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Mortality prognostic indicators in trauma patients: a metropolis study

Mehdi Nasr Isfahani [1,2], **Amir Reza Shahmohammadi** [1], **Neda Al-Sadat Fatemi** [2,3], **Amir Bahador Boroumand** [1], **Seyed Hamed Khajehbashi** [1*]

[1] Department of Emergency Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran
[2] Trauma Data Registration Center, Isfahan University of Medical Sciences, Isfahan, Iran
[3] Department of Health in Disasters and Emergencies, School of Management and Medical Informatics, Isfahan University of Medical Sciences, Isfahan, Iran

[*] **Corresponding author:** Seyed Hamed Khajehbashi. Department of Emergency Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran. **Email:** m_nasr54@med.mui.ac.ir

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Abstract

Background: Trauma can lead to significant complications and mortality for victims of accidents.
Objectives: The present study was conducted to determine the mortality caused by trauma and its related factors.
Methods: The present study was conducted using the data available in the Isfahan Trauma Registration System (ITR) and Hospital Information Systems (HIS). The number of 1266 deceased trauma patients who were registered in this system over 18 months (between September 2020 and March 2022) were included in the study and analyzed.
Results: Out of 1266 patients who died from trauma, 604 (47.7%) patients experienced early death, 427 (33.7%) delayed mortality, and 235 (18.6%) late mortality. The mechanism and type of trauma, and the pre-impact conditions were significantly different between the three death categories ($P<0.05$). There was a significant difference in oxygen level (SpO_2), heart rate, and respiratory rate at the time of admission and at the time of death between the three categories of mortality ($P<0.05$). Glasgow Coma Scale (GCS) was a predictor of early, delayed, and late mortality. Injury Severity Score (ISS) was a predictor of delayed mortality and age was also a predictor of late mortality.
Conclusion: The present study's results indicate that ISS and GCS are significant prognostic indicators of mortality in trauma patients, warranting greater attention during admission. The combination of GCS and ISS appears to improve the accuracy of outcome prediction, thereby enabling the creation of a novel predictive model.

Introduction

Trauma refers to any impact, injury, shock, wound, or event that affects the human body due to external causes, as opposed to internal factors like diseases.[1] The mechanisms of traumatic injuries include a wide spectrum of non-penetrating (blunt) trauma, penetrating trauma, and burns resulting from motor vehicle accidents, sports injuries, falls, natural disasters, and other physical harms that require prompt medical attention.[2] By 2030, trauma is predicted to become the seventh leading cause of death worldwide, owing to its devastating impact resulting in millions of deaths and disabilities.[3,4] The World Health Organization (WHO) has reported that unintentional injuries and violence claim the lives of 4.4 million individuals annually, and constitute nearly 8% of all deaths. Also for people age 5-29 years, three of the top five causes of death are injury-related, namely road traffic injuries, homicide, and suicide.[5]

According to the reviewed literatures, the mortality of traumatic patients ranged from 3.7 to 28.2% in developed countries.[3, 6-8]

In Iran, the mortality rate resulting from trauma, particularly Road Traffic Accidents (RTAs), is a pressing issue that requires attention. According to the latest WHO data published in 2020, road traffic deaths in Iran reached 17,803, or 5.36% of total deaths. The age-adjusted death rate is 22.15 per 100,000 population, ranking Iran 65th in the world.[9]

Previous research from around the world shows that Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), increasing age, gender, presence of comorbidities, mechanism of injury, traumatic brain injury, region, and timing were independent predictors of mortality among trauma patients.[4,8,10-13] Moreover, a significant proportion of trauma-related deaths are associated with multiple injuries (60.9%) and head injuries (30.4%).[4] On the other hand, research has indicated that the lack of access to medical help can heighten the chances of death for trauma patients, with potentially preventable mortality rates ranging from approximately 20 to 40%.[14-17]

Data from trauma registries often include vital signs at the time of admission, which are essential for computing patient physiological scoring systems. Such information is also vital for early mortality prediction in hospitals.[18] Various studies define early mortality as occurring within the first 24 hours, delayed mortality as happening between 1- and 7-day post-trauma, and late mortality as taking place 8 to 30 days afterward.[19-21]

Trauma management requires a multidisciplinary approach that begins with pre-hospital care at the site of injury and continues with hospitalization. Given that trauma-related injuries constitute one of the primary causes of death globally and exert a substantial direct and indirect socioeconomic burden on societies; policymakers, and health authorities must undertake fundamental measures to address this issue [4]. Evaluating trauma-related mortality through various methodologies is crucial to comprehending the trends and ultimately facilitating the provision of the highest standard of medical care to patients.

