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Cohort Study

Predicting factors and incidence of preventable trauma induced mortality

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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.

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, revised trauma score, and probability of survival based on TRISS method for each case were calculated. Eventually preventable and non-preventable death were defined and compared.

Results: Finally from the all 413 trauma deaths 246(54.9 %) files were enrolled. Dead persons were from 18 to 95 years. Of all 189(76.8 %) were males. Analysis manifested 135(54.9 %) of all deaths were potentially preventable and the rest 49.1 % was non-preventable for expiration($p = 0.001$). Data showed that from all variables systolic blood pressure ≥80 mmHg, respiratory rate >19 per minute, GCS>8, higher RTS, road traffic accidents and control of external bleeding were contributed to prediction of preventable trauma related mortality.

Conclusion: This study implied on that frequency of trauma related preventable death was regionally high and associating factors that could influence the number of these mortalities included systolic blood pressure, respiratory rate, GCS, revised trauma score, mechanism of trauma, and external bleeding of trauma patients.

1. Introduction

Trauma is globally the third common cause of death for all age groups and the first reason of mortality in first four decades of a human life [1]. It ranks fifth among reasons for disability worldwide [1]. In Iran, trauma corresponds for 28,000 and 300,000 annual death and disability respectively [2]. Males especially in their second decade of life are highly susceptible for trauma induced death [1]. Road-traffic accident is the most common mechanism followed by fall and assault [1,2]. Data showed that more than 50 % of trauma death occurred at the scene of event or immediately at the trauma bay [4]. Early death which is defined by the death during first hours of injury forms 30 % and late mortality that happens after days to weeks from 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 causes of post traumatic expiration [5]. Results were concluded in development of different types of trauma scaling system involve either patient's 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 methods commonly use to score the severity of trauma and prediction of probability of survival. There are expanded data regarding trauma, death, and possible preventing factors. Results of the latter are varied study by study. This diversity

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implies on this fact that whether the trauma nature or outcome is multifactorial. Difference in human, society, economy, income, education, civilization, knowledge, equipment, and health service characteristics could finally affect both trauma incidence and outcome [1,6–8]. Despite differences comprehensive investigations showed that one level develop in 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 and identifying possible factors that help to less trauma induced morbidity and mortality is certain. This study was aimed to evaluate victims of trauma to find probable factors if any which play preventing role from death.

2. Methods

This retrospective cohort study was conducted from the May 2017 to the October 2020 after obtaining ethics approval from ethics committee of University of Medical Sciences by registering code IR.KAUMS.MEDNT.REC.1399.088 and national trial registration code IRT201707133102C8 which is available at www.irct.ir. Data was extracted from trauma dead persons' registered archived medical files. Obtaining data from medical files was implemented after written consent was given from the chief of forensic unit of the university. All trauma patients who were 18 years or older who eventually expired in Medical University of Kashan referral trauma-based facilities available at the receiving hospital were enrolled. Files with lacking, unreadable or unregistered data were excluded.

Extracted data were included of medical file number, event date, gender, age, way of transferring to trauma bay (privately or with emergency medical service(EMS) ambulance), timing of trauma (pre-hospital and hospital to death time), trauma type (blunt or penetrating) and mechanism (road-traffic accident, fall, assault, and other), initial vital sign (systolic blood pressure(SBP), heart(HR) and respiratory rate (RR)), Glasgow coma scale(GCS), AIS, ISS, radiologic exam (FAST and brain CT scan), emergent intervention (chest or tracheal tube insertion, surgical operation including craniotomy, thoracotomy, laparotomy, and orthopedic procedures), and reason of the death (by forensic autopsy studies).

Immediate, early, and late death were defined based on previous studies 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 the event respectively [3–5].

Time errors, errors associated with clinical management of a trauma death, and also missed injuries were explored for every subject by internal Morbidity and Mortality team (M&M).

Time errors were categorized in two major items including of pre-hospital transfer interval and time from hospital arrival to death.

