CASE REPORT

Successful Non-Extracorporeal Rewarming from Hypothermic Cardiac Arrest: 2 Cases

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Accidental hypothermia (core temperature <35°C) is a complication in persons who have fallen into crevasses; hypothermic cardiac arrest is the most serious complication. Extracorporeal life support (ECLS) is the optimal method for rewarming hypothermic cardiac arrest patients, but it may not be readily available and non-ECLS rewarming may be required. We report the medical course of 2 patients with hypothermic cardiac arrest, each of whom had fallen into a crevasse. They were treated successfully with non-ECLS rewarming using peritoneal and thoracic lavage. We discuss non-ECLS treatment options for hypothermic cardiac arrest and describe successful non-ECLS rewarming in an outlying hospital without ECLS rewarming capability in the Grossglockner region of Austria in 1990 and 2003. Both patients survived neurologically intact. Non-ECLS rewarming in a trauma center without ECLS capabilities is feasible and can result in a good outcome when ECLS is not available. The best non-ECLS rewarming method for hypothermic cardiac arrest patients has not yet been established. Non-ECLS rewarming should be adapted to local capabilities. To obtain more robust evidence, it seems reasonable to pool data on the treatment and outcome of non-ECLS rewarming in hypothermic cardiac arrest patients.

Keywords: cardiopulmonary resuscitation, defibrillation, extracorporeal life support, accidental hypothermia, out-of-hospital cardiac arrest

Introduction

Accidental hypothermia, defined as a core temperature $\leq 35^{\circ}\text{C}$,^{1,4} is a serious complication of a fall into a crevasse. The risk of hypothermic cardiac arrest in young healthy persons increases substantially at core temperatures below 28°C.^{2,3} Extracorporeal life support (ECLS) is the optimal method for rewarming patients in hypothermic cardiac arrest.^{1,4} Access to an ECLS center can be prevented by transport times longer than 6 h⁴ or dangerous or impossible transport due to bad weather or darkness. ECLS might not be available when it is being used for other patients, such as when there are multiple patients with hypothermia.⁵ Non-ECLS rewarming may be

required in a hospital that has no ECLS-capability.^{5,6} There are no standard guidelines on how to perform non-ECLS rewarming in a hypothermic cardiac arrest patient. We report the successful non-ECLS rewarming of 2 patients with hypothermic cardiac arrest. Discussions with colleagues made us aware that many previous cases of hypothermic cardiac arrest have not previously been published. Although the incidents in this article occurred in 1990 and 2003, they were never reported. Several important lessons can be learned from these cases.

Case Reports

CASE 1

On a warm day in August 1990, a 21-y-old male was hiking with 2 friends in the Austrian Alps. He was wearing only a t-shirt, shorts, and light hiking shoes. At 1235, the 3 hikers were traversing a glacier at 2920 m when an ice bridge

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collapsed. The hikers were not a roped party, and the victim fell about 15 m into a crevasse. The emergency dispatch center was informed immediately. At 1255, a helicopter winched a mountain rescuer onto the glacier. With the help of some bystanders, the rescuer abseiled (rappelled) into the 0.5 m wide crevasse, where he found the patient mostly buried under snow and ice. The patient was still moving. After 15 min of digging, the mountain rescuer had freed the patient's head. His mouth and the nose had been in an air pocket. The patient was conscious and reported pain. During the next hour, the rescuers dug the patient out of the snow and ice. His cries diminished, and finally, after 45 min, he lost consciousness. The rescue team expedited the evacuation by attaching the patient's feet to a rope (his legs were the least buried) and pulling him feet-first out of the crevasse. He had been in the crevasse for approximately 100 min.

At 1415, on the glacier's surface, the helicopter's emergency physician determined that the patient was in cardiac arrest. Cardiopulmonary resuscitation was started. The pupils were fixed and dilated. The epitympanic temperature was 19.4°C. The patient was initially ventilated with a bag-valve mask before being intubated. Except for several bruises, no other injuries were found. The patient was flown to the nearest hospital, a trauma center without ECLS capabilities, arriving at 1445.

