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# Mild therapeutic hypothermia after cardiac arrest due to acute coronary syndrome — experience from the implementation of the method

## Łagodna hipotermia terapeutyczna po nagłym zatrzymaniu krążenia w przebiegu ostrego zespołu wieńcowego — doświadczenia z wdrażania metody

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## Abstract

**Introduction.** A mild therapeutic hypothermia (MTH) is a promising adjunct treatment in patients suffering from cardiac arrest.

**Material and methods.** In 2012–2013 a 13 out of 216 consecutive patients admitted due to cardiac arrest were qualified to MTH. Cooling was started at the admission with the intravenous infusion of saline at a degree of 4°C, then continued with intravascular automated cooling system.

**Results.** The study group consisted of five women and eight men (mean age 59 years). The most common mechanism of cardiac arrest was ventricular fibrillation or ventricular tachycardia due to acute myocardial infarction (92.3%). The mean time of return of spontaneous circulation (ROSC) was 15 min 54 s. The mean time from cardiac arrest to the start of the cooling was 1h 10 min. During MTH an increase in white blood cell count and serum level of amylase and CRP was observed. The in-hospital mortality was 7/13 patients (53.8%). Patients who survived were younger (53.8 vs. 63.6 years), had lower incidence of coronary artery disease and ventricular fibrillation was the mechanism of cardiac arrest. In addition, patients who survived had prolonged time to ROSC (median time 19 min vs. 13 min) and reduced time: to the start of cold saline infusion (median time 58 min vs. 85 min), from cardiac arrest to the beginning of the intravascular cooling (median time 3 h 20 min vs. 3 h 50 min) and hospital stay (median time 471 h vs. 1232 h) in comparison with patients with fatal outcome. Five patients were discharged from the hospital in a good neurological condition (4 patients — 0 points and 1 patient — 1 point in Rankin scale).

**Conclusions.** All the patients who survived and were treated with MTH, were discharged in a good neurological condition. The implementation of endovascular cooling device greatly improves precise temperature control in patients undergoing MTH.

Key words: mild therapeutic hypothermia, cardiac arrest, acute coronary syndrome

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## Introduction

Cardiac arrest due to cardiovascular diseases is one of the most common cause of death in developed countries. In cardiac intensive care units in Europe there are over 275 000 patients treated due to out-of-hospital cardiac arrest (OHCA). Around 25% of those patients are young, aged < 65years. Despite intensive treatment only less than 10% of patients are discharged home, whereas their annual mortality is estimated at 50% [1, 2]. The main cause of death in patients after successful cardiopulmonary resuscitation is post-ischemic central nervous system (CNS) injury. A mild therapeutic hypothermia (MHT) is a promising treatment method which may improve prognosis in above-mentioned patients [1, 2]. The method goal is to cool a patient to a target temperature of 32–34°C, maintain this temperature for 12–24 h and then gradually re-warm patient to normothermia. It can be achieved by using ice bags, cooling blankets, cold crystalloids intravenous infusion and intravascular automated cooling systems [3]. MHT was demonstrated to exert multi-directional neuroprotective effects. Due to neural cell structural integrity maintenance, inhibition of apoptosis and favorable impact on CNS cells metabolism it slows down set of events which account for post-ischemic brain injury [4].

Based on International Liaison Committee on Resuscitation (ILCOR) and European Resuscitation Council (ERC) guidelines, MHT has been recommended in adults after OHCA due to ventricular fibrillation (VF) with the return of spontaneous circulation (ROSC) [5, 6]. MHT is also recommended in patients after cardiac arrest due to mechanism other than ventricular fibrillation and after in-hospital cardiac arrest [1, 5]. MTH is also applied in patients suffering from traumatic CNS or spinal cord injury, stroke and acute liver failure [7–11]. MTH as a novel and invasive method of treatment that has some adverse effects may still rise concerns. Therefore its use may initially be regarded as controversial. The aim of this study was to present our experience concerning MTH implementation in patients after cardiac arrest admitted to Cardiac Intensive Care Unit (CICU) of Voivodeship Hospital in Kielce, Poland.

