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Case Report

Successful Extracorporeal Cardiopulmonary Resuscitation in Severe Accidental Hypothermia After Prolonged No-Perfusion and Hypoperfusion with Asystole: A Case Report and Literature Review

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Abstract

Introduction: We report a rare survival case of accidental hypothermia (core temperature 20 °C) with cardiac arrest and an initial rhythm of asystole, in which neurological recovery to the point of verbal communication was achieved after extracorporeal cardiopulmonary resuscitation (ECPR) despite prolonged no-perfusion (≥30 min) and hypoperfusion times (≥117 min), reviewing the relevant literature.

Case Presentation: A 78-year-old woman developed hypothermia while descending a snowy mountain and called emergency services at 13:53. Rescue was delayed and she was found around 18:00; she was handed over in asystole at 18:30. During ambulance transport, the rhythm changed to ventricular fibrillation (VF) and eight defibrillations were delivered. She arrived at the emergency department at 19:01 in cardiac arrest with VF; bladder temperature was 20 °C, with no evidence of trauma. Arterial blood gas analysis revealed mixed acidosis. Active surface rewarming and high-quality cardiopulmonary resuscitation (CPR) with intubation and mechanical ventilation were initiated. Veno-arterial extracorporeal membrane oxygenation (ECMO) was established 56 min after emergency department (ED) arrival. After rewarming to 35 °C, she was defibrillated to sinus rhythm. Targeted temperature management was continued for 48 h. ECMO was weaned on day 5 (62 h after initiation). Computed tomography (CT) on day 5 showed acute pancreatitis without hypoxic–ischemic brain injury. She was extubated on day 11, discontinued oxygen on day 16, and resumed oral intake on day 17. Brain magnetic resonance imaging (MRI) on day 36 demonstrated hypoxic encephalopathy with residual higher brain dysfunction. She was discharged on day 151 with a Cerebral Performance Category of 3.

Conclusion: ECPR may be considered for cardiac arrest due to severe accidental hypothermia, even in patients presenting with asystole and prolonged no-perfusion or hypoperfusion times.

Keywords: Hypothermia, Cardiopulmonary resuscitation, Ventricular fibrillation, Out-of-hospital cardiac arrest, Extracorporeal membrane oxygenation

Introduction

Accidental hypothermia (AH) is defined as a core body temperature of less than 35 °C. In severe AH (core body temperature of less than 28 °C), myocardial irritation is significantly increased, and the patient is more likely to develop lethal arrhythmias, leading to cardiac arrest (1-2). Recently, the efficacy of extracorporeal cardiopulmonary resuscitation (ECPR) has been reported in accidental hypothermia with cardiac arrest (3-5). It has been reported that the survival rate is low when the initial waveform is asystole, and that the longer the time from the start of CPR to the establishment of extracorporeal membrane oxygenation (ECMO) (hypoperfusion time), the lower the survival rate (6-8). In this study, we report a case of recovery to the point where the patient was able to talk after extracorporeal cardiopulmonary resuscitation for very severe accidental hypothermia with a core body temperature of 20 °C and initial waveform of asystole, in which the time between cardiac arrest and the start of CPR (no perfusion time) was at least 30 minutes and the hypoperfusion time was at least 117 minutes. This case is reported with a review of the literature.

Case Presentation

A 78-year-old female was transported in a state of cardiac arrest in February. She had climbed a mountain with seven friends and had become hypothermic while descending from the summit; at 1:53 p.m., she called 119 and awaited rescue. Rescue was difficult due to snow, and she was rescued at around 18:00. At 18:30, she was handed over to the emergency medical team at the foot of the mountain in asystole. The patient was transported by ambulance, and her waveform during transportation hanged to ventricular fibrillation (VF) after 3 minutes in the ambulance, and defibrillation was performed eight times. She was admitted to our hospital at 19:01.

She was in a state of cardiac arrest on arrival at the emergency department (ED) and her waveform was still VF. Core body temperature (bladder temperature) was 20 °C, and no external injuries were observed.

The results of arterial blood gas analysis under bag-valve mask ventilation are shown in Table 1. The pH was decreased, indicating mixed acidosis. Immediately, a warm air blanket (Warm Touch™) and an electric blanket were used to warm the patient's body surface, and high-quality cardiopulmonary resuscitation was performed with tracheal intubation and mechanical ventilation. Veno-arterial ECMO (VA-ECMO) was established 56 minutes after arrival at the ED (87 minutes after the first report), and she was admitted to the ICU.

