Survival after out-of-hospital cardiac arrest in Sydney, Australia

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ABSTRACT

Background: Out-of-hospital cardiac arrest (OHCA) is a significant cause of death, but there is little published information on its incidence and outcomes in Australia.

Aim: This study was undertaken to determine the incidence and survival from OHCA in Sydney, New South Wales.

Methods: Patients listed on the Ambulance Service of NSW database as having an OHCA during the 12-month period 1 June 2004 to 31 May 2005 were matched with the NSW Registry of Births, Deaths and Marriages to determine if they had died, and how long they survived. Survival was also determined for patients aged 80 years or older, and for the presenting electrocardiograph (ECG) rhythm.

Results: OHCAs were recorded for 2011 people in a population of 3.993 million. The age-standardised incidence was 52.6 events per 100 000 person-years (95% CI, 51.6–53.6). Incidence was significantly higher in older age groups. Only 24% of patients survived past the day of the OHCA. Survival for 28 days, 90 days and 1 year was 12.6%, 12.2%, and 11.5%, respectively. Survival was highest when the presentation ECG was ventricular fibrillation. Patients aged 80 years or older had lower survival rates.

Conclusion: Survival from OHCA in Sydney is low, and lower in patients aged 80 years or older. The incidence of OHCA in Sydney is similar to that in the rest of the world. Mortality occurs early after OHCA. Hence, for interventions to be effective in improving survival, they need to be targeted at the early stages of OHCA.

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Out-of-hospital cardiac arrest (OHCA) is a significant cause of death, but in Australia there is little recent published local information on outcomes. Internationally, the incidence of cardiac arrest is thought to be 0.5 per 1000 person-years (50 per 100 000 person-years) based on activation of emergency medical services, with survival generally estimated to be between 5% and 10%.[1]

In Australia, the regional and national incidence of OHCA appears to be underestimated. The Australian Institute of Health and Welfare listed 1915 separations coded as cardiac arrest from public hospitals in Australia over a 12-month reporting period in 2003–2004,[2] an incidence of 9.5 events per 100 000 person-years. The New South Wales Health Department recorded 900 separations from emergency departments in 2004 with diagnoses of cardiac arrest, an incidence of 13 events per 100 000 person-years, with a mortality rate of 67% (E S Choi, A/Manager, Performance Analysis and Reporting Branch, NSW Health, personal communication). In contrast, a study in Perth, Western Australia, recorded 3730 cardiorespiratory arrests from 1996 to 1999, in a population of 1.385 million people,[3] a crude incidence of 89.1 per 100 000 person-years. A Melbourne study recorded 451 patients having an OHCA in the western half of metropolitan Melbourne over 6 months in 1995, of whom only 3% survived to hospital discharge.[4]

Problems with incidence reporting are compounded by the many patients who suffer cardiac arrest but do not survive to hospital admission and are thus not recorded in hospital or emergency department databases. The lack of accurate information on cardiac arrest for Sydney, NSW, led us to undertake a study to determine the current incidence and survival from OHCA.

Methods

Study design

The database of the Ambulance Service of NSW was searched retrospectively for all patients with OHCA in the 12 months from 1 June 2004 to 31 May 2005 in the Sydney metropolitan area. Names were matched with the NSW Registry of Births, Deaths and Marriages database to determine if the patients had died and duration of survival. The study was approved by the human research ethics committees responsible for each organisation.

Cardiac arrest was defined as a medical event deemed likely to be cardiac in origin that required cardiopulmonary resuscitation (CPR) using basic or advanced life support, or would have required CPR if the decision had not been made to not actively treat the patient. Specific data on whether the OHCA was witnessed and by whom, and on treatment at the scene was not collected as this information was incomplete on the database. Patients not listed on the NSW Registry of Births, Deaths and Marriages as having died

Figure 1. Age distribution of the population of metropolitan Sydney in 2004, in 5-year age bands