## Materials and methods

### Eligibility assessment to MTH

Procedure implementation and patients' qualification to MTH was based on experience from other scientific centres [12]. We used the following inclusion criteria:

- age > 18 years;
- out-of-hospital cardiac arrest due to ventricular fibrillation, pulseless ventricular tachycardia, asystole or pulseless electrical activity (PEA);
- time from cardiac arrest < 4 h;
- 8 or less points in Glasgow Coma Scale (GCS);
- systolic blood pressure > 80 mm Hg without inotropic and vasopressor support.

The exclusion criteria consisted of:

- body temperature measured in urine bladder < 30°C
- advanced concomitant diseases indicating reduced life expectancy (end-stage kidney failure, chronic respiratory failure requiring oxygen therapy, end-stage heart failure, advanced neoplasm, severe hepatic diseases);
- active bleeding;
- any known congenital and acquired bleeding disorder (excl. patients who used anticoagulant agents);
- pregnancy;
- hypoglycemia (glucose < 50 mg/dl);
- other disorders of consciousness.

### MHT management

All the patients were mechanically ventilated via endotracheal tube with intermittent positive pressure ventilation (IPPV). Cooling was initiated with an intravenous infusion of saline at a degree of 4°C. The rate of administration was different among the study group. Sometimes maximal rate of infusion was implemented whereas in other cases saline was injected. A temperature sensor was placed in urine bladder in order to monitor body temperature. All the patients had coronary angiography and percutaneous coronary intervention (PCI), if necessary. In order to perform an intravascular cooling, a triple lumen catheter (diameter 9.3 F and length: 38 or 45 mm) (ICY Intervascular Heat Exchange Kit ZOLL Medical Corp.) was placed in the inferior vena cava via femoral vein shortly after the end of coronary intervention. Cooling was continued on the ward at a maximum rate using intravascular control unit Thermogard XP (ZOLL Medical Corp.). After reaching temperature target level at 33°C the patients were maintained in mild hypothermia for 36 hours [12]. After 36h patients were gradually re-warmed at a rate of 0.1°C/h to reach 36.5°C and then had their body temperature closely monitored. The intravascular control unit was not used longer than 5 days in each patient.

### Concomitant therapy

On admission all the patients were administered loading dose of 2 antiplatelet agents (300 mg of acetylsalicylic acid and 600 mg of clopidogrel), 5000 IU of unfractionated heparin, proton pomp inhibitor and antibiotic (cefuroxime 1.5 g IV every 8 hours), sedatives (midazolam or propofol) and muscle relaxants (atracurium or pipecuronium). The type of analgosedation used was dependant on the accessibility of agents and doctor's on call preferences. During MTH 2 of the following antiplatelet agents were administered at maintenance doses (75 mg QD of acetylsalicylic acid, 75 mg QD of clopidogrel or 90 mg BID of ticagrelor depending on the type of agent used before PCI), proton pomp inhibitor (40 mg q.d. of pantoprazole), antibiotic

(the dose was adjusted to kidney function), sedatives and muscle relaxants in continuous intravenous infusion. Some patients also required fentanyl administration. All the patients were given low molecular weight heparin as a prophylaxis of thromboembolic complications, atorvastatin 80 mg QD; amantadine 200 mg QD and furosemide 20 mg QD. In order to determine the amount and type of replaced fluids a diuresis, central venous pressure and blood pressure was analysed. Inotropic agents (dobutamine, dopamine) and vasopressor (norepinephrine) were applied depending on the hemodynamic state of each patient. After reaching body temperature of 36.0°C the muscle relaxants and then sedatives were discontinued. Parenteral and oral nutrition of patients was started at day 4–5 after normothermia was achieved.

## Patient monitoring

During MTH the following parameters were monitored in patients:

- body temperature assessed by urine bladder sensor;
- pulse;
- blood pressure measured invasively;
- central venous pressure;
- cardiac output (CO) measured invasively by using Vigileo (Edwards Lifesciences);
- oxygen saturation ($SaO_2$);
- a complete blood count, transferase and amylase activity; creatinine, creatinine kinase, and its cardiac isoenzyme levels; sodium, potassium, magnesium, glucose, C-reactive protein (CRP), brain natriuretic peptide (BNP), lipid profile, partial thromboplastin time (aPTT), international normalized ratio (INR), D-dimer values and arterial blood gas.

