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Cardiopulmonary resuscitation of out-of-hospital traumatic cardiac arrest in Qatar: A nationwide population-based study

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ABSTRACT

Background: Traumatic cardiac arrest studies have reported improved survival rates recently, ranging from 1.7–7.5%. This population-based nationwide study aims to describe the epidemiology, interventions and outcomes, and determine predictors of survival from out-of-hospital traumatic cardiac arrest (OHTCA) in Qatar.
Methods: An observational retrospective population-based study was conducted on OHTCA patients in Qatar, from January 2010 to December 2015. Traumatic cardiac arrest was redefined to include out-of-hospital traumatic cardiac arrest (OHTCA) and in-hospital traumatic cardiac arrest (IHTCA).
Results: A total of 410 OHTCA patients were included in the 6-year study period. The mean annual crude incidence rate of OHTCA was 4.0 per 100,000 population, in Qatar. OHTCA mostly occurred in males with a median age of 33. There was a preponderance of blunt injuries (94.3%) and head injuries (66.3%). Overall, the survival rate was 2.4%. Shockable rhythm, prehospital external hemorrhage control, in-hospital blood transfusion, and surgery were associated with higher odds of survival. Adrenaline (Epinephrine) lowered the odds of survival.
Conclusion: The incidence of OHTCA was less than expected, with a low rate of survival. Thoracotomy was not associated with improved survival while Adrenaline administration lowered survival in OHTCA patients with majority blunt injuries. Interventions to enable early prehospital control of hemorrhage, blood transfusion, thoracostomy and surgery improved survival.

1. Introduction

Prehospital or out-of-hospital traumatic cardiac arrest (OHTCA) is cardiac arrest in a trauma patient that is confirmed by the absence of signs of circulation or abnormal cardiac arrest rhythm and that occurs outside of a hospital setting [1]. The leading traumatic cardiac arrest etiologies are traumatic brain injury (TBI) and hemorrhage [2,3]. OHTCA due to presumed cardiac origin could also lead to a secondary traumatic event and is also classified as OHTCA [4]. Previous studies have reported that around 2.5–3% of medical cardiac arrests occur in cars that could lead to road traffic injury and be included as OHTCA [4,5]. We have also defined another study sub-population as in-hospital traumatic cardiac arrest (IHTCA), which is cardiac arrest in a trauma patient that is confirmed by the absence of signs of circulation or abnormal cardiac arrest rhythm that occurs in a hospital setting and was not cardiac rearrest. We defined traumatic cardiac arrest as including all trauma patients with cardiac arrest; OHTCA and IHTCA.

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In 2010, the International Liaison Committee on Resuscitation (ILCOR) published guidelines on emergency management of traumatic cardiac arrest including treatment of reversible causes, basic and advanced life support (BLS and ALS), and emergency thoracotomy [6,7]. Recent studies on traumatic cardiac arrest have reported improved survival rates of 5.6% (range 1.7–7.5%) [3,7–9]. Management of reversible causes of traumatic cardiac arrest included airway insertion and endotracheal intubation for hypoxemia or hypoventilation, external pressure (pressure dressings, tourniquet) for compressible hemorrhage, splints and intravenous fluids for non-compressible hemorrhage, chest decompression for tension pneumothorax, and immediate thoracotomy for massive hemothorax or cardiac tamponade [6–8].

Guidelines and a number of algorithms have been published for management of traumatic cardiac arrest [6,7]. However, there is still no established consensus on management of traumatic cardiac arrest patients with wide variability reported in epidemiology, standards of care, and outcomes. The objective of this study was to describe the epidemiology, peri-cardiac arrest and trauma characteristics, management and outcomes of OHTCA patients in Qatar, and to determine the factors that predict survival outcomes.

