Original Article

Recognition and Treatment of Out-of-Hospital Cardiac Arrests by Non-Emergency Ambulance Services in Singapore

Nausheen E Doctor, [1]*MBBS (S'pore), MMed, MRCSEd (A&E)*, Susan Yap, [1]*RN*, Han Nee Gan, [2]*MBBS (S'pore), M Med(Emergency Med), MRCS (A&E)*, Benjamin SH Leong, [3]*MBBS (S'pore), MRCSEd, MMed (Emergency Medicine)*, E Shaun Goh, [4]*MBBS(Melbourne), MRCSEd*, Michael YC Chia, [5]*MBBS (S'pore)*, Lai Peng Tham, [6]*MBBS (S'pore), MMed (Paediatrics)*, Yih Yng Ng, [1]*MBBS (S'pore), MRCSEd*, Swee Han Lim, [1]*MBBS (S'pore), FRCSEd (A&E)*, Marcus EH Ong, [1,7]*MBBS (S'pore), MPH*

Abstract

Introduction: Prompt recognition of cardiac arrest and initiation of cardiopulmonary resuscitation (CPR) and defibrillation is necessary for good outcomes from out-of-hospital cardiac arrest (OHCA). This study aims to describe the recognition and treatment of OHCA in patients conveyed by non-emergency ambulance services (EAS) in Singapore. Materials and Methods: This is a multi-centre, retrospective chart review, of cases presenting to public emergency departments (EDs), conveyed by non-EAS and found to be in cardiac arrest upon ED arrival. The study was from October 2002 to August 2009. The following variables were examined: ability to recognise cardiac arrest, whether CPR was carried out by the ambulance crew and whether an automated external defibrillator (AED) was applied. Results: Eighty-six patients were conveyed by non-EAS and found to be in cardiac arrest upon ED arrival. Mean age was 63 years (SD 21.8), 70.9% were males. A total of 53.5% of arrests occurred in the ambulance while 70.9% were found to be asystolic upon ED arrival. Seven patients had a known terminal illness. Survival to discharge was 3.5%. Cardiac arrest went unrecognised by the ambulance crew in 38 patients (44.2%). CPR was performed in 35 patients (40.7%) of the 86 patients and AED was applied in only 10 patients (11.6%). Conclusion: We found inadequate recognition and delayed initiation of treatment for OHCA. Possible reasons include a lack of training in patient monitoring and detection of cardiac arrest, lack of CPR training, lack of confidence in performing CPR, lack of AEDs on ambulances and lack of training in their use.

Ann Acad Med Singapore 2013;42:445-50

Key words: Automated external defibrillator (AED), Cardiopulmonary resuscitation (CPR), Emergency medical services, Prehospital

Introduction

The survival rates to hospital discharge from out-of-hospital cardiac arrest (OHCA) in Singapore, which is reported to be 2.0%,[1] is comparable to other large cities such as Hong Kong[2] (1.25%), Chicago[3] (2%), and New York (1.4%).[4] However this is lower than that reported in several North American cities (16.3%).[5] It is well-reported that survival rates from cardiac arrests that are witnessed by ambulance personnel are even higher,[6-8] with local data showing 13.8% survival for OHCA witnessed by Singapore's Emergency Ambulance Services (EAS).[1]

As a result of Singapore's compact landscape and extensive road network, ambulance transport times have been kept relatively short,[1] with patients usually arriving at their destinations within half an hour from a call. However, ambulance crews face potentially complex clinical scenarios that sometimes demand immediate and appropriate treatment en-route, such as time-sensitive conditions like cardiac arrest and stroke. Failure to administer appropriate treatment in time could lead to permanent disability or death for the patient.