Electrocardiogram and echocardiography were performed on admission, during next days of hospitalization and in case of deteriorating state of patients. Neurological state was assessed using Rankin scale (0 — no symptoms, 1 — no significant disability, despite some symptoms, 2 — slight disability, 3 — moderate disability, 4 — moderately severe disability, 5 — severe disability) before patient's discharge from hospital [13].

# Results

Between 1 January 2012 and 31 December 2013, 216 patients were hospitalized in CICU due to cardiac arrest. A severe heart failure, respiratory tract diseases, gastrointestinal bleeding, neurological disorders, intoxication, CNS injury were the cause of cardiac arrest in 155 patients (71.76%). In the other 61 patients (28.84%) the main cause of cardiac arrest was acute coronary syndrome (Fig. 1). From the latter group only 13 patients were qualified to MTH (21.3%). Patients did not fulfill eligibility criteria when the following occurred: more than 8 points in GCS,

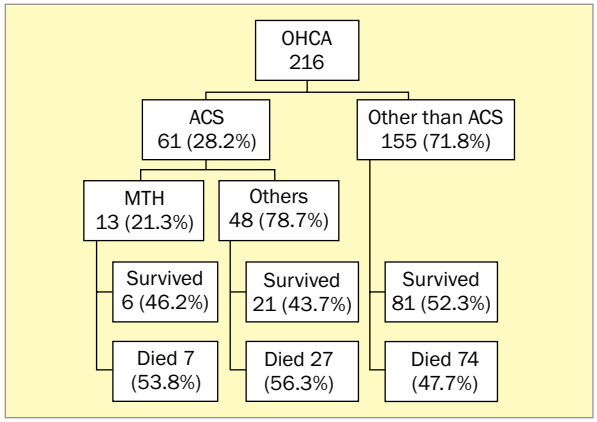


**Figure 1.** Patients after cardiac arrest hospitalized at the time of therapeutic hypothermia recruitment; OHCA — out-of hospital cardiac arrest, ACS — acute coronary syndrome, MTH — mild therapeutic hypothermia

hemodynamic instability requiring catecholamines, severe concomitant diseases with reduced life expectancy, in-hospital cardiac arrest and if the decision of doctor-on-call was negative. Despite the exclusion criteria, 2 patients after in-hospital cardiac arrest were qualified do MTH because we believed it could have improved their prognosis. The study group consisted of 5 women and 8 men. The mean age of patients was 59 years (59.8 years in women and 58.6 years in men). The most common cause of cardiac arrest was malignant ventricular arrhythmia (ventricular fibrillation or ventricular tachycardia). In more than half of the cases the cardiac arrest happened in the presence of medical staff. In all cases cardiac arrest was observed in the presence of a witness who initiated CPR and suspected acute coronary syndrome as a cause of the event. The final diagnosis of myocardial infarction was confirmed in 12/13 patients: 7/13 patients had ST-segment elevation myocardial infarction (STEMI) while in 5/13 a non-ST segment elevation myocardial infarction (NSTEMI) was observed (Table 1). The median time to ROSC was 18 min. After excluding 2 patients with CPR over 1 h, the median time for the study group reduced to 17 min. The median time from cardiac arrest to initial intravenous cooling with a cold saline infusion was 1h and median time from admission to the ward: 15 min. Median time from cardiac arrest to initial intravascular cooling was 3 h 40 min. The target body temperature of 33°C was achieved after 3 h 50 min (median time) from the beginning of the procedure and after 7 h 30 min from the cardiac arrest (median time). Median time from the cardiac arrest to complete re-warming of patients with body temperature of 36.5°C was 75 h 22 min. Median time from the beginning to the end of cooling was 30 h. Median time of intravascular control unit functioning after reaching target body temperature of 36.5°C was 21 h. Median time in patients from cardiac arrest to regaining of

