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Original Article

Predicting Factors of Early and Late Mortality in Severe Trauma Patients Following Immediate Intervention

Mahnaz Yadollahi [1], Amir Hossein Shams [1*], Mahsa Ahadi [1], Shiva Aminnia [2]

[1] Trauma Research Center, Shahid Rajaee (Emtiaz) Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, Iran.

[2] Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran.

*** Corresponding Author**: Amir Hossein Shams, MD. Trauma Research Center, Shahid Rajaee (Emtiaz) Trauma Hospital, Shiraz University of Medical Sciences, Shiraz, Iran., Tel: +98 917 897 8548, Email: amir.hn.shams@gmail.com.

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Abstract

Background: Strategies to prevent and provide an appropriate post-injury care system are vital save resources and reduce fatalities and disabilities. The present study aimed to evaluate risk factors for early and late mortality.

Method: This cross-sectional study was conducted at a trauma referral center in southern Iran from June 2019 to June 2020. Based on the length of hospital stay, the patient's outcomes were classified as short-term (within the first 48 hours of admission) or long-term (beyond 48 hours of admission) categories. Predictors of mortality evaluated included gender, age, Glasgow Coma Scale, presence of significant trauma using the Injury Severity Score, mechanism of injury, the need for intubation or chest tube placement, and hospital-acquired infection.

Results: This study was performed on 1281 patients with a mean age of 37.9 ± 19.1 years. The median length of hospital stay was 7.7 days, with a mean injury severity score of 16.3 ± 11.3. The primary mechanism of injury was road-traffic accidents (65.5%), followed by falling (15.2%). During the first 48 hours of hospitalization, 217 of 1281 patients died or were discharged, the long-term group included 1,064. The risk factors were age≥65 years (OR=5.71, CI:3.16-10.3), GCS 9-12 (OR=3.39, CI:1.55-7.42), GCS≤8 (OR=5.88, CI:3.14-11.03) major trauma (OR=1.92, CI:1.05-3.52), and chest tube insertion (OR=2.49, CI:1.4-4.43) for short-term mortality and 45-64 age group (OR=5.95, CI:3.18-11.15), age≥65 years (OR=22.12, CI:11.38-42.97), GCS 9-12 (OR=2.9, CI:1.4-6.02), GCS≤8 (OR=5.53, CI:3.03-10.11), major trauma (OR=1.99, CI:1.11-3.54), chest tube insertion (OR=2.96, CI:1.68-5.23), and incidence of hospital-acquired infection (OR=2.42, CI:1.43-4.1) for long-term mortality.

Conclusion: Despite the similarities in the predictors of short-term and long-term mortality in trauma patients, our study showed that the effect of the age in these two groups varied. To improve the prognosis of unstable trauma patients, they should be categorized based on time and age.

Keywords: Hospital Mortality; Accidents; Triage; Length of Stay; Prognosis.

Introduction

Trauma is the leading cause of death, hospitalization, and disability in all below 40 age groups [1]. According to the World Health Organization's (WHO) violence and injury fact sheet, more than five million lives are lost due to injuries each year, a quarter of which results from road traffic injuries. Road traffic injuries and falls, which are the leading causes of injury deaths, have a growing pattern and have been anticipated to become the 7th and 17th significant causes of death by 2030. In many developing countries, deaths caused by road traffic accidents have been increasing steadily. Disabilities are yet another aspect of injuries for the people who survive them. Approximately 6% of all years lived with disability have been reported to result from injuries [2].

Considering the burden imposed on healthcare systems by injuries, prevention and provision of an appropriate post-injury care system are two key strategies to save substantial resources and reduce fatalities and disabilities. Therefore, it is crucial to identify the predicting factors for death and disability in trauma patients and utilize this information to improve the patient triage system [3-6].

Predicting factors for trauma mortality can be categorized based on time. The highest mortality rate has been reported during the first 24 hours of hospital admission, especially the first 15 minutes [7-9]. In 1983, Trunkey described a trimodal distribution of deaths caused by traumas, with immediate (at the scene), early, and late deaths [10]. Gunst et al. referred to several changes in the distribution of trauma deaths. They indicated a rather bimodal distribution of trauma fatalities, with a persistent peak in early deaths and a significant decrease in late ones. This might be attributed to the improvements in prehospital care [11].

