Irish Medical Journal
Established 1867

Issue: Ir Med J; Vol 114; No. 9; P465

In-Hospital Cardiac Arrests: A study of Incidence and Outcomes

R. Gardiner[1], L. Byrne[1], N. Flaherty[1], C. Farrell[1,2], I. Mirza[1,2], C. Dunleavy[1], R. Murphy[1,2]

1. Department of Cardiology, St. James's Hospital, James Street, Dublin 8.
2. Trinity College Dublin, College Green, Dublin 2.

Abstract

Introduction

In-hospital cardiac arrest (IHCA) is a sentinel event for patients. Recent studies report the survival rate to be between 1.5 and 10.4 per 1000 patients/year. We aim to determine the incidence of IHCA in a tertiary Irish hospital in 2019 and examine outcomes following IHCA.

Methods

Data was collected on IHCAs using the electronic patient record (EPR) software. Descriptive statistics were used to describe patient characteristics and variables of each IHCA. The Chi-squared test, Fisher Exact test and unpaired Student's t-test were used to assess significance.

Results

The arrest code was activated 226 times. One hundred and nineteen patients (58%) met the criteria for IHCA. The incidence of IHCA was 5.1 per 1000 patients/year. Survival to discharge was 32.8% (N=39). The first rhythm was shockable in 39.5% of cases (N=47) with 48.9% (N=23) surviving until discharge. Fifty arrests (42%) occurred on ward level. There was a significant survival benefit seen with IHCAs occurring outside of ward level and those with an initial shockable rhythm ($p<0.05$).

Conclusion

This hospital is a large center for primary percutaneous coronary intervention. This may account for the higher incidence of shockable rhythms and thus higher survival rates. Monitoring of trends of IHCA incidence and outcomes is important for future planning, resource allocation and training provision.

Introduction

A cardiac arrest is defined by the Utstein criteria as the cessation of cardiac mechanical activity, which is confirmed by the absence of a palpable pulse, unresponsiveness and apnoea (or agonal respiratory attempts).[1] An 'in-hospital arrest', as per the Utstein criteria, is one that occurs in a hospitalised patient who had a pulse at the time of admission.[1]

There is a shortage of studies on in-hospital cardiac arrest (IHCA) in Ireland and there is currently no national registry. A study carried out in Cork University Hospital (CUH) in 2011 reported 63 IHCAs over a 1-year period, an incidence of 1.5 per 1000 patients/year.[2] This is in keeping with findings from the UK National Cardiac Arrest Audit, where an overall incidence of 1.6 per 1000 hospital admissions was reported.[3] Survival to discharge was 27% for patients in CUH and survival was worse for IHCAs occurring at ward level. 30.2% of arrests were shockable.[2] The UK data showed that 18.4% of patients suffering IHCA survived until discharge.[3]

Fennelly et al reported a higher incidence of 10.4 per 1000 patients/year in Beaumont Hospital from 2010-2013, of which 15.6% were shockable.[4] Overall, 18.4% survived until discharge. A significant association was identified between return of spontaneous circulation and shockable IHCAs (versus non-shockable). Again, arrests occurring at ward level were associated with reduced survival.

In the United States, between the years of 2008 and 2017, the incidence of IHCA is reported as 9.7 per 1000 hospitalisations.[5] The survival to rate in 2016 was 25.8%. On an international level, reported survival to discharge varies between 0% and 42%, with larger studies reporting a figure of approximately 20%.[1]

This study was carried out in St James's Hospital, a large university teaching hospital and a primary percutaneous coronary intervention (PCI) center. St James's Hospital preforms 25.8% of primary PCI cases in the Republic Ireland, the highest proportional nationally.[6]

A cardiac arrest alert is activated in St. James's Hospital by calling through to the hospital switchboard. The cardiac arrest team is alerted and attends promptly. During normal working hours the cardiac arrest team in St James's Hospital comprises of a cardiology registrar, cardiology senior house officer, cardiology intern, anesthetics registrar, resuscitation officer and cardiac care nurse. Outside of normal working hours a medical registrar, medical senior house officer and medical intern replace their cardiology counterparts. The resuscitation officer is replaced by the site nurse manager outside of working hours.