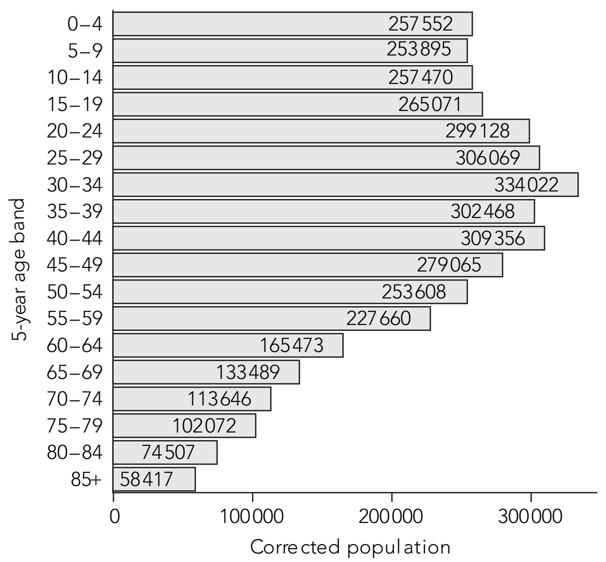
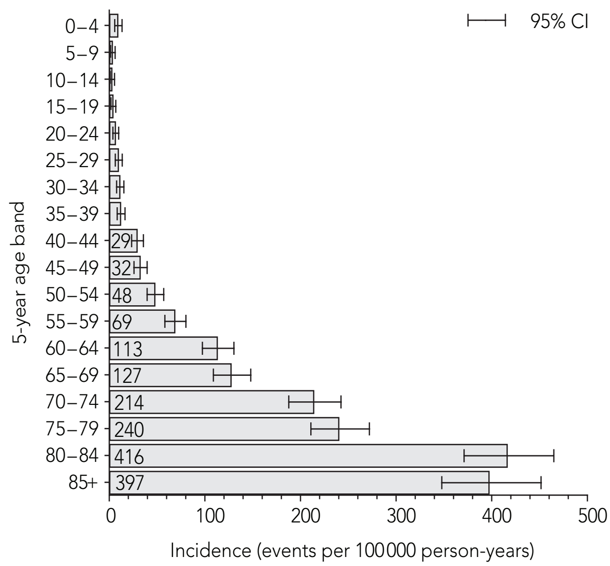


Figure 2. Incidence of out-of-hospital cardiac arrest in Sydney, 2004–2005, in 5-year age bands



were assumed to be alive. Duplicate patient entries that resulted from multiple ambulances attending the same patient were deleted. Patients whose names were unknown at the time of the OHCA were excluded from the analysis, as there was no practical method of follow-up.

Management of cardiac arrest

During the study period, the Ambulance Service of NSW was the only emergency medical services system available in the Sydney metropolitan area. This area was serviced by 120 road ambulance vehicles during peak hours, based at 46 ambulance stations. These were crewed by 930 ambulance officers and 360 paramedics. Most ambulances were staffed by two ambulance officers, with the rest being staffed by an ambulance officer and a paramedic. Cardiac arrest calls resulted in the ambulance that was geographically nearest being sent initially to the patient. An ambulance containing a paramedic was usually sent as backup if a paramedic was not available as the first responder. A small group of "rapid responders", comprising paramedics on motorcycles, was also available during the daytime. Treatment protocols were based on Australian Resuscitation Council guidelines.[5] Ambulance officers were trained to perform basic life support and defibrillation, and most were able to perform intravenous catheterisation and administer intravenous medications, but were generally not trained in endotracheal intubation. Traditionally, paramedics were trained to perform all the above tasks. Most defibrillation was performed using the Zoll M Series biphasic defibrillator (Zoll Medical Corporation, Burlington, Mass, USA) preset to semi-automatic mode. Drug packs contained adrenaline, atropine, lignocaine and sodium bicarbonate, but not amiodarone.

Outcomes

The main outcomes examined were survival past the day of the OHCA, at 28 days, at 90 days and at 1 year. As in-hospital information was not collected, survival to hospital discharge, as recommended in Utstein-style reporting,[6] was not determined. Subgroup survival was calculated for patients aged 80 years or older, and for electrocardiograph (ECG) rhythm subgroups of asystole, ventricular fibrillation (VF), ventricular tachycardia (VT), pulseless electrical activity (PEA), and an additional subgroup of asystole or pulseless bradycardia (AOPB). The latter term has been used in ambulance reporting in NSW because of historical problems with staff skill-mix and ECG interpretation, in particular difficulties in timing the length of "flatline" before calling a rhythm asystole when there is intermittent electrical activity.

