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ORIGINAL ARTICLE

Outcomes and characteristics of traumatic cardiac arrest in a level 1 Trauma Center in Riyadh, Saudi Arabia

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ABSTRACT

Objective: This study aimed to examine the characteristics and outcomes of adult traumatic cardiac arrest (TCA) patients treated at King Abdulaziz Medical City in Riyadh, Saudi Arabia, a center notably impacted by traumatic injuries.

Methods: This was a retrospective cohort chart review study designed to analyze the characteristics and outcomes of adult traumatic cardiac arrest in a level 1 trauma center, including all patients aged above 14 years, who were involved in in-hospital traumatic cardiac arrest between 2017 and 2023.

Results: A total of 92 patients were included in the study, with a majority being males (96.7%). The average age was 30.74 years, with 58.2% under 30 years. Furthermore, 52.2% of the patients were Saudi nationals. 82.4% of patients had a glasgow coma scale score of 3 upon arrival. In 81.5% of cases, the initial rhythm observed was pulseless electrical activity. Returning of spontaneous circulation was noted in 67.8% of cases.

Conclusion: This study underscores the incidence and outcomes of TCA in Saudi Arabia, identifying male gender and motor vehicle accidents as key risk factors. The majority of cases involved individuals under 30 years of age, with the best survival rates seen in those aged 30-50 years. The study noted a 58% rate of return of spontaneous circulation in the emergency department, contrasting with a low 5% 30-day survival rate. Further research is essential to clarify the factors affecting survival in TCA cases.

Keywords: Trauma, traumatic cardiac arrest, resuscitation, penetrating trauma, blunt trauma.

Introduction

Traumatic injuries worldwide result in approximately 40 million long-term disabilities. Unfortunately, in low- to middle-income countries, nearly 6 million lives are lost each year due to these injuries [1]. Traumatic cardiac arrest (TCA) is a potential consequence of traumatic injuries. TCA occurs when the heart stops pumping due to either blunt or penetrating trauma. Despite its significance, relatively few studies have investigated the interventions, causes, and outcomes associated with TCA.

For instance, a study conducted in Sweden focused on adults aged 15 years and older and found that the highest incidence of traumatic cardiac arrest occurred among individuals aged 15-24 years, with males being the majority (82%) [2]. Pulseless electrical activity (PEA) and asystole were the most common initial rhythms observed in traumatic cardiac arrest cases, accounting for about two-thirds of the cases [2]. PEA is characterized by a beating heart with no palpable pulses, often due to a state of hypovolemia [2]. Unfortunately, the survival rate was less than 11%, and none of the patients were discharged without disabilities [2]. Another recent study conducted in Saudi Arabia examined the outcomes and characteristics of pediatric traumatic cardiac arrest over 15 years and reported similar findings [3]. However, more recent studies have shown more promising results in terms of the return of spontaneous circulation

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and neurological outcomes [2]. For example, a study involving military personnel found that 24% of patients who received resuscitation for traumatic cardiac arrest survived.

Traumatic cardiac arrest can be caused by several mechanisms, such as severe head trauma, low blood pressure, blocked airways, air embolisms, low oxygen levels, tension pneumothorax, pericardial tamponade, myocardial contusion, and injuries to the heart and major blood vessels [3]. Alongside cardiopulmonary resuscitation, different adjunctive measures have been employed in the management of traumatic cardiac arrest. For instance, emergency department thoracotomy has been studied in cases of penetrating and blunt trauma, with a survival rate of 20% for patients with penetrating injuries compared to 2% for those with blunt trauma [4]. Some authors view TCA as a hopeless situation [2]. Nonetheless, recent improvements in resuscitation techniques and a deeper understanding of the causes and underlying processes of TCA have resulted in enhanced survival rates and neurological outcomes [5].

Saudi Arabia faces a significant number of fatalities due to road traffic accidents, ranking second only to ischemic heart disease [2]. The country has made significant progress in its medical resources, and this might have influenced the survival rate for traumatic cardiac arrests. This study examined the characteristics, outcomes, survival rates, and potential neurological outcomes of adult patients who experienced traumatic cardiac arrest and were treated at King Abdulaziz Medical City in Riyadh, Saudi Arabia.

Subjects and Methods

This retrospective cohort chart review study was designed to analyze the characteristics and outcomes of adult traumatic cardiac arrest in a Level 1 trauma center. This study was conducted at King Abdulaziz Medical City (KAMC), Riyadh, Saudi Arabia. This emergency department receives and sees more than 170,000 patients per year, or over 500 patients per day, with 15 beds allocated to the resuscitation unit alone.

