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Clinical paper

Direct transport to a PCI-capable hospital is associated with improved survival after adult out-of-hospital cardiac arrest of medical aetiology☆

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ABSTRACT

Aim: To compare survival outcomes of adults with out-of-hospital cardiac arrest (OHCA) of medical aetiology directly transported to a percutaneous-coronary-intervention capable (PCI-capable) hospital (direct transport) with patients transferred to a PCI-capable hospital via another hospital without PCI services available (indirect transport) by emergency medical services (EMS).

Methods: This retrospective cohort study used the St John Ambulance Western Australia OHCA Database and medical chart review. We included OHCA patients (≥18 years) admitted to any one of five PCI-capable hospitals in Perth between January 2012 and December 2015. Survival to hospital discharge (STHD) and survival up to 12-months after OHCA were compared between the direct and indirect transport groups using multivariable logistic and Cox-proportional hazards regression, respectively, while adjusting for so-called "Utstein variables" and other potential confounders.

Results: Of the 509 included patients, 404 (79.4%) were directly transported to a PCI-capable hospital and 105 (20.6%) transferred via another hospital to a PCI-capable hospital; 274/509 (53.8%) patients STHD and 253/509 (49.7%) survived to 12-months after OHCA. Direct transport patients were twice as likely to STHD (adjusted odds ratio 1.97, 95% confidence interval [CI] 1.13–3.43) than those transferred via another hospital. Indirect transport was also associated with a possible increased risk of death, up to 12-months, compared to direct transport (adjusted hazard ratio 1.36, 95% CI 1.00–1.84).

Conclusion: Direct transport to a PCI-capable hospital for post-resuscitation care is associated with a survival advantage for adults with OHCA of medical aetiology. This has implications for EMS transport protocols for patients with OHCA.

Introduction

Australian Resuscitation Council (ARC) guidelines recommend direct transport of adults with out-of-hospital cardiac arrest (OHCA) of presumed medical aetiology to a specialist cardiac arrest centre [1]. This recommendation is based on growing consensus that early access to a standardised post-resuscitation care bundle including percutaneous-coronary-intervention (PCI) and targeted-temperature-management (TTM) improves survival after OHCA [2]. However, Perth emergency medical services (EMS) have historically transported OHCA patients to the nearest emergency department (ED) [3], irrespective of whether PCI or an intensive care unit (ICU) is available.

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International consensus is that direct EMS transport of STEMI patients with OHCA to a PCI-capable hospital for early coronary revascularization and post-resuscitation care improves survival [4]. Whether this referral strategy increases survival in OHCA from medical causes other than STEMI is unknown. Observational studies from the United States [5,6], Japan [7], and Europe [1–10] suggest direct EMS transport of adult OHCA patients to a hospital with a high-level critical care service improves survival after adjustment for other risk factors. An Australian study found that in-hospital factors, including 24-h PCI-capability were significantly associated with improved survival to hospital discharge (STHD) for adult OHCA patients [11]. The authors concluded further research was needed to establish the generalisability of their findings given the variation in population distribution and distance to PCI-capable hospitals in Australia [11].

We aimed to determine if direct EMS transport of adults with OHCA of presumed medical aetiology, including those with OHCA due to non-STEMI or acute coronary syndrome (ACS), to a PCI-capable hospital (direct transport) was associated with improved STHD and 12-month survival compared to those transferred via another hospital where PCI was not available (indirect transport).

Methods

Study design

We conducted a retrospective cohort study across five PCI-capable hospitals in Perth for OHCA patients attended by St John Ambulance Western Australia (SJA-WA) between 1st January 2012 and 31st December 2015.

Study setting

Perth is the capital of Western Australia (WA). Its population was 2.04 million in 2015 [12]. Perth is serviced by a single road-based EMS provider, SJA-WA [13]. Paramedics provide advanced life support (ALS) according to SJA-WA Clinical Practice Guidelines [3] based on ARC Guidelines [14]. ALS skills include advanced airway management (endotracheal intubation or laryngeal mask), cardiac arrest drug administration and manual defibrillation [3].

In accordance with SJA-WA clinical guidelines at the time, OHCA patients who had resuscitation attempted by paramedics and not ceased in the field were transported to the nearest ED [3]. Subsequent inter-hospital transfer occurred when the diagnostic facilities, clinical expertise or therapeutic needs of a patient were beyond the capacity of the initial receiving hospital.