2. Material and methods

This was an observational retrospective study that analysed data from the Hamad Trauma Centre (HTC), trauma registry and out-of-hospital cardiac arrest registry, in Qatar. The out-of-hospital cardiac arrest registry was established according to the Utstein guidelines and collected prehospital data from Qatar's sole national Emergency Medical Services (EMS) provider, Hamad Medical Corporation Ambulance Service (HMCAS), Emergency department (ED) data and inpatient medical data from 4 EDs and 8 public hospitals of Hamad Medical Corporation, the public healthcare system provider for the State of Qatar [10]. The HTC trauma registry was based at the Level 1 national trauma referral centre and encodes and maintains records of all major trauma patients in Qatar in compliance with standards of the American College of Surgeons' Committee on Trauma. In addition to the above sources, patient medical record files were individually reviewed. Data were collected on OHTCA patients from 1 January 2010 till 31 December 2015. The Institutional Review Board of HMC provided the ethics approval and waiver of informed consent for the study (JIRB# 13-00071).

OHTCA was defined as cardiac arrest in a trauma patient determined by EMS and having received prehospital cardiopulmonary resuscitation (CPR) [11]. Inclusion criteria included adult (>18 years of age) OHTCA patients who were resuscitated by EMS and received prehospital cardiopulmonary resuscitation in Qatar. Exclusion criteria included IHTCA patients, OHTCA patients with clear signs of death (decapitation, incineration, decomposition, rigor mortis, and dependent lividity) and OHTCA patients with the following causes of hypoxemia; drowning, electrocution, conflagration, and burns. Data were collected on demographic features, peri-cardiac arrest variables, trauma characteristics, out-of-hospital variables, ED and Trauma Room (TR) procedures, and inpatient management. Peri-cardiac arrest variables included bystander witnessed arrest, bystander CPR, initial shockable rhythm, and defibrillation. Trauma characteristics included injury mechanism (pedestrian, motor vehicle collision and falls) and injury type (blunt/penetrating), and prehospital Glasgow Coma Scale (GCS). Out-of-hospital variables consisted of mode of transport, airway, intravenous fluids, adrenaline (epinephrine) administration, external hemorrhage control, and needle thoracostomy. ED and Trauma room resuscitation included thoracotomy, and inpatient management included blood transfusion and any surgery. The primary outcome was defined as 'survival to hospital discharge,' while secondary outcome was 'survival to hospital admission,' determined as sustained return of spontaneous circulation (ROSC) at ED handover.

2.1. Statistical methods

Incidence rate was calculated by using each year's mid-year population of the 6-year study duration. Categorical variables were described as frequencies and percentages. Normally distributed continuous variables were reported as means with standard deviation while non-normal distributed continuous variables were presented as medians with interquartile ranges (IQR). Comparison of baseline patient characteristics were performed using chi-square and Fisher's exact test for categorical variables, and *t*-test and Mann-Whitney test for continuous variables, as appropriate. Multivariate forward logistic regression models were constructed to determine predictors of outcomes; ROSC and survival. Variables with p-value <0.1 in univariate analysis were considered for model inclusion in the multivariable analysis. Model performance was evaluated by calculating the area under the receiver operator characteristic (ROC) curve for the model. Hosmer–Lemeshow goodness-of-fit test was tested for homogeneity of the model. Statistical analysis was performed using SPSS (IBM SPSS Statistics version 23.0).

3. Results

During the 6-year study period, a total of 718 trauma patients had cardiac arrest, in Qatar. Of these, 480 trauma patients met the criteria for OHTCA and 236 trauma patients had in-hospital traumatic cardiac arrest (IHTCA). Of 480 OHTCA patients, we excluded 70 cases; under 18 years of age (n = 31), missing OHTCA patients with no information (n = 26) and those OHTCA patients with hypoxia due to drowning, electrocution, conflagration, and burns (n = 13). After exclusion, a total of 410 OHTCA patients were included in the study.

