Characteristics and outcomes of out-of-hospital cardiac arrest cases responded by emergency medical services across three states in Malaysia

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ABSTRACT

Introduction: Out-of-hospital cardiac arrest (OHCA) is globally a critical, time-sensitive emergency with varying outcomes. In Asia, the Pan Asian Resuscitation Outcome Study reported survival rates between 0.5% to 8.5%. We aim to describe the characteristics and outcomes of OHCA cases responded to by Emergency Medical Services (EMS) across several cities in Sarawak, Penang and Klang Valley in Malaysia.

Materials and Methods: This retrospective observational study analysed EMS data from Sarawak, Penang and Klang Valley from 2010 to 2019. All OHCA cases where EMS performed cardiopulmonary resuscitation (CPR) were included, regardless of age or aetiology. The primary outcome was survival to hospital admission with the secondary outcome a return of spontaneous circulation (ROSC) prior to Emergency Department arrival.

Results: A total of 2,435 OHCA cases were analysed. Median patient age was 58 years, 70% of them are male with 63% had underlying medical conditions, with hypertension being the most common. Out of all cases, 71% of arrests occurred at home, 60% witnessed. Median time from arrest to 999 call was 20 minutes, median time for ambulance arrival thereafter is 17 minutes. Bystander CPR rate was 38%, bystander Automated External Defibrillator (AED) use 1.5-2.6%. Detection of shockable rhythm on first analysis by EMS was 3.9 to 7.7%. Overall survival to admission rate was 4.76%. ROSC rate before Emergency Department arrival was 2.8%. Survival to admission among bystander-witnessed arrests with shockable rhythm was 14.7%.

Conclusion: Survival to admission rates for OHCA patients in the studied Malaysian regions (1.3-6.7%) are lower compared to some Asian countries. Areas for improvement include reducing time from arrest to 999 calls, decreasing time to EMS arrival, and increasing bystander CPR and AED use rates. Implementing the Utstein ten-step implementation strategy, focusing on community-based interventions and improving EMS response, could potentially enhance survival rates in Malaysia.

KEYWORDS:
Out-of-hospital cardiac arrest, Emergency Medical Services, Cardiopulmonary resuscitation, survival rates, Utstein reporting

INTRODUCTION

Out of Hospital Cardiac Arrest (OHCA) is a time-sensitive, life-threatening emergency.[1] OHCA is defined as cessation of cardiac mechanical activity associated with absence of circulation outside of hospital setting.[2] Global incidence of OHCA average about 55 adults per 100,000 population per year.[1] Outcomes and survival of OHCA differ between countries.[3,4] There are limited reports reflecting lower middle and upper middle-income countries with developing EMS system.[3] In 2015, the Pan Asian Resuscitation Outcome Study (PAROS) reported survival rate across participating countries in Asia between 0.5% to 8.5%.[3] The report also shows that within the same country, the survival rate varies.[3] Malaysia, as a collaborator in PAROS, has survival rate of less than 10%.[3]

Worldwide there has been studies that shows a differing range of OHCA survival rates even within the same country.[3,5] The Utstein Formula for Survival describes that survival from OHCA is dependent on three interacting factors: science, education and local implementation of the chain of survival.[6] Modifiable factors related to OHCA survival are patient age, comorbidity, initial cardiac rhythm, witness status, bystander cardiopulmonary resuscitation (CPR), bystander defibrillation, emergency medical service (EMS) response time and interventions and in-hospital interventions.[7-9]

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EMS system in Malaysia is under the Emergency Medicine and Trauma Services.[10] The system is predominantly hospital-based provider utilising Assistant Medical Officers (AMO) as the core response personnel. AMO are authorised to provide manual defibrillation, provision of advanced airway intervention and administration of resuscitation medications when managing OHCA. The training of Advanced Life Support interventions for AMO in OHCA adheres to the National Committee on Resuscitation Training Ministry of Health.[11]

At present there is no National Cardiac Arrest Registry for Malaysia, however there is an interest to collect EMS data on OHCA by individual hospitals voluntarily. Malaysia is part of the original PAROS committee, which was established since 2009, with the registry data collection beginning in 2010.[12] Adapting the PAROS registry database collection, our study aims to provide a description of patients, public and EMS resuscitation efforts for cases of OHCA across 3 states in Malaysia. Understanding the demography and response factors related to OHCA intervention will allow policy makers and service operators to prioritise the logistics and finance required to improve survival rate within their own community.[13] It also prevents generalisation of intervention because each service operation may differ in terms of population demography, geographical challenges and disease pattern.

