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# Comparative evaluation of the usability of 2 different methods to perform mild hypothermia in patients with out-of-hospital cardiac arrest

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ABSTRACT

*Background:* Several studies have shown that mild hypothermia (32–34 °C) markedly mitigates brain damage after cardiac arrest (CA). This study aimed to compare the efficacy of the non-invasive cooling device Hilotherm® Clinic (Hilotherm® GmbH, Germany) with conventional cooling to induce and maintain mild hypothermia in patients after out-of-hospital CA.
*Methods:* 50 adult patients with an indication for controlled mild hypothermia were prospectively assigned to conventional cooling ($n=20$) or cooling with the Hilotherm system ($n=30$). Patients receiving a cooling therapy by Hilotherm were treated either with 0.35 $m^2$ ($n=20$) or with 0.7 $m^2$ ($n=10$) surface area of cooling sleeves.
*Results:* The speed of cooling was significantly higher in both Hilotherm groups compared to conventional cooling (Hilotherm 0.7 $m^2$: 0.91 ± 0.08 °C/h, Hilotherm 0.35 $m^2$: 0.47 ± 0.04 °C/h, and conventional: 0.3 ± 0.04 °C/h, $p \leq 0.003$). Temperature deviation from the target temperature of 33 °C was significantly higher in the conventional group compared to both Hilotherm groups. During induction of mild hypothermia a significant reduction of the mean arterial blood pressure and the heart rate was observed without significant differences between the groups. However, the speed of cooling (range 0.3–0.91 °C/h) did not correlate to the decrease of blood pressure and heart rate. Norepinephrine dosing during induction of mild hypothermia and re-warming (1st–2nd day) was significantly increased compared to the 3rd day after admission in all groups. Dobutamine dosing and 30 days in-hospital mortality did not differ significantly between the groups.
*Conclusions:* Rapid and reliable mild hypothermia can be better achieved by the non-invasive cooling system Hilotherm compared to conventional cooling with ice packs and cold infusion.


## 1. Introduction

Cardiac arrest (CA) is the leading cause of death in Europe and the USA affecting about 750,000 people annually [1]. Because of improved public training of cardiopulmonary resuscitation (CPR) and advances in professional emergency medical response [2], the rate of restoration of spontaneous circulation (ROSC) has risen in the past decades. Brain damage is one of the major causes of morbidity and mortality after CA and CPR in hospitalized patients [3,4]. Several studies have shown that mild systemic hypothermia (32–34 °C) markedly mitigates brain damage after CA in animals and human [5–7]. The exact mechanism for this cerebral resuscitative effect is not clear. A reduction in cerebral oxygen consumption [8,9] and other multifactorial chemical and physical mechanisms during and after ischemia have been postulated [10–12]. However, clinical studies have shown that patients treated with mild hypothermia after CA have an improved neurologic outcome, without important side effects, as compared with outcome in controls [6,13,14].

Since this evidence has been described different methods and technical devices have been proposed to induce mild hypothermia in patients with CA and after successful CPR and ROSC [13–15]. Conventional cooling without the help of technical devices consists of rapid infusion of 30 ml/kg ideal bodyweight of lactated Ringer's solution at 4 °C followed by surface cooling using ice and/or cold packs [15]. To avoid shivering, patients receive a continuous intravenous infusion of non-depolarising neuromuscular-blocking. A therapy with conventional cooling has been demonstrated to be effective in terms of achieving mild hypothermia. However, conventional cooling has disadvantages since it consumes human resources, temperature titration is delayed and deviation around the target temperature is

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common [15]. A further disadvantage of conventional cooling by cold infusions is the risk for volume overload which may be especially detrimental in patients with heart failure.

Water-circulating cooling systems consist of water-circulating cooling sleeves, placed under and/or over the patient. In some of these devices the sleeves are connected to an automatic temperature control module guided by the rectal or bladder temperature of the patient. However, temperature reduction is neither easy nor without risk. To be applicable in a larger number of patients, cooling has to be accomplished in an easy, controllable, minimally invasive and well-tolerated way. Little is known about the optimal method of temperature control. Therefore, this study aimed to evaluate the cooling device Hilotherm® Clinic (Hilotherm® GmbH, Germany) to perform mild hypothermia in patients after out-of-hospital CA. The data obtained from this device were compared with results achieved from conventional cooling.

## 2. Material and methods

### 2.1. Study population

Approval for the study was obtained from the relevant ethics committee at the RWTH Aachen University, Germany (CIS2007-237-f-M). The ethics committee waived the need for informed consent.

A total of 50 consecutive adult patients with an indication for controlled mild hypothermia were prospectively enrolled. The target temperature for mild hypothermia was a bladder temperature of 32–34 °C. In all patients mild hypothermia was conducted in the first 24 h after admission in the ICU.

