Mechanisms of traumatic cardiac arrest in Kuwait: A retrospective study
Dalal AlHasan, MD, MS, PhD, Ameen Yaseen

Abstract
The objective of this study is to describe the epidemiology and causes of traumatic cardiac arrest (TCA) in Kuwait aiming to provide a preliminary background to update the current guidelines and improve patients’ management.

This is a retrospective analysis of TCA cases retrieved from emergency medical services archived data between 1 January and 31 December 2017. The TCA cases were sub-grouped based on mechanism of injury then compared in terms of patient demographics, vital signs, patterns of injuries, resuscitation practices, and outcomes.

Outcomes: On scene mortality rate and pre-hospital return of spontaneous circulation.

Among the 204 TCA patients, 140 patients met the inclusion criteria. This whole group was then divided in to 4 subgroups: road traffic accident (RTA) 76% (n=106), fall from height (FFH) 13% (n=18), slip/fall 4% (n=6), and assaults 7% (n=10). There was significant difference between the four mechanisms in: mean age (P= < .001), type of injury (P= .005), head injury (P= .005), chest injury (P= .003), GCS score < 9 (P= .004) and initial hypertension (P= .001). Initial hypertension and GCS score < 9 were only documented in head injuries of RTA and slip/fall groups. Significant difference was also seen in cardiopulmonary resuscitation (P= .006), airway management (P= .035) and on scene mortality rate (P= .003). All patients who had isolated head injury in FFH were pronounced dead on scene, 60%.

Not all TCA incidents are the same, there are different pattern of injuries in each TCA mechanism. Head injuries are predominantly seen in RTA, FFH, slip/falls and chest injuries are seen in assaults. This can influence emergency medical services personal resuscitation plan. Further research is required to address the resuscitation of TCA of different mechanisms.

Abbreviations: CPR = cardiopulmonary resuscitation, EMS = emergency medical services, FFH = fall from height, NAEMSP = National Association of Emergency Medical Services Physicians, ROSC = return of spontaneous circulation, RTA = road traffic accident, TCA = traumatic cardiac arrest.

Keywords: emergency medical services, mechanism of injury, traumatic cardiac arrest

1. Introduction
Unintentional injury is the leading cause of mortality and morbidity in young adults worldwide. Traumatic cardiac arrest (TCA) alone causes 5.1 million deaths per year. TCA is defined as cardiac arrest resulting from an external application of kinetic energy. And while the National Association of Emergency Medical Services Physicians (NAEMSP), the American College of Surgeons Committee and the Western Trauma Association proposed some guidelines for TCA management in the pre-hospital setting, the complex pre-hospital setting and TCA variable presentations made TCA management very challenging. Understanding common mechanisms of TCA incidents can help in predicting pattern of injuries, adapting effective interventions, and hopefully improves TCA outcomes. One large scale study in England and Wales emergency departments on TCA identified head injury as the commonest injury pattern in TCA. The study recommended further research to evaluate and treat reversible underlying injuries of TCA. To our knowledge, there are limited number of studies on TCA mechanisms in the pre-hospital setting. This study is designed to describe the epidemiology and causes of TCA in Kuwait aiming to provide a preliminary background to update the current guidelines and improve patients’ management.

2. Method
2.1. Setting
Kuwait has a single, centralized dispatch center for all ambulance services; this is Arabic-based system and receives calls from the public and inter-hospital transportation. For emergency calls, Kuwait follows a European emergency response system. A universal emergency number 1–1–2 has automatic location identification with centralized dispatch for police, fire, and emergency medical services (EMS). If medical assistance is needed, the call is forwarded to an EMS call-taker who answers...
the call, reconfirms the address and responds by activating the nearest ambulance. The dispatched ambulance is staffed with 2 Emergency Medical Technicians (EMT) or 1 paramedic and 1 EMT. EMTs provide basic life support and paramedics provide advanced life support. Both based on North American resuscitation guidelines. As for TCA management, Kuwait EMS follows NAEMSP recommendation on TCA “if a patient presents or develops a blunt traumatic arrest, initiate cardiopulmonary resuscitation (CPR) on scene”.[3] The local EMS protocol restricts scene time to 10 minutes and the current local EMS response time is 9.3±5 minutes.[7]

This study was a retrospective analysis of TCA cases retrieved from EMS archived data between 1 January and 31 December 2017. The TCA cases were then sub-grouped based on mechanism of injury and compared in terms of; patient demographics, patterns of injuries, vital signs, EMS personal resuscitation, and outcomes. Primary outcomes were; on scene mortality rate and pre-hospital return of spontaneous circulation (ROSC).

