Original Article

Effect of Location of Out-of-Hospital Cardiac Arrest on Survival Outcomes

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Abstract

<u>Introduction</u>: This study aims to study how the effect of the location of patient collapses from cardiac arrest, in the residential and non-residential areas within Singapore, relates to certain survival outcomes. <u>Materials and Methods</u>: A retrospective cohort study of data were done from the Cardiac Arrest and Resuscitation Epidemiology (CARE) project. Out-of-hospital cardiac arrest (OHCA) data from October 2001 to October 2004 (CARE) were used. All patients with OHCA as confirmed by the absence of a pulse, unresponsiveness and apnoea were included. All events had occurred in Singapore. Analysis was performed and expressed in terms of the odds ratio (OR) and the corresponding 95% confidence interval (CI). <u>Results</u>: A total of 2375 cases were used for this analysis. Outcomes for OHCA in residential areas were poorer than in non-residential areas—1638 (68.9%) patients collapsed in residential areas, and 14 (0.9%) survived to discharge. This was significantly less than the 2.7% of patients who survived after collapsing in a non-residential area (OR 0.31 [0.16 – 0.62]). Multivariate logistic regression analysis showed that location alone had no independent effect on survival (adjusted OR 1.13 [0.32 – 4.05]); instead, underlying factors such as bystander CPR (OR 3.67 [1.13 – 11.97]) and initial shockable rhythms (OR 6.78 [1.95 – 23.53]) gave rise to better outcomes. <u>Conclusion</u>: Efforts to improve survival from OHCA in residential areas should include increasing CPR by family members, and reducing ambulance response times.

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Key words: Emergency Medical Services, Non-residential, Prehospital, Residential

Introduction

Out-of-hospital cardiac arrests (OHCAs) are an important health issue in Singapore with an incidence of 798 per year based on data from 2001 to 2002, and with projected further increases in subsequent years.[1] Survival to discharge is approximately 2%,[1] comparatively poor with regards to international results, which report a survival rate ranging from 2% to more than 20%.[2] Conventional wisdom regarding improvement of survival rates has generally hinged on the chain-of-survival concept, which suggests several key factors that can improve survival outcomes of OHCA: these are early access, early cardiopulmonary resuscitation (CPR), early defibrillation and early advanced care.[3,4]

In Singapore, a vast majority of households are multi-storey residences (94.3% in 2010).[5] Very few of household members have knowledge of performing CPR and even fewer are certified. Automated external defibrillators

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(AED) are newly installed in a small number of selected residential areas. However, most public areas such as the airport, shopping malls and schools, do have access to AEDs.

The idea that the location of a patient's collapse from cardiac arrest may affect OHCA survival outcomes was proposed and studied in several papers.[6-9] These showed that individuals who collapsed at home had poorer outcomes than those who collapsed in public locations. Various discussions and explanations for this phenomenon were proposed, including increased bystander CPR rates, decreased time to initiate CPR and higher incidences of shockable rhythms (ventricular fibrillation or pulseless ventricular tachycardia) in public locations. However, the location of collapse itself as an independent factor on survival outcomes still remains unclear.

The purpose of this study is to determine if survival outcomes were affected by whether patients collapsed in residential or non-residential areas. We also aimed to analyse characteristics usually associated with OHCA that may have affected survival outcomes between residential and non-residential areas.

Materials and Methods

A literature review on Pubmed and MEDLINE did not show any similar study for the Singapore population. A retrospective cohort analysis of data from the Cardiac Arrest and Resuscitation Epidemiology (CARE) project was done to derive certain patterns and conclusions of cardiac arrest within residential and commercial areas.

The CARE project was a prospective cardiac arrest registry from the 6 major public hospitals in Singapore; its database spanned from October 2001 to October 2004. This data is derived from records of OHCA in the now 7 major hospitals in Singapore. The CARE project collected data based on the Utstein style.

