Original Article

The Association between Time Intervals in Emergency Medical Services and In-hospital Mortality of Trauma Patients

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Abstract

Context: While the clinical practice recommends field stabilization in trauma patients, in some situations, the speed of transport is crucial. **Aims:** This study aimed to evaluate the association between emergency medical services (EMS) time intervals (response time [RT], scene time [ST], and transport time [TT]) and in-hospital mortality in trauma patients in Tehran, the largest metropolis of Iran. **Settings and Design:** A prospective cohort study was conducted between May 2017 and April 2018. **Methods:** All EMS operations related to trauma events in the Tehran city that were transferred to three targeted major trauma centers were included. **Statistical Analysis:** Logistic regression analysis was used to assess the relationship between EMS time intervals and other risk factors of trauma death. **Results:** A total of 14,372 trauma patients were included in the final analysis. In-hospital mortality occurred in 225 (1.6%) patients. After adjustment for confounding variables, older age (odds ratio [OR] = 1.04/year), female gender (OR = 2.16), low Mechanism, Glasgow Coma Scale (GCS), age, and arterial pressure score (OR = 0.84 for each unit), low GCS (OR = 0.56 for each unit), longer ST (OR = 1.17/10 min), and longer TT (OR = 1.21/10 min) were found to be risk factors for death in trauma. **Conclusions:** Our study showed that in-hospital mortality of trauma patients correlated with longer EMS ST and TT, but the RT was not associated with mortality. Our results recommend that the EMS system should consider ST and TT rather than RT, as indexes of quality control in prehospital care of trauma patients.

Keywords: Emergency medical services, mortality, prehospital, time, trauma

Introduction

Trauma, with over 6 million deaths annually, is the leading cause of mortality in the world and imposes huge socioeconomic burdens.[1,2] This issue is more critical in the low- and middle-income countries, where resources and capacities for timely management of trauma patients are limited. In Iran, trauma causes over 27,000 deaths plus 800,000 disabilities, and over 60% of deaths occur at the scene or on the way to the hospital.[3] The "Golden hour of trauma" is a well-known premise in literature, which underlines the importance of patient transport and delivering definite trauma care at a trauma center within an hour of injury.[4] Meeting such standard of care requires emergency medical service (EMS) to utilize all its resources including ambulances, choppers, and personnel at the highest possible level for traumatic injuries. Hence, this puts the whole EMS system under pressure and may increase the risk of injuries, burnout, and depreciation.[5-8]

Access this article online

Quick Response Code:

Website: www.archtrauma.com

DOI: 10.4103/atr.atr_89_19

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How to cite this article: Saberian P, Kolivand PH, Hassani-Sharamin P, Modaber M, Farhoud A, Karimialavijeh E. The association between time intervals in emergency medical services and In-hospital mortality of trauma patients. Arch Trauma Res 2020;9:75-80.

Received: 22-09-2019, **Revised:** 17-12-2019, **Accepted:** 05-02-2020, **Published:** 30-05-2020

Therefore, demonstrating the effectiveness of such a principle is of undisputed importance. Although the golden hour of trauma seems logical, evidence supporting this principle is challenging.[9,10] There are many studies on the relationship between prehospital time and patient outcome, but the majority of these studies have failed to demonstrate such a relationship.[7,11] In addition, there is still debate in the prehospital literature on the strategies for transferring trauma patients, mainly the "scoop and run" versus "stay and play."[12] While clinical practice recommends field stabilization in trauma patients, in some situations, the speed of transport is crucial.[4,13,14] Considering these debates, in this study, we specifically focused on the prehospital time intervals. The purpose of this study was to evaluate the association between prehospital time intervals and in-hospital mortality in all trauma patients in Tehran, the largest metropolis of Iran.

Subjects and Methods

This was a prospective cohort study conducted between May 2017 and April 2018. The Institutional Review Board of Tehran University of Medical Sciences (IR.TUMS.VCR.REC.1397.1042) approved the study design. In Iran, there is no national trauma registry system in hospitals. Therefore, we targeted three hospitals in Tehran to extract the data from their local databases. The targeted hospitals were University-Affiliated Urban Teaching Hospitals and Level-1 Trauma Centers.

All EMS operations related to trauma event that were transferred to the targeted trauma centers were included. Exclusion criteria were cases in which time intervals of the operation were not documented; patients received care at the scene without hospital transfer; death at the scene; and refusal to be transferred to the hospitals by EMS.