In this study we aim to determine the incidence and outcomes of IHCA in St. James's Hospital in 2019 and compare this to national and international figures. We aim to identify characteristics of IHCA that are associated with improved survival to discharge.

Methods

A record is made each time the cardiac arrest alert is activated via the hospital switchboard. This data was used as a starting point and the Electronic Patient Record (EPR) hospital computer software was accessed to consolidate this data. Information was gathered on baseline patient demographics, characteristics of IHCA and outcomes following IHCA.
The Utstein criteria were used to define IHCA. We excluded all incidences when the arrest code was activated for reasons other than IHCA. The Charlson Comorbidity Index (CCI) is used to describe the comorbidities of the patient population. Categorical variables are presented as percentages and continuous variables are presented as mean (+/- standard deviation). The Chi-squared test, Fisher Exact test and the unpaired Student's t test were used to determine clinical significance and a 2 tailed p value of <0.05 was deemed significant. Data collection and statistical analysis was performed using Microsoft Excel software.

Results

2019 saw in excess of 23,000 inpatient admissions, 300,000 outpatient attendances and 50,000 emergency department attendances to the hospital. During this period the cardiac arrest code was activated on 226 occasions. One hundred and nineteen events met the criteria for IHCA, an incidence of 5.1 per 1000 patients/year. For instances other than IHCA, the arrest code was activated most often for syncope, seizure, hypotension, airway compromise and desaturation.

Patient and arrest characteristics for the 119 episodes of IHCA are displayed in Table 1. Associations of characteristics with survival to discharge are displayed in Table 2.

Mean age at time of IHCA was 79.8 years (+/- 12.5). Seventy-nine patients were male (66.4%). The survival rate was 56.3% at 24 hours (N=67). Thirty-nine patients survived until discharge (32.8%). There was no significant association between age and survival until discharge ($p=0.13$). However, there was a trend towards improved survival in patients < 70 years of age. Females were more likely to survive until discharge (55.6% versus 30.4%, $p=0.02$).

The most common location for IHCA was on ward level (42%, N=50). This includes both medical and surgical wards. Arrests occurring on ward level were associated with a significantly worse survival to discharge when compared to other locations in the hospital (14% versus 46.4%, $p<0.001$).

The majority of IHCAs (70.6%) occurred outside of normal working hours (defined as between 09:00 and 17:00 on weekdays). There was no statistically significant difference in terms of survival to discharge between IHCAs occurring inside and outside of normal working hours (p=0.36).

Forty-eight patients were under the care of the cardiology team at the time of IHCA (40.3%). Surgical teams were caring for the patients in 23.5% of cases (N=28) and medical teams (other than cardiology) in 33.6% (N=40) of cases.

The first documented rhythm was shockable in 39.5% of cases (N=47) and of those, 48.9% (N=23) survived until discharge. This is compared to a 23.4% (N=15) survival rate when the first documented rhythm was non-shockable ($p<0.05$).

The most common discharge destination was home (56.4% of survivors, N=22). Twelve patients were transferred to another hospital (30.8%). In many of these cases patients were transferred to their local hospital post undergoing primary PCI in this center. The remainder were discharged to a long-term care facility (12.8%, N=5).

Patient comorbidities are listed in Table 3. Mean CCI scores for the patient groups are shown in Table 4. The most common comorbidity was myocardial infarction (54.6% of total patients, N=65). This was more common in men than women and more common in patients who survived until discharge (61%, N=24). Of the patients who did not survive until discharge, 11.3% had a metastatic solid tumor. Only 1 patient with a metastatic solid tumor survived until discharge after IHCA. There was no significant association between individual comorbidities and survival to discharge. Survivors of IHCA had a lower total CCI score when compared to patients who did not survive (4.9 vs 6.1, p=0.020685312).