The study was conducted in the critical coronary care unit (CCCU) of the university hospital in Aachen, Germany. Patients were excluded from the study if they had a bladder temperature <35.5 °C at the beginning of the study. In addition, patients were excluded if they suffered from severe hemodynamic instability, severe sepsis, or active bleeding or if they received renal replacement therapy. Severe hemodynamic instability was defined as the need for increasing amounts of vasoactive support, or requiring >0.5 μg/kg/min norepinephrine. Severe sepsis was defined as sepsis with organ dysfunction/failure. Active bleeding was defined as blood loss requiring more than 2 units of erythrocyte concentrates/24 h.

### 2.2. Study intervention

20 patients were assigned to conventional cooling and 30 patients to the water-circulating external cooling device Hilotherm® Clinic (Hilotherm® GmbH, Germany) (Fig. 1A). Patients who were receiving a cooling therapy by Hilotherm were further subdivided into 2 groups. 20 patients were treated with 1 Hilotherm device with 0.35 $m^2$ and 10 patients received a therapy with 2 Hilotherm devices with 0.7 $m^2$ cooling surface area. Following identification by the medical staff, the patients were included in the study and allocated to a cooling method. The order of the cooling method was determined randomly and was not influenced by the clinicians responsible for the individual patients.

Conventional cooling consisted of rapid infusion of 30 ml/kg ideal bodyweight of lactated Ringer's solution at 4 °C followed by surface cooling using ice and/or cold packs. Ice and/or cold packs were placed on both inguinals, both axillas and on the chest of the patient. Ice and/or cold packs were changed every 60 min. The cooling properties were judged by the attending nurse and guided by the patient's bladder temperature.

The water-circulating cooling system by Hilotherm consists of two large water-circulating cooling sleeves, placed on the chest and abdomen of the patient (Fig. 1B). The surface area of cooling sleeves was either 0.35 $m^2$ (1 Hilotherm device) or 0.7 $m^2$ (2 Hilotherm devices). In the latter case 2 further sleeves were placed on the thigh and groin areas of the patient. The temperature of the water circulating through the sleeves ranged between 10 °C and 30 °C. The temperature control of the device was initially set to 10 °C until the target temperature was reached. Thereafter, the attending nurse judged the temperature control guided by the patient's bladder temperature. Re-warming procedure in all groups was performed equally with conventional methods. In some patients re-warming failed by conventional methods so that for these patients the Warm Touch device (Covidien, Formerly Nellcor Puritan Bennett, Inc., USA) was used. By the help of this device warm air was introduced under the bedspread to improve re-warming.

### 2.3. Standard care

All patients were admitted to the CCCU, monitored and treated according to international standards. All patients were intubated and mechanically ventilated. Patients were sedated using midazolam and/or propofol to a Richmond Agitation–Sedation Scale of −5 and received adequate analgesia with fentanyl. During the procedure of mild hypothermia all patients received equal rocuronium dosages over 24 h to inhibit shivering. Vasoactive or inotropic support, usually norepinephrine or dobutamine was administered if necessary.

### 2.4. Data collection

Clinical, laboratory and pharmacological data were obtained through review of the medical records of each patient. Body temperature was measured continuously using a bladder temperature probe (400 Series Thermistor Foley Catheter Temperature Sensor, Smiths Catheter, USA) and recorded every 60 min throughout the study protocol.

Primary endpoints of the study were cooling speed to obtain the target temperature of 34 °C and temperature deviation from the target temperature of 33 °C during the first 24 h of treatment (defined as more than 0.2 °C above or below target temperature). When the temperature was out of range, the mean temperature change from target was calculated. If the target temperature was not reached within 24 h, treatment was considered as a failure.

Secondary endpoints of the study included norepinephrine and dobutamine dosing, 30 days in-hospital mortality, development of skin lesions, malfunction of the cooling device, changes in mean arterial blood pressure and heart rate.

### 2.5. Statistical analysis

All data are expressed as mean values ± 1 SEM unless otherwise stated. A one-way analysis of variance (ANOVA) with post hoc Bonferroni's test for multiple comparisons of means was used for repeated measures. The Student *t*-test was applied for quantitative variables. A $p$ value<0.05 was considered significant. Statistical analysis was done with SPSS software for windows Version 14.0 (SPSS Inc., Chicago, IL, USA).

## 3. Results

### 3.1. Baseline characteristics

The clinical and demographic characteristics of patients are shown in Table 1. No differences were found with respect to age, body mass index, initial temperature, first recorded ECG, past medical history, arrest etiology or APACHE II score.

