

## CASE REPORT

# Extracorporeal rewarming and support in severe hypothermia with cardiac arrest: a return from death

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## Abstract

Severe hypothermia leads to cardiac instability; however, it also has protective effects due to decreased metabolic activity. Therefore, prolonged resuscitation is advised in hypothermic cardiac arrest. We present a case of severe hypothermia without asphyxia, which is very important prognostically, leading to ventricular fibrillation. Conventional rewarming methods did not result in a higher body temperature. Extracorporeal circulation and rewarming was started after 210 minutes of conventional but adequate cardiopulmonary resuscitation. Good neurological recovery was observed after prolonged support on the intensive care unit. This case and other cases described in the literature should create awareness regarding the importance of prolonged resuscitation in hypothermic cardiac arrest. Extracorporeal rewarming and support could contribute to excellent recovery and therefore must be considered in similar cases.

## Introduction

'Nobody is dead until warm and dead' is a lesson taught during the early stages of medical training. Severe accidental hypothermia is associated with cardiac instability, ventricular arrhythmias, cardiac arrest and high mortality. However, due to decreased metabolic activity, hypothermia also has a protective effect during cardiac arrest. Probably because of this protection, good neurological recovery is often observed in successfully resuscitated and rewarmed hypothermic patients. Even after prolonged resuscitation, full recovery has been described in patients after immediate high-quality cardiopulmonary resuscitation (CPR). A mechanical chest compression system is preferred for high-quality CPR and the application of extracorporeal membrane oxygenation (ECMO) for rewarming and cardiorespiratory support should be considered.<sup>[1-7]</sup>

In mild hypothermia, conventional methods of rewarming including warm blankets, warm air convection, warm intravenous fluids and warm internal lavage of body cavities are usually sufficient. In severe hypothermia, rewarming with veno-arterial (VA)-ECMO is becoming the method of choice, due to increasing availability and the potential to prolong cardiopulmonary support after rewarming.<sup>[8]</sup>

Hypothermic cardiac arrest is usually encountered in situations involving homelessness, intoxication, mountaineering accidents, near-drowning accidents or suicide attempts. Prognosis is often good in patients when hypothermic cardiac arrest is caused by intoxication.<sup>[7]</sup> Other factors such as asphyxiation, serum potassium and lactate levels can help clinicians to prognosticate the benefit of resuscitating hypothermic patients with ECMO.<sup>[9-13]</sup> This case report describes hypothermic cardiac arrest and the use of VA-ECMO for rewarming and cardiopulmonary support after a prolonged period of conventional CPR and rewarming.

## Case report

A 41-year-old woman known with depression informed her therapist of suicidal thoughts. When no contact could be established, she was reported missing. A search action was started by local authorities. With phone tracing, she was positioned 120 km from her home address. A helicopter located her in sand dunes near the beach. When paramedics arrived at the dunes, she was unconscious and weak pulsations were felt. Next to her, empty strips of venlafaxine and mirtazapine pills were found. This event took place in November when the outside temperature was 6 °C. The body temperature could not be measured because the paramedics' thermometer only indicated 'low'. When moving the patient into the ambulance, ventricular fibrillation was observed and subsequent CPR was started. Return of spontaneous circulation was obtained after

**Table 1.** Case series with hypothermic cardiac arrest without asphyxia

Author	Year	N	Mechanism of hypothermia	Median age (range in years)	Presenting rhythm	Median temperature (range in °C)	Median time to ECMO (range in minutes)	Median ECMO duration (range in hours)	Survival at	Good neurological recovery
Wanscher	2012	7	Immersion	16 (15-17)	VF (4) Asystole (2) PEA (1)	18.4 (15.5-20.2)	226 (178-241)	2.5 (1.8-44)	7	6
Sawamoto	2014	12	Immersion or exposure to cold air	52 (48-60)	Asystole (5) Other (7)	24.1 (22.7-24.9)	55 (46-68)	-	12	8
Darocho	2016	10	Exposure to cold air or diving (1)	48.5 (25-78)	VF (5) Asystole (5)	22 (16.9-28.4)	156 (107-345)	22 (1.5-91)	7	7

ECMO = extracorporeal membrane oxygenation, PEA = pulseless electrical activity, VF = ventricular fibrillation

defibrillation. A period of alternating ventricular fibrillation and sinus rhythm with output followed. During ventricular fibrillation, CPR was started and defibrillation was attempted; 50 minutes after starting CPR for the first time the patient arrived at the emergency room of a nearby hospital (Medisch Centrum Haaglanden, The Hague, the Netherlands).

CPR was continued in the emergency room using an automatic chest compression device (LUCAS®). The heart rhythm showed continuous ventricular fibrillation and it was decided to give uninterrupted chest compressions without defibrillation until the patient was rewarmed again. The patient was directly intubated and mechanical ventilation was started. A central venous catheter was placed in the jugular vein. The body temperature measured rectally was now 25.0 °C. Warm intravenous fluids were given, the stomach and bladder were filled with warm fluids and warm air convection was used.

Arterial blood gas analysis showed a pH of 7.18, lactate level of 5.7 mmol/l and a serum potassium of 2.9 mmol/l. Unfortunately, after one hour the body temperature had only increased to 26.4 °C. The lactate level after one hour was 5.3 mmol/l, indicating adequate CPR. Because traditional rewarming methods had already failed and this hospital did not have the capacity for extracorporeal rewarming, the patient was transferred to a hospital with VA-ECMO capability (HagaZiekenhuis, the teaching hospital of The Hague).