Statistical analyses

Data were analysed using StatXact 4.0.1 (Cytel Software Corp, Cambridge, Mass, USA), SPSS 12.0.1 (SPSS Inc, Chicago, Ill, USA), and Microsoft Office Excel 2003 (Microsoft, Redmond, Wash, USA). Incidence was calculated using local government area populations defined by the Australian Bureau of Statistics.[7] Age standardisation was performed using national population estimates from 2004.[8] Kaplan–Meier survival curves were plotted, and the log rank statistic was used for comparisons. A sensitivity analysis was

Table 1. Age of patients with out-of-hospital cardiac arrest in Sydney, 2004–2005

	Total population	Males	Females
Age range (years)	0–104	0–104	0–102
Mean age (years)	66	64	70
Median age (years)	70	67	75
Standard deviation (years)	18.6	17.9	19.2

Table 2. Overall survival from out-of-hospital cardiac arrest in Sydney, 2004–2005

Survival	Percentage survival (no. of patients)	Sensitivity*
Past day of cardiac arrest	24.0% (415)	20.6%–34.7%
28 days	12.6% (217)	10.8%–24.8%
90 days	12.2% (211)	10.5%–24.5%
1 year	11.5% (199)	9.9%–23.9%

* For sensitivity analysis, survival was calculated firstly on the assumption that all patients listed as unknown had died, and secondly on the assumption that they all survived. ◆

performed to determine the effect on survival of two scenarios, firstly that all patients listed as unknown had died, and secondly that they all survived.

Results

During the 12-month study period, 2011 patients had an OHCA in the Sydney metropolitan area. Many patients were not initially able to be identified, and identifying information to enable mortality follow-up was available from the ambulance database for 1729 (86.0%).

Population and incidence

The Ambulance Service of NSW defines the Sydney metropolitan area as extending from Hawkesbury in the north to Wingecarribee in the south, and to the Blue Mountains and Wollondilly in the west. In 2005, this area had an estimated resident population of 3.993 million. The median age reported in the 2001 census for Sydney was 34 years.[9] The age distribution is shown in Figure 1.

The age-standardised incidence of OHCA was 52.6 events per 100 000 person-years (95% CI, 51.6–53.6 per 100 000 person-years), with a crude incidence of 50.3 events per 100 000 person-years (95% CI, 48.2–52.6 per 100 000 person-years). The incidence of OHCA increased with age (Figure 2), with rates of 8.9, 3.2 and 2.7 events per 100 000 person-years in the 0–4, 5–9 and 10–14 year age bands, respectively, increasing to 416 and 397 events per 100 000 person-years in the 80–84, and 85 years and older age bands.

Age and sex

Of the identifiable patients, 65.5% were male (95% CI, 63.2%–67.8%; 1133 patients), 34.2% were female (95% CI, 31.9%–36.5%; 591 patients), and 0.3% did not have sex recorded (95% CI, 0.1%–0.7%; 5 patients). Age information was obtained for 1681 (97.2%) patients. The mean and median ages of patients with OHCA are shown in Table 1; five patients were aged less than 1 year, 27 were aged less than 10 years, and 67 were aged 90 years or older.

Survival

Survival is shown in Table 2 and Figure 3. Initial survival dropped quickly, with only 24.0% of patients surviving the day of the cardiac arrest (Day 0), 19.6% surviving Day 1, 17.6% surviving Day 2, and 14.2% surviving Day 7.

Only 62.8% (1086 patients) of patients who were identifiable had a record of the initial ECG pattern at the time of the OHCA. The frequency of the individual ECG patterns is shown in Figure 4A, and survival for presenting ECG rhythm in Table 3 and Figure 5.

VF was associated with the best survival (log rank $P < 0.0001$), with survival from PEA also significantly better than from asystole and AOPB (log rank $P = 0.0002$). Survival was lowest for AOPB, with only one patient surviving past the day of OHCA. Ventricular tachycardia was not included in the table as only two patients presented with this rhythm; one patient died on the day of the OHCA, while the other was alive after 1 year.

