Full neurological recovery from profound (18.0°C) acute accidental hypothermia: successful resuscitation using active invasive rewarming techniques

Amy Hughes, Peter Riou, Christopher Day

The case of a 17-year-old girl brought into the emergency department (ED) having been found in a field semi-clad and overtly hypothermic is reported. A weak carotid pulse, agonal breathing and fixed dilated pupils were noted. On arrival in the ED she was in asystolic cardiopulmonary arrest. Initial core body temperature was 18°C. After 4 h of closed cardiopulmonary resuscitation and rewarming using a haemofiltration circuit, she made a full recovery with no adverse neurological sequelae. In this case report, the importance of prolonged resuscitation in cardiopulmonary arrest secondary to acute severe environmental hypothermia and the successful use of a haemofiltration circuit to deliver active core rewarming are highlighted.

A semi-clad 17-year-old girl was brought into the emergency department (ED) by helicopter having been found in a field. She had poor respiratory effort with agonal respirations and a weak carotid pulse. During transfer, she deteriorated into cardiopulmonary arrest, and cardiopulmonary resuscitation (CPR) was started. On arrival, the patient was asystolic. She was intubated, ventilated and 1 mg adrenaline was administered via an endotracheal tube. Blood glucose was 6.2 mmol/l.

With intravenous access secured, 1 mg adrenaline and 3 mg atropine were administered into the left external jugular vein. Uninterrupted CPR was continued with intermittent administration of adrenaline. Initial core temperature, measured rectally using a digital thermometer, was 18°C.

The patient's wet clothing was removed; she was towel dried and a forced-air blanket applied. Two litres of warmed (42°C) Hartmann's solution were infused and a 14Ch bladder catheter and large-bore orogastric tube inserted. Simultaneous bladder and gastric lavage were performed using warmed saline and water, respectively.

Resuscitation continued along standard Advanced Life Support guidelines. Transient episodes of fine ventricular fibrillation were shocked (biphasic, 150 J).

Venous blood gas analysis (uncorrected for temperature) demonstrated pH 7.17, PCO₂ 8.5 kPa, PO₂ 4.1 kPa, bicarbonate 19.0 mmol/l, base excess -6, sodium 137 mmol/l and potassium 3.2 mmol/l. Haematological profile showed haemoglobin 9.2 g/l, platelets 22×10⁹/l, white blood cells 4.4×10⁹/l, international normalised ratio 2.4,

fibrinogen 1.4 g/l, and activated partial thromboplastin time ratio 1.6.

Three units of packed red blood cells, four units of fresh frozen plasma and two adult therapeutic doses of platelets were administered.

After 40 min, a large-bore double-lumen venous catheter was inserted into the right femoral vein and active invasive core rewarming was started by using a continuous venovenous haemofiltration circuit, with the return blood passing through a Hotline blood warmer.

Following 3½ h of CPR and continuous active rewarming, her core body temperature had risen to 23°C. Spontaneous electrical activity was seen on ECG. She began maintaining her own cardiac output 15 min later, with a systolic blood pressure of 75 mm Hg and a temperature of 25°C. Adrenaline and magnesium infusions were started. A 12-lead ECG demonstrated long QT, J waves and a junctional rhythm.

After 4 h of resuscitation the patient was transferred to the intensive care unit, sedated and ventilated with a core body temperature of 31°C.

Inotropic support (adrenaline and dobutamine) was weaned over 12 h and she was extubated after 24 h. She received periods of continuous positive airway pressure and treatment for one episode of pulmonary oedema and aspiration pneumonia. Trans-thoracic echocardiogram on day 2 demonstrated mild left ventricular dysfunction and a small (<1 cm) pericardial effusion that resolved. She was discharged with a normal ECG and no obvious neurological deficit after 11 days.

