MMSL Military Medical Science Letters Since 1925

Mil. Med. Sci. Lett. (Voj. Zdrav. Listy) 2024, 93(1), 29-38
ISSN 2571-113X (Online)
DOI: 10.31482/mmsl.2022.056

ORIGINAL ARTICLE

DEVELOPMENT OF BODY TEMPERATURE AND ITS INFLUENCE ON THE OVERALL OUTCOME IN CRITICALLY ILL PATIENTS IN THE EMERGENCY DEPARTMENT

Jan Sládek [1], Pavlína Rabasová [2] ✉

[1] Department of Intensive Care Medicine, Emergency Medicine and Forensic Medicine, Faculty of Medicine, University of Ostrava, Czech Republic
[2] Department of Health and Social Studies, Faculty of Social Studies, University of Ostrava, Czech Republic

Received 24th September 2022.
Accepted 12th December 2022.
Published 1st March 2024.

Summary

Introduction: Thermoregulation is a complex process in the human body with the ability to maintain a constant optimal body temperature. Biochemical processes of the organism, as well as metabolic processes, are closely correlated with body temperature. Human temperature is determined by several laws, in particular metabolic production and heat flow between the organism and the environment. For the proper functioning of the organs in the human body, it is essential to maintain a constant optimum body temperature. This can be disturbed by inadequate internal and external factors and thermal discomfort can affect the patient's overall outcome. **Aim:** The aim of this study is to evaluate the development of body temperature in critically ill patients in the emergency department and its effect on overall patient outcome. **Design:** Quasi-experiment. **Methods:** Direct observation was performed, including measurement and analysis of body temperature in patients with serious condition in emergency admission. Data were collected in the emergency department of a teaching hospital with a trauma center status between March and December 2021. Statistical tests were evaluated at the level of statistical significance $\alpha=0.05$. **Results:** The study population consisted of 274 (100%) patients. Most negative readings were recorded at the time of patient admission. During the course of treatment, there was a gradual adjustment of body temperature to the physiological limit. The resulting body temperature values were within the desired or expected parameters. In terms of a more detailed description, the most significant values were identified in patients with cardiac problems. **Conclusions:** Knowing the direction of body temperature skew can be considered beneficial. Early correction of pathological values can have a major effect on the overall outcome of the patient.

Key words: thermoregulation; body temperature; emergency admission

Introduction

Although body temperature can be considered an important vital sign, little attention has been paid to its value compared to others (1). In their review article, Dostálová and Dostál (2) state that thermal homeostasis can be

✉ University of Ostrava, Faculty of Social Studies, Department of Health and Social Studies, Českobratrská 16, 702 00 Ostrava, Czech Republic
pavlina.rabasova@osu.cz, pavlina.rabasova@gmail.com

considered a sixth vital sign in humans and should be monitored and treated as intensively as the cardiovascular or respiratory system or the response to acute pain. The issue of thermal comfort has been raised many times in recent years. Unfortunately, it was predominantly in connection with perioperative care in the context of longer-term surgical procedures. Early identification of pathological body temperature values may be crucial in the treatment of critical conditions. Early monitoring can be launched at the moment of admission of the patient to the healthcare facility, namely, in the emergency room. The role of the emergency department is to treat critically ill patients. Critical conditions show the highest sensitivity to fluctuations in body temperature. The combination of a critical condition and a pathological body temperature can create a spiral that negatively affects the prognosis of the patient.

One of the serious conditions that negatively affects the hypothermia of the patient is polytrauma. Hypothermia is part of the so-called lethal triad in this condition. The importance of thermal comfort was recognized by the authors of the study by Vincent-Lambert *et al*. (3), who investigated hypothermia in trauma patients brought to the emergency department by the ambulance service. A second, relatively frequent, serious condition that occurs in the emergency department is stroke. Body temperature in these conditions is an important indicator as it is a definite predictor of prognosis. The issue of body temperature in this group has been investigated by Blanco *et al*. (4), who emphasize that body temperature increases during 72 hours, but the 24 and 48 hour period is absolutely crucial. An elevated body temperature above 37 °C was recorded in 9.4% of patients on admission.

The specifics of care for patients in the emergency department, such as complete undressing of the patient, frequency of diagnostic methods, frequency of consultation examinations, transport, application of infusion solutions, application of transfusion preparations, or application of anesthetics are factors that form an integral part of the care of the seriously ill and can deviate body temperature in one or the other undesirable direction. The effect of transfusion product administration on body temperature was addressed by Poder *et al*. (5), who compared the impact of pressurization on red blood cell hemolysis and patient output temperature when using a heater. The authors conclude that when transfusion is applied at a pressure of 300 mmHg, potential patient hypothermia cannot be avoided. On the other hand, Thongsukh *et al*. (6) investigated the effectiveness of the flow rate of the infusion solution on the heating of the fluid and thus on the outcome of the body temperature value.