MATERIALS AND METHODS

This is a retrospective observational study utilising EMS data from participating centres around Sarawak, Penang and Klang Valley. Ethics approval was obtained from the national Medical Research Ethics Committee NMRR-11-187-8792. Malaysia is part of the original PAROS committee which was established since 2009 wherein the registry database was inaugurated in 2010 for data collection. For this study our team used a common data collection form adapted from the PAROS registry.[12] For reporting purposes, centres are clustered into 3 states Penang, Klang Valley and Sarawak. Data from 2010 until 2019 were used for analysis.

The study included data of all OHCA cases adult, newborn or paediatric age group regardless of aetiology with cardiopulmonary resuscitation performed by EMS. The primary outcome measured was survival to hospital admission. Survival to hospital admission is defined as patients with return of spontaneous circulation (ROSC) that has been reviewed and planned for admission to definitive care. The secondary outcome measured was any ROSC reported by EMS prior to Emergency Department arrival. We did not measure 30-day survival rate as it is a summation of both EMS and in-hospital intervention, which was not the focus of our study.

Core data variables are clustered into several components such as patient demography, and bystander intervention. Patient age and EMS response times are summarised using mean standard deviation and median quartiles. Categorical data of EMS response and intervention, prehospital outcome, and outcome of patients at the Emergency Department are summarised compiled using frequency and percentages. All cases with missing variable data are excluded from the analysis. Incidence rates and outcome of OHCA are reported tabulated in frequencies and percentage according to state for comparison. Data analysis utilised SPSS Statistical software version 29.

RESULTS

A total of 2435 patients from 6 hospital-based EMS were included in the study. Table I shows the characteristics of patient between the 3 states from January 2010 till December 2019. The majority of patients age group was between 40 to 60 years, of which 0.5% of patients were less than 12 years of age. Median age of patients was 58 years old (mean 56, Standard deviation ± 18.31) whereby 70% of patients were male. The percentage of patients had underlying medical illnesses with hypertension as the most common comorbidity followed by diabetes mellitus was 63%, wherein 9% of patients had a combination of hypertension, diabetes mellitus and ischaemic heart disease.

Table II describes the cardiac arrest characteristics by states. A total of 71% of the arrest occurred at home residences compared to 10% that occurred in public or commercial buildings. Further, 60% of arrest were witnessed by either bystanders or EMS responders (53% and 7% respectively). Only 2% of arrest occurred during EMS care within the ambulance during transportation. The median time taken from arrest to 999 call was 20 minutes (mean 34 minutes, standard deviation ± 46 minutes). Klang Valley region had the longest median time from arrest to 999 call of 28 minutes (mean 39 minutes, standard deviation ± 47 minutes). Median time from 999 call to EMS arrival was 17 minutes (mean 18 minutes, standard deviation ± 11 minutes).

Table III describes the prehospital intervention by either bystander or EMS according to region. The overall bystander CPR rate is 38% with Klang Valley having only 35.5% bystander CPR. With regards to EMS intervention, Penang had a higher rate for defibrillation, use of mechanical CPR device, administration of adrenaline and advanced airway insertion (11.1%, 30.6%, and 65.8% respectively). Advanced airway intervention was widely used in Penang, with 70.3% of their patients had Laryngeal Mask Airway (LMA) applied during CPR. Sarawak performed more endotracheal intubation during CPR compared to the rest (31.3%). The primary outcome of survival to admission was 4.76% with Penang achieving 6.65%. Rate of ROSC prior to arrival to Emergency Department was 2.8% with Penang having a rate of 3.7%.