Other common comorbidities in the patient population included congestive heart failure (42%, N=50), localized solid tumor (21%, N=26), cerebrovascular accident/transient ischemic attack (18.5%, N=22), moderate to severe chronic kidney disease (17.6%, N=21), uncomplicated diabetes (12.6%, N=15), chronic obstructive pulmonary disease (10.9%, N=13) and peripheral vascular disease (10.9%, N=13).

Characteristic	Number of patients (% of total)	Characteristic	Number of patients (% of total)
Gender:		Rhythm:	
Male	79 (66.4%)	Shockable	47 (39.5%)
Female	40 (33.6%)	Non-shockable	64 (53.8%)
		Unknown	8 (6.7%)
Age:			
Mean (+/- SD)	79.8 years (+/- 12.5)	Survival at arrest:	
Median	74 years	Yes	73 (61.3%)
		No	46 (38.7%)
Timing:			
Working hours	31 (26.1%)	Survival at 24 hours:	
Outside of working hours	84 (70.6%)	Yes	67 (56.3%)
Unknown	4 (3.4%)	No	52 (43.7%)
Location:		Survival to discharge:	
Ward	50 (42%)	Yes	39 (32.8%)
ICU	20 (16.8%)	No	80 (67.2%)
CCU	15 (12.6%)		
Cardiac Catheterisation Lab	21 (17.6%)	Discharge destination:	
Other	13 (10.9%)	Home	22 (56.4%)
		Another hospital	12 (30.8%)
Treating team:		Long-term care	5 (12.8%)
Cardiology	48 (40.3%)		
Medical	40 (33.6%)		
Surgical	28 (23.5%)		
Other	3 (2.5%)		

Table 1: Patient and IHCA characteristics.

Characteristic	Number of patients surviving to discharge (% of total)	P value
Age:		
<70 years	19 (39.6%)	0.14
≥70 years	19 (26.8%)	
Gender:		
Male	24 (30.4%)	0.019188
Female	15 (55.6%)	
Time of arrest:		
Working hours	12 (38.7%)	0.362055
Outside of working hours	25 (29.8%)	
Location of arrest:		
Ward	7 (14%)	<0.001
Locations other than ward	32 (46.4%)	
Rhythm:		
Shockable	23 (48.9%)	0.005
Non-shockable	15 (23.4%)	

Table 2: Associations of patient and IHCA characteristics with survival to discharge.

Comorbidity	All patients (% of total)	Males (% of total)	Females (% of total)	Patients surviving to discharge (% of total)	Patients not surviving to discharge (% of total)	Association of CCI variable with survival to discharge (P value)
Myocardial infarction	65 (54.6%)	48 (60.8%)	17 (42.5%)	24 (61.5%)	41 (51.3%)	0.289987
Congestive heart failure	50 (42%)	33 (41.8%)	17 (42.5%)	16 (41%)	34 (42.5%)	0.878439
Peripheral vascular disease	13 (10.9%)	12 (15.2%)	1 (2.5%)	2 (5.1%)	11 (13.8%)	0.157004
Cerebrovascular accident/transient ischemic attack	22 (18.5%)	13 (16.5%)	9 (22.5%)	4 (10.3%)	18 (22.5%)	0.106319
Dementia	8 (6.7%)	6 (7.6%)	2 (5%)	1 (2.6%)	7 (8.8%)	0.205917
Chronic obstructive pulmonary disease	13 (10.9%)	8 (10.1%)	5 (12.5%)	4 (10.3%)	9 (11.3%)	0.870446
Connective tissue disease	5 (4.2%)	0	5 (12.5%)	1 (2.6%)	4 (5%)	0.534147
Peptic ulcer disease	2 (1.7%)	0	2 (5%)	0	2 (2.5%)	1
Liver disease (mild)	5 (4.2%)	5 (6.3%)	0	2 (5.1%)	3 (3.8%)	0 .72503
Liver disease (moderate to severe)	1 (0.8%)	1 (1.3%)	0	0	0	1
Diabetes (uncomplicated)	15 (12.6%)	12 (15.2%)	3 (7.5%)	4 (10.3%)	11 (13.8%)	0.589911
Diabetes (end-organ damage)	9 (7.6%)	6 (7.6%)	3 (7.5%)	3 (7.7%)	6 (7.5%)	0.970292
Hemiplegia	2 (1.7%)	1 (1.3%)	1 (2.5%)	0	2 (2.5%)	1
Chronic kidney disease (moderate to severe)	21 (17.6%)	19 (24.1%)	2 (5%)	5 (12.8%)	16 (20%)	0.334885
Solid tumor (localized)	26 (21%)	17 (21.5%)	9 (22.5%)	10 (25.6%)	16 (20%)	0.484548
Solid tumor (metastatic)	10 (8.4%)	3 (3.8%)	7 (17.5%)	1 (2.6%)	9 (11.3%)	0.108919
Leukemia	1 (0.8%)	1 (1.3%)	0	0	1 (1.3%)	1
Lymphoma	2 (1.7%)	1 (1.3%)	1 (2.5%)	1 (2.6%)	1 (1.3%)	0.600664
AIDS	0	0	0	0	0	1

