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ORIGINAL RESEARCH

TERMINAL-24 Score in Predicting Early and In-hospital Mortality of Trauma Patients; a Cross-sectional

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Abstract: Introduction: Determining the trauma patients' prognosis is crucial for patients' safety, triage, and appropriate management. This study aimed to evaluate the screening performance of Traumatic Emergency Room Major Injury Death At Least 24 hours (TERMINAL-24) score in predicting the mortality of trauma patients. **Methods:** This cross-sectional study was conducted in the emergency department (ED) of a referral trauma center, between October 2023 and September 2024. The main goals of the project were determining the value of TERMINAL-24 score in predicting early (within 8 hours of admission to ED) and in-hospital mortality of multi-trauma patients as well as comparing the accuracy of TERMINAL-24 with other trauma severity scores (GAP, RGAP, NTS) in this regard. **Results:** 963 multi-trauma patients were included in this study. The mean age of the patients was 37.75±17.10 years (73.2% male). 55 patients died in the emergency department and 46 patients died during hospitalization in other departments. Male gender ($p = 0.009$), older age ($p = 0.011$), traffic accidents ($p = 0.005$), more critical vital signs ($p = <0.001$), admitting in neurosurgery ward ($p < 0.001$), and higher trauma severity ($P < 0.001$) were significantly associated with higher mortality rate. The area under the curve (AUC) of TERMINAL-24 score in predicting early and in-hospital mortality of trauma patients were 0.964 (95%CI: 0.937-0.991) and 0.954 (95%CI: 0.925-0.983), respectively. The specificity and sensitivity of TERMINAL-24 score for predicting early mortality at its best cut-off point (cut-off = 2.5) were 95.04% (95%CI: 93.43-96.28) and 96.36% (95%CI: 87.63-99.35), respectively. For predicting in-hospital mortality, these measures were 98.84% (95%CI: 97.88–99.37) and 87.13% (95%CI: 79.22-92.32), respectively (best cut-off = 2.5). **Conclusion:** It seems that, TERMINAL-24 score has the same accuracy in predicting both early and in-hospital outcomes of trauma patients. Considering the calculation formula of this score and its simplicity, it can be used in pre-hospital and in-hospital settings to predict the outcome of trauma patients.

Keywords: Wounds and injuries; Mortality; Emergency service, hospital; Injury severity score

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1. Introduction

Trauma is considered an important cause of mortality and disability in developed and developing countries (1). Every year, approximately 1.2 million people die and more than 50 million are injured or disabled due to trauma caused by car accidents worldwide (1, 2). Traumatic injury causes more mortality than acquired immunodeficiency syndrome, malaria, and tuberculosis (3). Studies have determined that by 2030, injuries caused by road traffic accidents (RTAs) will be the third most common cause of disease burden in the world (4).

Appropriate trauma management, early aggressive resuscitation, and evaluation are very crucial in the early hours after trauma. Providing appropriate definitive treatment for trauma patients in the early hours reduces mortality (5). Proper management of traumas is also of particular importance, as patients with mild injuries need to be admitted to regional-level clinics, and referring them without a scientific cause results in a waste of limited financial and human resources (6). However, patients with severe injuries need fast referrals to higher-level hospitals; otherwise, the risk of patient death will increase.
In this regard, the efficacy of death prediction models has relationship with the balance between patient safety and the proper use of resources (7).
Traditionally, the initial decision to manage a trauma patient was based on the severity of the injury (8, 9). The prognostic result helps the physicians decide whether to intensify, change, or stop certain therapies (10). Risk is also defined

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as the possibility of harm, and it is the probability of an event that can affect the achievement of goals and harm them (11). Trauma prognostication models should include risk, prognostic, and triage indicators (12). Various scores have been designed to evaluate the severity of trauma (5, 13-15). Samuthtai and colleagues showed in their study that Traumatic Emergency Room Major Injury death At Least 24 hours (TERMINAL-24) was effective in predicting early death in an emergency (16).

TERMINAL-24 scoring system is a new score introduced by Samuthtai in 2022. The focus of this score is to determine the risk of early mortality less than 24 hours after hospitalization, especially less than 8 hours, which is the golden time for patient resuscitation in the emergency department (17).

