

A comparison of survival following out-of-hospital cardiac arrest in Sydney, Australia, between 2004–2005 and 2009–2010

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Background

In 2005, the international guidelines for cardiopulmonary resuscitation (CPR) were changed to reflect the evolving science in this area.^{1,2} Since then, some studies have reported improved survival following out-of-hospital cardiac arrest (OHCA) but others have not.^{3,4} The guidelines were changed again in 2010.^{5,6}

It is difficult to attribute causality for any perceived improvements in survival following OHCA after 2005, as the guidelines were not the only changes in prehospital and postresuscitation care that occurred during this period. Other changes included a shift in emphasis in the quality of CPR, such as minimising interruptions to chest compressions; the use of new defibrillation techniques, such as public access defibrillation programs; and new postresuscitation techniques, such as therapeutic hypothermia.⁷ Variation in practice, populations, reporting and definitions also causes difficulty when comparing OHCA incidence or survival rates between countries, states and local areas.⁸

In 2005, we conducted a study to determine the incidence and survival following OHCA in Sydney, Australia.⁹ Since then one Australian study has shown improved outcomes for OHCA in Melbourne.^{3,10} As the changes in survival from OHCA in Sydney over this period remained unknown, we have repeated our study. The main objective was to determine if survival following OHCA in Sydney has improved over the previous 5 years, with a secondary objective to determine if there has been a change in incidence.

Methods

Study design

We conducted our retrospective study using the Ambulance Service of New South Wales patient database. Data were extracted for a 12-month period, from June 2009 to May 2010 (which we refer to as the 2009–2010 period). All patients who were coded as having an OHCA in the Sydney metropolitan area were screened. The names of patients who fulfilled the selection criteria were matched with the NSW Registry of Births, Deaths and Marriages database to determine if the patients had died, and their duration of

ABSTRACT

Objective: To determine whether survival following out-of-hospital cardiac arrest (OHCA) in Sydney, Australia, improved between 2004–2005 and 2009–2010, and whether there was a change in incidence of OHCA.

Design: Retrospective study using the Ambulance Service of New South Wales and NSW Registry of Births, Deaths and Marriages databases.

Participants and setting: All patients who had an OHCA in the Sydney metropolitan area and who used the Ambulance Service of NSW between June 2009 and May 2010 (2009–2010), and between June 2004 and May 2005 (2004–2005).

Main outcome measures: Survival to 90 days. Other outcome measures included the incidence of OHCA and survival to the day following OHCA, 28 days and 1 year following OHCA. Survival and incidence were also calculated according to initial electrocardiograph rhythm.

Results: Survival to 90 days was 12.3% in 2004–2005 and 10.2% in 2009–2010 ($P=0.015$). In 2004–2005, the age-standardised incidence of OHCA was 52.6 events per 100 000 person-years (95% CI, 51.6–53.6 events per 100 000 person-years), and in 2009–2010 it was 48.4 events per 100 000 person-years (95% CI, 46.3–50.4 events per 100 000 person-years). In 2004–2005, the incidence of ventricular fibrillation (VF) was 31.3% (95% CI, 28.4%–33.9%) and in 2009–2010 it was 22.1% (95% CI, 20.0%–24.3%).

Conclusion: There was no improvement in survival following OHCA in Sydney between 2004–2005 and 2009–2010. There has been a decrease in overall survival from OHCA and a decrease in the overall age-standardised incidence of OHCA. The decrease in overall survival may be due to a decline in the incidence of VF.

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survival. The incidence of OHCA and survival following OHCA were calculated. We then compared the results with corresponding data from our previous study, which used the 12-month study period from June 2004 to May 2005

Table 1. Characteristics of patients having an OHCA in Sydney, 2004–2005 and 2009–2010

Patient characteristic	2004–2005	2009–2010	P*
Age or date of birth recorded (%)	83.6	92.8	–
Age (years)			
Median (interquartile range)	70 (55–80)	70 (56–80)	–
Mean (SD)	66 (19)	66 (20)	–
Aged < 5 years (%)	1.2	1.8	0.15
Aged ≥ 80 years (%)	26.9	28.6	0.25
Male (%)	65.5	63.9	0.31

OHCA = out-of-hospital cardiac arrest. * Using the Pearson χ^2 test.

