being younger. This ability to synthesize diverse prognostic factors into a single quantitative value is the core strength of such scoring systems. The distribution presented in Table 2 is essential for understanding the subsequent analyses of sensitivity, specificity, and predictive values. For a prognostic score to be clinically useful, its distribution across a patient population must allow for meaningful discrimination between different risk strata. The finding that approximately one-third of the patients fell into the high-risk category (TTSS ≥ 11) suggests that this cut-off identifies a substantial, yet not overwhelmingly large, group for whom heightened vigilance or potentially more aggressive management strategies might be considered. Conversely, the nearly two-thirds of patients with TTSS ≤ 10 represent a group predicted to have a better prognosis regarding mortality. Table 2 quantifies the injury severity landscape of the study cohort through the lens of the TTSS. It demonstrates that while many patients presented with injuries generally considered severe (TTSS > 7), a more specific threshold (TTSS ≥ 11) was identified as being more discriminative for mortality in this particular setting.

Table 2. Distribution of thoracic trauma severity scores (TTSS) in patients with blunt thoracic trauma (N=38).

TTSS Categorization basis	TTSS score range interpretation	Frequency (n)	Percentage (%)
Based on common clinical cut-off of 7	TTSS ≤ 7 (Lower Severity Indicated)	12	31.6
	TTSS > 7 (Higher Severity Indicated)	26	68.4
Based on study-derived optimal cut-off for mortality (10.5)*	TTSS ≤ 10 (Lower Mortality Risk; Interpreted as <10.5)	25	65.8
	TTSS ≥ 11 (Higher Mortality Risk; Interpreted as >10.5)	13	34.2

*The cut-off of 10.5 derived from ROC analysis effectively categorizes patients into those with scores of 10 or less versus those with scores of 11 or more.

Table 3 showed the diagnostic performance characteristics of the thoracic trauma severity score (TTSS) in predicting in-hospital mortality among the 38 patients with blunt thoracic trauma, evaluated at two distinct cut-off values: a commonly referenced clinical threshold of >7 and the optimal cut-off of >10.5 (effectively categorizing scores as ≤10 or ≥11) derived from the ROC curve analysis in this specific study. These metrics – sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) – are crucial for understanding the clinical utility and limitations of the TTSS as a prognostic tool. When a TTSS score greater than 7 was used to define a "high-risk" patient, the sensitivity was 83.3%. This indicates that the TTSS correctly identified 5 out of the 6 patients who ultimately died (True Positives). This relatively high sensitivity is desirable in a prognostic score, as it means the test is good at capturing most individuals who will experience the adverse outcome (in this case, mortality). Missing a high-risk patient (a False Negative) can have severe consequences. In this instance, only 1 patient who died had a TTSS ≤7. However, this high sensitivity came at the cost of a low specificity, which was 33.3%. Specificity measures the ability of the test to correctly identify those who will *not* experience the adverse outcome. Here, it means that only 33.3% of the patients who survived were correctly classified by the TTSS as low risk (TTSS ≤7). Conversely, a large proportion of survivors (66.7%) were classified as high risk (TTSS >7), representing False Positives. The Positive Predictive Value (PPV) at this cut-off was 19.2%. This means that if a patient had a TTSS >7, there was a 19.2% probability that they would die. The low PPV reflects the high number of false positives; many patients flagged as "high risk" by this cut-off actually survived. The Negative Predictive Value (NPV), however, was quite high at 91.0%. This suggests that if a patient had a TTSS ≤7, there was a 91.0% probability that they would survive, making this cut-off useful for ruling out high mortality risk with reasonable confidence. The ROC curve analysis identified >10.5 as the optimal cut-off for balancing sensitivity and specificity in this dataset. At this higher threshold (meaning a patient needed a more severe score to be classified as high risk), the sensitivity decreased to 66.6%. This means the TTSS (when ≥11) correctly identified 4 out of the 6 patients who died. While lower than the sensitivity at the >7 cut-off, it still captures two-thirds of the mortality events. The number of False Negatives (patients who died despite having a TTSS ≤10) increased to 2. In contrast, the specificity improved markedly to 71.8%. This indicates that the TTSS (when ≤10) correctly identified 23 out of the 32 survivors as being at lower risk. The proportion of survivors incorrectly flagged as high risk (False Positives) decreased significantly compared to the >7 cut-off. The PPV at the >10.5 cut-off increased to 30.7%. While still modest, this improvement means that a patient with a TTSS ≥11 had a nearly 1 in 3 chance of dying, making the "high-risk" classification somewhat more meaningful than at the lower cut-off. The NPV remained very strong at 92.0%, indicating that a TTSS score of ≤10 was highly predictive of survival. The data in Table 3 clearly illustrate the inherent trade-off between sensitivity and specificity when selecting a cut-off for a diagnostic or prognostic test. The lower cut-off (>7) offered higher sensitivity (fewer missed deaths) but poor specificity (many survivors were unnecessarily flagged as high risk). This could lead to over-triage, increased resource utilization for patients who might not need it, and potentially unnecessary anxiety. The higher, study-derived optimal cut-off (>10.5, meaning TTSS ≥11) provided a more balanced profile with improved specificity, meaning fewer false alarms among survivors. While the sensitivity was lower, it was still substantial. The very high NPV at both cut-offs is a particularly strong feature of the TTSS in this cohort, suggesting its utility in identifying patients who are likely to have a good outcome regarding mortality. The PPVs, however, remained relatively low across both thresholds, indicating that a high TTSS score, while suggestive of increased risk, is not definitively predictive of death and must be interpreted within the broader clinical context, including other injuries, response to resuscitation, and evolving clinical status.