Considering the recent introduction of the TERMINAL-24 score in predicting early mortality of trauma patients and the suggestion of the authors of the study (16) to conduct additional studies to confirm its value, we decided to conduct this study in a referral trauma center to evaluate this score in predicting early mortality of multi-trauma patients and compare it with previous valid scores. Therefore, this study aimed to evaluate the screening performance of TERMINAL-24 score in predicting the mortality of trauma patients and comparing its accuracy with other available trauma severity in this regard.

2. Methods

2.1. Study design and setting

This cross-sectional study was conducted in the emergency department (ED) of Imam Reza Hospital, a referral trauma center in the East Azerbaijan province, Tabriz, Iran, between October 2023 and September 2024. The main goals of the project were determining the value of TERMINAL-24 score in predicting the early (within 8 hours of admission to ED) and in-hospital mortality of multi-trauma patients as well as comparing the accuracy of TERMINAL-24 with other trauma severity scores (GAP, RGAP, NTS) in predicting the in-hospital mortality of trauma patients.

Imam Reza general Hospital is an educational, therapeutic and research hospital affiliated to Tabriz University of Medical Sciences with a capacity of 670 beds in East Azarbaijan province. This province with an area of about 45,000 square kilometers has a population of about 4 million people, about 2 million of which are the population of Tabriz city. There are 43 hospitals in the province, 20 of which are located in Tabriz city and the rest are located in other cities. About 110,000 patients are admitted to the emergency department of the study hospital every year.

Sampling was done after the approval of the ethics committee and as a census until reaching the final sample size. This study has been approved by the Ethics Committee of Tabriz University of Medical Sciences with code IR.TBZMED.REC.1403.060 on 22.04.2024.

2.2. Participants

All blunt multiple trauma patients who were referred to the emergency department during the study period were included. Discharge with personal consent, referral from other hospitals, inability to follow up with the patient, and lack of consent to participate in the study led to exclusion of cases.

2.3. Data gathering

At the time of admission and at the same time as the beginning of diagnostic and therapeutic measures, the required information including gender, age, vital signs (blood pressure, heart rate, arterial blood oxygen saturation, level of consciousness based on Glasgow Coma Scale (GCS)), trauma mechanism, location of accident (road, street, alley and other cases), duration of hospitalization (days), the hospitalization ward, disposition, and need for intubation were collected. Disposition in the emergency department included death, hospitalization, and discharge. The mortality time was divided to three groups, including death in under 8 hours (early mortality), death in 8-24 hours (intermediate mortality), and death after 24 hours (late mortality), based on time from admission to the ED and death. In addition, the outcome of the patients during discharge from the hospital was recorded as dead or alive and reported as in-hospital mortality.

Trauma severity was calculated at the time of admission to the ED for all patients using different scores, such as GAP (GCS, Age, and Pressure), R-GAP (Revised, GAP), NTS (New Trauma Score), and RTS (Revised Trauma Score), as the physiologic scores (2, 5, 12, 13). In addition to these scores, the TERMINAL-24 score was also calculated and recorded for all patients (16).

TERMINAL-24 Score

TERMINAL-24 score is designed based on 4 variables of tachycardia, hypotension, coma, and traffic injury (Supplementary table 1). The range of this score is between 0 and 5, the values of all positive parameters are added together and final score is calculated.

2.4. Statistical analysis

To calculate the sample size, the results of the study by W. Samuthtai and his colleagues (16) were used. In this study, the TERMINAL-24 score has a sensitivity of 75% and a specificity of 94% for predicting mortality in emergency department. Considering the above information with a 95% confidence interval, 5% acceptable error rate, and 30% prevalence of trauma patients referring to the emergency department, the sample size was calculated as 963 trauma patients using Dr. Lin Naing's software. This software is designed in Excel and used by statisticians to calculate sample size in predictive studies using sensitivity and specificity mentioned in a previous study.

The data were entered into the statistical software SPSS version 20. Kolmogorov-Smirnov test was used to determine the normal distribution of the data. To describe qualitative data, frequency (percentage) was used, and for quantitative data in the cases of normal distribution, mean ± standard deviation, and in the cases of non-normal distribution, median (interquartile range (IQR) 25-75) was used. The Chi-square test was used to compare qualitative data between groups. To compare quantitative data between the two groups, the independent t-test was used in the case of normal distribution, and the Mann Whitney U test was used in the case of non-normal distribution. Kruskal Wallis test was used to compare quantitative data with non-normal distribution between the three groups. To determine the accuracy of models in mortality prediction, the area under the Receiver Operating Characteristic (ROC) curve (AUC) with 95% confidence interval (CI) was calculated and screening performance characteristics of trauma severity models in predicting the early and in-hospital mortality were calculated at its best cut-off point based on the AUC. In all cases, a P value less than 0.05 was considered significant.

