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Clinical paper

Prehospital surface cooling is safe and can reduce time to target temperature after cardiac arrest☆

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ABSTRACT

Purpose: Mild therapeutic hypothermia proved to be beneficial when induced after cardiac arrest in humans. Prehospital cooling with i.v. fluids was associated with adverse side effects. Our primary objective was to compare time to target temperature of out-of hospital cardiac arrest patients cooled non-invasively either in the prehospital setting vs. the in-hospital (IH) setting, to assess surface-cooling safety profile and long term outcome.

Methods: In this retrospective, single center cohort study, a group of adult patients with restoration of spontaneous circulation (ROSC) after out-of hospital cardiac arrest were cooled with a surface cooling pad beginning either in the prehospital or IH setting for 24 h. Time to target temperature (33.9 °C), temperature on admission, time to admission after ROSC and outcome were compared. Also, rearrests and pulmonary edema were assessed. Neurologic outcome at 12 months was evaluated (Cerebral Performance Category, CPC 1–2, favorable outcome).

Results: Between September 2005 and February 2010, 56 prehospital cooled patients and 54 IH-cooled patients were treated. Target temperature was reached in 85 (66–117) min (prehospital) and in 135 (102–192) min (IH) after ROSC ($p < 0.001$). After prehospital cooling, hospital admission temperature was 35.2 (34.2–35.8) °C, and in the IH-cooling patients initial temperature was 35.8 (35.2–36.3) °C ($p = 0.001$). No difference in numbers of rearrests and pulmonary edema between groups was observed. In both groups, no skin lesions were observed. Favorable outcome was reached in 26.8% (prehospital) and in 37.0% (IH) of the patients ($p = 0.17$).

Conclusions: Using a non-invasive prehospital surface cooling method after cardiac arrest, target temperature can be reached faster without any major complications than starting cooling IH. The effect of early non-invasive cooling on long-term outcome remains to be determined in larger studies.

1. Introduction

Cardiac arrest is a major cause of death in the modern world with few therapies.[1] In the US, every year approximately 300,000 people experience a sudden cardiac death, approximately 92% of these patients die.[2] In the last years, several studies showed that mild therapeutic hypothermia improves outcome when induced after cardiac arrest in humans.[3,4] In 2010, the American Heart Association (AHA) and the European Resuscitation Council (ERC) published revised recommendations for temperature regulation in patients successfully resuscitated from cardiac arrest.[5,6] Recently, controversy has risen on the need for cooling patients after cardiac arrest. A recent publication did not find any differences in outcome between temperature management of 33 °C vs. 36 °C,[7] however AHA and ERC have not change their guidelines yet. Concerning timing of cooling, the European Resuscitation Council stated earlier: "... but, as yet, there are no human data proving that earlier time to target temperature produces better outcomes".[5] The AHA gave no recommendation on timing.[6] Animal data consistently show that a delay in cooling negates the beneficial effect of mild hypothermia,[8–12] whereas human studies show inconsistent results concerning the beneficial effect of early cooling.[13–19] These results might be partly explained by the retrospective design of the studies and various cooling methods used[13–17] or by the shortcomings of the cooling procedure itself.[18–20] A recently published

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randomized study showed no effects on outcome in early cooling versus late cooling with intravenous (i.v.) cold normal saline. Surprisingly, more rearrests and pulmonary edema in patients cooled in the prehospital setting were observed.[21] In that study, volume overload may have led to the complications that were reported.

An alternative cooling method that ensures rapid cooling and reliable maintenance of mild hypothermia but minimizes risk of pulmonary edema and/or re-arrest would be preferred.

Recently, several different invasive and non-invasive cooling methods have been developed,[22–28] but some of them are not feasible for the use by emergency medical service in the prehospital setting. However, one non-invasive, external cooling pad (EMCOOLS Flex.Pad®) with fast cooling rate was evaluated and successfully implemented in out-of-hospital and in-hospital post-resuscitation care.[29,30]

The primary objective of this study in patients successfully resuscitated from out-of-hospital cardiac arrest was to compare the time to target temperature between patients non-invasively cooled in the prehospital setting and patients cooled after admission using a conventional non-invasive in-hospital (IH) approach. We also assessed safety profile and long-term neurological outcome.

2. Materials and methods

This was a retrospective observational study carried out in cooperation with the Municipal Ambulance Service of Vienna. Data of a convenience sample of consecutive patients treated by the Ambulance Service after out-of-hospital cardiac arrest and transported to the department of emergency medicine of a tertiary care university hospital were collected and analyzed. The institutional ethical review board has approved this registry and the procedures were in accordance with the ethical standards. The ethical review board did not review individual patient records. The primary endpoint of this study was time (from ROSC) to target temperature (33.9 °C, as recommended by international guidelines[5,6]) of patients after cardiac arrest with prehospital treatment compared to patients with IH treatment. The secondary endpoints were hospital admission temperature, time to admission after restoration of spontaneous circulation (ROSC) and neurological outcome after 12 months. Furthermore, the number of rearrests and pulmonary edema was recorded in both groups.