(which we refer to as the 2004–2005 period).⁹ The study was approved by the Royal Prince Alfred Hospital ethics committee (HREC/10/RPAH/231).

Cardiac arrest was defined as a medical event in which CPR or defibrillation was performed, or when a patient had an initial electrocardiograph (ECG) coded as asystole, pulseless electrical activity (PEA) or ventricular fibrillation (VF). Patients were included if the arrest was deemed to be of cardiac origin, or the aetiology was uncertain and the patient did not have an exclusion diagnosis. Patients were excluded if the cardiac arrest resulted from major trauma, drug intoxication, envenomation, an environmental cause, the patient was classified as specialised care (such as neonatal), the arrest was attributed to a non-cardiac medical condition or if there was a major inconsistency in the data field.

Duplicate patient entries resulting from multiple ambulances attending the same patient were deleted. Patients not listed as having died on the Registry of Births, Deaths and Marriages database were assumed to be alive. Patients whose names were unknown at the time of the OHCA were excluded from the survival analysis, as there was no practical method of follow-up.

Data collection and outcome

Baseline data were extracted on age, sex, initial ECG rhythm and ambulance response time. Data were not extracted on CPR performed by bystanders, as this information was incomplete. Incidence of OHCA was calculated according to 5-year age bands.

The primary outcome of interest was survival to 90 days. Survival to the day following OHCA, 28 days, and 1 year following OHCA were also calculated. Survival to hospital discharge, as recommended in Utstein-style reporting, and neurological outcome were not determined, as this information was not available.¹¹

An analysis of incidence and survival following OHCA was performed according to the presenting ECG rhythms of asystole, PEA, VF, and in patients 80 years or older and patients younger than 80 years. It was recognised that changes in data definitions between the two comparison periods would confound results. In 2004–2005, a patient could be classified to a category called asystole or pulseless bradycardia (AOPB), because of historical problems with personnel skill mixes and rhythm interpretation. Personnel previously had difficulty in timing the length of flatline before classifying a rhythm as asystole when there was intermittent electrical activity. This subgroup classification was removed from the database definitions after 2005, resulting in subsequent patients being classified solely as being asystole or PEA, instead of AOPB. Also, in 2004–2005, PEA included atrial fibrillation and idioventricular and paced rhythms but in 2009–2010, PEA was redefined as its own distinct category.

Management of cardiac arrest

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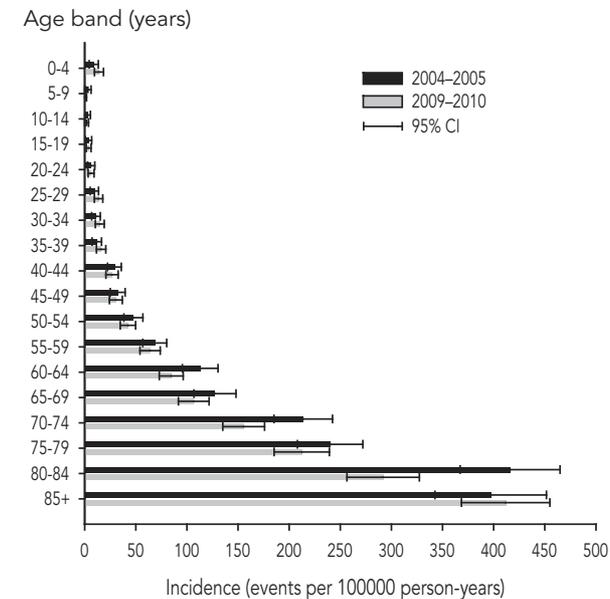
The Sydney metropolitan area extends from the Hawkesbury in the north to Wingecarribee in the south, and from the east coast to the Blue Mountains and Wollondilly in the west. The Ambulance Service of NSW was the only emergency service medical system available in the Sydney metropolitan area. The number of ambulance stations remained at 46 between the two study periods.

Ambulance officers were renamed paramedics, and paramedics were renamed paramedic specialists between the two study periods, but training and qualifications remained the same. Ambulances were crewed by 936 and 930 paramedics, and 360 and 340 paramedic specialists, in 2004–2005 and 2009–2010, respectively.