Time intervals were categorized as response time (RT: phone call to arriving on the scene); scene time (ST: arriving on the scene to leaving the scene); and transport time (TT: leaving the scene to hospital entry). The total interval was defined as the interval between the phone call and arrival at the hospital emergency department. Prehospital times from phone call to hospital delivery were recorded based on the manual entry of EMS technicians and automatic global positioning system data of ambulances. After obtaining permission from the authorities, the investigators assessed the data of EMS operations in the registry of Tehran EMS. Demographic data (age and gender) of the victims, characteristics of the injury, and the time intervals of ambulances were obtained. Trauma was defined as any harm (blunt, penetrating, crash injury, and burns) that the EMS provider identifies as the cause of injury. Injuries were coded as motor-vehicle occupant, motor-vehicle versus pedestrian or cyclist, fall, burn, assault, gunshot wound, stab, machinery or crushing injury, and explosion.

The Mechanism, Glasgow Coma Scale, age, and arterial pressure (MGAP) score was equal to the sum of the following scores:

(1) Mechanism of the injury: blunt (4 scores) or penetrating (0 score); (2) Glasgow Coma Scale (GCS); (3) age: age >60 years (0 score) and age <60 years (5 scores); (4) systolic blood pressure (BP): BP >120 mmHg (5 scores) and 60–120 mmHg (3 scores), and BP <60 mmHg (0 score).[15]

Three subgroups were defined based on the MGAP score: low-risk group: score of 23–29, moderate-risk group: score of 18–22, and high-risk group: score <18.[15] In addition, based on the mechanism of the injury, the patients were categorized into penetrating and blunt trauma groups. The outcome was in-hospital mortality defined as alive patients who received treatment in the hospital and died while still in the hospital.

Statistical analysis

Descriptive analysis was conducted on all available variables, and values were expressed as frequency (number and percentage) and mean (standard deviation [SD]), as appropriate. Chi-square tests were used for comparisons of categorical variables, and the independent sample *t*-test was used to compare numerical variables. We used graphical approaches and Shapiro–Wilk test for assessing normality assumption; so according to the establishment of assumptions, parametric test was done. We used logistic regression analysis based on Enter method to determine the risk factors of trauma death for patients transferred to the hospital. The level of statistical significance was defined as $P < 0.05$. Statistical analyses were performed using the SPSS software package, version 25 (SPSS Inc., Chicago, IL, USA).

Results

A total of 14,372 trauma patients who were transferred to the targeted hospitals were assessed. Of them, 81.6% were male, their mean ± SD age was 33.6 ± 15.3 years, and 225 (1.6%) patients died. The proportion of death was not statistically significantly different by gender ($P = 0.106$). The mean age of the dead patients was statistically significantly higher than that of the survivors (44.8 and 33.5, respectively) ($P < 0.001$). The proportion of death was significantly different regarding age difference, type of trauma, and severity of trauma (based on MGAP) categories.

According to the MGAP scoring system, people over and under the age of 60 years attained 0 and 5 scores, respectively. In the current study, statistical significance was seen in those over and under the age of 60 years ($P < 0.001$). Hence, the percentage of death for those over 60 years was equal to 5.8% and for patients under 60 was 2.1% [Table 1].

In those aged over 60 years, the chance of death was 2.5 times more than those under 60 years; in penetrating trauma, death was 1.8 times more than blunt trauma; and in high-risk trauma, death was 5.5 and 102.6 times more than moderate- and low-risk trauma, respectively [Table 1]. The mean of GCS for dead cases was significantly lower than that of alive cases (9.2 and 14.9, respectively); also, there was a significant difference between live and dead patients in term of the mean MGAP score (26.3 and 18.3, respectively, $P < 0.001$) [Table 1].

Table 2 summarizes prehospital times by type of trauma, dead or alive, and MGAP score in patients transferred to the hospital. The mean response, ST, and TT were 12.0, 18.4 min, and 16.5 min, respectively. The mean RT in dead cases was significantly higher than that of alive patients (13.8 min and 12 min, respectively, $P = 0.002$), whereas ST and TT in dead cases were significantly lower than those in alive patients. ST in penetrating trauma and TT in blunt trauma cases were significantly lower among dead patients. In blunt traumas, RT for high-risk MGAP score was significantly higher than low- and moderate-risk groups. In addition, in both blunt and penetrating traumas, ST was significantly shorter in the high-risk MGAP score.

