Prevalence and Factors Predicting Preventable Trauma Induced Mortality

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Original research

Keywords: death, ISS, preventable, probability of survival, trauma

Posted Date: January 18th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-146257/v1

Abstract

Introduction: Trauma is one of the most common causes of morbidity and mortality worldwide. Since the definition of preventable death has been described many studies, like current one, were conducted to evaluate this issue.

Materials and Methods: This cohort retrospective study investigated archived medical files of trauma victims from 2017 to 2020 in a referral single-center trauma hospital. Registered demographic data, vital signs, Glasgow coma scale (GCS), timing of trauma and death, executed interventions, type and mechanism of trauma in addition to time errors, clinical mismanagements and missed injuries were extracted. Injury severity score (ISS), revised trauma score (RTS) and probability of survival (Ps) based on TRISS method for each case were calculated. Eventually preventable and non-preventable death groups were compared.

Results: Finally from the all 413 trauma victims 246(54.9%) files were enrolled. Victims aged from 18 to 95 years. Of all 189(76.8%) were males. Analysis manifested 135(54.9%) of all deaths were potentially and 2(0.08%) were certainly preventable; while the other 49.1% were non-preventable for expiration(p=0.001). Data showed that from all variables systolic blood pressure (SBP) ≥80mmHg, respiratory rate (RR) ≥20 per minute, GCS ≥8, higher RTS, road traffic accidents and control of external bleeding were contribute to prediction of preventable trauma related mortality.

Conclusion: This study implied on frequency of trauma related preventable death was regionally high and associated factors that could be lessen the number of these mortalities including of SBP, RR, GCS, RTS, mechanism of trauma and external bleeding of trauma patients should be paid more attention.

Trial registration: Retrospectively registered.

Introduction

Trauma is globally the third common and the first cause of mortality during first four decades of life.[1] It ranks fifth among reasons of disability worldwide.[1] In Iran, trauma corresponds for 28,000 and 300,000 annual death and disability.[2] Males especially during their second decade of life are highly susceptible for trauma induced death.[1] Road-traffic accident is the most common mechanism followed by falling, assault and others.[1,2] Data showed that more than 50% of trauma death occurred at the scene of the event or immediately at the trauma bay.[4] Early death which is accompanied by first hours of injury forms 30% and late mortality that happens after days to weeks of trauma shares 20% of total deaths.[4] Since 50 years ago that the term preventable trauma related death has been described, many studies were conducted to find effective factors potentially preventing and/or at least predicting cause of post traumatic expiration.[5] Results were formation of different types of trauma scaling systems matured through the time and containing of variety of patient and/or trauma related variables. As instance injury severity score (ISS), abbreviated injury score (AIS), revised trauma score (RTS) and trauma related injury

severity score (TRISS) are commonly used methods to score the severity of trauma and probability of survival. There are much data available regarding trauma, death and explained possible preventing factors. Results for the latter are also varied study by study. This diversity is originated from the fact that trauma is multifactorial. Difference in human, society, economy, income, education, civilization, knowledge, equipment and health service characteristics could affect the trauma and outcomes.[1,6-8] Despite these differences investigations showed that one level develop of an average trauma hospital care system could lead to decrease in about 15,250 trauma related death annually.[9]

Considering above, regional evaluation of trauma outcomes and identifying possible factors that help to less trauma induced morbidity and mortality is certain. This study was aimed to evaluate trauma victims to find probable factors paly preventing role from death.