Cardiac arrest calls resulted in the ambulance that was geographically closest to the patient site being sent initially, with an ambulance containing a paramedic specialist sent as backup if one was not available as a first responder.

Treatment protocols were based on Australian Resuscitation Council guidelines.¹² Defibrillation was performed using biphasic defibrillators in semiautomatic mode. Medication packs contained adrenaline, atropine and lignocaine. Sodium bicarbonate was removed from and amiodarone added to the medication packs between the two study periods. Automated, mechanical CPR devices were not used. Paramedics were trained to administer intravenous cardiac arrest medications and to perform endotracheal intubation at their discretion.

Figure 1. Incidence of OHCA in Sydney, 2004–2005 and 2009–2010, by 5-year age bands



OHCA = out-of-hospital cardiac arrest. There were statistically significant decreases in the incidence of OHCA between the 2004–2005 and 2009–2010 periods for the 60–64-year ($P=0.004$), 70–74-year ($P=0.0006$) and 80–84-year ($P<0.0001$) age bands, using the χ^2 test.

Statistical analysis

Analysis was performed by an independent statistician using Office Excel 2003 (Microsoft), SigmaPlot version 11.0 (Systat Software), and Simple Interactive Statistical Analysis (<http://www.quantitativeskills.com/sisa/statistics/twoby2.htm>). Descriptive statistics were calculated for all study variables and the Pearson χ^2 test was used where appropriate.

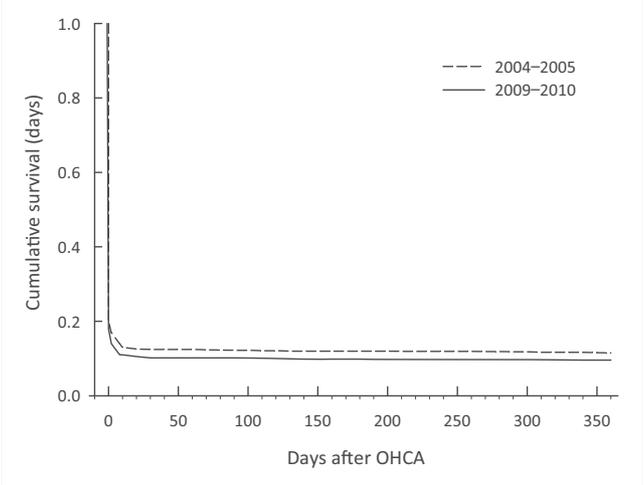
Incidence was calculated using estimated local government area populations in 2010 from the Australian Bureau of Statistics, with 95% confidence intervals calculated using the binomial method.¹³ Age standardisation was performed using back extrapolation from national population estimates from 2011.¹⁴

Survival was determined using the Kaplan–Meier method, and the log-rank (Mantel–Cox) test was used for comparison. The survival subgroups were compared using the χ^2 test with continuity correction.

Results

In 2004–2005, identifying information to enable mortality determination was available for 86% of patients. During the 2009–2010 study period, 2123 patients met the study criteria for OHCA, and identifying information was available for 95.2% of patients (2022).

Figure 2. Survival following OHCA in Sydney, 2004–2005 and 2009–2010



OHCA = out-of-hospital cardiac arrest. The Kaplan–Meier curves show a decrease in survival between the 2004–2005 and 2009–2010 periods ($P=0.015$, using the log-rank test).

Demographics

Patient demographics are detailed in Table 1. The median age reported in the 2001, 2006 and 2011 censuses for Sydney was 34, 35 and 36 years, respectively.^{15–17}

Population and incidence

In 2004–2005, the age-standardised incidence of OHCA was 52.6 events per 100 000 person-years (95% CI, 51.6–53.6 events per 100 000 person-years), with a crude incidence of 50.3 events per 100 000 person-years (95% CI, 48.2–52.6 events per 100 000 person-years). The estimated population in metropolitan Sydney in 2010 was 4.262 million.¹³ The age-standardised incidence of OHCA in 2009–2010 was 48.4 events per 100 000 person-years (95% CI, 46.3–50.4 events per 100 000 person-years), with a crude incidence of 49.8 events per 100 000 person-years (95% CI, 47.7–51.9 events per 100 000 person-years).