In the emergency department, the electrocardiogram showed asystole. Rectal temperature was 25°C. The patient was transferred to the operating room, where a central venous catheter was inserted. Capillary blood gas analysis revealed pH 7.12, bicarbonate 15 mmol·L⁻¹, and potassium 2.8 mmol·L⁻¹. At 1530, a laparotomy was performed to start peritoneal lavage with warm normal saline. Thirty minutes later, rectal temperature had increased to 26.7°C. A sternotomy was performed to allow cardiac lavage with warm normal saline. Ventricular fibrillation developed at 1645. Lidocaine was administered intravenously, followed by internal defibrillation. At 1650, the rhythm was converted to sinus bradycardia by defibrillation, and the patient began breathing spontaneously. Cardiopulmonary resuscitation was discontinued after having been administered for approximately 165 min. At 1700, the heart rate was 100 to 130 beats·min⁻¹, and blood pressure became measurable for the first time at 80/50 mm Hg. Blood pressure increased to 130/80 over the next 2 min. When the rectal temperature reached 29°C, at 1700, the pupils became less dilated and were reactive to light.

Cardiac lavage was discontinued, but peritoneal lavage was continued until 1830. To hasten rewarming, hemodialysis was started at 1700 with the catheter in the right internal jugular vein. At 1800, the rectal temperature reached 33°C. At 1900, it was 35.2°C, and hemodialysis was discontinued.

The patient was admitted to the intensive care unit. A computed tomography (CT) scan of the head showed no cerebral edema. On Day 2, weaning from ventilation was started, and 2 d later the patient opened his eyes. He started moving his extremities the next day. On Day 6, he was extubated. The patient developed symmetric myoclonus in all 4 extremities, successfully treated with intravenous clonazepam. On Day 17, he developed acute necrotizing pancreatitis with sepsis and respiratory failure. A laparotomy was performed. Fifty-four days after the accident, he was discharged from the intensive care unit. Rehabilitation lasted 3 mo. He made a full neurologic recovery.

CASE 2

On a summer day in 2003, a 40-y-old man was hiking alone on a glacier in the Grossglockner area in Austria when he fell feet-first into a crevasse. His feet were so tightly wedged in the crevasse that he was unable to free them. He was immersed to his shoulders in icy water. He was able to call for help using his mobile phone. The patient was stabilized by the rescue team with ropes around his body. He was pulled out of the crevasse in prone position 2 h after his fall (Figures 1 and 2). The epitympanic temperature was 29°C. The patient was flown with a long line to the site where the emergency physician was waiting. During this short flight, he lost consciousness. The Glasgow Coma Scale score was 7. He was sedated and intubated by the emergency physician on site. A helicopter flew the patient to the hospital in Lienz, Austria.

On admission to a trauma center without ECLS capabilities, the rectal temperature was 26.8°C and blood pressure was 120/80 mm Hg. He had large excoriations on both shoulders and arms from the fall and his attempts to extricate himself from the crevasse. Forced air warming was started with a Bair Hugger (3M, Maplewood, MN, USA). The patient went into ventricular fibrillation during transport to the CT scanner. Cardiopulmonary resuscitation was started. Three defibrillation attempts were unsuccessful. The patient was immediately transferred to the operating room, where a sternotomy and laparotomy were performed. Open cardiac massage and rewarming of the heart and peritoneal cavity with warm normal saline were started. After 2 h, the core temperature was 34°C. At that time, external defibrillation restored sinus rhythm. High doses of catecholamines were needed to maintain adequate blood pressure. Because of intraoperative blood loss and coagulopathy, packed red blood cells and fresh frozen plasma were administered. The post-resuscitation phase was complicated by acute respiratory distress syndrome and acute kidney failure. Intermittent hemofiltration was required until Day 5, followed by hemodialysis. Sedation was

Figure 1. Crevasse rescue of the patient (case 2) in the Grossglockner area, Austria.

discontinued on Day 8, but the patient did not regain consciousness. A CT scan showed signs of possible diffuse hypoxic brain damage. On Day 9, the patient was transferred to a hospital near his hometown. He was still intubated, on assisted spontaneous ventilation, and on renal replacement therapy. The next year, he visited one of the coauthors, personnel at the helicopter emergency medical service base and in the hospital, who had cared for him. He had resumed his job and fathered a healthy child. During the next 4 summers, he visited the area and hiked the local mountains.