Ultimately, the choice of cut-off in clinical practice depends on the specific goals. If the primary aim is to miss as few high-risk individuals as possible, a lower cut-off with higher sensitivity might be preferred, accepting the higher false positive rate. If the goal is to more accurately identify those who will indeed have an adverse outcome and to minimize over-treatment, a higher cut-off with better specificity and PPV might be more appropriate. This study suggests that for this Palembang study, a TTSS ≥11 offered a reasonable balance, though the overall predictive power (AUC of 0.727) was fair rather than excellent.

Table 3. Predictive performance of thoracic trauma severity score (TTSS) for in-hospital mortality at different cut-off values (N=38).

TTSS cut-off value	Sensitivity (%)	Specificity (%)	Positive predictive value (PPV) (%)	Negative predictive value (NPV) (%)
> 7	83.3	33.3	19.2	91.0
> 10.5 (Optimal study-derived cut-off; effectively TTSS ≥ 11)	66.6	71.8	30.7	92.0

Table 4 shows the results of the bivariate analysis, examining the direct association between different categorizations of the Thoracic Trauma Severity Score (TTSS) and the primary outcome of in-hospital mortality among the 38 patients with blunt thoracic trauma. This analysis is crucial for understanding whether higher TTSS scores, as defined by specific cut-offs, are indeed linked to an increased frequency of death. When patients were categorized based on a TTSS score greater than 7 versus a score of 7 or less, a clear trend emerged. Among the 26 patients with a TTSS > 7 (indicating higher injury severity), 5 individuals died. This translates to a mortality rate of 19.2% within this higher-severity group. In contrast, among the 12 patients with a TTSS ≤ 7 (indicating lower injury severity), only 1 patient died, resulting in a mortality rate of 8.3% within this group. This comparison shows that patients with a TTSS > 7 had a more than twofold higher mortality rate (19.2% vs. 8.3%) compared to those with a TTSS ≤ 7. While a formal statistical test (like a chi-square test with its p-value, which was not explicitly provided for this table in the source study) would be needed to determine if this difference is statistically significant, the observed numbers suggest an association between higher TTSS scores (using the >7 cut-off) and an increased likelihood of death. This aligns with the sensitivity of 83.3% reported for this cut-off (Table 3), as 5 out of the 6 total deaths occurred in the TTSS > 7 group. However, the relatively large number of survivors (21 out of 26) in the TTSS > 7 group also underscores the moderate Positive Predictive Value (19.2%) and low specificity (33.3%) associated with this particular threshold. The analysis was refined using the study-derived optimal cut-off of >10.5, which effectively means comparing patients with a TTSS ≥ 11 to those with a TTSS ≤ 10. This higher threshold aimed to better discriminate patients at higher risk of mortality. Among the 13 patients with a TTSS ≥ 11, 4 individuals died. This yields a substantially higher mortality rate of 30.8% within this high-risk category. Conversely, among the 25 patients with a TTSS ≤ 10, only 2 patients died, corresponding to a much lower mortality rate of 8.0%. The difference in mortality