The incidence of OHCA according to 5-year bands in 2004–2005 and 2009–2010 is detailed in Figure 1. The differences in incidence between the two periods for the 60–64, 70–74 and 80–84-year age bands were statistically significant.

In 2004–2005, the initial ECG rhythm was recorded in 62.8% of patients who were identifiable. AOPB was the initial rhythm in 9% of patients. Asystole, PEA, VT and VF were recorded in 39.1%, 20.5%, 0.2% and 31.3% (95% CI, 28.4%–33.9%) of patients, respectively. In 2009–2010, the initial ECG rhythm was recorded in 73.2% of patients who were identifiable (1481). Asystole, PEA, VT and VF

Table 2. Survival after OHCA in Sydney, 2004–2005 and 2009–2010, by initial ECG rhythm and age

Patient group or ECG rhythm	Period	Survival (%)				P
		Past day of OHCA	28 days	90 days*	1 year	
All patients	2004–2005	24.0	12.6	12.3	11.5	0.015 [†]
	2009–2010	19.5	10.6	10.2	9.6	
Asystole	2004–2005	15.5	3.1	2.4	2.4	0.52 [‡]
	2009–2010	11.1	3.5	3.4	3.3	
PEA	2004–2005	17.4	1.4	1.4	1.4	0.13 [‡]
	2009–2010	16.8	8.9	7.9	7.9	
VF	2004–2005	36.7	19.5	19.5	18.3	0.98 [‡]
	2009–2010	40.9	20.4	19.8	18.3	
Aged ≥ 80 years	2004–2005	18.8	9.3	8.6	8.0	0.012 [‡] <0.001 [§]
	2009–2010	11.5	5.3	5.1	4.1	
Aged < 80 years	2004–2005	26.1	13.6	13.5	12.8	0.43 [‡]
	2009–2010	22.9	12.7	12.2	11.8	

OHCA = out-of-hospital cardiac arrest. ECG = electrocardiograph. PEA = pulseless electrical activity. VF = ventricular fibrillation. * Primary outcome measure.

[†] Comparison performed using the Kaplan–Meier method with the log-rank (Mantel–Cox) test. [‡] Comparison performed using the χ^2 test with continuity correction. [§] Comparison of patients aged ≥ 80 years with patients aged < 80 years in 2009–2010 using the log-rank (Mantel–Cox) test.

were recorded in 57.5%, 6.8%, 0.5% and 22.1% (95% CI, 20.0%–24.3%) of patients, respectively.

In 2004–2005, VF was the initial ECG rhythm in 21.8% of patients aged 80 years or older (95% CI, 16.7%–26.8%). In 2009–2010, this proportion was 13.1% (95% CI, 9.7%–16.5%).

Survival

Survival following OHCA for 2004–2005 and 2009–2010 is shown in Figure 2. There was a statistically significant decrease in survival from 2004–2005 to 2009–2010.

Survival following OHCA for 2004–2005 and 2009–2010 according to ECG and age subgroups is shown in Table 2. There was a statistically significant decrease in survival from 2004–2005 to 2009–2010 in patients 80 years or older, but not in patients with asystole, PEA or VF or patients younger than 80 years.

In 2009–2010, survival in patients 80 years or older was significantly lower compared with patients younger than 80 years. In 2004–2005, in patients aged 80 years or older, 90-day survival from asystole, PEA and VF was 3%, 4% and 11%, respectively. In 2009–2010, 90-day survival for the corresponding rhythms was 1%, 10% and 10%.

Response times

Ambulance response times for OHCA were not available for 2004–2005. Response times in 2009–2010 were available

for 93.2% of patients. The median ambulance response time was 9 minutes and 8 seconds, and mean response time was 10 minutes and 29 seconds. The median ambulance response times for patients who survived to 90 days and those who did not were 9 minutes and 12 seconds, and 9 minutes and 9 seconds, respectively.

Discussion

Key findings

Our study has several key findings when comparing OHCA in Sydney between 2004–2005 and 2009–2010. There was a decrease in the overall age-standardised incidence of OHCA. Overall survival following OHCA remains low and has decreased during the 5-year course of the study.

