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Clinical Paper

Interventional strategies associated with improvements in survival for out-of-hospital cardiac arrests in Singapore over 10 years

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ABSTRACT

Aim: We aim to study if there has been an improvement in survival for Out-of-Hospital Cardiac Arrest (OHCA) in Singapore, the effects of various interventional strategies over the past 10 years, and identify strategies that contributed to improved survival.
Methods: Rates of OHCA survival were compared between 2001–2004 and 2010–2012, using nationwide data for all OHCA presenting to EMS and public hospitals. A multivariate logistic regression model for survival to discharge was constructed to identify strategies with significant impact.
Results: A total of 5453 cases were included, 2428 cases from 2001 to 2004 and 3025 cases from 2010 to 2012. There was significant improvement in Utstein (witnessed, shockable) survival to discharge from 2001–2004 (2.5%) to 2010–2012 (11.0%), adjusted odds ratio (OR) 9.6 [95% CI: 2.2–41.9]). Overall survival to discharge increased from 1.6% to 3.2% (adjusted OR 2.2 [1.5–3.3]). Bystander CPR rates increased from 19.7% to 22.4% ($p = 0.02$). The multivariate regression model (adjusted for important non-modifiable risk factors) showed that response time <8 min (OR 1.5 [1.0–2.3]), bystander AED (OR 5.8 [2.0–16.2]), and post-resuscitation hypothermia (OR 30.0 [11.5–78.0]) were significantly associated with survival to hospital discharge. Conversely, pre-hospital epinephrine (OR 0.6 [0.4–0.9]) was associated negatively with survival.
Conclusions: OHCA survival has improved in Singapore over the past 10 years. Improvement in response time, public AEDs and post-resuscitation hypothermia appear to have contributed to the increase in survival. Singapore's experience might suggest that developing EMS systems should focus on reducing times to basic life support, including bystander defibrillation and post-resuscitation care.

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1. Introduction

Out of Hospital Cardiac Arrest (OHCA) is defined as cessation of cardiac mechanical activity that occurs outside of the hospital setting and is confirmed by the absence of signs of circulation. In the concept of the "chain of survival", mortality from cardiac arrests can be reduced with early access, early cardiopulmonary resuscitation (CPR), early defibrillation, early advanced care and post resuscitation care.[1] However developing EMS systems with limited resources often face a dilemma on which interventions to prioritize.

The majority of OHCA sufferers, irrespective of aetiology, do not receive timely bystander-assisted CPR or other interventions thought to improve the likelihood of survival to hospital discharge (e.g., defibrillation). Nearly half of cardiac arrest events are witnessed and efforts to increase survival rates should focus not only on Emergency Medical Services (EMS) but also timely delivery of effective interventions by bystanders.[2] In Singapore, the previously published OHCA survival rate is 2% (2001–2002)[3] as compared to 16.3% in 10 North American sites, suggesting that there is still much room for improvement.[4]

Singapore is a city-state with a land area of 712.4 square kilometres and a population that has increased from 4.1 million (in 2002) to 5.3 million (in 2012).[5] The Singapore EMS is activated by a centralized, enhanced '995' dispatch system run by the Singapore Civil Defence Force (SCDF) and utilizing Computer Aided Dispatch, Medical Dispatch protocols, Global Positioning Satellite (GPS) Automatic Vehicle Locating Systems and road traffic monitoring systems.

From 2001 to 2012, there were several improvements in Singapore's EMS pre-hospital system in terms of equipment, paramedic skills and in-hospital care of OHCA patients. For example, public access defibrillators have started to be introduced, the number of ambulances was increased from 36 in 2001 to 46, paramedics were certified to give epinephrine intravenously and use laryngeal mask airway devices in 2004 and therapeutic hypothermia was introduced for post-resuscitation care in 2008. Public education on CPR has helped create more awareness and encouraged the public to learn CPR.

We aim to study if there has been an improvement in survival, the effects of various interventional strategies over the past 10 years, and to identify the strategies that contributed to improved survival. We hypothesize that survival to discharge for OHCA in Singapore has improved in the last 10 years, and that this improvement is due to improvements in several modifiable factors.