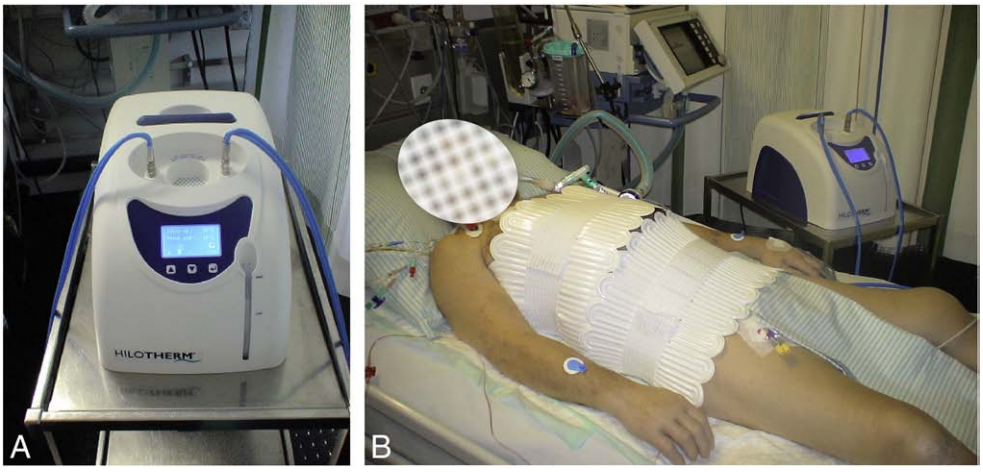


**Fig. 1.** Hilotherm® Clinic cooling device. (A) Image demonstrating the cooling device by Hilotherm®. (B) Demonstrating the Hilotherm device setup with 2 sleeves during the cooling procedure of a patient after out-of-hospital cardiac arrest.

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**Table 1**
Baseline characteristics of patients.

| | Conventional | Hilotherm 0.35 m² | Hilotherm 0.7 m² | *P* value |
|---|---|---|---|---|
| Gender male — no./total no. (%) | 15/20 (75) | 13/20 (65) | 7/10 (70) | 0.432 |
| Age (years) ± SD | 64.3 ± 9.4 | 61.6 ± 14.9 | 62.8 ± 11.5 | 0.521 |
| APACHE II ± SD | 31.1 ± 3.9 | 32.7 ± 5.7 | 30.7 ± 4.3 | 0.324 |
| BMI (kg/m²) ± SD | 28.0 ± 4.6 | 28.7 ± 4.9 | 29.4 ± 5.3 | 0.479 |
| Initial temperature ± SD | 36.3 ± 0.9 | 36.4 ± 0.3 | 36.6 ± 0.2 | 0.138 |
| Mean duration of CPR (min) ± SD | 24.5 ± 18.2 | 28.6 ± 16.9 | 26.3 ± 12.5 | 0.542 |
| *Past medical history — no./total no. (%)* | | | | |
| Diabetes | 5/20 (25) | 6/20 (30) | 3/10 (30) | 0.853 |
| Coronary heart disease | 9/20 (45) | 8/20 (40) | 4/10 (40) | 0.744 |
| Cerebrovascular disease | 1/20 (5) | 1/20 (5) | 0/10 (0) | 0.942 |
| Peripheral artery disease | 4/20 (20) | 5/20 (25) | 2/10 (20) | 0.937 |
| *Etiology of arrest — no./total no. (%)* | | | | |
| Myocardial infarction | 17/20 (85) | 16/20 (80) | 8/10 (80) | 0.573 |
| Pulmonary embolism | 2/20 (10) | 2/20 (10) | 1/10 (10) | 1.000 |
| Respiratory insufficiency | 1/20 (5) | 2/20 (10) | 1/10 (10) | 0.482 |
| *First ECG — no./total no. (%)* | | | | |
| Ventricular fibrillation | 13/20 (65) | 14/20 (70) | 7/10 (70) | 0.531 |
| Pulseless ventricular tachycardia | 2/20 (10) | 2/20 (10) | 0/10 (0) | 0.740 |
| Asystole | 5/20 (25) | 4/20 (20) | 3/10 (30) | 0.682 |

### 3.2. Cooling speed and temperature deviation

In all 3 groups mild hypothermia could be effectively achieved. Temperature curves of all 3 groups are depicted in Fig. 2. The speed of cooling was highest in the Hilotherm 0.7 m² group with 0.91 ± 0.08 °C/h followed by the Hilotherm 0.35 m² group with 0.47 ± 0.04 °C/h. The speed of cooling was lowest in the conventional group with 0.3 ± 0.04 °C/h (Fig. 3). The curve progression during re-warming was equal in all groups without significant differences.

A further primary endpoint was to compare temperature deviation from 33 °C during the first 24 h after induction of hypothermia. Temperature deviation was significantly higher in the conventional group compared to both Hilotherm groups (Hilotherm 0.7 m²: 0.4 ± 0.1 °C and Hilotherm 0.35 m²: 0.31 ± 0.12 °C vs. conventional: 0.94 ± 0.2 °C, $p \leq 0.03$, Fig. 4). No significant differences in temperature deviation were found between both Hilotherm groups ($p = 0.17$).