Figure 1 shows the summary of Utstein reporting parameters for Malaysia. The overall survival to admission rate for witnessed arrest with EMS cardiopulmonary resuscitation intervention and shockable rhythm analysis was 14.7%. There are 25 (2.5%) OHCA patients with initial rhythm that is non-shockable or asystole survived till admission.

DISCUSSION

Our study is the first to compare OHCA outcomes between states in Malaysia. Since Malaysia has not yet set up a

Table I: Patient demographics for all cases by states in Malaysia

Characteristic	Sarawak	Penang	Klang Valley
Total centres	2	1	3
Total population	77	767	1591
Age			
Mean	56	58	56
Std deviation	18.5	17.9	18.5
IQR:			
25	45	48	46
50	60	60	58
75	68	71	68
Gender (n, %)			
Male	60 (77.9)	557 (72.6)	1090 (68.5)
Female	17 (22.1)	210 (27.4)	500 (31.4)
Missing data			1 (0.1)
Past medical history (n, %)			
No known medical illness	8 (10.4)	59 (7.7)	391 (24.6)
Unknown if medical illness is present	20 (26.0)	249 (32.5)	184 (11.6)
Medical illness present	49 (63.6)	459 (59.8)	1016 (63.9)
Type of medical illness, when present (n, %)			
Heart disease, Hypertension, Diabetes (all present)	3 (4)	65 (8.5)	146 (9.2)
Heart disease	12 (16.9)	180 (23.5)	353 (22.2)
Diabetes	16 (20.8)	218 (28.4)	486 (30.5
Cancer	4 (5.2)	29 (3.8)	88 (5.5%)
Hypertension	28 (36.4)	235 (30.6)	549 (34.5)
Renal	3 (3.9)	59 (7.7)	122 (7.7)
Respiratory	4 (5.2)	44 (5.7)	127 (8.0)
Hyperlipidaemia	5 (6.5)	18 (2.3)	27 (1.7)
Stroke	4 (5.2)	34 (4.4)	79 (5.0)

Table II: OHCA characteristics for all cases by states in Malaysia

Characteristic	Sarawak	Penang	Klang Valley
Location type (n, %)			
Missing data			2 (0.13)
Home residence	43 (55.8)	488 (63.6)	1208 (75.9)
Healthcare facility	6 (7.7)	37 (4.8)	69 (4.3)
Public/commercial building	11 (14.3)	101 (13.2)	131 (8.2)
Nursing home	3 (3.9)	35 (4. 6)	15 (0.9)
Street/highway	58 (7.6)	69 (4.3)	134 (5.5)
Industrial place	1 (1.3)	6 (0.8)	13 (0.8)
Transport centre	1 (1.3)	2 (0.3)	15 (0.9)
Place of recreation	0 (0.0)	14 (1.8)	26 (1.6)
In EMS/private ambulance	4 (5.2)	20 (2.6)	15 (0.9)
Others	1 (1.3)	6 (0.8)	28 (1.76)
Arrest witnessed by (n, %)			
Missing data			1 (0.1)
Not witnessed	28 (36.4)	324 (42.2	630 (39.6)
Bystander	38 (49.4	355 (46.3%)	881 (55.4)
EMS	11 (14.3%)	88 (11.5)	79 (5.0)
Time from arrest to 999 call (minutes)			
Mean	39.9	19.8	38.7
Standard deviation	65.6	36.7	46.5
IQR:			
25	5	6	10
50	14	11	28
75	49	21	49.3
First arrest rhythm (n, %)			
Missing data			
VT/VF/unknown shockable	4 (5.2)	59 (7.7)	62 (3.9)
Unknown unshockable	1 (1.3)	102 (13.3)	176 (11.1)
Asystole	43 (55.8)	476 (62.1)	1196 (75.2)
Pulseless electrical activity	16 (20.8)	39 (5.1)	32 (2.0)
Unknown	13 (16.9)	91 (11.9)	125 (7.9)