The mean annual crude incidence rate of OHTCA was 4.0 per 100,000 population. The median age was 33 (IQR 27–46) and the majority of the patients were male (92.0%). Nepalese (n = 55, 13.4%), Qataris (n = 52, 12.7%) and Indians (n = 41, 10.0%) had the highest number of OHTCA. Most of the OHTCA occurred on the road/street (74.0%) followed by workplace (10.0%), public place (10.0%), and home (5.0%). The majority of the injuries in OHTCA were blunt (93.4%) in comparison with penetrating injuries (5.6%). Nearly half of the mechanisms of injury in OHTCA were attributed to motor vehicle collisions (42.0%) followed by pedestrian injuries (29.0%), falls (13.9%) and vulnerable road users (motorcyclists and cyclists- 3.4%). Assault (n = 7, 1.7%) and gunshot injuries (n = 4, 0.98%) were infrequent causes of traumatic cardiac arrest and were categorized under 'Others' in mechanism of injury. Head injury (66.0%) was common in OHTCA patients. Majority of the patients had a prehospital Glasgow Coma Scale (GCS) of 3 (n = 363, 88.5%). Bystander witnessed 43 (11.0%) OHTCA patients and bystander CPR was performed in 21 (5.0%) patients. Initial shockable rhythm defined as ventricular fibrillation and ventricular tachycardia was observed in 3.0% OHTCA patients. There were 17 (4.1%) patients who had an initial non-shockable rhythm which converted to a shockable rhythm. Rearrest occurred in 24.2% patients after initial ROSC (Table 1).

Ground ambulance (91.0%) was the preferred mode for transport from scene to hospital. Defibrillation was performed in 42 (10.2%) OHTCA patients. Airway was placed in 86.0% patients and mechanical chest compression device was utilized in 6.1% patients. Intravenous fluids and adrenaline were given to 72.4% and 69.8% patients, respectively. Prehospital control of external bleeding was attempted in 10.0% OHTCA patients. Out-of-hospital needle chest decompression and ED/Trauma room thoracotomy was performed in (3.4%) and (6.0%) patients, respectively. Blood was transfused in-hospital in (15.0%) patients and (7.0%) patients underwent surgery (Table 2).

Return of spontaneous circulation at ED admission was achieved in 61 patients (15.0%). In the univariate analysis; Caucasian and South Asian ethnicity, OHTCA due to falls injury, head injury, prehospital GCS, initial shockable rhythm, defibrillation, control of external bleeding and out-of-hospital needle chest decompression were associated with higher odds of ROSC. Adrenaline administration was associated with lower odds of ROSC (Table 1). In the multivariable analysis; initial shockable rhythm (OR 6.4, 95% CI 1.3–30.7, p = 0.02), hemorrhage control (OR 5.9, 95% CI 1.9–18.0, p < 0.00), and out-of- hospital needle thoracostomy (OR 5.3, 95% CI 1.3–21.7, p = 0.02) were associated with higher odds of ROSC (Table 3).

The overall survival rate was 2.4% (n = 10). In the univariate analysis; initial shockable rhythm, hemorrhage control, blood transfusion, and surgery were associated with higher odds of survival to leave hospital. Adrenaline administration was associated with lower odds of survival (Table 2).

4. Discussion

This is the first population-based OHTCA study from Asia and the Middle East. The study shows a lower than expected incidence and relatively low survival rate. Traumatic injury was mostly due to blunt injuries. There are a number of interventions that may improve survival in this setting.

Table 1
Characteristics of OHTCA patients with ROSC at ED admission.

