Original Article

Predicting Factors Associated with in-Hospital Mortality in Severe Multiple-Trauma Patients

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Abstract

Background and Objectives: Traumatic injuries have become a health problem worldwide, especially in low- to middle-income countries. Therefore, this study was conducted to identify predicting factors of death in adult severe multiple trauma patients. **Methods:** This retrospective cross-sectional study was performed on 1397 adult multiple trauma patients referred to the emergency department (ED) of Poursina Hospital between June 2019 and August 2021. The demographic characteristics, on admission clinical parameters, laboratory tests, the need for packed red blood cell transfusion, and the need for endotracheal intubation were recorded. The revised trauma score (RTS) was calculated according to the physiological variables collected on admission to ED. The primary outcome was 1-day mortality after admission. **Results:** The mean age of subjects was 37.12 ± 13.61 (18–60) years, and 1250 (89.5%) subjects were male. The 1-day mortality was 339 patients (24.3%). Initial RTS score and the mean Glasgow coma scale (GCS) scores were significantly higher in the survived group than in the nonsurvived group (6.6 ± 1.2 vs. 4.9 ± 1.0, 10.2 ± 3.7 vs. 4.9 ± 2.4, $P < 0.001$). The multivariate analysis resulted in low GCS (odds ratio [OR] = 1.527, 95%CI 1.434–1625, $P < 0.001$), low O_2 saturation (OR = 1.023, 95%CI 1.003–1.043, $P = 0.022$), and need for intubation in the ED (OR = 0.696, 95%CI 0.488–0.993, $P = 0.046$) as predictors of 1-day mortality. The area under the curves receiver operating characteristics of RTS and GCS scores to predict mortality were 0.853 (95% CI: 0.831–0.874) and 0.866 (95% CI: 0.846–0.887), respectively. **Conclusion:** Multiple factors associated with 1-day mortality were reduced GCS score, decreased oxygen saturation, and need for intubation in the ED. The RTS and GCS scores are good predictors of mortality survival in multiple trauma patients.

Keywords: Emergency department, mortality, multiple trauma, outcome, survival

Introduction

Trauma is the leading cause of death under the age of 40 years[1] and one of the most important causes of death and disability at all ages.[1,2] According to the world health organization report entitled Road Traffic Injuries, released in February 2020, approximately 1.35 million people die each year due to road accidents alone. According to these reports, 93% of road deaths occur in low- to middle-income countries (Iran is in the middle-income group); however, only 60% of the world's vehicles are in these countries.[2] In addition, trauma is one of the four leading causes of death in middle-income countries such as Iran.[3]

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Trauma has different causes; road accidents, followed by falls from heights, are the most common causes of trauma.[3-8] Previous studies have shown that these two mechanisms alone account for about 80% of trauma cases.[1,3,5,6] This number

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has been about 90% in Gilan Province.[6] In addition, the probability of death in trauma with these two mechanisms is higher than in other causes of trauma.[7,8]

Due to the high mortality rate of trauma patients, researchers have always sought to find independent factors influencing preventable death. The most increased mortality due to trauma is seen in men and people with lower levels of education and economic status.[2,7] Some studies showed that Glasgow coma scale (GCS) ≤8, age, injury severity score (ISS) >16, the mechanism of injury, blood pressure (BP), respiratory rate (RR), heart rate (HR), abnormal corneal size, and cervical spinal fractures were independent predictors of outcome in trauma patients.[7-10] GCS, blood pH, lactate dehydrogenase, coagulation disorders, and the need for intubation were also important factors associated with mortality.[11]

Another method of estimating the probability of mortality of trauma patients is scoring systems. In some studies, the prediction of the severity of injuries has been investigated by these scoring systems, and they are very useful methods for estimating outcomes such as mortality and trauma complications.[1,3,12] The Rapid Emergency Medicine Score, revised trauma score (RTS), and trauma injury severity score (TRISS) are some of the most commonly used scoring systems.

