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Warming of patients with accidental hypothermia using warm water pleural lavage[☆]

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KEYWORD

Hypothermia

Summary In all, five patients with accidental hypothermia below 32 °C are described. All were unconscious and in mortal danger, but with an intact circulation. The youngest was 11 years and the oldest 85 years of age. The two oldest patients suffered from critical hypothermia only, while the other cases were complicated by other trauma and drug poisoning. All were warmed using pleural lavage with warm saline. All were discharged to their own homes neurologically intact.

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Introduction

Traditionally, the levels of severity in hypothermia are divided into severe, moderate and mild groups, based upon the core temperature alone, typically with limits of 28, 32 and 35 °C. However, it is not temperature alone that determines the patient's treatment needs. We chose to classify the groups so that the clinical condition and temperatures are combined in order to be able to define the treatment that is indicated.

We decided to use the following classifications for the different treatment groups.

The mild group

The core temperature is less than 35 °C, but the patient is awake and there is a peripheral circulation. This patient can be re-warmed externally using warm air, and possibly a warm bath or warm drinks.

The moderate group

The core temperature is less than 32 °C, the patient is unconscious and there is poor peripheral circulation, but the heart rhythm is stable. This patient must be intubated, ventilated and re-warmed centrally. We most often use pleural lavage with warm fluid, but also have the possibility for using extracorporeal circulation in case of collapse of the circulation.

[☆] A Spanish translated version of the summary and keyword of this article appears as Appendix in the online version at [10.1016/j.resuscitation.2005.06.019](https://doi.org/10.1016/j.resuscitation.2005.06.019).

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The severe group

Deep hypothermia: the core temperature is less than 32 °C and the circulation is collapsed. We use extracorporeal circulation (ECC) and blood warming with cannulae inserted into the groin. The patient receives CPR until then but is not re-warmed peripherally. We allow the patient to remain at the primary hospital and we bring our mobile equipment to the hospital.¹

This report describes five consecutive patients who all were included in the moderate group. All patients in our moderate group were treated this way during this period.

Materials and methods

As the department has worked with the treatment of accidental hypothermia for many years, an organisation has been formed for dispatching an emergency response team to other hospitals. The team carries along mobile equipment for ECC.¹ Transport is most often by ambulance and helicopter from The Royal Danish Air Force (RDAF). When we examine the hypothermic patient, we make a decision as to which re-warming method is most suitable. When evaluating the temperature, our goal is to determine the core temperature, defined as the place where the body temperature is the highest. As an adaptation, in most cases we have used the bladder temperature but in other cases we have also used the oesophageal temperature. We have not inserted Swan–Ganz catheters, even though these would allow us to determine the central blood temperature. We feel this is a risk factor for triggering an arrhythmia. All of the patients in this report were unconscious and were intubated and ventilated. All had a spontaneous heart rhythm but poor peripheral circulation and all were assessed as being in the moderate treatment group. All had bilateral pleural drains inserted, following which approximately half litre of 40 °C warm isotonic saline was poured into the pleura in turn followed by clamping of the drain for about 2 min. After the drain was opened, the procedure was repeated on the opposite side. This procedure was continued until the bladder temperature was 35 °C. We used a microwave oven for heating the fluid and mixed together cold and warm fluid under strict temperature control.

Case histories

Patient no. 1

The patient was a 37-year-old man who was involved in a frontal automobile collision. He was

trapped for an hour in an outdoor temperature of 8 °C. He suffered from multiple trauma and had an ISS of 34. He underwent a laparotomy at the local hospital, but bled uncontrollably due to a fractured pelvis, ruptured spleen, mesentery and diaphragm as well as from an open fracture of the femur. His core temperature was first measured after transfusion of 60 units of blood and was found to be 30.2 °C. The blood pressure could not be raised to more than 50 mmHg systolic and the pupils were fixed and dilated. Warm saline solution at 40 °C was infused via the pleural drains until the core temperature was above 35 °C. The bleeding then stopped. After undergoing several orthopaedic operations, he has made a full recovery and has returned to work.

Patient no. 2

A healthy 85-year-old man slipped and fell in the snow and was not found until the following day. The outdoor temperature was –12 °C. He was unconscious when brought into the emergency department at the University Hospital, where it was ascertained that he had suffered from frostbite to the extremities and had fixed dilated pupils, a BP that could not be measured non-invasively and there was indeterminate but regular ECG activity. It was not possible to feel any pulse, but he was moving spontaneously a little. A core temperature of 25.3 °C was measured. The patient was intubated orally without anaesthesia, after which the bilateral pleural drains were inserted. After this he was re-warmed using 40 °C warm salt water until the core temperature was above 35 °C.

The patient regained full consciousness and subsequently was completely intact cerebrally and could recall the sequence of events until he fell in the snow. The frostbite regressed.

He was discharged home after a week.

Patient no. 3

While playing on a raft, an 11-year-old boy fell into the water and nearly drowned. He spent at least 20 min under the surface of the water before he was rescued by the ambulance service. The water temperature was 7 °C. He was unconscious when pulled out of the water and had spasms. He was treated with O₂ by mask on the way to the hospital. At the local hospital fixed dilated pupils, irregular ECG activity and possible atrial fibrillation were noted. The BP was low and the pulse was weak. The core temperature was 28 °C. He was intubated and staff with the mobile heart–lung machine were flown out to the patient by RDAF. With the heart–lung machine as a backup, he was re-warmed using water in the pleura until the core temperature reached 35 °C. Extracorporeal

circulation was not required. After 1 day in the critical care unit, he was awake and today suffers from no permanent sequelae.