Objectives

Therefore, this study aimed to assess the incidence and identify predictors of mortality among trauma patients admitted to the hospital.

Methods

The current retrospective study utilized data from Isfahan Trauma Registry (ITR) and Hospital Information Systems (HIS) to investigate fatalities between September 2020 and March 2022. The statistical population consisted of all trauma patients, who visited the Emergency Department (ED) of hospitals affiliated with Isfahan University of Medical Sciences within 18 months and died at the hospital. To ensure generalizability and representativeness of the sample and also to eliminate sampling bias we used census sampling method and finally, 1266 deceased patients were included in the study. In accordance with the categorization employed by previous researches, the present study classified deceased patients into three distinct groups based on the timing of their demise following trauma. These groups were defined as early death, occurring within the initial 24 hours post-trauma, delayed death, between 1- and 7-days post-trauma, and late death, between 8- and 30-days post-trauma.[19]

The inclusion criteria involved all trauma patients of any severity, brought to the hospitals affiliated with Isfahan University of Medical Sciences, including Al-Zahra, Kashani, Amin, Goldis in Shahin Shahr, Shafa in Kalishad, Manzarieh in Khomeini Shahr, Behnia in Tiran, Montazeri in Najafabad, and Fatemieh in Khansar; and mortality within the hospitals. Cases with incomplete and untraceable files, patients who died before reaching the hospitals and when transported by Emergency Medical Services (EMS), and those who died after discharge were excluded from the study.

Having achieved the necessary permission and ethical approval from Isfahan University of Medical Sciences, the researchers began to visit all affiliated hospitals. Patients' data including demographics, injury information such as cause and type of injury, victims' pre-impact conditions, and emergency department information including vital signs and state of consciousness, were gathered using a checklist from their medical electronic records and the ITR system. Finally, the severity of the patients' injuries was measured using the ISS calculator and recorded.

To decrease the risk of bias we employed standardized and validated data collection methods to gather information from participants. Retrospective research relies on participants' recollection of past events, which can be prone to recall bias. To minimize this bias, we considered using objective measures, such as medical records or other documented sources, like minimal data set (MDS) from Isfahan Trauma Registration Center. We also validated data from different sources and employed multiple data collection methods to cross-check the accuracy and reliability of information obtained in our retrospective study. While these strategies can help reduce bias in retrospective research, it may not, however, be possible to completely eliminate bias.

Statistical analysis

Descriptive statistics were performed for baseline characteristics. Categorical data are presented as proportions and percentages. Continuous data are presented as median and interquartile range (IQR). Categorical variables were compared using chi-square tests. Continuous variables were compared using T-test and Mann-Whitney test. Multivariate regression analysis was used to identify independent predictors of death (early, delayed, and late) in relation to other investigated variables. The odds ratio with its 95% confidence interval was calculated. All statistical analyses were performed with SPSS (version 16.0, SPSS Inc, Chicago, IL, USA). A "P-value" less than 0.05 was considered significant.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. The Isfahan University of Medical Sciences ethics committee approved this study (approval number: IR.MUI.MED.REC.1400.840). The informed oral consent was received from patients.

Results

A total of 1,266 patients who died from trauma within 18 months were evaluated. A total of 604 (47.7%) patients experienced early mortality within the first 24 hours, 427 (33.7%) experienced delayed mortality in 1 to 7 days after trauma, and 235 (18.6%) experienced late mortality 8 to 30 days after trauma. Table 1 presents the demographic status and characteristics related to trauma. In Tukey's post hoc test, a significant difference was found between road accidents and urban traffic accidents (P=0.013) as well as suffocation and road accidents (P=0.042). There was no significant difference among the three categories of mortality regarding age, gender, consciousness level at admission, and trauma severity score (P>0.05). However, there was a significant difference among the three mortality categories regarding the mechanism and type of trauma, and the pre-impact conditions (P<0.05) (Table 1).