All collapses from cardiac arrest in the out-of-hospital setting in Singapore were included for analysis. Patients of all ages were included, and collapses due to non-cardiac causes such as trauma were included as well. The majority of OHCA patients were conveyed to the hospital by public ambulance; however, patients that were conveyed by other means were also included. Exclusion criteria include those that were "obviously dead", defined by the presence of decomposition, rigor mortis, or dependent lividity.
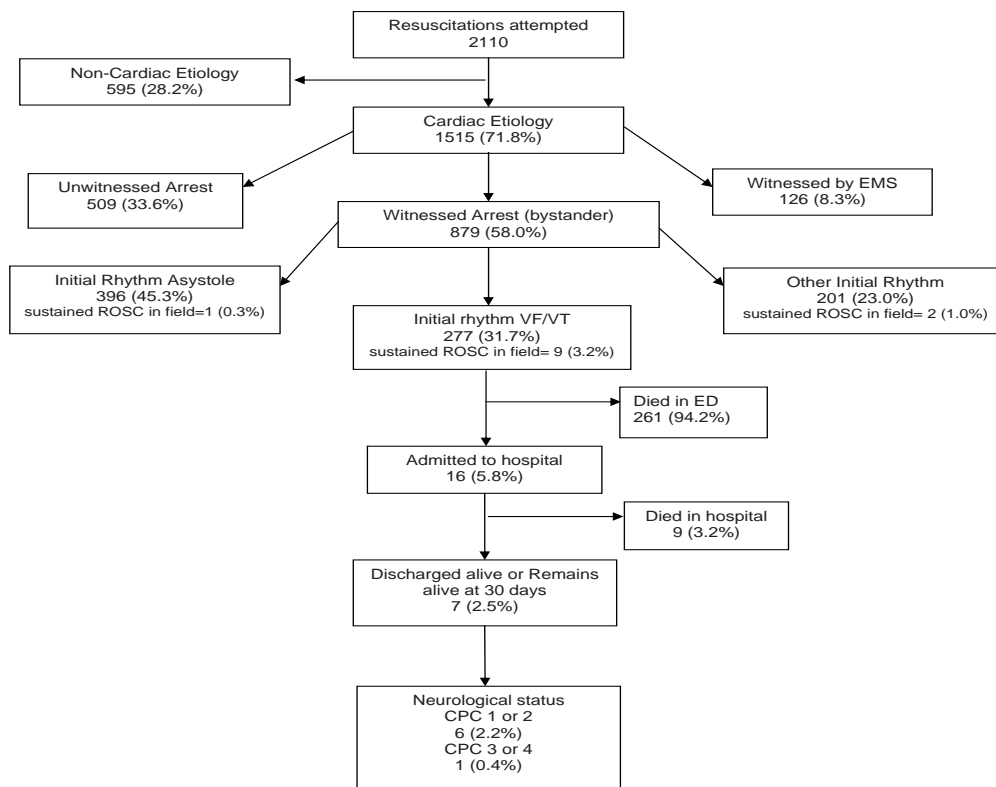

Fig. 1. CARE Utstein Flow Chart.

Cardiac arrest patients, whether from residential areas or commercial areas, were treated similarly during the period of study. Emergency medical service (EMS) protocols differed slightly during the time span with the addition of laryngeal mask insertion in 2004 and intravenous adrenaline in 2003. Emergency department protocols followed standard advanced cardiac life support (ACLS) pathways. Therapeutic hypothermia was not employed as standard of care during the period of study and none of the patients studied received therapeutic hypothermia.

Data recorded for the registries were drawn from EMS records, emergency department notes as well as hospital discharge records. EMS records were recorded by responders from the beginning of the ambulance run to handover of the patient at the emergency department.

The data collected based on the Utstein style, included age, gender and race of the patient, location where patient was found, EMS response time, whether or not bystander CPR was given, first arrest rhythm, and survival outcomes. EMS response timings included time from the emergency call to the ambulance's arrival at scene, time from arrival at scene to arrival of the paramedic at patient's side, and total time from the emergency call to arrival of the paramedic at patient's side.

