Clinical paper

The epidemiology and outcomes of adult in-hospital cardiac arrest in a high-income developing country

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Abstract

Aim: In-Hospital Cardiac Arrest (IHCA) is a significant burden on healthcare worldwide. Outcomes of IHCA are worse in developing countries compared with developed ones. We aimed to study the epidemiology and factors determining outcomes in adult IHCA in a high income developing country.

Methods: We abstracted prospectively collected data of adult patients admitted to our institution over a three-year period who suffered a cardiac arrest. We analysed patient demographics, arrest characteristics, including response time, initial rhythm and code duration. Pre-arrest vital signs, primary diagnoses, discharge and functional status, were obtained from the patients' electronic medical records.

Results: A total of 447 patients were studied. The IHCA rate was 8.6/1000 hospital admissions. Forty percent (40%) achieved ROSC with an overall survival to discharge rate of 10.8%, of which 59% had a good functional outcome, with a cerebral performance category score of 1 or 2. Fifty-four percent (54%) of patients had IHCA attributed to causes other than cardiac or respiratory. Admission Glasgow Coma Scale (GCS), shockable rhythm and short code duration were significantly associated with survival (p < 0.001).

Conclusion: A combination of patient and system-related factors, such as the underlying cause of cardiac arrest and a lack of DNAR policy, may explain the reduced survival rate in our setting compared with developed countries.

Keywords: In-hospital cardiac arrest, Determinants of outcomes, Developing country

Introduction

In-hospital cardiac arrest (IHCA) is a significant burden on healthcare all over the world. Most of the studies of IHCA are from developed countries with advanced healthcare systems. In the USA in 2017, there was an estimated 292,000 IHCAs resulting in 9 to 10 IHCA per 1000 hospital admissions.[1] The incidence in the UK in 2013 was estimated at 1.6 per 1000 hospital admissions.[2] Survival rates varied between studies and have increased steadily over the past

decade. In the USA, it currently stands at 25%.[3] In the UK, it is 18%,[2] while in Denmark and Sweden, it is as high as 30%.[4,5] Favourable neurological outcomes of up to 85% have also been reported in survivors.[3,6]

There are very few studies on the incidence and outcomes of IHCA in developing countries. These studies reported worse outcomes compared to the developed world. In a study from Thailand, of 639 patients of all ages, the reported rate of return of spontaneous circulation (ROSC) was 61.7%, and the survival rate was 6.9%. The authors did not report on functional status at discharge.[7] Ngunga and colleagues reported a 4.2% survival to discharge rate in a multicentre study from Kenya. The majority of the patients (98.6%) had non-shockable rhythm, but functional outcome at discharge was not reported.[8]

The United Arab Emirates (UAE) is a high-income developing country with a gross domestic product (GDP) per capita that is ranked 26th highest in the world, ahead of the UK, Spain and Italy.[9] Based on the association of high per capita income and improved healthcare,[10] we postulate that the outcomes of IHCA in our environment will be similar to that of developed countries. IHCA in UAE is, however, poorly studied. Aziz et al. in 2018 reported an IHCA incidence of 11.7 per 1000 hospital admissions and survival to discharge rate of 7.7% in the UAE. However, the study included infants and children and did not report on the neurological outcomes of survivors.[11] We aimed to study the epidemiology and factors that determine outcomes in adult IHCA patients at a Tertiary Centre in Al Ain City, UAE.

Methods

Setting

Al-Ain Hospital is one of two tertiary centres in Al Ain, with 669,000 inhabitants in Abu Dhabi Emirate, the UAE. It has 450 in-patient beds, including 20 ICU beds. All hospital staff have regular Basic Life Support (BLS) training updates. Nursing and medical staff working in critical care areas are Advance Cardiovascular Life Support (ACLS) certified.

Study population

We recruited all adult patients 18 years and above with IHCA at Al Ain Hospital from January 2017 to December 2019. We defined IHCA as an admitted patient who became unresponsive with an absent central pulse and breathing. We excluded the emergency department (ED) patients because IHCA in the ED included those with out-of-hospital cardiac arrests. In addition, our emergency medical team (Code Team) do not attend cardiac arrest calls in the ED.