3. Results

3.1. Baseline characteristics of studied cases

963 multi-trauma patients were included in this study. The mean age of the patients was 37.75±17.10 with a median of 34 (range: 3-99) years (73.2% male). The mechanism of trauma in 824 cases (85.6%) was traffic accidents and 139 cases (14.4%) were falls and fights. In trauma patients as a result of a traffic accident, the most common mechanisms of accident included 439 cases (53.3%) of car-car collision, 132 cases (16%) of car rollover, 121 cases (14.7%) of car-to-pedestrian accidents, 68 cases of car to fixed objects (8.2%), and the rest were other mechanisms. The place of traffic accidents in 506 cases (61.4%) was on inner-city streets, 210 cases (25.4%) were on roads and highways, and 108 cases (13.1%) were in inner-city alleys.

3.2. Outcomes

601 patients (62.4%) were discharged, 307 patients (31.9%) were hospitalized, and 55 patients (5.7%) died in emergency department. In terms of hospitalization, 92 patients (9.6%) were admitted to the general surgery department, 127 patients (13.2%) were admitted to the neurosurgery department, and 88 patients (9.1%) were admitted to the orthopedic department. 175 patients (18.2%) were intubated during hospitalization. The total number of patient mortality was 101 cases (10.5%), 55 of which died in the emergency department and 46 patients died during hospitalization in other departments. Table 1 compares the baseline characteristics of studied cases between survived and non-survived cases. Table 2 compares the demographic status, vital signs, and accident mechanism between the two groups. Male gender (p = 0.009), older age (p =0.011), traffic accidents (p = 0.005), more critical vital signs (p = <0.001), and admission in neurosurgery ward (p < 0.001) were significantly associated with higher mortality rate. The patients with higher trauma severity scores (based on different scoring systems) had higher early, intermediate, and late mortality rate (table 2).

3.3. The value of TERMINAL-24 score for predicting mortality

Table 3 shows the frequency of patients' early (< 8 hours of admission to ED) and in-hospital mortality in different levels of TERMINAL-24 score. The AUC of TERMINAL-24 score in determining early and in-hospital mortality of trauma patients were 0.964 (95%CI: 0.937-0.991) and 0.954 (95%CI: 0.925-0.983), respectively (Figure 1, Table 4). The specificity and sensitivity of TERMINAL-24 score for predicting early mortality at its best cut-off point (cut-off = 2.5) were 95.04% (95%CI: 93.43-96.28) and 96.36% (95%CI: 87.63-99.35), respectively. These measures for predicting the in-hospital mortality of trauma patients were 98.84% (95%CI: 97.88–99.37) and 87.13% (95%CI: 79.22-92.32), respectively (best cut-off = 2.5).

3.4. Comparing TERMINAL-24 and other trauma severity scores

Figure 2 shows the ROC curves of GAP, RGAP, NTS, and RTS scores in predicting early and in-hospital survival of multi-trauma patients. Comparing the TERMINAL-24 score with other trauma severity scores showed that the TERMINAL-24 score has the same accuracy in predicting multi-trauma patients' outcomes. So, based on the results shown in Table 4 and Figures 1 and 2, all scores have a high value in predicting the mortality of trauma patients in the early stage (under 8 hours) and at the hospital discharge stage.

4. Discussion

In this study, the TERMINAL-24 score was evaluated in predicting the mortality of trauma patients, especially early and in-hospital mortality.

Based on the results of this study, the predictive value of this score in determining early mortality of multi-trauma patients was the same as other evaluated scores (96.36% sensitivity and 95.04% specificity for a score above 2.5 as mentioned in Table 4).