Characteristic N (%)	Total number of patients N = 410	No ROSC at admission N = 349 (85.1%)	ROSC at admission N = 61 (14.9%)	Odds ratio (95% CI), p-value
Demographics				
Age (Median, IQR)	33 (27–46)	34 (28–47)	32 (25.5–45.5)	0.99 (0.96–1.01), p = 0.37
Total missing	118 (28.8%)			
Gender				
Female	29 (7.0%)	25 (7.2%)	4 (6.7%)	Reference
Male	377 (92.0%)	321 (92.8%)	56 (93.3%)	1.09 (0.37–3.25), p = 0.88
Total missing	4 (1%)			
Location				Overall p = 0.30
Street/Road	303 (74.0%)	262 (75.7%)	41 (68.3%)	Reference
Home	21 (5.0%)	18 (5.2%)	3 (5.0%)	1.07 (0.3–3.77), p = 0.92
Workplace	42 (10.0%)	36 (10.4%)	6 (10.0%)	1.07 (0.42–2.69), p = 0.89
Public place	40 (10.0%)	30 (8.7%)	10 (16.7%)	2.13 (0.97–4.68), p = 0.06
Total Missing	4 (1.0%)			
Ethnicity				Overall p = 0.11
Middle Eastern	103 (25.0%)	94 (38.2%)	9 (18.8%)	Reference
Caucasian	10 (2.4%)	7 (2.8%)	3 (6.3%)	**4.48 (0.98–20.38), p = 0.05**
South Asian	154 (37.6%)	123 (50.0%)	31 (64.6%)	**2.63 (1.2–5.8), p = 0.02**
Far Eastern	12 (3.0%)	10 (4.1%)	2 (4.2%)	2.09 (0.4–11.04), p = 0.39
African	15 (4.0%)	12 (4.9%)	3 (6.3%)	2.61 (0.62–11.0), p = 1.91
Total missing	116 (28.0%)			
Injury characteristics				
Mechanism of injury				Overall p = 0.03
Motor vehicle collision	172 (42.0%)	148 (42.4%)	24 (39.3%)	Reference
Falls	57 (13.9%)	42 (12.0%)	15 (24.6%)	**2.20 (1.06–4.57) p = 0.03**
Pedestrian	119 (29.0%)	106 (30.4%)	13 (21.3%)	0.76 (0.37–1.55), p = 0.45
Vulnerable road users	14 (3.4%)	14 (4.0%)	0	–
Others	48 (11.7%)	39 (11.2%)	9 (14.8%)	1.42 (0.61–3.31), p = 0.41
Type of injury				
Blunt	383 (93.4%)	327 (94.5%)	56 (93.3%)	Reference
Penetrating	23 (5.6%)	19 (5.5%)	4 (6.7%)	1.23 (0.40–3.75), p = 0.72
Total missing	4 (1.0%)			
Head injury	271 (66.0%)	222 (63.8%)	49 (80.3%)	**2.32 (1.19–4.52), p = 0.014**
Total Missing	1 (0.2%)			
Prehospital				
GCS (Mean ± SD)	3.44 ± 1.9	3.35 ± 1.76	3.95 ± 2.45	**1.13 (1.01–1.27), p = 0.03**
Total missing	19 (4.6%)			
Cardiac arrest features				
Arrest witnessed	43 (11.0%)	36 (10.6%)	7 (11.5%)	**1.09 (0.46–2.58), p = 0.84**
Total missing	10 (2.4%)			
Bystander CPR	21 (5.0%)	17 (4.9%)	4 (6.7%)	1.38 (0.45–4.3), p = 0.57
Total missing	4 (1.0%)			
Initial shockable rhythm	12 (3.0%)	7 (2.3%)	5 (11.4%)	**5.46 (1.65–18.03), p = 0.005**
Total missing	61 (14.9%)			
Out-of-hospital intervention				
Out-of-hospital transport				
Ground ambulance	373 (91.0%)	318 (93.0%)	55 (90.2%)	Reference
Air ambulance	30 (7.0%)	24 (7.0%)	6 (9.8%)	1.45 (0.57–3.70), p = 0.44
Total missing	7 (1.7%)			
Defibrillation	42 (10.2%)	31 (8.9%)	11 (18.0%)	**2.26 (1.07–4.78), p = 0.03**
Airway	353 (86.0%)	299 (86.7%)	54 (91.5%)	1.66 (0.63–4.37), p = 0.30
Total missing	6 (1.5%)			
Intravenous fluids	297 (72.4%)	247 (70.8%)	50 (80.2%)	1.88 (0.94–3.75), p = 0.07
Mechanical chest compression	25 (6.1%)	18 (5.2%)	7 (11.7%)	2.43 (0.97–6.09), p = 0.06
Adrenaline	286 (69.8%)	251 (71.9%)	35 (57.4%)	**0.53 (0.3–0.9), p = 0.02**
Hemorrhage control	40 (10.0%)	26 (7.5%)	14 (23.3%)	**3.75 (1.82–7.7), p < 0.000**
Total missing	4 (1.0%)			
Needle thoracostomy	14 (3.4%)	8 (2.3%)	6 (10.2%)	**4.75 (1.6–14.2), p = 0.005**
Total missing	7 (1.7%)			

