



Clinical paper

The association of body mass index with time to target temperature and outcomes following post-arrest targeted temperature management[☆]



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ARTICLE INFO

Article history:

Received 19 July 2013

Received in revised form

11 September 2013

Accepted 24 October 2013

Keywords:

Cardiac arrest

Targeted temperature management

Therapeutic hypothermia

Sudden death

Body mass index

Adverse events

ABSTRACT

Background: Evidence suggests that more rapid attainment of target temperature (32–34 °C) improves neurologic outcome following cardiac arrest and targeted temperature management (TTM). It is unclear to what extent body mass index (BMI) is associated with the time to reach target temperature and subsequent clinical outcomes.

Objective: We sought to determine whether the time to target temperature was affected by BMI. In addition, we wished to determine whether the incidence of skin breakdown, survival to discharge and neurologic outcomes were associated with BMI.

Methods: Multicenter retrospective cohort study of cardiac arrest patients who underwent TTM between July 2007 and December 2012. We examined the association between BMI and the time from initiation of cooling to attainment of target temperature (32–34 °C).

Results: Of 236 patients treated with TTM, 184 were included in the study. Mean age was 57.8 ± 17.0 years; 78/184 (42%) were female and 48/184 (26%) had VF/VT as the initial rhythm. Median time to reach target temperature from ROSC was 6.4 (4.1, 9.8) h and median time from initiation of TTM to target temperature was 3.4 (2.1, 5.8) h. Cooling duration was a median of 24.0 (23.0, 24.0) h and median rewarming time was 12.0 (9.5, 18.0) h. Overall, 104/184 (56.5%) achieved target temperature within 4 h and 128/184 (69.6%) within 6 h. Increased BMI was associated with a longer time to achieve target temperature from initiation of TTM ($p=0.01$). There was no significant difference across BMI groups in time to achieve target temperature from ROSC (0.07), skin breakdown ($p=0.35$), survival ($p=0.21$), nor rate of good neurologic outcome ($p=0.32$).

Conclusions: Target temperature was frequently achieved within 4–6 h; as BMI increased, the time to reach target temperature from initiation of TTM was prolonged. There was no significant difference across BMI groups for survival or good neurologic outcome.

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1. Introduction

The induction of Therapeutic Hypothermia or Targeted Temperature Management (TTM) after cardiac arrest has been shown to increase survival to discharge and neurologic recovery.^{1,2} Several

investigations suggest that establishing the desired target temperature (32–34 °C) rapidly may enhance survival.^{3,4} Current protocols in clinical use suggest reaching target temperature as quickly as possible but within 4–6 h.^{5–7} Reaching target temperature within this acceptable window in the obese patient population can be difficult.

Obesity is also a major public health concern in the United States with an estimated 119 million overweight or obese adults.⁸ Obesity has been shown to worsen the outcomes associated with a number of other health conditions including diabetes, musculoskeletal disorders, and cardiovascular disease.^{8,9} Whether obesity has an effect on outcomes in the post-arrest patient population treated with TTM is currently unknown.

[☆] A Spanish translated version of the summary of this article appears as Appendix in the final online version at <http://dx.doi.org/10.1016/j.resuscitation.2013.10.027>.

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In a post-arrest patient cohort treated with TTM, we sought to determine how frequently the target temperature was achieved within 4–6 h and whether the time to target temperature was affected by body mass index (BMI). In addition, we wished to determine whether survival to discharge and neurologic outcomes, as well as adverse events such as skin breakdown from external cooling systems, were associated with BMI.

2. Methods

We performed a retrospective cohort study of post-arrest patients who were treated with TTM at two hospitals within the University of Pennsylvania Health System. This study was approved by the University of Pennsylvania Institutional Review Board.

Post-arrest patients were included in our investigation if they had TTM administered at the Hospital of the University of Pennsylvania (HUP) or the Penn Presbyterian Medical Center (PPMC) between July 2007 and December 2012. Only those patients who achieved Return of Spontaneous Circulation (ROSC) and received a full course of TTM, including the attainment of normothermia after rewarming, were included. Patients were excluded from data analysis if cooling was begun at an outside hospital with no documented date and time of ROSC or TTM initiation, they did not complete TTM, did not reach target temperature, or did not have BMI clearly documented.

The post-arrest TTM protocol employed for patients in this cohort was similar at both institutions. All adult patients who achieved ROSC, regardless of arrest location (in-hospital or out-of-hospital) and regardless of presenting rhythm (ventricular fibrillation, pulseless ventricular tachycardia, pulseless electrical activity, asystole) were eligible to receive TTM. Initiation of TTM was begun as soon as possible following ROSC using an infusion of cold saline and external cooling wraps. Both TTM protocols required all patients to be treated with sedation and paralysis prior to initiation of cooling. The goal to achieve target temperature was within 4–6 h of initiation of ROSC. TTM was maintained for 24 h from the time target temperature was reached, at which point rewarming was initiated at a rate of $0.33\text{ }^{\circ}\text{C h}^{-1}$ until normothermia ($37\text{ }^{\circ}\text{C}$) was attained.