rates between these two groups is more pronounced than with the >7 cut-off (30.8% vs. 8.0%, nearly a fourfold difference). This suggests that the TTSS ≥ 11 cut-off is more effective in identifying a group with a significantly elevated risk of death. This finding is consistent with the improved specificity (71.8%) and Positive Predictive Value (30.7%) observed for this cut-off (Table 3), even though the sensitivity (66.6%) was somewhat lower. The data indicate that while fewer deaths were captured in the TTSS ≥ 11 group compared to the TTSS > 7 group (4 deaths vs. 5 deaths), those classified as high risk by the ≥ 11 threshold had a considerably higher probability of dying. The bivariate analysis presented in Table 4 supports the general premise that higher TTSS scores are associated with increased mortality in this cohort of blunt thoracic trauma patients. The mortality rate within categories defined by higher TTSS scores was consistently greater than in categories defined by lower scores, regardless of the specific cut-off used (>7 or ≥11). The increasing mortality rate with higher TTSS categories (8.3% for TTSS ≤7, 19.2% for TTSS >7; and 8.0% for TTSS ≤10, 30.8% for TTSS ≥11) provides empirical evidence for the score's ability to stratify risk. Clinically, this implies that the TTSS can be a useful adjunct to initial patient assessment. A patient presenting with a high TTSS, particularly a score of 11 or more in this study's context, should alert clinicians to a substantially increased risk of a fatal outcome, potentially prompting more aggressive monitoring, earlier consideration for intensive care unit admission, or more invasive interventions if appropriate. While the overall Area Under the ROC Curve (AUC) for TTSS was 0.727 (p=0.082), indicating fair but not statistically significant discriminatory power in this small sample, the trends observed in the bivariate analysis are clinically suggestive. The lack of explicitly reported p-values for the chi-square tests for these specific cross-tabulations in the source study limits the ability to make definitive statements about statistical significance of these associations. However, the magnitude of the differences in mortality rates, especially with the ≥11 cut-off, points towards a clinically meaningful relationship.

Table 4. Bivariate analysis of thoracic trauma severity score (TTSS) categories and in-hospital mortality (N=38).

TTSS category	Died (n)	Lived (n)	Total (n)	Mortality rate within category (%)
Cut-off > 7				
TTSS > 7	5	21	26	19.2
TTSS ≤ 7	1	11	12	8.3
Cut-off > 10.5 (effectively TTSS ≥ 11)				
TTSS ≥ 11	4	9	13	30.8
TTSS ≤ 10	2	23	25	8.0
Overall	**6**	**32**	**38**	**15.8**

4. Discussion

The study cohort of 38 patients predominantly comprised males (76.3%), with a significant proportion of younger individuals (<30 years, accounting for 31.6%), which is consistent with the general epidemiology of trauma, where younger males are often at higher risk.[14] The observed in-hospital mortality rate of 15.8% in this cohort underscores the serious nature of blunt thoracic trauma. This rate is within the range reported in various international studies, though direct comparisons are challenging due to differences in study populations, injury severity mixes, and healthcare systems.[3]