### 3.3. Changes in mean arterial blood pressure after induction of hypothermia and during re-warming

Mean arterial blood pressure curves of all 3 groups are depicted in Fig. 5A. To further characterize the changes in mean arterial blood pressure and heart rate during hypothermia (24 h) and the re-warming period (24 h) the means of each hemodynamic factor were divided in 4 time groups (T1: 0–12 h, T2: 13–24 h, T3: 25–36 h, and T4: 37–48 h). There was a significant blood pressure lowering during T2 and T3 compared to T1 in all groups with a significantly increase of blood pressure during T4 compared to T3 only for the Hilotherm 0.7 m² group (Fig. 5B).

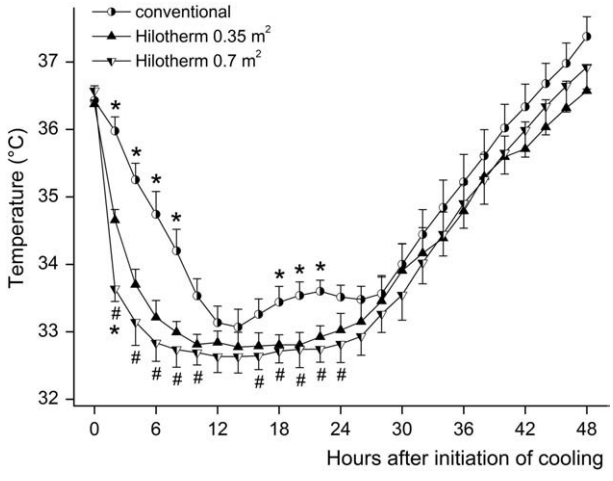


**Fig. 2.** Induction of mild hypothermia. Temperature curves of all 3 groups during induction of hypothermia and re-warming. Bars represent mean values ± SEM. Asterisks indicate significant differences, *$p<0.05$ vs. Hilotherm 0.35 m², #$p<0.05$ vs. conventional.

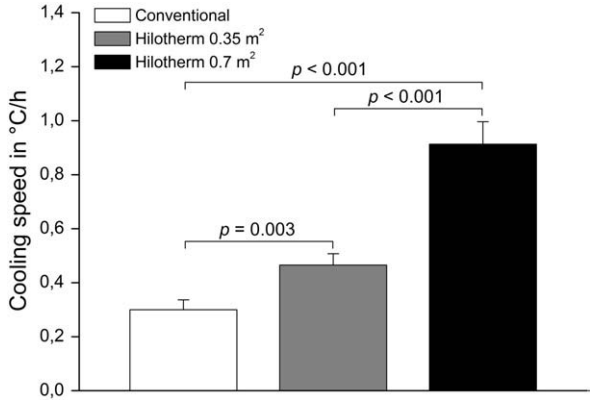


**Fig. 3.** Speed of cooling. The speed of cooling was significantly higher in both Hilotherm groups compared to conventional cooling.

### 3.4. Norepinephrine dosing

To investigate if the depression of arterial blood pressure during the induction of mild hypothermia is associated with the increased or decreased demand of catecholamines, the average amount of norepinephrine in μg/kg/min was calculated which was administered intravenously during the first 48 h (induction of mild hypothermia and re-warming = 1st–2nd day) and during 48–72 h (3rd day) after admission. During induction of mild hypothermia and re-warming patients received significantly more norepinephrine compared to the 3rd day in all groups (Fig. 6). However, there were no significant differences concerning the norepinephrine dosage at both time periods between the groups.

### 3.5. Changes in heart rate after induction of hypothermia and during re-warming

Fig. 7A demonstrated the heart rate curves of all groups. The mean heart rate during T2 was significantly lower compared to T1 in all groups (Fig. 7B). During the first re-warming phase (T3) the mean heart rate significantly increased compared to T2 in all groups followed by a further significant increase during T4 compared to T3 in all groups.

### 3.6. Dobutamine dosing

In analogy to the norepinephrine dosing, intravenously administered dobutamine in μg/kg/min was calculated. In contrast to norepinephrine dosing, patients during mild hypothermia and re-warming received equal dobutamine concentrations compared to the 3rd day in all 3 groups (Fig. 8). Furthermore, no significant changes of dobutamine administration were found comparing 1st–2nd day and 3rd day between both Hilotherm and the conventional groups.