2.1. Body mass index (BMI)

BMI was calculated as weight in kilograms (kg) divided by height in meters squared. Patients were categorized according to the World Health Organization classification as either: underweight ($\leq 18.4\text{ kg m}^{-2}$), normal ($18.5\text{--}25\text{ kg m}^{-2}$), overweight ($25.1\text{--}29.9\text{ kg m}^{-2}$) or obese ($\geq 30\text{ kg m}^{-2}$) based on their documented weight and height. Time from ROSC to attainment of target temperature and time from initiation of cooling to attainment of target temperature were then analyzed in each of the BMI categories, as well as the time from initiation of rewarming to normothermia in each group. Skin breakdown, survival to hospital discharge and survival with good neurologic outcomes were assessed in all groups. Skin breakdown was defined as any documentation in the integumentary section in the medical chart not within normal limits (reddened area through exposure of muscle or bone) from initiation through one day post rewarming. Good neurologic outcome was defined as a Cerebral Performance Category (CPC) of 1 or 2 at hospital discharge.

2.2. Statistical analysis

Data were analyzed using a standard statistical software package (STATA 12, Statacorp, College Station, TX). The Kruskal–Wallis rank test and the Chi-squared test were used

to compare continuous variables and BMI. We used the non-parametric test for trends across ordered groups to examine whether the time to target temperature increased as BMI increased or if outcomes differed as BMI increased.

3. Results

Of the 236 patients treated with TTM following cardiac arrest resuscitation, 184 were included in the study (Table 1). Thirty-six patients were excluded due to missing time data precluding the calculation of time to target temperature, 7 patients were excluded in whom BMI could not be calculated due to a missing height or weight documentation, and 9 patients were excluded because they were already at target temperature at ROSC.

In this TTM-treated cohort, mean age was 57.8 ± 17.0 years; 78/184 (42%) were female and 48/184 (26%) had VF/VT as the initial rhythm. Patient temperatures prior to TTM initiation were $36.2 \pm 1.5\text{ }^{\circ}\text{C}$. TTM initiation began a median of 2.0 (0.6, 4.4) h after ROSC. Median time to reach target temperature from ROSC was 6.4 (4.1, 9.8) h and median time from initiation of TTM to target temperature was 3.4 (2.1, 5.8) h. Cooling duration was a median of 24.0 (23.0, 24.0) h and median rewarming time was 12.0 (9.5, 18.0) h. Overall, 104/184 (56.5%) achieved target temperature within 4 h and 128/184 (69.6%) achieved target temperature within 6 h. Overall survival to discharge was 81/184 (44%). Rates of survival to hospital discharge were indistinguishable when time to target temperature was dichotomized to either 4 or 6 h.

Increasing BMI was not associated with a longer time from ROSC to initiation ($p=0.97$) nor from ROSC to reaching target temperature (0.07). However there was an association with increasing BMI and time from initiation of TTM to achieving target temperature ($p=0.01$). As BMI increased the time to reach target temperature between 4 h ($p=0.07$) and 6 h ($p=0.04$) decreased. However, there was no significant difference in the time required to rewarm across BMI groups ($p=0.84$). There were no statistically significant differences in clinical or demographic data between the BMI subgroups

Table 1

Demographics and clinical data in the TTM cohort ($n=184$).

Mean age, $y \pm$ SD	57.8 \pm 17.0
Gender, n (%)	
Female	78 (42%)
Male	106 (58%)
Location, n (%)	
Out-of-hospital	91 (49.5%)
In-hospital	54 (29%)
^a OSH Tx	38 (21%)
Other	1 (0.5%)
Initial rhythm, n (%)	
VF/VT	48 (25%)
PEA	87 (47%)
Asystole	31 (17%)
Other/unknown	18 (11%)
Time intervals	
ROSC to TTM initiation, h (IQR)	2.0 (0.6, 4.4)
ROSC to target temp, h (IQR)	6.4 (4.1, 9.8)
Initiation to target temp, h (IQR)	3.4 (2.1, 5.8)
Cooling duration, h (IQR)	24.0 (23.0, 24.0)
Rewarming duration, h (IQR)	12.0 (9.5, 18.0)
Outcomes	
Survival to discharge, n (%)	81 (44%)
Target temp. reached within 4 h, n (%)	104 (56.5%)
Target temp. reached within 6 h, n (%)	128 (69.6%)
CPC 1 or 2 (among survivors), n (%)	58 (72%)

TTM, targeted temperature management; y , years; h , hours; IQR, Interquartile range; SD, standard deviation; OSH Tx, Outside hospital transfer; VF/VT, ventricular fibrillation/ventricular tachycardia; PEA, pulseless electrical activity; CPC, cerebral performance category.

^a Of those whose arrest location was coded as 'OSH Tx', all patients were out-of-hospital arrests.

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