Introduction

In-hospital cardiac arrest (IHCA) is a major problem in modern healthcare. In the United States there are approximately 209,000 IHCAs per year with an in-hospital mortality of 60-80%¹, a mortality which has remained unchanged over 40 years².

Training and education of hospital staff in the recognition and treatment of IHCAs requires considerable resources. The major focus of such training is basic life support (BLS) and advanced cardiac life support (ACLS) which emphasises the importance of administration of early and effective chest compressions, as well as early and appropriate cardiac defibrillation. A previous single centre study³, however, suggested that less than a quarter of IHCAs had an initial defibrillation responsive rhythm. The generalisability of this finding to other hospitals in Australia and New Zealand (ANZ) is unknown. While the epidemiology of IHCA has been extensively studied in the United States and Europe⁴⁻¹¹ less is known on the epidemiology of these patients in ANZ.

We undertook a systematic review of studies reporting on the incidence, characteristics and outcomes of IHCA in ANZ to examine the frequency of IHCA. Furthermore, we assessed for an association between RRS presence and the incidence of IHCA. In addition, we assessed the documentation of pre-morbid patient demographics and co-morbidities, the details of the initial detected rhythm, and aspects of BLS and ACLS. Finally, we examined the outcomes of IHCA and associations with such outcomes.

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Materials and methods

Search strategy and cross checking of data

We reviewed Medline for studies published between January 1964 and November 2014 to detect all original studies and reviews using the following medical subject heading terms; “arrest AND hospital AND Australia”, “arrest AND hospital AND New Zealand”, “inpatient AND arrest AND Australia”, and “inpatient AND arrest AND New Zealand”.

Studies were included if they reported on the characteristics and outcomes of cardiac arrests occurring in adult patients (>18 years) on a general hospital ward. We excluded papers that involved exclusively out-of-hospital cardiac arrests or studies that were not conducted in Australia or New Zealand. We also excluded studies that examined cardiac arrests within the Intensive Care Unit (ICU). A single investigator (GF) screened all abstracts, reviewed all manuscripts and populated the study tables. Two additional investigators (AH and SR) double-checked all abstracts blindly to ascertain if any potential manuscripts were missed.

We assessed and reported separately on population studies and studies presenting detailed patient cohort analysis. Population studies were those from which overall IHCA data were available without investigators being able to extract original (raw) data.

Research questions and data collected

All authors agreed *a priori* the major research questions for the study, as well as the final analysis plan. These questions included evaluation of the cohort size, number of IHCA, number of hospital admissions during the study period, the incidence of IHCA per 1000 hospital admissions, and whether the study was conducted before or after the introduction of a rapid response system (RRS).

In studies where data were available, we also collected information of the demographics of the patients who suffered IHCA including; age and gender, place of residence, functional status, documented co-morbidities and admission diagnoses. In addition, we evaluated studies for the details of initial rhythm (ventricular tachycardia (VT), ventricular fibrillation (VF), pulseless electrical activity (PEA), asystole) or whether the rhythm was “shockable” (VT, VF) or “not shockable” (asystole, PEA, non-VF/VT). Furthermore, we assessed whether the IHCA was witnessed or monitored, as well as the time of day and day of week that the arrest was detected.

Details of the provision of BLS and ACLS were obtained. In particular, we documented whether there was a return of spontaneous circulation (ROSC) and the time to ROSC. We also recorded the outcome of the arrest including death during the cardiac arrest, death in-hospital, medium term mortality and functional outcome. Finally, we assessed manuscripts for analysis reporting on predictors or associations with in-hospital cardiac mortality, which we classified prospectively as “patient factors”, “initial rhythm”, “aspects of BLS / ACLS”, “logistic factors” and “other”.

Results

Details of literature review and included studies

We identified 934 studies, of which 60 were further analysed for suitability for inclusion, and 30 were finally included (Figure 1). Of the 30 studies included, four publications were “population studies” (IHCAs presented as aggregate data) and 26 studies were “cohort studies” (IHCAs presented as detailed data). The earliest study identified was published in 1987.