This study aimed to identify risk factors of death in adult severe multiple trauma patients admitted to the emergency department (ED) in a regional trauma center in Rasht, Iran.

Methods

Study setting and design

The retrospective cross-sectional study was conducted on patients with multiple trauma presenting to the ED of Poursina Hospital, Rasht, Iran, between June 2019 and August 2021. The Ethics Committee of Guilan University of Medical Sciences approved the study protocol (IR.GUMS.REC.1399.539).

Participants

All adult (age ≥18 years) patients with severe multiple trauma and level 1 triage based on emergency severity index (ESI) version 4 admitted to the ED were eligible. Patients older than 60 years, who died before ED arrival, transferred from other medical centers, and those who had missing variables were excluded.

ESI is a five-level ED triage method that offers clinically relevant classification of patients into five groups from 1 (most urgent) to 5 (least urgent) based on severity and resource needs.[5] The minimum required study sample size was 1159, with an odds ratio (OR) of 1.39 for TRISS score ≤0.9 and 9.02% prevalence of mortality in trauma patients,[12] at the 95% confidence interval (CI), and considering the power of 90%. Sampling was performed using the consecutive sampling method.

Data gathering

The data were collected by reviewing the patient case histories. The data included patient demographic characteristics (gender, age), mechanism of trauma, and at the time of admission clinical parameters (BP, HR, RR, GCS, oxygen saturation, temperature). The need for packed cell transfusion, laboratory tests (hematocrit, white blood cell, blood urea nitrogen, base excess), need for orotracheal intubation, and survival after 24 h of hospital admission was recorded. The RTS was calculated according to the physiological variables collected on admission to ED. The RTS consists of three physiological variables (GCS, systolic blood pressure [SBP], RR). $RTS = 0.9368\ GCS + 0.7326\ SBP + 0.2908\ RR$. The total score is between 0 and 7.8408.[13] A lower RTS score indicates a higher severity of the injury.

The primary outcome was 1-day mortality after admission. The associations of the RTS score and GCS with this outcome were investigated.

Statistical analysis

Variables analysis was done with SPSS version 21.0 (IBM, Armonk, NY, USA). Categorical variables were expressed as frequency (percentage), and continuous variables were defined as mean and standard deviation (SD). Chi-square was performed to compare categorical variables, and independent samples *t*-test or Mann–Whitney U test was performed to compare continuous variables.

A multivariate logistic regression analysis was conducted to identify the independent risk factors of 1-day mortality. The area under the curve (AUC) receiver operating characteristics (ROC) curve was performed to determine the ability of the RTS and GCS to predict 1-day mortality. A two-sided $P < 0.05$ was considered statistically significant.

Results

A total of 1397 multiple trauma patients were enrolled in the study. The mean SD age of subjects was 37.12 (13.61) years and 1250 (89.5%) subjects were male. The 1-day mortality was 339 patients (24.3%). Motor vehicle accidents (MVAs) were the most frequent mechanism of injury (57.3%). The baseline characteristics are reported in Table 1.

The mean (SD) GCS score was 8.9 (4.1), and the mean (SD) RTS score was 6.2 (1.3). The initial mean (SD) RTS score and the GCS scores were significantly higher in the survived group than in the nonsurvived group (6.6 ± 1.2 vs. 4.9 ± 1.0, 10.2 ± 3.7 vs. 4.9 ± 2.4, $P < 0.001$). Statistically significant differences between survived and nonsurvived groups were reported for gender ($P = 0.012$), and O2 sat ($P < 0.001$). Nonsurvived patients had higher prehospital intubation, ED intubation, and ED-packed red blood cell (RBC) transfusion (all $P < 0.001$).