This study followed specific inclusion criteria. All patients aged 14 years and above, who were involved in a cardiac arrest or a trauma team activation event in the emergency department during the years 2017-2023. In addition, an exclusion criterion was constructed as follows: (1) all pediatric patients aged < 14 years. (2) All non-traumatic cardiac arrests. (3) All cardiac arrests with no active cardiopulmonary resuscitation (CPR) ongoing (i.e., declared dead before arrival to the ED). (4) Any cardiac arrest outside the ED.

All data were collected through KAMC's Best Care electronic medical care system. Using a standardized data collection sheet, different variables were considered, such as patient gender, nationality, mode of arrival, glasgow coma scale (GCS) on arrival, initial rhythm in ED, last documented rhythm, mechanism of injury, body systems involved, interventions done during the arrest (e.g., needle decompression and chest tubes), thoracotomy (if done), number of CPR cycles, return of spontaneous circulation (ROSC), if survived, intensive care unit (ICU) length of stay, and survival at 30 days.

Descriptive data were presented as median and interquartile range for continuous variables and as numbers and percentages for categorical variables. Comparisons between groups were made using the Wilcoxon rank sum test for continuous variables. Chi-square test for discontinuous variables. Trends were evaluated using linear regression. The significance level was set to 0.05. All data were analyzed using R version 4.0.4 (R-studio core team 2021).

Results

This cohort comprised a total of 92 subjects. The vast majority, constituting 96.7%, were males. The age range spanned from 17 to 82 years, with an average age of 30.74 years. Furthermore, the majority of individuals (52.2%) were Saudi nationals (Table 1).

The average HR was 106.4681 beats per minute, whereas the average oxygen saturation was 85.6383. Blood pressure measurements were also taken for these patients, with the mean arterial pressure (MAP) calculated for 46 of them. The systolic blood pressure showed an average of 121 mmHg, ranging from 41 mmHg to 201 mmHg, and the diastolic blood pressure averaged a slightly

Table 1. *Demographics of included patients.*

Characteristic	Frequency (*N*)	Percentage (%)
Gender		
Male	89	96.7
Female	3	3.3
Age (years)		
< 30	53	58.2
30-50	31	34.1
>50	7	7.7
Nationality		
Saudi	47	52.2
Non-Saudi	43	47.8

*Note: Data for 1 subject was not available in "age" and 2 subjects had unknown nationality.

Table 2. *Patients' vitals as recorded in the emergency room.*

Vitals					
	N	**Minimum**	**Maximum**	**Mean**	**SD**
HR	47	38.00	173.00	106.4681	32.78908
O_2 Saturation (%)	47	54.00	100.00	85.6383	14.18270
Blood pressure					
Systolic	47	41.00	201.00	121.0000	37.13547
Diastolic	47	20.00	156.00	85.4255	37.79852
MAP	46	27.00	167.00	95.9348	38.10477

N; Number, SD; Standard Deviation, BMI; Body Mass Index, HR: Heart Rate, MAP; Mean Arterial Pressure.

Table 3. *BMI of included patients.*

Body mass index	Frequency	Percent
< 20	1	1.9
20-24	18	33.3
25-30	28	51.9
> 30	7	13.0
Total	54	100.0

Table 4. *Respiratory rates of included patients.*

Respiratory rate category	Frequency	Percent
< 12	1	2.3
12-20	11	25.6
> 20	31	72.1
Total	43	100.0

elevated mean of 85.4255 mmHg, with readings ranging from 20 mmHg to 156 mmHg (Table 2).

Of the total, 18 patients had a BMI between 20 and 24. Notably, the majority (28 patients) were found to fall into the BMI range of 25-30 (Table 3).

The majority (72.1%) had a respiratory rate exceeding 20 breaths per minute (Table 4).

The majority of patients arrived at the emergency department via ambulance (94.6%), while only three cases arrived in a personal vehicle. Of the patients, 82.6% experienced cardiac arrest in the hospital's emergency department. Upon arrival, vital signs were recorded in 73 cases, showing the majority of subjects (82.4%) having a GCS score of 3, with 10 cases scoring between 9 and 15, while only 6 cases scored between 4 and 8. In terms of the initial rhythm of cardiac arrest, most cases presented with a PEA (81.5%), while 12 cases showed a rhythm of asystole and only 5 cases of ventricular tachycardia (VT) or ventricular fibrillation (VF) were recorded. Likewise, in the last recorded rhythm of cardiac arrest, PEA was predominant (67.8%) compared to asystole and VT/VF, which were observed in 17 and 11 cases, respectively (Table 5).

The primary cause of TCA was motor vehicle accidents, accounting for 57 cases, followed by pedestrian rollovers, which affected 16 cases. In contrast, penetrating injuries such as stab and gunshot wounds were reported in only 6 patients. However, approximately 14.1% of cases had other causes for their sustained injuries, including burns, falls from height, and drowning, among others.