Discussion

Although these cases are old, several important lessons can be learned. First, successful non-ECLS rewarming

after hypothermic cardiac arrest with good neurologic outcome is possible. This has been reported previously.⁷ Non-ECLS rewarming is not always successful.⁸

The measured temperature depends on the site of measurement. In the first patient, an epitympanic temperature of 19.4°C was measured on scene. Forty minutes later, in the hospital, a rectal probe was inserted and a temperature of 25°C was measured. This discrepancy may have been caused by any of several factors.⁹ Epitympanic temperatures may be falsely low if the external auditory canal is filled with snow or cold water, and insulation of the measurement site is important to avoid a low measurement.^{9,10} Epitympanic measurement is not reliable in cardiac arrest.^{2,3} Esophageal temperature measurement closely approximates core temperature in patients with a secured upper airway if the probe is placed in the lower third of the esophagus.³ Rectal temperatures

Figure 2. Patient is rescued out of the crevasse in a vertical and prone position with ropes wrapped around his body.

may be falsely high because feces cool more slowly than the surrounding rectum,¹¹ and rectal temperatures may be falsely low during rewarming.⁹

The ideal methods for non-ECLS rewarming of hypothermic cardiac arrest patients have not yet been determined. Several non-ECLS rewarming techniques are available, with various degrees of invasiveness and differing rates of warming. Each technique has advantages and disadvantages, and a combination of techniques may increase the speed of rewarming. Hypothermic patients who are hemodynamically stable should be treated with minimally invasive rewarming, including heated intravenous fluids and forced air warming.¹⁻⁴ It is unclear which rewarming methods are most effective for patients in hypothermic cardiac arrest. ECLS rewarming is likely to be more effective than non-ECLS rewarming.¹⁻⁴ Survival rates of 23 to 100% have been reported for ECLS rewarming of patients in hypothermic cardiac arrest.¹²

Pooled outcome data for non-ECLS rewarming are not available. Non-ECLS rewarming is the only solution in circumstances in which transport to an ECLS center would be prolonged, unnecessarily hazardous, or impossible.

We do not believe any guidelines were available for accidental hypothermia in 1990, when the first patient experienced a witnessed cardiac arrest on the glacier. He was transported to the closest hospital, without ECLS capabilities, where the team performed a sternotomy to rewarm the heart directly. This was successful. The first article on successful ECLS rewarming after hypothermic cardiac arrest was published in 1997.¹³ In 2003, our second patient experienced witnessed hypothermic cardiac arrest in the same trauma center as the first patient. The medical team still remembered the treatment and favorable outcome of the first patient with hypothermic cardiac arrest 13 y earlier. The same non-ECLS rewarming method was chosen to rescue the second patient. Transfer to an ECLS center after in-hospital hypothermic cardiac arrest was not an option because no guidelines had been published. In addition, it was uncertain that transfer to an ECLS center, which would have taken at least 4 h, would have resulted in a better outcome.^{1-4,14}

Because cardiac arrest caused by accidental hypothermia is uncommon, prospective studies are not feasible. The International Hypothermia Registry (www.hypothermia-registry.org) has been established. To obtain a large number of patients, pooling data on the treatment and outcome of non-ECLS rewarming in hypothermic cardiac arrest patients might be helpful to gather information regarding rewarming techniques, including rates of rewarming, complications, and outcomes.

LIMITATIONS

Since the time of the 2 case reports, management of hypothermic cardiac arrest has evolved. Guidelines on the management of patients with accidental hypothermia have been published only since the 2010 European Resuscitation Council guidelines on special circumstances, followed by several others.^{1-4,14,15} ECLS rewarming is now the method of choice in hypothermic cardiac arrest patients, although ECLS may not always be available. Laparotomy and sternotomy are very invasive and are now rarely performed in central Europe. Because these are old cases, there are gaps in the medical records. One author treated both patients and filled in the gaps to the best of his recollection.

Conclusions

Non-ECLS rewarming of patients in hypothermic cardiac arrest is feasible and can result in good outcomes when ECLS is not available. It is not known which non-ECLS rewarming methods are optimal. The choice of non-ECLS rewarming methods depends on local capabilities, and non-ECLS rewarming should be adapted accordingly. To obtain more robust evidence, it seems reasonable to pool data on the treatment and outcome of non-ECLS rewarming in hypothermic cardiac arrest patients.

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