The logistic regression results for the 1-day mortality are shown in Table 2. The multivariate analysis resulted in low GCS (OR = 1.527, 95% CI 1.434–1625, $P < 0.001$), low O2

Table 1: Patients demographic and clinical characteristics

Characteristics	Total (*n*=1397), *n* (%)	Survived (*n*=1058), *n* (%)	Nonsurvived (*n*=339), *n* (%)	*P*
Age (years), mean±SD	37.10±13.65	36.92±13.52	37.67±14.08	0.375
Age in categories				
18-29	508 (36.4)	385 (36.4)	123 (36.3)	0.714
30-39	320 (22.9)	249 (23.5)	71 (20.9)	
40-49	172 (12.3)	130 (12.3)	42 (12.4)	
50-60	397 (28.4)	294 (27.8)	103 (30.4)	
Gender				
Female	147 (10.5)	99 (9.4)	48 (14.2)	0.012
Male	1250 (89.5)	959 (90.6)	291 (85.8)	
Mechanism				
MVAs	800 (57.3)	606 (57.5)	194 (56.4)	0.790
Pedestrian accidents	268 (19.2)	196 (18.6)	72 (20.9)	
Fall	270 (19.3)	207 (19.7)	63 (18.3)	
Others	59 (4.2)	44 (4.2)	15 (4.4)	
GCS				
3-8	694 (49.7)	378 (35.7)	316 (93.2)	<0.001
9-13	346 (24.8)	330 (31.2)	16 (4.7)	
14-15	357 (25.5)	350 (33.1)	7 (2.1)	
Comorbidity	299 (21.4)	219 (20.7)	80 (23.6)	0.257
Initial vital signs, mean±SD				
HR (bpm)	95.03±20.85	95.05±20.54	94.96±21.81	0.947
SBP (mmHg)	117.28±23.79	118.02±23.15	114.96±25.62	0.052
DBP (mmHg)	73.31±15.51	73.70±15.31	72.10±16.07	0.099
RR (bpm)	18.42±3.30	18.38±3.25	18.53±4.46	0.474
Temp (°C)	36.98±0.39	36.99±0.39	36.94±0.38	0.054
O_2 Sat (%)	90.69±7.30	91.90±5.78	86.88±4.83	<0.001
Initial laboratory fndings, mean±SD				
HCT	34.3±6.5	34.37±6.52	34.20±6.45	0.685
WBC (×10^3/ml)	15.9±6.3	15.9±6.1	16.4±6.8	0.196
BE	−4.78±7.1	−4.58±6.82	−5.43±7.78	0.072
BUN	14.9±5.6	15.0±5.6	14.7±5.4	0.384
Prehospital intubation	111 (7.9)	49 (4.6)	62 (18.3)	<0.001
Intubation in ED	598 (42.8)	344 (32.5)	254 (74.9)	<0.001
ED packed cell transfusion	451 (32.4)	276 (26.1)	175 (51.6)	<0.001
RTS, mean±SD	6.20±1.32	6.60±1.15	4.94±0.99	<0.001

SD: Standard deviation, GCS: Glasgow Coma Scale, MVAs: Motor vehicle accidents, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RR: Respiratory rate, Temp: Temperature, HCT: Hematocrit, WBC: White blood cell, BUN: Blood urea nitrogen, ED: Emergency department, RTS: Revised trauma score, O_2 Sat: Oxygen saturation, BE: Base excess

saturation (OR = 1.023, 95% CI 1.003–1.043, $P = 0.022$), and need for intubation in the ED (OR = 0.696, 95%CI 0.488–0.993, $P = 0.046$) as predictors of 1-day mortality.

The area under the ROC curves (AUC) of RTS, and GCS scores to predict 1-day mortality of severe trauma patients were 0.853 (95% CI: 0.831–0.874), and 0.866 (95% CI: 0.846–0.887), respectively [Figure 1]. The optimal cut-off values for the RTS and GCS scores were ≤5.3 for RTS and ≤6 for GCS.