She was defibrillated to sinus rhythm at a core temperature of 35 °C with VA-ECMO. She was sedated with midazolam 0.3 mg/kg/h and fentanyl 40 μg/h, and target temperature management therapy was performed for 48 hours. She was weaned from VA-ECMO on the 5th day (62 hours after establishment of extracorporeal circulation). The patient's hemodynamics stabilized, but she had a prolonged disturbance of consciousness on GCS-E3VTM4. A computed tomography (CT) scan taken on the 5th day showed acute pancreatitis but there was no evidence of hypoxic ischemic brain injury. Infusion management was performed with attention to intravascular dehydration for pancreatitis. On the 11th day, the patient was extubated and weaned from the ventilator. Oxygen therapy was no longer necessary on the 16th day, and oral intake became possible on the 17th day. She was transferred to the general ward on day 18. A magnetic resonance imaging (MRI) scan of the brain on the 36th day revealed hypoxic encephalopathy and residual higher brain dysfunction (Figure 1). The patient was transferred to the rehabilitation hospital on day 40, and was discharged from the hospital on day 151 in a condition equivalent to cerebral performance category 3.

Table 1. Laboratory findings on admission

Arterial blood gas analysis		Reference range
pH	6.82	7.35–7.45
$PaCO_2$	88.8 mmHg	35.0–45.0 mmHg
PaO_2	75.0 mmHg	75.0–100.0 mmHg
HCO_3^-	−14.2 mmol/L	22.0–26.0 mmHg
Blood Cell Counts		
White blood cells	1.4×10^4/μL	$4.0–10.0 \times 10^4$ /μL
Red blood cells	4.5×10^6/μL	$4.2–5.9 \times 10^6$/μL
Hemoglobin	14.2 g/dl	12.1–17.2 g/dL
Platelets	1.4×10^5/μL	$1.5–4.5 \times 10^5$/μL
Blood chemistries		
C-reactive protein	<0.1 mg/dL	<3.0 mg/dL
Calcium	8.1 mg/dL	8.5–10.2 mg/dL
Phosphorus	9.0 mg/dL	2.5–4.5 mg/dL
Sodium	136 mmol/L	135–145 mEq/L
Potassium	5.4 mmol/L	3.5–5.0 mEq/L
Chloride	101 mmol/L	98–106 mEq/L
Magnesium	3.3 mg/dL	1.7–2.2 mg/dL
Aspartate aminotransferase	316 IU/L	10–40 IU/L
Alanine aminotransferase	434 IU/L	7–56 IU/L
Creatine kinase	405 IU/L	38–336 IU/L
Lactate dehydrogenase	951 U/L	140–280 IU/L
Blood urea nitrogen	30 mg/dL	7–20 mg/dL
Creatinine	0.6 mg/dL	0.6–1.3 mg/dL
Amylase	104 IU/L	30–110 IU/L
Alkaline phosphatase	73 IU/L	44–147 IU/L
Brain natriuretic peptide	18 pg/mL	<100 pg/mL
Blood coagulation		
Prothrombin time	12.1 sec	11.0–13.5 sec
Prothrombin time-INR	1.0	0.9–1.1
Activated partial Thromboplastin time	32.9 sec	25.0–35.0 sec
Fibrinogen	230 mg/dl	200–400 mg/dL
D-dimer	16.6 μg/mL	<0.5 μg/mL

Notes: This table presents descriptive laboratory data from a single patient on admission; therefore, no statistical comparisons were performed and no statistical tests were applied (significance level: not applicable). Reference ranges are shown for clinical interpretation.

Abbreviations: pH: potential of hydrogen; $PaCO_2$: arterial partial pressure of carbon dioxide; PaO_2: arterial partial pressure of oxygen; HCO_3^-: bicarbonate; WBC: white blood cell count; RBC: red blood cell count; Hb: hemoglobin; Plt: platelet count; CRP: C-reactive protein; Na: sodium; K: potassium; Cl: chloride; Mg: magnesium; Ca: calcium; P: phosphorus; AST: aspartate aminotransferase; ALT: alanine aminotransferase; CK: creatine kinase; LDH: lactate dehydrogenase; BUN: blood urea nitrogen; Cr: creatinine; ALP: alkaline phosphatase; BNP: brain natriuretic peptide; PT: prothrombin time; INR: international normalized ratio; APTT: activated partial thromboplastin time; FDP: fibrin/fibrinogen degradation products; D-dimer: D-dimer.