Table 3: CCI variables in patient groups and association of CCI variables with survival to discharge.

	All patients	Males	Females	Patients surviving to discharge	Patients not surviving to discharge	P value (patients who survived to discharge vs patients who did not)
Mean CCI score (+/-standard deviation)	5.8 (+/-2.7)	5.7 (+/-2.7)	5.9 (+/-2.6)	4.9 (+/-2.5)	6.1 (+/-2.7)	
						0.020685312

Table 4: Mean CCI score in patient groups.

Discussion

We report an IHCA incidence of 5.1 per 1000 patients/year. This is higher than the incidence reported in Cork University Hospital in 2011 and that reported by the UK National Cardiac Arrest Audit.[2, 3] It is less than half of the incidence reported by Beaumont Hospital in 2010-2013 (10.4 per 1000 patients/year).[4] Shockable rhythms accounted for a larger proportion of arrests (39.5%) and the survival to discharge rate (32.8%) was notably higher than that reported in similar studies.

The higher incidence of shockable rhythms may be in part explained by the high volume of ST elevation myocardial infarctions (STEMI) treated with primary PCI in this hospital. The greater proportion of shockable rhythms is the likely explanation for the higher-than-expected survival rate.

A higher rate of survival to discharge was seen with female patients. The significance of this finding should be interpreted with caution given that the patient numbers in this study are small (40 female patients, 15 of whom survived until discharge). Many studies have failed to show that gender influences survival to discharge.[1] However, other studies such as that by Herlitz et al.[7] have shown female gender to be an independent predictor for survival to discharge.

Ofoma et al.[8] have demonstrated in a previous study of US patients that survival was significantly lower in patients who arrested during off-hours compared with on-hours (16.8% vs. 20.6%; $p < 0.0001$). Although survival in both groups improved over time (the study period was between 2000 and 2014), the survival difference persisted between the groups. In our study, there was no difference in survival between IHCAs occurring during and outside of normal working hours. This is reassuring and suggests a consistent standard of training in resuscitation techniques across the board for junior medical doctors.

In line with other studies, survival was worse for IHCAs occurring on the medical and surgical wards.[2, 4] This was the most frequent location for IHCA (42%). This suggests that additional systems need to be put in place to allow for the early detection of clinical deterioration on the ward level. When appropriate, high-risk patients can then be transferred to a more suitable clinical setting with more intensive monitoring.

