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Time-Based Trauma-Related Mortality Patterns in a Newly Created Trauma System

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Abstract

Background Data on time-based trauma mortality (TTM) patterns in developing countries are lacking.

Objective Our objective was to analyze the TTM in a newly established trauma center.

Methods A retrospective analysis of all trauma-related mortality between 2010 and 2012 was conducted in Qatar. Based on the time of injury, deceased cases were categorized into immediate (pre-hospital), early (first 24 h), and late (>24 h) groups. TTM was analyzed and compared.

Results A total of 4,966 trauma patients were admitted to the trauma center over 3 years; of them, 333 trauma-related deaths (6.8 %) were documented and reviewed. The death pattern peaked immediately post-trauma ($n = 142$), followed by 96 deaths within the first 24 h, 19 deaths within the time period >24 to 48 h, 50 deaths within the 3rd and 7th day (second peak), and 26 deaths after the 1st week. The majority of the deceased were males, with a mean age of 36 ± 17 years. Motor vehicle crashes (43.5 %) were the commonest mechanism of injury. At presentation, median injury severity score (ISS) was 32 (range 9–75). Bleeding, abdominal, and pelvic injuries were higher in the early group, whereas head injuries were observed more in the late mortality group. Co-morbidities and in-hospital complications were predominantly encountered in the late group. Head injury (odds ratio [OR] 3.760; 95 % confidence interval [CI] 1.311–10.797) was an independent predictor for late death, whereas the need for blood transfusion was a predictor for early death (OR 3.233; 95 % CI 1.125–9.345).

Conclusion The distribution of mortality shows a bimodal pattern. The high rate of death at the scene highlights the importance of pre-hospital care and the need for injury prevention programs.

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Introduction

Worldwide, trauma is the third leading cause of death for all age groups and particularly in the first 4 decades of life [1]. Namely, road traffic-related injuries (RTI), domestic violence, and suicide are the main causes of trauma-related deaths [2]. A significant proportion of severely injured patients often die before reaching the hospital or within the first few hours after admission [3]. Trauma-related mortality is classically described as tri-modal, with three distinct peaks (immediate, early, and late) based on their temporal relation to the time of the traumatic event [2, 3]. Over 30 years ago, Trunkey [4] described a trimodal mortality pattern with a large peak (50 %) immediately after trauma. The immediate and early deaths after fatal motor vehicle crashes (MVCs) are mostly attributed to exsanguination and severe head and cardiac injuries [2, 5]. Late mortality, which occurs from a few days to even months after the traumatic event is commonly related to injury-associated complications [2, 6–10].

More recent reports have suggested a bimodal distribution of trauma deaths that is attributed to a reduction in late mortality in mature urban trauma systems [11, 12]. Meislin et al. [13] reported a bimodal pattern of trauma-related mortality and observed a major peak for deaths in the immediate phase, followed by another peak at 48 h post injury.

The incidence of trauma and mortality varies according to geographic location and socioeconomic status, with the majority of reports originating from high-income, developed nations and few from the Middle East. In Qatar, during the period 2000–2006, the mean traffic-related death rate was 19.9 ± 4 per 100,000; however, this rate dropped significantly to 14.7 ± 1.5 in the period 2007–2010 [14]. The Hamad Trauma Center (HTC) was established in November 2007. It is based in Hamad General Hospital, is considered the nation's only level I trauma center, and serves as the main hub of the national trauma system of Qatar.

However, the impact of the newly created trauma system in Qatar on trauma mortality outcomes has not been studied. The objective of this study is to describe and analyze the time-based distribution and risk factors of trauma-related mortality in the only level I trauma center in the State of Qatar.

Methods

A retrospective analysis of all trauma-related deaths was conducted over a period of 3 years (January 2010–December 2012) at the HTC in Qatar. All victims of serious trauma in the country are mainly seen at the HTC. Gathered data included demographics (age, gender, and nationality), mechanism of injury, emergency medical services (EMS) time, abbreviated injury scale (AIS) for different body regions, injury severity score (ISS), emergency department (ED) disposition, blood transfusion, and co-morbidities (such as diabetes mellitus, hypertension, and asthma). Hospital length of stay and development of complications (ventilator-associated pneumonia [VAP], acute respiratory distress syndrome [ARDS], acute kidney injury (AKI) demanding hemodialysis, sepsis, and urinary tract infection) were also recorded.