The TERMINAL-24 score is easily calculated based on the findings of vital signs of heart rate, systolic blood pressure, level of consciousness based on GCS, as well as trauma mechanism (traffic or non-traffic) at the time of patients' admission to ED. This score is based on the prediction of early mortality in the emergency department (16). The risk of death from trauma is decreasing in developed trauma care systems. Quality improvement in trauma care is based on the prevention of mortality in cases of preventable death (18). Several trauma severity grading scores have been introduced to accurately calculate the probability of death from trauma. In the studies conducted to evaluate these scores, various results have been obtained to evaluate the accuracy of the trauma rating of these scores (19).

Based on the results of our study, the primary vital signs in the patients of the two groups had statistically significant differences, and these variables were more critical in the group with mortality. Adam Az and colleagues showed in their study that GCS 10 has good sensitivity and specificity to determine the mortality of multi-trauma patients (20). Ghelichkhani P. and colleagues showed in their study that GCS has a high power in predicting the mortality of trauma patients at the time of hospital discharge (21). Basak and colleagues have also achieved similar results (22). Regarding systolic blood pressure (SBP), Rauch and colleagues showed that SBP at the time of admitting a trauma patient is associated with an adverse outcome (23). Benhamed and colleagues showed that the relationship between mortality and SBP is nonlinear (24). The result of our study showed that the mortality rate is significantly increased in the male group. Zhu and colleagues showed that the survival probability of women after severe trauma and hospitalization complications is lower than men, which can indicate the important role of sex hormones after severe traumatic injury (25). Pandya and colleagues showed that the male gender is associated with increased mortality in the trauma-elderly group (26). However, Saberian did not find a relationship between gender and mortality due to trauma (27).

In the study of Jin and colleagues, mortality time is divided into three categories: immediate mortality (within minutes after injury), death within 24 hours, and death in hospital after 24 hours. Most deaths in the hospital occur in the second and third categories. Direct trauma-related factors often cause mortality in the second period, but the immediate effects of injury diminish in the third period, during which death is caused by complications such as sepsis and multi-organ failure (28). However, in this study, the patients were divided into three groups of early mortality in the emergency department (less than 8 hours), medium-term mortality (between 8-24 hours), and long-term mortality (more than 24 hours) based on the time of death. Due to the difference between early and late mortality due to trauma and for simplicity in the conclusion, we examined two groups of early mortality and overall mortality.

The TERMINAL-24 score is one of the scores whose role has been evaluated in determining mortality in the emergency department (16). Both in the study by Samuthtai and in our study, this score had a high value in determining early mortality. In another study conducted by Bucak and colleagues, the Emergency Trauma Score (EMTRAS) had good accuracy in predicting early mortality in the emergency department, but this score also includes variables related to laboratory results (29). Given that most trauma-related deaths occur in the first 24 to 48 hours (30), the determination of early mortality in the emergency department is very important; because the survival of patients admitted to the emergency room is determined by the severity of the disease at the time of visit and the time of starting the treatment. Therefore, patients should be triaged quickly and the worst affected should be treated quickly (28).

Gholipour and colleagues in their study, based on the autopsy results of deceased trauma patients, showed that 80% of the deaths that occurred were preventable, which indicates the lack of proper diagnosis and treatment. Also, the time for emergency medical services (EMS) to arrive at the scene of trauma patients is longer than in other countries (31). Kunitake and colleagues evaluated the TEMPT score in predicting early mortality of patients and concluded that this score is highly accurate in determining the 28-day outcome of patients and can be easily calculated in the early hours after the injury (15). Early mortality in the study of Dai and colleagues was defined as 7-day mortality for trauma patients. In this study, they concluded that the trauma index and shock index have a high value in predicting the risk of early death in acute trauma patients (32). Kahnamoui and colleagues have reported the role of TRAAGIC (transfusion, age, airway, hyperglycemia, international normalized ratio, creatinine) score in determining in-hospital mortality of highly severe trauma patients. However, this point also has laboratory results (33).

In our study, other evaluated scores, including GAP, RGAP, RTS, and NTS, had a similar value in predicting early and in-hospital outcome of multi-trauma patients. According to the obtained ROC curve, these scores can be used to predict the survival of patients. Similar results were obtained in previous studies (5, 12, 34). However, in most studies, these scores and similar cases have been used to predict the overall mortality of trauma patients during hospitalization (13, 14, 35, 36).

