

Cite this article as: Mroczek T, Gladki M, Skalski J. Successful resuscitation from accidental hypothermia of 11.8°C: where is the lower bound for human beings? Eur J Cardiothorac Surg 2020;58:1091–2.

Successful resuscitation from accidental hypothermia of 11.8°C: where is the lower bound for human beings?

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Received 5 January 2020; received in revised form 8 April 2020; accepted 15 April 2020

Abstract

We present the case of a 27-month-old boy who underwent accidental hypothermia to 11.8°C and was resuscitated with prolonged rewarming with extracorporeal membrane oxygenation without significant neurological impairments. This is probably the lowest temperature ever documented, at which a human being has been successfully resuscitated from accidental hypothermia after the long period of circulatory arrest.

Keywords: Accidental hypothermia • Extracorporeal membrane oxygenation • Prolonged rewarming

The 27-month-old toddler (body weight of 14 kg) living in a small village ~60 km from Krakow spontaneously left the house—probably between 3 and 4 a.m., when the outside temperature overnight was -7°C. His departure was discovered before 7 a.m. The boy was found by a police officer at 9.00 a.m. ~620 m from the house, dressed only in the upper part of his pyjamas and bare-foot. He showed no signs of life and had fixed, dilated pupils. The boy was carried to the nearest house, where resuscitation was initiated and continued until the paramedics arrived at 9:24 a.m. guided by a coordinator from the Severe Hypothermia Treatment Centre in Krakow [1]. The measured temperature was beyond the scope of an available thermometer (below 20°C). The only parameter measured during transportation was glucose level—19.5 mmol/l. Due to the foggy weather, a helicopter could not reach the area, so the boy was transferred to a hospital by a heated ambulance. The intubation was deferred due to stiffness of tissues and the patient was initially ventilated with an Ambu bag. Due to rigor mortis, only a tibial intraosseous access was possible. He arrived at the hospital at 10:50 a.m., reached the operating room at 10:58 a.m. and veno-arterial extracorporeal membrane oxygenation (ECMO) with crystalloid priming was initiated through the sternotomy and central cannulation at 11:07 a.m (Fig. 1). The ECG line was isoelectric, and the initial rectal temperature was 12.6°C. After 10 min of reperfusion, the patient's temperature dropped to 11.8°C. In the first blood sample obtained from the ECMO machine, potassium concentration was 4.9 mmol/l, lactate level 5.2 mmol/l and haematocrit 19%. The slow, active rewarming process was started after 60 min of reperfusion, when arterial and venous access were obtained, as well as confirming the integrity of tissues and microcirculation and

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stable level of biochemical parameters. The initial pump flow was 1.8 l/min/m², then increased to 3.0 l/min/m², when the rewarming process was started. The first ECG activity was noted at 17°C. After another 70 min, his temperature was 29.2°C and the child was transferred to the intensive care unit. Then the boy was gradually rewarmed to 35°C and left at that body temperature for the next 18 h. Subsequently rewarmed to 36°C, he was weaned from bypass with support of dopamine and milrinone. The chest was left open for 24 h. The computed tomography and magnetic resonance imaging of the head performed 24 h after weaning from ECMO did not show any abnormalities (as at 7 and 25 days post op). The boy was extubated 36 h later and a few minutes after extubation, was able to answer simple questions and within the next hours, started to eat, communicate with the staff and play with toys. He spent 9 days in CICU. The pneumonia and an inflammatory process involving the left cheek were treated. The boy presented peripheral paraesthesia with limitation of precise movements of the extremities and complains of erythromelalgia. The dedicated rehabilitation allowed for verticalization and practising precise movements. After 64 days, the boy was very active and was discharged home. Currently, the total follow-up is 5 years. The patient lives normally with imperceptible limitations of precise movements, although impairment of peripheral nerve transmission is detectable. Psychological assessments revealed a higher than average level of development.