Our trauma database registry did not include information from victims of drowning and poisoning or count deaths that were not reported to the trauma center and were shifted directly from the scene to a mortuary. However, the registry documented all trauma patients who were declared dead immediately on arrival at the ED (where no intervention was initiated apart from the EMS care at the scene and or during transportation); those cases were reported as pre-hospital deaths. Post-hospital discharge deaths were not included in the present analysis.

The AIS was used to define the severity of the six separate regional injuries [15, 16]. The Medical Research Center at Hamad Medical Corporation, Doha, Qatar, approved the study (IRB# 12263/12).

Statistical Analysis

The data were presented as proportions, medians, or mean ± standard deviation (SD), as appropriate. Based on the interval between injury and death, deceased patients were divided into three groups: immediate (died before hospital admission), early (died within the first 24 h), and late (died after 24 h). The group of immediate deaths was discussed separately to reflect pre-hospital care. Early and late death groups were compared. Further, to investigate the impact of hospital care until death, the late death group was subdivided into three subgroups (died between >24 and 48 h, 3–7 days, and >7 days). Differences in categorical variables between the early and late death groups were analyzed using the Chi squared test, and the continuous variables were analyzed using the Student's t test (normal distributed data) or the Mann–Whitney U test (skewed data). Sub-analysis was also performed to compare the clinical presentation of patients who died after trauma according to different age groups (group 1: ≤18 years; group 2: 19–44 years; group 3: 45–59 years, and group 4: ≥60 years). Multivariate logistic regression analysis was performed to show the predictors for early versus late mortality after adjusting for the relevant variables such as age, head/chest/abdomen/pelvic injuries, ISS, and the need for blood transfusion. Data were expressed using odds ratios (ORs) and 95 % confidence intervals (CI). Two tailed p values <0.05 were considered significant. All data analyses were carried out using the statistical package for the social sciences, version 18 (SPSS Inc., Chicago, IL, USA).

Results

During the study period, 4,966 cases were admitted to the HTC; of these, 333 patients died (6.8 %). Most deaths (42.7 %) occurred immediately post-injury and before reaching hospital care, while 28.8 % died within the first 24 h after arrival to the hospital and 28.5 % died later during their hospital course. Figure 1 shows the breakdown

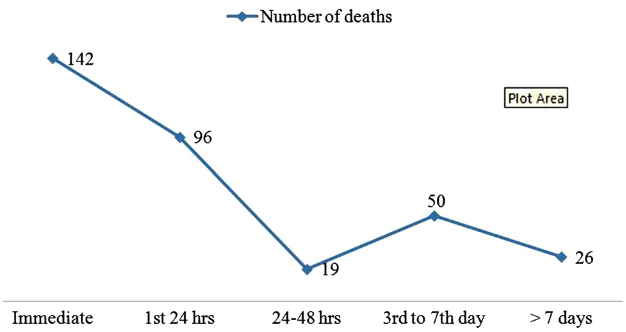

Fig. 1 Time-based death pattern

of the time-based mortality pattern. In-hospital deaths accounted for 3.9 % of all admissions, and most in-hospital deaths occurred between 3 and 7 days after injury. The majority of the deceased were males (95 %), with a mean age of 36 ± 17 years. MVCs (43.5 %), pedestrian injuries (28.7 %), and falls (13.3 %) were the most common mechanisms of injury, while penetrating injuries were very rare. The distribution of the mechanism of injury among the deceased is shown in Table 1.

The head (66.7 %), chest (45.3 %), abdomen (25.8 %), and upper (22.0 %) and lower (26.4 %) extremities were the most frequently injured body regions. A large proportion of patients from the ED were transferred to the operating room (47 %). The median EMS time (time from call received to arrival at the receiving hospital) was 60.5 min (range 3–160), and the majority of patients (84 %) were transported by ground ambulance. The median hospital length of stay was 1 day (range 1–144), and the overall median ISS was 32 (range 9–75). Moreover, the median ISS for the early group was 33 (range 13–75) and that for the late group was 30 (range 9–59). However, 88 % of patients who died in the hospital were admitted with an ISS ≥25.

