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The Lung Organ Failure Score (LOFS) as an Early Predictor of Mortality in Blunt Thoracic Trauma: A Preliminary Validation Study in a Southeast Asian Cohort

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A B S T R A C T

Introduction: Blunt thoracic trauma is a leading cause of trauma-related mortality. Early and accurate risk stratification is essential for optimizing outcomes, yet many prognostic scores lack validation in diverse populations. This study aimed to perform a preliminary evaluation of the prognostic value of the lung organ failure score (LOFS) for predicting in-hospital mortality in patients with blunt thoracic trauma in an Indonesian tertiary trauma center. **Methods:** This retrospective, single-center, exploratory cohort study included adult patients (≥18 years) admitted with blunt thoracic trauma to Dr. Mohammad Hoesin General Hospital from January 2023 to January 2025. Data on demographics, injury characteristics, initial physiological parameters, and clinical outcomes were collected. The LOFS was calculated for each patient. The primary outcome was in-hospital mortality. Statistical analyses included bivariate comparisons, Kendall's Tau correlation, and Receiver Operating Characteristic (ROC) curve analysis. **Results:** A total of 32 patients were included. The overall in-hospital mortality rate was 21.9% (n=7). The non-survivor group had a significantly higher mean LOFS than the survivor group (21.00±5.29 vs. 14.16±3.92, p=0.001). LOFS demonstrated a moderate, positive correlation with mortality (Kendall's Tau r=+0.568, p=0.001). ROC analysis showed that LOFS had excellent discriminative ability for mortality, with an Area Under the Curve (AUC) of 0.840 (95% CI: 0.685–0.995, p=0.001). An optimal cut-off score of ≥18 yielded a sensitivity of 85.7% and a specificity of 80.0%. **Conclusion:** In this preliminary study, LOFS was strongly associated with in-hospital mortality and demonstrated excellent discriminative performance. The findings suggest LOFS is a promising and simple tool for early risk stratification in this high-risk population. However, the study's small sample size precluded a reliable assessment of its independence from other risk factors. Further validation in larger, prospective multicenter studies is essential to confirm these findings.

1. Introduction

Trauma remains a global public health scourge and the leading cause of death for individuals under the age of 45. Within this broad spectrum of injury, thoracic trauma holds a particularly ominous position, contributing to approximately one in four trauma-related deaths and significantly complicating the clinical trajectory of up to 50% of all polytrauma patients.[1] Blunt force mechanisms—resulting from motor vehicle collisions, falls, and direct impacts—are responsible for over 70% of these chest injuries. The associated mortality rates can be staggering, approaching 60% in severely injured cohorts, a statistic that underscores the profound need for rapid, accurate, and decisive clinical management.[2]

The clinical challenge posed by blunt thoracic trauma lies in its complex and often insidious pathophysiology.[3] The initial mechanical impact, or

"first hit," inflicts direct damage to the chest wall (such as rib fractures and flail chest) and underlying viscera, most notably the lung parenchyma, leading to pulmonary contusion and laceration. This primary injury precipitates a cascade of deleterious events: pain-induced respiratory splinting, atelectasis, ventilation-perfusion mismatch, and progressive hypoxemia. Compounding this local insult is the systemic inflammatory response syndrome (SIRS), a global biological firestorm triggered by tissue damage and shock.[4] This systemic inflammation dramatically increases capillary permeability, rendering the already-injured lungs exquisitely vulnerable to fluid extravasation and the development of acute respiratory distress syndrome (ARDS), a primary driver of late mortality in trauma patients.[5]

Consequently, a cornerstone of modern trauma care is the ability to predict, at the earliest possible juncture, which patients are destined for this downward spiral.[6] Early identification of high-risk individuals allows for proactive and targeted interventions, such as consideration for early intensive care unit (ICU) admission, aggressive multimodal pain control (such as regional anesthesia), optimized fluid resuscitation strategies, and advanced respiratory support. Over the decades, numerous scoring systems have been developed to aid in this prognostic challenge. General trauma scores like the injury severity score (ISS) and the revised trauma score (RTS) provide a global assessment of anatomical and physiological derangement, but often lack the specificity to capture the unique pulmonary risks associated with chest trauma.[7] An ISS of 25 from orthopedic injuries, for instance, carries a vastly different prognosis than an ISS of 25 driven by a severe bilateral pulmonary contusion. Thorax-specific scores, including the thorax trauma severity score (TTSS), have been introduced to address this gap, but their complexity or inconsistent validation across diverse clinical settings has hindered their widespread adoption.[8] This leaves an unmet need for a simple, reliable, and easily applicable tool for risk stratification in this specific patient population.

