Assessment of the Initial Risk Factors for Mortality among Patients with Severe Trauma on Admission to the Emergency Department

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Background: For decades, trauma has been recognized globally as a major cause of death. Reducing the mortality of patients with trauma is an extremely pressing issue, particularly for those with severe trauma. An early and accurate assessment of the risk of mortality among patients with severe trauma is important for improving patient outcomes. **Methods:** We performed a retrospective medical record review of 582 patients with severe trauma admitted to the emergency department between July 2011 and June 2016. We analyzed the associations of in-hospital mortality with the baseline characteristics and initial biochemical markers of patients with severe trauma on admission. **Results:** The overall in-hospital mortality rate was 14.9%. Multivariate logistic regression analysis showed that the patient's Rapid Emergency Medicine Score (REMS; odds ratio [OR], 1.186; 95% confidence interval [CI], 1.018–1.383; p=0.029), Emergency Trauma Score (EMTRAS; OR, 2.168; 95% CI, 1.570–2.994; p<0.001), serum lactate levels (SLL; OR, 1.298; 95% CI, 1.118–1.507; p<0.001), and Injury Severity Score (ISS; OR, 1.038; 95% CI, 1.010–1.130; p=0.021) were significantly associated with in-hospital mortality. **Conclusion:** The REMS, EMTRAS, and SLL can easily and rapidly be used as alternatives to the injury severity score to predict in-hospital mortality for patients who present to the emergency department with severe trauma.

Key words: 1. Wounds and injuries
2. Mortality
3. Risk factors
4. Injury Severity Score
5. Lactic acid

Introduction

Recent improvements in the management of trauma and in critical care have reduced mortality globally among patients with multiple trauma [1,2]. However, trauma is still recognized as one of the most important public health problems worldwide, since it is a major cause of death and disability [2,3]. Approximately 5.8 million people die each year due to trauma, accounting for 10% of worldwide mortality [3,4]. Reducing mortality among patients with trauma is an extremely pressing issue, particularly in patients with severe trauma [5]. Mortality can be reduced by promptly identifying patients with injuries

Table 1. The REMS scoring system

Variable	REMS score						
	0	+1	+2	+3	+4	+5	+6
Age (yr)	<45		45–54	55–64		65–74	>74
Mean arterial pressure (mm Hg)	70–109		110–129 50–69	130–159	>159 ≤49		
Heart rate (bpm)	70–109		110–139 55–69	140–179 40–54	>179 ≤39		
Respiratory rate (breaths/min)	12–24	25–34 10–11	6–9	35–49	>49 ≤5		
O_2 saturation (%)	>89	86–89		75–85	<75		
Glasgow Coma Scale	14–15	11–13	8–10	5–7	3–4		

REMS, Rapid Emergency Medicine Score.

associated with high mortality rates at an early stage and providing adequate treatment, including intensive care, promptly [3,5]. Strategies implemented to identify patients with injuries associated with high mortality include the development of severity scoring systems. Several trauma scores have been developed to predict mortality among patients with trauma, of which the Injury Severity Score (ISS) is the most commonly used [6,7]. The ISS is associated with mortality, and severe trauma is defined as an ISS >15 [6]. While it is commonly used to predict mortality, there are limits to the use of the ISS as a decision tool in the emergency setting [7]. As the calculations needed for the ISS are complex and time-consuming, they are generally used for auditing and research purposes rather than for clinical decision-making [7,8]. To overcome this limitation, several studies have sought to identify biochemical markers or to develop new scoring systems (e.g., the Rapid Emergency Medicine Score [REMS] and Emergency Trauma Score [EMTRAS]) that can be used to predict mortality [3,7-11]. Unlike the ISS, using new scoring systems and biochemical markers to predict mortality has the advantage of generating scores rapidly [7-9]. However, not many studies have assessed the ability of these new scoring systems and biochemical makers to predict the mortality rate in severe trauma patients. Thus, we analyzed the usefulness of these new scoring systems and various biochemical values as predictors of in-hospital mortality among patients with severe trauma (ISS >15) and compared the discriminating power of those values to that of the ISS.