[1]Department of Emergency Medicine, Singapore General Hospital, Singapore
[2]Department of Emergency Medicine, Changi General Hospital, Singapore
[3]Emergency Medicine Department, National University of Singapore, Singapore
[4]Department of Acute Care and Emergency, Khoo Teck Puat Hospital, Singapore
[5]Emergency Department, Tan Tock Seng Hospital, Singapore
[6]Children's Emergency, KK Women's and Children's Hospital, Singapore
[7]Office of Clinical Sciences, Duke-NUS Graduate Medical School, Singapore
Address for correspondence: Dr Nausheen E Doctor, Department of Emergency Medicine, Singapore General Hospital, Outram Road, Singapore 169608.
Email: nausheen.doctor@sgh.com.sg

With regards to OHCA, we know that prompt recognition of cardiac arrest and initiation of cardiopulmonary resuscitation (CPR) and defibrillation are vital in ensuring good outcomes. These encompass the first 3 links in the 'Chain of Survival' concept described by Cummins et al in 1991.[9] It states that early access to Emergency Medical Services (EMS), early cardiopulmonary resuscitation (CPR), early defibrillation and early access to advanced care are vital in achieving successful resuscitation and improving survival in sudden cardiac arrest.

EAS for public use in Singapore are provided by the Singapore Civil Defence Force (SCDF), which forms the mainstay of the public EMS system. EAS ambulances are activated by a single, universal emergency number '995', are dispatched from fire stations and are under the governance of the SCDF. In this study, we defined non-EAS as those that do not operate under the SCDF and are not activated by '995'.

Currently, various providers such as commercial operators, international non-government organisations and voluntary welfare organisations provide non-EAS in Singapore. At the time of writing, there are an estimated 102 non-EAS providers running a total of 264 ambulances, usually with a crew consisting of a driver and a patient care aid (also known as ambulance assistant). This is in contrast to the SCDF which, at the time of the study, had 32 ambulances, each with a trained paramedic, ambulance assistant and driver on board.

There are no large international or local studies to date that describe OHCA in non-emergency ambulances. This study aims to describe the occurrence, recognition and treatment of OHCA in patients conveyed by non-EAS in Singapore. We suspect that OHCA is not a rare occurrence during non-EAS transport. A better understanding of the problems faced during non-EAS transport and achieving early treatment of cardiac arrest will improve survival.

Materials and Methods

Design

A multi-centre retrospective chart review, of all patients conveyed to the emergency departments (ED) of the 6 (at that time) public restructured hospitals in Singapore via non-EAS and found to be in cardiac arrest upon ED arrival.

Setting

Singapore is a city state with a land area of 710.3 square kilometers and a population of 4.98 million.[10] The population is multi-racial with the major ethnic groups being Chinese, Malay and Indian. The public EAS is run by the SCDF whose emergency ambulances are activated by a universal centralised access number '995' using computer-aided dispatch and medical dispatch protocols in a single-tiered system. They convey patients to the nearest public restructured hospital for urgent care. They are staffed by paramedics who are able to provide Basic Cardiac Life Support and defibrillation with automated external defibrillators (AEDs).[1,11,12] They can also administer a few drugs including intravenous adrenaline and insert laryngeal mask airways.

In contrast, 102 different non-EAS service providers run ambulances for patient transport. They are activated by their own direct dispatch numbers or use a separate non-emergency ambulance number (1777). They are able to transport patients to any hospital of the patient's choice. Staffing levels vary. Many operate with a crew consisting of a driver and a patient care aid (also known as ambulance assistant) who is usually trained in Basic Cardiac Life Support and first aid, while others have nurses, paramedics or even physicians on-board. The majority do not carry defibrillators or emergency drugs. There are currently no regulations in place that stipulate the staffing or equipping of ambulances in Singapore.

There is indirect medical oversight by a multi-disciplinary Medical Advisory Committee of the Ministry of Home Affairs for the SCDF EAS, but no national medical oversight currently exists for non-EAS operators.

Selection of Patients

All patients above 16 years of age conveyed to hospital by non-EAS, that were noted to be in cardiac arrest upon arrival at the ED, were included in the study. Exclusion criteria were those "obviously dead" who did not require resuscitation, as defined by the presence of decomposition, rigor mortis, or dependent lividity.