The lung organ failure score (LOFS), first proposed by Wutzler et al., was specifically engineered to fill this void. It was designed to predict the likelihood of severe pulmonary organ failure in polytrauma patients with concomitant chest injuries.[9] Its strength lies in its composite nature, integrating ten readily available parameters at admission. These include demographic factors (age, gender), measures of anatomical injury severity (ISS, Abbreviated Injury Scale [AIS] scores for the thorax and head), and markers of physiological insult and the iatrogenic burden of resuscitation (initial fluid volume, need for emergency and multiple surgeries). By synthesizing these distinct domains of risk, LOFS aims to provide a more holistic and nuanced prediction of lung-related complications than its predecessors.

Despite its theoretical appeal, the validation and application of LOFS have been largely confined to the European populations in which it was developed. Its utility for predicting the ultimate outcome of mortality, rather than just organ failure, remains under-investigated. This is particularly true in developing nations and diverse demographic settings, such as Southeast Asia, where differences in injury patterns, healthcare resources, and patient physiology may impact the score's performance. A previous Indonesian study by Setiawan et al. showed LOFS to be superior to TTSS for predicting ventilator use, but its direct prognostic value for mortality has not been specifically evaluated.[10]

The novelty of this research lies in it being the first study to specifically validate and quantify the utility of LOFS as a mortality prediction tool in this distinct patient population, with the goal of providing an evidence-based framework for early risk stratification in a resource-constrained healthcare environment. Therefore, this study aims to conduct a preliminary evaluation of the prognostic value of the lung organ failure score (LOFS) for predicting in-hospital mortality in patients with blunt thoracic trauma at a tertiary trauma center in Indonesia.

2. Methods

This study was a retrospective, single-center, exploratory cohort analysis conducted at Dr. Mohammad Hoesin General Hospital in Palembang, South Sumatra, Indonesia. As a national referral hospital and the primary tertiary care trauma center for the province, it manages a high volume of complex injury cases. The study protocol was reviewed by the Institutional Review Board, which granted an ethical exemption due to the retrospective and de-identified nature of the data analysis (No.DP.04.03/D.XVIII.06.08/ETIK/218/2025). The requirement for individual informed consent was waived. This report was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

The study population included all patients with a diagnosis of blunt thoracic trauma admitted to the hospital between January 1st, 2023, and January 31st, 2025. Patients were identified using the hospital's medical records database and relevant International Classification of Diseases, 10th Revision (ICD-10) codes for thoracic injuries. Inclusion criteria were: (1) adult patients aged 18 years or older at admission, and (2) a primary or significant secondary diagnosis of blunt thoracic trauma necessitating hospital admission. Exclusion criteria were: (1) patients with isolated penetrating thoracic trauma (such as stab or gunshot wounds); (2) patients who were dead on arrival or died in the emergency department prior to comprehensive diagnostic evaluation, precluding full LOFS calculation; (3) pregnant patients; and (4) patients with medical records containing data insufficient for LOFS calculation or primary outcome ascertainment.