Discussion

The incidence of multiple traumas is increasing, especially in developing countries. Despite improvements in injury prevention and medical care, trauma deaths are a significant public health problem worldwide. To improve survival, it is essential to quickly and accurately determine hospitalized patients at risk of death in the ED.

In this retrospective cross-sectional study, the risk factors that affected the death in adult severe multiple trauma patients presenting to the ED were evaluated. Based on the results of the present study, the low GCS, low initial O_2 saturation as well as the need for endotracheal intubation in the ED have been identified as independent predictors of 1-day mortality in multiple trauma patients. Based on calculated AUCs, RTS and GCS were good predictors of mortality occurring within 24 h after admission.

In the current study, the mortality rate was 24.3%, which is similar to Dharap *et al.*'s study in which the mortality rate was 24.0%[14] and slightly higher than the results of other previous studies, where the mortality rate was 18.7%–22.8%.[15] This

Table 2: The logistic regression models for risk factors for 1-day mortality in multiple trauma patients

Variable	*B*	SE	OR (95% CI)	*P*
Un adjusted model				
Age	0.003	0.007	1.003 (0.990-1.017)	0.628
Gender	−0.348	0.248	0.706 (0.434-1.148)	0.160
GCS	0.403	0.040	1.496 (1.383-1.618)	0.000
HR	−0.003	0.004	0.997 (0.990-1.005)	0.457
SBP	0.003	0.006	1.003 (0.991-1.014)	0.663
DBP	−0.005	0.009	0.995 (0.978-1.012)	0.573
RR	−0.017	0.023	0.984 (0.940-1.030)	0.480
Temp	0.243	0.204	1.275 (0.854-1.904)	0.234
O_2 Sat	0.023	0.010	1.023 (1.004-1.044)	0.020
HCT	0.008	0.012	1.008 (0.984-1.032)	0.514
WBC	0.004	0.012	1.004 (0.982-1.028)	0.702
BE	−0.006	0.011	0.994 (0.973-1.015)	0.563
BUN	0.018	0.014	1.018 (0.990-1.048)	0.210
Packed RBC transfusion	0.102	0.162	1.107 (0.806-1.521)	0.529
Prehospital intubation	0.307	0.347	1.360 (0.689-2.685)	0.376
Intubation in ED	−0.537	0.272	0.585 (0.343-0.996)	0.048
Comorbidity	0.239	0.233	1.270 (0.804-2.005)	0.305
Constant	−13.804	7.627	0.000	0.070
Adjusted model				
Gender	−0.411	0.237	0.663 (0.417-1.056)	0.083
GCS	0.423	0.032	1.527 (1.434-1.625)	0.000
Intubation in ED	−0.362	0.181	0.696 (0.488-0.993)	0.046
O_2 Sat	0.023	0.010	1.023 (1.003-1.043)	0.022
Constant	−3.590	0.879		

GCS: Glasgow Coma Scale, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RR: Respiratory rate, Temp: Temperature, HCT: Hematocrit, WBC: White blood cell, BUN: Blood urea nitrogen, ED: Emergency department, O_2 Sat: Oxygen saturation, BE: Base excess, RBC: Red blood cell, OR: Odds ratio, CI: Confidence interval, SE: Standard error

can be due to differences in the patients studied (age and sex), prehospital and hospital care, type of injury, mechanism of injury, and the severity of trauma.

Four previous studies found a relationship between mortality rate and gender in older patients with severe trauma. Three of these studies demonstrated an increased risk of death in men, and one showed the opposite.[16] Other studies have not found a relationship between gender and mortality rate.[3-12] In the current study, the statistically significant difference between survived and nonsurvived groups was reported for gender, still, multivariate logistic regression analysis did not result in gender as a predictor of mortality.

Numerous studies reported that with increasing age, the mortality rate of trauma patients increased significantly; The highest mortality rate due to trauma occurred in people over 60 years of age,[3,4,9,12] but this result was not found in the present study. One possible reason for this discrepancy is the limited age range of patients (18–60 years old) participating in the present study.