Methods

1) Study population and ethics approval

We retrospectively collected data from all patients admitted to the emergency department (ED) of South Korea's Gyeongsang National University Hospital with an ISS >15 who were treated for severe trauma between July 2011 and June 2016. The following exclusion criteria were applied: ISS ≤15, age <15 years, penetrating injuries, patients discharged from the ED, death on arrival to hospital, or incomplete medical data. Overall, 582 patients were included in the study. Their medical records and electronic laboratory results were reviewed and the following information was extracted: patient demographics, mechanism of injury, ISS, biochemical markers on arrival at the ED, and in-hospital mortality. Due to the retrospective nature of this study, the requirement for informed consent was waived. The study protocol was approved by the Institutional Review Board of Gyeongsang National University Hospital (IRB approval no., GNUH 2018-03-008).

2) Definitions

The ISS is an injury severity scoring system that generates an overall score for patients with multiple trauma, with severe trauma defined as an ISS >15 [6]. An abbreviated injury scale (AIS) score is assigned to each injury in 1 of 6 body regions: head, face, chest, abdomen, distal (including pelvis), and external [6]. The scores for the 3 most severely injured body regions are squared and then summed to obtain the ISS score (range, 0 to 75) [6]. If an injury is assigned an AIS of 6 (unsurvivable injury), the ISS is

automatically scored as 75 [6]. When considering mortality, we did not assess the specific cause of death.

The REMS is a new prognostic tool for in-hospital mortality assessment among patients admitted to the ED; it was developed by Olsson et al. [10] in 2004. It is a simplified version of the Acute Physiology and Chronic Health Evaluation (APACHE) II that allows for a rapid score calculation in 20 minutes [10]. The REMS is calculated based on patients' Glasgow Coma Scale (GCS) score, respiration rate (RR), oxygen saturation, mean arterial pressure (MAP), and heart rate (HR); higher scores are associated with worse prognoses [10]. Table 1 shows the method of calculating the REMS.

The EMTRAS was developed by Raum et al. [11] in 2009; it combines 4 early parameters from the ED, specifically age, GCS score, base excess (BE), and prothrombin time (PT). Raum et al. [11] suggested that the EMTRAS can be calculated within 30 minutes and accurately predicts mortality. Table 2 shows the method used to calculate the EMTRAS; higher scores are associated with worse prognoses [11].

3) Data analysis

We calculated p-values using the Mann-Whitney U-test for continuous variables and used the Fisher exact test or the Pearson chi-square test for categorical variables. Significance was set at $p < 0.05$. To evaluate the risk factors for in-hospital mortality, we used logistic regression analysis. The efficacy of the various scores and biochemical parameters analyzed in this study for predicting mortality we included relevant variables with $p < 0.20$ in the univariate analysis. We calculated the associations between the variables included in the multivariate analysis, with significance set at $p < 0.05$. Sensitivity and specificity were defined using receiver operating characteristic (ROC) curves. The discriminant power of the REMS, EMTRAS, ISS, and serum lactate level (SLL) were compared using area under the ROC curve (AUC) analyses. Statistical analyses were performed using IBM SPSS software ver. 24.0 (IBM Corp., Armonk, NY, USA) and R software ver. 3.3.4 for Windows (R Foundation for Statistical Computing, Vienna, Austria).

Table 2. The EMTRAS scoring system

Variable	Category	EMTRAS scoring weight
Age (yr)	<40	0
	41–60	1
	61–75	2
	>75	3
Glasgow Coma Scale	13–15	0
	10–12	1
	6–9	2
	3–5	3
Base excess (mmol/L)	>-1	0
	-1 to -5	1
	-5.1 to -10	2
	<-10	3
Prothrombin time (%)	>80	0
	50–80	1
	20–49	2
	<20	3

EMTRAS, Emergency Trauma Score.

Results

Of the 582 patients included in this study, 87 (14.9%) died. Of the deaths, 58 (66.7%) were in patients with head injuries, 15 (17.2%) were due to thoracic injuries, 8 (9.2%) were due to abdominal injuries, 5 were due to cervical injuries (5.7%), and 1 person (1.1%) died of a pulmonary embolism. The median age was 59 years (interquartile range [IQR], 46–78 years) and the majority of patients were male (72.2%). Falls were the main cause of trauma (29.0%), followed by car accidents (23.2%), motorcycle accidents (18.9%), pedestrian accidents (15.1%), and slips (13.7%). The median ISS, REMS, and EMTRAS were 22 (IQR, 17–25), 6 (IQR, 3–8), and 4 (IQR, 2–5), respectively. Patients who survived had a median age of 57 years (IQR, 46–70 years) with a median ISS of 20 (IQR, 17–25), and 13.1% were involved in pedestrian accidents. Patients who died had a median age of 69 years (IQR, 55–78 years) with a median ISS of 25 (IQR, 20–29), and 26.4% were involved in pedestrian accidents. There were significant differences between survivors and non-survivors in age ($p < 0.001$), involvement in a pedestrian accident (p=0.003), REMS ($p < 0.001$), EMTRAS ($p < 0.001$), and ISS ($p < 0.001$). However, there were no significant differences in other variables (Table 3). Differences