It is suggested that multicenter studies with a bigger sample size be designed to confirm the validity of this score. Considering that in the present study based on the TERMINAL-24 score, a heart rate above 120 and below 120 is considered, while a heart rate above 100 is a shock criterion, it is suggested to conduct future studies with a heart rate above 100.

5. Limitations

Our study was conducted in one trauma center and this can be one of our limitations. Also, in the present study, according to the study setting, patients with penetrating trauma were not evaluated. TERMINAL-24 score was compared only with physiological trauma severity scores and not with anatomical trauma severity scores such as Trauma Score and Injury Severity Score (TRISS) and Injury Severity Score (ISS).

6. Conclusions

It seems that, TERMINAL-24 score has high accuracy in predicting early and in-hospital mortality of trauma patients. Considering the calculation formula of this score and its simplicity, it can be used both in the pre-hospital setting and ED to predict the outcome. This score can also be used to evaluate the quality of care for trauma patients.

7. Declarations

7.1. Acknowledgments

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7.3. Author contribution

SA: data collection, visualization, SA, FR, and HSB: literature search and data collection. HEB and FR: manuscript writing (original version, manuscript writing, edits, and revision). All authors contributed significantly to the manuscript and have read and approved its final version.

7.4. Conflict of interest

The authors declare that there was no conflict of interest.

7.5. Ethical issues

This study has been approved by the Ethics Committee of Tabriz University of Medical Sciences with code IR.TBZMED.REC.1403.060 on 22.04.2024.

7.6. Using artificial intelligence chatbots

None.

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Table 1: Comparison of demographic features, vital signs, and trauma mechanism between survived and non-survived cases

Variables	Non-survived (n=101)	Survived (n=862)	P value
Age (years)			
Median (IQR)	38 (26-60)	33 (23-48)	0.011
Gender			
Male	84 (83.2)	621 (72)	0.009
Female	17 (16.8)	241 (28)	
Mechanism of Trauma			
RTA	95 (94.1)	729 (84.6)	0.005
None RTA	6 (5.9)	133 (15.4)	
Vital Signs			
GCS	5.93±3.30	14.50±1.47	0.001
SBP (mmHg)	86.94±32.96	118.67±16.65	0.001
Respiratory Rate (/minute)	18.42±8.60	17.58±3.90	0.086
Heart Rate (/minute)	109.68±23.26	86.26±19.84	0.001
O2 saturation (%)	71.01±23.79	94.16±7.17	0.001
Admission ward			
None	55 (54.5)	601 (69.7)	0.001
Surgery	10 (9.9)	82 (9.5)	
Neurosurgery	35 (34.7)	92 (10.7)	
Orthopedic	1 (1.0)	87 (10.1)	
Duration of Admission			
Median (IQR)	1 (1-4)	1 (1-3)	0.321

Data are presented as median (interquartile range (IQR)) or frequency (%). GCS: Glasgow Coma Scale; RTA: Road Traffic Accident; SBP: Systolic Blood Pressure.

Table 2: Comparing the trauma severity of survived and non-survived patients (at different time points after admission to ED) based on different trauma severity scores

Scores	Alive (N=862)	Time from ED admission to death (hours)			P value
		<8 (n=55)	8-24 (n=13)	>24 (n=33)	
RTS	7.84 (7.84-7.84)	4.09 (2.98-4.50)	4.09 (2.62-5.97)	4.09 (3.56-6.43)	0.001
GAP	22 (22-24)	10 (10-12)	10 (7-13)	14 (10-18)	0.001
Revised GAP	22 (21-24)	9 (7-11)	10 (5 -13.50)	12 (8-17)	0.001
New Trauma	23 (21-23)	8 (6-9)	9 (4.50-12)	11 (7-18)	0.001
TERMINAL-24	1 (1-1)	4 (4-5)	4 (3-4.50)	4 (2-4)	0.001

Data are presented as median (inter quartile range). RTS: Revised Trauma Score; GCS: Glasgow coma scale; GAP: GCS, age, blood pressure; ED: emergency department; TERMINAL-24: Traumatic Emergency Room Major Injury Death At Least 24 hours.