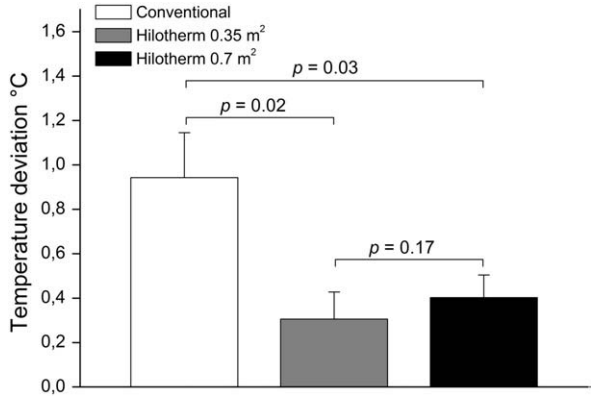


**Fig. 4.** Temperature deviation. Temperature deviation was significantly higher in the conventional group compared to both Hilotherm groups. No significant differences were found between the Hilotherm groups.

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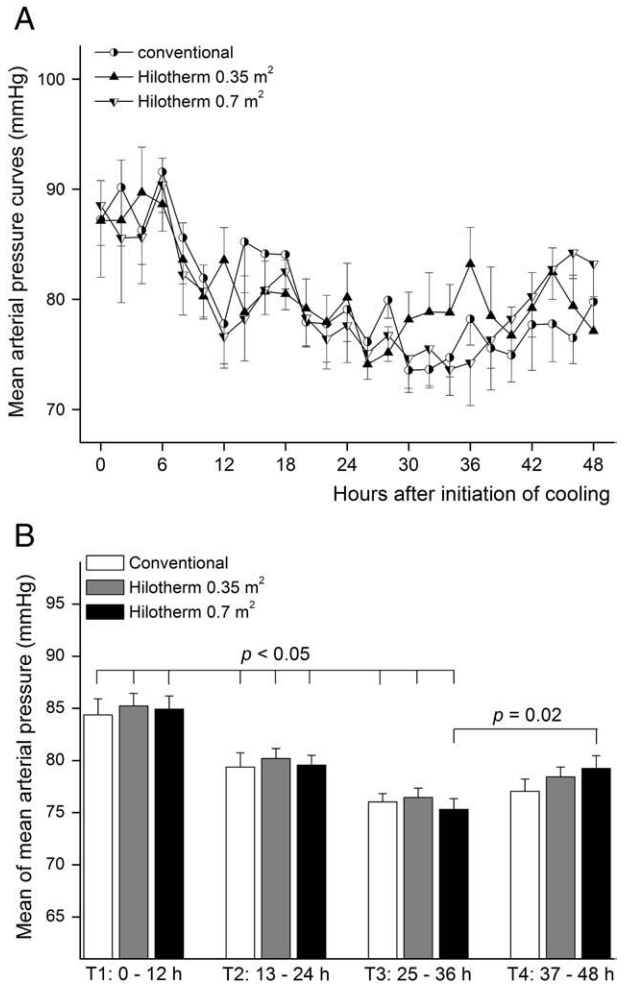


**Fig. 5.** Changes in mean arterial blood pressure. (A) Mean arterial blood pressure curves during hypothermia and re-warming of all 3 groups. (B) There was a significant blood pressure lowering during T2 and T3 compared to T1 in all groups with a significant increase of blood pressure during T4 compared to T3 only for the Hilotherm 0.7 $m^2$ group.

### 3.7. 30 days in-hospital mortality

Next we analyzed the 30 days in-hospital mortality. In the Hilotherm 0.7 $m^2$ group 3 of 10 (30%), in the Hilotherm 0.35 $m^2$ group 6 of 18 (33.3%) and in the conventional group 7 of 18 (38.9%) patients died during the first 30 days after hospital admission. There were no significant differences in the 30 days in-hospital mortality between the groups.

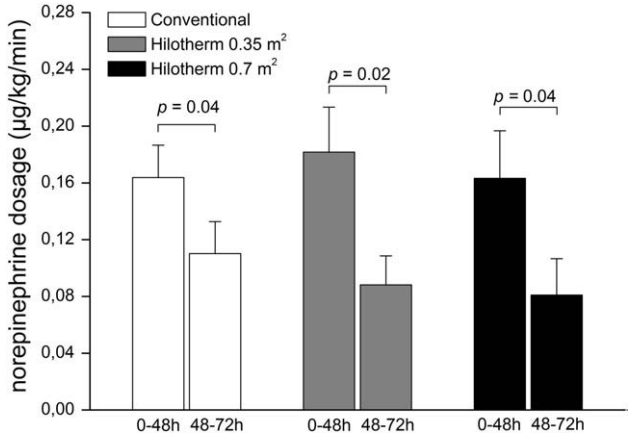


**Fig. 6.** Norepinephrine dosing. During 0–48 h patients received significantly more norepinephrine intravenously compared to the 3rd day in all groups. However, there were no significant differences concerning the norepinephrine dosage at both time periods between the groups.