Table 3. Comparison of baseline characteristics between survivors and non-survivors

Variable	Total (n=582)	Survivors (n=495)	Non-survivors (n=87)	p-value
Age (yr)	59 (46–78)	57 (46–70)	69 (55–78)	<0.001
Sex (male)	420 (72.2)	359 (72.5)	61 (70.1)	0.697
Mechanism				
Pedestrian accident	88 (15.1)	65 (13.1)	23 (26.4)	0.003
Slip	80 (13.7)	73 (14.7)	7 (8.0)	0.127
Motorcycle accident	110 (18.9)	98 (19.8)	12 (13.8)	0.235
Car accident	135 (23.2)	120 (24.2)	15 (17.2)	0.170
Falls	169 (29.0)	139 (28.1)	30 (34.5)	0.249
Past medical history				
Hypertension	85 (14.6)	75 (15.2)	10 (11.5)	0.415
Diabetes mellitus	43 (7.4)	39 (7.9)	4 (4.6)	0.375
Cerebrovascular attack	9 (1.5)	7 (1.4)	2 (2.3)	0.561
Acute coronary syndrome*	5 (0.9)	4 (0.8)	1 (1.1)	0.761
Cancer	4 (0.7)	3 (0.6)	1 (1.1)	0.600
Injury Severity Score	22 (17–25)	20 (17–25)	25 (20–29)	<0.001
Rapid Emergency Medicine Score	6 (3–8)	5 (3–7)	10 (8–12)	<0.001
Emergency Trauma Score	4 (2–5)	3 (2–5)	7 (5–8)	<0.001

Values are presented as median (interquartile range) for continuous values or number (%) for categorical values.
*Included unstable angina, non-ST elevation myocardial infarction, and ST elevation myocardial infarction.

Table 4. Comparison of biochemical markers between survivors and non-survivors

Variable	Total (n=582)	Survivors (n=495)	Non-survivors (n=87)	p-value
PCO_2 (mm Hg)	35 (30 to 40)	35 (31 to 40)	32 (27 to 42)	0.104
PO_2 (mm Hg)	83.0 (53 to 102)	84 (67 to 103)	77 (52 to 102)	0.058
Base excess (mmol/L)	-2.9 (-11.1 to -0.6)	-2.7 (-5.4 to -0.5)	-6.1 (-10.9 to -1.7)	<0.001
Hemoglobin (g/dL)	12.7 (11.2 to 14.0)	12.9 (11.4 to 14.1)	12.0 (9.9 to 13.7)	<0.001
Hematocrit (%)	38 (33 to 44)	38 (34 to 42)	36 (30 to 41)	<0.001
Platelet ($\times 10^3$/mm^3)	228 (182 to 270)	234 (189 to 278)	189 (165 to 238)	<0.001
Prothrombin time/international normalized ratio	1.10 (1.02 to 1.56)	1.08 (1.02 to 1.19)	1.35 (1.13 to 1.84)	<0.001
Blood urea nitrogen (mg/dL)	15.6 (12.1 to 18.7)	15.6 (12.5 to 18.8)	15.0 (11.5 to 18.6)	0.185
Creatinine (mg/dL)	0.85 (0.68 to 1.03)	0.84 (0.67 to 1.00)	0.96 (0.80 to 1.16)	0.001
Albumin (g/dL)	4.0 (3.5 to 4.3)	4.0 (3.6 to 4.3)	3.7 (3.0 to 4.1)	<0.001
Aspartate aminotransferase (U/L)	50 (31 to 114)	48 (30 to 105)	72 (40 to 227)	0.001
Alanine aminotransferase (U/L)	35 (20 to 64)	33 (20 to 63)	43 (23 to 117)	0.012
Lactate (mmol/L)	2.70 (1.48 to 7.91)	2.4 (1.4 to 4.2)	4.7 (3.0 to 8.7)	<0.001
C-reactive protein (mg/L)	0.9 (0.4 to 2.7)	1.0 (0.5 to 2.9)	0.8 (0.4 to 2.3)	0.179
Creatine kinase (U/L)	314 (179 to 547)	304 (175 to 555)	373 (212 to 541)	0.242
Troponin I (ng/mL)	0.10 (0.10 to 0.13)	0.10 (0.10 to 0.11)	0.10 (0.10 to 0.26)	0.003