The bold figures in the table have borderline significant p-values (0.05) and confidence intervals.

Previous studies have primarily extracted data on traumatic cardiac arrest patients from either the trauma registry or the cardiac arrest registry based on the Utstein template [11–13]. The disadvantage of data extraction only from pre-existing cardiac arrest or trauma registries is that data mostly includes variables on either trauma or cardiac arrest characteristics depending on the parent registry. This study differs from other studies in that it was designed to collect data on both cardiac and trauma variables from multiple sources including linking cardiac arrest and trauma registries, as well as review of patient electronic medical records and medical record files [11–13].

The mean annual crude incidence of OHTCA in Qatar (4.0 per 100,000 population) was lower than the mean annual crude incidence of 6.0 per 100,000 reported in a recent Australian study [9]. According to the World Health Organization (WHO), Qatar has a road traffic death rate of 15.2 per 100,000 population whereas it is 5.4 per 100,000 population for Australia [14]. The lower than expected OHTCA incidence in our study, despite high overall trauma rate, could be due to several reasons: firstly, it could be due to exclusion of in-hospital traumatic cardiac arrest (IHTCA) patients from the study; secondly it could probably be due to the injuries being more severe and OHTCA at scene would probably be fatal before the EMS reaches the patient; lastly

Table 2
Characteristics of OHTCA patients with survival to hospital discharge.