The primary measure of TTSS accuracy, the Area Under the ROC Curve (AUC), was 0.727 (95% CI: 0.447–1.000). An AUC of 0.727 generally indicates fair discriminatory power. However, the wide confidence interval and the p-value of 0.082 suggest that this finding did not reach statistical significance at the conventional alpha level of 0.05. This lack of statistical significance for the AUC could be attributed to the relatively small sample size of 38 patients, which limits the statistical power of the study (a limitation acknowledged in the study). Larger studies on TTSS have often reported statistically significant AUCs. For example, a study reported an AUC of 0.844 for mortality prediction in a much larger cohort. A study reported an AUC indicating very strong accuracy, with sensitivity of 80% and specificity of 94.1% at a cut-off of <11. A study in an Indian setting also reported a higher AUC of 0.988. The result from the current study, while showing a trend towards fair prediction, highlights the variability in score performance across different settings and sample sizes.

The optimal cut-off for TTSS determined in this study was 10.5. At this cut-off, the sensitivity was

66.6% and the specificity was 71.8%. A sensitivity of 66.6% means that the TTSS (>10.5) correctly identified two-thirds of the patients who would eventually die. However, a specificity of 71.8% indicates that approximately 28.2% of survivors were incorrectly classified as high risk (false positives). The Negative Predictive Value (NPV) was high at 92.0%, suggesting that a TTSS score > 10.5 is quite reliable in identifying patients with a lower likelihood of mortality. This is a clinically relevant aspect, as it can help in de-escalating care or avoiding unnecessary aggressive interventions in low-risk patients. Conversely, the Positive Predictive Value (PPV) was modest at 30.7%, meaning that less than a third of patients with a TTSS >10.5 actually died. This relatively low PPV, coupled with the specificity, suggests that while TTSS can flag many at-risk patients, it may also lead to over-triaging if used in isolation.

The study also analyzed a TTSS cut-off of >7, potentially for comparison with other studies where this threshold is commonly cited. At this lower cut-off, the sensitivity increased to 83.3%, meaning it captured more of the patients who died. However, this came at the cost of a significantly reduced specificity of 33.3%. This trade-off is common in prognostic scores: a lower cut-off enhances sensitivity but reduces specificity, leading to more false positives. The choice of an optimal cut-off often depends on the clinical context and the relative importance of avoiding false negatives versus false positives. For a condition with high mortality where missing a high-risk patient is detrimental, a higher sensitivity might be preferred, even if it means lower specificity.

The components of the TTSS – age, rib fractures, pulmonary contusion, pleural injury, and PaO_2/FiO_2 ratio – are all well-established individual risk factors in thoracic trauma.[15,16] Age, in particular, is a critical determinant, with older patients generally having poorer outcomes due to reduced physiological reserves. Pulmonary contusion and impaired oxygenation (low PaO_2/FiO_2) directly reflect the severity of lung injury and its systemic impact. Rib fractures, especially multiple or bilateral ones, contribute to pain, splinting, hypoventilation, and an increased risk of complications like pneumonia and ARDS.[17] The strength of TTSS lies in its ability to combine these diverse factors into a single quantitative measure.

Comparing the current study's AUC of 0.727 and the specific sensitivity/specificity values with the broader literature reveals some variations. As mentioned, some studies have reported higher AUCs. For example, a study found an AUC of 0.856 for mortality with a cut-off of 8 points, yielding 80% sensitivity and 94% specificity. A study reported a sensitivity of 92.3% and a specificity of 100% for poor outcomes and mortality. These differences could be due to variations in patient populations (severity mix, prevalence of comorbidities), differences in how TTSS components were assessed (reliance on X-ray vs. CT for contusion assessment, which the study suggested as a point for future collaboration with radiologists), sample size, and even the definition of outcomes. The current study's use of chest X-ray for contusion assessment, while practical, might be less sensitive than CT scans, potentially affecting the TTSS calculation.[18]