From the above findings, it is evident that monitoring body temperature is an essential component in the care of critically ill patients. Monitoring should begin early while the patient is still in the emergency department. However, the question remains whether an initial one-time measurement is sufficient or whether continuous measurement is needed given the interventions that are being performed.

This paper presents the results of research focused on the issue of thermoregulation in critically ill patients in the emergency department and its influence on the course and development of the patient's health status (7).

Aim

The aim of this study is to assess the development of body temperature in patients in serious condition in the emergency department and its influence on overall patient outcome.

Methods

Design

The quasiexperiment was conducted through direct observation and measurement. An observational technique was included to assess the occurrence of selected clinical signs: tremor or shivering, pallor, cold periphery, behavioral disturbance, amnesia, disturbance of consciousness, hallucinations, delirium, sweating and flushed skin. Measurement was the most appropriate method in our research to assess the development of body temperature.

Sample

The study population consisted of patients admitted to the emergency admission hall of a teaching hospital with the status of a trauma center in the Czech Republic. The inclusion criteria for the study were age 18 and older, primary referral, subsequent hospitalization, and a minimum 45-minute length of stay in the emergency admission hall. A total of 358 patients were observed and measured during the study period from the 1st of March to the 31st of December in 2021. The observation and measurement data were recorded on the assessment form. Due to insufficient completion of the documents or the failure to meet the inclusion criteria for the study, 84 assessment forms were discarded. The final sample (n=274) consisted of men and women in a ratio of 170:104; 62.04%:37.96%. The minimum age was 18 years and the maximum age was 96 years, while the mean age was 61 years.

Data Collection

An assessment form was used as the research instrument for data collection, which included data on body temperature, state of consciousness, pulse oximetry, sex, age, diagnosis, emergency admission stay, location of measurement, diagnostics, interventions to achieve normothermia, amount of transfusion products administered, arrhythmia, and occurrence of clinical signs. Body temperature, state of consciousness, and pulse oximetry values were analyzed and recorded in the assessment form at ten-minute intervals. The study was carried out with the written consent of the relevant health care facility.

Data Analysis

Data from completed forms were coded and tabulated in MS Excel. Subsequently, the data were analyzed using NCSS statistical software. Furthermore, the data were processed using descriptive statistics (absolute and relative frequency, arithmetic mean, median, standard deviation, maximum and minimum values). Nonparametric Spearman's coefficient, two-sample Mann-Whitney test, and nonparametric Kruskal-Wallis analysis of variance (ANOVA) tests were used for bivariate data analysis. Statistical tests were evaluated at the level of statistical significance $\alpha=0.05$.

Results and Discussion

In the total cohort of 272 (99.27%) cases, body temperature was monitored by axillary monitoring. Esophageal and rectal measurements were taken in 1 case (0.39%). Monitoring body temperature using the axillary method can be considered as the least appropriate in the hierarchy of options, but it is crucial for emergency admission. Individual methods may present specificities that may not be acceptable or feasible for emergency admission in terms of time and labor. Body temperature was measured at ten-minute intervals and the results are presented as initial values, values after thirty, sixty and ninety minutes of treatment, and final values.

There were 42 (15.33%) patients in the hypothermia zone or below the cutoff point of 35.0 °C. A total of 124 (45.26%) patients were in the range of 35.0 and 36.0 °C. The lowest mean body temperature on admission was 35.8 °C. Average body temperature values tended to increase during the course of treatment, which can be considered a positive phenomenon. When the patients were transferred from the emergency room, the mean body temperature amounted to 36.1 °C. The lowest minimum body temperature value was identified on admission (26.5 °C). The minimum body temperature values also showed an increasing trend. At the time of patient transfer, the minimum body temperature was 29.3 °C. Twelve (4.38%) patients were identified in the range above 37.5 °C. On admission, the maximum body temperature was recorded at 40.5 °C. The maximum values were decreasing in nature, which may be attributed to pharmacological intervention. The most significant correlation is evident between the initial and final temperature ($r=0.894137$; $p<0.001$). This correlation is positive and quite strong, thus it can be assumed that there is a statistically significant difference in the body temperature values of the patient on admission to the emergency admission hall, during the course of treatment and on transfer (Table 1). Initial body temperature measurement can be considered beneficial, as the parameters can serve as a predictor of the evolution of the clinical condition. This aspect was also investigated in the study by Erkens et al. (8), who evaluated admission body temperature in patients in the intensive care unit as an independent predictor. Of the 6 514 patients, 1 036 (16%) were in the hypothermia zone (<36 °C). 4 617 (71%) patients were in the physiological range. There were 861 (13 %) patients in the hyperthermia range (> 37.5 °C). The study showed that monitoring of body temperature on admission to the intensive care unit is clearly useful as it may be a predictor of mortality. Any variation of 1 °C or more is undesirable and associated with a higher risk of mortality regardless of the direction of the deviation.