Characteristic N (%)	Total number N = 410	Not Survived N = 400 (97.6%)	Survived N = 10 (2.4%)	Odds ratio (95% CI), p-value
Demographics				
Age (Median, IQR)	33.0 (27–46)	33.5 (27–46)	28.5 (23–37.8)	0.97 (0.92–1.03), p = 0.29
Total missing	118 (28.8%)			
Gender				
Female	29 (7.0%)	29 (7.3%)	0	Reference
Male	377 (92.0%)	368 (92.7%)	9 (100%)	–
Total missing	4 (1.0%)			
Location				Overall p = 0.65
Road	303 (74.0%)	296 (74.7%)	7 (70.0%)	Reference
Home	21 (5.0%)	21 (5.3%)	0	–
Workplace	42 (10.0%)	41 (10.4%)	1 (10.0%)	1.03 (0.12–8.6), p = 0.98
Public place	40 (10.0%)	38 (9.6%)	2 (20.0%)	2.23 (0.45–11.11), p = 0.33
Total missing	4 (1.0%)			
Ethnicity				Overall p = 0.35
Middle Eastern	103 (25.0%)	101 (35.6%)	2 (20.0%)	Reference
Caucasian	10 (2.4%)	10 (3.5%)	0	–
South Asian	154 (37.6%)	147 (51.8%)	7 (70.0%)	2.41 (0.49–11.8), p = 0.28
Far Eastern	12 (3.0%)	12 (4.2%)	0	–
African	15 (4.0%)	14 (4.9%)	1 (10.0%)	3.61 (0.31–42.42), p = 0.31
Total missing	116 (28.0%)			
Injury characteristics				
Mechanism of injury				Overall p = 0.90
Motor vehicle collision	172 (42.0%)	168 (42.0%)	4 (40.0%)	Reference
Falls	57 (13.9%)	56 (14.0%)	1 (10.0%)	0.75 (0.08–6.85), p = 0.8
Pedestrian	119 (29.0%)	116 (29.0%)	3 (30.0%)	1.09 (0.24–4.94), p = 0.92
Vulnerable road users	14 (3.4%)	14 (3.5%)	0	–
Others	48 (11.7%)	46 (11.5%)	2 (20.0%)	1.83 (0.32–10.28), p = 0.5
Type of injury				
Blunt	383 (93.4%)	374 (94.4%)	9 (90.0%)	Reference
Penetrating	23 (5.6%)	22 (5.6%)	1 (10.0%)	1.89 (0.23–15.58), p = 0.56
Total missing	4 (1.0%)			
Head injury	271 (66.0%)	265 (66.4%)	6 (60.0%)	0.76 (0.21–2.73), p = 0.67
Total missing	1 (0.2%)			
Prehospital GCS (Mean ± SD)	3.44 ± 1.89	3.42 ± 1.88	4.22 ± 2.44	1.14 (0.92–1.40), p = 0.238
Total Missing	19 (4.6%)			
Cardiac arrest features				
Arrest witnessed	43 (11.0%)	43 (11%)	0	–
Total missing	10 (2.4%)			
Bystander CPR	21 (5.0%)	21 (5.3%)	0	–
Total missing	4 (1.0%)			
Initial shockable rhythm	12 (3.0%)	11 (3.2%)	1 (25.0%)	**10.12 (0.97–105.23), p = 0.05**
Total missing	61 (14.9%)			
Rearrest	97 (24.2%)	93 (23.8%)	4 (40.0%)	2.14 (0.59–7.73), p = 0.25
Total missing	9 (2.2%)			
Out-of-hospital intervention				
Out-of-hospital transport				
Ground ambulance	373 (91.0%)	364 (92.6%)	9 (90.0%)	Reference
Air ambulance	30 (7.0%)	29 (7.4%)	1 (10.0%)	1.40 (0.17–11.39), p = 0.54
Total missing	7 (1.7%)			
Defibrillation	42 (10.2%)	41 (10.3%)	1 (10.0%)	0.97 (0.12–7.87), p = 0.98
Airway	353 (86.0%)	345 (87.6%)	8 (80.0%)	0.57 (0.12–2.75), p = 0.37
Total Missing	6 (1.5%)			
Intravenous fluids	297 (72.4%)	290 (72.5%)	7 (70.0%)	0.89 (0.23–3.48), p = 0.86
Mechanical chest compression device	25 (6.1%)	25 (6.3%)	0	–
Total missing	1 (0.2%)			
Adrenaline	286 (69.8%)	285 (71.3%)	1 (10%)	**0.045 (0.006–0.358), p = 0.003**
Hemorrhage control	40 (10.0%)	37 (9.3%)	3 (30.0%)	**4.2 (1.03–16.8), p = 0.045**
Total missing	4 (1.0%)			
Needle thoracostomy	14 (3.4%)	13 (3.3%)	1 (10.0%)	3.25 (0.4–27.6), p = 0.28
Total missing	7 (1.7%)			
Hospital management				
ED/Trauma room thoracotomy	25 (6.0%)	24 (6.1%)	1 (10.0%)	1.7 (0.2–14.0), p = 0.62
Total missing	7 (1.7%)			
Blood transfusion	61 (15.0%)	55 (14.0%)	6 (60.0%)	**9.22 (2.5–33.7), p = 0.001**
Total missing	7 (1.7%)			
Surgery	29 (7.0%)	23 (5.9%)	6 (66.7%)	**32.1 (7.54–136.6), p < 0.000**
Total missing	9 (2.2%)			

The bold figures have borderline significant p-values (0.05) and confidence intervals.

it could be due to selection bias with some OHTCA cases not included at all since they were not "clean" traumas or cardiac arrest. However, the reason for low OHTCA incidence in the case of higher trauma burden is not clear and merits further investigation.