Determining the predicted factors for mortality can improve patients' triage, which is especially important in patients who are severely injured and need immediate intervention. However, identifying these factors without considering the influence of time can be misleading. Previous studies suggested factors for predicting the mortality of trauma patients, but selecting critically ill patients and categorizing them based on their hospital length of stay can help us provide optimal care for them. Without this mindset, treatment becomes irrelevant. The present study aimed to determine factors predicting early and late mortality in critically ill trauma patients.

Methods

This cross-sectional study was conducted at Shahid Rajaee Trauma Center of Shiraz University of Medical Sciences (a level I trauma referral center located in southern Iran) from June 2019 to June 2020. This study aimed to evaluate and compare the causes of early and late mortality in critical trauma patients. The source of information was the hospital administrative records.

Study population

All adult critical trauma patients who entered the Emergency Department at Shahid Rajaee Hospital were selected via the census. All trauma patients aged above 15 years were assigned to levels I and II based on the Canadian Triage and Acuity System (CTAS) [12] triage system and were categorized as S.00 to T79.7 in the International Statistical Classification of Diseases and Related Health Problems (ICD) were included. Patients with burns and corrosion injuries (T20.0-T32.9), foreign bodies (T15.0-T19.9), environmental exposures (T33.0-T35.7, T66-T75.8), and poisonings (T36.0-T65.9), as well as those who were dead on arrival, were excluded from the study. Eventually, 1281 patients who met the criteria were entered into the study.

Data collection

The patients' information was collected based on a researcher-made form containing demographic information, GCS, Abbreviated Injury Scale (AIS) [13], diagnosis, cause of hospitalization (including accidents by type of injury, stabbing, falling, suicide and self-immolation, electric shock, and drowning), placement of endotracheal and chest tube, hospital-acquired infection, length of hospital stay, outcome (dead or discharged), and ICD code of the disease (S.00 to T79.7).

Outcome measurements

Length of hospital stay and outcomes (dead or discharged) were calculated and analyzed in early (within 48 hours of admission) and late (beyond 48 hours of admission) categories. The cut-off of 48 hours was set to evaluate the association between hospital-acquired infection and mortality rate. Individuals with positive cultures and hospitalization for more than 48 hours were considered to have a nosocomial infection.

Statistical analysis

After gathering the necessary information, the research hypotheses were analyzed using the Stata 14 software. The quantitative variables were presented as mean and Standard Deviation (SD), while the qualitative ones were presented as absolute and relative frequency. The relationship between the qualitative variables such as gender, time of the accident, accident mechanism, and injury severity index was assessed using the chi-square test. Additionally, a t-test or its non-parametric equivalent was used to evaluate the relationship between such quantitative variables as age and length of hospital stay. Finally, the risk of short-term and long-term mortality was determined by logistic regression modeling (forward method).

Ethical consideration

Ethical approval was obtained from the Institutional Review Board (IRB) and the Research Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.REC.1400.273).

Results

This study was performed on 1281 patients with a mean age of 37.9 ± 19.1 years (ranging from 15 to 100 years). The study population consisted mainly of male patients, with a male-to-female ratio of 4.8:1. The average length of hospital stay was 12.2 days (SD = 13.8), with a minimum of 1 hour and a maximum of 126 days. The overall mortality was 13.7%. Young adults (15-44 years old) made up 68.7% of the study population, 6.7% of whom died. However, only 12.3% of the patients were over 65 years old and had a mortality rate of 42.4% (**Table 1**). The mean ISS was 16.3 ± 11.3. Accordingly, half of the patients (49.3%) had significant trauma (ISS > 15). The most common site of injury was the chest (55.8%), followed by the head and neck region (52.4%) and the limbs (44.1%). Furthermore, hospital-acquired infection was observed in 18.5% of the patients (n = 237), 21.9% of whom died. In this study, the primary mechanism of injury was road accidents (65.5%), including vehicle, motorcycle, and pedestrian accidents. The second most common cause of injury was falling (15.2%) (**Figure 1,2**). Different age groups were affected by various mechanisms of injury. According to the results, falling down damage was more prominent in the elderly, while younger adults (under 65 years of age) were more affected by road traffic. The main mechanisms of injury that led to death were also road traffic accidents and falls, which were responsible for 76% and 20% of all deaths, respectively. Other injury mechanisms were assault, stabbing, gunshot, suicide, self-harm, and sports injuries detected in 19% of the population.