Frequency of IHCAs

Population studies

Four population studies reported aggregate data on the frequency and outcomes of IHCAs, representing the findings from more than 11.5 million hospital admissions (Table 1). The frequency of IHCAs in these studies ranged from 1.31 to 6.11 per 1000 admissions.

Cohort studies

Sixteen single centre studies and one multi-centre study reported specific data on the frequency of IHCAs, with values ranging from 0.58 to 4.59 per 1000 admissions (Table 2). Of these, 13 studies simultaneously reported data on both hospital admissions and the number of IHCAs, a total of 2,302 IHCAs in 1,021,262 admissions (aggregate frequency 2.25 IHCAs per 1000 admissions).

Presence of Rapid Response System (RRS)

Overall, 12 studies documented information on both IHCA and the presence of a RRS (Tables 3A and 3B). Where there was no RRS, the frequency of IHCA ranged from 2.90 to 5.06 per 1000 admissions (Table 3A) with raw data from three studies reporting an aggregated value of 4.11 IHCA per 1000 admissions. In contrast, in the presence of a RRS the frequency of IHCA ranged from 0.58 to 3.76 per 1000 admissions (Table 3B) with raw data from seven studies reporting an aggregated value of 1.32 IHCA per 1000 admissions. The respective frequencies reflect an odds ratio of 0.32 for IHCA where a RRS is present (95% CI 0.28-0.37; $p < 0.001$).

Demographics of patients suffering IHCA

Only seven studies reported some demographic details of IHCA (Table 4). In aggregated data from five studies providing information on patient gender, 63.5% were male and in six studies providing information on patient age, the average ranged between 66.5 and 74.9 years. Three studies reported on the type of admission, and when combined, 72.5% of IHCA occurred in non-surgical admissions. Co-morbidities were only reported by Smith et al²⁸ for 91 IHCA. The Charlson co-morbidity index was 1 to 4 in 68% and greater than 4 in 7% of patients. No study provided information on initial place of residence or admission diagnosis.

Initial cardiac rhythm and details of treatment

The initial rhythm was documented in ten studies (Table 5). When combined, the initial rhythm was VT or VF in 31.4% of IHCAs, with a range of 19.0 to 48.8%. However, the documentation of whether IHCAs were witnessed or monitored was poor with only three studies reporting whether the IHCA was witnessed, and four reporting whether the patient was monitored..

No studies reported on specific details of adherence to BLS or ACLS guidelines. Jones et al²⁵ reported median times to CPR (0.5 mins), to defibrillation (1 mins), to adrenaline (4 mins) and to intubation (8 mins). Two studies reported on time intervals from collapse to ROSC^{25,35} and one on automated external defibrillator (AED) use³⁸. The median time from collapse to ROSC was reported as 10 minutes (IQR 3-20) by Jones et al²⁵ and 12 minutes (IQR 4-26) by Boyde et al³⁵. No studies reported on number of DC-shocks or other details of medications used.

Smith et al³⁸ reported on differences in patient characteristics and outcomes before and after implementation of AEDs. Although they found a similar percentage of witnessed and shockable events, and ROSC improved from 36% to 54% in the post-AED group ($p=0.02$), there was no difference in mortality (19 vs 22%, $p=0.56$).

Outcomes

Table 6 shows the reported outcomes of IHCA. ROSC was achieved in 46% of patients. Mortality in population studies ranged from 59.4 to 77.5% (Table 1). In 19 cohort studies, the aggregated in-hospital mortality was 74.6% (Table 6). Mortality was similar in the presence or absence of aRRS (Table 3). In the three

studies reporting on IHCAs prior to RRS, the aggregated mortality was 75.0%, versus 75.4% in the five studies reporting after RRS implementation (OR = 1.02 ; 95% CI 0.73-1.41; p = 0.91).

Cohn et al³⁶ reports no correlation between survival and major co-morbidities.

Two studies provided data on the discharge destination. Amongst the combined data on the 85 survivors reported by Smith et al²⁸ and Jones et al²⁵, only 63.5% were discharged home. Only four studies provided data on longer term survival after hospital discharge. All 34 survivors reported by Smith et al²⁸ were alive at 90 days. For patients discharged alive, one-year survival was high, ranging from 85.7 to 97.0%^{14,25,31}.