Table 1. Development of body temperature in critically ill patients in the emergency department.

Time intervals	Baseline BT	BT in 30 min.	BT in 60 min.	BT in 90 min.	Endpoint BT
average values BT °C	35.8	35.9	36.0	36.1	36.1
minimum values BT °C	26.5	26.6	27.5	28.0	29.3
maximum values BT °C	40.5	39.4	39.2	38.9	38.5
p-value*			p<0.001		
rSp**			0.894137		

Legend: *p < 0.05; rSp** – Spearman Correlation Coefficient; BT – body temperature; °C – degree Celsius; min. – minute.

It is generally known that the elderly are much more susceptible to extreme temperatures. Blatteis (9) in his review article states that numerous epidemiological studies have shown a difference in body temperature values depending on age. Both men and women over the age of 60-65 generally have a lower body temperature than their younger counterparts. Of course, many variables need to be taken into account. However, the authors report that there is a 0.4 °C temperature difference between adult (20-64 years) and geriatric patients (65-95 years), which is considered a statistically significant difference, but negligible from a physiological point of view. In our research, substantially the opposite has been shown. The correlation of each temperature measurement with age was relatively small, close to zero, as assessed by large p-values (>0.05). The mean body temperature for both men and women on admission was 35.8 °C (r=0.033327; p>0.582). Body temperature values increased slightly during the course of treatment, but were identical in both categories. The endpoint body temperature value in both categories was 36.1 °C (r=-0.09113; p>0.132). In our study, there were no differences in body temperature values in patients with severe disease depending on age. Therefore, the results show that there is no significant relationship between age and body temperature.

It is believed that gender is one of many factors that can influence the development of body temperature. The relationship between body temperature and gender was also addressed in a unicentric observational study by Obare Pyszková *et al*. (10), which examined the aforementioned relationship in patients in the perioperative period. In the study, there was no significant relationship between body temperature change and gender. The same result was identified in our research. The mean body temperature in both men and women on admission was 35.8 °C (p>0.974). During the course of treatment, body temperature values increased slightly in both sexes, but were identical in both categories. The endpoint mean body temperature value in both categories was 36.1 °C (p>0.222). Therefore, in our study, there was no significant relationship between gender and body temperature in patients in serious condition at the time of emergency admission.

In terms of the spectrum of patients, trauma diagnoses made up the largest diagnostic group (n-100; 36.50%). Patients with neurological and neurosurgical diagnoses formed the second largest spectrum (n-89; 32.48%). A less numerous but significant spectrum included internal medicine diagnoses (n-38; 13.87%) and cardiac diagnoses, together with cardiac surgery (n-33; 12.04%). COVID diagnoses comprised 11 cases (4.01%), and the "other" spectrum comprised 3 cases (1.09%). Predicting trends in body temperature based on the primary condition is an important aspect of patient care, especially in the adjustment of interventions to reinforce positive direction for the overall outcome of the patient. In severe conditions, this aspect can be crucial. Even the study by Erkens *et al.* (8) showed that hypothermia is a strong predictor of adverse events in patients with heart failure and acute coronary syndrome (ACS). It is hypothermia that has been negatively associated with ACS. In our research, cardiac and cardiac surgery diagnoses were also confronted with pathological body temperature values. The mean body temperature on admission was 35.6 °C in this segment of diagnoses. The minimum value of body temperature at the initial measurement was recorded at 27.2 °C. The 36.0 °C threshold was not exceeded throughout the treatment. The trauma segment of the diagnoses showed an increasing trend of body temperature in our study. Although these were only minor changes, this phenomenon can be considered positive. The lowest body temperature in the traumatology section was 32.1 °C. The lowest median body temperature value was identified at patient admission and reached 36.2 °C, which can be considered very good. After 30 minutes of treatment, the temperature increased by 0.1 °C. Throughout the course of the treatment of trauma patients, there was no decrease in body temperature below the admission median values, on the contrary, they showed an increasing trend. The evolution of body temperature in trauma patients was also investigated by Vincent-Lambert *et al*. (3). The study aimed to analyze body temperature in trauma patients brought to the emergency department. Body temperature was measured on admission and after thirty minutes of treatment. The study results concluded that 65% of the patients in the immediate priority group had a body temperature below 36.0 °C. A drop in body temperature below 34 °C was associated with a higher incidence of post-traumatic complications. Body temperature below 32 °C was associated with higher mortality. The study also showed that 20.7% of the patients were admitted clinically hypothermic (<35 °C). Body temperature below 34 °C occurred in 10% of the patients. The fact that 56% of the patients had a body temperature below 36 °C after 30 minutes of treatment can be considered a rather significant factor. It is also worth highlighting that 28 % of the patients did not exceed 35 °C. In the context of neurological issues, strokes are worth mentioning as they constitute a large group and body temperature is a significant factor. This issue was investigated by Blanco *et al*. (4), who monitored body temperature on admission every 6 hours for 72 hours. High body temperature >37°C was established in 9.4% of patients on admission. The percentage of patients with high body temperature increased significantly over time. During a 24-hour period, high body temperature occurred in 22.9% of the cases.