A total of 1281 admitted (short-term group). During the first 48 hours, 73 patients were deceased, and 71 were discharged. The long-term group consisted of 1064 patients receiving treatment after 48 hours (**Figure 3**).

Table 1: Demographic characteristics of patients in need of immediate intervention.

	Short-term					Long-term			
	Survived n=1208	Dead n=73	Total n=1281	P-Value		Survived n=961	Dead n=103	Total n=1064	P-Value
Gender				0.63					0.73
Male (N, %)	1003 (94.4%)	59 (5.6%)	1062 (82.9%)			799 (90.2%)	87 (9.8%)	886 (83.3%)	
Female (N, %)	205 (93.6%)	14 (6.4%)	219 (17.1%)			162 (91%)	16 (9%)	178 (16.7%)	
Age*	37.1 ± 18.6	50.8 ± 23	37.9 ± 19.1	<0.001		35.6 ± 17.2	56.8 ± 21.4	37.7 ± 18.8	<0.001
15-44 (N, %)	847 (96.3%)	33 (3.8%)	880 (68.7%)			704 (96.4%)	26 (3.6%)	730 (68.6%)	
45-64 (N, %)	231 (95.1%)	12 (4.9%)	243 (19%)			176 (82.2%)	38 (17.8%)	214 (20.1%)	
≥ 65 (N, %)	130 (82.3%)	28 (17.7%)	158 (12.3%)			81 (67.5%)	39 (32.5%)	120 (11.3%)	
Mechanism of injury				<0.001					<0.001
Traffic accident (N, %)	826 (93.5%)	57 (6.5%)	883 (65.5%)			679 (89.9%)	76 (10.1%)	755 (71%)	
Falls (N, %)	184 (94.4%)	11 (5.6%)	195 (15.2%)			130 (84.4%)	24 (15.6%)	154 (14.5%)	
Other (N, %)	198 (97.5%)	5 (2.5%)	203 (19.3%)			152 (98.1%)	3 (1.9%)	155 (14.6%)	

*Mean ± standard deviation;

The mortality rate was 5.6% in the short-term group and 9.6% in the long-term group. The mean age of patients who deceased within the first 48 hours of hospitalization was lower than the long-term group (50.8 vs. 56.8 years old). Also, they had lower mean GCS (7.8 vs. 9.1). Most patients had a minor traumatic brain injury (64%) in the long-term and short-term groups. In the short-term group, about 74% of patients who expired suffered from Major trauma (ISS ≥ 16); this proportion was also similar in the long-term group (77%). Three hundred forty-six patients got intubated during their hospitalization, and 246 received chest tube insertion (**Table 2**).

Table 2: Clinical characteristics of patients in need of immediate intervention.

	Short-term					Long-term			
	Survived n=1208	**Dead n=73**	**Total n=1281**	**P-Value**		**Survived n=961**	**Dead n=103**	**Total n=1064**	**P-Value**
GCS*	12.2 ± 3.8	7.8 ± 4.5	12±4	<0.001		12.4 ± 3.6	9.1 ± 4.5	12.1 ± 3.8	<0.001
13-15 (N, %)	754 (97.8%)	17 (2.2%)	771 (63.7%)			609 (95.5%)	29 (4.5%)	638 (63.6%)	
9-12 (N, %)	144 (91.7%)	13 (8.3%)	157 (13%)			115 (87.1%)	17 (12.9%)	132 (13.2%)	
3-8 (N, %)	246 (86.9%)	37 (13.1%)	283 (23.4%)			187 (80.3%)	46 (19.7%)	233 (23.2%)	
Injury distribution									
Head and neck (N, %)	633 (94.3%)	38 (5.7%)	671 (52.5%)	0.9		512 (86.3%)	81 (13.7%)	593 (55.8%)	<0.001
Face (N, %)	249 (97.3%)	7 (2.7%)	256 (20%)	0.02		214 (89.2%)	26 (10.8%)	240 (22.6%)	0.49
Thorax (N, %)	668 (93.4%)	47 (6.6%)	715 (55.8%)	0.13		557 (88.8%)	70 (11.2%)	627 (58.9%)	0.05
Abdomen (N, %)	213 (91%)	21 (9%)	234 (18.3%)	0.02		182 (89.2%)	22 (10.8%)	204 (19.2%)	0.55
Extremities (N, %)	531 (94%)	34 (6%)	565 (44.1%)	0.66		428 (89.4%)	51 (10.6%)	479 (45%)	0.33
External (N, %)	380 (92.9%)	29 (7.1%)	409 (31.9%)	0.141		289 (89.8%)	33 (10.2%)	322 (30.3%)	0.68
ISS*	15.9 ± 11.1	22.1 ± 13.1	16.3 ± 11.3	<0.001		16.3 ± 10.4	24.2 ± 12.3	17.1 ± 10.9	<0.001
Major Trauma (N, %)	580 (91.5%)	54 (8.5%)	634 (49.5%)	<0.001		478 (85.8%)	79 (14.2%)	557 (52.3%)	<0.001
Intubation (N, %)	309 (89.3%)	37 (10.7%)	346 (27%)	<0.001		248 (81.6%)	56 (18.4%)	304 (28.6%)	<0.001
Chest Tube (N, %)	221 (89.8%)	25 (10.2%)	246 (19.2%)	0.001		181 (83%)	37 (17%)	218 (20.5%)	<0.001
HAI (N, %)**	-	-		-		185 (78.1%)	52 (21.9%)	237 (22.3%)	<0.001