Table 3: Frequency of patient's early (< 8 hours of admission to ED) and in-hospital mortality in different levels of TERMINAL-24 score

Score	Frequency of patients	Time of mortality	
		Early	In-hospital
0	120 (12.5)	0 (0.0)	0 (0.0)
1	694 (72.1)	2 (0.3)	9 (1.3)
2	51 (5.3)	0 (0.0)	4 (7.8)
3	28 (2.9)	11 (39.2)	21 (75)
4	47 (4.9)	26 (55.3)	45 (95.7)
5	23 (2.4)	16 (69.6)	22 (95.6)

Data are presented as number (%). ED: emergency department; TERMINAL-24: Traumatic Emergency Room Major Injury Death At Least 24 hours.

Supplementary table 1: The calculation of TERMINAL-24 Score

Variable	Yes	No
Tachycardia (Heart Rate ≥120)	1	0
Hypotension (: Systolic Blood Pressure <90)	1	0
Coma (Glasgow coma scale <9)	2	0
Traffic injury	1	0

TERMINAL-24: Traumatic Emergency Room Major Injury Death At Least 24 hours.

Table 4: Frequency of patient's early (< 8 hours of admission to ED) and in-hospital mortality in different levels of TERMINAL-24 score

Score	AUC	Cut-off	Sensitivity	Specificity	PLR	NLR
Early mortality						
TERMINAL-24	0.964 (0.937-0.991)	2.5	96.36 (87.68-99.35)	95.04 (93.43-96.28)	54.04 (44.25-63.61)	99.77 (99.16-99.96)
RTS	0.978 (0.968-0.987)	5.44	89.09 (78.17-94.90)	96.37 (94.94-97.40)	59.76 (48.94-69.70)	99.32 (98.52-99.69)
GAP	0.975 (0.965-0.986)	14.5	92.73 (82.74-97.14)	95.04 (93.43-96.28)	53.13 (43.22-62.79)	99.54 (98.82-99.82)
RGAP	0.973 (0.963-0.988)	12.5	92.73 (82.7497.14)	96.04 (94.56-97.12)	58.62 (48.12-68.39)	99.54 (98.83-9982)
NTS	0.976 (0.961-0.986)	12.5	96.36 (87.68-99.35)	95.15 (93.56-96.37)	54.64 (44.74-64.18)	99.77 (99.16-99.96)
In-hospital mortality						
TERMINAL-24	0.954 (0.925-0.983)	2.5	87.13 (79.22-92.32)	98.84 (97.88-99.37)	89.80 (82.23-94.36)	98.50 (97.45-99.12)
RTS	0.962 (0.934-0.990)	6.07	91.09 (83.93-95.24)	98.61 (97.58-99.20)	88.46 (80.91-93.28)	98.95 (98.02-99.45)
GAP	0.95 (0.929-0.985)	16.5	87.13 (79.22-92.32)	96.06 (94.54-97.16)	72.13 (63.59-79.32)	98.45 (97.37-99.09)
RGAP	0.960 (0.934-0.986)	16.5	90.10 (82.73-94.53)	95.13 (93.48-96.38)	68.42 (60.10-75.71)	98.80 (97.80-99.34)
NTS	0.953 (0.921-0.985)	15.5	89.11 (81.54-93.81)	94.20 (92.43-95.57)	64.29 (56.06-71.74)	98.66 (97.62-99.25)

All measures are presented with 95% confidence interval. RTS: Revised Trauma Score; GCS: Glasgow coma scale; GAP: GCS, age, blood pressure; NTS: New Trauma Score; ED: emergency department; TERMINAL-24: Traumatic Emergency Room Major Injury Death At Least 24 hours. *Result from receiver operating characteristic (ROC) curve (Figures 1 and 2). AUC: area under the ROC curve; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