During the study, 11 hospitals had an ED that provided 24-h emergency services to adult OHCA patients; four tertiary, three general, three private public partnership (PPP) and one private hospital. Of these, six hospitals (four tertiary, one PPP and one private hospital) were PCI-capable as they had an onsite cardiac catheterisation laboratory (CCL) and the ability to perform PCI [15]. We excluded the few patients admitted to the private hospital as we did not seek Human Research Ethics Committee (HREC) approval at that hospital.

Of the five PCI-capable hospitals included in the study, two tertiary hospitals had restricted operating periods. Site A operated from January 2012 to February 2015 and site B operated from February 2015 to December 2015. The PPP hospital with PCI capability (site C) operated from November 2012. Patients transferred via another hospital where PCI was not available to a PCI-capable hospital within 24 h of the EMS call were defined as 'indirect transport' patients.

Study cohort

We included patients (≥18 years) with OHCA from presumed medical aetiologies (presumed cardiac or unknown, other medical causes) [16], resuscitated by paramedics and admitted with return of spontaneous circulation (ROSC). We excluded patients with missing medical charts, OHCA within 7 days of hospital discharge and 'Hospital in the Home' patients as they were already receiving acute hospital level care [17].

Data sources

Patients were identified from the prospectively collected SJA-WA OHCA Database. We abstracted demographic and clinical data including transport group (direct versus indirect), age, sex, arrest location, witness status (bystander, paramedic, unwitnessed), bystander cardiopulmonary resuscitation (CPR) (yes/no), initial arrest rhythm (unknown classified as non-shockable), asystole or ventricular fibrillation (VF) ever reported, day and time of arrest, and any prehospital ROSC.

Data abstracted from medical chart review included a medical diagnosis of ACS in ED, coronary angiography, PCI within the first 24 h of EMS call and therapeutic interventions in ICU, including mechanical ventilation (MV) and TTM. We defined TTM as any attempt to control core body temperature within the first 24-h of ICU admission [18,19].

Survival outcomes were collected from medical chart review and deaths were confirmed by the WA Death Registry [20]. All data were collected by trained research nurses and Cohen's Kappa inter-rater reliability was high ($\kappa = 0.96$, 95% CI 0.88–1.0, $p < 0.001$) [21].

Study outcomes

The primary outcome was STHD. Secondary outcomes were: 30-day survival, 12-month survival (both from the date of the OHCA) and good neurological outcome at hospital discharge using the Cerebral Performance Categories (CPC) Scale [22]. CPC scores of 1 (good cerebral performance) or 2 (moderate cerebral disability) were considered to be 'good' neurological outcomes [22].

Statistical analysis

To examine the association between transport group and survival, we analysed the total cohort of patients admitted to a PCI-capable hospital, as well as three subgroups of patients admitted to ICU. The first subgroup included all patients admitted to ICU and the second included patients who also received coronary angiography within 24 h of the EMS call. The third subgroup included patients who proceeded to PCI. Patients not receiving MV on arrival to ICU were excluded from subgroup analyses to reduce clinical heterogeneity.

Descriptive statistics describe and compare demographic and clinical characteristics and patient outcomes between the direct and indirect transport groups and also between these groups combined and those patients who remained at a non-PCI-capable hospital. Continuous variables were reported as medians with interquartile range (IQR) and categorical variables as percentages. Differences between transport groups were assessed using the student's t-test and Mann-Whitney U test for continuous variables, and Pearson chi-square analysis, Chi Square and Fisher's Exact Test for categorical variables as appropriate. A p value < 0.05 was considered statistically significant for all analyses. We used the Statistical Package for Social Sciences (SPSS) Version 24.0 (IBM, Armonk, NY, USA).

Multivariable logistic regression models examined the independent association of transport group with STHD and Cox proportional hazards models for 12-month survival. Multivariable models were adjusted for Utstein variables and other potential explanatory factors (Table 2). To eliminate the effect of any potential non-proportionality in hazards in the 12-month survival analysis, we used Kaplan-Meier survival curves and log rank test to compare transport groups.

We conducted two sensitivity analyses to assess the robustness of our results. Firstly, we excluded all patients in the total cohort whose initial arrest rhythm was 'unknown' to estimate the effect of these