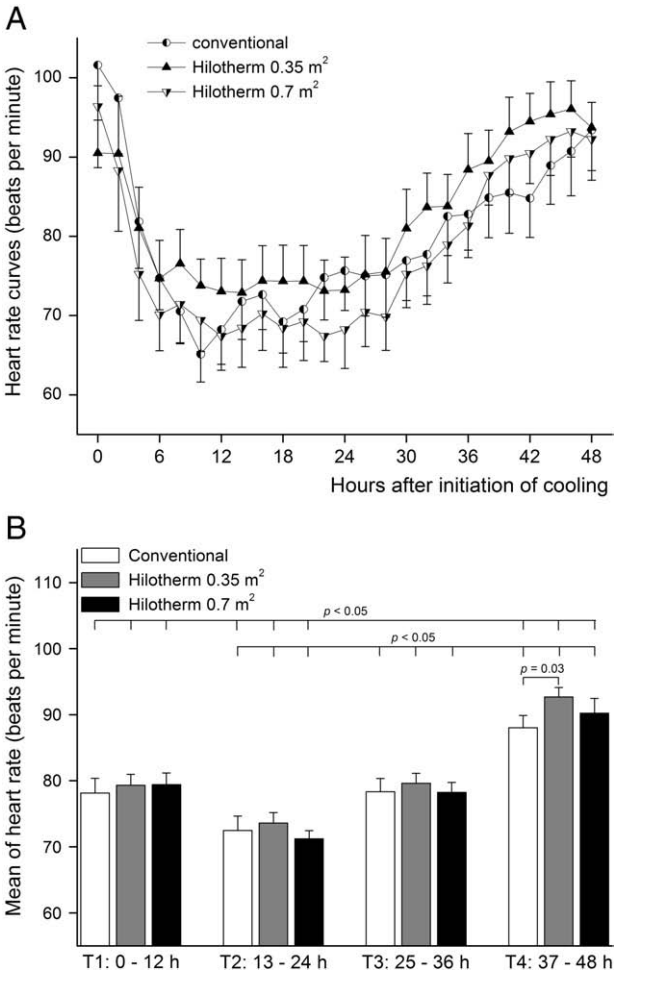


**Fig. 7.** Changes in heart rate. (A) Heart rate curves during hypothermia and re-warming of all 3 groups. (B) The mean heart rate during T2 was significantly lower compared to T1 in all groups. In the first re-warming phase (T3) the mean heart rate significantly increased compared to T2 in all groups followed by a further significant increase during T4 compared to T3 in all groups.

### 3.8. Device malfunctioning, skin lesions and costs

Throughout the study malfunctioning of the Hilotherm cooling device did not occur. Skin lesions were not visible in any group. The costs for ice packs or crushed ice are not worthy of mention. The Hilotherm Clinic cooling device is distributed by the

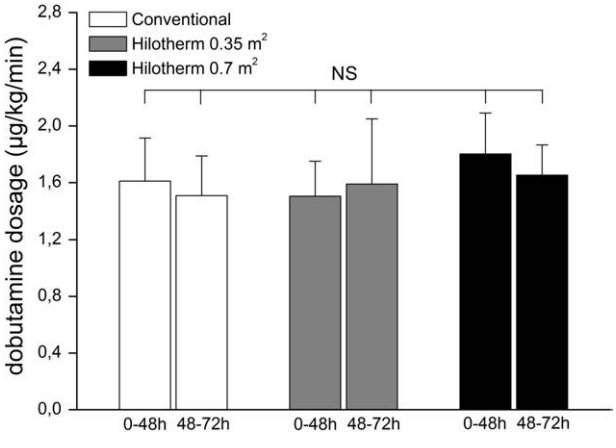


**Fig. 8.** Dobutamine dosing. In contrast to norepinephrine dosing, patients during mild hypothermia and re-warming received equal dobutamine concentrations compared to the 3rd day in all 3 groups. Furthermore, no significant changes of dobutamine administration were found comparing 1st–2nd day and 3rd day between both Hilotherm and the conventional group.

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**Table 2**
Comparison of costs and dimensions of different cooling devices.

| | Price of cooling device in €[a] | Price of sleeves, gel pads in €[a] | Re-usability of sleeves, gel pads | Dimensions (H–W–D) in cm |
|---|---|---|---|---|
| Hilotherm — Hilotherm Clinic | 3900 | 360 | Yes | 28–27–43 |
| Medivance — Arctic Sun 2000 | 25,000 | 750 | No | 76–32–56 |
| CSZ — Blanketrol III | 18,800 | 530[b] | No[c] | 95–43–43 |
| MTRE — CritiCool | 18,900 | 330 | No | 94–26–62 |

[a] Approximately prices as of May 2010 without VAT in Germany.
[b] Price for one-way sleeves.
[c] Some items are re-useable.

company Hilotherm. The costs for 1 Hilotherm device without the water-circulating sleeves are approximately 3900 euros (Table 2). Up to 2 sleeves can be connected to 1 device. The sleeves provided by Hilotherm are re-useable up to ~50 times.