The code team and recording

The code team, which comprised a board-certified physician, an intensive care nurse, a respiratory specialist and a senior nurse, treated all the patients. The IHCA patients received.

cardiopulmonary resuscitation, including electrical defibrillation as appropriate, followed by standard post-resuscitation care at the Intensive Care Unit (ICU). The event data from the cardiac arrest were collected in real-time by a code team member on a standardised cardiac arrest template (Supplementary file 1). A carbon copy of the arrest template is sent to the resuscitation department, and the original is scanned and kept with the patients' electronic medical records (EMR). A third copy is sent to the manager of the location of

the cardiac arrest. The information in the arrest template is checked for any discrepancies before it is entered into the cardiac arrest data bank. Because our template did not capture pre-arrest vital signs, discharge status and neurological outcomes, these variables were retrospectively obtained through a direct search of the EMR by members of the study team (NAM, MA, and YOH). One of the authors (DOA) validated the data by randomly reviewing 10% of the eligible patients. Finally, in cases of multiple cardiac arrests in a single patient, the first episode was included in the final analysis.

Studied variables

The studied variables were: patient's demographic data (age, sex), arrest recognition day (weekday or weekend) and time (work-hours or off-hours), location (non-critical care or critical care areas), response time, code duration, initial rhythm, shockable rhythm or not, ROSC, primary diagnosis, admission GCS, systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate and respiratory rate. We defined critical care areas as the ICU, Coronary Care Unit (CCU) and Cardiac Catheter lab. Non-critical care areas were surgical, medical and other hospital wards. Working hours were 08:00–17:00, off-hours were 17:01–07:59. Weekend days were Friday and Saturday in accordance with the religion and cultural norms in the UAE. Functional outcome was determined using the cerebral performance category score- a five-point scale ranging from 1 (good cerebral performance) to 5 (brain death).

Ethical consideration

Al-Ain Hospital Research Ethics Governance Committee, Al Ain, the UAE, gave ethical approval for this study (Ref: AAHEC-12–20-031).

Statistical analysis

Data are presented as number (percentage) for categorical, median (interquartile range) for ordinal and continuous variables. We used Pearson's Chi-square or Fisher's Exact Tests to compare categorical independent groups and Mann-Whitney U test for continuous and ordinal variables. We used Statistical Package for the Social Sciences (IBM-SPSS version 26, Chicago, IL) for our analyses. A *p-value* of less than 0.05 was accepted to be significant.

Results

There were 1248 IHCA events in the database during the study period. We excluded patients below 18 years, traumatic cardiac arrests, ED location and duplicate entries due to multiple arrests. 447 patients were eligible for inclusion in the study (Fig. 1). During the study period, the annual average number of hospital admissions was 17412, giving an IHCA rate of 8.6/1000 hospital admissions. The median age (interquartile range) of the patients was 70 (55–81), and 279 (65.8%) patients were male.

Table 1 compared the group that survived with those that died. The proportion of males in the group that survived was higher than those who died (80.4% versus 63.7%, p = 0.032). There was a significant difference in the admission SBP and DBP in those that survived compared with those that died (129 mmHg and 71 mmHg versus 119 mmHg and 66 mmHg, respectively).