Data Collection and Processing

The OHCA patients were obtained from the CARE (Cardiac Arrest and Resuscitation Epidemiology) nationwide registry database from October 2002 to August 2009.[1] Data were obtained from ED medical records of the 6 public hospitals in Singapore. It is not the practice of non-EAS to make pre-hospital ambulance records available to the hospitals and all pre-hospital data was collected from review of ED notes instead. Cause of death was established from Coroners' reports. Institutional review board approval was obtained for the study.

Emergency physicians and representatives from the respective receiving hospitals assisted with data collection. Research coordinators assisted in reviewing case notes and data entry.

Outcome Variables

The outcome measures were (i) the percentage of OHCA that went unrecognised by the ambulance crew, (ii) whether CPR was performed in the ambulance or during transfer, and (iii) whether an AED was in use/ attached to the patient on arrival in the ED (independent of whether defibrillation was performed or not).

Data analysis was performed using the SPSS version 14.0 for Windows (Chicago, USA). Descriptive statistics were used as appropriate.

Results

Table 1 shows the characteristics of patients transported to the ED by non-EAS, with OHCA, from 2002 to 2009. We found that a total of 86 patients were conveyed to public EDs by non-emergency ambulance and found to be in cardiac arrest by ED staff upon ED arrival from October 2002 to August 2009. Mean age was 63 years (SD 21.8), 70.9% were males. A total of 53.5% of arrests occurred in the ambulance and 39.5% occured in public areas (including industrial areas and airports) and during transfer from patient's location to the ambulance. Also, 70.9% were found to be in asystole on ED arrival. Only 7 patients had a known terminal illness. Survival to discharge was 3.5%.

Of these 86 cases, cardiac arrest went unrecognised by the ambulance crew in 38 patients (44.2%) and was recognised by them in 48 patients (55.8%) (Fig. 1).

Sixty-nine patients had data available on whether cardio-pulmonary resuscitation (CPR) was performed before arrival to the ED. On ED arrival, CPR was not performed for 34 (49.3%) patients, either in the ambulance at the scene, or en route to hospital. CPR was performed for 35 patients (50.7%) (Fig. 2).

An AED was applied in only 10 (12.8%) patients arriving to the ED in cardiac arrest. It was not applied in 68 (87.2%) of the patients (Fig. 3). Inclusive of missing data, in the best case scenario, 79.1 % of patients did not have an AED applied.

Table 2 shows the number of EAS and non-EAS ambulances that conveyed patients to various emergency departments in Singapore in July 2012, along with total ED attendances for comparison. Non-EAS account for between 5.4% and 28.2% of all ambulance transports in a month.

Discussion

In this study, we found that OHCA was not a rare event during non-EAS transport. Cardiac arrest went unrecognised by non-EAS crews in almost half of the cases (38/86 = 44.2%) and CPR was not performed in almost half (34/69 = 49.3%, 17 unknown). These results highlight the challenges

Table 1. Characteristics of OHCA Patients Transported to the ED by non-EAS

Characteristics	**n = 86**
Mean Age, years (SD)	63 (21.8)
Male (%)	61 (70.9)
Race (%)	
Chinese	50 (58.1)
Malay	11 (12.7)
Indian	16 (18.6)
Others	9 (10.5)
Location of collapse (%)	
Residence	6 (7.0)
In Ambulance	46 (53.5)
Others	34 (39.5)
- Airport	15 (17.4)
- Industrial areas	5 (5.8)
- Hospital	2 (2.3)
- Other public areas, and during transfer from patient's location to the ambulance	12 (13.9)
Initial rhythm noted in ambulance (%)	
Asystole	2 (2.3)
Ventricular fibrillation (and shock delivered)	4 (4.6)
Unknown	80 (93.0)
First rhythm noted in the Emergency Department (%)	
Asystole	61 (70.9)
Ventricular Fibrillation	3 (3.5)
Pulseless Electrical Activity	18 (20.9)
Ventricular Tachycardia	1 (1.2)
Unknown	3 (3.5)
Cause of Death (%)	
Cardiac cause	38 (44.2)
Non-cardiac cause	30 (34.9)
Trauma-related causes	7 (8.1)
Medical history (%)	
Terminal disease	7 (8.1)
Heart disease	21 (24.4)
Diabetes mellitus	22 (25.6)
Hypertension	24 (27.9)
Stroke	10 (11.6)
Non-terminal cancer	9 (10.5)
Survival to discharge or 30 days	3 (3.5)