Table 2 shows the distribution of ISS by time of death and injury mechanism. Further, at presentation, a higher proportion of the deceased had moderate (ISS 9–15) and profound (ISS ≥25) sustained MVC-related injuries. Severe injury (ISS 16–24) was mainly observed in victims of fall from height. Head injury cases were severely injured, with a mean AIS of 4.5 ± 0.9. Blood transfusion was required in 41.7 % of cases, with a median of seven blood units (range 1–40). Positive blood alcohol levels were documented in 4.5 % of all cases. According to their medical records, few cases had a history of co-morbidities such as diabetes mellitus (5.7 %), hypertension (4.2 %), and hemodialysis (2.4 %). VAP (10 %) was the most common in-hospital complication, followed by sepsis (3.3 %), urinary tract infection (2.4 %), and ARDS (2 %).

Time-based trauma-related mortality

A bimodal death pattern peaked immediately post-trauma (142 deaths) and was followed by a smaller late in-hospital peak. There were 96 deaths within the first 24 h post-injury, followed by a significant drop to 19 deaths (>24–48 h). The second mortality peak (50 deaths) occurred between the 3rd and 7th day. Patients who died within the late peak had a higher rate of chest and head injuries (60 and 94 %, respectively, $p < 0.001$). The distribution of mortality rate according to each year of the study shows a declining trend of deaths (37 % of the total deaths was seen in 2010, whereas 32 and 31 % occurred in 2011 and 2012, respectively).

Table 3 shows the comparison between patients in the early (0–24 h) and late (>24 h) death groups. Early mortality was significantly associated with young age compared with late mortality (33 ± 14 vs. 39 ± 19; $p = 0.03$). In comparison with the late group, the early group had a trend towards more victims of MVCs and falling of heavy objects, but it did not reach statistical significance. Abdominal (52 vs. 28 %; $p = 0.001$) and pelvic (30 vs. 16 %; $p = 0.02$) injuries were significantly associated with the early group, whereas head injuries (88.4 vs. 53 %; $p = 0.001$) were significantly higher in the late group. The need for blood transfusion was higher in the early group (78 vs. 59 %; $p = 0.004$) than in the late group. Co-morbidities such as diabetes mellitus (13.7 vs. 5.2 %; $p = 0.040$) and hypertension (13.7 vs. 0.0 %; $p = 0.001$) were significantly higher in the late than in the early death group. Similarly, in-hospital complications (VAP, ARDS, sepsis, and renal failure) were more frequently observed in the late group. In the immediate death group, the majority of the deceased were males (94.4 %), mostly injured in an MVC (46.3 %) and sustained head (61.0 %) and chest (28.0 %) injuries.

Sub-analysis of cases according to different age groups showed that abdominal injury (74.2 %; $p = 0.021$) was significantly associated with young adults aged 19–44 years, while VAP (35 %; $p = 0.005$) was seen more among the elderly (≥60 years) (Table 4). Although statistically non-significant, a greater proportion of immediate deaths (52 %) occurred in patients aged ≤18 years. Early deaths (31 %) were observed more in adults aged 19–44 years. Moreover, the incidence of late mortality (56.5 %) was higher among the elderly (≥60 years).

Multivariate logistic regression analysis was performed to show the predictors for early versus late mortality after adjusting for the relevant variables that showed significant difference on univariate analysis, including age, head/abdomen/pelvic injuries, ISS, and need for blood transfusion. The need for transfusion was the predictor for early

Table 1 Demographics, mechanism of injury, and clinical presentation of patients who died after traumatic injuries

Characteristic	
Patients	$n = 333$
Male	316 (95)
Age	36 ± 17
Mechanism of injury	
MVC	141 (43.5)
Pedestrian	93 (28.7)
Fall from height	43 (13.3)
Motorcycle crash	12 (3.6)
Fall of heavy objects	9 (2.8)
All train vehicles	6 (1.9)
Assault	4 (1.2)
Others	16 (4.9)
Unspecified	9 (2.8)
Involved injuries	
Head	222 (66.7)
Chest	151 (45.3)
Abdomen	86 (25.8)
Upper extremities	73 (22)
Lower extremities	88 (26.4)
Mode of transport	
Ground ambulance	269 (80.8)
Air	35 (10.5)
Private car	16 (4.8)
Unspecified	13 (3.9)
EMS time	60.5 (3–160)
Scene pulse	95 (36–193)
Scene SBP	123 (25–248)
Scene GCS	3 (3–15)
TRU pulse	106 (6–182)
TRU SBP	105 (16–219)
TRU GCS	3 (3–15)
Head AIS	5 (1–6)
Chest AIS	3 (1–6)
Abdominal AIS	2 (2–5)
Injury severity score	32 (9–75)
Hospital LOS	1 (1–144)
Blood transfusion	139 (41.7)
Number of blood units	7 (1–40)
Blood alcohol level	38.2 ± 17.9
Ethanol intake	15 (4.5)
Diabetes mellitus	19 (5.7)
Hypertension	14 (4.2)
Asthma	3 (0.9)
Complications	
VAP	32 (9.6)
Sepsis	11 (3.3)
Hemodialysis	8 (2.4)
ARDS	7 (2.1)
Urinary tract infection	8 (2.4)
Bed sore	3 (0.9)
Clostridium difficile infection	3 (0.9)
Time of death	
Immediate (pre-hospital)	142 (42.7)
Early (first 24 h)	96 (28.8)
Late (>24 h)	95 (28.5)
Place of death	
On-scene	142 (42.7)
ICU	131 (39.3)
TRU	33 (10)
Operating room	25 (7.5)
Floor	2 (0.6)