2.1. Prehospital cooling protocol

The inclusion and exclusion criteria for prehospital cooling were identical to those in our prior feasibility study.[29] After CPR, patients had to have >5 min of ROSC and not be capable of obeying any verbal command at any time prior to initiation of cooling. Patients were excluded if their initial esophageal temperature (Tes) was <34 °C or if they had a known coagulopathy, pregnancy and/or terminal disease, which did not allow any further intensive care escalation. Furthermore, patients with prehospital cooling who were cooled with invasive devices or i.v. cold fluids after admission were excluded from final analysis.

After ROSC, temperature was measured by inserting an esophageal temperature probe (Mon-a-therm General Purpose, 12 Fr, Mallinckrodt Medical Inc., St. Louis, MO, USA) with placement guided by a tracheal tube. The temperature probe was connected to a monitoring device before initiating cooling.

Cooling was performed by application of cooling pads[29] (EMCOOLS Flex.Pad®, EMCOOLS – Emergency Medical Cooling Systems AG, Pfaffstätten, Austria) on the thorax, back, abdomen and thighs (Fig. 1). Time of cooling start and first Tes measured prior to cooling was documented. These cooling pads consisted of multiple

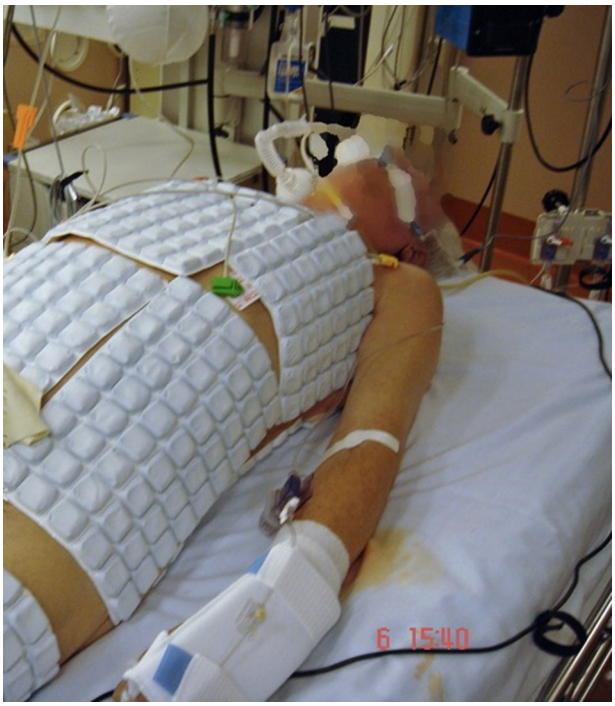

Fig. 1. Cooling pads applied to a patient after hospital admission.

cooling cells filled with a cooling gel. The inner layer was a biocompatible film, which adhered to the patient's skin on application and provided intimate pad to skin contact for efficient heat transfer.

During the study period, 3 out of 18 ambulances in the city were equipped with the cooling pad. Before use, the cooling pad was stored in a cooling box at approximately −9 °C in the ambulance. During transport in the ambulance, the cooling procedure was continued. After admission of patients in whom cooling had been initiated in the prehospital setting, Tes was again measured and monitored. The cooling pads were inspected by the attending physicians and nurses and exchanged if the cooling gel inside had already melted. The entire cooling pad was removed when Tes reached 33.9 °C and due to the cold skin, the cooling down process continued to a certain extend. After reaching Tes of 33 °C, external cooling was continued for 24 h by using the cooling pad guided by an established protocol[30]: During maintenance cooling, two single cooling units were applied as needed to keep Tes between 33 °C and 33.5 °C. No additional cooling method was applied. After 24 h of maintenance cooling, patients were allowed to rewarm passively.

During the entire process, sedation and anesthesia were given using the following protocol: sedation, analgesia and paralysis were initiated with a midazolam bolus of 5 mg, followed by continuous infusion (250 mg/50 mL midazolam, started at 0.125 mg/kg/h and adjusted as needed); a fentanyl bolus of 0.1 mg, followed by continuous infusion (2.5 mg/50 mL fentanyl, started at 0.002 μg/kg/h and adjusted as needed); and a rocuronium bolus of 0.5 mg/kg, followed by continuous infusion of 0.5 mg/kg/h.

2.2. In-hospital (IH) cooling protocol

In patients not cooled in the prehospital setting, Tes was measured immediately after admission by using an esophageal temperature probe as described above.

All other procedures were similar to those used in the patients treated with prehospital cooling including application of the cooling pads.

The same protocol for sedation, analgesia and neuromuscular blockade was used and cooling was continued for 24 h.