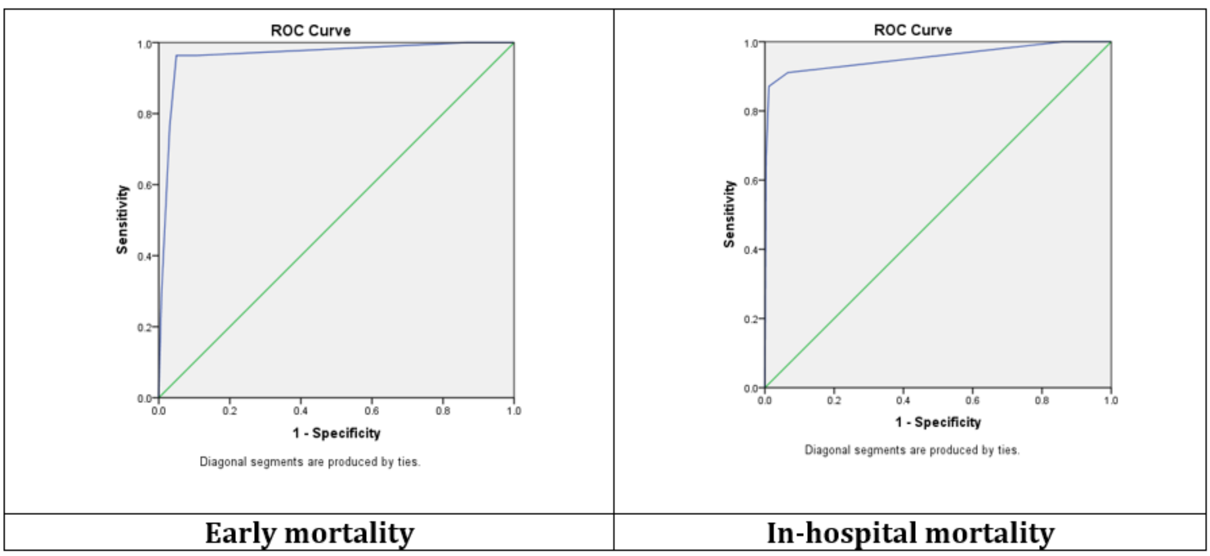

Figure 1: Area under the ROC curve of TERMINAL-24 trauma severity score in predicting patients' early (< 8 hours of admission to ED) and in-hospital mortality. ED: emergency department; TERMINAL-24: Traumatic Emergency Room Major Injury Death At Least 24 hours; ROC: receiver operating characteristic.

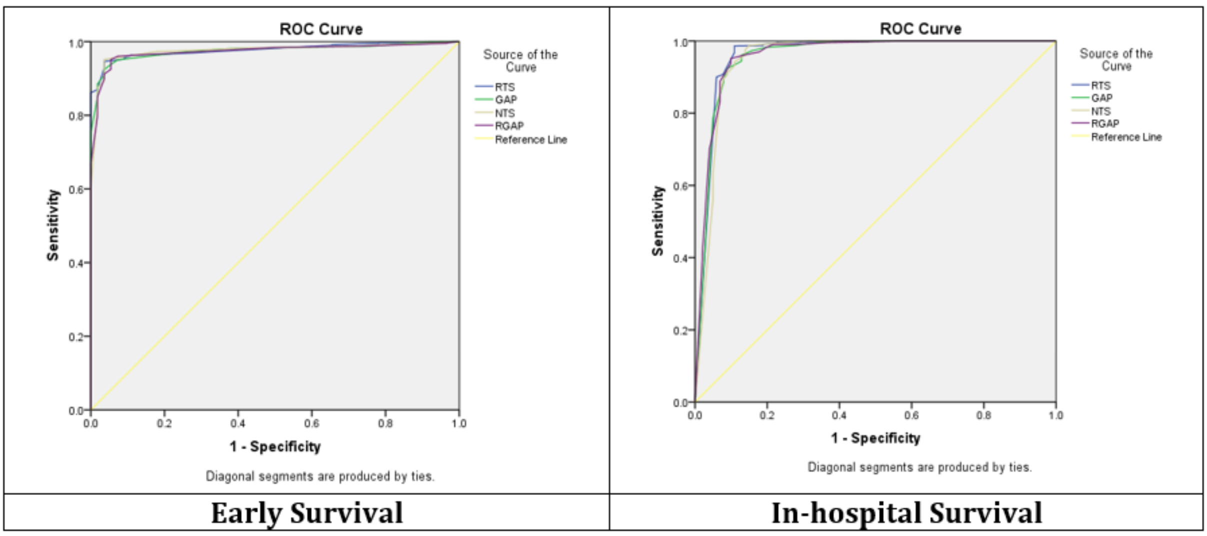

Figure 2: Area under the ROC curve of different trauma severity scores in predicting the patient's survival in the early (< 8 hours of admission to ED) and in-hospital admission time. RTS: Revised Trauma Score; NTS: New Trauma Score; GAP: GCS, age, blood pressure; RGAP: Revised GAP; ED: emergency department; ROC: receiver operating characteristic.