Materials And Method

This retrospective descriptive cohort study was conducted from the May 2017 to the October 2020. Data was extracted from registered data from trauma victims' archived medical files. All trauma patients aged 18 years or over who have expired in Medical University of Kashan referral trauma hospital were enrolled. Victims with lacking, unreadable or unregistered data were excluded. Extracted data were included of patients medical file number, event date, gender, age, way of transferring to trauma bay (private or with emergency medical service(EMS) ambulance), timing of trauma (pre-hospital time including of event to EMS arrival plus the EMS to hospital interval, hospital to death time and total event to death interval), trauma type (blunt or penetrating) and mechanism (road-traffic accident, falling, assault, and other), initial vital sign(systolic blood pressure(SBP), heart rate(HR) and respiratory rate(RR)), Glasgow coma scale(GCS), AIS, ISS, radiologic evaluation(FAST and brain CT scan), intervention type (chest and tracheal tube insertion, surgical operation including craniotomy, thoracotomy, laparotomy, and orthopedic procedures), and death reason. Immediate, early, and late death were defined as post traumatic expiration at the scene or at the time of hospital arrival with unsuccessful resuscitation, during first 3 days, and after 3 days from event respectively. Then study errors including time errors, errors associated with clinical management of trauma victims, and also missed injuries were defined for every participant. Time errors were categorized in two major items including of pre-hospital transfer interval, and time from hospital arrival to operate if needed. These major items have divided totally to six parts. Regarding clinical mismanagements we evaluate eleven errors including resuscitation didn't perform based on last version of ATLS guide, trachea was not intubated in GCS≤8, fluid therapy was inadequate in concurrent hemorrhage, insufficient external bleeding control, poor immobilization of patient, missing early pleural space decompression, chest tube was not inserted in hemothorax, FAST, diagnostic peritoneal lavage(DPL) or exploratory laparotomy was neglected when unstable hemoperitoneum was probable, avoiding emergent thoracotomy if needed, perform abdominal laparotomy in stable case of retroperitoneal hematoma or pure pelvic fracture, and lack of brain CT scanning during first 2 hours of hospitalization in GCS≤13. Missing injuries were considered for major injuries led to death because of loss of true clinical judge or misinterpreting paraclinic results. These included musculoskeletal (rib, hip,

and femur fracture), abdominal (solid organ laceration), and major vessel injury missing diagnosis. According to TRISS method RTS and probability of survival (Ps) for every victim were calculated. For the latter calculated Ps<0.5 considered as non-preventable(NPD) and greater numbers defined as death which could be preventable(PD). Finally all trauma victims were appointed to PD and NPD group based on Ps score.

Parametric variables were addressed by mean and standard deviation. Non parametric factors were presented by numbers and percent. To compare means the independent t-test and the ANOVA were used. Analysis of parametric variables was performed through the chi-squared exam. To examine correlation of variables in two groups of study the multivariable logistic regression test was applied and the ROC curve was customized. Significant level of analysis was considered as the $p < 0.05$. All statistical analysis was performed under the SPSS version 21 computer program.

Results

Overall 26,655 trauma medical files were archived. Of these there were 413(1.5%) victims. Through the all trauma victims finally 246 files were eligible to enroll. Males were dominant (189 cases, 76.8%) (p<0.001). The ages were from 18 to 95 years. Considering event to death time totally 27(11%), 138(56.1%), and 81(32.9%) victims died immediately, early, and late respectively (p<0.001). The calculated Ps showed 135 (54.9%) potentially PDs (p=0.001). Finding of registered trauma victims' characteristics is shown in table 1 according to death probability status.

Table 1

Registered trauma victims' characteristics

Variable	Unit	Probability status of death		P
		Preventable	Non-preventable	
Gender	Male	104(77) *	85(76.6)	0.9
	Female	31(23)	26(23.4)	
Age(year)	<55	82(60.7)	68(61.3)	0.9
	≥55	53(39.3)	43(38.7)	
Transfer type	EMS	131(97)	109(98.2)	0.5
	Private	4(3)	2(1.8)	
Injury type	Blunt	132(97.8)	106(95.5)	0.04
	penetrating	3(2.2)	5(4.5)	
Mechanism	Road-traffic accident	103(76.3)	95(85)	0.001
	Falling	26(19.3)	10(9)	
	assault	3(2.2)	2(1.8)	
	others	3(2.2)	4(36)	
Time interval(min)	PHT[1]	28.2±13.1	31.6±13.2	0.4
	HTD[2]	11502.3±14998	4644.2±9575.4	<0.001

1 pre-hospital transfer 2 hospital to death *n(%)

As table 1 shows no statistically significant difference between PD and NPD groups for gender, age, transfer type, and pre-hospital transfer interval was present; while other table content variables including of injury type, mechanism of trauma, and hospital to death interval time were obviously different.