The longer term functional status of survivors of IHCA was also reported to be good, with 93.3 to 97.1% having Cerebral Performance Category (CPC) of 1 or 2 at one year^{25,36}. Rankin³¹ reported that 44% of patients with shockable rhythms were alive at one year, and all had CPC of 1, whereas if the rhythm was non-shockable, only 12% were alive at one year and only 73% of these had CPC of 1.

Associations with in-hospital mortality following cardiac arrest

Eight studies provided information on the outcome associated with monitoring or the initial cardiac rhythm (Table 7).

Monitored or witnessed arrest

ROSC was higher in monitored arrests (64.3% vs 36.4%, Cohn et al³⁶ $p=0.038$ and 66.1% vs 42.8%, Jones et al²⁵ $p<0.001$) and in witnessed or monitored arrests (71.8% vs 21.4%, Boyde et al³⁵ $p<0.001$). Smith et al²⁸ report that patients in monitored areas were more likely to have shockable rhythms (48.3%) than those in non monitored areas (19.4%, $p=0.022$). This was also the only study that showed a survival advantage (58.6% vs 27.4%, $p=0.012$) among patients who had an IHCA during monitoring. Jones et al²⁵ reported that patients in non-“cardiac arrest team” areas were more likely to die (63% vs 39%, $p<0.001$).

Initial cardiac rhythm

An initial shockable rhythm (VT or VF) was associated with greater rates of ROSC in two studies (66.3% vs 24.4%, Smith et al³⁷, $p<0.0001$ and 81.5% vs 41.7%, Boyde et al³⁵, $p<0.001$), and greater survival to discharge (56.4% vs 15.6%) Jones et al²⁵ reported that survivors had shorter CPR (6.4 min vs 20.4 min, $p<0.001$). No asystolic unwitnessed events survived in the study by Cohn et al³⁶.

Patient age

Increasing age was associated with an increased mortality in three studies^{12,25,37}, with one³⁷ finding that ROSC was reduced by 35% ($p=0.0002$) and survival to discharge was reduced by 36% ($p=0.0004$) with each decade of life.

Time of day

Four studies found that daytime cardiac arrests were associated with better outcome with two reporting greater ROSC (41.4% vs 17.0%, $p < 0.001$ ²⁵ and 58.9% vs 41.0%, $p = 0.04$ ³⁵), and two others^{34,37} reporting higher survival.

Discussion

Summary of major findings

We conducted a systematic review on the epidemiology of IHCA in ANZ between January 1964 and November 2014. The overall frequency of IHCA was approximately 2 per 1000 admissions but varied from 1.3 to 6 per 1000. The incidence of IHCA was significantly lower in hospitals with a RRS. Although IHCA were often witnessed, the initial cardiac rhythm was often non-shockable. In addition, ROSC was achieved in a minority of cases and overall survival was uncommon. However, for those surviving to hospital discharge, long-term survival and functional status was generally acceptable.

Comparison with previous studies

Multiple international studies⁴⁻¹¹ have reported on the epidemiology of IHCA. Peberdy et al¹¹ found 0.17 IHCA per bed per year, an average of 54 events per year for a notional 260 bed hospital. In keeping with our findings, several studies outside of ANZ also confirm worse patient outcomes with increasing age⁴⁻⁸, IHCA occurring on general wards⁴, when unwitnessed⁶ and occurring after hours^{7,8}.

Previous international studies provide findings which are consistent with those in our study. Several studies have reported that the initial cardiac rhythm is mostly

non-shockable (65 to 80%)^{8,9,11}, that non-shockable rhythms have worse survival when compared to shockable rhythms^{6-8,11} and that older people with non-shockable rhythms have a particularly low survival⁵. Other studies report that ROSC occurs in 20.8 to 54.1%^{5,7,9,11}, that survival is higher if CPR is begun within one minute⁸ and if the total duration of CPR is shorter^{6,7}. Survival is very low (2.6%) in older people who had greater than 4 minutes of CPR⁵. Only half of patients with ROSC survive to discharge⁵⁻⁷ and overall survival is reported to be between 15.2 to 18.7%^{5-7,9,11}. Peberdy et al¹¹ reported no changes in the overall outcome of IHCA over 40 years.