According to the current data, injuries had a predominant effect on the thoracic, head, and neck regions, accounting for 39.8% and 31.8%, respectively. Compared to the abdominal regions and other areas, which constituted the lowest percentages in this cohort with 8% and 5.7%, respectively.

CPR was administered in 5 or fewer cycles in 60 cases; however, more than 10 cycles were performed in 7 cases only. In addition, thoracotomy was done in only a few patients (4 cases), similarly, intubation and central line intervention were performed in only 9 and 8 cases, respectively. Conversely, bilateral needle decompression and bilateral chest tube interventions were conducted in a significant number of cases, 40.7%. Notably, 37 individuals did not receive any interventions. Consequently, ROSC was achieved in more than half of the patients (63%) (Table 6).

Most of the patients (84 cases) spent less than one day in the ICU) whereas the remaining 7 cases stayed for longer than one day in the ICU. In terms of survival at 30 days, only 5 patients have survived, contrasting with the vast majority of cases (94.5%) who did not survive. The survival rate at 30 days was highest among penetrating injury subjects (20%) compared to Motor vehicle accidents (MVA) (3.5%), pedestrians (6.7%), and others (7.7%). The difference was statistically insignificant with a *p*-value = 0.565 (Table 7).

The survival rate was highest for the 30-50 years age group (9.75) compared to the < 30 years age group (3.8%) and > 50 years age (0%). The difference between the three groups was statistically insignificant, with a *p*-value = 0.426 (Table 8).

Discussion

Traumatic cardiac arrest is a contentious topic, with different studies reporting varied statistical outcomes. ROSC has been found to range from as low as 2% to as high as 31.6%, and some studies suggested that CPR for traumatic cardiac arrest might be futile [6-8].

This study is consistent with global trends, showing that males are more likely to experience TCA than females. This gender disparity can be attributed to factors such as the societal norms that discourage women from driving. Additionally, males are more likely to engage in risky

Table 5. *Baseline characteristics of included patients.*

Characteristics	Frequency (*N*)	Percentage (%)
Mode of arrival		
Ambulance	87	94.6
Personal car	3	3.3
Location of cardiac arrest		
Pre-hospital	16	17.4
Hospital ER	76	82.6
Vitals documented in ER		
Yes	73	79.3
No	19	20.7
GCS score on arrival		
3	75	82.4
4-8	6	6.6
9-15	10	11
Initial rhythm of cardiac arrest		
Asystole	12	13
PEA	75	81.5
VT or VF	5	5.4
Last documented rhythm of cardiac arrest		
Asystole	17	19.5
PEA	59	67.8
VT or VF	11	12.6

*N; Number, ER; Emergency room, GSC; Glascow coma scale, PEA; Pulseless electric activity, VT; Ventricular tachycardia, VF; Ventricular fibrillation.

Table 6. *Interventions provided to the patients.*

Intervention	Frequency (*N*)	Percentage (%)
CPR cycles		
≤ 5	60	67.4
6-10	22	24.7
> 10	7	7.9
Thoracotomy		
Yes	4	4.3
No	88	95.7
Bilateral needle decompression and bilateral chest tubes	37	40.7
Central line	8	8.8
Intubation	9	9.9
No intervention done	37	40.7

CPR; cardiopulmonary resuscitation.

behaviors, which further contributes to their higher TCA incidence [9].

The age distribution of TCA patients in this study revealed that the majority of cases were concentrated among individuals under 30 years old. Interestingly, the highest survival rate was observed in the 30- to 50-year-old age group, followed by the under-30-year-old group, while no survivors were found in the over-50-year-old group. However, statistical analysis revealed that these differences in survival rates based on age were not statistically significant. This suggested that age might not be a significant determining factor for survival in TCA patients in this study population.

MVAs emerged as the leading cause of TCA in this study, consistent with findings from other studies worldwide [6,7,10]. Notably, penetrating injuries exhibited the highest 30-day survival rate compared to other causes, although the differences were not statistically significant. These results highlighted the need for comprehensive strategies to prevent MVAs and improve outcomes in TCA cases.