Registered clinical findings extracted from medical files prior to tracheal intubation –if performed- in addition to frequency of study errors are shown by table 2. Data analysis in table 2 shows that significantly different clinical features between PD and NPDs were SBP, RR, GCS, and breathing type. Findings consisted of no difference when HR, ISS, and external bleeding were regarded. Calculated RTS and TRISS also had significant difference between groups.

Table 2

Comparison of clinical data and frequency of study errors among PD and NPDs.

Variable	Unit	Probability status of death		p
		Preventable	Non-preventable	
SBP[1](mmHg)	<80	10(7.4)*	59(53.2)	<0.001
	≥80	125(92.6)	52(46.8)	
HR[2](per minute)	<100	67(49.6)	65(58.6)	0.1
	≥100	68(50.4)	46(41.4)	
RR[3](per minute)	<20	66(48.9)	70(63.1)	0.02
	≥20	69(51.1)	41(36.9)	
GCS[4]	13-15	42(31.1)	2(1.8)	<0.001
	9-12	16(11.9)	2(1.8)	
	6-8	31(23)	5(4.5)	
	4-5	28(20.7)	15(13.5)	
	3	18(13.3)	87(78.4)	
ISS[5]	<16	20(14.8)	7(6.3)	0.3
	≥16	115(85.2)	104(93.7)	
Breathing type	Normal	57(42.2)	18(16.2)	0.001
	Assisted	78(57.8)	93(83.8)	
External bleeding severity	None	68(50.4)	65(58.6)	0.3
	Mild	47(34.8)	29(26.1)	
	Moderate	12(8.9)	13(11.7)	
	Severe	8(5.9)	4(3.6)	
RTS[6]		5.6±1.3	2.5±1.6	<0.001
TRISS[7]		0.7±0.3	0.2±0.1	<0.001
Time error		91(67.4)	83(73.9)	0.2
Mismanagement		97(71.9)	78(68.5)	0.5
Missing injury		33(45)	25(22.5)	0.06

1systolic blood pressure 2heart rate 3respiratory rate 4glasgow coma scale 5injury severity score 6 revised trauma score 7 trauma related ISS *n(%)

Although time, clinical management, and missing errors of the study generally had no difference in total numbers (p>0.05); there was obvious diversity when insufficient external bleeding control (14.8% vs. 6.3% respectively in PD and NPD) from clinical management errors was regarded(p=0.03).

Performed interventions for patients prior to expiration whether invasive or not in addition to registered reason of death are introduced in table 3. As table 3 shows no significant difference was present between PD and NPD about positive FAST exam, time to transfer the patient to the operating room, and frequency of reasons made death. However, more emergent operation was performed among victims with potential PD (p=0.02). Frequent emergent operations for the latter subsequently included of craniotomy and exploratory abdominal laparotomy (both equal to 16.3%), thoracotomy (5.2%), and orthopedic (3.7%).

Table 3

Comparison of performed intervention and cause of death among trauma victims

Variable		Probability status of death		p
		Preventable	Non-preventable	
FAST[1] (if positive)		38(28.1)	24(21.6)	0.1
BCT[2]		102(75.6)	71(64)	<0.001
Emergent operation		56(41.5)	33(29.7)	0.02
OR[3] transfer time(min)		180.1±152	176.6±182.4	0.5
Cause of death	Cardiac arrest	27(20)	20(18)	0.1
	CNS[4]	66(48.9)	67(60.4)	
	Thorcic	7(5.2)	5(4.5)	
	Abdominopelvic	14(10.4)	11(9.9)	
	Non specified	21(15.6)	8(7.2)	

1 focused assessment sonography for trauma 2 brain CT 3 operating room 4 central nervous system *n(%)

Independent significant predictive factors for preventable death including of SBP, RR, GCS, road-traffic accident, higher RTS, and adequate external bleeding control are shown in table 4.