In keeping with our findings, international studies have reported an overall mortality of 83% and that nearly 90% of all people who suffer IHCA are dead at one year^{6,7}. In another study¹¹, 51% of the few immediate survivors returned home, yet 44% were discharged to a nursing home, other hospital or rehab facility, compared to only 14% of those who originally resided in these places. In contrast to our findings, at least two international studies reveal that about 10% of survivors had severe disability (classified as CPC greater than 2) and 44% of patients had a CPC score less than what they were admitted with⁹, which was worse if the patient was older than 70 years⁸. A large number of older patients had reduced functional outcome post discharge⁵.

Implications for clinicians and policy makers

It has previously been argued that sub-optimal end of life care, sub-optimal detection and recognition of deterioration, and “sudden and unexpected” deterioration may all predispose to IHCAs⁴¹. The data available in current literature does not permit allocation to these three categories.

However irrespective of predisposing factors, our findings imply that in ANZ hospitals, IHCA's are infrequent. This makes it unlikely that an individual ward staff member will see more than one or two such events per year. Moreover, two thirds of such events have an initial non-shockable rhythm and more than two thirds of patients die. These observations imply that prevention is more logical than intervention in this field and that current approaches to treatment are broadly ineffective.

Study limitations

The major limitation of our study relates to the quality of the data contained within the publications. Such data do not report many important details of patient management before, during and after IHCA. However, the key findings are consistent and repeated across populations and cohorts. As many of the studies assessed are small and single centred, there is a high risk of bias in many of the outcome measures. Such bias is likely to affect the aggregated rates and proportions presented in our article.

The association of hospital with a RRS and decreased frequency of cardiac arrests is consistent with previous observations, but due to the nature of our study, no causative inference is possible. Finally, we have no data on the cost of care of such patients after IHCA.

Areas for future research

There is a need to better understand the factors leading up to IHCA and what can be done to prevent them by improving end of life care planning and the detection of deteriorating patients. Such research might also help identify which patients are most at risk of IHCA, so that prevention can be targeted. In addition, knowledge of the patho-physiological mode of death may be helpful. If progressive cardiogenic shock is a more common mode of death than neurological damage then extra-corporeal membrane oxygenation (ECMO) may improve outcomes⁴¹ for selected cases of IHCA.

Conclusions

IHCAs appear to be relatively infrequent in ANZ hospitals and often not amenable to electrical cardioversion. Three quarters of patients die in hospital, but long-term functional status in hospital survivors appears acceptable. The incidence of IHCAs appear to be lower in hospitals with an RRS. Better treatment strategies are needed to improve outcomes of IHCA.

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Table 1: Frequency and mortality of IHCA in Australia and New Zealand, derived from four population studies

Study	Hospitals, n (location)	Admissions, n	IHCA frequency, per 1000 (range)	IHCA mortality, per 1000 (range)	IHCA mortality, %	RRS
Weerasinghe et al, 2002 ¹²	19+ (NSW)	1,824,510†	2.04	-	67.7	Unknown
Hillman et al, 2005 ¹³	23 baseline (ANZ)	125,132	- (1.60 - 2.61)	-	-	No
Hillman et al, 2005 ¹³	11 control (ANZ)	150,000†	1.64	-	-	No
Hillman et al, 2005 ¹³	12 intervention (ANZ)	190,840†	1.31	-	-	Yes
Chen et al, 2014 ¹⁴	82 (NSW)	9,221,138	- (1.85 - 3.72)	- (1.26-2.71)	67.7-72.7	Mix
Chen et al, 2014 ¹⁵	4 (NSW)	1,346,484	- (1.47 - 6.11)	- (1.18-4.72)	-	Mix
Chen et al, 2014 ¹⁵	1 (NSW)	479,194	- (1.47 - 2.64)	1.62 (1.18-2.18)	77.5	Yes
Chen et al, 2014 ¹⁵	3 (NSW)	942,368	- (2.98 - 6.11)	2.72 (1.99-4.72)	68.5	No
Chen et al, 2014 ¹⁵	2 (NSW)	103,049	- (2.47 - 2.73)	1.84 (1.70-1.94)	70.2	Yes
Chen et al, 2014 ¹⁵	1 (NSW)	43,074	- (3.25 - 4.52)	1.93 (1.93-3.20)	59.4	No

Abbreviations: ANZ = Australia and New Zealand, NSW = New South Wales, Australia, IHCA = in-hospital cardiac arrest, RRS = rapid response system

Notes: These 10 data-sets are derived from 4 population based studies, each data-set comprising different time periods or different institutions.