Data are presented as *n* (%), mean ± standard deviation, or median (range)

AIS abbreviated injury score, *ARDS* acute respiratory distress syndrome, *GCS* Glasgow coma score, *ICU* intensive care unit, *ISS* injury severity core, *LOS* length of stay, *MVC* motor vehicle crash, *SBP* systolic blood pressure, *TRU* trauma resuscitation unit, *VAP* ventilator-associated pneumonia

death (OR 3.233; 95 % CI 1.125–9.345; $p = 0.030$). Head injury (OR 3.760; 95 % CI 1.311–10.797; $p = 0.014$) and age (OR 1.033; 95 % CI 1.004–1.058; $p = 0.025$) were independent predictors for late death (Fig. 2).

Discussion

This is a unique report from the Arab Middle East that describes the time-based trauma mortality pattern after the nationwide institution of a trauma system. The report covers the early maturation phase of Qatar's trauma system, from year 4 to year 6 of its existence in 2007. The overall mortality rate (ISS unadjusted) at the HTC is 6.8 %. However, in-hospital mortality after excluding those who were brought in dead accounted for only 3.9 % of total admissions, which is consistent with the 2012 National Trauma Data Bank of the American College of Surgeons Committee on Trauma (3.8 %) [17]. The most interesting finding of our study is the bimodal mortality distribution, where most post-injury deaths happened in the pre-hospital setting (43 %).

The temporal pattern of mortality distribution has varied in different studies since the first description of the trimodal pattern [4]. Table 5 summarizes seven studies from different countries with different mortality patterns [12, 18–23]. In four studies, no classic temporal distribution of

Table 2 Injury severity by time of death and mechanism

ISS	n (%)	Time to death		Mechanism of injury			
		Early	Late	MVC	Pedestrian	FFH	Others
Moderate (9–15)	4 (2.1)	1 (25)	3 (75)	2 (50)	1 (25)	1 (25)	0 (0)
Severe (16–24)	16 (9.5)	7 (43.8)	9 (56.2)	6 (33)	3 (17)	7 (39)	2 (11)
Profound (≥25)	151 (88.4)	69 (45.7)	82 (54.3)	68 (41)	47 (28.5)	22 (13.5)	28 (17)

Data are presented as n (%)

Time to death is classified as 'early death' within the first 24 h and 'late death' after first day

FFH fall from height, *ISS* injury severity score, *MVC* motor vehicle crashes

death was described, one study from the USA described a bimodal death pattern, one study from Auckland, New Zealand, could not demonstrate the trimodal pattern of death, and one study from Australia described a trimodal pattern that skewed toward early death. The latter two studies used autopsies to confirm the final cause of death. This is in contrast with our study, which lacks post-mortem evaluation.

Recent studies have shown that immediate death is constant (50–60 %) in spite of all of the advancements that have taken place regarding road and vehicle safety and trauma system development for pre-hospital care, transfer, and center establishments [11]. The relatively lower percentage of trauma mortalities occurring in the pre-hospital phase in our study could be the result of under-counting or under-reporting, as we were unable to fully account for the trauma deaths taken directly to the mortuary. It was not likely to be due to the ability of the ambulance services to bring into the hospital very severely injured patients who would normally not survive. The average EMS time in the present as well as previous work from our center is around 60 min [24].