*Mean ± standard deviation; **Hospital-acquired infection

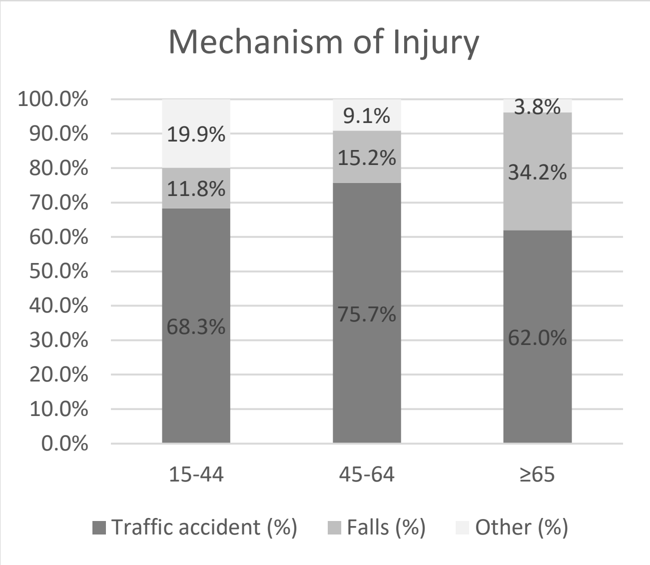

Figure 1: Mechanism of injury categorized by age groups

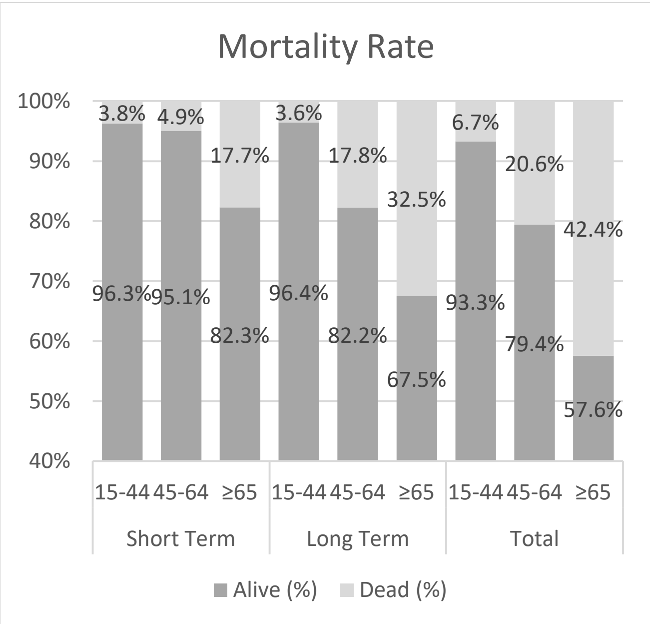

Figure 2: Mortality rate categorized by age groups.