Within 72 hours, 33.3% of the patients were involved. Poor health outcomes were seen in 38.14% of the patients. Patients with poor outcomes had higher values in all follow-up periods. Patients with low body temperature <36.0°C on admission were associated with a better outcome at 3 months. Body temperature can be concluded to increase over the 72-hour period, but the 24- and 48-hour periods are pivotal. In our research, strokes were included in the section on neurological and neurosurgical diagnoses. The lowest body temperature in this segment was 32.0 °C. The median body temperature on admission was 36.0 °C. During the course of treatment, the values did not deviate toward pathological ranges, which can be perceived positively. Most of the diagnoses we observed had rather fluctuating body temperatures, however, it should be said that these were not significant fluctuations. It can be considered a very positive finding that no significant hypothermia was identified in the median values in any segment of the diagnoses. A second positive finding can be considered in the fact that there was no significant leap in the hypothermia or hyperthermia range during treatment or during transfer. The highest median body temperature value of 37.5 °C on patient admission can be seen in the diagnosis of COVID and in the "other" segment. Elevated body temperature is expected in patients with COVID. Additionally, a pharmacological intervention is expected as there is a decrease in temperature. Physical cooling was not used in these patients. The "other" segment of diagnoses included acute cystitis and renal disease of nonspecific etiology. On the basis of these diseases, a potential inflammatory process and therefore elevated body temperature values are suggested. In all segments studied, the p-values were less than the significance level ($p<0.05$). Therefore, there is a significant relationship between body temperature and the primary condition (Table 2).

Table 2. Development of body temperature in patients depending on primary disability (primary diagnosis).

Diagnosis	Baseline BT	BT in 30 min.	BT in 60 min.	BT in 90 min.	Endpoint BT
DHK 1 - median BT °C	36.3	36.3	36.3	36.4	36.2
DHK 2 - median BT °C	35.6	35.7	35.5	35.9	35.6
DHK 3 - median BT °C	36.2	36.3	36.4	36.5	36.5
DHK 4 - median BT °C	36.0	36.0	36.1	36.3	36.1
DHK 5 - median BT °C	37.5	37.5	37.3	36.1	36.9
DHK 6 - median BT °C	37.5	38.0	38.0	37.6	38.0
p-value*[a]	0.000	0.000	0.000	0.009	0.000

Legend: *$p < 0.05$; [a] Kruskall-Wallis test; DHK – diagnosis hospitalization category; BT – body temperature; °C – degree Celsius; min. – minute; DHK 1 – internal diagnoses; DHK 2 – cardiology and cardiac surgery diagnoses; DHK 3 – trauma diagnoses; DHK 4 – neurology and neurosurgery diagnoses; DHK 5 – COVID diagnosis and DHK 6 – other.

Ševčík *et al*. (11) reported that as body temperature decreases, the hemoglobin dissociation curve shifts to the left. This phenomenon results in impaired oxygen delivery to tissues, and hence tissue hypoxia. It can also be assumed that patients receiving artificial pulmonary ventilation may have significantly lower body temperature values than spontaneously ventilated patients. Muscle shivering, as an important factor in maintaining spontaneous thermogenesis, is already increased initially in the zone of mild hypothermia. However, in patients with artificial pulmonary ventilation, this factor can be precluded by muscle relaxation. In terms of ventilation, 220 patients (80.29%) were spontaneously ventilated in our study. The median body temperature in spontaneously ventilated patients on admission to the emergency admission hall was 36.2 °C. During the course of treatment, body temperature showed a predominantly increasing trend. Controlled ventilation patients (n-49; 17.88%) were in the hypothermia range of 34.9 °C on admission. During the course of treatment, body temperature showed a fluctuating pattern. The endpoint body temperature was 35.1 °C. The transition from spontaneous to controlled ventilation was made in only 5 cases (1.82 %). The median body temperature on admission in this group was 34.9 °C, while the endpoint body temperature was 35.3 °C. Some fluctuations were observed during the course of treatment. There was a decrease of 0.5 °C at 90 min. However, upon transfer, the values were at the original levels. Clearly, p-values equaling zero showed a significant relationship between body temperature and ventilation mode (Table 3).

