Use of Thoracic Trauma Severity Score (TTSS) Components and Systems in Predicting Mortality in Thoracic Trauma

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Abstract.
Thoracic trauma contributes significantly to global mortality, necessitating early risk stratification to guide management. The Thoracic Trauma Severity Score (TTSS) integrates anatomical and physiological parameters to predict outcomes, but validation data from Southeast Asian populations remain limited. This retrospective cohort study included 77 thoracic trauma patients admitted to Prof. Dr. R.D. Kandou General Hospital, Manado, between 2021–2023. TTSS was calculated based on age, PaO_2/FiO_2 ratio, rib fracture count, pulmonary contusion, and pleural involvement. The primary outcome was in-hospital mortality. Statistical analyses included bivariate comparisons, Kaplan–Meier survival analysis, and receiver operating characteristic (ROC) curve analysis. Overall mortality was 29.9%. Non-survivors had significantly higher TTSS values than survivors (median 5 vs. 2.5, $p < 0.001$). Patients requiring ICU admission also demonstrated higher TTSS (median 6 vs. 3, $p = 0.002$). Pulmonary contusion ($p = 0.021$), $PaO_2/FiO_2 \leq 400$ ($p = 0.018$), and age >30 years ($p = 0.011$) were significantly associated with mortality. ROC analysis showed good discriminatory ability for mortality (AUC ≈ 0.80, sensitivity 91%, specificity 50%). TTSS is a practical and effective tool for early mortality risk stratification in thoracic trauma patients, with good predictive performance. Its application in resource-limited settings may facilitate timely triage and escalation of care.
Keywords: *Thoracic Trauma Severity Score, Thoracic Trauma, Mortality Prediction, Risk Stratification and Intensive Care Unit Admission.*

I. INTRODUCTION

Thoracic trauma remains a critical focus in trauma care due to its substantial contribution to mortality and morbidity across diverse healthcare settings [1]. Worldwide, trauma is a leading cause of death, particularly among productive-age populations, with thoracic injuries accounting for approximately 20–25% of all trauma-related fatalities. These injuries often act as either the direct cause or a significant contributor to death in patients with multiple trauma, presenting a wide spectrum ranging from mild pulmonary contusion to life-threatening conditions such as flail chest and major vascular injury [2][3][4]. Anatomic and physiologic perturbations within the chest including rib and chest wall injuries, pulmonary contusion, pneumothorax, and associated respiratory compromise drive the risk of respiratory failure, the need for mechanical ventilation, and death. Consequently, clinicians have sought structured scoring systems that can be applied at presentation to identify patients at greatest risk for complications and mortality, guide initial management, and optimize resource allocation in busy emergency and critical care settings [5], [6].

Among these scoring systems, the Thoracic Trauma Severity Score (TTSS) was developed to fuse anatomical and functional information available during the initial evaluation to predict thoracic complications and mortality, with the aim of guiding triage and early therapeutic decisions in both primary and secondary care settings. The TTSS incorporates parameters such as age, PaO_2/FiO_2 ratio, number of rib fractures, pulmonary contusion, and pleural involvement, thereby reflecting both structural chest wall injury and physiologic impairment of gas exchange or ventilation [5], [6]. This dual-component design is intended to bridge injury pattern with clinical trajectory, enabling prompt escalation of care for higher-risk patients while safely continuing conservative management for those at lower risk. Early investigations demonstrated that TTSS could discriminate risk for both complications and mortality in thoracic trauma, offering a pragmatic framework for decision-making in blunt chest injuries, including mild thoracic trauma where early identification of at-risk patients is especially valuable. Subsequent empirical work has shown that TTSS values correlate with injury burden for example, in surgical rib fixation cohorts, median TTSS values around 11 were observed in patients with extensive thoracic injury patterns, and TTSS emerged as an independent predictor of postoperative complications in multivariable analyses [7].

The predictive performance of TTSS has been quantified in multiple studies, demonstrating moderate-to-high discrimination for both complications and mortality. A synthesis of the literature indicates that TTSS can achieve area under the receiver operating characteristic curve (AUC) values in the vicinity of 0.84–0.86 for predicting complications or mortality, with commonly reported thresholds around 7–8 points that optimize sensitivity and specificity for these outcomes across various cohorts [5], [8]. For instance, one study reported that a TTSS cutoff of eight points yielded sensitivity around 66% and specificity around 94% for predicting complications, and sensitivity around 80% with similar specificity for predicting mortality, highlighting TTSS as a clinically useful, though not perfect, predictor of adverse outcomes in mild-to-moderate thoracic trauma [5]. However, the TTSS is not uniformly superior to other scoring frameworks; comparative work suggests that in certain severe thoracic trauma populations, TRISS may outperform TTSS in predicting death, emphasizing that context matters for scoring-system selection [6]. Broader trauma registries further indicate that comprehensive death prediction in polytrauma contexts often relies on composite, multi-system scores such as TRISS, SAPS, and RISC II, which account for concomitant injuries and physiologic derangements beyond the chest [2], [4], [9].