A standardized data collection instrument was utilized to retrospectively extract data from electronic and paper-based medical records. To ensure data integrity, two researchers independently performed the data abstraction, with a senior surgeon resolving any discrepancies. The following variables were collected; (1) Demographics: Age (in years), gender (male/female), and Body Mass Index (BMI), calculated as weight (kg) / height $(m)^2$; (2) Clinical History: Pre-existing comorbidities (hypertension, diabetes mellitus, chronic pulmonary disease) and smoking status; (3) Injury Characteristics: The mechanism of injury was recorded. Injury severity was coded using the Abbreviated Injury Scale (AIS), 2005 version. The Injury Severity Score (ISS) was calculated as the sum of the squares of the highest AIS scores in the three most severely injured body regions. Severe thoracic injury was defined as an AIS score for the thorax region of ≥4, and severe head injury was defined as an AIS score for the head/neck region of ≥3. All AIS and ISS calculations were performed retrospectively by trained personnel based on a comprehensive review of all imaging reports (CT, X-ray) and operative notes; (4) Initial Resuscitation and Management: Glasgow Coma Scale (GCS) score on arrival, initial arterial lactate level (mmol/L), and base deficit (mmol/L). The total volume of intravenous fluids (crystalloids and colloids) administered within the first 6 hours of emergency department arrival was recorded in liters. The number of packed red blood cell (PRBC) units transfused in the first 24 hours was noted. The performance of any emergency surgery, defined as an urgent, non-elective procedure required to manage life-threatening hemorrhage, contamination, or physiological instability (including exploratory laparotomy, thoracotomy, and major vascular repair), was recorded. The total number of surgical interventions during the hospital stay was also collected; (5) Hospital Course and Outcomes: The primary outcome was in-hospital mortality, defined as death from any cause during the index hospitalization. Secondary outcomes included the need for mechanical ventilation and the total length of hospital stay (in days). The LOFS was calculated for each patient according to the original methodology described by Wutzler et al. Points were assigned for ten independent predictors, and the total score was derived from their sum, as detailed in Table 1.

Table 1. Calculation of the Lung Organ Failure Score (LOFS)

POINTS	VARIABLE
4	Two or more planned surgical interventions
3	One planned surgical intervention
3	Any emergency surgery
3	Severe thoracic injury (AIS Thorax score = 5)
2	Severe thoracic injury (AIS Thorax score = 4)
2	Severe head injury (AIS Head score ≥ 3)
2	Male sex
1	Per 2 liters of fluid volume administered (first 6 hours)
1	Per 8 points of the Injury Severity Score (ISS)
1	Per 10 years of age
Total Score: Sum of all applicable points	

AIS: Abbreviated Injury Scale; **ISS:** Injury Severity Score.

All data were analyzed using IBM SPSS Statistics for Windows, Version 25.0 (Armonk, NY: IBM Corp). Continuous variables were assessed for normality using the Shapiro-Wilk test, appropriate for the sample size (<50). Normally distributed data were presented as mean ± standard deviation (SD), while non-normally distributed data were presented as median and interquartile range (IQR). Categorical variables were described using frequencies and percentages. To compare characteristics between the survivor and non-survivor groups, the independent samples t-test was used for normally distributed continuous variables, and the Mann-Whitney U test was used for non-normally distributed continuous variables. The Chi-square test or Fisher's exact test (for cell counts <5) was used for categorical variables. The correlation between the LOFS (as a continuous variable) and the dichotomous outcome of mortality was assessed using the Kendall's Tau correlation coefficient. This non-parametric test was chosen due to the small sample size and non-normally distributed data, providing a robust measure of association. To evaluate the overall discriminative performance of LOFS for mortality, a Receiver Operating Characteristic (ROC) curve was constructed. The Area Under the Curve (AUC) with its 95% confidence

interval (CI) was calculated. An AUC of 0.7–0.8 is considered acceptable, 0.8–0.9 is excellent, and >0.9 is outstanding. The optimal cut-off value for LOFS that maximized the Youden's index (Sensitivity + Specificity - 1) was determined to provide a clinically relevant threshold. Given the small number of mortality events (n=7), a multivariate logistic regression analysis was not performed. Such an analysis would be statistically invalid due to severe overfitting (fewer than 10 events per predictor variable), yielding unreliable estimates of independent association. Therefore, this study focuses on associative and discriminative analyses only. A two-tailed p-value of <0.05 was considered statistically significant for all analyses.

3. Results

During the two-year study period, 38 patients were initially identified with blunt thoracic trauma. Following the application of exclusion criteria, 6 patients were excluded: 5 were under the age of 18, and 1 had a significant concomitant penetrating injury. This resulted in a final cohort of 32 patients for analysis. The patient selection process is outlined in Figure 1.