In comparison with our findings, Gunst et al. [18] reported a higher rate of immediate deaths (61 %), but a similar rate of early deaths (29 %). This could be evidence of the significant role played by the severity of the initial injury for early deaths from trauma, such that even mature trauma systems are unable to pose a significant reduction in these deaths. Recently, the impact of establishing a national trauma system on the temporal pattern of mortality has been described [25–29]. The increase in the number of immediate deaths and decrease in the deaths that occurred 1 week after injury could shift the mortality pattern toward a bimodal distribution of death [29].

The definition of the late death period used in the present analysis was based on a previous report in which the mortality rate was comparable to that in our results (∼28 %) [11]. Moreover, we analyzed the in-hospital deaths to identify factors that influence the occurrence of late trauma mortality. Based on this breakdown, the second peak of death was observed between the 3rd and 7th day after injury in the present study. The main characteristics for this period included the higher rate of chest and head injuries.

Table 3 Comparison of early versus late deaths

	Early (within 24 h)	Late (after 24 h)	p value[a]
Age	33 ± 14	39 ± 19	0.030
Males	94.8	95.8	0.751
Mechanism of injury			
MVC (%)	47.3	35.8	0.120
Pedestrian (%)	26.9	28.4	
Fall from height (%)	8.6	21.1	
Fall of heavy object (%)	5.4	1.1	
Mode of transport			
Ground ambulance (%)	78.9	77.9	0.650
Flight ambulance (%)	15.8	13.7	
Private car (%)	5.3	8.4	
Injury severity score	35 ± 11	31 ± 9	0.053
Median (range)	33 (13–75)	30 (9–59)	
Associated injury (%)			
Head (%)	53	88.4	0.001
Chest (%)	60.4	55.8	0.511
Abdomen (%)	52.1	28.4	0.001
Pelvis (%)	30.2	15.8	0.022
Blood transfusion (%)	78	58.9	0.004
Diabetes mellitus (%)	5.2	13.7	0.045
Hypertension	NA	13.7	0.001
Asthma (%)	NA	2.1	0.150
VAP (%)	0	34	0.001
ARDS (%)	0	7.4	0.007
Sepsis (%)	0	12	0.001
Hemodialysis (%)	0	8.4	0.004

Data are presented as percentage, mean ± standard deviation, or median (range) unless otherwise indicated

ARDS acute respiratory distress syndrome, *MVC* motor vehicle crash, *NA* not applicable, *VAP* ventilator-associated pneumonia

[a] Mann–Whitney U test for skewed and Student's t test for normal distributed, r continuous variables, and Chi squared test was used for categorical variables

Table 4 Morbidity and mortality according to age

	Age (years)				p value[a]
	≤18 (10 %)	19–44 (60 %)	45–59 (20 %)	≥60 (10 %)	
Head injury	76	72.5	72	74.9	0.981
Chest injury	44	50.3	46	52.2	0.892
Abdominal injury	8	33	24	13	0.020
ISS	30 ± 5.8	34 ± 9.6	34 ± 11.3	28.4 ± 13.2	0.130
Scene GCS	3 (3–10)	3 (3–15)	3 (3–15)	3 (3–15)	0.393
Head AIS	4.5 ± 0.7	4.6 ± 0.8	4.7 ± 0.9	4.1 ± 0.8	0.210
Chest AIS	3 ± 0.6	3.2 ± 0.7	2.8 ± 0.9	3.2 ± 1.1	0.384
Abdomen AIS	2 ± 0.1	2.8 ± 1.1	3 ± 1.01	2.5 ± 0.7	0.670
Blood transfusion	28	47	40	34.8	0.263
VAP	4	12.1	8	35	0.005
Time of death					0.160
Immediate	52	34	42	26	
Early	20	31	20	17	
Late	28	36	38	56.5	
Place of death					0.520
At the scene	52	33.6	42	26	
ICU	40	47	46	56.5	
TRU	4	14	6	13	
Operating room	4	6.7	4	0	

Data are presented as percentage, mean ± standard deviation, or median (range) unless otherwise indicated

AIS abbreviated injury score, *ANOVA* analysis of variance, *GCS* Glasgow coma score, *ICU* intensive care unit, *ISS* injury severity score, *TRU* trauma resuscitation unit, *VAP* ventilator-associated pneumonia

[a] One way ANOVA was used for continuous variables, Chi square test was used for categorical variables and kruskal–wallis test was done for skewed continuous variables