Location of collapse was defined as where the patient was found at the time of incident. Location of collapse was divided into residential and non-residential areas. Residential areas were defined as a person's home (whether the patient's or someone else's) and the home's nearby surroundings (including ground floor areas and car parks of multistorey residences). Non-residential areas were defined as areas outside the premises of home. These included areas of work, nursing homes and public areas, such as shopping areas, department stores or parks.

In this study we also looked at the incident of bystander CPR, which is defined as chest compressions with or without ventilation. Bystanders were inclusive of family members, laypersons or healthcare providers. Healthcare providers include those formally trained in basic cardiac life support such as general practitioner doctors, nurses, medics and police/fire first responders.

First arrest rhythm was defined as the first cardiac arrest rhythm, captured by either the EMS team, private ambulance or automated external defibrillator (AED). These were divided into shockable and non-shockable rhythms. Shockable rhythms included ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT); non-shockable rhythms included pulseless electrical activity (PEA) and asystole.

The primary outcome measurement for the study was a "good" outcome or survival outcome. This was defined as either survival to discharge or survival in hospital at the 30th day post-arrest; as this was when follow-up was stopped. Unfavourable outcomes included death at any time up till 30 days post arrest.

Data were processed with Excel for Windows, and analysis was performed using SPSS version 16.0 (SPSS, Inc., Chicago, IL). Relevant frequencies, odds ratios (OR) and corresponding 95% confidence intervals (CI) were obtained. Multivariate logistic regression was carried out to adjust for several factors previously associated with cardiac arrest survival,[10] namely age of patient, bystander CPR, EMS response time and initial collapse rhythm. The storey on which the patient collapsed was also adjusted for. To assess significance of differences, the chi-square test was performed for discrete variables, and the t-test was used for continuous variables. Odds ratios were deemed as insignificant if their corresponding 95% confidence intervals crossed 1.

Results

A total of 2375 cases were used for this study. Table 1 shows the characteristics of patients in residential areas and non-residential areas. A total of 68.9% of all OHCA cases occurred in residential areas. Residential area patients were significantly older (62.9 vs 55.9), experienced a longer EMS response time in minutes (11:16 vs 10:55), had lower rates of bystander CPR (13.6% vs 38.9%) and had initially shockable arrest rhythms less often (14.8% vs 28.7%) as compared to non-residential area patients.

Notably, OHCAs occurring in residential areas had a poorer survival outcome than those in non-residential areas —only 0.9% had survival to hospital discharge, compared to 2.7% of those in non-residential areas.

To establish if location had a significant independent effect on survival outcomes, the results were adjusted for other contributing factors and expressed in Table 2.

Table 2 shows that after adjustment for other variables, location no longer demonstrates a significant effect on survival outcome. After adjustment, the factors which remained statistically significant were initial rhythm and bystander CPR. Initial rhythm showed a larger effect on survival outcome (adjusted OR 6.78 [95% CI, 1.95 – 23.53]) as compared to bystander CPR (adjusted OR 3.67 [95% CI, 1.13 – 11.97]).

The effect of residential location on the underlying factors was examined as demonstrated in Table 3, and 2 factors likely to affect survival outcomes were chosen. These were bystander CPR and initial arrest rhythm. The results show that even after adjustment for other background factors, OHCA patients in residential locations had initial shockable rhythms significantly less often (adjusted OR