Both papers from Chen et al^{14,15} used the same database with some overlap.

†= admissions were estimated from reported 3722 IHCAs¹², 246 IHCAs¹³, and 250 IHCAs¹³ respectively.

Table 2: Frequency of IHCA in cohort centre studies in Australia and New Zealand

Study	IHCA, n	Admissions, n	IHCA frequency, per 1000 admissions	RRS
Bristow et al, 2000 ¹⁶	234	50942	4.59	Mixed
Salamonson et al, 2001 ¹⁷	43	-	0.7-0.8	Yes
Buist et al, 2002 ¹⁸	120	53995	2.22	Mixed
Weerasinge et al, 2002 ^{12†}	201	57975	3.47	Unknown
Jones et al, 2005 ³	279	145463	1.92	Mixed
Jacques et al, 2006 ¹⁹	5	3160	1.58	Yes
Buist et al, 2007 ²⁰	271	186070	1.46	Yes
Peters et al, 2007 ²¹	128	36727	3.49	Unknown
Smith et al, 2009 ²²	152	58098	2.62	Unknown
Santamaria et al, 2010 ²³	-	-	0.58 - 2.93	Mixed
Vetro et al, 2011 ²⁴	22	16142	1.36	Yes
Jones et al, 2011 ^{25‡}	415	235205	1.76	Unknown
Kansal et al, 2012 ²⁶	-	53665	0.95-1.30	Yes
Drower et al, 2013 ^{27‡}	168	44184	3.80	Unknown
Smith et al, 2014 ²⁸	91	43385	2.10	Yes
Herod et al, 2014 ²⁹	-	-	1.1-1.4	Yes
Husband et al, 2014 ³⁰	259	143581	1.80	Yes
Totals	2345	1074927	2.25 [2302/1021262]	

Abbreviations: IHCA = in-hospital cardiac arrest, RRS = rapid response system

Notes:

†All were single centre studies, except Weerasinge et al¹².

‡All studies were Australian except Drower et al²⁷ and Jones et al²⁵ which were from New Zealand.

Table 3: Frequency and mortality of IHCA before and after implementation of RRS

Table 3A: Pre-RRS					
Study	Admissions, n	IHCA, n	IHCA frequency, per 1000 admissions	IHCA mortality, % [n]	IHCA mortality, per 1000 admissions
Rankin, 1998 ^{31†}	-	133	-	73.7 [98]	-
Bristow et al, 2000 ¹⁶ (pre-RRS)	32604	165	5.06	-	-
Buist et al, 2002 ¹⁸ (pre-RRS)	25194	73	2.90	76.7 [56]	2.22
Jones et al, 2005 ³ (pre-RRS)	16246	66	4.06	75.8 [50]	3.08
Santamaria et al, 2010 ²³ (pre-RRS)	-	-	2.93	-	-
Totals	74044	437	4.11 [304/74044]	75.0 [204/272]	2.56 [106/41440]