Despite its clinical appeal, substantial heterogeneity exists in TTSS-derived thresholds and their predictive performance depending on population characteristics, injury patterns, and data availability. Protocols and reviews emphasize the need to validate TTSS in low-resource environments and to compare its performance with other prognostic scores in specific patient populations to determine where TTSS offers the greatest incremental value [2], [4], [6]. Moreover, the discriminative power of TTSS in extremely severe chest trauma or polytrauma with dominant non-thoracic injuries may be more limited, necessitating integration with systemic severity scores for comprehensive mortality risk assessment [4], [5], [8]. The interplay of TTSS with age, comorbidities, mechanism of injury, and concomitant CNS injury remains an important area for further study to refine TTSS-based risk stratification and its clinical utility [4], [8], [10]. Therefore, this study aims to assess the role of the Thoracic Trauma Severity Score in predicting mortality in thoracic trauma patients at Prof. Dr. R.D. Kandou General Hospital, Manado, contributing much-needed data from a tertiary referral center in Indonesia and addressing the current gap in validation within Southeast Asian populations.

II. METHOD

This analytical observational study employed a retrospective cohort design and was conducted at Prof. Dr. R.D. Kandou General Hospital, Manado, using medical records of patients with thoracic trauma admitted between January 1, 2021, and December 31, 2023. The study population comprised all patients diagnosed with thoracic trauma. Patients with complete clinical and radiological data required to calculate the Thoracic Trauma Severity Score (TTSS) were included, whereas those with incomplete records or inaccessible medical files were excluded. The primary independent variable was the TTSS, calculated based on five components: age, PaO_2/FiO_2 ratio, number of rib fractures, pulmonary contusion, and pleural involvement. The primary outcome was in-hospital mortality, while the requirement for intensive care unit (ICU) admission was analyzed as a secondary outcome. Statistical analyses were performed using appropriate statistical software. Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. Bivariate analyses were conducted to evaluate the association between TTSS and mortality using appropriate statistical tests according to the type and distribution of the data. Survival analysis was performed using the Kaplan–Meier method, with differences between groups assessed by the log-rank test. The predictive performance of TTSS for mortality was evaluated by receiver operating characteristic (ROC) curve analysis, including calculation of the area under the curve (AUC), sensitivity, and specificity. A two-sided p-value of <0.05 was considered statistically significant. Ethical approval for the study was obtained from the Health Research Ethics Committee of Prof. Dr. R.D. Kandou General Hospital, Manado.

III. RESULT AND DISCUSSION

Table 1. Baseline Characteristics of the Study Population

Variable	n (%)	Median (Q1–Q3)
Sex		

Variable	n (%)	Median (Q1–Q3)
Male	61 (79.2)	
Female	16 (20.8)	
Age (years)		44 (29–61)
PaO_2/FiO_2 (%)		439 (422–466)
TTSS Grade		
Grade 1 (0–4)	47 (61.0)	
Grade 2 (5–8)	28 (36.4)	
Grade 3 (>8)	2 (2.6)	
Number of rib fractures		
0	46 (59.7)	
1–3	16 (20.8)	
>3	15 (19.5)	
Pulmonary contusion		
Yes	14 (18.2)	
No	63 (81.8)	
Pleural involvement		
Yes	33 (42.9)	
No	44 (57.1)	
Mortality		
Survived	54 (70.1)	
Died	23 (29.9)	
ICU admission		
Yes	7 (9.1)	
No	70 (90.9)	
Length of hospital stay (days)		7 (4–11)

Patients with adverse outcomes demonstrated significantly higher TTSS values than those with favorable outcomes. The median TTSS among patients requiring ICU admission was significantly higher than among those managed in general wards (6 vs. 3, $p = 0.002$). Similarly, non-survivors had significantly higher TTSS values than survivors (5 vs. 2.5, $p < 0.001$), indicating that increasing TTSS was associated with greater injury severity and poorer prognosis.