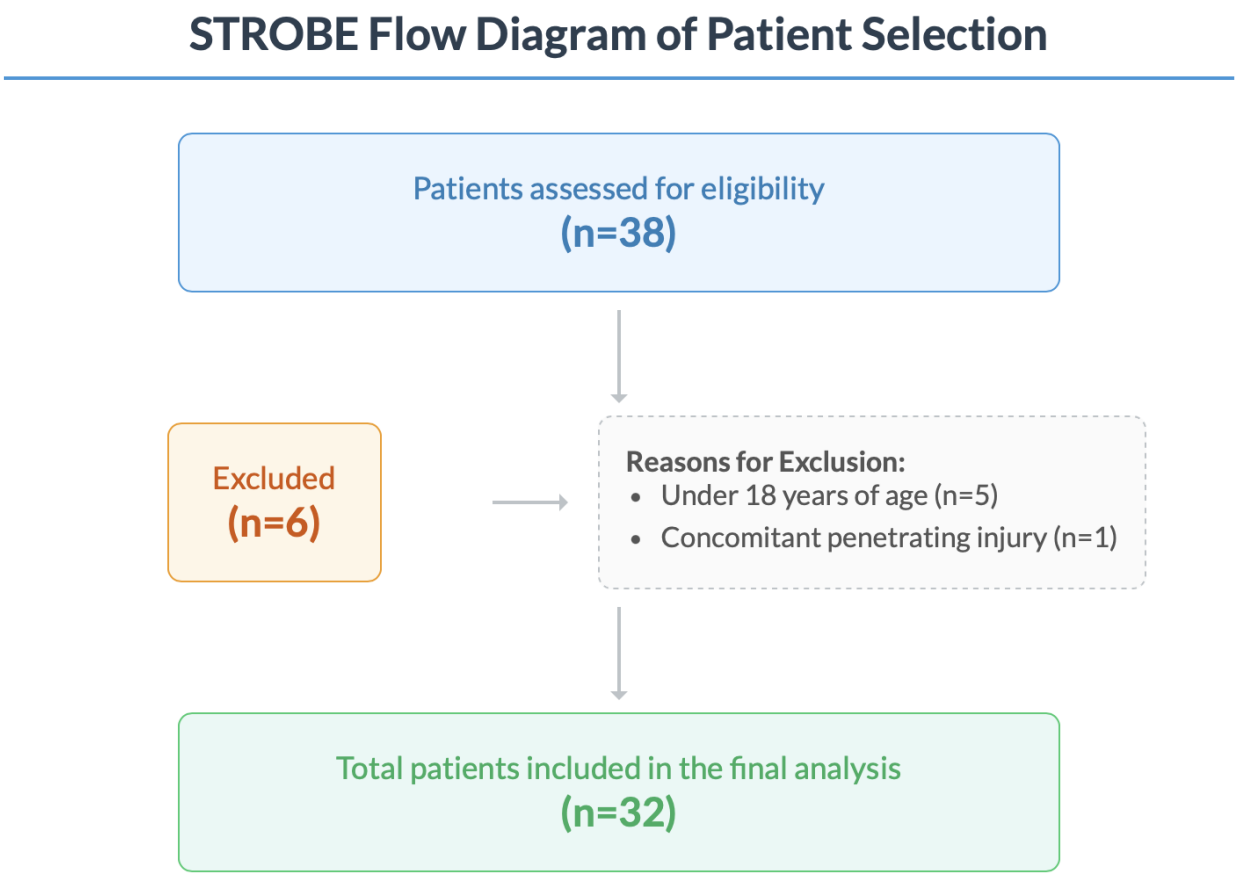

Figure 1. STROBE flow diagram of patient selection.

The demographic and clinical characteristics of the study cohort are detailed in Table 2. The mean age was 45.00±16.31 years, with a significant male predominance (78.1%). The cohort presented with a high burden of injury, reflected by a median GCS of 13, a median ISS of 25.0, and evidence of significant physiological derangement with a median lactate of 3.2 mmol/L. The most common mechanism of injury was

motor vehicle collision (65.6%). A high percentage of patients were active smokers (75.0%), and hypertension was the most common comorbidity (50.0%). The severity of injuries necessitated emergency surgery in 75.0% of cases and mechanical ventilation in 46.9% of the cohort. The overall in-hospital mortality rate was 21.9% (7 of 32 patients).