Table 4

Assessment of predictive factors for preventable trauma induced mortality

Factor	Odds ratio	95% confident interval	p
Gender	1	0.5-1.8	0.9
Age<55 years	0.9	0.5-1.6	0.9
SBP≥80 mmHg	14.1	6.7-29.8	<0.001
HR<100 per minute	1.4	0.8-2.3	0.1
RR≥20 per minute	1.7	1-2.9	0.02
GCS≥8	3.3	1-10.3	0.03
Higher RTS	4.9	3.1-7.5	<0.001
Road-traffic accident	1.7	1-3.1	0.04
External bleeding	1.1	0.8-1.5	0.3
Adequate external bleeding control	3.4	1.2-9.7	0.02

The ROC curve statistic pointed to that RTS ≥4.46 was accompanied with 90% sensitivity to predict PD. Similarly RR ≥24 per minute, SBP ≥82 mmHg, and GCS ≥9 were associated with prediction sensitivity of 85, 68, and 60% respectively.

Discussion

Trauma is accused for 148 death and 2,000 disability per every hour worldwide.[6-8] According to the WHO reports trauma would rank third for DALY and low income countries would affect more since 2030.[1,10,11] Global distribution of trauma outcome is unclear and neither health systems nor reports optimally cover the latter.[3,6-8] Additionally, trauma is a negative outcome of variety of life aspects of human whether at individual level or at society. Therefore, regional health system could discover its noxious points making susceptibility for trauma. Since 50 years ago that trauma induced death prevention has been described many scientific states declared considering contributive factors to lessen mortality from trauma. This study was conducted to extend the burden of the latter issue.

Overall regional rate of trauma induced mortalities in our referral trauma bay was 1.5%. Others claimed 5-25% of mortality rate.[12-14] Recent WHO report regarding trauma PDs noticed that about 20% of all annual trauma mortalities are preventable.[10] Statistical analysis of this study after calculating the probability of survival via the TRISS method showed preventable death rate among victims over 18 years was about 55%. Although it seems a great number, identical studies regarded spectrum of this value from 1 to 81%.[15,16] For example in Brazil, united states, New Zealand, Britain, and Iran PD frequency was 1,7, 24, 39,

and 46% respectively.[3] In case of certainly preventable death which in this study was 0.8%, other stated statistic was varied 0.5-4.2%.[13,15,17-19] Notwithstanding the goal of trauma health care systems should be decrease PDs to as least as possible.

Although male victims like other studies were dominant (77 vs. 23%),[3,6,11,15,17-21] younger ages and being male or female didn't influence on survival probability in this study. However, opponents considered whether being female or being over 60-65 years could decrease survival rate.[9,20,21]

Post traumatic GCS ≥8 in this study was in association with better prognosis; namely patients with higher GCS than 7 had 3.3 times more chance to survive in comparison with some who had lower score(CI95%:1-10.3). Advocates declared that lower GCS was accompanied with either pre-hospital or in-hospital 10 to 13 times higher mortality rate respectively.[20,21] The sensitivity for prediction of death in the latter study achieved to 68% for GCS≤5.5.[20] Our survey manifested that GCS≥9 was accompanied with 60% sensitivity to predict preventability of trauma related mortality.

Another independent predictive factor for PDs in this study was SBP ≥80 mmHg (OR:14.1; CI95%:6.7-29.8). The systolic blood pressure over 82 mmHg was up to 68% sensitive to predict survival. Other authors have claimed that SBP lesser than 90 and 60 mmHg was contributed to 2.5 and 2.2 times more possibility for post traumatic death.[20,21]

This study showed that respiratory rate ≥20 per minute prior to every breathing assistance increased the probability of survival 1.7 times(CI95%:1-2.9). Based on our knowledge, no identical study was found to compare for the latter finding.

Analysis didn't clarify power of prediction in case of ISS ≥16. However, some other authors opposed by believe in that the lower the ISS the higher the possibility of survival.[20] Implicitly for the latter sensitivity and specificity were introduced 94 and 60% respectively if ISS was less than 9.[20] These difference could be due to sample size and study method diversity. They involved every over 13 years old sufferer with both death and survive outcome.[20] Other opponents defined ISS ≥27 as a cut point predicting pre-hospital mortality.[22] Beside these contrasts, many other authors presented their findings in lined with us.[1,3,12,17,22-25]

Current study calculated that RTS ≥4.46 could be predictable for survival in trauma patients with 90% sensitivity (OR:4.9; CI95%:3.1-7.5). an identical study revealed that RTS ≥7.69 was respectively 95 and 67% sensitive and specific for predicting survival among trauma subjects.[20] Again in the latter study pre-hospital death event was contributed with RTS<7.6 (OR:6; CI95%:2-13.7).[20] Hence, calculated RTS is a reliable value to predict prognosis of trauma.