Table 3B: Post-RRS					
Study	Admissions, n	IHCA, n	IHCA frequency, per 1000 admissions	IHCA mortality, % [n]	IHCA mortality, per 1000 admissions
Lee et al, 1995 ³²	-	148	-	-	-
Bristow et al, 2000 ¹⁶ (post-RRS)	18338	69	3.76	-	-
Salamonson et al, 2001 ¹⁷	-	43	0.7-0.8	-	-
Buist et al, 2002 ¹⁸ (post-RRS)	28801	47	1.63	55.3 [26]	0.90
Jones et al, 2005 ³ (1 yr post-RRS)	25216	51	2.02	82.4 [42]	1.67
Jones et al, 2005 ³ (4 yrs post-RRS)	104001	162	1.56	84.0 [136]	1.31
Jacques et al, 2006 ¹⁹	3160	5	1.58	-	-
Buist et al, 2007 ²⁰	186070	271	1.46	-	-
Santamaria et al, 2010 ²³ (1-2 yrs post-RRS)	-	-	2.90	-	-
Santamaria et al, 2010 (3-4 yrs post-RRS) ²³	-	-	1.51	-	-
Santamaria et al, 2010 ²³ (5-8 yrs post-RRS)	-	-	0.58	-	-
Trinkle et al, 2011 ³³	-	31	-	90.3 [28]	-
Husband et al, 2014 ³⁰	143581	259	1.80	63.3 [194]	1.35
Smith et al, 2014 ²⁸	43385	91	2.10	62.6 [57]	1.31
Totals	552552	955	1.33 [733/552552]	75.4 [483/641]	1.32 [455/344994]

Abbreviations: IHCA = in-hospital cardiac arrest, RRS = rapid response system

Note:

† all studies were Australian except Rankin³¹ which was from New Zealand.

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Table 4: Demographics of patients suffering IHCA

Study	IHCA, n	Age, years	Male, % [n]	Non-surgical, % [n]
Twidale et al, 1989 ³⁴	34	-	82.4 [28]	-
Jones et al, 2005 ³	279	71.3†	-	68.5 [191]
Trinkle et al, 2011 ³³	31	74.9 (12.2)†	-	-
Jones, et al, 2011 ^{25§}	415	66.5 (15.5)†	59.3 [246]	-
Boyde et al, 2013 ³⁵	519	69 (56-78)‡	63.1 [328]	-
Smith et al, 2014 ²⁸	91	70 (62-78)‡	67.0 [61]	60.4 [55]
Husband et al, 2014 ³⁰	259	71.3 (61-81) ‡	67.2 [174]	81.1 [210]
Totals	1733	-	63.5 [837/1318]	72.5 [456/629]

Abbreviation: IHCA = in-hospital cardiac arrest

Notes:

† = mean (+/- standard deviation), ‡ = median (inter-quartile range)

§all studies were Australian except Jones et al²⁵, which was from New Zealand

Table 5: Details of monitoring and the initial detected rhythm for patients suffering IHCA

Study	IHCA, n	Witnessed, % [n]	Monitored, % [n]	Shockable (VF or VT), % [n]	Non-shockable, % [n]	PEA, % [n]	Asystole, % [n]	Other rhythm, % [n]†
Twidale et al, 1989 ³⁴	56	-	39.3 [22]	41.1 [23]	58.9 [33]	-	-	-
Rankin, 1998 ³¹	133	-	-	32.3 [43]	67.7 [90]	-	20.3 [27]	47.4 [63]
Salamonson et al, 2001 ¹⁷	43	-	-	48.8 [21]	51.2 [22]	-	-	-
Cohn et al, 2004 ³⁶	105	47.6 [50]	26.6 [28]	19.0 [20]	81.0 [85]	33.3 [35]	47.6 [50]	-
Jones et al, 2005 ³	279	-	-	22.6 [63]	77.4 [216]	25.1 [70]	43.7 [122]	8.6 [24]
Smith et al, 2007 ³⁷	243	-	-	34.2 [83]	65.8 [160]	-	-	-
Jones et al, 2011 ²⁵	415	88.2 [366]	66.7 [277]	35.7 [148]	64.3 [267]	22.4 [93]	22.4 [93]	19.5 [81]
Boyde et al, 2013 ³⁵	519	73.8 [383]	-	31.2 [162]	68.8 [357]	-	-	-
Drower et al, 2013 ²⁷	168	-	-	33.3 [56]	66.7 [112]	35.1 [59]	24.4 [41]	7.1 [12]
Smith et al, 2014 ²⁸	91	-	31.9 [29]	28.6 [26]	71.4 [65]	-	-	-
Totals	2052	80.2 [749/934]	53.4 [356/667]	31.4 [645/2052]	68.6 [1407/2052]§	26.6 [257/967]	26.5 [292/1100]	18.1 [180/995]

Abbreviations: IHCA = in-hospital cardiac arrest, VF = ventricular fibrillation, VT = ventricular tachycardia, PEA = pulseless electrical activity

Notes:

† "Other rhythm" can include PEA, asystole, bradycardia, not recorded, respiratory arrest or otherwise classified as "non-shockable".