In our study, in 47.3% of cases, the cardiac arrest code was activated for reasons other than cardiac arrest. This suggests a protentional role for a medical emergency team (MET), that could be called upon in the case of a clinically deteriorating patient, not meeting the criteria for IHCA. A MET team typically consists of medical and nursing staff from the intensive care and general medical teams. Studies on the effectiveness of MET teams have shown promising results.[1]

Following the introduction of a MET system in a tertiary referral hospital, Bellomo et al.[9] reported a relative risk reduction of 65% in the incidence of IHCA, 55% in death following cardiac arrest and 88% in overall in-hospital mortality. In the UK, the Aintree University Hospitals Trust implemented this system and reported a sustained 33% decrease in cardiac arrest calls as a result. In addition, there was a reduction of >50% of clinical incidents relating to failure to manage acute deterioration.[10]

From an Irish perspective, an Emergency Response System was implemented in Tallaght University Hospital in 2012. An audit in 2014 showed a 21% decrease in the number of IHCA calls in a one-year period. Of the patients who triggered an Emergency Response Team call, 63% were discharged home, 31% did not survive to discharge and 6% were still inpatients at the end of the study period.[11]

However, the majority of studies on METs have not been double-blinded or placebo-controlled. This must be taken into account when interpreting the results. The positive results may partly be explained by an increase in the number of not-for-resuscitation orders and the education of staff on the ward that is typical prior to the introduction of a MET.[1, 12, 13] When Hillman et al.[14] randomised 23 hospitals in Australia to continue functioning as usual or to introduce a MET system, they found no significant difference in the incidence of IHCA, unplanned intensive care unit (ICU) admissions or unexpected deaths between the groups.

Improvements in the standard of living and advances in healthcare has resulted in people living for longer.[15] The population of Ireland is aging and the prevalence of frailty increases with age. Frailty places older adults at risk of hospitalization with longer duration of hospital stays. It is therefore likely that the number of IHCAs will increase in line with this. Holmberg et al estimated a 23% increase in the annual incidence of IHCA in the United States from 2008 (268200 cases) to 2017 (328700 cases).[5] The health system in Ireland needs to be prepared for the public health burden from IHCA that we can expect in the coming years.

Older age is also associated with worse survival following IHCA. A Swedish study of more than 11,000 patients found that the thirty-day survival rate was 28% for patients aged 70–79 years, 20% for patients aged 80–89 years, and 14% for patients aged ≥90 years.[16] Differences in cut-off values for age leads to difficulty in making comparisons between studies. Age above and below 70 years has been used as a cut off value in multiple studies.[17-19] Although there was no significant association between age and survival to discharge in our study, there was a trend towards improved survival in patients < 70 years of age.

It is important that up-to-date statistics on incidence and outcomes of IHCA are available when informing patients and family members about likely prognosis should IHCA occur. It can inform decision making on resuscitation status and avoid inappropriate ICU admissions. It is also imperative to guide allocation of hospital resources. This includes the Basic Life Support and Advanced Cardiac Life Support training programmes and the provision of intensive care beds within the hospital.

In 2016 Sinha et al.[20] reported a striking lack of randomised control trials on treatments for IHCA. In order to improve outcomes, more research needs to be carried out in this area.

We acknowledge that not all episodes of IHCA result in activation of the arrest code, in particular IHCAs that occur in the cardiac catheterisation lab or in the ICU. In these cases, there is often sufficient trained personnel present who can manage the arrest without the need for additional support. For this reason, the incidence of IHCA may be greater than reported.

As data was collected retrospectively for this study, not all data points could not be obtained for each episode of IHCA. Missing data accounts for <1% of the total data points.

Declaration of Conflicts of Interest:
No conflicts of interest to declare.

Corresponding Author:
Roisin Gardiner
Department of Cardiology,
St. James's Hospital,
Dublin 8
E-Mail: roisingardiner@gmail.com

References:

1. Sandroni C, Nolan J, Cavallaro F, Antonelli M. In-hospital cardiac arrest: incidence, prognosis and possible measures to improve survival. Intensive Care Med. 2007;33(2):237-45.
2. O'Sullivan E, Deasy C. In-hospital Cardiac Arrest at Cork University Hospital. Ir Med J. 2016;109(1):335-8.
3. Nolan JP, Soar J, Smith GB, Gwinnutt C, Parrott F, Power S, et al. Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. Resuscitation. 2014;85(8):987-92.
4. Fennelly NK, McPhillips C, Gilligan P. Arrest in hospital: a study of in hospital cardiac arrest outcomes. Ir Med J. 2014;107(4):105-7.
5. Holmberg MJ, Ross CE, Fitzmaurice GM, Chan PS, Duval-Arnould J, Grossestreuer AV, et al. Annual Incidence of Adult and Pediatric In-Hospital Cardiac Arrest in the United States. Circ Cardiovasc Qual Outcomes. 2019;12(7):e005580.
6. Jennings S, Daly K, Cavanagh B, O'Donnell C. Standardising care for heart attack (STEMI) patients, Ireland. International Journal of Integrated Care. 2017;17(3):A133.
7. Herlitz J, Rundqvist S, Bång A, Aune S, Lundström G, Ekström L, et al. Is there a difference between women and men in characteristics and outcome after in hospital cardiac arrest? Resuscitation. 2001;49(1):15-23.
8. Ofoma UR, Basnet S, Berger A, Kirchner HL, Girotra S, Investigators AHAGWtGR. Trends in Survival After In-Hospital Cardiac Arrest During Nights and Weekends. J Am Coll Cardiol. 2018;71(4):402-11.
9. Bellomo R, Goldsmith D, Uchino S, Buckmaster J, Hart GK, Opdam H, et al. A prospective before-and-after trial of a medical emergency team. Med J Aust. 2003;179(6):283-7.
10. The Aintree Medical Emergency Team [Internet]. NICE. 2011 [cited 11 January 2021]. Available from: https://www.nice.org.uk/sharedlearning/the-aintree-medical-emergency-team
11. An Audit of the Emergency Response System in Tallaght Hospital 2014 - State Claims Agency [Internet]. Stateclaims.ie. 2016 [cited 11 January 2021]. Available from: https://stateclaims.ie/ezine/an-audit-of-the-emergency-response-system-in-tallaght-hospital-2014
12. Smith GB, Nolan J. Medical emergency teams and cardiac arrests in hospital. Results may have been due to education of ward staff. BMJ. 2002;324(7347):1215; author reply
13. Parr MJ, Hadfield JH, Flabouris A, Bishop G, Hillman K. The Medical Emergency Team: 12 month analysis of reasons for activation, immediate outcome and not-for-resuscitation orders. Resuscitation. 2001;50(1):39-44.
14. Hillman K, Chen J, Cretikos M, Bellomo R, Brown D, Doig G, et al. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. Lancet. 2005;365(9477):2091-7.

15. Roe L, Normand C, Wren MA, Browne J, O'Halloran AM. The impact of frailty on healthcare utilisation in Ireland: evidence from the Irish longitudinal study on ageing. BMC Geriatr. 2017;17(1):203.
16. Hirlekar G, Karlsson T, Aune S, Ravn-Fischer A, Albertsson P, Herlitz J, et al. Survival and neurological outcome in the elderly after in-hospital cardiac arrest. Resuscitation. 2017;118:101-6.
17. de Vos R, Koster RW, De Haan RJ, Oosting H, van der Wouw PA, Lampe-Schoenmaeckers AJ. In-hospital cardiopulmonary resuscitation: prearrest morbidity and outcome. Arch Intern Med. 1999;159(8):845-50.
18. Cooper S, Cade J. Predicting survival, in-hospital cardiac arrests: resuscitation survival variables and training effectiveness. Resuscitation. 1997;35(1):17-22.
19. Di Bari M, Chiarlone M, Fumagalli S, Boncinelli L, Tarantini F, Ungar A, et al. Cardiopulmonary resuscitation of older, inhospital patients: immediate efficacy and long-term outcome. Crit Care Med. 2000;28(7):2320-5.
20. Sinha SS, Sukul D, Lazarus JJ, Polavarapu V, Chan PS, Neumar RW, et al. Identifying Important Gaps in Randomized Controlled Trials of Adult Cardiac Arrest Treatments: A Systematic Review of the Published Literature. Circ Cardiovasc Qual Outcomes. 2016;9(6):749-56.