Table 3. Development of body temperature depending on the ventilation method.

	Baseline BT vs. VENT	BT in 30 min. vs. VENT	BT in 60 min. vs. VENT	BT in 90 min. vs. VENT	Endpoint BT vs. VENT
Median BT °C - spont.	36.2	36.3	36.4	36.5	36.4
Median BT °C - UPV	34.9	35.0	35.1	35.6	35.1
Median BT °C - SV/UPV	34.9	35.0	35.3	34.8	35.3
p-value*[a]	0.000	0.000	0.000	0.000	0.000

Legend: *p < 0.05; [a] Kruskall-Wallis test; VENT – ventilation; BT – body temperature; °C – degree Celsius; min. – minute; spont. – spontaneous ventilation; UPV – artificial pulmonary ventilation; SV/UPV – transition from spontaneous ventilation to artificial pulmonary ventilation.

Data on the effect of anesthetics on the development of body temperature are quite robust in our research. Anesthetics were administered in 59 cases (21.53%). The mean body temperature of patients without anesthetics on admission was in the temperature range of 36.1 °C. The body temperature of these patients was increasing, but the changes were in the order of tenths. However, patients with anesthetics applied or under sedation showed more variable parameters. The initial mean body temperature was in the hypothermia range of 34.8 °C. Overall, body temperature values increased in each time section, with minor changes in the order of tenths up to 60 minutes of treatment, but a leap of 0.4 °C was observed at 90 minutes. The mean endpoint body temperature was 35.3 °C. Thus, it can be concluded that sedated patients were below the physiological norm while in the emergency room. In our study, there was a relationship between body temperature and administered anesthetics (p<0.05) (Table 4). A similar issue is also addressed by Dostálová and Dostál (2) in their review article. The authors report that the decrease in body temperature occurs after the introduction to general anesthesia, in three phases. The most pronounced decrease occurs in the first 30 minutes. This is a consequence of vasodilatation and a change in the threshold for vasoconstriction in the hypothalamus. A linear decline occurs about 1 hour after the onset as a result of the relationship between heat loss and heat production. The plateau phase occurs within 3-5 hours after the equilibrium between loss and heat production is established. Furthermore, the authors report that in approximately 60% of patients, the body temperature falls slightly below 36 °C. Approximately 20 % of patients have a body temperature slightly below. 35,5 °C. In 10 % of cases, a fall below 35 °C is observed.

Table 4. Development of body temperature based on sedation.

	Baseline BT vs. ANES	BT in 30 min. vs. ANES	BT in 60 min. vs. ANES	BT in 90 min. vs. ANES	Endpoint BT vs. ANES
mean value BT °C - ANES 1	34.8	34.9	35.0	35.4	35.3
mean value BT °C - ANES 2	36.1	36.2	36.3	36.4	36.3
p-value*[b]	0.000	0.000	0.000	0.000	0.000

Legend: *p < 0.05; [b] Mann-Whitney U test; ANES – anesthetics; BT – body temperature; °C – degrees Celsius; min. – minute; ANES 1 – patients with anesthetics; ANES 2 – patients without anesthetics.

During the course of treatment, the patient is subjected to various diagnostic methods in the emergency room. Therefore, in our research, attention was also paid to the evolution of body temperature in critically ill patients in the emergency department in relation to the frequency of diagnostic imaging methods. CT scans were performed in 197 cases (71.90%) and X-ray examinations in 199 cases (72.63%). Sonographic examination was performed in 16 cases and echocardiographic examination was performed in 40 cases (14.60%). One diagnostic method was indicated in 103 (37.60%) patients, two diagnostic methods were indicated in 141 (51.46%) patients, 21 (7.67%) patients underwent three imaging methods and 1 (0.36%) patient underwent four imaging methods. Patients undergoing 3-4 diagnostic methods had the lowest mean body temperature (35.2 °C). Patients with two imaging methods had body temperature values slightly below the physiological range (35.9 °C). There was no significant fluctuation in body temperature during diagnostic procedures.