‡ New Zealand based studies, the rest were from Australia.

§ Individual totals for non-shockable rhythms (PEA, asystole and other rhythm) add to >68.6% because of irregular classification of non-shockable rhythms.

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Table 6: Clinical outcomes of patients suffering IHCA in Australia and New Zealand

Study	Admissions, n	IHCA, n	IHCA frequency, per 1000 admissions	ROSC, % [n]	IHCA mortality, % [n]
Woog et al, 1987 ³⁹	-	76	-	34.2 [26]	89.5 [68]
Twidale et al, 1989 ³⁴	-	56	-	37.5 [21]	80.3 [45]
Cox et al, 1993 ⁴⁰	-	44	-	31.8 [14]	81.8 [36]
Lee et al, 1995 ³²	-	148	-	-	71.0
Rankin, 1998 ³¹ †	-	133	-	35.3 [47]	73.7 [98]
Weerasinghe et al, 2002 ¹²	57975	201	3.47	-	69.7 [140]
Buist et al, 2002 ¹⁸	53995	120	2.22	-	68.3 [82]
Cohn et al, 2004 ³⁶	-	105	-	43.8 [46]	79.0 [83]
Jones et al, 2005 ³	145463	279	1.92	39.1 [109]	81.7 [228]
Smith et al, 2007 ³⁷ †	-	243	-	38.7 [94]	79.0 [192]
Peters et al, 2007 ²¹	36727	128	3.49	-	68.0 [87]
Smith et al, 2009 ²²	58098	152	2.62	-	65.1 [99]
Trinkle et al, 2011 ³³	-	31	-	-	90.3 [28]
Jones, et al, 2011 ²⁵ †	235205	415	1.76	58.3 [242]	72.8 [302]
Smith et al, 2011 ³⁸	-	166	-	-	80.1 [133]
Vetro et al, 2011 ²⁴	16142	22	1.36	-	72.7 [16]
Boyde et al, 2013 ³⁵	-	519	-	54.1 [281]	69.6 [361]
Smith et al, 2014 ²⁸	43385	91	2.10	-	62.6 [57]
Husband et al, 2014 ³⁰	143581	259	1.80	-	74.9 [194]
Totals	1128592	4188	2.14 [2624/1074927]	46.0 [989/2149]	74.6 [2477/3319]

Abbreviations: ROSC = return of spontaneous circulation, IHCA = in-hospital cardiac arrest.

Note:

† New Zealand based studies, the rest were from Australia.

Table 7: Associations with in-hospital mortality and survival for patients suffering IHCA