We found road-traffic accident as the trauma mechanism was a predicting factor for preventable death (Or:1.7; CI95%:1-3.1). Fortunately, it was also the most common among all type of trauma mechanisms

(80%) followed by falling (15%). In almost all other studies road-traffic accident was the most prevalent mechanism.[1,16,21,25]

Regarding study errors, despite equivalence of external bleeding severity among all of the study subjects, insufficient external hemorrhage control was significantly more among PDs. Analysis revealed if bleeding control adequately it could promote survival rate 3.4 times more (CI9%:1.2-9.7). Similar studies manifested other type of errors including time errors mostly because of delay to initiate treatment (3-53%), clinical management errors consisting of inappropriate clinical judge (5-90%), false diagnosis (4-12%), and ineffective treatment (13%), and errors contributing to neglected injuries (6-40%).[12,17,19,23] Undoubtedly regional aforementioned errors are exist irrespective to whether the type or the frequency. Therefore, continuous review of trauma health care system status recommends.

In this report, no statistical results implied on that other rest variables including regarded times and type of trauma, heart rate, positive FAST exam, type of emergent operations, and cause of death had neither difference nor enough power to predict survival. Considering limitations of the study, it should be noted that this retrospective study was performed in a single-center referral trauma hospital. Data was extracted from archived medical files of trauma victims through a section of time. Because all subjects were not eligible to enroll, data was limited to medical files registered either complete or readable.

Conclusion

Preventable death prevalence was partially high in our region. Investigatory analysis identified a number of factors could independently predict potentially preventable death among post traumatic subjects. These included systolic blood pressure, respiratory rate, Glasgow coma scale, calculated revised trauma score, road-traffic accident, and external bleeding control. Paying attention to these factors could point to survival probability among trauma patients.

List Of Abbreviations

AIS: Abbreviated Injury Score; ANOVA: Analysis of Variance; ATLS: Advanced Trauma Life Support; BCT: Brain Computed Tomography; CNS: Central Nervous System; EMS: Emergency Medical Service; FAST: Focused Assessment Sonography for Trauma; GCS: Glasgow Coma Scale; HR: Heart Rate; HTD: Hospital to Death; ISS: Injury Severity Score; NPD: Non-Preventable Death; PD: Preventable Death; PHT: Pre-Hospital Transfer; Ps: Probability of Survival; RTS: Revised Trauma Score; RR: Respiratory Rate; SBP: Systolic Blood Pressure; TRISS: Trauma Related Injury Severity Score; WHO: World Health Organization.

Declaration

Ethics approval and consent to participate

This study was performed under supervision of University of Medical Sciences and ethics committee has approved study design by registering code IR.KAUMS.MEDNT.REC.1399.088.

Consent for publication

Not applicable

Availability of data and material

The data used to support findings of this study is available in medical file archive unit of Beheshti Hospital, Kashan; Iran.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was conducted under order and supervision of Kashan University of Medical Sciences and all advantages referred back to this university.

Authors' contributions

Abbas Hajian: study design, data collection, data Analysis, interpret results, drafting article

Abdoulhodein Davoodabadi: study design, supervision, interpret results

Esmail Abdourrahim Kashi: study design, supervision, interpret results

Mojtaba Sehat: statistical advisement

Shahrzad Ale Mohammad: data collection

Acknowledgements

We present our great thanks to departments of emergency medicine, general surgery, neurosurgery, and orthopedy and also to Trauma Research Center of the University of Medical Sciences, Kashan, Iran. We also respect unlimitedly to medical files archive unit of Beheshti Hospital and also EMS institute of Kashan facilitating data availability.

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