Regarding clinical mismanagements we evaluated eleven errors included resuscitation didn't perform based on last version of the Acute Trauma Life Support (ATLS) guide, trachea was not intubated in GCS≤8, fluid therapy was inadequate in concurrent hemorrhage, insufficient external bleeding control, poor immobilization, 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 suspected, avoided emergent thoracotomy if needed, performed abdominal laparotomy in stable case of retroperitoneal hematoma or pure pelvic fracture, and lack of brain CT scanning during first 2 h of hospitalization when GCS≤13.

Pre-hospital interventions were limited to primary trauma resuscitation including of tracheal intubation, CPR, fluid initiation and whole blood transfusion, patient immobilization, needle thoracostomy placement, and bleeding control with direct pressure or tourniquet placing in limbs.

In theatre a portable C-Arm X-ray device helped surgical team. Although the center was not equipped with interventional angiography to control bleeding there were CT and MR scanning for stabilized trauma patients.

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 with neglected diagnosis. According to the TRISS method RTS and probability of survival (Ps) for every death were calculated. Namely calculated Ps < 0.5 considered as non-preventable(NPD) and greater numbers defined as a death which could be preventable(PD). Finally all trauma dead were allocated to PD and NPD group based on Ps score and aforementioned variables were compared between them.

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 non-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 by SPSS version 21 computer program. This study was prepared in lined with STROCSS criteria [10].

3. Results

Total 26,655 trauma medical archived files were reviewed. From all, 413(1.5 %) dead were identified. According to study criteria finally 246 (59.6 %) files were eligible to enroll. Males were dominant (189 cases, 76.8 %) (p < 0.001). 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). Age ranged from 18 to 95 years (47.4 ± 22). The calculated Ps showed 135 (54.9 %) potentially PDs (p = 0.001). Finding of registered trauma dead patients' characteristics is shown in Table 1 according to death probability status.

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 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 in Table 2.

Data analysis in Table 2 showed significant difference between PD and NPDs considering clinical features including 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

Table 1
Registered trauma dead patients' 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
	Fall	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 ± 14,998	4644.2 ± 9575.4	<0.001

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

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

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

significant difference between groups ($p < 0.001$). Although trauma related errors of the study generally had no difference between groups ($p > 0.05$) there was obvious diversity when insufficient external bleeding control (14.8 % vs. 6.3 % respectively in PD and NPD) was regarded ($p = 0.03$).

Distribution of mismanagements for groups of study is illustrated by Table 3.

According to Table 3, poor external bleeding control was the point for significant difference between groups with different type of death. There was no remarkable contrast for other variables regarding clinical mismanagement.

Performed interventions for patients prior to expiration whether invasive or not in addition to registered reason of death were introduced in Table 4.

As Table 4 showed no significant difference was present between PD and NPDs considering positive FAST exam, time of patient's transfer to the theatre, and frequency of reasons of death. However, more emergent operation was performed among deaths with potential PD ($p = 0.02$). Craniotomy and exploratory abdominal laparotomy (both equal to 16.3 %) followed by thoracotomy (5.2 %), and orthopedic (3.7 %) surgery were subsequent emergent operations.

Potentially predictive factors for preventable death were shown in Table 5.

As Table 5 showed SBP, RR, GCS, road-traffic accident, higher RTS, and adequate external bleeding control were factors could be predictable for preventable trauma related death. The ROC curve statistic

Table 4
Comparison of performed intervention and cause of death among trauma dead patients.

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(%)

Table 5
Assessment of potentially 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 [1]≥80 mmHg	14.1	6.7–29.8	<0.01
HR [2]<100 per minute	1.4	0.8–2.3	0.1
RR [3]≥20 per minute	1.7	1–2.9	0.02
GCS [4]≥9	3.3	1–10.3	0.03
Higher RTS [5]	4.9	3.1–7.5	<0.01
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

1 systolic blood pressure 2 heart rate 3 respiratory rate 4 glasgow coma scale 5 revised trauma score.

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. Among all predictive factors, it is highlighted that reaching to favorable SBP could widely change elderly trauma patient's end from death toward survive.