Based on the results presented in Table 3, the age group ≥ 65 years (OR = 5.71, 95% CI [3.19 – 10.3]), GCS 9-12 (OR = 3.39, 95% CI [1.55-7.42]), GCS 3-8 (OR = 5.88, 95% CI [3.14-11.23]), major trauma (OR = 1.92, 95% CI [1.05-3.52]), and chest tube insertion (OR = 2.49, 95% CI [1.4-4.43]) were the most prominent risk factors for short-term mortality (**Table 3**). The factors affecting long-term mortality (**Table 4**) included the 45-64 age group (OR = 5.95, 95% CI [3.18-11.15]), age ≥ 65 years (OR = 22.12, 95% CI [11.38-42.97]), GCS 9-12 (OR = 2.9, 95% CI [1.4-6.02]), GCS 3-8 (OR = 5.53, 95% CI [3.03-10.11]), major trauma (OR = 1.99, 95% CI [1.11-3.54]), chest tube insertion (OR = 2.96, 95% CI [1.68-5.23]), and hospital-acquired infection (OR = 2.42, 95% CI [1.43-4.1]).

Table 3 : Short-term Mortality predicting factors.

Variables	**OR***	**CI****		**P-value**
		Lower	**Upper**	
Age				
15-44	1			0<001
45-64	0.98	0.45	2.13	0.95
≥65	5.71	3.16	10.3	0<001
GCS				
13-15	1			0<001
9-12	3.39	1.55	7.42	0.002
3-8	5.88	3.14	11.03	0.000
Major Trauma	1.92	1.05	3.52	0.034
Chest Tube insertion	2.49	1.4	4.43	0.002
*Odds ratio; ** Confidence interval				

Table 4: Long-term Mortality predicting factors.

Variables	**OR***	**CI****		**P-value**
		Lower	**Upper**	
Age				
15-44	1			0<001
45-64	5.95	3.18	11.15	0<001
≥65	22.12	11.38	42.97	0<001
GCS				
13-15	1			0<001
9-12	2.9	1.4	6.02	0.004
3-8	5.53	3.03	10.11	0<001
Major Trauma	1.99	1.11	3.54	0.02
Chest Tube insertion	2.96	1.68	5.23	0<001
HAI	2.42	1.43	4.1	0.001
*Odds ratio; ** Confidence interval; ***Hospital-acquired infection				

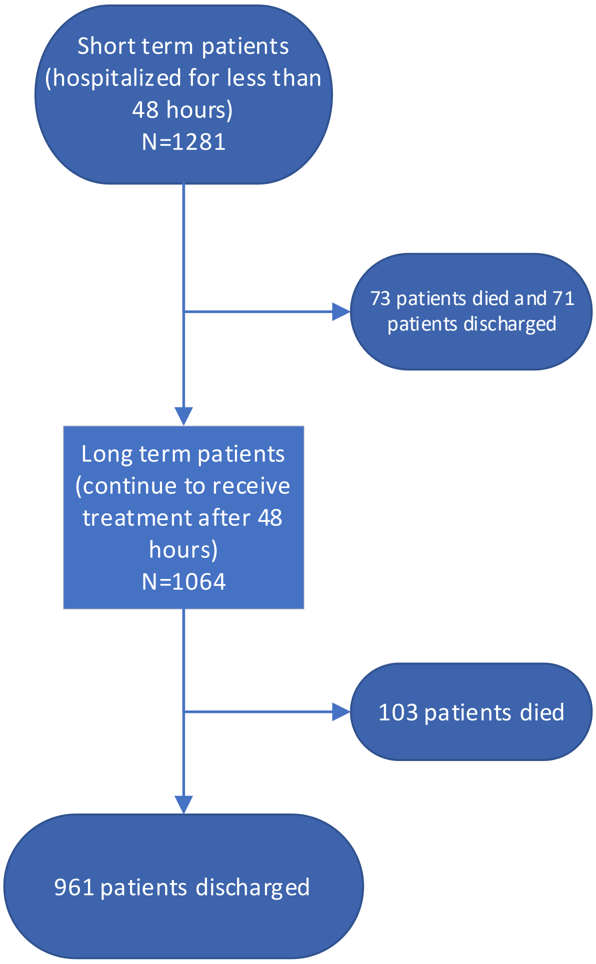

Figure 3: Flow chart of admitted patients.