2. Methods

We conducted a nationwide retrospective cohort analysis of all OHCA cases presenting to EMS and public hospitals. We utilized data from the Singapore Cardiac Arrest and Resuscitation Epidemiology (CARE) project from 2001 to 2004 and 2010 to 2012. Singapore has a comprehensive, single provider, fire-based EMS system which only sends cases to public hospitals. Both cohorts covered exactly the same population-base over different time periods and used the same case ascertainment, data definitions, data collection methods and data variables.

The study was approved by the local Institutional Review Boards. It was classified as minimal risk research with waiver of informed consent.

The CARE project is a prospective registry of cardiac arrests, with initial data collection from October 2001 to October 2004 involving the six (at the time) major hospitals in Singapore. There was no nationwide data collection between 2005 and 2009 due to a lapse of research funding. Subsequently with restored funding, all OHCA cases from April 2010 to May 2012 were included for analysis in the 'after' phase.

In both cohorts, all patients with OHCA as confirmed by the absence of a pulse, unresponsiveness and apnoea were included. Exclusion criteria were those 'obviously dead' as defined by the presence of decomposition, rigour mortis or dependant lividity and traumatic arrests. Patient characteristics, cardiac arrest circumstances, ECG rhythms, EMS response times and outcomes were recorded in a standard report according to the Utstein template.[6] Aetiology of arrests were determined by coroner's report and inpatient discharge records for survivors.

Data were drawn from prospectively filled study forms, EMS records, Emergency Department (ED) notes as well as hospital discharge records. EMS response timings were extracted from a centralized dispatch system and ambulance records. In Singapore, time at patient's side is routinely radioed to dispatch, which captures the timing electronically. Data was managed using a secure, online electronic data-capture platform. Data entered in the system was periodically checked by research coordinators for accuracy and completeness. Incomplete data variables were sent back to respective site principal investigators for clarification and verification. Utstein survival refers to survival to hospital discharge of those cardiac patients whose arrest events were witnessed by a bystander and who had an initial rhythm of ventricular fibrillation or pulseless ventricular tachycardia.

To test the various hypotheses, the survival rate was first compared by logistic regression and second the distribution of resuscitation factors was compared by Chi-squared test or Mann–Whitney test, between the 2 datasets corresponding to the 2 time periods. Finally, the effect on survival outcome, of non-modifiable factors such as age, gender, past medical history, as well as modifiable factors such as bystander AED was investigated using univariate logistic regression followed by multivariate logistic regression using the a merged dataset. For each factor, both unadjusted and adjusted odds ratios (95% confidence intervals) for the univariate and multivariate analysis respectively were reported. The multivariate logistic regression model for survival to discharge was implemented adjusting for age, witnessed/unwitnessed arrest, initial rhythm, bystander CPR, bystander AED, response time, ambulance defibrillation, ambulance mechanical CPR, pre-hospital advanced airway, IV epinephrine administration and therapeutic hypothermia. The selection of variables for the model was based on factors known from the literature which were previously associated with cardiac arrest survival.[7,8] All data analyses were performed using SPSS version 17.0.

3. Results

From October 2001 to October 2004, 2428 cases were included. From April 2010 to May 2012, 3025 cases were included, for a total of 5453 cases. Despite an increase in the population between 2002 and 2012, the number of cardiac arrests per 100,000 population remained similar between the two time periods (59.2 in 2002 vs. 57.1 in 2012). The mean age of the 2001–2004 patients was 60.6 years with 63.0% male and 63.5 years for 2010–2012 with 65.7% male. The top 3 locations of arrests for both 2001–2004 and 2010–2012 were home residence (70.1% vs. 70.0%), public/commercial building (7.1% vs. 7.8%) and street/highway (4.4% vs. 5.9%) (Table 1).

Table 2 shows resuscitation factors for the two time periods. Bystander CPR rates increased from 19.7% in 2001–2004 to 22.4% in 2010–2012 ($p = 0.02$). Bystander AED applied rates (layperson defibrillator applied) increased from 0.0% in 2001–2004 to 1.8% in 2010–2012 ($p < 0.01$) while the Public Access Defibrillation (PAD) rate (layperson defibrillation-shock given) increased from 0.0% to 1.0% ($p < 0.01$) for all arrests. Pre-hospital drug administration increased from 13.4% to 46.8% ($p < 0.01$).