Table 2. Baseline Demographic and Clinical Characteristics of the Study Cohort (n=32)

CHARACTERISTIC	TOTAL COHORT (N=32)
Demographics	
Age (years), mean ± SD	45.00 ± 16.31
Male Sex, n (%)	25 (78.1)
BMI (kg/m^2), median (IQR)	23.77 (2.56)
Clinical History	
Active Smoker, n (%)	24 (75.0)
Comorbidities, n (%)	
↳ Hypertension	16 (50.0)
↳ Diabetes Mellitus Type 2	2 (6.3)
↳ Chronic Pulmonary Disease	7 (21.9)
Injury & Resuscitation	
Mechanism: Motor Vehicle Collision, n (%)	21 (65.6)
GCS on Arrival, median (IQR)	13 (6)
Lactate (mmol/L), median (IQR)	3.2 (2.1)
Base Deficit (mmol/L), median (IQR)	-5.0 (3.5)
Severe Thoracic Injury (AIS ≥ 4), n (%)	11 (34.4)
Severe Head Injury (AIS ≥ 3), n (%)	10 (31.3)
ISS, median (IQR)	25.00 (18.00)
Management & Hospital Course	
Fluid Volume (first 6h, L), median (IQR)	3.00 (2.00)
PRBCs Transfused (first 24h), median (IQR)	2 (3)
Emergency Operation, n (%)	24 (75.0)
≥2 Surgical Interventions, n (%)	22 (68.8)
Mechanical Ventilation, n (%)	15 (46.9)
Length of Stay (days), median (IQR)	7.00 (7.00)
Outcome	
In-Hospital Mortality, n (%)	**7 (21.9)**

Abbreviations: SD, Standard Deviation; **BMI**, Body Mass Index; **IQR**, Interquartile Range; **GCS**, Glasgow Coma Scale; **AIS**, Abbreviated Injury Scale; **ISS**, Injury Severity Score; **PRBCs**, Packed Red Blood Cells.

Table 3 provides a bivariate comparison of characteristics between patients who survived and those who died. The non-survivor group demonstrated evidence of more profound shock and severe injury on arrival. They had a significantly lower median GCS (9 vs. 14, p=0.010), higher median lactate (4.8 vs. 2.9 mmol/L, p=0.002), and required a greater volume of initial fluid resuscitation (median 4.00 L vs. 3.00 L, p=0.001).

Anatomically, the injury burden was substantially higher among non-survivors, with a significantly higher median ISS (41.0 vs. 25.0, p=0.017) and a markedly higher prevalence of severe thoracic injury (AIS Thorax ≥ 4: 85.7% vs. 20.0%, p=0.003). Consequently, the need for mechanical ventilation was significantly greater in the non-survivor group (85.7% vs. 36.0%, p=0.033). While non-survivors tended to be older, this difference was not statistically significant.

Table 3. Bivariate Comparison of Characteristics Between Survivors and Non-Survivors

CHARACTERISTIC	NON-SURVIVORS (N=7)	SURVIVORS (N=25)	P-VALUE
Age (years), mean ± SD	51.14 ± 13.28	43.28 ± 16.89	0.266
Male Sex, n (%)	6 (85.7)	19 (76.0)	1.000
GCS on Arrival, median (IQR)	**9.0 (5.0)**	**14.0 (4.0)**	**0.010**
Lactate (mmol/L), median (IQR)	**4.8 (1.9)**	**2.9 (1.8)**	**0.002**
Severe Thoracic Injury (AIS ≥ 4), n (%)	**6 (85.7)**	**5 (20.0)**	**0.003**
Severe Head Injury (AIS ≥ 3), n (%)	4 (57.1)	6 (24.0)	0.165
ISS, median (IQR)	**41.0 (24.0)**	**25.0 (14.0)**	**0.017**
Fluid Volume (first 6h, L), median (IQR)	**4.00 (2.00)**	**3.00 (1.00)**	**0.001**
Mechanical Ventilation, n (%)	**6 (85.7)**	**9 (36.0)**	**0.033**
Length of Stay (days), median (IQR)	4.00 (15.00)	7.00 (7.00)	0.801
LOFS, mean ± SD	**21.00 ± 5.29**	**14.16 ± 3.92**	**<0.001**

Statistical Tests: [a]Independent samples t-test; [b]Mann-Whitney U test; [c]Fisher's exact test.
Note: Rows with statistically significant p-values (<0.05) are highlighted.