Values are presented as median (interquartile range) for continuous values.
PCO_2, partial pressure of carbon dioxide; PO_2, partial pressure of oxygen.

in biochemical markers between survivors and non-survivors were studied. We assessed the partial pressure of carbon dioxide (PCO_2), partial pressure of oxygen (PO_2), BE, hemoglobin, hematocrit, platelets, PT/international normalized ratio (PT/INR), blood urea nitrogen (BUN), creatinine, albumin, aspartate aminotransferase, alanine aminotransferase, lactate, C-reactive protein (CRP), creatine kinase (CK), and troponin I. Table 4 sets out the crude associations between initial biochemical markers on arrival at the ED and in-hospital mortality for patients with severe trauma. Statistically significant differences between

Table 5. Logistic regression analysis of risk factors for mortality in patients with severe trauma (n=582)[a]

| Risk factors	Univariate		Multivariate	
	OR (95% CI)	p-value	OR (95% CI)	p-value[b]
Age	1.036 (1.020–1.052)	<0.001	0.990 (0.959–1.022)	0.526
Sex (male)	0.889 (0.539–1.465)	0.644		
Pedestrianaccident	2.377 (1.381–4.093)	0.002	1.058 (0.391–2.862)	0.912
Slips	0.056 (0.225–1.139)	0.100	0.281 (0.069–1.138)	0.075
Motorcycleaccident	0.648 (0.339–1.239)	0.190	0.631 (0.219–1.818)	0.394
Car accident	0.651 (0.360–1.178)	0.156	0.845 (0.298–2.396)	0.375
Falls	1.348 (0.831–2.186)	0.226		
Hypertension	1.378 (0.682–2.784)	0.371		
Diabetes mellitus	1.779 (0.619–5.109)	0.285		
Cerebrovascular attack	0.611 (0.125–2.990)	0.543		
Acute coronary syndrome	0.702 (0.078–6.357)	0.753		
Cancer	0.525 (0.054–5.110)	0.579		
Injury Severity Score	1.071 (1.037–1.107)	<0.001	1.068 (1.010–1.130)	**0.021**
Rapid Emergency Medicine Score	1.535 (1.405–1.678)	<0.001	1.186 (1.018–1.383)	**0.029**
Emergency Trauma Score	2.063 (1.788–2.380)	<0.001	2.168 (1.570–2.994)	**<0.001**
PCO_2	1.015 (0.991–1.039)	0.220		
PO_2	0.998 (0.992–1.004)	0.531		
Base excess	0.900 (0.865–0.937)	<0.001	1.007 (0.912–1.112)	0.894
Hemoglobin	0.809 (0.735–0.890)	<0.001	0.861 (0.360–2.058)	0.737
Hematocrit	0.932 (0.901–0.964)	<0.001	1.293 (0.858–1.949)	0.220
Platelet	0.992 (0.988–0.996)	<0.001	0.994 (0.998–1.000)	0.063
Prothrombin time/international normalized ratio	1.416 (1.121–1.789)	0.004	0.910 (0.726–1.142)	0.417
Blood urea nitrogen	0.997 (0.963–1.032)	0.866		
Creatinine	1.625 (1.131–2.332)	0.009	1.293 (0.858–1.949)	0.220
Albumin	0.444 (0.325–0.606)	<0.001	0.955 (0.419–2.177)	0.912
Aspartate aminotransferase	1.001 (1.000–1.002)	0.071	0.999 (0.997–1.002)	0.570
Alanine aminotransferase	1.001 (1.000–1.002)	0.110	1.001 (0.998–1.005)	0.451
Lactate	1.314 (1.224–1.412)	<0.001	1.298 (1.118–1.507)	**<0.001**
C-reactive protein	0.991 (0.979–1.003)	0.134	0.997 (0.987–1.006)	0.505
Creatine kinase	1.000 (1.000–1.000)	0.963		
Troponin I	1.168 (0.945–1.444)	0.150	0.901 (0.599–1.355)	0.618