Discussion

This study was conducted on 1281 severely injured patients in a level one trauma referral center in southern Iran. Young adults comprised most of the trauma patients, consistent with other studies conducted on the issue [14, 15]. Additionally, most of the study participants were male, with a male-to-female ratio of 4.8:1. This pattern was also detected in similar studies performed in this region, which could result from cultural norms such as the predominant usage of motor vehicles by men [16, 17]. Moreover, the overall mortality rate was 13.7%, which agrees with previous studies conducted on severely injured patients [16]. The mean ISS was 16.3 ± 11.3, and nearly half of the patients had significant trauma. This might be because the study population included level 1 and 2 patients who mainly needed the CPR unit care. The most common injury site was the chest area (55.8%), followed by the head and neck region (52.4%). Abdominal trauma comprised only 18.3% of the injuries. Similar results were also obtained in other studies [15].

The previous studies conducted in this center showed that males had a higher late-mortality rate than females [18], which was supported by the findings of other studies [19]. However, the current study results revealed no significant difference between males and females in terms of mortality in both short- and long-term groups. Hence, this issue needs to be further evaluated.

In the current research, the mean length of hospital stay was 12.2 days (13.8 SD), dramatically different from the findings of similar studies reporting the mean length of hospital stay as below seven days [20, 21]. This inconsistency could be related to the condition of the patients enrolled in the study. As mentioned earlier, severely injured patients with poor conditions were recruited in this study. Previous studies showed that increased age and ISS, gender (male), motor vehicle accidents, and nosocomial infections significantly increased the length of hospital stay [21]. Another influential factor in the size of hospital stay in the present study was the disproportion in gender in the research population. Additionally, the most frequent mechanism of injury in this study was road traffic accidents, which played an indefinite role in the length of hospital stay.

Multiple studies were conducted during the last decades to evaluate the time from injury to death amongst trauma patients. Older studies suggested a consistent trimodal time-based distribution of fatalities, with immediate deaths (at the scene) mainly caused by nonsurvivable injuries, early deaths caused by severe injuries and bleeding, and late mortalities associated with multiple-organ failure and sepsis [10, 22]. However, this pattern seemed to change in later investigations. Lefering et al. assessed trauma fatalities in two European trauma registries and suggested a constantly decreasing incidence of deaths. The results indicated that almost half of all deaths occurred within the first 24 hours of admission [23]. Recent reviews also demonstrated the predominantly bimodal distribution of trauma deaths, as relatively unchanged immediate deaths nearly eliminated the late peak. They also pointed out that early deaths happened much earlier than in previous studies [24, 25]. In the present study, 41% of the deaths occurred within the first 48 hours, while the remaining 59% of mortalities happened after 48 hours. These results were contrary to those of the latest epidemiological studies. This discrepancy can be explained by the fact that the present study population included severely injured patients with triage levels 1 and 2 who were in poor conditions. As a result, the distribution and pattern of mortalities were different from the general population.

Moreover, improvements in the critical care system and management of potentially fatal yet preventable and treatable complications might be the reason for the decrease in early deaths. However, sepsis and multi-organ failure, the leading causes of late death, seemed not to be desirably treated in the system. Overall, the persistence of a high rate of early death despite all the actions taken to prevent injuries as well as advances in patient transfer systems and resuscitation measures, implies that a more significant number of critical patients are being transferred to hospitals compared to the past when they were pronounced dead on the scene [11].

The current study findings revealed age as one of the crucial factors affecting both short- and long-term mortalities, which was in agreement with the results of other studies [26, 27]. Accordingly, young adults (15-44 years old) made up 68.7% of the research population and had a mortality rate of 6.7%, while only 12.3% of the patients were over 65 years old and had a mortality rate of 42.4%. Thus, age above 65 was a significant risk factor for increased mortality. Furthermore, a significant difference was observed between different age groups with similar ISS regarding the mortality rate, which was consistent with the findings of other studies. For instance, Alberdi et al. indicated that patients over 65 had a doubled risk of mortality compared to young adults with the same level of injury [28]. One probable reason for this difference is the higher frequency of preexisting conditions [29, 30], including cardiovascular structural changes that reduce the myocardial reserve and make cardiogenic shocks harder to diagnose and more lethal [31-33]. The use of multiple medications, such as anticoagulant agents, in this population, can be another reason for this discrepancy [27]. Overall, a lack of physical reserves and insufficient systemic compensation ability seem to put older adults at a higher risk of death after injuries [33]. Different age groups also suffer from other mechanisms of injury, leading to further complications. Studies have shown that young adults (15-44 years old) are primarily victims of road traffic injuries and human aggression, while deaths caused by falls mainly occur in the elderly population [34]. Although some studies have reported Trauma and Injury Severity Score (TRISS) as the strongest predictor of mortality in geriatric patients [35, 36], it is still crucial to employ more developed injury severity measurements specified for this age group.