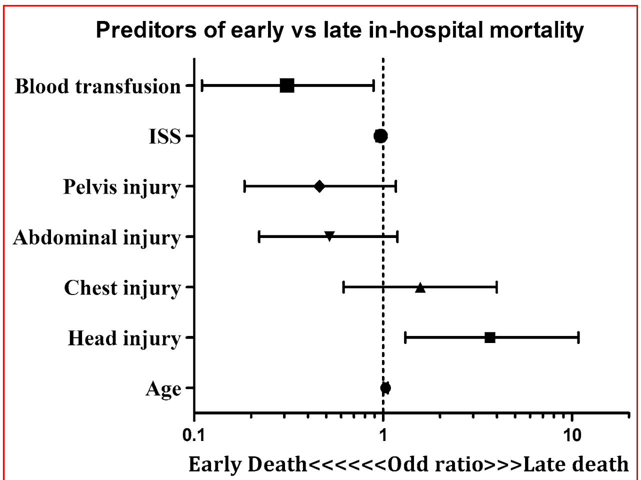

Fig. 2 Predictors of early versus late mortality. *ISS* injury severity score

In our study, patients who survived to reach hospital were severely injured, received an average of seven units of packed red blood cells, and two-thirds of them had traumatic brain injury of variable degrees of severity. In the hospital, early post-injury deaths were frequently associated with young age, need for blood transfusion, and occurrence of abdominal or pelvic injuries. However, those who died later were older, had relatively lower ISS, and suffered mainly from head injury.

In general, our database registry indicates that around 60–65 % of trauma cases in Qatar occur in subjects aged between 19 and 44 years; 70–75 % of them are males. This young and male predominance is related to the fact that Qatar is a rapidly developing country with huge construction projects that depend mainly on expatriates (~ 80 % of the total population). Moreover, in comparison with other studies, our data showed a very low incidence of intentional injuries (i.e. penetrating interpersonal violence). For instance, the 9-year report from the mature level 1 trauma centers in Seattle in the USA showed that 26 % of trauma was penetrating, with an overall mortality rate of 5.8 % of all trauma admissions [30]. Earlier, in Denver city and county, Sauaia et al. [10] reported that the main mechanism of injury was gunshot (42 %), whereas our study reported a lower rate of penetrating injury (9 %).

Gabbe et al. [31] reported that age, ISS, development of complications, and triage category were common predictors of mortality. In addition, several studies have demonstrated

Table 5 Review of recent studies analyzing mortality trend in trauma patients

Country	Study design	Cases (*n*)	Duration (years)	Exclusion	Mechanism	Mortality: Within 1 h	Mortality: Within 1–24 h	Mortality: Late deaths >24 h	Conclusion
Italy [19]	Prospective (no autopsy)	286	1	Self-inflicted; ISS < 16	Blunt 98.4 %; penetrating 1.6 %	62.2 %	17.5 %	20.3	No classic temporal distribution; most pts dead at scene
USA [20]	Retrospective (autopsy review)	900	10	Not transported to a level I trauma center	Blunt 59.7 %; penetrating 40 %	37.6 %	32.2 %	30.2 %	Primary and secondary CNS injuries are the leading causes of death; no classic temporal distribution
UK [21]	Retrospective analysis of prospectively maintained data (autopsy review)	302	4	Incomplete data (743 cases)	Blunt 79 %; penetrating 21 %	25.8 %	29 %	45.2 %	No trimodal distribution of death; overall mortality dropped from 8.8 to 5.8 %
Netherlands [22]	Prospective database study (no autopsy)	720	12	Drowning, poisoning, overdose	Blunt 94.7 %; penetrating 3.3 %	7.6 %	36.4 %	56 %	No trimodal distribution; early deaths: exsanguinations; late deaths: CNS injury
USA [18]	Population-based study (no autopsy)	678	1	Drug overdose, poisoning, burn, foreign-body aspiration, non-residents	Blunt 52 %; penetrating 48 %	61.4 %	29.4 %	9.2 %	Bimodal distribution; lower late deaths showed improvements in resuscitation and critical care
NZ [23]	Retrospective from hospital trauma, coroner autopsy, and police records	186	1	Pts who resided outside Auckland	Blunt: around 94 %	80.6 %[a]	11.3 %[a]	8.1 %[a]	Trimodal distribution of trauma deaths not demonstrated; main cause of death was CNS-related, followed by hemorrhage
Australia [12]	Prospective, population-based study; autopsies included	175	1	NA	High-energy[b] 59 %; low-energy 41 %	66 %[a]	27 %[a]	7 %[a]	Classic trimodal death distribution much more skewed to early deaths; two-thirds of cases died due to CNS injuries and exsanguination (33 % for each)
Qatar[c]	Retrospective analysis (no autopsy)	333	3	Drowning and poisoning victims	Blunt 91 %; penetrating 9 %	42.7 %	28.8 %	28.5 %	Bimodal death pattern; young age associated with early post-injury death; higher death rate at scene