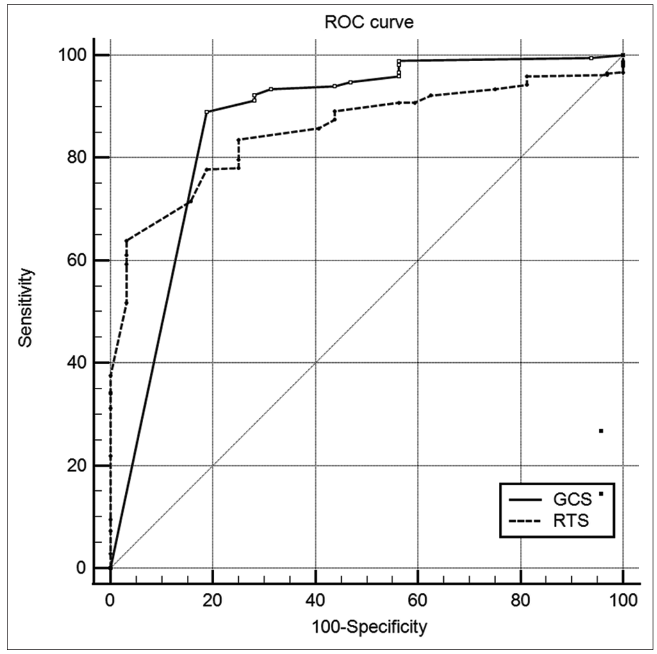

Figure 1: Receiver operating characteristic curves of RTS and GCS for predicting mortality in multiple trauma patients

Variable	AUC	SE	95% CI
GCS	0.866	0.011	0.846-0.887
RTS	0.853	0.011	0.831-0.874

AUC: Area under the curve, GCS: Glasgow Coma Scale, RTS: Revised trauma score, SE: Standard error, CI: Confidence interval

Previous studies reported that lower GCS increased the mortality rate in multiple trauma patients.[1,3,6,7] Chiang *et al*.[17] said that decreased GCS score was a strong predictor of mortality after severe trauma. Bieler *et al*.[18] demonstrated that at-scene GCS of trauma patients was higher in the survived group (7.4 ± 4.3) than in the nonsurvived group (6.6 ± 4.5). In the study by Heydari *et al*.,[1] the GCS score was good predictor of mortality in multiple trauma patients (AUC = 0.85). These results were in accordance with the present study (AUC = 0.87). In contrast with these results, Huei *et al*.[19] found that GCS was not a significant predictor of early mortality. Decreased GCS that was not related to head injuries may not be a significant predictor of mortality.

Based on our results, the RTS score had acceptable predictive values for 1-day mortality in severe trauma patients and was a good choice for use in emergency settings (AUC = 0.853). Similar to previous studies, the mean RTS score in patients with 24-h survival was significantly higher than in patients without 24-h survival. Yadollahi *et al*.[12] stated that RTS is highly sensitive in predicting the risk of death in trauma patients. Kuza *et al*.[20] reported that RTS had a good mortality predictive ability in multiple trauma patients. The AUC for mortality for RTS was 0.845 (95% CI 0.815, 0.875). Huei *et al*.[19] demonstrated that the mean RTS score in nonsurvived patients was significantly lower than in survived patients.

In the present study, patients who underwent endotracheal intubation both in prehospital and ED had lower 1-day survival than nonintubated trauma patients. However, only ED endotracheal intubation had a statistically significant association with increased mortality. This result was confirmed by other studies. In the study by Chiang *et al*.,[17] a significant difference was found between survived and nonsurvived patients regarding ED endotracheal intubation. In contrast to the present study, Bieler *et al*.[18] showed that the intubation rate was significantly higher for the survived group than for the nonsurvived group in trauma patients. The need for emergent intervention such as intubation indicated the severity of life-threatening injury in the patient. Von Rüden *et al*. found that the need for prehospital intubation was significantly higher in patients with severe trauma (ISS ≥50) compared with patients with ISS <50.[21] The lack of a clear relationship between intubation rate and mortality risk may be due to differences in attitudes toward management and the unequal distribution of specific variables in the affected population.