DISCUSSION

Acute severe hypothermia is a medical emergency associated with high mortality.¹⁻³ The outcome of such cases depends on various factors including age, pre-morbid health, rate of cooling, mechanism of hypothermia, initial arterial pH, serum potassium levels and rewarming method.¹⁻⁴

Rewarming can be classified into passive, active external and active internal techniques (table 1).^{1,2} Resources for passive and active external warming techniques are available in all EDs and can be used immediately. Active internal rewarming techniques include warmed gas ventilation; administration of warm intravenous fluids; gastric, bladder, peritoneal and pleural lavage; and extracorporeal circuits, such as haemofilters or cardiopulmonary bypass (CPB). CPB is considered the most effective method of rewarming a patient with profound hypothermia but is rarely available in district general hospitals and alternative invasive methods should be considered.^{1,3}

Ventilation using warm gases (40–45°C) increases the patient's temperature

Table 1 Methods of rewarming a patient with profound hypothermia^{1,2}

Classification	Method	Rewarming rate °C/h (approx rates)
External passive	Removing wet clothing	0.5–4
	Blankets	
	Warm drinks	
External active	Forced heated air	1–2
	Hot-water bottles	2–4
	Hot-water immersion	
Internal active	Inhalation of warm air	0.7–1.2
	Intravenous fluids	Variable
	Body lavage: peritoneal	1–3
	Haemodialysis/filtration	2–3
	Extracorporeal: CPB	7–10

CPB, cardiopulmonary bypass.

by approximately 1.2°C/h.^{1,2} Depending on the quantity of fluid administered and the patient's initial core temperature, intravenous fluids warmed to 42°C can increase body temperature. Fluids used at room temperature may lead to vasoconstriction and hypoxia.²

Lavage of most body cavities can be performed. Non-surgical approaches include bladder and gastric washout using warmed saline and water, respectively. However, both cavities have a small mucosal surface area available for heat exchange and hence make limited contributions to rewarming.¹ If resources are available, peritoneal and/or thoracic lavage can be used.^{1,2}

Haemofiltration is an effective rewarming method if CPB is not available.^{1,2} Haemofiltration is easy to establish, readily available and rewarms the patient at an approximate rate of 2–3°C/h as compared with CPB (7–10°C/h).¹ A

double-lumen catheter is inserted into a large vein and the return limb connected to a fluid warmer allowing venovenous exchange. Anticoagulation is required. Haemofiltration can also be beneficial in correcting any metabolic abnormalities.

SUMMARY

This case illustrates the effectiveness of prolonged resuscitation efforts coupled with active core rewarming using a haemofiltration circuit in cardiopulmonary arrest secondary to acute severe environmental hypothermia when CPB is not available. In such cases, good basic cardiopulmonary resuscitation skills combined with simple and advanced rewarming techniques can prove to be immensely effective.

Emerg Med J 2007;**24**:511–512.
doi: 10.1136/emj.2006.040261

Authors' affiliations

Amy Hughes, Peter Riou, Christopher Day,
Royal Devon and Exeter Hospital, Exeter,
Devon, UK

Correspondence to: Dr A Hughes, Royal Devon and Exeter Hospital, Exeter, Devon, UK; amyhughes@doctors.org.uk

Accepted 5 December 2006

Competing interests: None.

REFERENCES

- 1 Kempainen R, Brunette D. The evaluation and management of accidental hypothermia. *Respir Care* 2004;**49**:192–205.
- 2 Brandstrom H, Paton B, Hamlet M, et al. Hypothermia—cold injuries and cold water near drowning. *Socialstyrelsen*. Stockholm, Sweden: National Board of Health and Welfare, 1997.
- 3 Walpoth B, Walpoth-Aslan B, Mattle H, et al. Outcome of survivors of accidental deep hypothermia and circulatory arrest treated with extracorporeal blood warming. *N Engl J Med* 1997;**337**:1500.
- 4 Silfvast T, Pettila V. Outcome from severe accidental hypothermia in Southern Finland—a 10 year review. *Resuscitation* 2003;**59**:285–90.