2.2. Participants
Study population included adult patients (>18 years old) with TCA that activated EMS and were treated and transported by EMS. TCA cases caused by road traffic accident (RTA), fall from height (FFH), slip/fall and assaults were included in the analysis. Patients with cardiac arrest aetiology, patients for whom resuscitation was not attempted (decapitation, rigor mortis and dependent lividity) were excluded.

2.3. Data collection/measurement
Patient report forms were the only data source for TCA cases. Patient report forms are filled on scene by EMS personal and then stored in EMS audit department archived files. The researcher collected manually patient report forms from EMS audit department archived data. All data were present in the patient report form including patient demographic, mechanism of injury, final diagnosis, patterns of injury, vital signs, resuscitation practices, and outcomes.

Patient report forms with cardiac arrest as a final diagnosis and mechanism of injury of RTA, FFH, slip/fall and assaults were included in the analysis. Pattern of injuries were based on the anatomical location of the injury with special attention to head injuries. Because of England and Wales large scale study results.[8] The investigator decided to analyze head injuries in terms of; patient demographics, patterns of injuries, vital signs, EMS personal resuscitation, and outcomes. Primary outcomes were: on scene mortality rate and pre-hospital return of spontaneous circulation (ROSC).

During the project, all data were kept in a password locked computer files that only the research investigator can open. No data sharing was allowed outside the context of this project.

2.4. Sample size
Convenient sampling was used in this study. All eligible TCA patients treated by EMS during the study period were included.

2.5. Statistical methods
Statistical analysis was performed using Excel and Statistical Package for Social Sciences (IBM SPSS Version 23, NY). TCA mechanisms subgroups were compared using Chi-squared test for dichotomous variables, and Student’s t-test for continuous variables. Two-sided tests were applied and a P-value ≤.05 was interpreted as statistically significant. Missing data were kept missing, i.e., not imputed or estimated.

2.6. Ethical considerations
The study had IRB approval from Kuwait Ministry of Health Independent Ethics Committee on 26 August 2016 (No.448). No informed consent was sought from participants. This is because all data were kept anonymous during this research.

3. Results
Out of the 204 TCA patients, 140 patients met the inclusion criteria (Fig. 1). Patients were divided into 4 subgroups: RTA 76% (n=106), FFH 13% (n=18), slip/fall 4% (n=6), and assaults 7% (n=10). Patients’ demographics, vital signs, patterns of injury, resuscitation, and outcome were compared between the 4 groups (Tables 1 and 2).

Our results showed significant difference in the mean age (P<.001), type of injury (P=.005), head injury (P=.005), and chest injury (P=.003) between the 4 groups. GCS score <9 and initial hypertension were only documented in head injuries of the RTA and slip/fall subgroups, and showed significant difference with P=.004 and P=.001 respectively (Table 1).

Our results also showed significant difference in CPR (P=.006), airway management (P=.035) and on scene mortality (P=.003). All patients who had isolated head injury in FFH group (60%) were pronounced dead on scene (Table 2).

4. Discussion
This study described the different etiologies of TCA in Kuwait, which is not reported before. Our results showed that FFH had the worst TCA outcome. The on scene mortality rate was equal to 60% (P=.003). The current study FFH mortality rate is higher than other studies, 2.7%.[10] In terms of ROSC, there was no significant difference between the 4 subgroups. In demographic characteristics, there was significant difference in age across the 4 subgroups (P=.005). RTA patients were young adults, mean age of 32±16 and fall/slip patients were middle aged adults, mean age 50±15. These findings are partially consistent with the present literature.[11] young adults were seen in RTA, whereas elderly patients were reported in fall/slip.[11] In terms of TCA patterns of injury, head injury was widely seen in RTA, FFH, slip/fall, and chest injuries were seen in assaults. This adds to England and Wales study results on TCA, the study...
identified head injury as the commonest injury pattern in TCA patients. However, it did not identify head injury subtypes or associate head injury with any mechanism of injury.

In RTA, 80% of the patients had head injury and approximately half of these patients had other injuries (Table 1), these findings are different from regional studies, Bener et al (1992) reported head injury was seen in 40% of RTA patients and only 14% had other injuries. One more important finding for RTA patients with head injury was the unstable physiological parameters. Our study observed initial hypertension and GCS