OR, odds ratio; CI, confidence interval; PCO_2, partial pressure of carbon dioxide; PO_2, partial pressure of oxygen.
[a]The multivariate analysis included variables with significant associations in the univariate analysis (p<0.2). [b]Boldface indicates significant differences in the statistical comparisons of baseline characteristics.

survivors and non-survivors were found for almost all biochemical makers (except PCO_2, PO_2, BUN, CRP, and CK). Table 5 shows the results of the logistic regression analysis. Univariate logistic regression analysis revealed that in-hospital mortality of patients with severe trauma was significantly associated with the following: age, involvement in a pedestrian accident, ISS, REMS, EMTRAS, BE, hemoglobin, hematocrit, platelets, PT/INR, creatinine, albumin, and lactate. In the multivariate logistic regression analysis, in-hospital mortality was independently significantly associated with ISS (odds ratio [OR], 1.068;

95% confidence interval [CI], 1.010–1.130; p=0.021), REMS (OR, 1.186; 95% CI, 1.018–1.383; p=0.029), EMTRAS (OR, 2.168; 95% CI, 1.570–2.994; p<0.001), and SLL (OR, 1.355; 95% CI, 1.155–1.591; p<0.001).

ROC curves were used to estimate the sensitivity, specificity, and cutoff values of the ISS, REMS, EMTRAS, and SLL to predict in-hospital mortality (Fig. 1). A REMS value of 8 was set as the cutoff for in-hospital mortality. The in-hospital mortality rate for patients with severe trauma with a REMS >8 was 47.8%, compared with an in-hospital mortality rate of 5.1% for those with a REMS ≤8 (p<0.001; OR, 16.894).
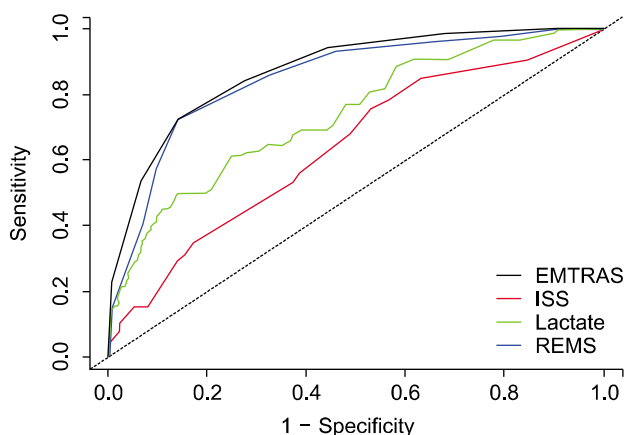
	AUC
EMTRAS	0.873
ISS	0.639
Lactate	0.737
REMS	0.850

Fig. 1. Receiver operating characteristic curves for mortality in patients with severe trauma. AUC, area under the receiver operating characteristic curve; EMTRAS, Emergency Trauma Score; ISS, Injury Severity Score; REMS, Rapid Emergency Medicine Score.

Table 6. Sensitivity, specificity, PPV, and NPV of REMS, EMTRAS, and lactate for in-hospital mortality

Variable	REMS >8	EMTRAS >5	Lactate >3.5 mmol/L	ISS >24
Mortality (%)	47.8	47.1	28.4	20.0
Sensitivity (%)	77.0	83.9	64.4	56.8
Specificity (%)	79.0	72.5	65.3	60.9
PPV (%)	39.2	34.9	24.6	20.3
NPV (%)	95.1	96.2	91.2	88.9

PPV, positive predictive value; NPV, negative predictive value; REMS, Rapid Emergency Medicine Score; EMTRAS, Emergency Trauma Score; ISS, Injury Severity Score.

Table 7. Pairwise comparison of the area under the curve for various predictors

Variable	Difference between the areas	Standard error	Z	p-value
REMS–ISS	0.211	0.039	5.490	<0.001
EMTRAS–ISS	0.234	0.0038	6.304	<0.001
Lactate–ISS	0.099	0.043	2.277	0.023

REMS, Rapid Emergency Medicine Score; ISS, Injury Severity Score; EMTRAS, Emergency Trauma Score.