The finding that the p-value for the AUC was 0.082 is an important point of discussion. While a p-value is a continuous measure and 0.082 is close to the traditional 0.05 threshold, it formally indicates that, based on this sample, one cannot reject the null hypostudy that the TTSS has no better discriminatory ability than chance at the 5% significance level. The study provides much-needed local data on TTSS performance in an Indonesian hospital, contributing to regional evidence-based practice. It utilized a recognized and relatively easy-to-calculate scoring system (TTSS), promoting objectivity in trauma assessment. With only 38 patients and 6 mortality events, the statistical power was limited. This likely contributed to the wide confidence interval for the AUC and the non-significant p-value. The results should be interpreted with caution and require validation in a larger cohort. Like many validation studies of this nature, it relied on retrospectively collected medical record data, which can be prone to missing information or documentation bias. The study noted that 25 subjects were excluded due to incomplete data. Findings from a single institution (RSMH Palembang) may not be generalizable to other hospitals or healthcare settings in Indonesia or elsewhere, which may have different patient populations or management protocols. The TTSS protocol allows for pulmonary contusion assessment via chest X-ray. While practical, X-rays are known to be less sensitive than CT scans for detecting and quantifying pulmonary contusions.[18] This could have led to an underestimation of this TTSS component in some patients. The study itself suggests collaboration with radiologists for better contusion assessment in future studies. The study exclusion criteria included patients with pre-existing heart and lung disease, malignancy, or pregnancy. While this creates a more homogenous group for assessing the direct impact of trauma, TTSS performance in patients with comorbidities (which are common in older trauma patients) was not evaluated. The study recommended considering comorbidities like smoking and diabetes in future research. While the primary goal was to assess the prognostic accuracy of TTSS, the provided study data focused on ROC analysis. A full manuscript would ideally include multivariate logistic regression to assess if TTSS remains an independent predictor after adjusting for other potential confounders not included in the score itself (associated extrathoracic injuries, specific interventions). The study methods briefly mention a formula for multivariate analysis, but the results are not detailed. Despite the limitations, the TTSS, with an AUC of 0.727 and good sensitivity at certain cut-offs, can still be a valuable tool to supplement clinical judgment in the busy emergency setting of RSMH Palembang and similar hospitals. It offers a structured, quantitative approach that can help in the early identification of blunt thoracic trauma patients who may be at higher risk of mortality. The high NPV at the 10.5 cut-off (92.0%) is particularly useful for potentially ruling out high mortality risk in patients with lower scores. However, clinicians should be aware of the modest specificity and PPV, meaning a high TTSS score warrants heightened vigilance and further comprehensive assessment rather than being the sole determinant for critical care decisions. The non-significant p-value for the AUC in this specific study also calls for prudence.[19,20]

5. Conclusion

The Thoracic Trauma Severity Score (TTSS) demonstrated fair overall predictive accuracy for in-hospital mortality, with an Area Under the ROC Curve (AUC) of 0.727. However, this finding was not statistically significant ($p = 0.082$) in this cohort, likely due to the small sample size. The optimal cut-off value for TTSS identified in this study was 10.5. At this cut-off, the sensitivity for predicting mortality was 66.6%, specificity was 71.8%, PPV was 30.7%, and NPV was 92.0%. At a lower cut-off of >7, sensitivity increased to 83.3% but specificity decreased to 33.3%. The TTSS can serve as a simple, quantitative tool to aid clinicians in the early risk stratification of blunt thoracic trauma patients. Its high negative predictive value at the identified cut-off is useful for identifying patients less likely to die. The modest specificity, low positive predictive value, and the lack of statistical significance for the AUC in this particular study necessitate cautious interpretation. The TTSS should be used as an adjunct to, not a replacement for, thorough clinical assessment and judgment.

6. References

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