Table 1. Trauma-related demographic status and characteristics

Variable	Early Mortality	Delayed Mortality	Late Mortality	Total	P value
Age, year, (mean±SD) Min-Max	46.89±23.91 (0-95)	46.15±23.65 (0-94)	48.4±23.8 (2-95)	47.14±23.78 (0-95)	0.503 [1]
Sex, n (%)					
Male	488 (80.8)	348 (81.5)	196 (83.4)	1032 (81.5)	0.682 [2]
Female	116 (19.2)	79 (18.5)	39 (16.6)	234 (18.5)	
GCS in Admission, n (%)					
13-15	249 (41.2)	183 (42.9)	95 (40.4)	527 (41.6)	0.184 [2]
9-12	162 (26.8)	118 (27.6)	60 (25.5)	340 (26.8)	
3-8	193 (32)	126 (29.5)	80 (34)	399 (31.5)	
ISS (median (IQR))	46 (19-60)	43 (26-70)	44 (20-60)	46 (19-70)	0.230 [3]
Mechanism of Trauma, n (%)					
Road accidents	131 (21.7)	125 (29.3)	76 (32.3)	332 (26.2)	0.018 [2]
Urban traffic accidents	316 (52.3)	209 (48.9)	103 (43.8)	628 (49.6)	
Fall	73 (12.1)	51 (11.9)	25 (10.6)	149 (11.7)	
Poisoning	23 (3.8)	19 (4.4)	13 (5.5)	55 (4)	
Cut/ Stab	18 (3)	11 (2.6)	9 (3.8)	38 (3)	
Suffocation	29 (4.8)	8 (1.9)	6 (2.6)	43 (3.3)	
Electrocution	14 (2.3)	4 (0.9)	3 (1.3)	21 (1.6)	
Type of Trauma, n (%)					
Blunt	541 (89.6)	401 (93.9)	215 (91.5)	1157 (91.5)	0.050 [2]
Penetrating	63 (10.4)	26 (6.1)	20 (8.5)	109 (8.6)	
Pre-impact Conditions, n (%)					
Pedestrian	179 (29.6)	132 (30.9)	62 (26.4)	373 (29.4)	0.030 [2]
Motorcyclist	169 (28)	142 (33.3)	71 (30.2)	382 (30.1)	
Car passenger/Driver	125 (20.8)	86 (20.1)	68 (28.9)	279 (22)	
Cyclist	7 (1.2)	3 (0.7)	2 (0.9)	12 (0.9)	
Unknown	124 (20.5)	64 (29.1)	32 (14.5)	220 (17.4)	

SD: Standard Deviation; n: number; GCS: Glasgow Coma Scale; Injury Severity Score; IQR: The interquartile range; Min: Minimum; Max: Maximum. 1. Comparisons were made using the Mann-Whitney test. 2. The comparison performed using the Chi-square test. 3. Comparison performed using an independent t-test.

Table 2 represents the vital symptoms of the deceased at admission and death time points. There was a significant difference among the three mortality groups regarding oxygen saturation (SpO_2), heart rate (HR), and respiratory rate (RR) at admission ($p<0.05$). Specifically, the RR and SpO_2 were higher in late mortality, while the HR was higher in delayed mortality. At the time of death, SpO_2, HR, and RR significantly differed among the three mortality groups ($p<0.05$). In particular, RR and SpO_2 were higher in late mortality, whereas HR was higher in delayed mortality.

Table 3 demonstrates early, delayed, and late mortality predictors. The *GCS* was identified as a predictor of early mortality. Additionally, ISS and GCS were predictors of delayed mortality, while age and GCS were predictors of late mortality.