The high percentage of males (92.0%) affected was proportionally higher and median age of 33 years were lower than previous OHTCA reports, for example in Australia (male-77.5%, median age of 36 years) and North America (male-79%, mean age of 39–40 years) [11,12]. The

Table 3
Multivariate analysis of OHTCA patients with ROSC.

Variables	Adjusted odds ratio	95% confidence interval	p-Value
Initial shockable rhythm	6.39	(1.3–30.7)	p = 0.02
Hemorrhage control	5.86	(1.9–18.0)	p = 0.002
Needle thoracostomy	5.28	(1.3–21.7)	p = 0.02

majority of the traumatic cardiac arrests occurred in patients of South Asian (37.6%) ethnicity which corresponds with South Asians forming the largest ethnic group of Qatar's population. This reflects the young, majority male (nearly 75%) and expatriate (over 80%) population in Qatar [15]. Most of the traumatic cardiac arrests occurred on streets and roads (74.0%) and was similar to that reported in other studies [11,12].

Road traffic injuries were by far the leading cause of OHTCA. This corresponds with other OHTCA studies that identify motor vehicle collisions as the most common cause of trauma [11]. However the proportion of OHTCAs due to motor vehicle collisions was less in a North American study (28–24%). Also, while gunshot wounds (24–26%) were the second leading cause of injuries in N. America, it was a rare cause of traumatic cardiac arrest in our study [11]. The high proportion of blunt injuries (93.4%) also corresponds with very few assault and gunshot penetrating injuries in traumatic cardiac arrest patients in Qatar. Head injuries also occurred in 271 (66.0%) patients and were associated with increased odds of ROSC that did not persist after controlling for other prognostic factors. Patients with isolated severe head injuries could have had increased odds of ROSC but there was no effect on survival to discharge due to the natural temporal progression and delayed pathophysiology of brain herniation causing death later in a patient's course.

Bystander witnessed OHTCA and bystander CPR was lower than that reported in an Australian study [12,13]. Presence of shockable rhythm in 3.0% patients was higher than the shockable rhythm of 1.6% reported in the Australian study [12]. Shockable rhythm was associated with increased odds of ROSC and survival. Defibrillation performed on 42 (10.2%) OHTCA patients, was lower compared to 26.4% of patients who received defibrillation in a German study [13]. The disparity in initial shockable rhythm and defibrillation performed, was explained by 17 (4.1%) patients who had an initial non- shockable rhythm which converted to a shockable rhythm and were defibrillated and the high number of missing observations for initial cardiac arrest rhythm (n = 61, 15%). The increased odds of ROSC for prehospital thoracostomy and increased odds of survival for external hemorrhage control were in line with previous studies [4,11]. Prehospital interventions that were not associated with ROSC or survival included airway placement, intravenous fluid administration and mechanical chest compression device usage. The low utilization of a chest compression device (6.1%) was because our EMS resuscitation training guidelines advised against the use of external chest compression device on chest trauma patients. Prehospital Adrenaline administration in traumatic cardiac arrest is controversial and a recent study advocated its use and reported that it was associated with increased short-term survival [16]. In our study, Adrenaline administration was associated with lower odds of ROSC and survival reinforcing the fact that the most common causes of OHTCA in this study, hemorrhagic shock and head injury, were not improved by Adrenaline administration.