The REMS had a sensitivity of 77.0% and a specificity of 79.0% for in-hospital mortality. The positive predictive value (PPV) was 39.2%, but its negative predictive value (NPV) was higher than expected, at 95.1%. An EMTRAS value of 5 was set as the cutoff for predicting in-hospital mortality. The in-hospital mortality rate for patients with severe trauma with an EMTRAS >5 was 47.1%, compared with the in-hospital mortality rate of 5.4% for those with an EMTRAS ≤5 (p<0.001; OR, 15.676). The EMTRAS had a sensitivity of 83.9% and a specificity of 72.5% for in-hospital mortality. The PPV was 34.9% and the NPV was again higher than expected, at 96.2%. A SLL of 3.5 mmol/L was set as the cutoff value for predicting in-hospital mortality, as 28.4% of patients with a SLL >3.5 mmol/L died versus 8.4% with a SLL ≤3.5 mmol/L (p<0.001; OR, 4.276). At this cutoff value, SLL as a predictor of mortality had a sensitivity of 64.4%, specificity of 65.3%, PPV of 24.6%, and NPV of 91.2%. An ISS value of 24 was set as the cutoff for predicting in-hospital mortality, as 20.0%

of patients with an ISS >24 died versus 11.6% with an ISS ≤24 (p=0.006; OR, 1.909). At this cutoff value, the sensitivity and specificity values for ISS as a predictor of in-hospital mortality were 56.8% and 60.9%, respectively. For the ISS, the PPV was 20.3% and the NPV was 88.9% (Table 6). In a pairwise AUC comparison, REMS (p=0.002), EMTRAS (p<0.001), and SLL (p=0.043) were each significantly better predictors of in-hospital mortality than the ISS (Table 7, Fig. 1).

Discussion

Despite advances in injury prevention and medical care, trauma-related mortality remains a major public health problem worldwide [1,2]. Trauma is the leading cause of death in the United States among people under 44 years of age and among the top 5 causes of death in people over 45 years of age [12]. Prompt provision of appropriate treatment for patients with trauma is crucial for overall survival and treatment outcomes [3]. In order to improve overall survival and treatment outcomes, it is important to promptly

and accurately determine the severity of patients with trauma in the ED [1,3]. Therefore, we assessed the initial risk factors for in-hospital mortality among patients with severe trauma in the ED. We conducted a retrospective medical record review of 582 patients with severe trauma (ISS >15) between July 2011 and June 2016, and analyzed the associations of in-hospital mortality with the baseline characteristics and initial biochemical markers of patients with severe trauma on admission. We found that the REMS, EMTRAS, and SLL could easily and rapidly be used to predict in-hospital mortality of patients with severe trauma in the ED.

Several scoring systems have been developed to objectively measure the initial condition of a patient with trauma, and these may also serve as a prognostic indicator for specific patients [11]. The ISS, developed by Copes et al. [6] in 1988, is the most commonly used injury scoring system. The ISS is an anatomical scoring system based upon the AIS, and an ISS >15 has traditionally been considered as a marker of severe injuries [3,6]. Several studies have shown that the ISS is a valid predictor of mortality, length of stay in the hospital or the intensive care unit (ICU), and cost of trauma care [13-15]. Recent studies evaluating the medical records of over 50,000 patients with trauma found that the ISS was a better discriminator of patients with a high risk of mortality [15,16]. We found that the ISS (OR, 1.038; 95% CI, 1.010–1.130; p=0.021) was a statistically significant risk factor for in-hospital mortality in patients with severe trauma, corroborating the results of the above studies.