There was no significant difference in cardiac arrest event frequency on weekday versus weekend and work-hours versus off-hours (Supplementary file 2). Critical care areas had the highest number of cases, with 337 (79.1%). Overall survival to discharge
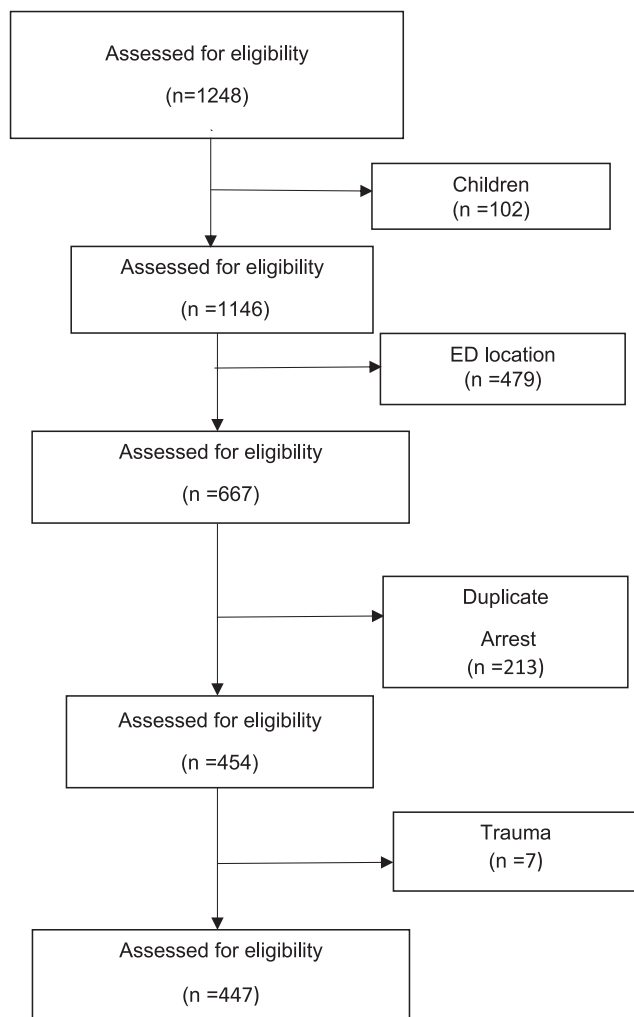
Fig. 1 – Patient flow diagram.

was 10.8%. The survival outcome was not different between non-critical care and critical care areas.

The overall median (IQR) response time was 0 (0–0) minutes. The median (IQR) of the response time was significantly different between the group that survived compared with the group that died (0 (0.0–0.25) and 0 (0.0–0.0), respectively (p = 0.024). The overall median (IQR) code duration was 12 (1.75–22) minutes. The code duration was shorter in those that survived compared with those that died; 2 (0.0–4.25) versus 16 (2–22) minutes, p < 0.001). Non-shockable rhythm (PEA and asystole) constitutes 92.3% of our study population. Of those that died, 95% had an initial non-shockable rhythm compared with 67.4% of those that survived. The overall rate of return of spontaneous circulation (ROSC) was 40.1%.

Other causes of cardiac arrest constitute 54.0% in our study cohort, while cardiac and respiratory causes accounted for 24.6% and 19.7%, respectively (Supplementary file 3). The proportion of those with cardiac and respiratory causes of IHCA was higher in those who survived compared with those who died (54.3% versus 43.9%) but did not reach statistical significance.

Almost two-thirds (58.7%) of the patients who survived to discharge had a Cerebral Performance Category Score (CPC) of 1 or 2, which equates to a good or satisfactory outcome (Supplementary file 4).

The group that survived had shorter median (IQR) code duration, higher proportion of initial Shockable Rhythm and a higher median (IQR) admission GCS compared with those that died (2 (0.0–4.25) versus 16 (2–22), 32.6% versus 4.7%, and 15(15–15) versus 13 (6–15) respectively, (p-value < 0.001).

Discussion

The annual incidence of IHCA in this study was 8.6 per 1000 hospital admissions. Overall survival to discharge was 10.8%, of which about two-thirds (58.7%) had a satisfactory neurological outcome, with a CPC score of 1 or 2.

Incidence and survival rate
The incidence of IHCA in this study was similar to the 9–10 per 1000 hospital admissions reported from the USA [1] but substantially higher than the 1.6 per 1000 hospital admissions reported from the UK.[2] The wide variations may be due to the differences in study populations and patient selection.

Our survival rate of 10.8% is less than that reported from the UK and the USA[2,3] but better than reports from Thailand and Kenya.[7,8] Outcomes of IHCA in developing countries are generally worse than in developed ones. Various factors may be contributing to the poor outcomes, including underfunding of the health sector, underdeveloped systems of care and deficiencies in resuscitation research and science.[13] However, these factors are only partially applicable to the UAE- a developing country with one of the highest per capita incomes in the world.