## 4. Discussion

The present study introduces a new cooling device named Hilotherm® Clinic (Hilotherm® GmbH, Germany) to induce and maintain mild hypothermia in patients with out-of-hospital CA. The speed of cooling by the water-circulating system was significantly higher compared to conventional cooling. Furthermore, temperature deviation was significantly lower by Hilotherm compared to conventional cooling. Conventional cooling was effective in our study without treatment failures defined as not achieving target temperature within 24 h after the initiation of cooling. This is in contrast to the study of Hoedemaekers et al. where a treatment failure of 60% was reported [15]. However, conventional cooling can be performed in different ways, is highly dependent on the cooling protocol and can differ in each hospital. Therefore, in previous studies the average temperature decrease of conventional cooling has been reported to vary considerably between 0.3 °C and 2.5 °C per hour [15–19]. In the recent study the cooling speed by conventional cooling was 0.3 °C/h which is in line with previous studies [15–19].

In the present study a cooling speed of 0.91 °C/h could be achieved by the Hilotherm device with a cooling surface area of 0.7 $m^2$. By using a cooling surface area of 0.35 $m^2$ (1 Hilotherm device) a cooling speed of 0.47 °C/h could be achieved. This is in line with previous studies. Hoedemaekers et al. demonstrated a cooling speed of 1.33 °C/h by their water-circulating cooling device with a cooling surface area of 0.77 $m^2$ [15].

The Hypothermia After Cardiac Arrest Study Group demonstrated an increased rate of a favorable neurologic outcome and a reduced mortality by inducing mild hypothermia [6]. However, in the latter study mild hypothermia was induced by a combination of air and conventional cooling and was achieved after 8 h. Although the speed of cooling was low compared to recent cooling devices a favorable neurologic outcome could be documented. Therefore, the target time to achieve mild hypothermia should be 8 h or below. In the present study mild hypothermia could be achieved in 2.9 h by Hilotherm 0.7 $m^2$, in 4.5 h by Hilotherm 0.35 $m^2$ and in 9.7 h by conventional cooling.

In a further study intravascular cooling has been shown to be more effective than air- and water-circulating cooling in both inducing and maintaining hypothermia [16]. The superiority of endovascular cooling is most likely due to the direct heat exchange between catheter and blood, resulting in a rapid transfer of cold blood through the body, whereas surface cooling depends on relatively slow conduction of cold mainly through the tissue itself. However, the time to achieve mild hypothermia in the comparative study by endovascular cooling catheters was 190 ± 110 min [16], whereas mild hypothermia by Hilotherm was achieved in 174 ± 48 min. Despite an equal cooling speed one has to be aware of the complications during insertion of a central venous catheter by the endovascular cooling system. On the other hand, this drawback is relative since most patients in the ICU need central venous access under these conditions.

Further advantages of the Hilotherm system compared to other available cooling systems are cost-efficiency and small device dimensions. Table 2 demonstrates the costs and device dimensions of different water-circulating devices. A disadvantage of conventional cooling by cold infusions is the risk for volume overload which may be especially detrimental in patients with heart failure.

A reduction of heart rate during mild hypothermia has been reported in several studies [7–10]. In line with previous studies we observed a significant reduction of the heart rate during mild hypothermia. However, there was no critical decrease requiring temporary pacemaker in any patient. The maximum of heart rate lowering was achieved during T2 (13–24 h) followed by a significant increase of the heart rate during re-warming in all groups. The speed of cooling (range 0.3–0.91 °C/h) did not correlate to the decrease of heart rate between the groups with approximately equal dobutamine dosing.

In the present study we also describe a significant reduction of the mean arterial blood pressure during induction of mild hypothermia. This contributed to the need for significantly increased norepinephrine infusion during hypothermia and re-warming (0–48 h) compared to the 3rd day (48–72 h). However, one cannot exclude the possibility of an increased norepinephrine demand during the first 48 h because of a decreased inotropy and cardiac output after coronary occlusion and myocardial infarction which increases after 48 h. In analogy to the heart rate, the speed of cooling did not correlate to the blood pressure reduction between the groups with equal norepinephrine dosing during the first 48 h.

The 30 days in-hospital mortality did not differ significantly between the groups. Mild hypothermia by conventional cooling has been described to be a safe method without increased mortality compared to other cooling methods [15]. Although limited by numbers cooling with the non-invasive cooling system applied in this study seems to be effective and safe.