Figure 3. Cumulative survival from out-of-hospital cardiac arrest (OHCA) in Sydney, 2004–2005

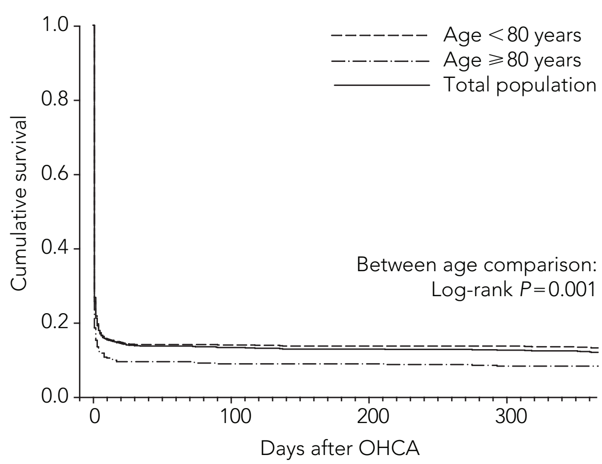
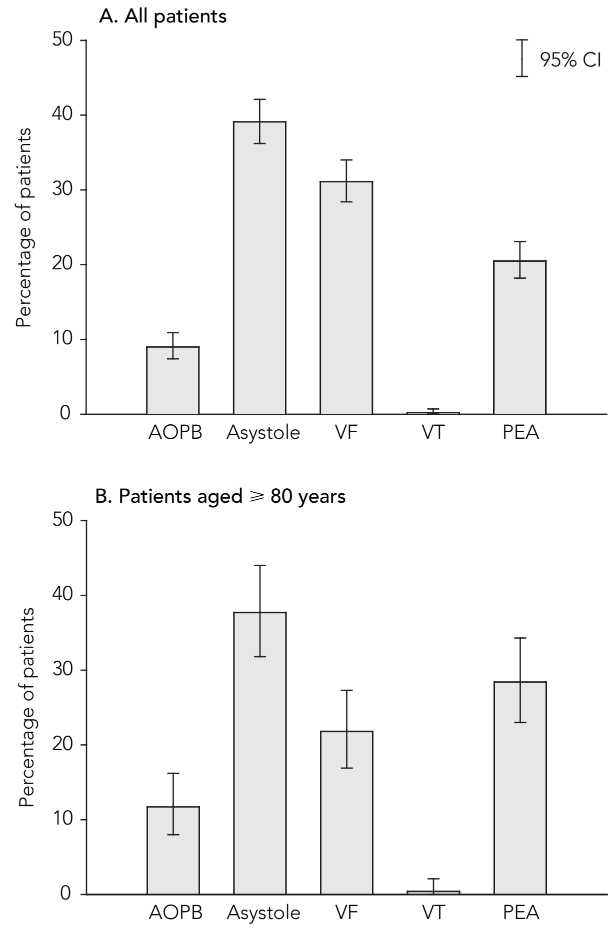


Figure 4. Presenting electrocardiograph rhythm for out-of-hospital cardiac arrest in Sydney, 2004–2005



AOPB = asystole or pulseless bradycardia. VF = ventricular fibrillation. VT = ventricular tachycardia. PEA = pulseless electrical activity. ◆

Patients aged 80 years and older

Of the 1681 patients who had age information available, 453 were aged 80 or older (26.9%). Their survival from OHCA (Figure 3) was significantly lower than survival in the general population (log rank $P = 0.001$), with only 18.8% (85 patients) surviving past the day of OHCA. Survival to 28 days, 90 days and 1 year was 9.3% (42 patients), 8.6% (39 patients) and 7.9% (36 patients), respectively.

Patients aged 80 or older had higher rates of PEA and lower rates of VF compared with the general population (Figure 4B). Survival in this age group was similarly poor compared with that of the general population for all presenting ECG rhythms (Table 3).