| Table 1 | A comparison between traumatic cardiac arrest mechanisms in terms of patients’ demographics, vital signs, and patterns of injury, using Chi-squared test. |
|---------|---------------------------------------------------------------|
| Variable | Road traffic accidents | Fall from height | Slip/fall | Assault | P value (CI 95%) |
|         | N = 106 (%) | N = 16 (%) | N = 10 (%) | N = 6 (%) |               |
| Demographics | | | | | < .001 |
| 1. Type of injury | | | | | |
| a. Blunt | 104 (98) | 16 (88) | 10 (100) | 1 (7) | .001 |
| b. Penetrating | 2 (2) | 2 (12) | 0 (0) | 5 (83) | .76 |
| 2. Gender | | | | | .76 |
| a. Male | 92 (87) | 17 (94) | 9 (90) | 5 (83) | .005 |
| b. Female | 15 (13) | 1 (6) | 1 (10) | 1 (7) | .005 |
| Age (mean ± std.) | 32 ± 16 | 36.6 ± 14 | 50 ± 15 | 41 ± 10 | .005 |
| Patterns of injury | | | | | .005 |
| 1. Head injury | | | | | .005 |
| a. Isolated head injury | 40 (38) | 11 (60) | 8 (80) | 1 (11) | .003 |
| b. Head injury and other injuries | 45 (42) | 5 (28) | 0 (0) | 1 (11) | .363 |
| c. No head injury | 21 (20) | 2 (12) | 2 (20) | 4 (88) | .886 |
| 2. Chest injury | 19 (18) | 1 (5.5) | 0 (0) | 4 (88) | .096 |
| 3. Abdomen | 7 (6.6) | 0 (0) | 0 (0) | 1 (11) | .096 |
| 4. Pelvic fracture | 2 (2) | 0 (0) | 0 (0) | 0 (0) | .096 |
| 5. Lower extremities | 31 (29) | 4 (22) | 0 (0) | 0 (0) | .096 |
| Vital signs | | | | | .005 |
| Blood pressure (*SBP >140 mm Hg or *DBP >90 mm Hg) | 14 (13) | 0 (0) | 7 (70) | 0 (0) | .001 |
| Pulse | 14 (13) | 2 (12) | 2 (20) | 0 (0) | .399 |
| Respiratory rate | 10 (9) | 1 (6) | 1 (10) | 0 (0) | .620 |
| *GCS score less than 9 | 103 (99) | 17 (99) | 9 (90) | 6 (100) | .004 |
score < 9 only in RTA patients with head injury. The documentation of those unstable parameters in RTA head injuries is vital. Grady et al. (1988) declared hypertension and low GCS indicate raised intracranial pressure. Head injuries with raised intracranial pressure have specific pre-hospital management and transportation guidelines. Our study shed a new light on the physiological parameters of RTA patient’s with head injury. Further investigations by other cohorts or randomized controlled trials are needed to confirm these associations.

We also showed FFH led to lethal isolated head injury, 60% (P = .003) and only few FFH patients had chest injuries of 5.5% (P = .003) (Table 1). This is different from the current literature, 88% of FFH patients had head injuries however 15% of them were lethal. Chest injuries were seen more frequently in FFH, 28%. Again, the majority of slip/fall incidents had isolated head injuries, 80%. This is inconsistent with the literature, head injuries were seen in 10% of US slip/fall incidents. Furthermore, this research showed not all slip/fall patients had high BP. Initial hypertension was only seen in head injury patients. This again can help EMS personal clinical and transportation decisions during slip/fall.

In terms of slip/fall mortality, third of slip/fall patients were declared dead on scene.

In assaults, penetrating chest injury was the underlying cause of TCA. And they were the least to be declared dead on scene, 15%.

As for TCA resuscitation, CPR is recommended by the current NAEMSP guidelines and Kuwait EMS implement these guidelines. This research confirmed that the local TCA resuscitation format was CPR and airway management especially during RTA and slip/fall incidents (Table 2). However, adapting CPR by EMS personal deviated their focus from airway management, 55% (n = 77) and fluid resuscitation, 1% (n = 1) (Table 2). Airway management and fluid resuscitation are essential for treating TCAs with underlying etiology of head injury or chest injury. Furthermore, CPR impact on TCA outcome is controversial in the literature. This study again question CPR effectiveness during TCA of different mechanisms.

In this study we have established the dominant injury pattern in each TCA mechanism. Head injuries are predominantly seen in RTA, FFH, slip/falls, and chest injuries are seen in assaults. This can influence EMS personal resuscitation plan. Further research is required to address resuscitation in TCA of different etiologies.

5. Conclusion
Not all TCA incidents are the same, there are different pattern of injuries in each TCA mechanism. Head injuries are predominantly seen in RTA, FFH, slip/falls, and chest injuries are seen in assaults. This can influence EMS personal resuscitation plan. Further research is required to address resuscitation in TCA of different etiologies.

Acknowledgments
The author would like to acknowledge and thank Dr. Faisal Al-Ghanim for his enormous help and support rendered in the course of gathering the necessary data for the study.

Author contributions
Study conception and design: DA.
Acquisition of data: AY.
Analysis and interpretation of data: DA.
Drafting of manuscript: DA.
Critical revision: DA.
All authors read and approved the final manuscript.