**Table 1.** Clinical characteristics

| Variable | All the patients n = 13 | Patients who survived n = 6 | Patients who died n = 7 |
|---|---|---|---|
| Mean age, years | 59.1 | 53.8 | 63.6 |
| Sex: | | | |
| • female | 5 (38.5%) | 2 (33.3%) | 3 (42.8%) |
| • male | 8 (61.5%) | 4 (66.7%) | 4 (57.1%) |
| Location of cardiac arrest: | | | |
| • home | 6 (46.1%) | 3 (50%) | 3 (42,9%) |
| • hospital/out-patient clinic | 5 (38.5%) | 1 (16.7%) | 4 (47.1%) |
| • ambulance | 2 (15.4%) | 2 (33.3%) | 0 |
| Cardiac arrest mechanism: | | | |
| • VF | 11 (84.6%) | 6 (100%) | 5 (71.4%) |
| • asystole | 2 (15.4%) | 0 | 2 (28.6%) |
| Primary cause: | | | |
| • myocardial infarction | 12 (92.3%) | 6 (100%) | 6 (85.7%) |
| • other | 1 (7.7%) | 0 | 1 (14.3%) |
| Type of ACS: | | | |
| • STEMI | 7 (53.8%) | 4 (66.7%) | 3 (42.9%) |
| • NSTEMI | 5 (38.5%) | 2 (33.3%) | 3 (42.9%) |
| Concomitant diseases: | | | |
| • CAD | 6 (46.1%) | 2 (33.3%) | 4 (47.1%) |
| • HTN | 8 (61.5%) | 3 (50%) | 5 (71.4%) |
| • CKD | 1 (7.7%) | 1 (16.7%) | 0 |
| • DM | 2 (15.4%) | 1 (16.7%) | 1 (14.3%) |
| • stroke in anamnesis | 2 (15.4%) | 1 (16.7%) | 1 (14.3%) |
| • alcoholism | 4 (30.8%) | 3 (50%) | 1 (14.3%) |
| • narcotics | 1 (7.7%) | 1 (16.7%) | 0 |

VF — ventricular tachycardia; ACS — acute coronary syndrome; STEMI — myocardial infarction with ST segment elevation; NSTEMI — myocardial infarction without ST segment elevation; CAD — coronary artery disease; HTN — hypertension; CKD — chronic kidney disease; DM — diabetes mellitus

consciousness was 130 h. Median time from cardiac arrest to patient's discharge from hospital was 574 days, that is 24 days (Table 2). The mean body temperature of patients on admission was 36.3°C. Ten patients were qualified to PCI, in 2 cases we observed disseminated atherosclerotic lesions in coronary arteries that required qualification to CABG. In one patient no atherosclerotic lesions in coronary arteries were noted. During MHT an increase in white blood count, amylase activity and C-reactive protein was observed while hemoglobin level, heart rate and diastolic blood pressure decreased. No changes in other parameters were noted (Table 3, Figure 2). During MHT patients required increased amount of fluids infusion and temporary use of catecholamines (Table 4). Among the adverse effects the following were observed: malignant ventricular arrhythmias (23.1%), upper gastrointestinal bleeding (7.7%), acute stent thrombosis (7.7%), acute kidney failure (7.7%), acute lower limb ischaemia (7.7%). After the end of hypothermia pneumonia (30.8%), sepsis (7.7%) and upper gastrointestinal bleeding (7.7%) occurred. The in-hospital mortality in the study group was 53.8%. In group of patients with fatal outcome we observed a death during cooling due to acute lower limb ischaemia (procedure-related complication) and respiratory failure requiring prolonged mechanical ventilation (68 days). Four patients did not regain consciousness. The in-hospital mortality in patients after cardiac arrest due to acute coronary syndrome that were not qualified to MTH was 56% while in the group with other typical comorbidities the mortality rate was 47.7%. Among the 6 MTH patients who survived, 5 were discharged from hospital without any neurological disorder (0 pts in 4 patients, 1 pt in 1 patient in Rankin scale) and one patient was transferred to neurological rehabilitation centre (3 pts in Rankin scale). In the group of patients who survived the following parameters