In the present study, initial O2 saturation was significantly higher in the survived group than in the nonsurvived group. The multivariate analysis identified O2 saturation as a risk factor for 1-day mortality. In the study by Yucel *et al*.,[7] the nonsurvivors had significantly lower oxygen saturation than survivors. The univariate analysis also demonstrated low O2 saturation on ED arrival as being associated with mortality in trauma patients. Low oxygen saturation may indicate early respiratory failure and an urgent need for endotracheal intubation.

Recently, lactate and base excess have been performed to diagnose tissue hypoperfusion, determine the need for treatment to help improve outcomes and predict mortality.[7] High serum lactate and low base excess were potentially treatable predictors of early mortality in trauma patients.[18] Lichtveld *et al*.[22] found base excess as mortality risk factor in trauma patients. Previous studies have reported that elevated serum lactate on admission is associated with higher mortality and the need for blood transfusion in multiple trauma patients.[7,9,15,23] In the present study, no association was found between admission base excess and mortality in multiple trauma. Like the current finding, Freitas and Franzon[24] reported no correlations between lactate level on admission and mortality in trauma patients. Base excess and lactate had a strong correlation.

Limitations

There were some limitations in the present study. First, this was a retrospective study, and as a result, there was a possibility of selection bias and miscoding. Second, it was conducted at a single center, which may influence the generalizability of the results. Third, geriatric patients were not included in our study. There are some factors affecting mortality in older patients (such as physiological derangement, mechanism of injury, and medications) that are different in younger patients.

Conclusion

Nonsurvived patients had higher frequencies of prehospital intubation, ED intubation, and ED-packed RBC transfusion. Multiple factors associated with 1-day mortality were reduced GCS score, decreased oxygen saturation, and need for intubation in the ED. The RTS and GCS scores are good predictors of mortality survival in multiple trauma patients.

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Conflicts of interest

There are no conflicts of interest.