OHCA: Out-of-hospital cardiac arrest; EAS: Emergency ambulance services

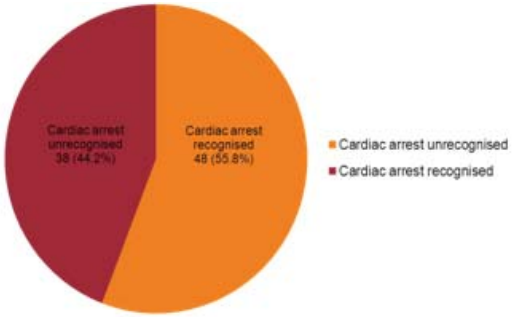

Fig. 1. Recognition of cardiac arrest by non-EAS1 crew.

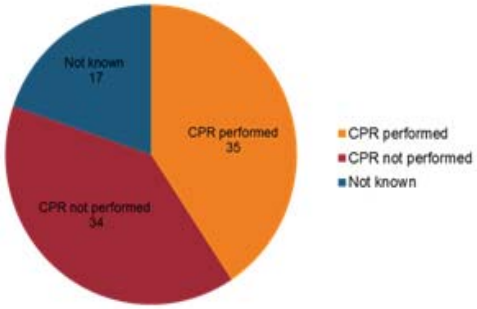

Fig. 2. CPR of cardiac arrest patients in non-EAS1.

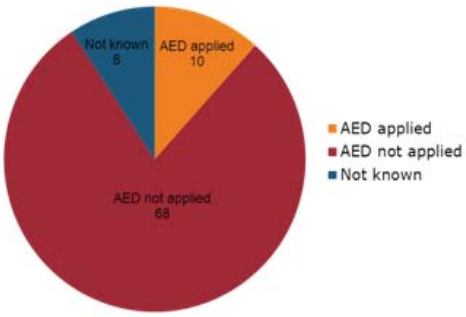

Fig. 3. Use of automated external defibrillators for cardiac arrest patients in non-EAS.*
* Emergency Ambulance Services

faced by non-EAS crews and the need for adequate training to recognise the severely ill patient. As for the low rate of AED use (10/78 = 12.8%, 8 not known), this may have been due to the lack of an AED in the vehicle or the lack of recognition that it was needed.

Interestingly, 48 patients had a recognised collapse and yet only 35 patients were brought into the ED with ongoing CPR. Note that in this study, CPR was presumed not done if the patient did not have ongoing CPR on arrival at ED. Inclusive of missing data, in the best case scenario 60.5% received CPR but a significant 39.5% did not receive CPR for OHCA.

Out of the 86 patients with OHCA upon arrival at the ED, only 7 patients had a known terminal illness. Two of them received CPR. However 4 of the other patients with terminal disease had unrecognised cardiac arrest. Assuming CPR was appropriately omitted for the 5 patients with terminal disease who did not receive CPR, there were still 29 other patients (45.3%) who required CPR but did not receive it [(34 – 5) / (35 + 29) = 29/64 = 45.3%].

There is currently no comparative literature that looks at cardiac arrests in non-emergency ambulances or other non-emergency vehicles. The value of early CPR is that it can buy time for the cardiac arrest patient by producing enough blood flow to the central nervous system and the myocardium to maintain temporary viability.[13] To do so, however, CPR must be started early, and the earlier the better. Initial CPR should be followed by rapid defibrillation, intubation, and administration of cardiovascular medications. Victims who receive early CPR are also more likely after defibrillation to convert to a cardiac rhythm associated with restoration of spontaneous circulation.[14-16]

The probability of survival from cardiac arrests is said to decrease by a factor of 7% to 10% for every minute of delay from time of arrest to commencement of resuscitation.[17]

Table 2. Number of Patients Conveyed by Ambulance at Various Hospital Emergency Department in July 2012