Initial arrest rhythm
The proportion of shockable rhythm was about seven times higher in the group that survived compared with the group that died (32.6% versus 4.7%). A higher percentage of patients with shockable rhythm survived compared with those with non-shockable rhythm 15 (45.5%) versus 31 (7.9%). Similarly, Skrifvars and colleagues reported a survival odds ratio of 4.9 in those that had a shockable rhythm compared with non-shockable rhythm.[14] However, 92.3% of our cohort had a non-shockable rhythm. This contrasts with the 81% reported in the Get with the Guideline-Resuscitation (GWTG-R) from the USA and the 72.3% from the UK.[3,2] It is, however, similar to that reported from Thailand and Kenya.[7,8] The initial rhythm composition of our IHCA is thus similar to that in developing countries, but outcomes in the shockable group were similar to those in the developed countries.

Underlying causes of arrest
Studies from the USA, Italy and South Korea reported cardiac (50–60%) and respiratory (15–40%) as the main causes of IHCA.[15,16,17] This contrasts with our results, in which cardiac and respiratory causes accounted for only 44% (Supplementary file 3). The higher percentage of non-cardiac causes of IHCA in our cohort may have resulted in a disproportionately lower shockable rhythm and a lower overall survival to discharge rate. The UAE belief system and cultural practices did not allow for advanced directives for cardio-pulmonary resuscitation. As a result, none of our patients had an advance Do Not Attempt Resuscitation (DNAR) in place at the time of their cardiac arrest. All were given cardio-pulmonary resuscitation regardless of the underlying pathology or reduced likelihood of success. In a study from the UK, Hodgett and colleagues reported a DNAR rate

Table 1 – Patients' demographic information, admission data, arrest data by outcome.

Variables	Survived (N = 46)	Died (N = 380)	p-value
Age [median(IQR)]	62.5 (47.5–80.8)	70 (55–81)	0.074
Sex [n(%)]			0.032
Male	37 (80.4)	242 (63.7)	
Female	9 (19.6)	138 (36.3)	
Admission Parameters [median(IQR)]			
Glasgow Coma Scale	15 (15–15)	13 (6–15)	<0.001
Systolic Blood Pressure	129 (113–146)	119 (100–140)	0.019
Diastolic Blood Pressure	71 (65.5–93.0)	66 (56–79)	0.003
Heart Rate	89 (74–113.5)	91 (79–109)	0.561
Respiratory rate	19 (17–24)	19 (17–24)	0.932
Arrest Recognition Day [n(%)]			0.719
Weekday	36 (78.3)	283 (74.5)	
Weekend	10 (21.7)	97 (25.5)	
Arrest Recognition Time [n(%)]			0.149
Work-Hours	23 (50.0)	144 (37.9)	
Off-Hours	23 (50.0)	236 (62.1)	
Location [n(%)]			0.846
Non-critical care Area	11 (23.9)	78 (20.5)	
Critical care Area	35 (76.1)	302 (79.5)	
Primary Diagnosis [n(%)]			0.343
Cardiac	15 (32.6)	90 (24.1)	
Respiratory	10 (21.7)	74 (19.8)	
Others	21 (45.7)	216 (56.0)	
Response Time [median(IQR)]	0 (0.0–0.25)	0 (0.0–0.0)	0.024
Initial Rhythm [n(%)]			<0.001
Asystole	8 (17.4)	192 (50.5)	
PEA	23 (50.0)	170 (44.7)	
VF	13 (28.3)	8 (2.1)	
pVT	2 (4.3)	10 (2.6)	
Shockable Rhythm [n(%)]			<0.001
Yes	15 (32.6)	18 (4.7)	
No	31 (67.4)	362 (95.3)	
Code Duration [median(IQR)]	2 (0.0–4.25)	16 (2–22)	<0.001
ROSC [n(%)]			<0.001
Yes	46 (100)	125 (32.9)	
No	0 (0.0)	255 (67.1)	

Data are presented as median (interquartile range) or number (%) as appropriate.