**Table 2.** Mean and median time (hours: minutes) from cardiac arrest to next stages of treatment

| Stage of treatment | All the patients n = 13 | Patients who survive n = 6 | Patients who died n = 7 |
|---|---|---|---|
| **ROSC** | | | |
| Mean | 00:24 | 00:27 | 00:21 |
| Median time | 00:18 | 00:19 | 00:13 |
| **Cooling initiation** | | | |
| Mean | 01:11 | 01:00 | 01:20 |
| Median time | 01:00 | 00:58 | 01:25 |
| **Hypothermia catheter** | | | |
| Mean | 03:40 | 03:20 | 03:57 |
| Median time | 03:40 | 03:20 | 03:50 |
| **Target body temperature of 33°C** | | | |
| Mean | 07:30 | 05:50 | 08:50 |
| Median time | 07:30 | 05:00 | 08:22 |
| **Hypothermia catheter removal** | | | |
| Mean | 110:51 | 100:36 | 120:07 |
| Median time | 113:57 | 105:15 | 121:00 |
| **Regaining of consciousness** | | | |
| Mean | 228:00 | 173:00 | 391:00* |
| Median time | 130:25 | 130:25 | 391:00* |
| **Return of spontaneous breathing** | | | |
| Mean | 450:46 | 301:00 | 1345:00** |
| Median time | 259:05 | 136:10 | – |
| **Discharge from hospital** | | | |
| Mean | 870:00 | 666:00 | 1047:00 |
| Median time | 574:36 | 471:24 | 1232:25 |

*2 patients; **1 patient; ROSC – return of spontaneous circulation

were observed: younger age (53.8 vs. 63.6 years), lower incidence of coronary artery disease, more frequent ventricular fibrillation as a cause of cardiac arrest, longer time to ROSC (median time: 19 vs. 13 min), reduced time to initial cold saline infusion (median time 58 vs. 85 min), reduced time from cardiac arrest to intravascular cooling (median time 3 h 20 min vs. 3h 50 min) and reduced hospital stay (median time 471 vs. 1232 h).

## Discussion

Therapeutic hypothermia has become a matter of an interest among clinicians since the publication of guidelines based on multicenter randomized clinical trials [14, 15]. Undoubtedly this attitude is associated with MTH favourable impact on prognosis in patient after OHCA [14–17]. MTH is a novel method and therefore its use and implementation provides many observations and sometimes contradictory conclusions that enrich our knowledge. Based on our preliminary experience with MTH, it has to be stated that

**Table 3.** Mean values of chosen variables in consecutive stages of hypothermia

| Variable | 1st day | 2nd day | 3rd day |
|---|---|---|---|
| HR [$min^{-1}$] | 95 | 78 | 83 |
| MAP [mm Hg] | 90.6 | 88.6 | 88.5 |
| Mean diuresis [mL] | 3009 | 3734 | 2309 |
| Hgb [g/L] | 146 | 142 | 115 |
| Hct | 0.44 | 0.42 | 0.34 |
| PLT [$10^9$/L] | 221 | 186 | 152 |
| White blood count [$10^9$/L] | 15.0 | 15.4 | 13.0 |
| CRP [mg/L]* | 19.5 | 81.2 | 124.7 |
| Amylase [U/L]** | 114 | 385 | 217 |
| Creatinine [mg/dL] | 1.3 | 1.35 | 1.33*** |
| Potassium [mmol/L] | 4.12 | 4.38 | 4.53 |
| pH | 7.2 | 7.3 | 7.4 |

*Amylase – upper limit 108 U/L; **CRP – upper limit 5 mg/L; ***after excluding patient with acute kidney failure; HR – heart rate; MAP – mean arterial pressure; Hgb – hemoglobin; Hct – hematocrit; PLT – platelets; CRP – C-reactive protein