References

1. Heydari F, Azizkhani R, Ahmadi O, Majidinejad S, Nasr-Esfahani M, Ahmadi A. Physiologic scoring systems versus Glasgow Coma Scale in predicting in-hospital mortality of trauma patients; a diagnostic accuracy study. Arch Acad Emerg Med 2021;9:e64.
2. World Health Organization (WHO). Global status report on road safety. Geneva: World Health Organization; 2018.
3. Heydari F, Majidinejad S, Ahmadi A, Nasr-Esfahani M, Shayannejad H, Fatemi NA. A comparison between Modified Early Warning Score, Worthing Physiological Scoring System, National Early Warning Score, and Rapid Emergency Medicine Score in predicting in hospital mortality in multiple trauma patients. Arch Trauma Res 2021;10:189.
4. Yadollahi M, Zamani M, Jamali K, Mahmoudi A, Rasaee MA, Kashkooe A. A survey of accidental fall-induced injuries and mortality in a central trauma hospital in Iran: 2015-2016. Trauma Mon 2019;24:1-6.
5. Heydari F, Maghami MH, Esmailian M, Zamani M. The effect of implementation of the standard clinical practice guideline (CPG) for management of multiple trauma patients admitted to an emergency department. Adv J Emerg Med 2018;2:e5.
6. Yousefzadeh S, Ahmadi DM, Mohammadi MH, Dehnadi MA, Hemati H, Shaabani S. Epidemiology of injuries and their causes among traumatic patients admitted into Poursina Hospital, Rasht (second half of the year 2005). J Kermanshah Univ Med Sci 2007;11:286-95.
7. Yucel N, Ozturk Demir T, Derya S, Oguzturk H, Bicakcioglu M, Yetkin F. Potential risk factors for in-hospital mortality in patients with moderate-to-severe blunt multiple trauma who survive initial resuscitation. Emerg Med Int 2018;2018:6461072.
8. Zamani M, Esmailian M, Mirazimi MS, Ebrahimian M, Golshani K. Cause and final outcome of trauma in patients referred to the emergency department: A cross sectional study. Iran J Emerg Med 2014;1:22-7.
9. Jelodar S, Jafari P, Yadollahi M, Sabetian Jahromi G, Khalili H, Abbasi H, *et al.* Potential risk factors of death in multiple trauma patients. Emergency (Tehran) 2014;2:170-3.
10. Demetriades D, Murray J, Charalambides K, Alo K, Velmahos G, Rhee P, *et al*. Trauma fatalities: Time and location of hospital deaths. J Am Coll Surg 2004;198:20-6.
11. Valentino TP. Major trauma: What is important for the best outcome and survival? J Postgrad Med 2017;63:149-50.
12. Yadollahi M, Kashkooe A, Rezaiee R, Jamali K, Niakan MH. A comparative study of injury severity scales as predictors of mortality in trauma patients: Which scale is the best? Bull Emerg Trauma 2020;8:27-33.
13. Javali RH, Patil A, Srinivasarangan M. Comparison of injury severity score, new injury severity score, revised trauma score and trauma and injury severity score for mortality prediction in elderly trauma patients. Indian J Crit Care Med 2019;2:73-7.
14. Dharap SB, Kamath S, Kumar V. Does prehospital time affect survival of major trauma patients where there is no prehospital care? J Postgrad Med 2017;63:169-75.
15. Sim J, Lee J, Lee JC, Heo Y, Wang H, Jung K. Risk factors for mortality of severe trauma based on 3 years' data at a single Korean institution. Ann Surg Treat Res 2015;89:215-9.
16. Sammy I, Lecky F, Sutton A, Leaviss J, O'Cathain A. Factors affecting mortality in older trauma patients – A systematic review and meta-analysis. Injury 2016;47:1170-83.
17. Chiang YT, Lin TH, Hu RH, Lee PC, Shih HC. Predicting factors for major trauma patient mortality analyzed from trauma registry system.

Asian J Surg 2021;44:262-8.

18. Bieler D, Paffrath T, Schmidt A, Völlmecke M, Lefering R, Kulla M, *et al*. Why do some trauma patients die while others survive? A matched-pair analysis based on data from Trauma Register DGU®. Chin J Traumatol 2020;23:224-32.
19. Huei TJ, Mohamad Y, Lip HT, Md Noh N, Imran Alwi R. Prognostic predictors of early mortality from exsanguination in adult trauma: A Malaysian trauma center experience. Trauma Surg Acute Care Open 2017;2:e000070.
20. Kuza CM, Matsushima K, Mack WJ, Pham C, Hourany T, Lee J, *et al.* The role of the American Society of anesthesiologists physical status classification in predicting trauma mortality and outcomes. Am J Surg 2019;218:1143-51.
21. von Rüden C, Woltmann A, Röse M, Wurm S, Rüger M, Hierholzer C, *et al*. Outcome after severe multiple trauma: A retrospective analysis. J Trauma Manag Outcomes 2013;7:4.
22. Lichtveld RA, Panhuizen IF, Smit RB, Holtslag HR, van der Werken C. Predictors of death in trauma patients who are alive on arrival at hospital. Eur J Trauma Emerg Surg 2007;33:46-51.
23. Odom SR, Howell MD, Silva GS, Nielsen VM, Gupta A, Shapiro NI, *et al.* Lactate clearance as a predictor of mortality in trauma patients. J Trauma Acute Care Surg 2013;74:999-1004.
24. Freitas AD, Franzon O. Lactate as predictor of mortality in polytrauma. Arq Bras Cir Dig 2015;28:163-6.