Hospital	Mode of Arrival			Total ED Attendance
	EAS Ambulance (%)	Non-EAS Ambulance (%)	Total ambulance	
SGH	1045 (71.8)	410 (28.2)	1455	12667
CGH	1986 (93.4)	141 (6.6)	2127	13420
NUH	1940 (89.6)	225 (10.4)	2165	10460
TTSH	2503 (87.8)	347 (12.2)	2850	14711
KTPH	1888 (94.6)	108 (5.4)	1996	12167

SGH: Singapore General Hospital; CGH: Changi General Hospital; NUH: National University Hospital; TTSH: Tan Tock Seng Hospital; KTPH: Khoo Teck Puat Hospital

From this data, it is evident that patients can and do deteriorate during non-EAS transports. Recognition of ill patients and initiation of appropriate treatment for cardiac arrest was inadequate in this study. Possible reasons for this include a lack of training in patient monitoring and detecting a critically ill patient, a lack of cardiac life support training, a lack of confidence in performing CPR, lack of recertification of skills, as well as a lack of AEDs on these ambulances and of training in their use. To illustrate, there are currently 102 non-EAS in operation under the '1777' non-emergency central dispatch system. Of these, only 49 are known to carry an AED.[18] Our results suggest that it is vital to ensure that all ambulance services are always ready and able to provide good standards of care for the local population and make efforts to remain current in knowledge and skills.

There is presently no legislation to differentiate between the emergency and non-emergency ambulance providers, and no legislation to enforce compliance to the Ministry of Health's current 'Guidelines for Private Ambulance Services' that include staff training requirements.[19] The actual quality and training of staffing for non-EAS varies greatly. While emergency service providers (SCDF) have internal quality assurance and improvement (QAI) processes in place by way of half yearly and annual service audits for example, much less is known about the QAI processes of the non-EAS providers in Singapore.

There is also a lack of criteria for the type of patients that can be transported by non-EAS ambulances as well as public ignorance on the different types of ambulances and when to call for each. This leads to critically ill patients and those with time-sensitive conditions such as stroke, being conveyed to hospital by non-emergency ambulances rather than SCDF emergency ambulances. Hence, public education is needed to heighten the awareness of the difference between emergency and non-emergency conditions.

There is a need to strengthen the regulatory framework, legislation and continuous quality improvement for non-EAS in Singapore as well as closer supervision through medical oversight by dedicated, specifically-trained physicians, such as mandated in the USA.[20] In addition, there is also a need for standardised training, certification and licensing of EMS personnel within the local non-EAS as well as opportunities for professional development.

By improving the 2nd and 3rd links in the "chain of survival", [9] namely "early CPR" and "early defibrillation", the chance of a successful resuscitation can be improved, potentially leading to improvements in the survival rate of out-of-hospital cardiac arrest. This can be evaluated through a future prospective study, as part of a national cardiac arrest registry.

Study Limitations

This study is the first of its kind looking at initiation of treatment for OHCA in non-EAS. The limitations of this study are that it is a retrospective study and thus may not be fully representative of all the cases of OHCA in Singapore during the study period.

The number of patients was small despite the long duration of the study. Furthermore, there were 3 hospitals that did not participate in the data sample from March 2006 to August 2009 and there was missing data from October 2004 to March 2006. It is likely that incomplete ED records and missing data elements resulted in an under-reporting of similar cases of 'missed' cardiac arrest brought by non-EAS. We believe there are many more similar cases that would have been detected in a prospective study and if the 3 non-participating hospitals were included.

Conclusion

A large proportion of cardiac arrests go unrecognised and untreated in non-EAS in Singapore. This could be due to inadequate training of ambulance staff as well as a lack of a legislated regulatory framework. These are areas to be addressed in the near future to improve patient care and survival outcomes.

Acknowledgements

We thank Ms Nur Shahidah Ahmad, Research Coordinator at the Department of Emergency Medicine, Singapore General Hospital.

The results were presented as a poster at the SingHealth Duke-NUS Scientific Congress 2010 on 15 October 2010.