Discussion

The patient was lost on the summit of a mountain and took nearly 5 hours to rescue, with an estimated no-perfusion time of more than 30 minutes and an estimated hypoperfusion time of more than 117 minutes. Regarding no-perfusion time, it has been reported that in out-of-hospital or in-hospital cardiac arrest patients undergoing ECPR, longer no-perfusion time is associated with lower survival rates and longer cardiopulmonary resuscitation (CPR) times, and in one study, 5 minutes no-perfusion time or more was reported to lead to poor results (9). There are also reports that initiating CPR within 5 minutes of cardiac arrest in out-of-hospital cardiac arrest patients undergoing ECPR is important for improving neurological prognosis (10). Although there are no reports on the impact of perfusion time on survival and neurological prognosis in patients with accidental hypothermia, the fact that our patient recovered to the point of being able to talk despite an estimated perfusion time of more than 30 minutes, suggests that there is no need to be reluctant to perform ECPR simply because the no-perfusion time is long. Regarding hypoperfusion time, Amir et al. found that although hypoperfusion time is not an independent predictor of survival, it is associated

Table 2. Characteristics and outcomes of patients treated with ECPR for cardiac arrest associated with accidental hypothermia

	Region	Publication year	Study design	Number of patients	age	Sex (male)	Asystole initial waveform	Core body temperature	CPR duration	Survival rate	CPC 1 or 2
Takauji. et al. 2023 (3)	Japan	2023	Multi-center prospective	57	80 (67.0–84.0)	17 (42.4)	8 (33.3)	21 (87.5)	19 (16–45)	14 (58.3)	10 (41.7)
Melissa. et al. 2020 (5)	United States	2020	Systematic review	47	48 (29.0–56.0)	34 (75.6)	11 (26.2)	24.6 (22.2–26.0)	120 (88–135)	38 (80.0)	No data
Nagama. et al, 2023 (6)	Japan	2023	Single-center retrospective	32	67 (54.3–77.0)	14 (41)	12 (35.2)	23 (20.9–25.4)	No data	25 (66.0)	18 (56.0)
Tomasz. et al, 2020 (12)	Poland	2020	Multi-center retrospective	98	53.8 (39.1–68.5)	86 (87.8)	27 (27.6)	24.6 (22.2–26.0)	130 (80–180)	52 (53.1)	49 (50.0)
Ohbe. et al, 2019 (13)	Japan	2019	Nationwide DPC database analysis	318	71 (58.0–80.0)	196 (62)	No data	23.2 (20.6–25.8)	No data	110 (35)	No data

Notes: This table summarizes previously published clinical studies on ECPR/ECMO for accidental hypothermia-associated cardiac arrest. Data are presented as reported in each publication; no pooled analysis or between-study statistical comparisons were performed. Accordingly, no statistical tests were applied (significance level: not applicable). Continuous variables are shown as median (interquartile range), and categorical variables as *n* (%), when available in the original articles.

Abbreviations: ECPR: extracorporeal cardiopulmonary resuscitation; ECMO: extracorporeal membrane oxygenation; CPR: cardiopulmonary resuscitation; CPC: cerebral performance category; DPC: diagnosis procedure combination; IQR: interquartile range; PEA: pulseless electrical activity.