Table 2. Vital symptoms of the deceased at admission and death

Variable	Early Mortality	Delayed Mortality	Late Mortality	*P value*
Mean Arterial Pressure				
At admission	82.61±18.82	89.2±20.41	91.33±16.69	0.158
Death	79.9±27.09	80.2±16.8	86.7±25.95	0.586
RR (breaths per min)				
At admission	12.34±8.17	16.27±7.85	20.38±19.18	0.035
Death	10.9±9.09	16±7.84	21.56±16.1	0.003
HR (beats per min)				
At admission	64.95±44.07	90.48±40.63	82.55±24.15	0.026
Death	59.06±49.45	87.71±40.79	83.94±27.01	0.014
Spo_2 (%)				
At admission	66.13±40.49	80.71±29.16	87.33±22.09	0.054
Death	56.02±43.65	81.89±29.62	85.94±22.18	0.002

RR: Respiratory Rate; HR: Heart Rate; Spo2: Oxygen Saturation; Min: Minimum. All comparisons performed using the Mann-Whitney test.

Table 3. Predictive factors of early, delayed, and late mortality

Variable	P value	Odds ratios (95 % CI)
Early Mortality		
ISS	0.140	2.34 (1.18-3.12)
Age	0.224	2.68 (1.64-4.09)
GCS	0.029	3.42 (2.67-3.98)
Systolic Blood Pressure at Admission	0.123	0.98 (0.13-1.65)
Abnormal Respiratory Rate (>26 or ≤10)	0.109	1.2 (0.93-2.27)
Delayed Mortality		
ISS	0.003	5.43 (3.85-5.9)
Age	0.287	3.82 (2.67-4.32)
GCS	0.017	2.69 (1.24-2.84)
Systolic blood Pressure at Admission	0.229	0.78 (0.38-1.49)
Abnormal Respiratory Rate (>26 or ≤10)	0.118	1.65 (0.89-2.69)
Late Mortality		
ISS	0.367	1.86 (0.69-2.69)
Age	0.043	0.98 (0.27-3.13)
GCS	0.013	3.29 (1.88-3.58)
Systolic Blood Pressure at Admission	0.089	2.26 (1.31-3.42)
Abnormal Respiratory Rate (>26 or ≤10)	0.063	3.55 (2.47-4.09)

GCS: Glasgow Coma Scale; Injury Severity Score; CI: Confidence Intervals

Discussion

According to the current study, approximately 50% of the patients died within 24 hours of the trauma. This finding aligns with the study conducted in Germany by Rauf et al in 2019.[22] They evaluated 78,130 trauma patients in Germany and reported mortality rates of 10.8%

within one hour of hospitalization, 25.5% within the first 6 hours, 40.0% within 12 hours, 53.2% within 24 hours, and 61.9% within 48 hours.

The results of the present study indicated that a single score increase in GCS was significantly associated with a 40% reduction in the risk of mortality. Conversely, a one-unit increase in ISS was found to be linked with a 10% increase in the risk of mortality. In 2021, Bhandarkar et al.,[19] conducted a study on a sample of 9,354 patients in India, reporting early mortality rates of 15.4%, delayed mortality rates of 59.1%, and late mortality rates of 25.5%. The deceased patients had low systolic blood pressure (SBP) and high SpO_2, GCS, HR, and RR. The results of the two studies differed significantly, with early mortality being approximately three times higher in the present study, while delayed and late mortality were much lower. This inconsistency may be attributed to the differences in the severity of the injury, or the type and quality of care provided to the patients with higher levels of triage according to the Emergency Severity Index (ESI) triage system. For instance, more attention is typically given to patients who have a lower GCS score. The study results highlight the need for further research to identify effective interventions for reducing early mortality rates.

In China in 2023, Zhou et al.,[23] reported that a higher ISS was an independent predictor of increased mortality. Our study supports their finding by showing delayed mortality prediction by ISS.

The elderly population, in particular, is susceptible to injuries resulting from minor traumas such as same-level falls.[24] Yadollahi et al.,[25] in 2019 assessed 849 trauma patients in Shiraz and found that 60.4% were between 15 and 39 years old, with motorcycle accidents being the most common cause of injury. The present study found that advanced age was positively correlated with a high likelihood of mortality. In a four-year follow-up of elderly individuals in the United States in 2020, Albrecht et al.,[26] found that any moderate to severe injury resulting from accidents was associated with higher mortality. Furthermore, the present study identified age as a predictor of late mortality.

