Favorable neurologic outcome in a patient with accidental hypothermia following cardiopulmonary resuscitation for over 165 minutes and intensive care for post-cardiac arrest syndrome

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Abstract: A 29-year-old man who experienced accidental hypothermia and out-of-hospital cardiac arrest (CA) was transported to our hospital while receiving prolonged cardiopulmonary resuscitation (CPR). His body temperature (BT) on admission (146 minutes after the start of CPR) was 22.4℃, and an electrocardiogram showed ventricular fibrillation, so that extracorporeal CPR (ECPR) was immediately started 165 minutes after the start of CPR and continued for 30 hours. Simultaneously, therapeutic hypothermia was performed with a target BT of 33℃ and was continued for 24 hours. A sinus cardiac rhythm was restored during ECPR. Although severe rhabdomyolysis and acute renal failure consequently occurred, his renal function recovered after renal replacement therapy for 30 days. The neurological impairment following CA also gradually improved. He was discharged with intact cerebral performance on 60th hospital day. We experienced a case of accidental hypothermia with favorable outcome following prolonged CA who was treated with ECPR and intensive care for post-cardiac arrest syndrome.

Key words: ① accidental hypothermia, ② extracorporeal cardiopulmonary resuscitation, ③ therapeutic hypothermia

Introduction

Backcountry skiing is associated with a risk of potentially fatal accidents. For example, cardiac arrest (CA) may occur while an individual is on a backcountry mountainside during winter season. In such situation, cardiopulmonary resuscitation (CPR) must prolong while transporting the subject to a hospital. Accidental deep hypothermia (core temperature < 28℃) has been shown a protective effect on the brain during CPR. The reported longest duration of CPR before initiation of extracorporeal CPR (ECPR) with favorable neurologic outcome after CA with accidental hypothermia is 190 minutes. However, it is still unknown how long CPR actually sustain a life without any neurological deficit.

We report a case of successful neurological recovery using ECPR after 165 minutes of CPR and intensive care for post-cardiac arrest syndrome.

Case report

A 29-year-old man who had bivouacked to avoid a snowstorm while backcountry skiing was rescued by a police helicopter but unresponsive. The helicopter crew did not check for breathing or a pulse. The exact time at that CA occurred was unclear. After the helicopter landing, the emergency life-saving technician (ELT) confirmed that he had experienced CA. He received CPR immediately and then was transported to a hospital located about 25 km from the landing spot required 26 minutes by ambulance. On arrival at the regional hospital, his body temperature (BT) was less than 32℃, which meant beyond the range of the thermometer and an electrocardiogram (ECG) showed ventricular fibrillation (VF). The VF was unresponsive to the first defibrillation and tracheal intubation was performed. Then he was again transferred to our hospital for more aggressive treatment under continuing CPR, located about 33 km distant from the first hospital, required 42 minutes by ambulance.

He arrived at our hospital 146 minutes after the initiation of CPR. Upon admission to our hospital, he was comatose with Glasgow coma scale (GCS) of 3, his BT was 22.4℃ (urinary bladder temperature), and his ECG showed VF. ECPR was started using venoarterial bypass 165 minutes after the initiation of CPR. An extracorporeal circulation system (ECS), constructed with a membrane oxygenator (Capiox-SX18; Terumo Co., Japan) and a centrifugal pump (CX-SP45; Terumo Co., Japan)
Japan) were used for the ECPR. An initial flow was set at 3.0 l/min. The rewarming by ECS was started at the same time with temperature setting of transmitted blood at 36°C. After rewarming to 30°C, 228 minutes after the start of CPR, the temperature setting of the circuit was changed to 33°C, and the ECS was continued for 30 hours thereafter. The maximum values of serum potassium and lactate were 7.9 mmol/l and 100 mg/dl, respectively. Intravenous injections of sodium bicarbonate and a glucose-insulin therapy were performed. Sixty-nine minutes after the start of ECPR, 234 minutes after the start of CPR, a sinus rhythm was obtained at the same time after the fifth defibrillation. At that time, his body temperature was 31.0°C and he remained comatose with GCS of 7 (Fig. 1).

After rapid rewarming to 33°C using ECS, 266 minutes after the start of CPR, therapeutic hypothermia (TH) was continuously maintained with a target BT of 33°C for 24 hours, and rewarming after TH was then conducted at 0.5°C per 12 hours up to a target BT of 36°C (Fig. 1). Body temperature was controlled by both ECS and blanket. Continuous intravenous injections of midazolam, buprenorphine and vecuronium were performed for the prevention of shivering during TH for 4 days. Dopamine and dobutamine infusions were required for 3 days, and his breathing was supported by a mechanical ventilator during TH.

