

Brief Reports



EXTRACORPOREAL LIFE SUPPORT FOR REFRACTORY CARDIAC ARREST FROM ACCIDENTAL HYPOTHERMIA: A 10-YEAR EXPERIENCE IN EDINBURGH

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Abstract—Background: Cardiac arrest caused by accidental hypothermia is a rare phenomenon with a significant mortality rate if untreated. The consensus is that these patients should be rewarmed with extracorporeal life support (ECLS) with the potential for excellent survival and neurologic outcomes. However, given the lack of robust data and clinical trials, the optimal management of such patients remains elusive. **Objective:** In this single-center study, we looked at the outcomes of all adult patients undergoing salvage ECLS for cardiac arrest caused by accidental hypothermia over a 10-year period from June 2006 to June 2016. **Methods:** These data were obtained from the Royal Infirmary of Edinburgh cardiothoracic surgery database. The patients' hard copy case notes, TrakCare (InterSystems Corp, Cambridge, MA), picture archiving and communications system (PACS), and WardWatcher databases were used to cross-check the accuracy of the acquired data. **Results:** Eleven patients met the inclusion criteria. The etiology of hypothermia was exposure to cold air (64%) and cold water immersion (36%). Two (18%) were treated with extracorporeal membrane oxygenation and the rest with cardiopulmonary bypass. The mean age was 51 years (range 32–73), and the mean core body temperature on admission

was 20.6°C (range <18–24°C). The overall survival rate to hospital discharge was 72%, with 75% of survivors having no chronic neurologic impairment. **Conclusion:** Our case series shows the remarkable salvageability of patients suffering prolonged cardiac arrest caused by accidental hypothermia, particularly in the absence of asphyxia, trauma, or severe hyperkalemia. ECLS is a safe and effective rewarming treatment and should be used to aggressively manage this patient group. © 2016 Elsevier Inc. All rights reserved.

Keywords—extracorporeal membrane oxygenation; heart arrest; hypothermia

INTRODUCTION

The effect of hypothermia on the body was first studied by Wilfred Bigelow in the 1950s (1). Hypothermia is defined as a reduction in core body temperature (T_{CORE}) below 35°C (95°F) and can be classified as either primary, secondary, or therapeutic. Primary hypothermia occurs in healthy individuals when heat production is overcome by environmental factors and may be accidental, suicidal, or homicidal. Secondary hypothermia complicates a systemic illness or drug therapy, and can even occur in warm conditions (2).

Drs Khorsandi and Dougherty contributed equally to this article.

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Hypothermia may be further subcategorized into mild, moderate, and severe, with mild usually being 32–35°C and severe $\leq 28^{\circ}\text{C}$ (3,4). Some experts advocate an additional category, profound hypothermia, $\leq 24^{\circ}\text{C}$ or $\leq 20^{\circ}\text{C}$ (5,6). However, in-field measurement of T_{CORE} may be impossible or unreliable, and therefore clinical signs are used to infer actual T_{CORE} —many guidelines have moved to the Swiss system for staging hypothermia, shown in Table 1 (7,8).

Severe accidental hypothermia is seasonally and geographically pervasive, although is more common in urban settings, where homelessness, alcohol excess, substance abuse, and psychiatric disorders often coexist (7,9). Accidental hypothermia is associated with significant mortality but is a rare cause of death. In Ireland, it was found to be responsible for 18.1 deaths per million individuals, and in Glasgow, comparable mortality rates of 22 per million were observed (10,11). Official UK figures implicate hypothermia in 300 deaths per year (3).

While severe accidental hypothermia is associated with high rates of mortality, many clinicians have also witnessed profoundly cold and lifeless victims undergoing incredible “reanimations.” The maxim “not dead until warm and dead” is a valuable reminder of what is possible. However, controversy and debate permeate many aspects of accidental hypothermia management, and much remains unknown about the optimal treatment of this condition. Expert opinion is divided, from prehospital management to in-hospital rewarming strategies for hypothermic cardiac arrest (9,11,12). The evidence for clinical decision making is limited and must be informed largely on only a few randomized controlled trials, numerous case series and single case reports, experiments on mildly hypothermic subjects, and experimental physiology studies; no controlled studies comparing rewarming methods in moderately and severely hypothermic subjects exist, nor are they likely to. What is clear is that in hypothermic cardiac arrest, rewarming with extracorporeal life support (ECLS)—either with cardiopulmonary bypass (CPB) or extracorporeal membrane oxygenation (ECMO)—is the

criterion standard but without clinical trials of outcome we are unable to determine the best modality (13).

In this case series, we looked at the outcome of accidental hypothermic cardiac arrest salvaged with ECLS over a 10-year period within our institution.

MATERIALS AND METHODS

The Royal Infirmary of Edinburgh (RIE) is a tertiary referral university hospital located in Edinburgh, Scotland at 55.9°N latitude. The warmest month is July, with a mean air temperature of 15°C. The coldest month is January, with a mean air temperature of 3°C and water temperature of 6.1°C. The RIE is the only hospital in east of Scotland with ECLS facilities and manages all cases of accidental hypothermic cardiac arrests in this region, covering an approximate area of 4732 km and with a population of 850,000 (14).

This was a monocentric, retrospective study of the RIE cardiothoracic surgery database. Adult patients (≥ 16 years of age) who underwent ECLS for accidental hypothermia cardiac arrest between June 2006 to June 2016 were eligible. We also cross-checked our data with the WardWatcher Universal Scottish Intensive Care Society database with the keyword “hypothermia” to ensure that all eligible patients admitted to RIE within the study period had been included. Once the patient identifiable details were collected, we gained more specific clinical details from the patients’ hard copy case notes and the TrakCare (InterSystems Corp, Cambridge, MA) and picture archiving and communication system (PACS) databases. In patients who had been dead for ≥ 5 years, we were unable to gain more information from the hard copy case notes because these notes were destroyed as per the National Health Service (NHS) Lothian policy.

All patients were resuscitated by the prehospital emergency medical team as per the advanced life support (ALS) guidelines (Table 1). Three (27%) had documented bystander cardiopulmonary resuscitation (CPR) before the arrival of the prehospital emergency team. The rewarming process had been started at the emergency

Table 1. The Swiss Criteria for Classification and Management of Hypothermia

Hypothermia (HT) Stage	Clinical Symptoms	Core Body Temperature ($^{\circ}\text{C}$)	Therapeutic Measure
I	Fully conscious with rigors	35–32	Simple measures (e.g., warm sheets, mobilization, and warm, sweet drinks)
II	Impaired consciousness without rigors	32–28	Cardiac monitoring and minimal invasive electrical heating
III	Unconscious, without rigors but vital present	28–24	As for HT II with added ECMO in cases of cardiac instability
IV	Absent vital signs	<24	Airway management, active external and internal rewarming, CPR, and ECMO

CPR = cardiopulmonary resuscitation; ECMO = extracorporeal membrane oxygenation.

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