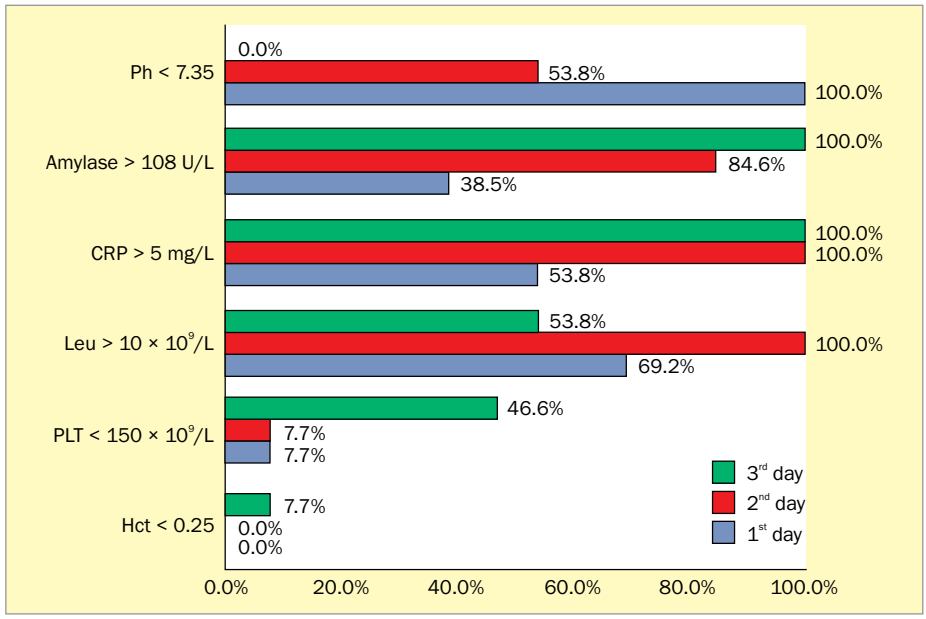


**Figure 2.** Significant deviations in laboratory tests in consecutive days of hypothermia; CRP — C-reactive protein; Leu — white blood count; PLT — platelets; Hct — hematocrit

**Table 4.** Concomitant pharmacotherapy

| Drug | 1st day | 2nd day | 3rd day |
|---|---|---|---|
| Mean fluid intake [mL] | 3707 | 3275 | 3695 |
| Sedation (number of patients) | | | |
| Midazolam | 10 (76.9%) | 9 (69.2%) | 8 (61.5%) |
| Propofol | 3 (23.1%) | 4 (30.1%) | 5 (38.5%) |
| Fentanyl | 3 (23.1%) | 9 (69.2%) | 3 (23.1%) |
| Muscle relaxation (number of patients) | | | |
| *Rocuronium* | 7 (53.8%) | 7 (53.8%) | 7 (53.8%) |
| *Pipecuronium* | 6 (46.1%) | 6 (46.1%) | 6 (46.1%) |
| Catecholamines (number of patients) | | | |
| Dopamine | 4 (30.1%) | 3 (23.1%) | 0 |
| Dobutamine | 1 (7.7%) | 0 | 0 |
| Norepinephrine | 9 (69.2%) | 9 (69.2%) | 7 (53.8%) |
| No catecholamines | 2 (15.4%) | 2 (15.4%) | 5 (38.5%) |

despite its easy implementation associated with automated cooling technology, MTH still requires multidisciplinary approach to patients. There are often many doubts whether to qualify patient or not. The decision about cooling should be made quickly and as early as possible. The decision is not always easy bearing in mind that physician has to do it alone, on a night shift, often not having enough data concerning patient's condition. If patient has normal reflexes and motor response and medical aid was provided shortly after cardiac arrest occurred there is a chance that he/she will quickly regain consciousness and good neurological status after the treatment. Unfortunately such scenario do not happen in all patients after cardiac arrest. Perhaps implementation of hypothermia in this group would improve the rate of successful therapy. After analyzing the study data we found that 8 patients who might have been potential candidates for MTH were not qualified to the procedure due to doctor's on call decision. It happened during

initial implementation of the procedure in our centre. The doubts were mostly associated with patients' neurological status, with often more than 8 pts in GCS which reflected preserved reactions to external stimuli. Those patients, however, required administration of sedatives and muscle relaxants in order to optimize mechanical ventilation and perform invasive procedures or due to respiratory failure. Therefore, we may assume that in majority of cases in this group the use of MHT would not have prolonged the time of sedation and mechanical ventilation, but could have improved the prognosis.

Despite the inclusion criteria we decided to perform MTH in 2 patients after in-hospital cardiac arrest assuming that this treatment might have significantly improved their prognosis. MTH was implemented in young male who had multiple ventricular fibrillations during STEMI and after significantly prolonged CPR. As a result, a complete regain of consciousness without any neurological disorders was noted [18]. On the contrary, in case of a young woman who had no lesions in coronary arteries, MTH did not offer any benefit.