Table 1. Characteristics of Patients in Residential and Non-residential Areas

Variable	Residential (n = 1638)	Non-Residential (n = 737)	P*
Mean age (SD)	62.9 (18.8)	55.9 (18.7)	<0.001
Gender (%)			
Male	1045 (63.8)	593 (36.2)	<0.001
Female	572 (77.6)	165 (22.4)	
Race (%)			
Chinese	1182 (72.3)	465 (63.1)	<0.001
Malay	238 (14.5)	118 (16.0)	
Indian	169 (10.3)	96 (13.0)	
Other	47 (2.9)	58 (7.9)	
Response Times (mm:ss)			
Call to Arrival at Scene			
Median	08:55	09:04	0.28
Interquartile Range	06:51 – 11:18	06:35 – 11:59	
Scene to Patient's Side			
Median	02:02	01:08	0.48
Interquartile Range	01:09 – 03:15	00:38 – 02:19	
Call to Patient's Side			
Median	11:16	10:55	<0.001
Interquartile Range	09:05 – 14:09	08:03 – 13:28	
Bystander CPR (%)			
Yes	206 (13.6)	234 (38.9)	<0.001
No	1305 (86.4)	367 (61.1)	
Collapsed Witnessed (%)			
Bystander	872 (53.3)	418 (56.7)	<0.001
EMS	125 (7.6)	129 (17.5)	
Not witnessed	637 (38.9)	188 (25.5)	

CPR: Cardiopulmonary resuscitation; EMS: Emergency medical services;

Table 1. Characteristics of Patients in Residential and Non-residential Areas (Con't)

Variable	Residential (n = 1638)	Non-Residential (n = 737)	P*
Level of patient's location (%)			
Multi-storey (above ground floor)	1351 (82.5)	135 (18.6)	<0.001
Non multi-storey	286 (17.5)	589 (81.4)	
First Arrest Rhythm (%)			
Shockable			<0.001
VF	235 (14.8)	187 (28.7)	
VT	7 (0.4)	5 (0.8)	
Unknown shockable	0 (0)	0 (0)	
Non-shockable			
Idioventricular/PEA	433 (27.3)	204 (31.3)	
Asystole	909 (57.3)	253 (38.9)	
Unknown non-shockable	1 (0.1)	2 (0.3)	
ROSC (%)			
Yes (Patients may ROSC en route and in ED)	266 (16.2)	139 (18.9)	0.13
No	1372 (83.8)	598 (81.1)	
Outcomes (%)			
Discharged alive/survived till 30 days post-arrest	14 (0.9)	20 (2.7)	<0.001
Died in Hospital (ED/Ward)	1624 (99.1)	717 (97.3)	

VF: Ventricular fibrillation; VT: Ventricular trachycardia; PEA: Pulseless electrical activity; ROSC: Return of Spontaneous Circulation; ED: Emergency department

*Chi-square test performed for discrete variables; t test for continuous variables.

P was considered not significant (NS) if *P* >0.05; Non-residential includes: healthcare facility, public/commercial building, nursing home, transport center, street/highway, place of recreation, in EMS/Private ambulance

0.70 [95% CI, 0.51 – 0.95]). Bystander CPR rates were significantly lower in residential areas (adjusted OR 0.35 [95% CI, 0.26 – 0.46]).

Limitations

There were several limitations we identified in the study. The first being that non-residential grouping was too broad and could have been better stratified further into parks, commercial buildings, or industrial buildings. Owing to the small numbers in each category, we had decided to merge the categories together for the purpose of this study.

However we do acknowledge that there may have been differences in each category such as there is a higher rate of non-cardiogenic OHCA in industrial areas such as trauma or drowning. Access to several industrial areas for EMS would also have differed, especially where there would have been a security or safety risk. Healthcare facilities have staff trained in basic life support and this may account for some differences in outcomes.

Residential areas could have also been better divided into further stratifications related to the type of accommodation present in Singapore as each stratification could have yielded different results in outcome. Generally, accommodations are divided into houses, private condominiums, apartments and multistorey flats. Also public residential areas or common areas, such as car parks or ground floor open areas, could have been stratified as well. Another fact to consider is the presence of lift landing at every floor as some flats do not have lifts which stop at every floor. This may have affect time and treatment administered due to difficulty in maneuvering.