3.1. Discussion

Trauma is accused for 148 death and 2000 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 by 2030 [1,11,12]. 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 generation. Since 50 years ago that trauma induced death prevention has been described many scientific states considered contributive factors to decrease mortality from trauma. This study also was

Table 3
Distribution of mismanagements between preventable and non-preventable death.

Type of death	n(%)	M1[1]	M2[2]	M3[3]	M4[4]	M5[5]	M6[6]	M7[7]	Others [8]	Total
Preventable	135(54.9)	66(48.9)	15(11.1)	42(31.1)	20(14.8)	33(24.2)	22(16.3)	30(22.2)	13(9.6)	97(71.9)
Non-preventable	111(45.1)	47(42.3)	12(10.8)	37(33.3)	7(6.3)	27(34.3)	13(11.7)	27(24.3)	21(18.9)	78(68.5)
P	–	0.3	0.9	0.7	0.03	0.9	0.3	0.6	≥0.5	0.5

1 resuscitation didn't perform based on ATLS 2 trachea was not intubated in GCS≤8 3 fluid therapy was inadequate in concurrent hemorrhage 4 insufficient external bleeding control 5 poor immobilization 6 FAST, DPL or exploratory laparotomy was neglected 7 lack of brain CT 8 chest tube was not inserted/avoided emergent thoracotomy/performed non-indicated abdominal laparotomy.

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 % for mortality rate [13–15]. 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 % [16,17]. For example in Brazil, united states, New Zealand, Britain, and Iran frequency of PDs 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 % [14,16–20]. 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 %) [3,6,12,16–22] younger ages and being whether 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 [9,21,22].

Post traumatic GCS ≥9 in this study was in association with better prognosis; namely patients with higher GCS over 8 had 3.3 times more chance to survive in comparison with some who had lower scores (CI95 %:1–10.3). Advocates declared that lower GCS was accompanied with either pre-hospital or in-hospital 10–13 times higher mortality rate [20,21]. The sensitivity for prediction of death for GCS ≤5.5 in prior study achieved to 68 % [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 82 mmHg and over was up to 68 % sensitive to predict survival. Other authors have claimed that SBP lesser than 60 and 90 mmHg was contributed to 2.5 and 2.2 times more possibility for post traumatic death [21,22].

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 for ISS ≥16. However, some other authors opposed by believing in that the lower the ISS the higher the possibility of survival [21]. Implicitly sensitivity and specificity were introduced 94 and 60 % respectively if ISS was less than 9 in other studies [20]. These difference could be due to sample size and study method diversity. They involved every 13 years old and over injured patients with either death or survive outcome [21]. Other opponents defined ISS ≥27 as a cut point for predicting pre-hospital mortality [23]. Beside these contrasts, many other authors presented their findings in lined with us considering the potency of ISS for prediction of post traumatic death [1,3,13,18,23–26].

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 to RTS <7.6 (OR:6; CI95 %:2–13.7) [21].

We found road-traffic accident as a 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 %). Similarly in almost all other studies road-traffic accident was the most prevalent mechanism [1,17,22,26].

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 that if bleeding was adequately controlled it could promote survival rate 3.4 times more (CI9%:1.2–9.7). Similar studies identified other errors more common including delay to initiate treatment (3–53 %), inappropriate clinical judge (5–90 %), false diagnosis (4–12 %), and ineffective treatment (13 %), and errors contributing to neglected injuries (6–40 %) [13,18,20,24]. Therefore continuous administration for trauma health care system status is recommended to manage error changes.

In this study, variables including timing and type of trauma, heart rate, positive FAST exam, emergent operation, and causes of death had neither significant difference nor enough potency to predict survival.

3.2. Limitations

This retrospective study was performed in a single-center referral trauma hospital. Data was extracted from archived medical files of trauma deaths through a section of time. Because all subjects were not eligible to enroll data was limited to medical files registered either complete or readable.