In terms of resuscitation efforts, this study found a 58% rate of ROSC in the emergency department, while the 30-

Table 7. *Mechanism of injury and survival at 30 days cross-tabulation.*

			Survival at 30 days		Total
			No	Yes	
Mechanism of injury	MVA	Count	55	2	57
		% within the Mechanism of injury	96.5	3.5	100.0
		% within survival at 30 days	64.0	40.0	62.6
	Pedestrian	Count	14	1	15
		% within the Mechanism of injury	93.3	6.7	100.0
		% within survival at 30 days	16.3	20.0	16.5
	penetrating injury (stab and gunshot)	Count	5	1	6
		% within the Mechanism of injury	83.3	16.7	100.0
		% within survival at 30 days	5.8	20.0	6.6
	others	Count	12	1	13
		% within the Mechanism of injury	92.3	7.7	100.0
		% within survival at 30 days	14.0	20.0	14.3
Total		Count	86	5	91
		% within the Mechanism of injury	94.5%	5.5	100.0
		% within survival at 30 days	100.0%	100.0	100.0

Table 8. *Age and survival at 30 days cross-tabulation.*

			Survival at 30 days		Total
			No	Yes	
Age group	<30 years	Count	50	2	52
		% within the age group	96.2	3.8	100.0
		% within survival at 30 days	58.8	40.0	57.8
	30-50 years	Count	28	3	31
		% within the age group	90.3	9.7	100.0
		% within survival at 30 days	32.9	60.0	34.4
	> 50 years	Count	7	0	7
		% within the age group	100.0	0.0	100.0
		% within survival at 30 days	8.2	0.0	7.8
Total		Count	85	5	90
		% within the age group	94.4%	5.6	100.0
		% within survival at 30 days	100.0%	100.0	100.0

day survival rate was 5%. These findings emphasize the challenges associated with resuscitating TCA patients, as the overall survival rates remained low. Further research is necessary to discover effective interventions and enhance outcomes in cases of TCA.

Several measures can serve as indicators of the success of CPR. These measures include the initial rhythm, CPR initiation timing, time from arrest to CPR start, use of epinephrine, following ATLS guidelines, and the injury type (blunt or penetrating).

Previous literature has identified factors that predict mortality in cases of TCA. These factors include the requirement for massive blood transfusions exceeding 10 packs of red blood cells, on-scene blood pressure of 0, age equal to or greater than 55 years, and base excess equal to or less than 8 [11]. Additionally, specific initial rhythms such as PEA, agonal rhythm, ventricular fibrillation, asystole, and a low heart rate ranging from 1 to 39 have been associated with increased mortality [12-14]. Prolonged duration of prehospital CPR exceeding 5 minutes in blunt injuries and more than 15 minutes in penetrating injuries, CPR duration exceeding 20 minutes, and loss of neurological function were identified as predictors of survival [15,16].

Certain factors were found to positively predict survival following TCA. These include the presence of sinus rhythm, reactive pupils, a measurable pulse or blood pressure, a GCS score greater than 4 at the scene, and respiratory efforts [13,15,17-20].

Cardiac motion observed on ultrasound, initial shockable rhythm, witnessed arrest, use of pre- or intra-hospital epinephrine administration, and prehospital tracheal intubation were associated with higher odds of achieving ROSC [21]. Numerous studies reported that bleeding (60%), hypovolemic shock (40%), and traumatic brain injury (43%) are common causes of death in TCA patients [6,3].

The study's shortcomings include those inherent to a retrospective database review, which introduced inherent biases and limitations in data collection and analysis. Second, the study was conducted at a level 1 trauma center in (KAMC), Riyadh, which limited the generalizability of the results to other healthcare settings. Third, the sample size of the study was relatively small, with only 81 subjects included. Finally, the study focused solely on survival at 30 days and neurological outcomes at discharge. By not considering a longer term follow-up.

Future studies with larger sample sizes, prospective designs, multiple centers, and thorough evaluation of the neurological outcomes would provide a better understanding of the outcomes and characteristics of traumatic cardiac arrest.

Conclusion

This study sheds light on the incidence and outcomes of TCA in Saudi Arabia, a problem that has received little attention in the region. The findings align with global trends, identifying male gender and motor vehicle accidents as prominent risk factors. The majority of cases are concentrated among individuals under 30 years old, with the highest survival rate in the 30- to 50-year-old age group. MVA emerged as the leading cause of TCA, with penetrating injuries showing the highest 30-day survival rate. The study found a 58% rate of ROSC in the emergency department, while the 30-day survival rate was 5%. Larger retrospective studies are needed to validate these findings and enhance the understanding of the complex factors influencing survival in cases of traumatic cardiac arrest.

List of Abbreviations

CPR	Cardiopulmonary resuscitation
GCS	Glasgow coma scale
MVA	Motor vehicle accident
MAP	Mean arterial pressure
ROSC	Return of spontaneous circulation
TCA	Traumatic cardiac arrest

Conflict of interest

The authors declared that there is no conflict of interest regarding the publication of this article.

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Consent to participate

Informed consent was obtained from all the participants.

Ethical approval

Ethical approval was granted by the Institutional Review Board of King Abdullah International Medical Research Center, National Guard Health Affairs, Riyadh, Saudi Arabia via reference number RYD-23-419812-104533. Date: 07/05/2023.

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