In our research, the development of body temperature was also monitored in relation to the application of interventions to ensure normothermia. The results show a relationship between body temperature and the interventions applied (Table 5). The dynamics of body temperature can be influenced by certain factors. Interventions to ensure normothermia clearly belong to these factors. Anticipating or knowing the effect of these interventions can be considered indispensable. Interventions have been classified into four categories (Table 5). The first category included patients in whom no intervention was performed to achieve normothermia. The second category represented patients whose normothermia was achieved by administering warming. Patients who received application of warm infusion solution fell into the third category. The last category was a combination of the previous forms, that is, simultaneous administration of warming and application of the warm infusion solution. Of the 274 (100%) patients, 183 (66.79%) were without intervention. In 52 (18.98%) patients, the intervention was done only by heating. Separate application of warm infusion solution was performed in 4 (1.46%) patients. On the other hand, the last category included 35 (12.77%) patients. The results showed that the patients who did not receive any intervention were within the physiological range. The initial mean body temperature was 36.1 °C. There was no drop below this value throughout the treatment period and the increase in body temperature was gradual. The difference between the input and output values was 0.2 °C. The second category showed more varied values. In this segment, the average input body temperature was 35.8 °C. Body temperature increased during the course of the treatment. At 60 minutes after admission, the body temperature was 36.0 °C. The difference between the input and output body temperature was 0.4 °C. The intervention with a warm infusion solution, or the third segment, showed relatively similar values. The mean value of the initial body temperature was 35.3 °C. At 60 min after admission, the body temperature value was 36.0 °C. Thereafter, there was a negligible decrease, but the mean body temperature at the endpoint was 35.9 °C. The last category (administration of rewarming and warm infusion solution) ranged more radically. The baseline mean body temperature was 34.1 °C, with the highest value recorded 90 minutes after admission (35.1 °C). The endpoint body temperature value was 35.0 °C. The difference between the baseline and endpoint values was 0.9 °C. Knowing or predicting how body temperature will evolve in specific cases or at specific times of treatment can be considered a useful preventive benefit. On the other hand, it is necessary to know how specific interventions work to ensure normothermia. The effectiveness of warming the body through intravenous fluid application was investigated by Thongsukh *et al*. (6). The solution was applied at several speed levels through a heater with a set temperature of 42 °C. The results of the study showed that flow velocity had an effect on the heating efficiency outcome, however, all flow velocities exceeded the so-called effective warming threshold. The importance of thermal comfort was also recognized by Watts *et al*. (12), who investigated the effectiveness of warming in prehospital care. Thermal comfort was controlled by several schemes, namely cotton sheet or blanket, heat pack, and intravenous fluid administration.

Table 5. Development of body temperature based on the administration of interventions aimed to ensure normothermia.

Intervention	Baseline BT vs. OTIR	BT at 60 min. vs. OTIR	Endpoint BT vs. OTIR
1 – no intervention (mean value BT °C)	36.1	36.3	36.3
2 – heating administered (mean value BT °C)	35.8	36.0	36.2
3 – warm infusion administered (mean value BT °C)	35.3	36.0	35.9
4 – heating and warm infusion administered (mean value BT °C)	34.1	34.7	35.0
p-value*[b]	0.000	0.002	0.031

Legend: *$p < 0.05$; [b] Mann-Whitney U test; BT – body temperature; °C – degrees Celsius; min. – minute; OTIR – heating and warm infusion (intervention).

The first position in terms of efficacy was clearly occupied by the heat pack, which increased body temperature by 0.8 °C during transport. The other techniques showed a decrease in temperature. On the other hand, our study showed that the combination of warming and the administration of a warm infusion solution was the most effective alternative. This technique increased body temperature by 0.9 °C. Administration of a warm infusion solution alone increased body temperature by 0.6 °C. Administration of warming alone increased the temperature by 0.4 °C. From these results it is quite clear which method is the most effective. It is worth saying that neither method showed a significant decrease in body temperature after a certain period of time.

Statistical significance was also demonstrated in our study between the incidence of heart rhythm disturbances and pathological body temperature (Table 6). The lowest initial body temperature value of 35.3 °C was recorded in patients with heart rhythm disorder. On the contrary, the highest value of 36.4 °C was recorded in patients without pathological body temperature. Patients with heart rhythm disorder showed fluctuating values during the course of treatment, which did not exceed 36.0 °C during the treatment period. In contrast, patients with pathological values of body temperature without heart rhythm disturbance had relatively more stable and increasing values ≥36.0 °C. Heart rhythm disturbances are one of many adverse events in pathological temperature fluctuations, but can be fatal. It is generally known that heart rate decreases as body temperature decreases. Saigal *et al*. (13) reported that sinus bradycardia occurs when body temperature falls below 35.5 °C. Ventricular tachycardia or ventricular fibrillation can develop when the temperature drops below 28 °C. Therefore, the body temperature should be maintained above 30 °C, as the effectiveness of drugs and defibrillation decreases below this value.