Table III: Prehospital care interventions and outcomes for all out-of-hospital cardiac arrest by states in Malaysia

Characteristic	Sarawak	Penang	Klang Valley
Time 999 call to EMS arrival (minutes)			
Mean	19	15.4	20.5
Std deviation	9.2	8.9	11.8
IQR:			
25	12	10	14
50	17	14	19
75	23	19	25
Bystander intervention (n, %)			
Bystander Cardiopulmonary Resuscitation (CPR)	32 (41.6)	321 (41.9)	564 (35.5)
Bystander using Automated External Defibrillation (AED) device	2 (2.6)	19 (2.5)	23 (1.5)
EMS responder intervention (n, %)			
Prehospital defibrillation	6 (7.8)	85 (11.1)	89 (5.6)
Prehospital adrenaline	30 (39)	504 (65.7)	401 (25.2)
Prehospital mechanical CPR device	1 (1.3)	235 (30.6)	87 (5.5)
Prehospital advanced airway	31 (40.3)	620 (80.8)	508 (31.9)
OHCA outcomes (n, %)			
ROSC at scene	6 (7.8)	28 (3.7)	34 (2.1)
Arrive to ED in ROSC	4 (5.2)	23 (3. 0)	22 (1.4)
Survived to admission	1 (1.3)	51 (6.7)	64 (4.0)
Survived till discharge	0 (0.0)	5 (0.7)	15 (0.9)