Discussion

Incidence

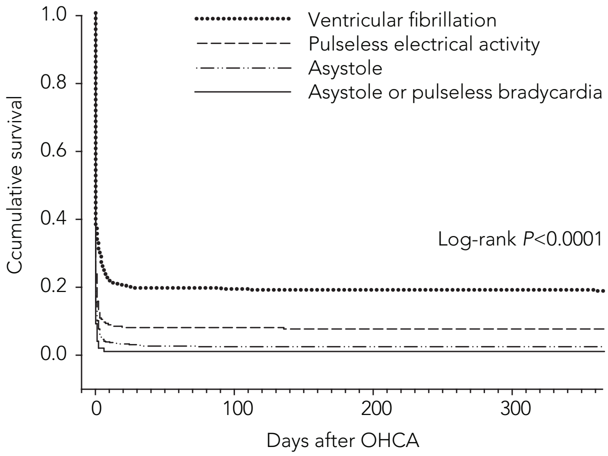
The incidence of OHCA in Sydney is similar to the worldwide estimate of 0.5 per 1000 person-years (50 per 100 000 person-years).[1] In comparison, Perth had a higher age-standardised incidence of 94.5 per 100 000 person-years over a 4-year period from 1996 to 1999, with an age-standardised rate where resuscitation was attempted of 32.9 per 100 000 person-years.[3] We do not know accurately how many patients in this study did not have CPR attempted.

The reason for the differences between cities and countries is unknown, but likely to be multifactorial. The time period studied in Perth was 5–8 years before that studied in Sydney. Age may account for some differences in other countries, but probably not in Australia. Perth had a younger population, with a median age of 33 years according to the 1996 census, compared with 34 years for Sydney according to the 2001 census. Perth also had only 10.8% of the population aged over 65 years in 1996 compared with

Table 3. Survival from out-of-hospital cardiac arrest based on presenting electrocardiograph (ECG) rhythm in all patients and those aged 80 years and over

Patient age group and initial ECG pattern	Percentage survival (number of patients)			
	Past day of cardiac arrest	28-day survival	90-day survival	1-year survival
All patients				
Asystole or pulseless bradycardia	1.0% (1)	1.0% (1)	1.0% (1)	1.0% (1)
Asystole	15.5% (66)	3.1% (13)	2.4% (10)	2.4% (10)
Ventricular fibrillation	36.7% (124)	19.5% (66)	19.2% (65)	18.3% (62)
Pulseless electrical activity	24.7% (55)	8.1% (18)	8.1% (18)	7.6% (17)
Patients aged ⩾ 80 years				
Asystole or pulseless bradycardia	0	0	0	0
Asystole	12% (12)	4% (4)	3% (3)	3% (3)
Ventricular fibrillation	30% (17)	11% (6)	11% (6)	11% (6)
Pulseless electrical activity	16% (12)	4% (3)	4% (3)	4% (3)

Figure 5. Cumulative survival for presenting electrocardiograph rhythm in out-of-hospital cardiac arrest (OHCA) in Sydney, 2004–2005



11.8% in Sydney in 2001.[9] If age was a significant factor, then incidence of OHCA should have been marginally higher in Sydney. The major influence on incidence is probably related to other population characteristics and cardiac risk factors, although changes in prevention strategies for cardiovascular disease may also have had an effect. It is also possible that the incidence found in our study is an underestimate, as some patients with a cardiac arrest may not have had an ambulance called or may have been transported to hospital by other means.

The incidence of OHCA rose with age, but we could not find recently published cardiac-arrest age-band information for comparison. Internationally, women have a lower incidence than men of OHCA.[10-12] This sex bias was seen in the Perth study, where males comprised 72.4% of the cases.[3] The mean age of 66 years in our study appears similar to the age of populations enrolled in major coronary heart disease studies, but children included in our analysis are usually excluded from cardiac trials. A meta-analysis of 31 000 patients from 41 countries presenting with acute coronary syndromes in several interventional studies over the period 1994–2000 found a baseline age of 64 years, of whom 65% were male.[13]

Survival

Survival from OHCA in Sydney is low, with only 24.0% of patients in this study surviving the day of the arrest. Survival plummets sharply initially and then flattens off and stabilises after the first few days. Therefore, intuitively, for any intervention to have a significant impact on survival, it must be instituted early. The overall survival at 1 year of 11.5% remains low, but is better than many other countries. In Nagoya, Japan, only 2.8% of patients suffering OHCA survived for 1 month.[14] A recent Hong Kong study showed a survival to hospital discharge rate of 1.25%,[15] with an average call-to-CPR interval of 9.8 minutes. A Swedish study showed 1-month survival rates of 2.5% and 6.8% in two different cities,[16] a difference attributed to ambulance density and response times, while a Canadian study of over 5000 patients showed a survival to hospital discharge of 5% in the years 1994–2002.[17] Our study did not examine response times of emergency medical services or time to initiation of CPR.