DISCUSSION

ECMO has been employed for resuscitation from very deep hypothermia since the early nineties [2], and its usefulness has been subsequently confirmed in many centres [3]. Until now, the

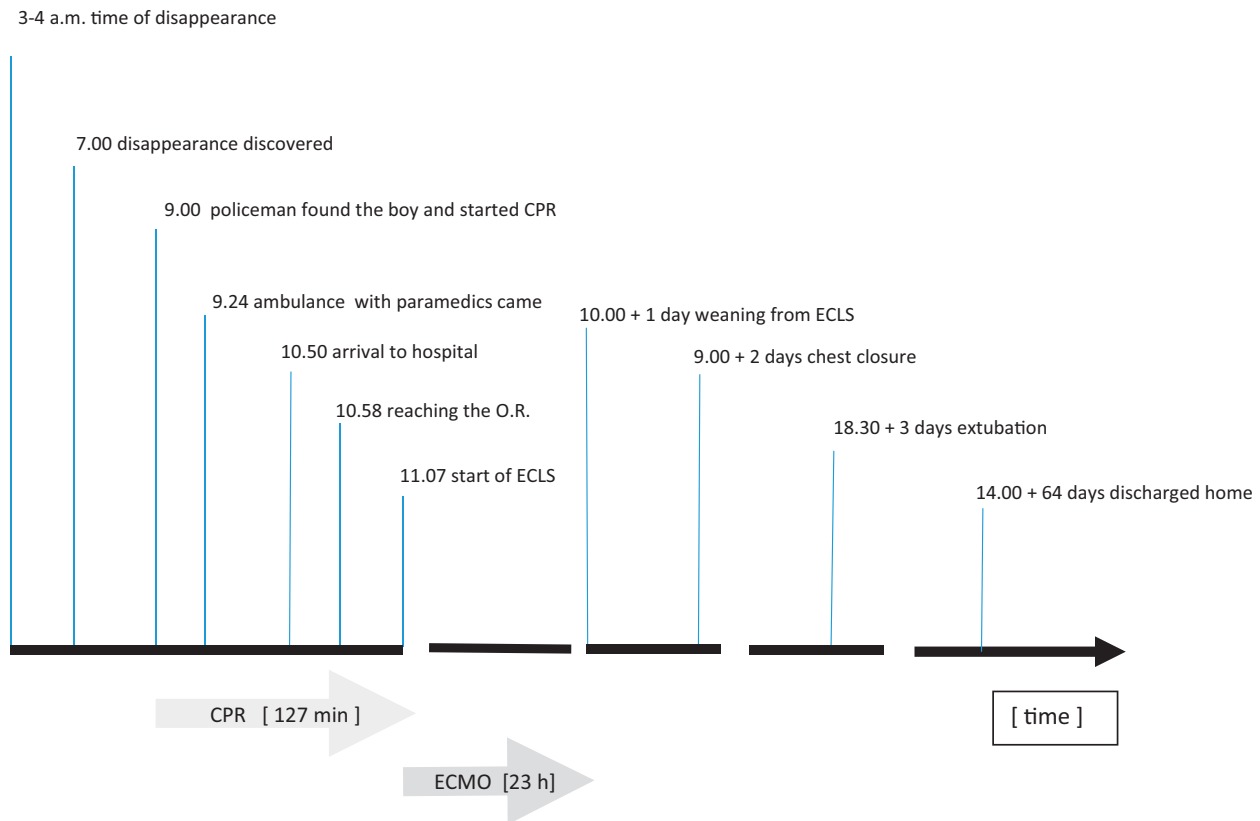


Figure 1: Timeline of medical processes. CPR: cardiopulmonary resuscitation; ECMO: extracorporeal membrane oxygenation; OR: operating room.

lowest reported temperature from which the patient has recovered without significant impairment is 13.7°C [4]. Accidental hypothermia reaching the level of 11.8°C is the lowest on record, in which a human was resuscitated without neurological sequelae of the central nervous system attributable to the hypothermia and circulatory arrest at the 5-year follow-up. This suggests that even a temperature close to 10°C should not be a contraindication for making the decision about initiating resuscitation. Moreover, it means that the guidelines or algorithm should not indicate the lowest temperature at all [5]. Another suggestion is that the process of progressing centralization of circulation during cooling due to accidental hypothermia may be sufficient (at least in children, in whom the cooling rate may be higher) to protect the central nervous system from the results of hypoxia. We postulate that an ECMO strategy with slow, prolonged, high flow rewarming performed at an experienced centre, after an episode of accidental hypothermia, may prevent end-organ failure, preserve heart function even after long-lasting resuscitation and lead to a 'miraculous' survival.

CONCLUSION

In conclusion, this is the case, to our knowledge, of the lowest temperature of accidental hypothermia, from which a human being has recovered with excellent cardiovascular and neurological results at the 5-year follow-up.

Conflict of interest: none declared.

Reviewer information

European Journal of Cardio-Thoracic Surgery thanks Marko Turina and the other, anonymous reviewer(s) for their contribution to the peer-review process of this article.

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