Table 6. Incidence of heart rhythm disturbances at respective BT values.

	Baseline BT vs. Arrhythmia	BT in 30 min. vs. Arrhythmia	BT in 60 min. vs. Arrhythmia	BT in 90 min. vs. Arrhythmia	Endpoint BT vs. Arrhythmia
mean value BT °C-A1	35.3	35.4	35.3	35.6	35.3
mean value BT °C-A2	35.7	35.8	36.1	36.2	36.1
mean value BT °C-A3	36.4	36.4	36.5	36.5	36.5
p-value*[a]	0.000	0.000	0.000	0.0011	0.000

Legend: *$p < 0.05$; [a] Kruskall-Wallis test; BT – body temperature; °C – degrees Celsius; A1 – identified arrhythmia at pathological BT value; A2 – no arrhythmia at pathological BT value; A3 – without pathological BT value

Body temperature affects many areas of the human body functioning and, in terms of vitality, the state of consciousness at the level of the central nervous system should also be taken into account. Initially, mild hypothermia is associated with confusion and sometimes amnesia. Paradoxical undressing, dysarthria, and progression of impaired consciousness occur as hypothermia deepens. Loss of consciousness occurs at the 30 °C threshold. In our study, 194 (70.80%) patients were conscious on admission with a mean body temperature on admission of 36.2 °C. Impaired consciousness in the form of somnolence was present in 18 (6.57%) patients with a mean body temperature of 35.2 °C. Sopor was present in 12 (4.38%) patients with a mean body temperature of 34.8 °C. Unconsciousness was recorded in 8 (2.92%) patients with a mean body temperature of 33.4 °C. Sedation occurred in 42 (15.33%) patients with a mean body temperature of 35.1 °C. On the other hand, 192 (70.07%) patients were alert at the time of transfer from the emergency admission room. Twenty (7.30%) patients were in a somnolent state. A soporific state occurred in 6 (2.19%) patients. A fall in body temperature was observed in 4 patients (1.46%) in the unconscious section. The sedated group of 52 (18.98%) patients experienced an increase in body temperature. The state of consciousness and body temperature were compared at the same time interval. Therefore, the results of our study (Table 7) clearly show a dependence between body temperature and state of consciousness.

Table 7. Relationship between impaired consciousness and BT value.

	Baseline BT vs. Baseline consciousness	BT at 30 min. vs. Consciousness at 30 min.	BT at 60 min. vs. Consciousness at 60 min.	BT at 90 min. vs. Consciousness at 90 min.	Endpoint BT vs. Endpoint consciousness
n – number	274	274	249	146	274
p-value*	0	0	0	0	0
rSp**	-0.3905	-0.4181	-0.4516	-0.4036	-0.4469

Legend: *$p < 0.05$; rSp** – Spearman correlation coefficient; BT – body temperature.

The presence of clinical signs is an indispensable indicator of the patient's health status. It is the presence of clinical signs associated with hypothermia or hyperthermia that was evaluated in our study in patients in the initial minutes after admission to the emergency room. Of the total cohort, patients who did not show any clinical signs constituted the largest group (Table 8). This segment comprised 137 (50%) patients. In terms of clinical characteristics, only 4 characteristics exceeded the threshold of 20 occurrences, namely cold periphery, impaired consciousness, pallor, and tremor. Sweating, amnesia, behavioral disturbance, and flushed skin occurred in much smaller numbers. On the contrary, hallucinations and delirium did not occur in any patient. Saigal *et al*. (13) reported that tremor starts at 35.5 °C. In addition, Ševčík *et al*. (11) confirmed that muscle tremor is increased in the mild hypothermia zone. In our research, shivering was recorded in 34 cases (12.41%) with an average body temperature of 36.1 °C. Ševčík *et al*. (11) further state that loss of consciousness occurs at temperatures below 30 °C. In our results, impaired consciousness was recorded in 33 patients (12.04%). The mean value of body temperature was 34.9 °C, but it should be noted that this factor may be influenced by the primary condition of the patient. Ševčík *et al*. (11) also report that in mild hypothermia, the patient presents with cool white skin. In our study, the cold periphery occurred in 79 patients (28.33%) with a mean value of 34.8 °C. Pallor was identified in 21 cases (7.66%) with a mean body temperature of 35.3 °C.