The primary analysis revealed a profound and highly statistically significant difference in LOFS between the two outcome groups. The mean LOFS for non-survivors was 21.00 ± 5.29, compared to 14.16 ± 3.92 for survivors (p<0.001). This finding demonstrates that higher LOFS values, calculated from admission data, are strongly associated with subsequent in-hospital mortality. This relationship was further quantified using correlation analysis. The Kendall's Tau test revealed a moderate, positive, and significant correlation between the LOFS and mortality (r = +0.568, p=0.001). This indicates that as the LOFS increases, the risk of death increases proportionally.

The overall ability of LOFS to discriminate between survivors and non-survivors was evaluated using ROC curve analysis (Figure 2). The LOFS demonstrated

excellent predictive accuracy, with an Area Under the Curve (AUC) of 0.840 (95% CI: 0.685–0.995; p=0.001). Based on Youden's index, the optimal cut-off value for LOFS in predicting mortality in this cohort was determined to be ≥18. This threshold yielded a sensitivity of 85.7%, a specificity of 80.0%, a positive predictive value (PPV) of 54.5%, and a negative predictive value (NPV) of 95.2%. The high NPV is particularly noteworthy, suggesting that patients with a LOFS below 18 are at a very low risk of in-hospital mortality. The Area Under the Curve (AUC) was 0.840, indicating excellent discrimination between survivors and non-survivors.