REFERENCES

1. Eng Hock Ong M, Chan YH, Anantharaman V, Lau ST, Lim SH, Seldrup J. Cardiac arrest and resuscitation epidemiology in Singapore (CARE I study). Prehosp Emerg Care 2003;7:427-33.
2. Leung LP, Wong TW, Tong HK, Lo CB, Kan PG. Out of hospital cardiac arrest in Hong Kong. Prehosp Emerg Care 2001;5:308-11.
3. Becker LB, Ostrander MP, Barret J, Kondos GT. Outcome of CPR in a large metropolitan area—where are the survivors? Ann Emerg Med 1991;20:355-61.
4. Lombardi G, Gallagher J, Gennis P. Outcome of out-of-hospital cardiac arrest in New York City: the Pre-Hospital Arrest Survival Evaluation (PHASE) study. JAMA 1994;271:678-83.
5. Nichol G, Thomas E, Callaway CW, Hedges J, Powell JL, Aufderheide TP, et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA 2008;300:1423-31.
6. Hostler D, Thomas EG, Emerson SS, Christenson J, Stiell IG, Rittenberger JC, et al. Increased survival after EMS witnessed cardiac arrest. Observations from the Resuscitation Outcomes Consortium (ROC) Epistry-Cardiac arrest. Resuscitation 2010;81:826-30.

7. De Maio VJ, Stiell IG, Wells GA, Spaite DW. Cardiac arrest witnessed by emergency medical services personnel: descriptive epidemiology, prodromal symptoms, and predictors of survival. OPALS study group. Ann Emerg Med 2000;35:138-46.
8. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes 2010;3:63-81.
9. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving Survival From Sudden Cardiac Arrest: The "Chain of Survival" Concept. Circulation 1991;83:1832-47.
10. Ministry of health, Singapore; Population and Vital Statistics 2009. Available at: http://www.moh.gov.sg/mohcorp/statistics. Accessed 10 January 2011.
11. Ong ME, Tan EH, Ng FS, Panchalingam A, Lim SH, Manning PG, et al. Survival outcomes with the introduction of intravenous epinephrine in the management of out-of-hospital cardiac arrest. Cardiac Arrest and Resuscitation Epidemiology Study Group. Ann Emerg Med 2007;50:635-42.
12. Ong ME, Tan EH, Yan X, Anushia P, Lim SH, Leong BS, et al. An observational study describing the geographic-time distribution of cardiac arrests in Singapore: what is the utility of geographic information systems for planning public access defibrillation? (PADS Phase I). Resuscitation 2008;76:388-96.
13. Cummins R, Graves J: Clinical results of standard CPR: Prehospital and inhospital. Cardiopulmonary Resuscitation 1989;87-102
14. Pepe P. Advanced cardiac life support: State of the art. In: Vincent JL. editor. Emergency and Intensive Care. Berlin: Springer-Verlag, 1990.
15. Pepe P. Presumptive diagnosis of death versus whom to resuscitate. In Kuehl A, ed. EMS Medical Director's Handbook for the National Association of EMS Physicians. St. Louis: CV Mosby Co, 1989.
16. Cummins RO, Eisenberg MS, Hallstrom AP, Litwin PE. Survival of out-of-hospital cardiac arrest with early initiation of cardiopulmonary resuscitation. Am J Emerg Med 1985;3:114-9.
17. Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: a graphic model. Ann Emerg Med 1993;22:1652-8.
18. Singapore Civil Defence Force. Information on SCDF and 1777 ambulance services. Available at: http://www.scdf.gov.sg/content/dam/scdf_inter/amb_charges/1777_amb_charges.html. Accessed 28 January 2011.
19. Ministry of Health, Singapore. 'Guidelines for Private Ambulance Service'. 1998 [updated 1998 April23]. Available at: https://www.moh-ela.gov.sg/ela/content/TC_1998_Ambulance%. Accessed 10 December 2010.
20. Snyder JA, Baren JM, Ryan SD, Chew JL, Seidel JS. Emergency medical service system development : results of state-wide emergency medical service technical assessment program. Ann Emerg Med 1995;25:768-75.