Table 8. Presence of clinical signs at the initial assessment of body temperature.

Signs	Baseline BT °C	n	n%	p-value*	rSp**
tremor	36.1	34	12.41	0.194	-0.0786
pallor	35.3	21	7.66	0.847	-0.0116
cold periphery	34.8	79	28.33	0*	0.4167
behavioral disturbance	37.0	4	1.46	0.014*	-0.1477
amnesia	35.8	7	2.55	0.641	0,0282
disturbance of consciousness	34.9	33	12.04	0.114	0.0955
hallucinations	–	0	0.00	1	0
delirium	–	0	0.00	1	0
sweating	36.9	8	2.92	0.208	-0.0762
flushed skin	27.3	1	0.36	0.088	0.1030
no signs	36.1	137	50.00	0.001*	-0.1960

Legend: *p < 0.05; rSp** – Spearman correlation coefficient; BT – body temperature; n – number, n% – relative frequency; BT – body temperature; °C – degree Celsius.

The results of our study clearly confirm the importance of not only the initial assessment of body temperature in critically ill patients, but also its continuous measurement throughout the treatment in the emergency department. The association of body temperature with both exogenous and endogenous factors significantly influences the outcome of indispensable physiological functions, which in turn can affect the overall health outcome.

Conclusion

The results of our research show that the dynamics of body temperature in critically ill patients in the emergency department are very diverse and its values can significantly influence the course of care in the context of the choice of medical therapeutic and nursing interventions. Knowing the direction of body temperature deviation can be considered very beneficial, as in certain cases hypothermia or hyperthermia can have a negative impact on the prognosis of the patient. Early correction of pathological values can have a pivotal effect on the overall outcome of the patient.

Authors' declaration of potential conflict of interest

The authors have no conflict of interest.

Adherence to Ethical Standards

This article contains only anonymous data. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Bibliography and references

1. Nakajima Y. Controversies in the temperature management of critically ill patients. Journal of Anesthesia. 2016;30(5):873-883.
2. Dostálová V, Dostál P. Perioperative Hypotermia in Elective Therapeutical and Diagnostic Procedures. Anesteziologie. 2015; 26(1):8-16.
3. Vincent-Lambert C, Smith CM, Goldstein LN. Hypothermia in trauma patients arriving at an emergency department by ambulance in Johannesburg, South Africa: a prospective study. Pan African Medical Journal. 2018;31:136.
4. Blanco M, Campos F, Rodríguez-Yáñez M, et al. Neuroprotection or Increased Brain Damage Mediated by Temperature in Stroke Is Time Dependent. PLoS ONE. 2012;7(2): e30700.
5. Poder TG, Pruneau D, Dorval J, et al. Pressure Infusion Cuff and Blood Warmer during Massive Transfusion: An Experimental Study About Hemolysis and Hypothermia. PLOS ONE. 2016;11(10): e0163429.
6. Thongsukh V, Kositratana Ch, Jandonpai A. Effect of Fluid Flow Rate on Efficacy of Fluid Warmer: An *In Vitro* Experimental Study. Anesthesiology Research and Practice. 2018;2018:8792125.
7. Sládek J. Importance of thermoregulation in patients on emergency admission. Ostrava, 2022. Master Thesis. University of Ostrava. Faculty of Medicine Department of Intensive Medicine, Emergency Medicine and Forensic Studies. Thesis supervisor: Pavlína Rabasová.
8. Erkens R, Wernly B, Masyuk M, et al. Admission Body Temperature in Critically Ill Patients as an Independent Risk Predictor for Overall Outcome. Medical Principles and Practice. 2020;29(4):389-395.
9. Blatteis CM. Age-Dependent Changes in Temperature Regulation - A Mini Review. Gerontology. 2011;58(4):289-295.
10. Obare Pyszková L, Nevtípilová M, Žáčková D, et al. Incidence of Peri-operative Hypothermia -- A Unicentric, Sbservational study. Anesteziologie a Intenzivní Medicína. 2014;25(4):267-273.
11. Ševčík P, et al. Intensive medicine. 3rd revised and expanded edition Prague: Galén;2014.
12. Watts DD, Roche M, Tricarico R, et al. The utility of traditional prehospital interventions in maintaining thermostasis. Prehospital Emergency Care. 1999;3(2):115-122.
13. Saigal S, Sharma JP, Dhurwe R, et al. Targeted temperature management: Current evidence and practices in critical care. Indian Journal of Critical Care Medicine. 2015;19(9):537-546.