Despite MTH recognition as an improving prognosis treatment initially used external cooling methods caused difficulties and significantly limited the use of this procedure. Over the last few years novel devices have been introduced enabling to precisely control the body temperature by using intravascular cooling. In studies comparing different types of cooling this method has been regarded as significantly better due to easy management, possibility of setting and controlling the desired temperature and control of gradual re-warming process [19]. The use of intravascular cooling requires placement of catheter in the inferior vena cava via femoral vein. In our centre the procedure was performed shortly after coronary angiography or PCI and was not associated with any adverse event. No complications due to catheter implantation were observed. The management of the intravascular cooling device, target body temperature setting, its control and re-warming process were free of any adverse event. In one patient on the first day of cooling an adverse event occurred. It was an acute lower limb ischaemia associated with PCI that required MTH termination. In most of the studies the researchers have emphasized the importance of correlation between MTH efficacy and time to its start from cardiac arrest. The recommended method reducing time to initiation of proper cooling is intravenous infusion of cold saline [20, 21]. However, there have been opinions recently questioning safety and efficacy of this type of treatment. Kim et al. [22] observed in randomized trial that patients who were given 2 litres of cold saline in the post-hospital period more often suffered from another cardiac arrest and pulmonary oedema and required higher doses of diuretics. In addition, faster reduction of body temperature to 34 °C was not associated with the improvement in the prognosis. In our centre we performed initial cooling with cold saline infusion but the amount of fluids was significantly lower (500–700 ml) than in Kim's et al study. We did not observed any negative impact on hemodynamic state of patients. According to our observations those patients who survived had sooner been cooled with cold saline infusion and intravascular cooling device. In addition, due to lower body temperature prior to intravascular cooling, target body temperature was faster achieved in those patients. The data concerning correlation between time to ROSC and MTH effectiveness are controversial. There are some studies suggesting that MTH effectiveness is higher in patients with time to ROSC 3–8 min and worse outcome is associated both with longer and shorter CPR time [23]. Other studies indicate inverse relationship with favorable impact on prognosis in hypothermia patients who had shorter time to ROSC [24].

In our study MTH patients who survived and were discharged home had longer time to ROSC in comparison with patients who died. Data concerning time and course of CPR (gained from families or ambulance crew) are ambiguous and not precise and thus not always can be trustworthy. For this reason many scientists do not include this parameter in the analysis or substitute it with time from first medical contact [21].

In some studies patients' higher body temperature on admission was associated with better MTH effectiveness [19]. In our study no such correlation was found.

In many articles MTH is said to have a favorable impact on late neurological status in patients after cardiac arrest [14, 25]. The time to regain consciousness in patients undergoing cooling is different. According to data it usually exceeds 3 days [26]. There have been reported cases of prolonged coma in patients after CPR who regained consciousness and had good neurological status [27]. MTH is said to alter the anoxic brain injury and prolong time to neurological improvement in patients with anoxic encephalopathy [16, 26]. The additional predictive factors of regaining consciousness and final neurological status are still unknown [26]. The correlation between time to regain consciousness and neurological status on discharge from hospital is regarded important by many authors but it still needs further investigations [26]. In our study time to regain consciousness was circa 7.2 days. Two patients who later regained consciousness died before discharge.

Last year there have been published some articles questioning the efficacy of MTH in patients after OHCA. In FINNRESUSCI study MTH effectiveness was confirmed in patients with ventricular fibrillation or ventricular tachycardia requiring electrical cardioversion. No benefits were observed in patients with asystole or PEA [25]. An intensive discussion started after publication of the results of a Nielsen's et al study. This study showed no differences in mortality and neurological state in patients after OHCA cooled to 33 °C in comparison with patients who had body

temperature of 36°C [28]. Some scientists claim this is an evidence for protective impact of antipyretic treatment in this group of patients [29]. Others emphasize long time from cardiac arrest to initiation of cooling (the inclusion time criteria: 4 h from cardiac arrest to randomization, and 4 h from randomization to target body temperature below 34°C) [30] and very fast re-warming process (6 h from 33°C to 36°C) [31] that could have had a negative impact on the prognosis. In addition, in the vast majority of patients recruited in this study cardiac arrest occurred in the presence of witnesses who immediately started CPR [32]. Currently, study of Nielsen et al. is not regarded as an adequate evidence in favor of terminating MHT in patients after OHCA.