Table 1: Distribution of trauma death by trauma characteristic variables for patients transferred to the hospital

Variable	Alive	Dead	*P*
Age, mean±SD (%)	33.5±15.1	44.8±21.2	<0.001
Over 60	1043 (94.2)	64 (5.8)	
Under 60	13083 (98.8)	160 (1.2)	
Gender (%)			
Male	11539 (98.4)	193 (1.6)	0.106
Female	2606 (98.8)	32 (1.2)	
Type of trauma (%)			
Penetrating trauma	2666 (97.5)	67 (2.5)	<0.001
Blunt trauma	11481 (98.4)	158 (1.4)	
The severity of trauma (based on MGAP) (%)			
Low risk	13468 (99.5)	66 (0.5)	<0.001
Moderate risk	563 (90.7)	58 (9.3)	
High risk	95 (48.7)	100 (51.3)	
GCS, mean±SD	14.9±0.63	9.2±4.8	<0.001
MGAP Score, mean±SD	26.3±2.2	18.3±6.4	<0.001

SD: Standard deviation, GCS: Glasgow Coma Scale, MGAP: Mechanism, Glasgow Coma Scale, age, and arterial pressure

In penetrating and blunt trauma patients, for each score of decreased GCS, the probability of death increased by 1.93 and 2.13 times, respectively, but this was not statistically significant ($P > 0.05$). Multivariate analysis showed that in penetrating trauma, in-hospital mortality was only related to MGAP score and GCS without any association with the time intervals. Whereas, in blunt trauma, in-hospital mortality was related to the ST (odds ratio [OR] = 1.2) and TT (OR = 1.2) [Table 3].

After adjustment for confounding variables by multivariate logistic model, older age (OR = 1.04/year), female gender (OR = 2.16), low MGAP score (OR = 0.84 for each unit), low GCS (OR = 0.56 for each unit), longer ST (OR = 1.17/10 min), and longer TT (OR = 1.21/10 min) were found to be risk factors for death in trauma [Table 4].

Discussion

The results of the present study showed that in-hospital mortality among transferred trauma patients correlated with increased EMS ST and TT [Figure 1]. Other associated factors were low MGAP score, low GCS, older age, and female gender. In our study, multivariate analysis showed that RT was not associated with in-hospital mortality among trauma patients who were transferred to the hospital. This finding implies that in order to decrease in-hospital mortality in trauma patients, EMS care must be more focused on improving the ST and TT.[16] A large number of previous studies have failed to

Table 2: Prehospital times by type of trauma, dead or alive, and Mechanism, Glasgow Coma Scale, age, and arterial pressure score in patients transferred to the hospital

	Dead or alive			MGAP score			
	Dead, mean±SD	Alive, mean±SD	*P*	Low risk, mean±SD	Moderate risk, mean±SD	High risk, mean±SD	*P*
In penetrating trauma (min)							
RT	14.1±8.9	11.7±7.9	0.011	11.7±7.3	11.1±7.1	13.1±8.1	0.069
ST	15.3±15.7	19.1±11.6	0.011	19.1±11.7	18.8±12.9	15.8±10.3	0.012
TT	14.5±10.2	16.1±10.6	0.261	16.2±10.8	15.5±9.1	14.4±5.7	0.199
Total prehospital time	43.9±19.5	46.9±17.1	0.40	47±17.3	45.4±17.5	43.3±16	0.055
In blunt trauma (min)							
RT	13.7±7.9	12.1±7.2	0.007	12.1±7.2	12.3±7.3	15.3±8.8	0.001
ST	16.7±14.4	18.3±11.6	0104	18.3±11.6	17.3±11.8	15.2±13.6	0.035
TT	14.8±11.1	16.7±11.3	0.049	16.7±11.3	16.5±12.2	14.3±9.8	0.317
Total prehospital time	45.2±18.3	47.1±18	0.412	47.1±19	46.1±18	44.8±17.2	0.76
In total patients (min)							
RT	13.8±8.2	12.0±7.2	0.002	12.0±7.2	11.9±7.3	13.8±8.3	0.003
ST	16.3±14.8	18.4±11.6	0.008	18.4±11.6	17.8±12.1	15.7±11.5	0.003
TT	14.7±10.8	16.5±11.2	0.019	16.6±11.2	16.2±11.4	14.4±9.7	0.037
Total prehospital time	44.8±18.4	46.9±18.1	0.35	47±18.2	45.9±18.3	43.9±16.3	0.08

SD: Standard deviation, MGAP: Mechanism, Glasgow Coma Scale, age, and arterial pressure, ST: Scene time, TT: Transport time, RT: Response time