CNS central nervous system, *ISS* injury severity score, *NA* not applicable, *NZ* New Zealand, *pts* patients

[a] Times of death were (1) pre-hospital, <2 days, and ≥2 days, respectively

[b] High-energy: falls >3 m, road and traffic related, industrial, major burns, gunshot and stabbing

[c] Present study

a significant association between the need for blood transfusion and trauma-related mortality [32–34]. Our analysis showed that head injury increased the risk for late death four times, whereas the need for blood transfusion was associated with a threefold increase in the risk of early death.

Previous studies have reported that head injury and hemorrhage are the most frequent causes of immediate death [10, 13]. Moreover, it has been shown that the causes of immediate and early deaths are similar and mainly attributed to injuries of the head and excessive bleeding [13, 35, 36]. However, as post-mortem examinations are not routinely performed for most trauma mortalities in Qatar, the exact cause of pre-hospital death remains unclear for most of the immediate deaths in our series. Meislin et al. [13] demonstrated that about half of the late deaths were due to head injuries, followed by hemorrhage (35 %) and multiple organ failure (16 %). Cowley [37] reported severe infection and head injuries to be mainly associated with late mortality. Consistent with other studies, our findings indicated a high rate of head injury, VAP, ARDS, sepsis, and acute renal failure in those who died late in the hospital [11, 37, 38].

In a further sub-analysis, we categorized our study population into different age groups. All the variables were comparable in the four age groups, except for the presence of abdominal injury and the development of VAP, which were mainly seen among the young and old age groups, respectively.

The present study reflects the maturation phase of our trauma system and is considered the first of many steps that will be undertaken to objectively evaluate the effectiveness of each of the elements of our trauma system. Pre-hospital and early deaths may reflect not only the performance of ambulance and paramedic services (i.e. pre-hospital transport time and care provided) but also the injury prevention program and other governmental and community stakeholders. Although it is a complex issue, late death pattern reflects in-hospital services and needs to be monitored through continuous quality assurance and patient safety initiatives. Specific parameters could be used as quality assurance tools for specific services (i.e. VAP rate for the intensive care unit service).

Limitations

The main limitations of this study include the retrospective design and lack of autopsy reports. Furthermore, data are missing from some patient records regarding co-morbidities for immediate and early death. Unfortunately, we could not consistently calculate the probability of patient survival using the trauma and injury severity score (TRISS), for example, due to incomplete data encoding, and therefore we could not draw a clear picture on this particular variable. Moreover, defining the time to death is challenging as there are no standards for these intervals and it is inconsistently reported by various investigators [11]; this confounds the ability to compare our results with those of others. As there is follow-up, the study does not include those who died after hospital discharge.

Summary and conclusion

Over a 3-year period at the HTC, the time-based trauma-related mortality pattern shows a bimodal curve in which pre-hospital death accounted for the first peak, with the second peak occurring within the first week of admission. Notably, young patients are more susceptible to early post-injury death in our population.

Moreover, this temporal distribution of death reflects the severity of sustained injuries and so the need for injury mitigation. RTIs are the most common cause of trauma-related death, while intentional violence-related injuries are very rare in Qatar. We need to concentrate our primary prevention programs on driver, occupant, and pedestrian safety in order to significantly reduce these early and immediate trauma-related deaths. Further work must focus on analyzing pre-hospital deaths to guide preventive efforts and evaluate the quality of pre-hospital trauma care. This more specific documentation and analysis of trauma-related mortality is essential for the continued assessment of the maturation and efficiency of national trauma systems. Accurate and up-to-date mortality statistics are essential to inform health policy makers by serving as a prioritizing tool for prevention initiatives, guiding emergency readiness, and informing trauma system development. Stringent trauma quality improvement and critical care education programs have been implemented since the last year of this study period, and we will describe the evaluation of such in a subsequent report.

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