After arrival at this hospital, a venous and an arterial cannula were placed in the femoral vein and femoral artery, respectively, under ultrasound guidance during constant automatic chest compressions; 20 minutes after arriving extracorporeal circulation was accomplished. This was 210 minutes after first circulatory arrest. ECMO flow was increased to 3.5 l/min. It was decided to defibrillate once and sinus rhythm was established. Cardiac ultrasound showed opening of the aortic valve. Rewarming the patient with VA-ECMO was started. The body temperature gradually increased to normothermia in the next eight hours.

During the following 24 hours the patient was kept sedated and targeted temperature management was performed according to the local hospital protocol. This period was complicated by high ventilation conditions and a radiographic image of acute respiratory distress syndrome, which was probably induced by hypothermic lung oedema. The patient was turned into the prone position for several hours, after which a stable respiratory situation developed and improved tidal volumes were achieved. After discontinuing sedation, the patient spontaneously opened her eyes and withdrawal from a pain stimulus was observed. The patient was sedated again because of agitation. Cardiac output, when estimated with ultrasound, improved after temporarily decreasing the ECMO flow during the weaning attempts. After 36 hours, the VA-ECMO could be explanted. Echocardiography after ECMO explantation under low-dose dobutamine showed recovery of the right ventricle to good function and mild dysfunction of the left ventricle. Sedation was stopped but during the following nine days the patient did not respond to any stimuli. In the meantime, toxic levels of venlafaxine and its metabolites were measured at presentation and at consecutive measurements (maximum 7 mg/l). Continuous renal replacement therapy was already started at admission, but was considered not to contribute to clearance of venlafaxine or its metabolites. At day 12, the patient suddenly opened her eyes and was able to move her eyes when asked. Due to IC-acquired weakness she could not move her arms or legs. The patient developed ventilator-associated pneumonia for which she received ceftriaxone. On day 14 a tracheostomy was performed and weaning off the ventilator started. She was moved to a hospital near her home address in a stable condition for further recovery. After one month of intensive care unit (ICU) admission she was discharged to the internal medicine department with a consulting psychiatrist as collaborator in her treatment. Another month later, she was discharged to an open psychiatric clinic for treatment of her mental health. Her physical health recovered to normal functioning status.

## Discussion and conclusions

The chances of achieving return of spontaneous circulation after 30 minutes of CPR are extremely low. In case of surviving prolonged CPR is associated with unfavourable neurological outcome.<sup>[14]</sup> This is often an argument to stop CPR in refractory cardiac arrest. When it comes to hypothermic patients, a different approach should be applied because full neurological recovery is often observed after prolonged resuscitation in hypothermic cardiac arrest.<sup>[1-5,7]</sup> The review by Dunne et al. revealed a 67.7% survival to discharge and 61.5% rate of good neurological recovery for patients presenting with pure hypothermic cardiac arrest.<sup>[1]</sup> When hypoxaemia is the primary reason for cardiac arrest and hypothermia develops afterwards, chances of survival drop dramatically.<sup>[1,6,15]</sup> Dunne et al. observed 23.4% survival and a 9.4% rate of good neurological outcome in those presenting with a combination of hypoxic and hypothermic cardiac arrest.<sup>[1]</sup> In reality, the cause of cardiac arrest is not always obvious. When possible, critical evaluation of circumstantial factors can guide predictions of prognosis. Other predictors found to be associated with poor outcome are asystole as presenting rhythm,<sup>[1,6]</sup> unwitnessed cardiac arrest,<sup>[2]</sup> high serum potassium<sup>[1,2,12,13]</sup> and high lactate levels.<sup>[6]</sup>

Our case is an example of a hypothermic cardiac arrest due to exposure to cold air without asphyxia. We searched the literature for outcome results in similar cases. Dunne et al. already demonstrated that the presence of asphyxia has a big influence on prognosis. Therefore, we selected case series that only included hypothermic patients without asphyxia (i.e. immersion and exposure to cold air). We found three relevant case series published in the last ten years covering the subject of hypothermic cardiac arrest and the use of extracorporeal rewarming and support.<sup>[3,5,16]</sup> Patient characteristics and outcome data are presented in *table 1*.

A total of 29 patients were included in these case series. The lowest recorded body temperature was 15.4 °C and the patient made a full recovery.<sup>[16]</sup> The longest time to ECMO was 345 minutes and this patient also fully recovered.<sup>[3]</sup> Of the 29 patients, 26 survived (90%) and 21 demonstrated good neurological recovery (72%). These numbers illustrate that even in extreme conditions recovery can be excellent. Our case is another example of hypothermic cardiac arrest without asphyxia. In line with the above results, good neurological recovery was observed.

The above stresses the importance of effective CPR and early consideration of the use of ECMO for effective rewarming and cardiopulmonary support in patients with persistent ventricular fibrillation and deep hypothermia. Prolonged ICU support can be necessary for the development of good neurological recovery in patients after intoxicated hypothermic cardiac arrest.

## Disclosures

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Informed consent was obtained from the patient's legal representative for the publication of this case report.

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