Generally, falls and motor vehicle accidents are the most common causes of trauma [37-39]. In the current research, the main trauma mechanisms were road traffic injuries (65.5%), including vehicle, motorcycle, and pedestrian accidents, followed by falls. These two mechanisms were responsible for 76% and 20% of all deaths, respectively [8, 38, 40, 41].

The present study results revealed a significant relationship between short- and long-term mortality and trauma due to traumatic brain injury. Studies consistently indicate that the two most common causes of immediate trauma deaths are Central Nervous System (CNS) injuries and hemorrhage [8, 22, 38, 40-42]. CNS injuries are generally categorized as direct damage (direct neuronal damage) and secondary damage (diffuse cerebral edema, necrosis, and herniation). As Hadfield et al. suggested, critical care's primary objective must be preventing CNS secondary injuries to reduce mortality [40, 43]. On the other hand, a systematic review performed in 2020 disclosed that organ failure was a more prevalent cause of death than brain injury, especially before the turn of the century. This review explained this change in the pattern by the recent improvements in trauma care prevention, treatment of ARDS and sepsis, volume resuscitation, mechanical ventilation, and early enteral nutrition [44].

Previous studies on the aforementioned trimodal distribution of trauma casualties suggested that infection and multi-organ failure were the reasons for more than half of late deaths [22, 40, 42, 45]. Recent studies showed that the late death peak was nearly eliminated due to advanced critical care [11]. On the contrary, 18.5% of the present study patients contracted nosocomial infections, about 22% of whom deceased. Compared to similar studies, the increase in late deaths in this study might be related to the patient's conditions. The patients in this study were primarily in critical situations and, consequently, were more susceptible to further complications. Another reason could be the improvement in early resuscitation and urgent care. As a result, patients in more severe conditions who were previously categorized as short-term deaths might survive longer. On the other hand, the high incidence of multidrug resistance in Iran [46, 47] might contribute to the non-optimal control of nosocomial infections. Thus, this issue is recommended to be addressed explicitly in further studies.

Despite all the efforts to reduce trauma mortality, desirable outcomes are still far from reach. The mature patient transfer system, more aggressive resuscitation, and intensive care seem insufficient to reduce fatalities. Prevention is the crucial point in controlling trauma mortality. Different age groups need measures to reach optimal trauma prevention and management systems.

Limitations

This study was conducted in one trauma center. Therefore, multi-center studies are required to attain more realistic statistics on this issue. In addition, the data were accessible only to the patients who were taken to the hospital. Hence, deaths that were confirmed on the scenes were not appraised in this study.

Conclusion

This study demonstrated the importance of age, GCS, major trauma, need for chest tube placement as critical factors for predicting patient mortality in trauma patients who need immediate intervention. We found similar predictors of short-term and long-term mortality; However, it is essential to note that the probability of mortality increased for older patients as the duration of hospitalization increased. Results indicated the need for management based on the characteristics of each patient rather than caring for them as a single group. This approach will undoubtedly improve trauma patients' prognosis and quality of life.

Disclosure statement

Authors declare no conflicts of interests.

Authors' contributions

Conceptualization: Mahnaz Yadollahi, Amir Hossein Shams; Methodology: Mahnaz Yadollahi; Formal analysis and investigation: Mahnaz Yadollahi, Amir Hossein Shams; Writing - original draft preparation: Mahsa Ahadi, Amir Hosein Shams, Shiva Aminnia; Writing - review and editing: Mahnaz Yadollahi, Mahsa Ahadi, Shiva Aminnia; Supervision: Mahnaz Yadollahi.

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Ethical Statement

Ethical approval was obtained from the Institutional Review Board (IRB) and the Research Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.REC.1400.273).

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