Incidence

The reason for the decrease in the overall incidence of OHCA between 2004–2005 and 2009–2010 is unclear. The falling incidence of OHCA may be a consequence of a reduction in acute myocardial infarction rates, seen in other studies, but these observations are controversial.^{18,19} Reductions in coronary heart disease deaths have been attributed to improvements in primary prevention and risk factor modification.¹⁹ Recent Australian campaigns to raise awareness of heart disease may have helped in this regard.²⁰ However, it is difficult to determine whether the worldwide

incidence of OHCA is actually declining due to differences in data definitions.²¹

The falling incidence of OHCA reported in this study may be partially explained by significant improvements in data quality and completeness in the Ambulance Service of NSW database between the two study periods. In 2004–2005, the incidence of OHCA may have been overreported, as all patients coded as cardiac arrest were included. Verification was not used, as data collection was less complete than it was for the 2009–2010 period. For the 2009–2010 period, only patients for whom OHCA could be verified by ECG rhythm or the use of CPR were included. Patients whose data did not reflect cardiac arrest were excluded. For example, patients coded as cardiac arrest, but whose presenting ECG, heart rate, blood pressure and Glasgow coma score were normal were excluded.

Our study shows a fall in the incidence of VF between 2004–2005 and 2009–2010. This finding mirrors previous reports of declining VF incidence, although a recent study suggests this decline may be ending.^{22,23} The decline in VF incidence has also been attributed to improvements in the management of coronary artery disease, as most VF is ascribed to coronary ischaemia.²³

Our study confirms the previous observation that the incidence of OHCA increase with age.⁹ This observation mirrors the age-related increases in incidence seen in myocardial infarction and heart failure.²⁴

Survival

There are several possible explanations for the overall decrease in survival from 2004–2005 to 2009–2010. The decrease may be attributable to the lower proportion of patients presenting with the initial ECG rhythm of VF. Patients with VF had a higher survival rate compared with patients with asystole and PEA, but it is difficult to interpret actual changes in incidence and survival rates for asystole and PEA, due to the differences in data definitions mentioned earlier.

The decrease in overall survival may be partially explained by the decrease between 2004–2005 and 2009–2010 in survival in patients 80 years or over. The decline in incidence of VF in this group may explain the lower overall survival, as survival from VF was similar between the two periods in these patients.

It is possible that the decrease in survival and decrease in VF incidence may be a result of longer ambulance response times. Delays in ambulance response times are associated with poorer survival, and a 1-minute reduction in response time may improve the odds of survival by 24%.²⁵ We had no comparison data from 2004–2005, however. Patients who survived to 90 days and those who did not had similar response times in our study.

It is possible that the patients in 2004–2005 had fewer malignant ECG rhythms but there is no method of verifying this possibility, as ECG data were only recorded in 62.8% of patients who were identifiable.

Significance of findings

It is difficult to know whether we should be alarmed at our findings. It appears that patients are now less likely to have an OHCA. The changes to prehospital and postresuscitation care that have occurred in recent years appear to have made no significant improvement to survival from an OHCA. Patients having an OHCA are now less likely to survive. Our findings could suggest that addressing OHCA prevention may be a better public health initiative than trying to improve the way we manage OHCA.

Strengths and limitations

The strength of our study was its size. Data quality improved significantly between the two study periods, but incomplete data entry from the original database in 2004–2005 was the major limitation in comparing results. Other limitations to our study were its retrospective nature, and the inability to determine the survival status of patients who could not be identified or who had moved interstate. Patients who were under the auspices of the state coroner were also not officially listed as dead. Therefore it is possible that survival may have been overestimated in both periods.

Implications for future research

Our study generates an interesting hypothesis that the incidence of and survival from OHCA is declining. Future studies need to confirm these observations, examine the reasons for these changes, and determine whether current therapies are actually improving outcomes in OHCA.

Conclusion

There has been no improvement in survival following OHCA in Sydney between 2004–2005 and 2009–2010. There has been a decrease in overall survival from OHCA and a decrease in the overall age-standardised incidence of OHCA between the two periods. The reason for the decrease in incidence is not known, but the decrease in survival may be due to the decline in the incidence of VF.

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Competing interests

None declared.

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