Patient no. 4

A 43-year-old woman with a known psychiatric amnesia had ingested a large amount of psychopharmacological drugs in addition to alcohol and had left her home to commit suicide. The amount of psychopharmacological drugs ingested was in itself potentially lethal. She was found in a field by a police dog following a search lasting several hours. The outdoor temperature was 8 °C. The patient was admitted to the local hospital. She was unconscious with fixed dilated pupils and unmeasurable BP. There had been an episode of tachycardia, followed by bradycardia. The core temperature was 30.6 °C. An emergency response team from the University Hospital was called. The patient was intubated and re-warmed using warm saline via bilateral pleural drains, until a core temperature above 35 °C was reached. A mobile heart–lung machine was brought along but was not used. The reason for not using ECC was that it was possible to measure the BP invasively. She had short episodes of a drop in BP but this recovered each time without the use of ECC. The patient had to undergo prolonged intensive therapy, during which, among other things, dialysis was necessary due to the amount of medication that had been ingested. She was discharged home completely intact cerebrally.

Patient no. 5

The patient was a 78-year-old woman with no history of prior illness, who had been trapped under a fallen tree in a hurricane for an entire night. The outdoor temperature was 4 °C. The patient was admitted to the local hospital and was unconscious with fixed dilated pupils, a BP that was not measurable and bradycardia. It was possible to detect a carotic pulse. There was discolouration in the dependent parts of the body, which resembled



Figure 1 The patient has discolouration on dependent parts of the body, which resembles post mortem lividity.

post mortem lividity (Figure 1). She was intubated without anaesthesia and the emergency response team from the University Hospital was called. A core temperature of 25.8 °C was recorded. The patient was re-warmed using bilateral pleural drains to a core temperature above 35 °C and the discolouration regressed. The patient made a full recovery and was discharged home neurologically intact after 5 days.

Four of the patients were warmed up by us at other hospitals as it was regarded too risky to transport the patients. Very large quantities of saline were used (Table 1). The entire procedure took between 3 and 5 h. In all of the patients, there was a fluctuating but upward temperature curve during the procedure. From time to time, the bladder temperature fell slightly as, for example, an extremity quite suddenly became warm; due apparently to a type of “afterdrop” with the elimination of vessel contraction in a peripheral area. None of the patients regained consciousness immediately, but after 2 days four of them were awake, while the patient suffering from multiple trauma first woke

Table 1 Patient’s condition prior to warming up

	Patient no.				
	1	2	3	4	5
Age (years)	37	85	11	43	78
Core temperature (°C)	30.2	25.3	28.0	30.6	25.8
a-pH	7.11	7.19	7.22	7.16	7.26
Temp. corrected pH (α -stat)	7.21	7.37	7.36	7.26	7.43
St. bicarbonate	13.6	18.9	15.0	18.0	15
GCS	3	3	4	5	8
Amount of water for warming up (L)	70	102	32	70	63

up after several days and operations for various fractures.

All of the patients were discharged home and all were neurologically intact.

Discussion

Most organ systems are affected by hypothermia, including neurological functions, circulation and coagulation.² Another cause of coagulopathy can be metabolic acidosis³ due to poor peripheral circulation, which was seen in all patients in this report. Hypothermia can, however, also have a protective effect against hypoxic injuries, which might explain why hypothermic patients often recover from even severe neurological abnormalities.

While the temperature including the body core can vary considerably in different parts of the body, even during controlled hypothermia,⁴ it is agreed that some kind of core temperature must be monitored. We used bladder temperature. The clinical condition can vary substantially among patients with the same core temperature and can also be affected by other illnesses.⁵

The patient, who is unconscious due to hypothermia, belongs in the moderate or the severe treatment group. It is generally agreed that re-warming should occur centrally with surgical procedures. Peripheral warming can potentially transmit cold, acidotic blood from the extremities to the core causing temperature and pH to drop further.^{6,7} The extremities can be insulated using blankets, however, direct warmth should not be supplied.

Many invasive procedures have been described for core re-warming of patients with an intact circulation, including peritoneal or pleural lavage,^{6,7} while extracorporeal circulation appears preferable in the absence of spontaneous circulation.⁸ ECC can itself have complications, is less available than other techniques, and in the absence of cardiac arrest, has not been reported to improve outcome versus surface re-warming.⁹ Guidelines 2000 for CPR has a whole section alone dealing with the complexity of treating the hypothermic patient.¹⁰

The use of pleural re-warming to overcome experimental hypothermia has been described in animal experiments.^{11,12} Hall and Syverud described the saving of two humans using pleural warming where ECC was not available.¹³ In Novosibirsk, Russia, perfusionless hypothermic circulatory arrest in surgery for certain congenital cardiac defects is used, followed by pleural re-warming.¹⁴

We report on five consecutive cases of successful re-warming via the pleural cavity. Although not scientifically compared, in our experience pleural

functions better than peritoneum. We are in a fortunate position as we can always use ECC, should the patient's condition deteriorate.

The specific heat of man approximates to that of water. Seventy litres of water cooled, on average, by 5 °C in the pleural cavity, should increase body temperature of a person weighing 70 kg by 5 °C. Quite a few flushes will be required as the limit seems to around half litre at a time.

We have not experienced any complications using pleural warming. Complications have been described using a pleural drain in one case with simultaneous bleeding from an overlooked lung lesion.¹⁵ A trauma patient should naturally be monitored for unresolved bleeding from the thorax due to trauma, so that such cases are handled correctly. In case of diffuse pleural adhesions we would anticipate difficulties in using pleural warming.

It is important to avoid overshoots in the treatment of hypothermic patients. Hyperthermia appears detrimental in most situations of ischaemic or hypoxic brain damage while mild hypothermia might be beneficial.¹⁶ We attempt, therefore, not to exceed 35 °C.

‘‘The principle is to keep the heart warm and the head cold’’.

Conflict of interest

There are no conflicts of interest.

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