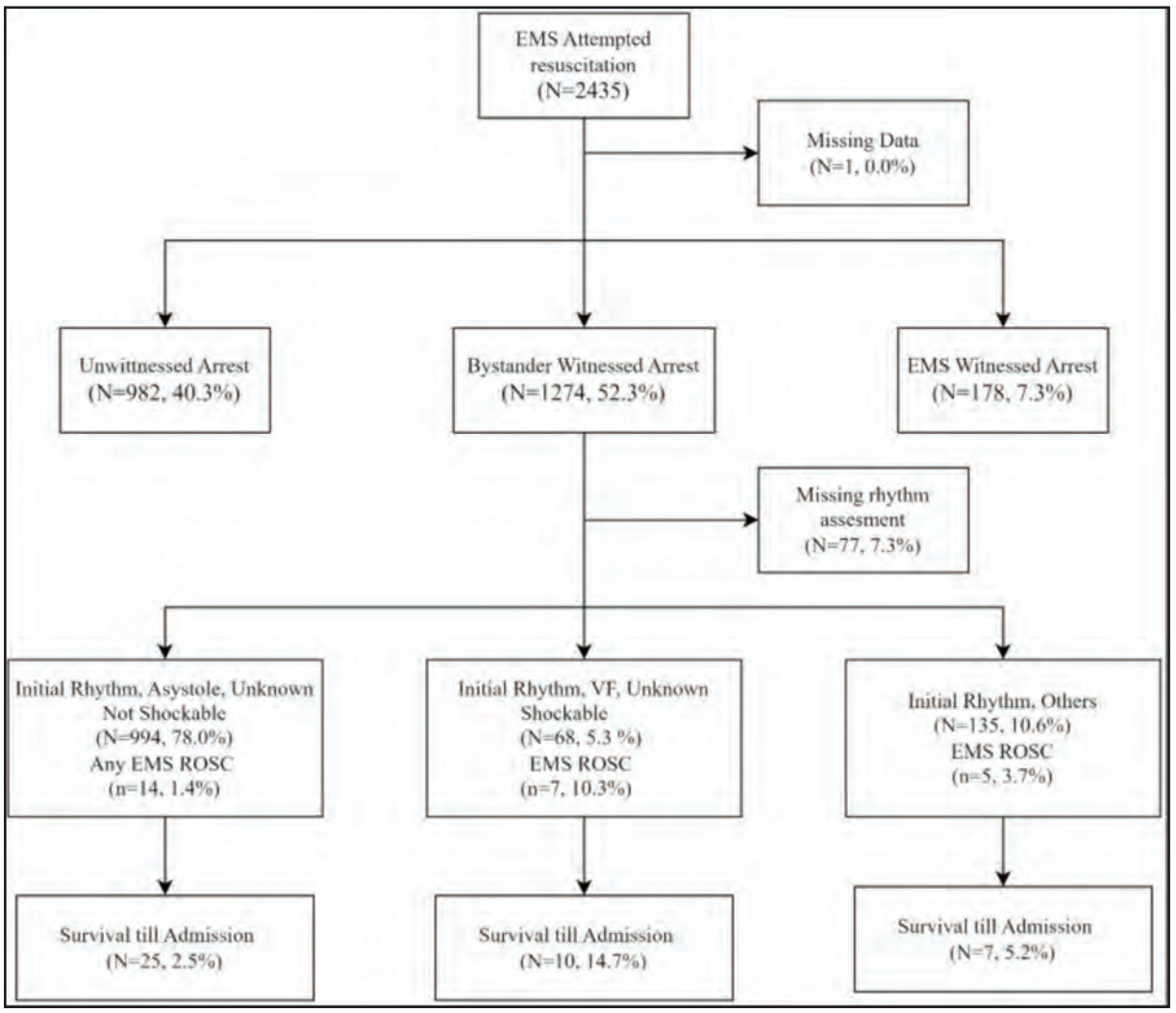

Fig. 1: Utstein survival reporting chart for overall OHCA outcome in Malaysia

National Cardiac Arrest Registry, EMS data collection for hospitals in each state are voluntary. Our data capture the EMS in major cities such as Georgetown, Kuala Lumpur, Petaling Jaya, Ampang, Kuching and Miri. Therefore, the findings reflect urban EMS systems. Among the three states; centres from Sarawak have the lowest population density with 48.3 to 754 per square kilometre. Centres from Penang and Klang Valley have higher population density of 2500 to 3000 per square kilometre.[14] In 2015, the PAROS investigators published their first report analysing OHCA in 7 countries across Asia.[3] Data from Malaysia utilised in their analysis at that time was only 389 for the period of 2010 until 2012. Our study extended the data collection period until 2019 with more centres contributing data. In total we analysed 2435 OHCA cases with CPR initiated or continued by EMS.

Our study shows that majority of OHCA occur among patients who are still within the working age group. Our mean age of 56 to 58 years is younger compared to Singapore of 66 years and Thailand of 67 years.[15,16] The PAROS team reported much younger age of OHCA victims in United Arab Emirates-Dubai which is 49 years old. It was attributed to younger migrant population within the country.[3] The same observation is not seen in our study. Similarities across the region of Asia, majority of victims are male and majority of OHCA occurred at home residence (56 to 76%).[3] The overall bystander CPR rate of 36 to 42% seen in our study is better than previously reported by PAROS at 16.5 to 21%.[17] 999 Dispatchers in Malaysia have been providing Dispatch Assisted CPR (DA-CPR) instructions since 2011. Compared to other Asian countries providing DA-CPR intervention, our rate of bystander CPR is lower compared to Singapore (50.4%) and Korea (47.3%).[17] Both Korea and Singapore have implemented the Utstein Ten-Step Implementation Strategy (UTIS) which advocates community bundle programs of DA-CPR and school CPR.[18,19] Based on our findings most witnessed OHCA occurs at home. We need to start educating and at least adopt a school CPR program in secondary schools. This initiative potentially leads to one rescuer for each household. This, together with DA-CPR will improve our bystander CPR rate. This is a critical factor to consider in the planning of Public Access AED programs.