In a similar study conducted in the United States in 2022, Jure et al examined the traditional threshold ISS ≥ 16 and its association with mortality in adult trauma patients with different mechanisms of injury. Its hypothesis was that the performance of the ISS score varies across different mechanisms, which is congruent with our findings.[27]

It should be noted that the GCS alone may not provide a definitive assessment of the pre-impact victims' conditions and outcomes, as some deceased individuals did not exhibit head trauma or shock phase symptoms but died from severe multiple traumas. Additionally, the GCS does not decrease until the victim enters the shock phase and experiences a decreased level of consciousness. Therefore, the GCS cannot be considered an independent determinant of mortality. However, in clinical practice, patients with a lower GCS receive increased attention, care, and priority for treatment, which may reduce preventable or potentially preventable deaths or somehow prolong the dying process of non-preventable deaths. Nonetheless, if the required infrastructure and resources are accessible for the precise and reasonably accurate computation of the ISS upon the arrival of the injured person at the triage unit, and with a more accurate calculation of the ISS score while in the ED, this scale can prove to be a valuable tool for prioritizing the treatment of trauma victims and ultimately enhancing their chances of survival.

The study's findings have important implications for various stakeholders involved in trauma patient care, including EMS personnel, emergency department staff, trauma surgeons, and healthcare policymakers. EMS personnel should accurately record the Glasgow Coma Scale (GCS) at the accident scene to identify high-risk patients and make appropriate triage decisions. Emergency department staff should prioritize assessing both GCS and the Injury Severity Score (ISS) in trauma patients to allocate resources and consult with trauma surgeons effectively. Trauma surgeons should routinely calculate the ISS to guide interventions based on injury severity. Healthcare policymakers should establish protocols and systems to assess and document the ISS accurately, consider electronic medical records for consistent documentation, and foster interdisciplinary collaboration. Education programs, automated tools, and resource allocation for specialized trauma centers are also important interventions. Recognizing the significance of GCS and ISS and implementing these interventions can improve prognostic accuracy, treatment decisions, and patient outcomes.

A limitation of the present study was the inadequate availability of data from centers lacking a Trauma Data Registration System. Another limitation was inability to investigate and follow up the status of all patients discharged from the hospital. In fact, the variations in the definition of patients dead on arrival (DOA) and thirty-day mortality after trauma may have, to some extent, distorted the interpretation of mortality outcomes.

Conclusions

Based on the findings of this study, ISS and GCS are crucial determinants for prognosticating mortality in the aftermath of trauma. Therefore, it is imperative to take these factors into account upon admission. Notably, the GCS, because of its simplicity, can be quickly and easily recorded at the accident scene by EMS personnel. Additionally, it is advisable to measure and document the ISS in trauma patients admitted to the ED, alongside the computation of the GCS, if the required infra-structures are available. The combination of GCS and ISS appears to improve the accuracy of clinical outcome predictions, thereby enabling the creation of a more effective predictive system.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

World Health Organization: WHO;
Isfahan Trauma Registry: ITR;
National Trauma Registry of Iran: NTRI;
Hospital Information System: HIS;
Glasgow Coma Scale: GCS;
Injury Severity Score: ISS;
Emergency Department: ED;
Road Traffic Accident: RTA;
Emergency Medical Services: EMS;
Minimal Data-set: MDS;
Emergency Severity Index: ESI;
Dead on Arrival: DOA.

Authors' contributions

MNI, HKH, ABBJ, and NSF contributed to the conception and design of the work. MNI, HKH, ABBJ, ARSH, NSF and DSH contributed to data interpretation, drafting, and critical revision of the paper. DSH also assisted with data analysis. NSF and ARSH helped with data collection. All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Role of the funding source

None.

Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The Isfahan University of Medical Sciences ethics committee approved this study (approval number: IR.MUI.MED.REC.1400.840). Through informed oral consent of patients or their first-degree relatives, data were collected and presented anonymously in this project.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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