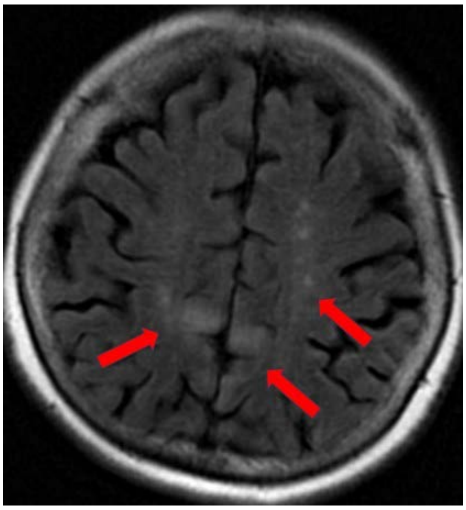

Figure 1. Brain MRI scan

with prolonged CPR time, and since prolonged CPR time may adversely affect survival after cardiac arrest, a CPR time that leads to a good neurological outcome (30 min or less) requires hypoperfusion time cutoff values of 27 minutes or less (9,11). In a study that proposed using the HOPE score to predict outcomes after ECPR in patients with hypothermic cardiac arrest, CPR duration was 106 minutes (IQR 64–165 minutes) in the survival group and 120 minutes (IQR 90–169 minutes) in the non-survival group, indicating that CPR duration is a significant value for predicting outcome; the duration of low-perfusion time, which influences CPR duration, should be short (7). This patient was lost at the summit of a mountain. Because this patient was lost on a mountaintop, the time between rescue and hospital transport was long, and the survival and neurological prognosis predicted by the low-perfusion time was poor.

The initial waveform in the present case was asystole; in the ICE CRASH study, of 57 cases of severe hypothermia transported for cardiac arrest, PEA/asystole was reported in 33.3% (8/24) of cases with ECMO and 84.8% (28/33) of cases without ECMO (3). In the HOPE score study, among 256 cases of hypothermia transported for asystole, the survival rate of asystole cases was reported to be low, 23% (32/139) for survivors and 77% (107/139) for non-survivors (7). In a review of the literature, the survival rate for cardiac asystole was also low, and the initial asystole waveform may have been one of the factors that led to the non-introduction of ECMO; also, ECPR may not have been performed in such cases, depending on the hospital to which the patient was transported.

We reviewed articles with clinical studies on ECPR for patients with accidental hypothermia (3, 5-6,12,13) (Table 2). We searched PubMed for articles published in the last five years using the keywords “accidental hypothermia,” “ECMO,” and “ECPR”. We also included five articles, excluding case reports and case series (Table 2). Focusing on items other than asystole and no- or low-perfusion time, it is possible that the cutoff age regarding ECMO introduction is lower in other countries than in Japan. In Japan, even elderly patients aged 65 years or older are often introduced to ECMO, while in other countries, most reported patients receiving ECMO are relatively young, aged 60 years or younger. With regard to gender, males are less likely to be on ECMO and may have a lower survival rate, which should be further investigated. Core body temperature tends to be lower in patients on ECMO, and the lower the core body temperature, the more likely it is that the cardiac arrest will be severe enough to require ECPR. The number of cases with witnesses tended to be lower in cases with ECMO and higher in surviving cases, suggesting that the presence or absence of witnesses may not be a hurdle to the introduction of ECMO.

In this study, the patient was 78 years old, and her core body temperature was remarkably low at 20 °C. It is difficult to say whether she would have been able to undergo ECPR or not, and the fact that she was female may be a factor to expect a higher survival rate. However, the combination of the initial waveform and the no-perfusion and low-perfusion times suggests that the choice not to perform ECPR is not unlikely.

Although this case would generally be considered poor prognosis and difficult to save, the patient recovered well enough to be able to talk after ECPR. In patients with severe accidental hypothermia, it is important to perform life-saving resuscitative measures regardless of the duration of no-perfusion, hypoperfusion, or initial waveform.

Conclusion

ECPR can be a life-saving intervention for patients with severe accidental hypothermia, even in cases where the initial cardiac rhythm is asystole and there are prolonged no-perfusion or hypoperfusion times. Therefore, ECPR implementation should be considered in hypothermic cardiac arrest regardless of initial rhythm or downtime, particularly in facilities equipped with extracorporeal support systems.

Authors' Contribution

Conceptualization: Ryuto Yokoyama, Kenya Yarimizu, and Kento Sakaguchi
Data curation: Ryuto Yokoyama
Formal analysis: Ryuto Yokoyama
Investigation: Ryuto Yokoyama
Methodology: Ryuto Yokoyama and Kenya Yarimizu
Project administration: Ryuto Yokoyama
Resources: Ryuto Yokoyama
Software: Ryuto Yokoyama
Supervision: Kenya Yarimizu and Kento Sakaguchi
Validation: Ryuto Yokoyama
Visualization: Ryuto Yokoyama
Writing–original draft: Ryuto Yokoyama

Competing Interests

None.

Ethical Approval

This manuscript complies with the Personal Information Protection Law in Japan. The patient and family provided informed consent for the publication of her case report and any associated images.

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