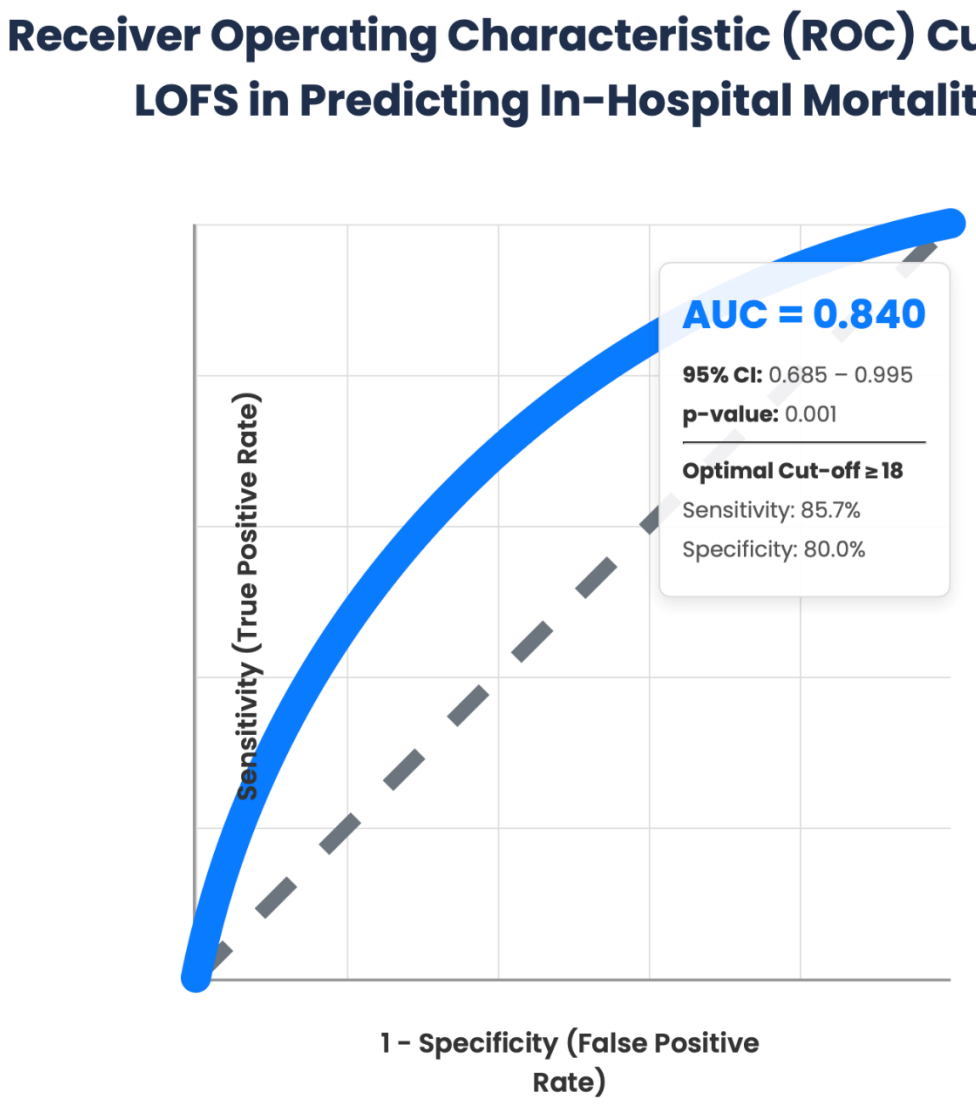

Figure 2. Receiver operating characteristic (ROC) curve for LOFS in predicting in-hospital mortality.

4. Discussion

This study represents the first focused evaluation of the lung organ failure score (LOFS) as a prognostic tool for mortality in blunt thoracic trauma patients within an Indonesian and broader Southeast Asian context.[11] The principal finding of this preliminary

research is that a higher LOFS, calculated from readily available admission data, is strongly associated with in-hospital death and demonstrates excellent discriminative capability. Patients who did not survive had a mean LOFS of 21, a full 7 points higher than the mean score of 14 in those who survived. The AUC of 0.840 indicates that the score is highly effective at distinguishing between patients who will live and those who will die. These findings suggest that LOFS holds considerable promise as a simple, early, and effective risk stratification tool in this high-risk population. The robust performance of LOFS can be attributed to its sophisticated integration of multiple, distinct pathophysiological domains that converge to determine a patient's outcome.[12] It moves beyond a simple anatomical summary of injuries to create a more holistic portrait of the patient's condition.

The score heavily weights anatomical injury severity, specifically through the ISS and AIS scores for the thorax and head.[13] Our data strongly support this, showing that severe thoracic injury was over four times more prevalent in non-survivors (85.7% vs. 20.0%). Severe blunt thoracic trauma represents the quintessential "first hit": direct mechanical violence to the lung parenchyma and chest wall that initiates a vicious cycle of pain, hypovilation, atelectasis, and localized inflammation. This localized damage primes the lung for further injury. The overall trauma burden, quantified by the ISS, triggers a systemic inflammatory response (SIRS), which constitutes the initial phase of the "second hit". This systemic inflammation enhances capillary permeability globally, but its effects are most devastating in the already-compromised pulmonary vasculature, paving the way for ARDS and multiple organ dysfunction syndrome (MODS), the leading causes of late trauma mortality.[14]

The inclusion of severe head injury (AIS Head ≥ 3) in LOFS is a particularly insightful component, acknowledging the critical importance of the brain-lung axis. A severe traumatic brain injury (TBI) can precipitate neurogenic pulmonary edema (NPE) through a massive sympathetic surge, causing a rapid and damaging shift of fluid into the pulmonary interstitium and alveoli.[15] Furthermore, the injured brain releases a torrent of pro-inflammatory cytokines that cross the disrupted blood-brain barrier, propagating a systemic inflammatory state that synergistically worsens the primary lung injury and heightens ARDS risk. This destructive crosstalk explains why concomitant TBI is such a potent harbinger of poor outcomes, a principle effectively captured by the LOFS.

LOFS also incorporates crucial markers of physiological insult and the subsequent therapeutic response. The volume of initial fluid resuscitation is a critical—and controversial—component of early trauma care. While essential for treating hemorrhagic shock, aggressive fluid administration is a double-edged sword. Our study confirmed that non-survivors received significantly more fluid in the first six hours. Excessive crystalloid infusion can lead to dilutional coagulopathy, acidosis, hypothermia, and, most critically, endothelial injury and glycocalyx shedding.[16] This iatrogenic "resuscitation injury" exacerbates capillary leak, leading to generalized tissue edema. In the lungs, this manifests as worsening pulmonary edema, which impairs gas exchange, reduces compliance, and directly contributes to respiratory failure and death.