In contrast, an American study showed survival to hospital discharge of 22%–44%, but 1-year survival of only 1.4%–6.1%.[18] The differences in outcome may be partly explained by differing practices in both initial cardiac arrest management and end-of-life care. Up to 50% of survivors of VF in the American study had a discharge diagnosis of severe neurological damage, implying probable discharge to long-term care or a ventilator facility. Australian cultural beliefs and lack of long-term care facilities for patients with severe hypoxic brain injury may mean that patients have treatment withdrawn relatively early. In reality, the variation in survival is probably multifactorial, and outcomes are likely to be altered by many pre-hospital factors that we did not examine, such as population characteristics, whether arrests were witnessed, rates of bystander CPR, and activation intervals and response times of emergency medical services.

Studies describe rates of VF in OHCA varying worldwide between 12% and 100%.[19,20] The most common initial rhythm in our study was asystole, which is often interpreted as a sign of a dead heart. The largest study of asystole in Australia revealed only one survivor to hospital discharge out of 778 patients.[21] Our study found similarly dismal outcomes, and the survival curves demonstrate that mortality is early for all ECG rhythms. VF had the best prognosis. Survival from VF varies widely,[22-24] but, in large interventional trials, survival to hospital discharge tends to range from 5% to 15%.[17,23-25] Worldwide, the incidence of VF appears to be declining.[26,27] The reason is unknown, but may be related to the decline in age-adjusted death rates from heart disease. VF is thought to be a manifestation of severe undiagnosed coronary heart disease, and therefore improvements in testing, prevention and management of heart disease may have resulted in earlier diagnosis and hence a decline in undiagnosed patients with severe coronary heart disease.[26]

In animal studies of systemic tissue ischaemia, cardiovascular collapse is followed by PEA, which eventually decays to asystole.[26] PEA probably represents a point where myocardial compensation to hypoxia is no longer possible. It is therefore not surprising that PEA was also associated with a poor outcome in our study.

AOPB was associated with the worst prognosis, with all but one of the patients dying on the day of the OHCA. This was not unexpected, as most rhythms interpreted as AOPB are probably in reality asystole, with the occasional idioventricular ectopic, and can be considered as the transition stage from PEA to asystole. Unfortunately, many initial AOPB ECG rhythms were not recorded and therefore could not be retrospectively analysed to determine the precise rhythm.

Patients aged 80 years or older

Age has traditionally been perceived as a good predictor of mortality in OHCA, but several studies demonstrate that it is not as accurate in determining outcome as other predictors, such as bystander CPR, response times of emergency medical services, initial ECG rhythm, and whether the cardiac arrest was witnessed.[28-30] Patients aged 80 years or older in our study had similar rates of asystole, but lower rates of VF and higher rates of PEA compared with the total patient group. Although survival in this age group was lower than in the general population, age does not appear to be an absolute predictor of outcome. However, it is clear that older patients suffering OHCA with asystole or PEA as the initial ECG rhythm have little chance of surviving.

Limitations

The main limitation of our study was the quality and completeness of data collection. Although attempts were made to correct for duplicate entries and data entry errors, these problems made interpretation less precise. Patients whose names were unknown at the time of the OHCA (14%) did not receive mortality follow-up. It is not known whether survival would have changed if this information was more complete. Also, the NSW Registry of Births, Deaths and Marriages only records deaths in the state of NSW. If patients died outside NSW or were being investigated by the State Coroner, they would not have been recorded as deceased, leading to overestimation of survival. However, despite its imperfections, our method is probably the most realistic way to analyse this type of cohort in Australia.

Conclusion

The aim of this study was to provide an accurate snapshot of OHCA in Sydney, Australia. Survival from OHCA in Sydney is low, but marginally better than in many other countries. It is clear from our study that, for any intervention to change outcome, it must be targeted at the initial management and response, especially given that 76% of patients in this study died on the day of the OHCA. The post-arrest hospital period provides another opportunity to alter outcomes, but for any intervention to have an effect it is intuitive that it must also be provided early. It remains to be seen if survival for OHCA in Sydney and the rest of the world will improve in the future.

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