4. Conclusion

Preventable death prevalence was relatively high in our region. Investigatory analysis identified that a number of factors could independently predict potentially preventable death for trauma victims. These were 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 rescue some trauma patients from death. This study implied on maintaining favorable SBP especially by adequate external bleeding control should get principle for all trauma team levels which could finally rescue patients from grave prognosis. Designing multicenter of such studies with stratification of injured patients to specific subgroups is highly recommended in order to both decrease trauma related mortality and enhance implementation quality of current trauma guidelines.

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.

Provenance and peer review

Not commissioned, externally peer-reviewed

Declaration of competing interest

Authors did not have any conflicts of interest in writing this article.

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Appendix ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2021.102609.

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

Ethical Approval

This study was conducted under ethics committee consult and approval of the Kashan University of Medical Sciences. Study approval was registered and available in www.kaums.ac.ir with registering code IR.KAUMS.MEDNT.REC.1399.088 and also and national trial registration code IRT201707133102C8 which is available at www.irct.ir.

Consent

Obtaining data from medical files was implemented followed by giving written consent form from the chief of forensic unit of the university.

Author contribution

AD: study design, supervision, interpret results. EAK: study design, supervision, interpret results. MM: study design, supervision, interpret results. NM: study design, supervision, interpret results. SS: study design, supervision, interpret results. LG: study design, supervision, interpret results. MS: statistical advisement. SAM: data collection. AH: study design, data collection, data Analysis, interpret results, drafting article.

Registration of Research Studies

This study was conducted under supervision of the Kashan University of Medical Sciencesand registered in national trial registration platform with reference code IRT201707133102C8 which is available at www.irct.ir.