Table 2. TTSS According to ICU Admission and Mortality

Variable	Median (Q1–Q3)	*p*-value
ICU admission		
Non-ICU	3 (2–5)	0.002
ICU	6 (5.5–7)	
Mortality		
Survived	2.5 (1–5)	<0.001
Died	5 (4–6.5)	

Evaluation of individual TTSS components demonstrated that age >30 years ($p = 0.011$) and pulmonary contusion ($p = 0.021$) were significantly associated with mortality. A PaO_2/FiO_2 ratio ≤400 was associated with an almost threefold increased risk of death (IRR 2.9; 95% CI 1.1–7.0; $p = 0.018$), whereas pulmonary contusion increased mortality risk by more than fourfold ($p = 0.001$). Although a TTSS >2 showed a trend toward increased mortality (IRR 4.0; 95% CI 1–35), this association did not reach statistical significance (p = 0.058). Kaplan–Meier survival analysis demonstrated significantly lower survival probabilities among patients with higher TTSS (log-rank $p < 0.05$). Receiver operating characteristic (ROC) analysis showed good discriminatory ability of TTSS for predicting in-hospital mortality, with an area under the curve (AUC) of approximately 0.80, a sensitivity of 91%, and a specificity of 50% [11].

The present study demonstrates that TTSS is an effective prognostic tool for predicting mortality and ICU requirement in patients with thoracic trauma. Patients with higher TTSS consistently experienced worse clinical outcomes, supporting the role of TTSS as an early risk stratification instrument. By integrating both physiological parameters (age and PaO_2/FiO_2 ratio) and anatomical injury characteristics (rib fractures, pulmonary contusion, and pleural involvement), TTSS provides a comprehensive assessment of thoracic injury severity [12].

Among the individual TTSS components, pulmonary contusion emerged as the strongest predictor of mortality. This finding is consistent with the pathophysiology of pulmonary contusion, which impairs alveolar gas exchange, increases intrapulmonary shunting, and predisposes patients to respiratory failure and acute respiratory distress syndrome (ARDS). Likewise, a reduced PaO_2/FiO_2 ratio reflects clinically significant hypoxemia and was independently associated with poorer outcomes. Older age was also associated with increased mortality, likely reflecting diminished physiological reserve and greater vulnerability to post-traumatic complications [13]–[15].

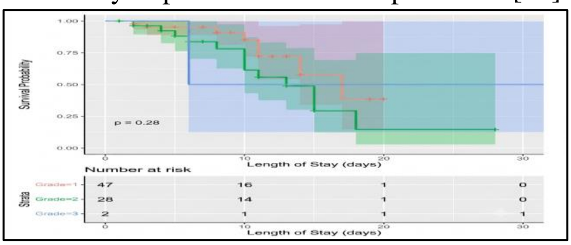

Fig. 1. Survival Probability of Thoracic Trauma Patients Stratified by Length of Stay and TTSS Grade

Although not every TTSS component was independently associated with mortality, the overall composite score demonstrated good predictive performance, emphasizing that the combined assessment provides greater prognostic value than individual variables alone. The AUC of approximately 0.80 indicates good discrimination, while the high sensitivity (91%) suggests that TTSS is particularly useful for identifying patients at high risk who may benefit from closer monitoring or early ICU admission. The relatively modest specificity (50%), however, indicates that TTSS should be interpreted alongside comprehensive clinical evaluation rather than used as a standalone decision-making tool.

This study has several limitations. Its retrospective single-center design may introduce information bias and limit external validity. In addition, the relatively small sample size may have reduced statistical power, particularly for subgroup analyses. Nevertheless, the findings support the use of TTSS as a practical and readily applicable scoring system for early risk stratification of thoracic trauma patients, especially in resource-limited healthcare settings.

IV. CONCLUSION

The Thoracic Trauma Severity Score (TTSS) demonstrates good predictive performance for in-hospital mortality in patients with thoracic trauma, with an area under the ROC curve of approximately 0.80, high sensitivity (91%), and moderate specificity (50%). Higher TTSS values were significantly associated with increased mortality and greater likelihood of intensive care unit admission, confirming the score's utility as an early risk stratification tool. Among the individual TTSS components, pulmonary contusion, reduced PaO_2/FiO_2 ratio, and older age emerged as important predictors of adverse outcomes, reflecting the score's integrated assessment of both anatomical injury burden and physiological impairment. Despite its retrospective single-center design and limited sample size, this study contributes valuable data from a tertiary referral center in Indonesia, addressing a gap in TTSS validation within Southeast Asian populations. The findings support the clinical application of TTSS as a practical and readily available instrument for guiding triage decisions, identifying high-risk patients who may benefit from early escalation of care, and optimizing resource allocation in emergency and critical care settings. However, given the modest specificity, TTSS should be used in conjunction with comprehensive clinical judgment rather than as a standalone prognostic tool. Future prospective multicenter studies with larger sample sizes are warranted to validate these findings, establish population-specific thresholds, and further evaluate the integration of TTSS with other trauma scoring systems to enhance mortality prediction in thoracic trauma patients.

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