Table 3: Risk factors of death based on the trauma type

	Univariate				Multivariate			
	β	OR	95% CI for OR	*P*	β	OR	95% CI for OR	*P*
Penetrating								
Age	0.025	1.03	1.01-1.04	0.001	0.019	1.02	0.99-1.05	0.161
Sex								
Male		1.0				1.0		
Female	−0.291	0.75	0.38-1.48	0.403	0.382	1.47	0.45-4.80	0.528
MGAP score	−0.587	0.56	0.51-0.61	<0.001	−0.314	0.73	0.58-0.93	0.009
GCS	−0.657	0.52	0.47-0.57	<0.001	−0.343	0.71	0.54-0.93	0.012
RT (per 10 min)	0.257	1.29	1.02-1.64	0.035	0.054	1.06	0.69-1.62	0.804
ST (per 10 min)	−0.232	0.79	0.63-1.0	0.049	0.087	1.09	0.83-1.44	0.541
TT (per 10 min)	0.070	1.07	0.88-1.31	0.482	0.193	1.21	0.92-1.60	0.175
Blunt								
Age	0.043	1.04	1.03-1.05	<0.001	0.043	1.04	1.03-1.06	<0.001
Sex								
Male		1.0				1.0		
Female	0.436	1.55	0.98-2.43	0.059	0.881	2.41	1.24-4.70	0.010
MGAP score	−0.612	0.54	0.51-0.58	<0.001	−0.129	0.88	0.77-1.0	0.050
GCS	−0.749	0.47	0.44-0.51	<0.001	−0.662	0.52	0.44-0.60	<0.001
RT (per 10 min)	0.197	1.22	1.03-1.44	0.022	−0.036	0.97	0.74-1.27	0.798
ST (per 10 min)	−0.005	0.1.0	0.88-1.13	0.935	0.184	1.20	1.03-1.40	0.020
TT (per 10 min)	0.040	1.04	0.92-1.18	0.522	0.194	1.21	1.05-1.41	0.009

β: Logistic regression coefficient, OR: Odds Ratio; CI: Confidence interval, GCS: Glasgow Coma Scale, MGAP: Mechanism, Glasgow Coma Scale, age, and arterial pressure, RT: Response time, ST: Scene time, TT: Transport time

Table 4: Risk factors of trauma death for transferred patients

	Univariate				Multivariate			
	β	OR	95% CI for OR	*P*	β	OR	95% CI for OR	*P*
Age	0.038	1.04	1.03-1.05	<0.001	0.038	1.04	1.03-1.05	<0.001
Sex								
Male		1.0				1.0		
Female	0.309	1.36	0.94-1.99	0.108	0.770	2.16	1.22-3.83	0.009
Type of trauma								
Blunt		1.0				1.0		
Penetrating	−0.151	1.83	1.37-2.44	<0.001	0.142	1.15	0.95-3.29	0.074
MGAP score	−0.507	0.60	0.58-0.63	<0.001	−0.170	0.84	0.75-0.94	0.003
GCS	−0.721	0.49	0.46-0.52	<0.001	−0.581	0.56	0.49-0.64	<0.001
RT (per 10 min)	0.213	1.24	1.08-1.42	0.003	−0.014	0.99	0.78-1.24	0.906
ST (per 10 min)	−0.056	0.95	0.85-1.06	0.325	0.156	1.17	1.02-1.34	0.023
TT (per 10 min)	0.046	1.05	0.94-1.16	0.387	0.191	1.21	1.06-1.39	0.004

β: Logistic regression coefficient, OR: Odds ratio, CI: Confidence interval, GCS: Glasgow Coma Scale, MGAP: Mechanism, Glasgow Coma Scale, age, and arterial pressure, RT: Response time, ST: Scene time, TT: Transport time

demonstrate an association between prehospital time intervals and patient outcome in trauma.[10,17-19] Newgard *et al*. in a multicentric study among 3656 trauma patients transported to 51 trauma centers in the United States and Canada did not find a correlation between mortality and prehospital time of victims. They stated that "time might be less crucial than once thought."[7]

There are many patients in whom injury does not need time-dependent interventions even in the presence of physiologic compromise.[20-22] Trauma patients are heterogeneous in terms of clinical conditions; some of them suffer from a time-dependent clinical condition such as tension pneumothorax or tamponade, whereas others may not have such a condition.