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References

[1] K. Soreide, Epidemiology of major trauma, Br. J. Surg. 96 (7) (2009) 697–698.
[2] A. Montazeri, Road-traffic-related mortality in Iran: a descriptive study, Publ. Health 118 (2) (2004) 110–113.
[3] C. Gholipour, B. Samadi Rad, S.S. Vahdati, A. Ghaffarzad, A. Masoud, Assessment of causes of preventable deaths in pre-hospital SettingsAssessment of causes of preventable deaths in pre-hospital settings, erciyes medical journal 38 (2016) 66–69.
[4] H. Tien, P.T. Chu, F. Brenneman, Causes of death following multiple trauma, Curr. Orthop. 18 (4) (2004) 304–310.
[5] P.G. Teixeira, K. Inaba, P. Hadjizacharia, C. Brown, A. Salim, P. Rhee, et al., Preventable or potentially preventable mortality at a mature trauma center, J. Trauma 63 (6) (2007) 1338–1346.
[6] M.A. Gad, A. Saber, S. Farrag, M.E. Shams, G.M. Ellabban, Incidence, patterns, and factors predicting mortality of abdominal injuries in trauma patients, N. Am. J. Med. Sci. 4 (3) (2012) 129–134.
[7] B.S. Roudsari, K. Sharzei, M. Zargar, Sex and age distribution in transport-related injuries in Tehran, Accid. Anal. Prev. 36 (2004) 391–398.
[8] M. Zargar, M.H. Modaghegh, H. Rezaishiraz, Urban injuries in Tehran: demography of trauma patients and evaluation of trauma care, Injury 32 (2001) 613–617.
[9] M.A. de Moya, D. Manolakaki, Y. Chang, I. Amygdalos, F. Gao, H.B. Alam, et al., Blunt pulmonary contusion: admission computed tomography scan predicts mechanical ventilation, J. Trauma 71 (2011) 1543–1547.
[10] R. Agha, A. Abdall-Razak, E. Crossley, N. Dowlut, C. Iosifidis, G. Mathew, for the Strocss Group, The STROCSS 2019 guideline: strengthening the reporting of cohort studies in surgery, Int. J. Surg. 72 (2019) 156–165.
[11] C. Settervall, C. Domingues, Sousa Regina, Nogueira L. Preventable trauma deaths, Rev. Saude Publica 46 (2012) 367–375.
[12] G.F. Pogorzelski, T.A. Silva, T. Piazza, T.M. Lacerda, F.A. Spencer Netto, A. C. Jorge, et al., Epidemiology, prognostic factors, and outcome of trauma patients admitted in a Brazilian intensive care unit, Open Access Emerg. Med. 27 (10) (2018) 81–88.
[13] R.L. Gruen, G.J. Jurkovich, L.K. McIntyre, H.M. Foy, R.V. Maier, Patterns of errors contributing to trauma mortality: lessons learned from 2,594 deaths, Ann. Surg. 244 (3) (2006) 371–380.
[14] C. Schoeneberg, M. Schilling, B. Hussmann, D. Schmitz, S. Lendemans, S. Ruchholtz, Preventable and potentially preventable deaths in severely injured patients: a retrospective analysis including patterns of errors, Eur. J. Trauma Emerg. Surg. 43 (4) (2017) 481–489.
[15] C.S. Byun, I.H. Park, J.H. Oh, K.S. Bae, K.H. Lee, E. Lee, Epidemiology of trauma patients and analysis of 268 mortality cases: trends of a single center in Korea, Yonsei Med. J. 56 (1) (2015) 220–226.
[16] C. Gholipour, B.S. Rad, S.S. Vahdati, A. Ghaffarzad, A. Masoud, Evaluation of preventable trauma death in emergency department of Imam Reza hospital, World J Emerg Med 7 (2) (2016) 135–137.
[17] R.R. Ivatury, K. Guilford, A.K. Malhotra, T. Duane, M. Aboutanos, N. Martin, Patient safety in trauma: maximal impact management errors at a level I trauma center, J. Trauma 64 (2) (2008) 265–270.
[18] P.G. Teixeira, K. Inaba, P. Hadjizacharia, C. Brown, A. Salim, P. Rhee, et al., Preventable or potentially preventable mortality at a mature trauma center, J. Trauma 63 (6) (2007) 1338–1346.
[19] B. Beck, K. Smith, E. Mercier, S. Bernard, C. Jones, B. Meadley, et al., Potentially preventable trauma deaths: a retrospective review, Injury 50 (5) (2019) 1009–1016.
[20] S. Matsumoto, K. Jung, A. Smith, R. Coimbra, Trauma center maturity measured by an analysis of preventable and potentially preventable deaths: there is always something to be learned, Surg. Today 48 (11) (2018) 1004–1010.
[21] M. Yadollahi, A. Kashkooe, R. Rezaiee, K. Jamali, M.H. Niakan, A comparative study of injury severity scales as predictors of mortality in trauma patients: which scale is the best? Bull Emerg Trauma 8 (1) (2020) 27–33.
[22] J. González-Robledo, F. Martín-González, M. Moreno-García, M. Sánchez-Barba, F. Sánchez-Hernández, Prognostic factors associated with mortality in patients with severe trauma: from prehospital care to the Intensive Care Unit, Med. Intensiva 39 (7) (2015) 412–421.
[23] S.M. Vioque, P.K. Kim, J. McMaster, J. Gallagher, S.R. Allen, D.N. Holena, et al., Classifying errors in preventable and potentially preventable trauma deaths: a 9-year review using the Joint Commission's standardized methodology, Am. J. Surg. 208 (2) (2014) 187–194.
[24] T.P. Saltzherr, K.W. Wendt, P. Nieboer, M. Nijsten, J. Valk, J. Luitse, et al., Preventability of trauma deaths in a Dutch Level-1 trauma centre, Injury 42 (9) (2011) 870–873.
[25] J.J. Morrison, L.Z. Yapp, A. Beattie, E. Devlin, M. Samarage, C. McCaffer, et al., The epidemiology of Scottish trauma: a comparison of pre-hospital and in-hospital deaths, 2000 to 2011, Surgeon 1 (14) (2016) 1–6.
[26] P. Joosse, J.C. Goslings, J.S. Luitse, K.J. Ponsen, M-study; arguments for regional trauma databases, J. Trauma 58 (2005) 1272–1276.