Table 2. Unadjusted and Adjusted Odds Ratios for Good Outcome

Variable	Number with good outcome† (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Location			
Residential	14 (0.9)	0.31 (0.16 – 0.62)	1.13 (0.32 – 4.05)
Non-residential	20 (2.7)	reference	reference
Age*	-	0.98 (0.96 – 0.99)	0.97 (0.94 – 1.00)
Level of collapse			
Above ground floor	11 (0.7)	0.28 (0.13 – 0.57)	0.65 (0.17 – 2.46)
Ground floor	23 (2.6)	reference	reference
Bystander CPR			
Yes	10 (2.3)	4.84 (1.90 – 12.33)	3.67 (1.13 – 11.97)
No	8 (0.5)	reference	reference
EMS response time*	-	1.00 (0.99 – 1.00)	1.00 (0.99 – 1.00)
Initial rhythm			
Shockable	23 (5.3)	14.35 (6.12 – 33.69)	6.78 (1.95 – 23.53)
Non-shockable	7 (0.4)	reference	reference

EMS: Emergency medical services; CPR: Cardiopulmonary resuscitation

*Analysed as continuous variables

†Defined as discharged alive/survival till 30 days post-arrest

The study also did not differentiate non-cardiogenic OHCA. General categories of such are trauma, drowning, respiratory, electrocution. Outcomes may be different in each of these categories.

Neurological outcome at 30 days and at 3 months was also not taken into account in the outcome study. This was due to difficulty in follow-up of patients after discharge. This would have related to patient disability and ability to return to normal life and work. Also CARE registry did not look extensively into neurological and functional outcomes but rather survival.

There was no comparison in cases in which the collapse was witnessed by a bystander. This may had potentially affected outcomes in the time taken to activate emergency services or administration of treatment.

Some potential confounders that were not addressed in the study are time of collapse—cardiac arrest while the patient is sleeping would be more likely to remain undiscovered for a greater length of time, resulting in poorer outcomes. The study did not have any exclusion criteria for patients that were obviously dead (e.g. hypostasis, rigor mortis); these obviously dead patients would also conceivably be more likely found at home than outside home. Such patients would very unlikely to respond to resuscitative attempts. Patients with active 'do-not-resuscitate' orders or those with advanced end stage malignancies, who died from cardiac arrest, were also not excluded from the study.

An issue that we would have liked to investigate further, but which was beyond the scope of this study, was the demographic of bystanders who attended to the

Table 3. Adjusted Odd Ratio for Residential Location's Effect on Outcome, Initial Rhythm and Bystander CPR

Location	Outcome		Initial Rhythm		Bystander CPR	
	Good†	Adjusted OR[1] (95% CI)	Shockable	Adjusted OR[2] (95% CI)	Yes	Adjusted OR[3] (95% CI)
Residential (%)	14 (0.9)	1.13 (0.32 – 4.05)	242 (15.3)	0.70 (0.51 – 0.95)	206 (13.6)	0.35 (0.26 – 0.46)
Non-Residential (%)	20 (2.7)	Reference	192 (29.5)	Reference	234 (38.9)	Reference

CPR: cardio-pulmonary resuscitation

†Defined as discharged alive/survival till 30 days post arrest

[1]Adjusted for level of collapse, bystander CPR, age, EMS response time, initial rhythm

[2]Adjusted for level of collapse, bystander CPR, age and EMS response time

[3]Adjusted for level of collapse, age, gender, race

collapsed patient in residential and non-residential areas (e.g. bystander age, the frequency of bystanders trained in CPR, the quality of CPR administered). Quality of CPR administered, in particular, may have formed part of the reason why bystander CPR did not have a statistically significant effect after adjusting for other factors. It may also influence how best to address the issue of poor survival outcomes of residential OHCA cases.

Discussion

In Singapore, the majority of OHCAs occur within residences.[1] In addition to this fact, our study had concluded that survival outcomes from OHCA within residential areas were poorer compared with non-residential areas. We identified the reason to be not due to the location itself, but rather other factors such as age, initial cardiac rhythm, EMS response time and bystander CPR rates that resulted in increased mortality in residential areas.

Age

Patient age is a well-known contributing factor to survival outcomes. Older patients had more comorbid factors and lesser likelihood of survival from cardiac arrest.