Nevertheless, there are other studies in favor of the golden hour of trauma in a specific subgroup of traumas. Newgard *et al*. investigated 81 EMS agencies and 46 Level I and II trauma centers and reported that traumatic patients who were in shock state and arrived at the hospital after 60 min of trauma had higher mortality rates.[11] Dinh *et al*. reported that in patients with severe head injuries, there was a survival benefit for the rapid transfer of patients.[16] In the present study, in penetrating

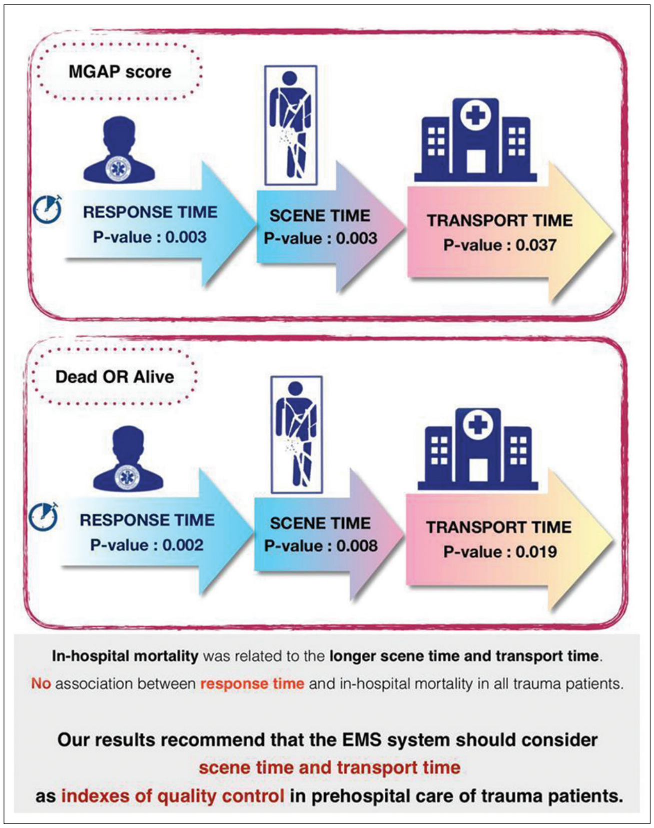

Figure 1: Major findings and recommendations

traumas, death occurred 1.8 times °™∞™ more than blunt traumas. Subgroup analysis revealed that in penetrating and blunt traumas with high-risk MGAP score, the ST was shorter than that of low- and moderate-risk groups.

Although RTs were longer in the death cases, in the multivariate analysis, there was no significant relationship between the RT and death, whereas older age and lower GCS were significantly related to in-hospital mortality.

It may be better for emergency medical dispatchers to inquire about the level of consciousness of the injured patients to prioritize ambulance dispatch and to consider solutions for faster response in cases with lower GCS, such as coordinating with the traffic control system or responding with siren and alarms.

Besides, ST in penetrating trauma and TT in blunt trauma cases were significantly lower among dead cases. These results can be justified by the fact that in severe traumas, EMS personnel naturally tend to move faster and perform quicker, but severe traumas are also more prone to death on their own.

We did not find an association between EMS time intervals and in-hospital mortality in penetrating trauma patients. This is in contrast with prior researches; for instance, a recent study indicated that longer EMS ST is related to the in-hospital mortality in penetrating traumas.[23] One justification for this different result is that our study included a smaller population of trauma patients. Furthermore, the differences in the care of trauma patients in our country, including using more limited resources and medical technologies, may have affected our results.

Although the concept of golden hour is not completely fallible, it helps people realize the importance of timely management of trauma patients in simple words.[13] In order to optimize the EMS care, improve patient outcome, and reduce EMS costs and occupational risk, it is necessary to accurately identify and define traumatic patients that need time-dependent interventions.[11]

Limitations

One limitation of our study is that other factors affecting the prognosis of a trauma patient, including medical comorbidities and using anticoagulant or antiplatelet drugs, were not evaluated in our analysis. In addition, the exact cause of death and the anatomic location of the insult (head, neck, chest, abdomen, pelvis, or limbs) were missing in our data. In addition, in some cases, we did not have all the prehospital times and so for some participants, we could not count the total mission time.

There is evidence that EMS provider behavior (e.g., performance on the scene and faster light and siren driving) may be affected by the severity of trauma.[7,24,25] Consequently, patients with severe injuries and poor prognosis will have shorter out-of-hospital time intervals. This fact will prevent an unbiased evaluation of the association between prehospital time intervals and patient outcome.

Last but not the least, lack of a national hospital trauma registry system in Iran made us choose three hospitals in Tehran and use their local registry system. This was a potential source of bias and affected the total number of included patients.

Conclusions

Our study was performed in the largest metropolis of a developing country and showed that in-hospital mortality was related to the longer ST and TT. We did not find an association between RT and in-hospital mortality in all trauma patients. Our results recommend that the EMS system should consider ST and TT as indexes of quality control in prehospital care of trauma patients. Further research is necessary in order to identify traumas that need time-dependent interventions exactly.

Financial support and sponsorship

This study was financially supported by the Tehran EMS Center (grant number EMS-98123).

Conflicts of interest

There are no conflicts of interest.

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