Our bystander rate of using Automated External Defibrillator (AED) is between 1.5 to 2.6%. During the study period, Malaysia has yet to initiate a nationwide Public Access Defibrillator (PAD) program. Only in the state of Penang, since 2016 PAD program was initiated and led by the state government. It is only in 2022, that the Minister of Health proposed to make AED compulsory in all government buildings.[20] Since the majority of OHCA occurs within the home residence, it is also imperative that Public AED program include residential areas such as condominiums and public housing. Placement of AEDs within public access on its own will not lead to improved utilisation. As mentioned by Chew et. al reducing fear regarding its utilisation and promoting societal expectation change that use of an AED is an expected intervention when someone was to collapse is also critical.[21]

The median time from arrest to 999 calls ranges between 11 to 28 minutes (Table II). This has not much improved compared to 19 minutes reported by PAROS.[3] After 10 years initiation of Malaysian Emergency Response System 999 (MERS999) we have yet to targeted achieved 2 to 3 minutes time from arrest to 999 calls as seen in Japan, Korea and Singapore.[3] Median time from 999 call to EMS arrival ranges between 17 to 19 minutes. This may reflect our hospital-based EMS where the ambulance is stationed within hospitals rather than closer to community. One of the modifiable factors to improve survival in OHCA is to have an EMS arrival time of less than 8 minutes.[8] Having a faster EMS arrival time improves the chances of shockable rhythm or Ventricular Fibrillation (VF) on first rhythm analysis.[22] Our study showed detection of shockable rhythm or VF on first rhythm analysis by EMS is between 3.9 to 7.7%. This finding has not improved from the PAROS report.[3] Therefore, it is important for Malaysia especially in densely populated areas to improve its ambulance arrival time.

The overall survival to admission among OHCA patients was between 1.3 to 6.7%. This is lower compared to previous report of 8% by the PAROS investigators.[3] Penang has the highest rate of survival to admission at 6.7% compared to Sarawak (1.3%) and Klang Valley (4.0%). This may be due to a faster median time from call to ambulance arrival, higher bystander CPR rate and higher prehospital defibrillation rate. Penang also has higher rate of mechanical CPR device being used. The benefit of mechanical CPR device during transport is its ability to provide a constant high-quality compression in a moving ambulance.[23] Utilising the Utstein template of reporting, we found that overall survival to admission among bystander witnessed arrest and presence of shockable rhythm on first rhythm analysis was 14.7%. Our survival to admission rate is lower compared to Thailand of 40.8%.[24]

Our analysis shows the deficit within our public awareness and EMS system in managing OHCA. The Utstein Formula for Survival describes that survival from OHCA is dependent on three interacting factors: science, education and local implementation of the chain of survival.[6] Adopting the UTIS recommendation for Malaysia especially on the community-based intervention may improve the overall survival as seen in countries that has begun to implement the strategy.[8,13,18] Besides improving our EMS response time; our community must be educated on the importance of their action to start CPR and early defibrillation whenever an AED is available nearby in OHCA situation. We must also, realize the aspirations of the then Health Minister to make AED compulsory in all government buildings.[20]

Our study is limited by the number of participating sites contributing data. Data are collected voluntarily, and it does not reflect total cases responded for each state. Since the sites are all urban centres, our study also does not reflect non-urban communities. Another limitation of the study is that our team also could not differentiate between traumatic arrest and non-traumatic arrest. Many of the EMS data obtained did not specify the probable cause of arrest as either traumatic arrest, or presumed cardiac arrest, or respiratory arrest or unknown. The majority of the sites classify the arrest as unknown. Future research needs to differentiate between the two as the intervention provided by EMS is different. Based on our study, we recommend Malaysia to set up a National Out of Hospital Cardiac Arrest Registry for robust data collection and provide better insight to interventions

that can improve survival rate. Future research is required to investigate individual areas such as type of arrest, age category and location category.

CONCLUSION

Our study found that survival to admission rates among OHCA patients in 3 regions of Malaysia are between 1.3 to 6.7%. These survival rates are low and could be improved if Malaysia adopts the UTIS bundle program aimed at improving modifiable OHCA survival factors such as bystander CPR and defibrillation. This also includes increasing resources towards further efforts at improving EMS arrival time.

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