Initial cardiac rhythm: Numerous studies have shown that initial arrest rhythm is an important prognostic factor for patient survival.[11,12] In this study, initial arrest rhythm was identified as the most significant reason for poor outcome in residential areas, even after adjustment for other background factors. The high incidence of non-shockable rhythms in the residential group may be related to EMS response time or the presence of bystander CPR. Other potential factors include time of discovery which may have differed from the actual incident, or presence of other comorbidities which were not studied.

EMS Response Time: The study showed that there was greater delay in EMS response timings in residential areas. The EMS response time in this study did not display any independent effect on survival [Odds Ratio 1.00 (0.99 – 1.00)]. However, many other studies have demonstrated that EMS response time do have an independent effect on survival outcomes;[13-18] furthermore, it is known that VT and VF will degenerate to a non-shockable rhythm over time, and thus EMS response time and time until first application of the AED would play a significant role in initial rhythm. Optimising the EMS response time to residential areas is always an issue to improve upon.

Bystander CPR Rates: Bystander CPR has been shown to improve survival of OHCA,[19,20] although the quality of CPR administered is a confounder for this and remains an important consideration.[21,22] Presence of bystander CPR also increases incidence of initial shockable rhythms.[23,24] Low bystander CPR rates in residential areas is therefore an area of concern, and one that should be actively targeted, with a view to improving quality of CPR administered as well.

In tackling the issue of poor survival outcomes in residential areas, the areas in which attention should be focused are EMS response time and bystander CPR. In particular, bystander CPR rates reflected in this study (20.8% overall) are poor compared to international standards (for example, 31% in the United States,[25] 34% in London,[26] 41% in Copenhagen,[27] and 55% in Sweden[28]). Efforts should be made to improve bystander CPR rates in Singapore.

CPR training may be most beneficial if targeted at people living in the same households with individuals who are of higher risk of OHCA such as the elderly or patients with significant comorbidities. Family members or domestic helpers should be trained in CPR as they are the closest and have easier access to the collapsed patient. This has previously been suggested by many authors.[29-34] The poor cost effectiveness of mass CPR training and refresher courses has also been cited as a reason to move towards targeted CPR training.[35] Also, poor awareness and education in individual or family healthcare contribute to the low numbers of the public taking up CPR courses and low bystander CPR rates. This may also contribute to poor recognition of ailing patients and delays in EMS activation.

Studies have shown that spouses of individuals with cardiac disease are the most likely people to witness a cardiac arrest.[36] This goal of one CPR-trained individual per high-risk household can be targeted by "prescribing" CPR to family members living with a high-risk individual.[37] This may be accomplished at the primary physician level or at public hospitals, where regular CPR courses are held, and family members encouraged to attend. Studies have been shown that such programme reduces anxiety and create a feeling of empowerment for family members.[38,39] Singapore hospitals have yet to adopt the idea of "prescribed" CPR.

Another possible area of improving bystander CPR rates is to explore telephone-assisted CPR instruction. This has been shown to have the potential to increase the incidence of bystander CPR as well as improve survival outcomes for OHCAs.[40] It has previously also been criticised as being too slow and difficult to be effective;[41] however, with the new guidelines advocating chest-compression-only CPR (CCOCPR) for untrained laypersons,[42] several authors have recommended teaching CCOCPR over the phone as well.[43,44] This may help untrained family members to provide CPR for an OHCA patient before EMS personnel arrive. The emergency hotline (995) personnel should be trained to give clear and succinct over-the-phone CPR instruction for this purpose.

Conclusion

Residential-area OHCA cases in Singapore have a significantly poorer prognosis in survival outcomes than OHCAs in non-residential areas. Location itself was not a significant independent factor in survival; but we identified other significant factors related to location of collapses. These included the initial rhythm and bystander CPR rates. EMS response time in this study was not shown to influence outcomes but may still contribute to survival. Hence, efforts should be made to improve survival outcomes by focusing on these factors.

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