References
[1] Aufderheide T, Nolan J, Jacobs I, et al. Global health and emergency care: a resuscitation research agenda-Part 1. Acad Emerg Med 2013; 20:1289–96.
[2] Barnard E, Sandbach D, Nicholls T, et al. Prehospital determinants of successful resuscitation after traumatic and non-traumatic out-of-hospital cardiac arrest. Emerg Med J 2019;36:333–9.

---

Table 2
A comparison between traumatic cardiac arrest mechanisms in terms of resuscitation and outcomes, using Chi-squared test.

| Variable          | Road traffic accidents | Fall from height | Slip/fall | Assault | Total |
|-------------------|------------------------|------------------|-----------|---------|-------|
|                  | N = 106 (%)            | N = 18 (%)       | N = 10 (%)| N = 6 (%) | N = 140 (%) |
| CPR               | 74 (70)                | 7 (39)           | 10 (100)  | 3 (50)   | 94 (67) |
| Airway management |                        |                  | 8 (80)    | 2 (33)   | 77 (55) |
| IV fluids         | 1 (1)                  | 0 (0)            | 0 (0)     | 1 (1)    | 1 (1)  |
| Scene time (mean ± std) | 2 ± 5              | 4.6 ± 10         | 3.6 ± 7   | 1 ± 5    | 2.4 ± 6 |
| On scene mortality rate | 26 (24)             | 11 (60)          | 3 (30)    | 1 (15)   | 40 (28) |
| ROSC              | 3 (2.8)                | 0 (0)            | 1 (10)    | 0 (0)    | 4 (2.8) |

* CPR = Cardiopulmonary resuscitation, IV = Intravenous fluid, ROSC = Return of spontaneous circulation.
[3] National Association of EMS Physicians. Withholding of resuscitation for adult traumatic cardiopulmonary arrest. Prehospital Emerg Care. 2013;17:291.
[4] Adler E. Defining the limits of resuscitative emergency department thoracotomy: a contemporary western trauma association perspective. J Emerg Med 2011;41:231–2.
[5] Brenard E, Yates D, Edward A, et al. Epidemiology and aetiology of traumatic cardiac arrest in England and Wales – a retrospective database analysis. Resuscitation 2017;110:90–4.
[6] Evan C, Petersen A, Meier N, et al. Prehospital traumatic cardiac arrest: management and outcomes from the resuscitation outcomes consortium epiusy-trauma and PROPHET registries. J Trauma Acute Care Surg 2016;81:285–93.
[7] Kuwait Emergency Medical Services Operation Department Annual Report. Kuwait: Kuwait Operation Unit. 2013.
[8] Pélieu I, Kull C, Walder B. Prehospital and emergency care in adult patients with acute traumatic brain injury. Med Sci 2019;7:12.
[9] Grady P, Blaumanis O. Physiologic parameters of the Cushing reflex. Surg Neurol 1988;29:454–61.
[10] Parreira J, Matar M, Torres A, et al. Comparative analysis between identified injuries of victims of fall from height and other mechanisms of closed trauma. Rev Col Bras Cir 2014;41:272–7.
[11] Centers of Disease Control and Prevention. Important Facts about Falls. Centers of Disease Control and Prevention: United States. 2017. Available at https://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html. (Accessed March 20, 2020).
[12] Benet A, Absood G, Achan N, et al. Road traffic injuries in Al-Ain City, United Arab Emirates. J R Soc Health 1992;112:273–6.
[13] Geeraerts L, Van L, Abdennour L, et al. Guidelines management of severe traumatic brain injury (first 24 hours). Anaesth Crit Care Pain Med 2018;37:171–86.
[14] Mobbs R, Stoddley M, Fuller J. Effect of cervical hard collar on intracranial pressure after head injury. ANZ J Surg 2002;72:389–91.
[15] Christodoulou I, Pogonidis C, Xenodoxidou E, et al. Falls from heights: the approach to multiple trauma. Resuscitation 2006;70:338.
[16] Ojo P, O’connor J, Donald K, et al. Patterns of injury in geriatric falls. Conn Med 2009;73:139–45.
[17] Leis C, Hernandez C, Blanco M. Traumatic cardiac arrest: should advanced life support be initiated? Trauma 2013;74:634–8.
[18] Willis C, Cameron P, Bernard S, et al. Cardiopulmonary resuscitation after traumatic cardiac arrest is not always futile. Injury 2006;37:448–54.
[19] Yamamoto R, Suzuki M, Hayashida K, et al. Epinephrine during resuscitation of traumatic cardiac arrest and increased mortality: a post hoc analysis of prospective observational study. Scand J Trauma Resusc Emerg Med 2019;27:4. https://doi.org/10.1186/s13049-019-0657-8.
[20] World Health OrganizationGlobal Health Observatory Data Repository. Switzerland: World Health Organization; 2013.