Severe rhabdomyolysis and subsequent acute renal failure began on day 1 and developed. The serum level of creatinine phosphokinase increased to 423,200 IU/l on day 5. Renal replacement therapy was continued for 30 days. The continuous hemodiafiltration was performed for the first 18 days. Following that, 7 times of hemodialysis were performed (Fig. 2).

Impaired consciousness had been observed for 30 days. From day 5, athetoid movements were observed and oral muscle relaxant was administrated. His GCS was 7 at that time. They gradually improved but continued for about 1 month. On day 16, extubation was performed and his GCS was 10 at that time. On day 22, he started to speak, and his GCS was 12. His consciousness level gradually improved. Peripheral polynuropathy and muscle weakness, confirmed after the examination 4 months later. Although an electroencephalogram on day 50 revealed periodic spike and wave discharges, no seizures were observed. MRI on day 53 showed slight cerebral atrophy.

On day 60, he was discharged with intact cerebral performance. A follow-up MRI performed after 10 months from the admission showed an improvement in the cerebral atrophy. No neurological deficits were observed during a physical examination. He had resumed his former activities and lifestyle.

Discussion

VF is common in accidental deep hypothermic victims whose body temperature is below about 27°C, and is particularly likely to develop in the situation such as sudden physical movement4). In addition, the VF is usually extremely resistant to attempts at electrical cardioversion until rewarming has been achieved5). It is one of the reasons that extend CPR time in the patients.

Among accidental deep hypothermic patients, the CPR time has been suggested to be a reliable predictor of mortality5). Farstad, et al investigated 26 accidental deep hypothermic patients who received CPR ranging from 0 to 295 minutes. Out of the 26 patients, 8 (31%) were resuscitated and survived, of which 7 (27%) were neurologically intact survivors. The mean CPR-time of 8 survivors was significantly shorter than that of 18 non-survivors (72 ± 71 vs. 185 ± 71 minutes,
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P<0.005)\(^5\). However, hypothermia has been shown to exert a protective effect for hypoxic state on the brain\(^1\), decelerating metabolic processes and reducing oxygen consumption\(^6\). The cerebral metabolic rate of oxygen (CMRO\(_2\)) at 27°C is 40% of the normothermic control values, and the CMRO\(_2\) at 17°C is 8%\(^6\). Thus, under the prolonged hypothermic state on the brain during CPR, deep hypothermia is a protective condition for the brain. Several case reports have indicated the intact neurological survival after receiving prolonged CPR in accidental deep hypothermia\(^7\),\(^8\). Walpoth, et al reported that 7 deep hypothermic patients, whose CPR time ranged from 84 to 222 minutes, regained their prior activity free from sequelae\(^7\).

The prolonged transportation time by ambulance is also problematic. To maintain high-quality CPR, paramedics are recommended to rotate the task of chest compressions every 2 minutes\(^9\). However, such rotations are practically impossible in the narrow confines of an ambulance. The CPR was provided without intermission with their efforts without intermission even such under harsh conditions.

ECPR rapidly provides hemodynamic support, is used to resuscitate patients, and can also perform the rewarming by ECS. Walpoth, et al reported that the long-term outcome of survivors of accidental deep hypothermia with prolonged CA and rewarming with ECS was favorable and ECS appeared to be an efficacious rewarming technique\(^10\).

We performed therapeutic mild hypothermia after CPR in the present case, but evidence in support of this approach in deep hypothermic out-of-hospital cardiac arrest was lacking. However, some experts recommend 24 hours of therapeutic hypothermia\(^3\) after resuscitation for CA due to accidental deep hypothermia.

Six main reasons may account for the successful neurological recovery in the present case. First, the hypothermia was deep\(^1\),\(^6\). Second, asphyxia did not occur\(^11\). Third, the patient was young and in good health before CA\(^7\). Fourth, VF was observed at the time of admission\(^12\). Fifth, the serum potassium level at the time of admission was less than 8 mmol/l\(^11\). And sixth, ECPR and therapeutic hypothermia were started immediately after admission\(^1\),\(^3\).

Finally, the ultimate goal of CPR is to return patients to their pre-arrest functional levels. The present case demonstrates that, even if a patient has received prolonged interval of CPR, a deep hypothermic victim had the possibility of surviving without neurological deficit.

**Conclusion**

We experienced a rare case of accidental deep hypothermia with CA who experienced a successful neurological recovery using ECPR after 165 minutes of CPR and intensive post-CA care.

**Conflict of interest**

None.

**References**


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**Fig. 2** Clinical course after admission

BT, body temperature; CAI, catecholamine index; CHDF, continuous hemodiafiltration; CPK, creatinine phosphokinase; ECPR, extracorporeal cardiopulmonary resuscitation; HD, hemodialysis; TH, therapeutic hypothermia.