



Clinical paper

Potential impact of a prehospital redirection system for refractory cardiac arrest[☆]

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ABSTRACT

Aim: A change in prehospital redirection practice could potentially increase the proportion of E-CPR eligible patients with out-of-hospital cardiac arrest (OHCA) transported to extracorporeal cardiopulmonary resuscitation (E-CPR) capable centers. The objective of this study was to quantify this potential increase of E-CPR candidates transported to E-CPR capable centers.

Methods: Adults with non-traumatic OHCA refractory to 15 min of resuscitation were selected from a registry of adult OHCA collected between 2010 and 2015 in Montreal, Canada. Using this cohort, three simulation scenarios allowing prehospital redirection to E-CPR centers were created. Stringent eligibility criteria for E-CPR and redirection for E-CPR (e.g. age <60 years old, initial shockable rhythm) were used in the first scenario, intermediate eligibility criteria (e.g. age <65 years old, at least one shock given) in the second scenario and inclusive eligibility criteria (e.g. age <70 years old, initial rhythm ≠ asystole) in the third scenario. All three scenarios were contrasted with equivalent scenarios in which patients were transported to the closest hospital. Proportions were compared using McNemar's test.

Results: The proportion of E-CPR eligible patients transported to E-CPR capable centers increased in each scenario (stringent criteria: 48 [24.5%] vs 155 patients [79.1%], $p < 0.001$; intermediate criteria: 81 [29.6%] vs 262 patients [95.6%], $p < 0.001$; inclusive criteria: 238 [23.9%] vs 981 patients [98.5%], $p < 0.001$).

Conclusions: A prehospital redirection system could significantly increase the number of patients with refractory OHCA transported to E-CPR capable centers, thus increasing their access to this potentially life-saving procedure, provided allocated resources are planned accordingly.

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Introduction

Over 300 000 people are victims of out-of-hospital cardiac arrest (OHCA) each year in the United States [1]. Despite advances in medical care, survival amongst these patients remains low, with only 5–10% surviving to discharge [1,2]. Extracorporeal

cardiopulmonary resuscitation (E-CPR), which incorporates an extracorporeal cardiopulmonary bypass circuit to obtain cardiopulmonary support during resuscitation, has recently been proposed as an effective complement to traditional resuscitation [3–9]. Because of the expertise and physical, human and economic resources required for E-CPR, its availability is often limited to dedicated, specialized centers. In addition, determining patient eligibility criteria is critical, judging by the variation observed in survival benefits (less than 2% to over 50%) seen in patient groups [3,10].

Changes in the organization of regional prehospital systems has successfully decreased morbidity and mortality in patients suffer-

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Table 1
Criteria used to select E-CPR candidates in simulation scenarios.

	Stringent criteria		Intermediate criteria		Inclusive criteria	
	Without prehospital redirection	With prehospital redirection	Without prehospital redirection	With prehospital redirection	Without prehospital redirection	With prehospital redirection
Age	<60	<60	<65	<65	<70	<70
Initial rhythm	VF/VT	VF/VT	Non asystole	Non asystole	Non asystole	Non asystole
Shock given	Yes	Yes	Yes	Yes	Not necessary	Not necessary
Time before cardiac massage initiation (min)	Immediate	Immediate	<5	<5	<10	<10
Time to E-CPR initiation (min)	<60	<60	<80	<80	<100	<100
Maximum hospital transport time to an E-CPR capable center (min)	≤15	≤15	≤18	≤18	≤21	≤21
Prehospital redirection allowed	No	Yes	No	Yes	No	Yes

E-CPR: extracorporeal cardiopulmonary resuscitation; VF: Ventricular fibrillation; VT: Ventricular tachycardia.

ing from ST-segment elevation myocardial infarction and severe trauma. This is partly because of direct transport to dedicated centers, bypassing primary or secondary care centers when necessary, thereby reducing the total time to definitive care [11–14]. Since refractory OHCA is also a time-sensitive condition with a low survival rate, it is plausible that, for appropriately selected patients, a similar approach could be of benefit [10,15,16]. Indeed, bypassing a closer hospital in favor of an advanced-care center where E-CPR is available could improve survival if the delay incurred is short, which is the case in urban settings where hospitals are clustered in the same area.

Estimating the potential effect of such a system could help allocate resources accordingly. The main objective of this study was to quantify the potential increase of the proportion of E-CPR candidates transported directly to E-CPR capable centers by simulating prehospital redirection scenarios with varying criteria. The secondary objective was to evaluate the potential effect of this redirection on the hospital transport time for E-CPR candidates.

Methods

Design and setting

This simulation study used a registry of OHCA. The data available were used to simulate scenarios in which redirection to an E-CPR capable center was guided by three different sets of inclusion criteria. These scenarios were compared to scenarios with equivalent inclusion criteria, but for which there was no prehospital redirection (i.e. transport to the closest hospital), which reflects current practice. This study was carried out in association with the Hôpital du Sacré-Coeur de Montréal, the local emergency medical services (EMS) agency (Urgences-santé) and the Université de Montréal. It was approved by the Institutional Review Board of the Hôpital du Sacré-Coeur de Montréal and conducted in accordance with the Declaration of Helsinki.

This study used data from the region of Montreal, Canada. A single public EMS agency coordinates the prehospital care for the two million citizens in the serviced area. First responders and paramedics treat patients suffering from OHCA by following resuscitation protocols based on the American Heart Association guidelines [17–19]. Patients suffering from OHCA are normally transported to the closest of the 20 local hospitals, five of which have the necessary resources and expertise to perform E-CPR.

Study population

All patients aged 18 years and older treated for an OHCA from April 2010 until December 2015 were screened for inclusion.

Patients were excluded from the initial registry if their death was considered obvious according to EMS criteria (e.g. decapitation, advanced putrefaction, etc.), if the cause of the OHCA was traumatic or in cases where ‘do-not-resuscitate’ directives were known [17]. In addition, patients who experienced ROSC within 15 min of either first responders’ or paramedics’ arrival were excluded because these patients are generally not considered for E-CPR.

Study groups

In half of the proposed scenarios, it was considered that E-CPR candidates would be transported to the closest hospital (current practice; no prehospital redirection). In the other half, transport to the closest E-CPR capable center was simulated (hypothetical prehospital practice; with prehospital redirection) (Table 1).

Since there is no consensus on which criteria should be used to determine patient eligibility for E-CPR, clinical variables (age, initial rhythm, whether or not a shock was delivered, time to initiation of cardiac massage, total time to E-CPR initiation and hospital transport time) that have previously been used to select patients for E-CPR or that have been associated with survival following E-CPR were used [3,6,8,15,20]. In order to increase the external validity of the study, these variables were used to construct three sets of varying clinical criteria to select E-CPR candidates: one with stringent eligibility criteria, one with intermediate eligibility criteria and one with inclusive eligibility criteria (Table 1).

Outcome measurements

For the primary objective, the outcome measure was the proportion of E-CPR candidates being transported to an E-CPR capable center using the stringent eligibility criteria. For the secondary objective, the outcome measure was the hospital transport time (total transport time from scene to hospital in minutes).

Data collection and management

According to provincial law, OHCA patient data are entered by paramedics on a ‘run-sheet’ following every call. This information is then entered into a database that includes demographic (gender, age) and clinical characteristics (chief complaint, core Utstein-style data, etc.) [21]. Call times are automatically registered in a separate database that is linked to the patient-care information database. When the data on hospital transport time was not available in the database (e.g. on-site termination of resuscitation), it was estimated using an online geospatial service (Google Distance API, Mountain view, CA, USA).

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