P-value = Fisher's Exact test for categorical data and Mann Whitney U test for ordinal or continuous data.

of 88.5 %.[18] Others have reported rates varying from 28% to 90 %.[19,20,21] The reported incidence of IHCA would have been lower and survival to discharge rate higher in our cohort if we had similar DNAR rates. Advanced directive planning in terminally ill patients with cancer, chronic renal disease, and cerebrovascular accidents, for example, is cost-effective as it utilises fewer critical care resources. In addition, it allows terminally ill patients to die with dignity and reduces post-traumatic stress disorder in bereaved families.[22] Although there is now an initiative to introduce the practice of DNAR in our region, we anticipate it will take time to embed it in our clinical practice due to cultural barriers.

Factors associated with survival

Our study showed that higher admission GCS, male sex, shockable rhythm and short code duration showed significant association with survival. This is similar to the report from Taiwan.[23] Those who died had a higher mean duration of resuscitation. Fernando et al., in a recent meta-analysis, reported a survival odds ratio of 0.12 when the duration of resuscitation is more than 15 minutes.[24] This might

reflect the absence of non-reversible causes but may also indicate a lack of early recognition of futility by our emergency medical team. In a study of out-of-hospital cardiac arrest from Sweden, Engdahl and colleagues reported a 2.5 fold increase in survival to discharge in patients with cardiac causes of arrest as compared with non-cardiac causes.[25] Future studies are required to determine outcomes in IHCA patients with non-cardiac causes who had an initial shockable rhythm.

This study showed no difference in survival to discharge in IHCA in critical care areas compared with non-critical care areas. This is at variance with reports from the UK, which showed better survival in IHCA that occurred in critical care areas of the hospital.[12] The fact that 79% of our patients were already admitted to a critical care area by the time of their IHCA may have influenced our results. There was a significant difference in response time between the two groups. A delayed response time could lead to the degeneration of an initial shockable rhythm to non-shockable.

Previous studies have reported an increased incidence of IHCA at weekends and office hours.[12,14,26] Our results have shown no sig-

nificant difference in the incidence and outcomes of IHCA by days of the week or working hours. A possible explanation for this is that our medical and nursing staff operate a seven-day working week, and there is no difference in staffing levels by day of the week.

Survival was significantly higher in males than in females in our study. Studies on out-of-hospital cardiac arrest have shown that female sex is associated with worse survival to hospital discharge and poorer neurological outcomes at six months.[27,28] This is because females have worse arrest characteristics such as older age, increased unwitnessed arrest, less likely to receive bystander CPR, fewer shockable rhythms, and fewer presumed cardiac causes of arrest. Some of these factors are relevant to IHCA and may explain our results.[27,28]

Limitations

The current study has some limitations. First, this is a single-centre study, and the results may not be generalisable to the whole of the country. Nonetheless, the staffing level and practices are similar in all of the centres in our region. Second, we excluded all cardiac arrests that occurred in the ED because most of those were out-of-hospital cardiac arrests. However, in so doing, we may have excluded some cardiac arrests that occurred primarily in the ED. Third, we do not know the final cause of death in our cohort because the UAE does not allow post-mortem examination for religious and cultural reasons. Fourth, having more than 50% of patients in the non-cardiac and non-respiratory diagnoses category might have affected our results compared to developed systems. Finally, we do not currently have a national IHCA registry that can provide much more extensive and more detailed data on long term outcomes of IHCA.

Conclusions

This is the first study on the incidence and outcomes of adult in-hospital cardiac arrest in the UAE that has highlighted the adverse role of underlying pathology on outcomes of IHCA. Code duration, admission GCS and initial rhythm are significantly associated with IHCA survival. However, other factors such as the underlying cause of the arrest may play a significant role and should be the subject of future studies. Our results showed IHCA incidence that is similar to some developed countries but with a lower survival to discharge rate.

There is a need for studies and research on cardiac arrest from countries with different economic and developmental indices. This study provides an additional perspective to the complex interplay of resources and setting on the clinical outcomes of cardiac arrest. Future studies are required to validate the results of the current study.

Contribution of authors

DOA was responsible for the study conception and design. NAM, YOH, MA, and EHD contributed to the acquisition and coding of data. AAC and DOA analyzed the data and wrote the results section. DOA drafted the manuscript. AAC, NAM, YOH, MA, EHD and ZJ critically read the manuscript. All authors read and approved the final manuscript.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2022.100220.

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