Overall thoracotomy was performed on 25 (6.0%) patients and 40% of patients who achieved ROSC, but did not significantly increase survival. A study by Davies and Lockey, reported on-scene thoracotomy by physicians for penetrating knife-related wounds with cardiac tamponade had a survival rate of 18% [17]. Of 25 patients who underwent thoracotomy in our study, only 2 had penetrating injuries which may explain why thoracotomy did not impact on survival in our study. A previous study had stated blunt trauma as a contraindication to resuscitative thoracotomy [18]. Consistent with previous studies, blood transfusion and surgery were associated with improved survival [6,18,19]. ROSC was lower (15.0%) compared to reported rate of 26%, in previous study [13]. The overall survival in this study (2.4%) was higher than 1.7%, reported in a recent Australian study [9,20]. However, our OHTCA survival rate was much lower than 6–7.5% reported in some recent studies [3,11,20,21].

There are many possible reasons for the lower ROSC and survival rates in our study. We had evidence of cardiac arrest rhythm in 85% of the cases while other OHTCA studies did not confirm evidence of the cardiac arrest rhythm and thus could also have included extremely hypotensive trauma patients with better survival rates compared to trauma patients with true cardiac arrest [11]. We excluded in-hospital traumatic cardiac arrest (IHTCA) patients while other studies have not been consistent with the denominator of the study population with varying inclusion and exclusion criteria and definitions for traumatic cardiac arrest leading to higher survival rates [22]. Also our study included younger traumatic cardiac arrest patients (median age −33) compared to other studies indicating that the majority of these patients received cardiac arrest post severe trauma and were less likely to survive [11,12]. In contrast other studies have higher median ages leading to a greater probability of ischemic heart disease patients who first get a cardiac arrest followed by secondary trauma with higher shockable rhythm and survival rates [4]. Traumatic cardiac arrest patients with penetrating injuries have better survival possibly because of localized injury with sparing of vital organs [12]. Our study had the largest proportion of blunt injuries (93.4%) compared with 68–80% in other studies [11,12]. Approximately half of bystander witnessed OHTCA received bystander CPR. All the medical and traumatic cardiac arrest patients in Qatar receive advanced cardiac life support (ACLS) by certified Critical Care Paramedic (CCP) professionals. Recent studies have advocated the use of algorithms to guide effective management of traumatic cardiac arrest [23]. With uniform consensus and formalization of protocols and guidelines for management of traumatic cardiac arrest disparities in survival of traumatic cardiac arrest could be mitigated.

4.1. Limitations

The main limitation of this study was that it was observational and associations do not imply causality. Associations such as increased survival with interventions may be because of survival bias and provider bias. The small number of survivors limited exploration of prognostic factors in this group. Multivariable analysis for survival could not be performed and only unadjusted odds ratio for survival were possible. However, we had sufficient numbers for ROSC and multivariate analysis for ROSC was performed. Because of a large number of missing observations for 'Age' (28.8%), age-sex standardization of incidence rates was not feasible. As with other studies on traumatic and non-traumatic cardiac arrest, etiology could only be presumed on clinical assessment without any confirmation by autopsy. EMS median time intervals; response time, scene time, and transport time were not consistently available for all patients. Prehospital interventions are critical to manage reversible causes of traumatic cardiac arrest. Thoracotomy is the only established emergency operative intervention that improves outcomes [6]. EMS time intervals could provide valuable information on response times, prehospital interventions at scene, and quick transport of patients to ED for thoracotomy and surgery. Measures of severity of trauma in OHTCA patients, for example by determination of Injury Severity Score, could not be assessed clinically. This is unfortunately consistent

with other traumatic cardiac arrest studies that also did not report measures of trauma severity.

5. Conclusions

There was a lower incidence of OHTCA than expected mainly affecting young people with blunt injuries from road traffic injuries. Assault and gunshot wounds causing penetrating injuries were uncommon. The presence of shockable rhythm increased the odds of ROSC and survival. Emergency management including hemorrhage control, needle thoracostomy, blood transfusion, and surgery were associated with improved ROSC and survival.

Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

Acknowledgements

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Ethics approval.

The study obtained ethics approval from Institutional Review Board, Hamad Medical Corporation, JIRB#13-00071. The study was given waiver of informed consent.

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