## 5. Conclusions

The results of our study demonstrate that the water-circulating system by Hilotherm is more efficient in inducing and maintaining hypothermia as compared to conventional cooling in our clinical setup. Furthermore, temperature deviation was significantly lower by Hilotherm compared to conventional cooling. Mild hypothermia is associated with decreased heart rate and mean arterial blood pressure. The speed of cooling did not correlate to heart rate and blood pressure reduction. During the induction of mild hypothermia and re-warming (1st – 2nd day) an increased norepinephrine and unchanged dobutamine demand was revealed compared to the 3rd day. The 30 days in-hospital mortality did not differ between the groups.

## Competing interests

The authors declare that they have no competing interests.

## Acknowledgments

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## References


[1] 2005 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care — part 3: overview of CPR. Circulation 2005;112: 1–203.

[2] Becker L, Gold LS, Eisenberg M, White L, Hearne T, Rea T. Ventricular fibrillation in King County, Washington: a 30-year perspective. Resuscitation 2008;79:22–7.

[3] Brain Resuscitation Clinical Trial I Study Group. Randomized clinical study of thiopental loading in comatose survivors of cardiac arrest. N Engl J Med 1986;314: 397–403.

[4] Brain Resuscitation Clinical Trial II Study Group. A randomized clinical study of a calcium entry blocker (lidoflazine) in the treatment of comatose survivors of cardiac arrest. N Engl J Med 1991;324:1225–31.

[5] Safar P, Xiao F, Radovsky A, et al. Improved cerebral resuscitation from cardiac arrest in dogs with mild hypothermia plus blood flow promotion. Stroke 1996;27: 105–13.

[6] Hypothermia after Cardiac Arrest Study Group. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N Engl J Med 2002;346:549–56.

[7] Derwall M, Stoppe C, Brücken D, Rossaint R, Fries M. Changes in S-100 protein serum levels in survivors of out-of-hospital cardiac arrest treated with mild therapeutic hypothermia: a prospective, observational study. Crit Care 2009;13:R58.

[8] Hegnauer AH, D'Amato HE. Oxygen consumption and cardiac output in the hypothermic dog. Am J Physiol 1954;178:138–42.

[9] Mezrow CK, Sadeghi AM, Gandsas A, et al. Cerebral blood flow and metabolism in hypothermic circulatory arrest. Ann Thorac Surg 1992;54:609–15.

[10] Chopp M, Knight R, Tidwell CD, Helpern JA, Brown E, Welch KM. The metabolic effects of mild hypothermia on global cerebral ischemia and recirculation in the cat: comparison to normothermia and hyperthermia. J Cereb Blood Flow Metab 1989;9:141–8.

[11] Dempsey RJ, Combs DJ, Maley ME, Cowen DE, Roy MW, Donaldson DL. Moderate hypothermia reduces postischemic edema development and leukotriene production. Neurosurgery 1987;21:177–81.

[12] Natale JA, D'Alecy LG. Protection from cerebral ischemia by brain cooling without reduced lactate accumulation in dogs. Stroke 1989;20:770–7.

[13] Nagao K, Hayashi N, Kanmatsuse K, et al. Cardiopulmonary cerebral resuscitation using emergency cardiopulmonary bypass, coronary reperfusion therapy and mild hypothermia in patients with cardiac arrest outside the hospital. J Am Coll Cardiol 2000;36:776–83.

[14] Zeiner A, Holzer M, Sterz F, et al. Mild resuscitative hypothermia to improve neurological outcome after cardiac arrest. A clinical feasibility trial. Hypothermia After Cardiac Arrest (HACA) Study Group. Stroke 2000;31:86–94.

[15] Hoedemaekers CW, Ezzahti M, Gerritsen A, van der Hoeven JG. Comparison of cooling methods to induce and maintain normo- and hypothermia in intensive care unit patients: a prospective intervention study. Crit Care 2007;11:R91.

[16] Keller E, Imhof HG, Gasser S, Terzic A, Yonekawa Y. Endovascular cooling with heat exchange catheters: a new method to induce and maintain hypothermia. Intensive Care Med 2003;29:939–43.

[17] Bernard S, Buist M, Monteiro O, Smith K. Induced hypothermia using large volume, ice-cold intravenous fluid in comatose survivors of out-of-hospital cardiac arrest: a preliminary report. Resuscitation 2003;56:9–13.

[18] Rajek A, Greif R, Sessler DI, Baumgardner J, Laciny S, Bastanmehr H. Core cooling by central venous infusion of ice-cold (4 degrees C and 20 degrees C) fluid: isolation of core and peripheral thermal compartments. Anesthesiology 2000;93: 629–37.

[19] Virkkunen I, Yli-Hankala A, Silfvast T. Induction of therapeutic hypothermia after cardiac arrest in prehospital patients using ice-cold Ringer's solution: a pilot study. Resuscitation 2004;62:299–302.

[20] Coats AJ. Ethical authorship and publishing. Int J Cardiol 2009;131:149–50.


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