Patients after out-of-hospital cardiac arrest due to STEMI have better prognosis than patients with other common diseases [21]. In addition, fast MHT implementation in patients with ACS, both STEMI and NSTEMI, helps to improve their neurological status but has no impact on 30-day mortality rate [21, 33]. In presented group of patients after OHCA due to ACS treated with MTH there was a slight difference in mortality rate in comparison with patients with ACS with a standard treatment and other than ACS common disease. An objective comparison between those groups cannot be made due to different numbers of people in each group. Small difference in mortality in favor of patients treated with MTH may be caused by initial severe neurological state and poorer prognosis as a consequence. The results could have been influenced by the sample size which was not significant enough to draw statistical conclusions. Particular attention should be paid to the fact that almost all of our patients (5 out of 6) who survived to the discharge remained in good neurological condition. The data concerning adverse events in patients after cardiac arrest due to ACS, treated invasively and with MTH are controversial. There are studies suggesting more pronounced bleeding, thrombotic and infective complications in this group of patients [34, 35]. In our study group we observed one case of acute stent thrombosis that happened shortly after hypothermia initiation. Acute lower limb ischaemia was noted in one patient suffering from lower limb atherosclerosis but the provocative factor could have been associated with femoral artery puncture. Infectious complications were the most common. Moreover, the diagnosis of infection in patients treated with MTH may pose serious problems due to difficulties in controlling body temperature. In addition, elevated CRP level and white blood count are also observed. Some of the noted adverse events such as bleeding or acute kidney failure could have been associated with therapeutic procedures (coronary angiography, PCI, dual antiplatelet therapy) but not with hypothermia.

### Limitations of the study

No evaluation of statistically significant differences between patients who survived and who died was performed.

## Conclusions

All the patients who survived and were treated with MTH were discharged in very good neurological status. The implementation of intravascular cooling device enables precise control of body temperature in patients undergoing the abovementioned procedure.

## Conflict(s) of interest

The authors declare that there are no conflicts of interest.


### Streszczenie

**Wstęp.** Łagodna hipotermia terapeutyczna (MTH) jest obiecującą metodą wspomagającą leczenie chorych po nagłym zatrzymaniu krążenia (NZK).

**Materiał i metody.** W latach 2012–2013 spośród kolejnych 216 chorych po NZK do MTH zakwalifikowano 13 pacjentów. Schładzanie rozpoczynano w chwili przyjęcia wlewem dożylnym soli fizjologicznej o temperaturze 4°C, następnie kontynuowano hipotermię za pomocą zautomatyzowanego systemu wewnątrznaczyniowego.

**Wyniki.** Badaną grupę stanowiło 5 kobiet i 8 mężczyzn (średni wiek 59 lat). Najczęstszym mechanizmem NZK były migotanie komór lub częstoskurcz komorowy w przebiegu zawału serca (92,3%). Średni czas do uzyskania spontanicznego krążenia (ROSC) wynosił 15 min 54 s, a od NZK do rozpoczęcia chłodzenia — 1 h 10 min. Podczas MTH obserwowano zwiększone leukocytozę, aktywności amylazy i stężenie CRP. W szpitalu zmarło 7 chorych (53,8%). Grupę pacjentów, którzy przeżyli, charakteryzowały: młodszy wiek (53,8 *v.* 63,6 roku), rzadszy wywiad choroby niedokrwiennej serca,

częstsze występowanie migotania komór jako mechanizmu NZK, dłuższy czas do ROSC (mediana 19 *v.* 13 min), krótszy czas do rozpoczęcia wlewu zimnej soli fizjologicznej (mediana 58 *v.* 85 min), krótszy czas od NZK do rozpoczęcia chłodzenia śródnaczyniowego (mediana 3 h 20 min *v.* 3 h 50 min) oraz krótszy czas pobytu w szpitalu (mediana 471 *v.* 1232 h). Pięć osób wypisano ze szpitala w bardzo dobrym stanie neurologicznym (4 pacjentów — 0 pkt., 1 pacjent — 1 pkt w skali Rankina).

**Wnioski.** Wszyscy pacjenci, którzy przeżyli, a byli leczeni za pomocą MTH, zostali wypisani w bardzo dobrym stanie neurologicznym. Stosowanie urządzenia do wewnątrznaczyniowego chłodzenia pozwala na precyzyjną kontrolę temperatury u pacjentów poddanych procedurze.

Słowa kluczowe: łagodna hipotermia terapeutyczna, nagłe zatrzymanie krążenia, ostry zespół wieńcowy

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