Finally, the need for surgical intervention—especially emergency surgery or multiple procedures—is a powerful surrogate for both injury severity and the physiological stress of the ongoing "second hit". A major operation, though life-saving, induces its own significant inflammatory response, adding fuel to the post-traumatic SIRS cascade. This can be the final insult that tips a patient with compromised pulmonary reserve into overt, irreversible ARDS. The inclusion of age and male gender reflects established demographic risk factors, with advancing age corresponding to diminished physiological reserve and immunosenescence.[17]

Figure 3. Pathophysiological rationale and integration of risk domains.

Our findings, which are remarkably consistent with the original developmental study by Wutzler et al. concerning the predictive factors for pulmonary failure, extend their work by demonstrating that this same constellation of factors, synthesized by the LOFS, is also highly predictive of mortality.[18] The identified optimal LOFS cut-off of ≥18 in our cohort provides a practical, albeit preliminary, threshold for clinicians. A patient presenting with a score above this value warrants heightened vigilance and could be a trigger for a pre-defined care pathway. This might include immediate ICU consultation, early consideration for invasive monitoring, aggressive pulmonary toilet, protocolized pain management with regional anesthetic techniques, and a judicious fluid management strategy. The score's high negative predictive value (95.2%) is perhaps its most powerful feature; a score below 18 can provide a degree of reassurance, potentially allowing for the safe allocation of less resource-intensive care, a critical consideration in any healthcare environment.[19]

The future of trauma prognostication lies in moving from population-based estimates to individualized risk prediction. While LOFS is a step in this direction, the next logical step is to conduct a large-scale, prospective, multicenter validation study.[20] Such a study would be necessary to confirm our findings, refine the optimal cut-off value, and definitively establish the score's independent predictive value through a robust multivariate analysis. Furthermore, future research could explore the integration of novel biomarkers of inflammation (such as interleukins and cell-free DNA) or endothelial injury into the LOFS framework to potentially enhance its predictive power.

This study has several important limitations that must be acknowledged. The primary limitation is its preliminary, single-center, retrospective design and, most significantly, its small sample size. The cohort of 32 patients with only 7 mortality events provided insufficient statistical power to perform a multivariate analysis. Therefore, while our study demonstrates a strong association and excellent discrimination, it cannot establish LOFS as an independent predictor of mortality, as its effect cannot be reliably disentangled from other confounding factors.

Second, the exclusion of patients who died in the emergency department prior to comprehensive evaluation introduces a potential for survivorship bias. These patients represent the most severe spectrum of injury, and their exclusion means our findings are only applicable to patients who survive the initial phase of resuscitation. This may lead to an underestimation of the overall mortality associated with blunt thoracic trauma and could potentially inflate the score's performance metrics. Third, the findings from our single Indonesian trauma center may not be immediately generalizable to other populations or healthcare systems with different injury patterns, pre-hospital care systems, or in-hospital treatment protocols. Finally, the optimal LOFS cut-off value of ≥18 identified in this study should be considered exploratory and requires rigorous validation in a larger, more diverse cohort before it can be confidently recommended for widespread clinical implementation.

5. Conclusion

In this preliminary retrospective study, the Lung Organ Failure Score demonstrated excellent discriminative ability for predicting in-hospital mortality in adult patients with blunt thoracic trauma. A higher LOFS, calculated from simple admission parameters, was strongly associated with an increased risk of death. These findings suggest LOFS is a promising and simple tool for early risk stratification, capable of integrating key anatomical, physiological, and therapeutic variables into a single, clinically useful metric. Its implementation may help clinicians identify high-risk patients for more aggressive monitoring and targeted interventions. However, due to the study's small sample size, its independent predictive value could not be determined. Further validation in larger, prospective, multicenter studies is essential to confirm these findings and establish its definitive role in clinical practice.

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