Study	Type of arrest	Shockable, % [n/N]	ROSC, % [n/N]	Survival to discharge, % [n/N]
Twidale et al, 1989 ³⁴	Monitored	50.0 [11/22]	36.4 [8/22]	13.6 [3/22]
	Unmonitored	35.3 [12/34]	38.2 [13/34]	23.5 [8/34]
Rankin, 1998 ³¹ §	Monitored	65.1 [28/43]	-	-
	Unmonitored	38.9 [35/90]	-	-
	Shockable	-	-	46.5 [20/43]
	Non-shockable	-	-	16.7 [15/90]
Cohn et al, 2004 ³⁶	Witnessed	-	38.0 [19/50]	-
	Unwitnessed	-	49.0 [27/55]	-
	Monitored	-	64.3 [18/28]†	-
	Unmonitored	-	36.4 [28/77]†	-
	Shockable	-	65.0 [13/20]	45.0 [9/20] †
	Non-shockable	-	38.8 [33/85]	15.3 [13/85]†
Peters et al, 2007 ²¹	Witnessed	-	-	37.5 [33/88]
	Unwitnessed	-	-	45.0 [18/40]
	Monitored	-	50.0 [23/46]	37.0 [17/46]
	Unmonitored	-	40.1 [33/82]	19.5 [16/82]
	Shockable	-	-	57.1 [24/42]†
	Non-shockable	-	-	19.8 [17/86]†
Smith et al, 2007 ³⁷ §	Shockable	-	66.3 [55/83]†	39.8 [33/83]†
	Non-shockable	-	24.4 [39/160]†	11.3 [18/160]†
Jones et al, 2011 ²⁵ §	Witnessed	-	15.7 [14/89]	-
	Unwitnessed	-	10.0 [5/49]	-
	Monitored	-	66.1 [183/277]†	-
	Unmonitored	-	42.8 [59/138]†	-
	Shockable	-	-	52.7 [78/148]†
	Non-shockable	-	-	13.1 [35/267]†
Boyde et al, 2013 ³⁵	Witnessed and/or monitored‡	-	71.8 [242/337]†	-
	Not witnessed nor monitored‡	-	21.4 [39/182]†	-
	Shockable	-	81.5 [132/162]†	57.4 [93/162]†
	Non-shockable	-	41.7 [149/359]†	18.2 [65/357]†
Smith et al, 2014 ²⁸	Monitored	48.3 [14/29]	-	58.6 [17/29]†
	Unmonitored	19.4 [12/62]	-	27.4 [17/62]†
	Totals	Shockable, % [n/N]	ROSC, % [n/N]	Survival to discharge, % [n/N]
	Monitored	56.4 [53/94]	62.2 [232/373]	38.1 [37/97]
	Unmonitored	31.7 [59/186]	40.2 [133/331]	23.0 [41/178]
	Witnessed	-	23.7 [33/139]	37.5 [33/88]
	Unwitnessed	-	30.8 [32/104]	45.0 [18/40]
	Shockable	-	75.5 [200/265]	56.4 [257/456]
	Non-Shockable	-	36.5 [221/604]	15.6 [163/1045]

Abbreviations: ROSC = return of spontaneous circulation, IHCA = in-hospital cardiac arrest, Shockable = VF or VT, Non-Shockable = asystole, PEA, non-VF, non-VT.

Notes:

† p-value for significance reported in body of text, otherwise differences are not significant.

‡ Witnessed or monitored were not differentiated and were reported together.

§ New Zealand based studies, the rest were from Australia..

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Title:

The epidemiology of in-hospital cardiac arrests in Australia and New Zealand

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Title:

The epidemiology of in-hospital cardiac arrests in Australia and New Zealand. G Fennessy, A Hilton, S Radford, R Bellomo, D Jones.

Abstract:

Background: The epidemiology of in-hospital cardiac arrests (IHCAs) in Australia and New Zealand (ANZ) has not been systematically assessed.

Aim: To conduct a systematic review of the frequency, characteristics and outcomes of adult IHCAs in ANZ.

Method: Medline search for studies published 1964 to 2014 using MeSH terms “arrest AND hospital AND Australia”, “arrest AND hospital AND New Zealand”, “inpatient AND arrest AND Australia”, and “inpatient AND arrest AND New Zealand”.

Results: We screened 934 studies, analysed 50 and included 30. Frequency of IHCAs ranged from 1.31-6.11 per 1000 admissions in four population studies and 0.58-4.59 per 1000 in 16 cohort studies. The frequency was 4.11 vs 1.32 per 1000 admissions in hospitals with rapid response system (RRS) compared to those without (OR: 0.32; 95% CI 0.28-0.37; $p < 0.001$). On aggregate, the initial cardiac rhythm was ventricular tachycardia/fibrillation in 31.4% (range 19.0-48.8%) in 10 studies reporting such data. On aggregate, IHCAs were witnessed in 80.2% cases (three studies) and monitored patients in 53.4% cases (four studies). Details of life support were poorly documented. On aggregate, return of spontaneous circulation (ROSC) occurred in 46.0% of patients. Overall, 74.6% (range 59.4-77.5%) died in-hospital but survival was higher among monitored or younger patients, in those with a shockable rhythm, or during working hours.

Conclusions: IHCA's are uncommon in ANZ and three quarters die in hospital.

However, their frequency varies markedly across institutions and may be affected by the presence of RRS. Where reported, the long term outcomes survivors appear to have acceptable neurological outcomes.

Keywords:

cardiac arrest, in-hospital, mortality, rapid response, defibrillation

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