The APACHE II is a trauma severity scoring system for use in patients in the ICU. The APACHE II is assessed within 1 day of the patient's admission to the ICU; higher APACHE II scores are associated with higher mortality [17]. However, the APACHE II score is calculated using the patient's age and 12 routine physiological measurements; therefore, it has limited use as a rapid scoring system in the ED [10]. The REMS is an abbreviated version of the APACHE II, and includes the GCS score, RR, oxygen saturation, MAP, and HR [10]. The REMS can be rapidly determined in 20 minutes and has been shown to correlate with mortality in patients with trauma in several previous studies [16]. Imhoff et al. [16] showed that a higher REMS was associated with increased

mortality (OR, 1.51; 95% CI, 1.45–1.58; p=0.001) in American patients with trauma. Nakhjavan-Shahraki et al. [18] suggested that the REMS could be used for predicting mortality (AUC=0.93) and poor outcomes (p=0.001) in patients with trauma in emergency settings. Our findings for patients with severe trauma with an ISS >15 are consistent with these previous findings. We found that the in-hospital mortality of patients with severe trauma was significantly associated with the REMS (OR, 1.186; 95% CI, 1.018–1.383; p=0.029), suggesting that a higher REMS might be an accurate, rapid predictor of in-hospital mortality for patients with severe trauma; in fact, in a pairwise AUC comparison, the REMS was significantly better than the ISS as a predictor of in-hospital mortality (p<0.001).

The EMTRAS was developed by Raum et al. [11] in 2009 as an easy-to-use tool to predict mortality among patients with trauma in emergency settings. The EMTRAS is based on 4 parameters (age, GCS score, BE, and PT) and has been found to correlate with the mortality of trauma patients in previous studies [3,11,19]. Park et al. [3] showed that the EMTRAS predicted in-hospital mortality for patients with trauma more easily and accurately than other trauma scores (p<0.001, AUC=0.957). A comparison of the EMTRAS with other scores was performed among 150 patients in Italy [19]. Those researchers found that the EMTRAS correlated well with mortality (AUC=0.809) and suggested that it should be performed before other examinations, such as computed tomography, in patients with trauma because it provides simple and rapid findings [3]. Our study of patients with severe trauma with an ISS >15 showed similar results. We found that in-hospital mortality of patients with severe trauma was significantly associated with the EMTRAS (OR, 2.168; 95% CI, 1.570–2.994; p<0.001); in a pairwise AUC comparison, the EMTRAS was a significantly better predictor of in-hospital mortality than the ISS (p<0.001).

Lactate is constantly produced from pyruvate during normal metabolism and exercise, and the lactate level does not increase until the production rate exceeds the removal rate [20]. Metabolism from pyruvic acid to lactate is increased in tissue with inadequate perfusion, and higher lactate concentrations than in the normal state are associated with severe trauma, post-traumatic respiratory failure, and death

[20,21]. Several studies have investigated SLL as predictor of mortality among patients with trauma [21,22]. Abramson et al. [22] studied SLL in 76 patients with multiple trauma admitted to the ICU and concluded that SLL was a useful value for predicting the prognosis of patients with severe trauma. Parsikia et al. [23] reviewed 1,941 patients with trauma between 2007 and 2012 in a prospectively maintained database and found that the median SLL among non-survivors was 32 mg/dL (IQR, 17–62 mg/dL), versus 21 mg/dL (IQR, 14–32 mg/dL) for survivors (p < 0.001). In their multivariate analysis, SLL was a significant covariant risk factor for mortality (OR, 1.010; 95% CI, 1.002–1.019; p < 0.001) [23]. Our findings are consistent with the above studies, which found that SLL was significantly associated with treatment outcomes in patients with trauma. In our study, SLL (OR, 1.038; 95% CI, 1.010–1.130; p=0.021) was a statistically significant risk factor associated with mortality among patients with severe trauma; in a pairwise AUC comparison, SLL was a significantly better predictor of in-hospital mortality than the ISS (p=0.023).

Our study has several limitations. First, we evaluated a relatively small number of patients with severe trauma and larger studies are required to validate our findings. Second, our study evaluated patients from a single hospital, which may have introduced selection bias. Third, our study was a retrospective evaluation and, as with all trauma registries, the accuracy of the recorded data may vary [24]. Accurate prospective and larger-population studies are needed to support our findings.

In conclusion, this study found that the REMS, EMTRAS, SLL, and ISS were statistically significant risk factors for mortality among patients with severe trauma. However, the ISS calculations are complex, time-consuming, and are not used to guide early resuscitation in practice [11,16]. Unlike the ISS, the REMS, EMTRAS, and SLL are based on measurements that are easier to obtain and were found to be significantly better predictors of in-hospital mortality than the ISS upon pairwise comparisons of the AUC. Therefore, we suggest that the REMS. EMTRAS, and SLL be used as easy and rapid predictors of mortality among patients with severe trauma on admission to the ED.

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