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ACCIDENTAL HYPOTHERMIA AND RELATED FACTORS AMONG BURNED PATIENTS

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ABSTRACT

INTRODUCTION: Early diagnosis, control and management of hypothermia are decisive in the outcome of burns. Various factors play a role in creating or aggravating accidental hypothermia in these patients. This study was conducted with the aim of determining accidental hypothermia prevalence and related factors among burned patients referred to Shahid Motahhari Hospital in Tehran, Iran in 2021.

MATERIAL AND METHODS: In this prospective observational study, 151 burn patients who were transferred to the emergency department by EMS were selected through available sampling from February 2021 to August 2021. Data was collected and recorded in three areas (pre-hospital, emergency ward, and burn center) through observation and interview of patients and their relations and review of records from admission to discharge. The ambient temperature and core body temperature (CBT) of the patients was measured by a calibrated tympanic thermometer at the time of arrival. Individual, clinical, environmental, and care variables were investigated as factors related to hypothermia. The research data were analyzed using descriptive and inferential statistics such as Pearson correlation, chi-score, and multiple linear regression by SPSS software version 22. A significance level of less than 0.05 was considered.

RESULTS: Forty-seven percent of patients had a CBT of less than 36 degrees Celsius at arrival. Through multiple linear regression, 15 independent variables were entered with the backward model. Only the kind of airway management ($\beta = -0.296$, $p < 0.001$), and volume of fluids received ($\beta = 0.144$, $p = 0.082$) were as predicting factors for accidental hypothermia in burn patients.

CONCLUSIONS: About half of the patients were hypothermic at the time of admission. Optimizing care in pre-hospital and burn departments and empowering the healthcare team in the assessment of burn patients, and early detection, prevention, and proper management of accidental hypothermia are highly expected.

KEY WORDS: accidental hypothermia; burn; pre-hospital care; core body temperature (CBT); risk factors; Iran

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INTRODUCTION

With an incidence of 9 million and a prevalence of 90 million cases in 2017, burns are considered one of the most frequent incidents worldwide [1]. Due to the high prevalence of burns and their unpleasant consequences, costs, and association with high mortality, care measures should be based on preventing burns and their resultant complications [2, 3].

One of the common complications of burns is hypothermia caused due to extensive skin damage. Various studies have reported the prevalence of hypothermia between 34 and 79.2% [3–7]. These patients become hypothermic during transfer to the

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burn center or during wound care [2]. Hypothermia is expected to be associated with increased mortality and unpleasant consequences, but the evidence is limited in this regard [3].

Hypothermia is classified into two types: therapeutic and accidental [8]. Accidental hypothermia generally refers to the reduction of CBT to less than 35 [9]. In patients with burns and skin tissue damage, a temperature of less than 36°C in some studies [10–13] and less than 36.5°C in others has been defined as hypothermia [5, 14]. Hypothermia or CBT below 36°C can lead to dangerous complications for burn patients [15]. Hypothermia is physiologically known as hemodynamic instability, suppression of the immune system, mild metabolism of drugs [4], and homeostasis disorder, and it forms a deadly triad in trauma and burns patients with blood coagulation disorder and acidosis [4, 6, 7, 16–19].

Some studies have suggested various factors such as cooling the burn wound at the scene, injecting a lot of fluids, and the long distance to the burn ward as factors involved in hypothermia [20]. Some other studies have introduced variables such as age, gender, percentage of burn surface, type, mechanism and degree of burn, injury location, injury season, trauma severity, the way of temperature measurement, rapid pre-hospital treatment, fluid injection, endotracheal intubation, level of consciousness, instability of the physiological state, and the duration and the way of transfer to the burn ward as the risk factors for hypothermia [5, 16, 21–23].

Although hypothermia is a serious threat to pre-hospital patients, especially injured patients [24, 25], the evidence in this regard is limited [3]. Weak evidence and information regarding pre-hospital measures and guidelines [26], insufficient knowledge of the healthcare team about hypothermia, and neglect to implement hypothermia management guidelines [20, 27, 28] emphasize the need for more studies in this field. This study was conducted to investigate accidental hypothermia and its related factors among burn patients referred to Shahid Motahari Hospital in Tehran.

MATERIAL AND METHODS

This prospective observational study was conducted on eligible burn patients referred to Shahid Motahari Hospital in Tehran. Before being conducted, this study obtained permission from the Research Ethics Committee of Zanjan University of Medical Sciences (IR.ZUMS.REC.1399.183).

Data were collected from patients referring to Shahid Motahari Hospital in Tehran. This hospital, with a capacity of 112 active beds, includes outpatient and inpatient emergency, ICU, operating room, internal, infectious, surgical, pediatric, sub-specialized reconstructive surgery, orthopedics, physiotherapy, and occupational therapy wards and admits burn patients referred from all over Tehran province and other parts of Iran.

One hundred and fifty-one patients with burns above 20% of body surface area (BSA) who were transported by EMS staff to the hospital's emergency ward were included in the study through convenience sampling from February to August 2021. Patients sent from other medical centers and patients transported by private vehicles were excluded from the study.

CBT upon admission, ambient temperature upon admission, level of consciousness in the pre-hospital stage, type of burn, degree of burn, age, gender, transfer time, cooling at the scene, underlying disease, percentage of arterial oxygen, the volume of fluids received, response time, drug intake, BSA, and airway type were checked and recorded.

The CBT variable using a tympanic thermometer (model Gp-300 iso9001, identification code of Manufacturer: Harbin XianDe, with a measurement accuracy of 0.1 and measurement error of 0.2°C) and the ambient temperature varies with a thermometer (ATA.152. Dl. 39 with an accuracy of 1°C) were measured and recorded at the time of entering the burn emergency ward. The data was collected through the researcher's datasheet using observation and interviews with patients and their companions and patient files. BSAs were calculated using Lund Broder's chart (the gold standard for BSA calculations), which was calculated by the burn emergency department nurse and documented in the patient's medical record. The study included patients with a BSA of 20% or higher. In this study, the cut point for accidental hypothermia was determined to be 36°C.

Data analysis was performed using descriptive statistics and Pearson's correlation coefficient test, analysis of variance (ANOVA), and multiple linear regression analysis and analyzed with SPSS version 22 software. A significance level was considered less than 5%.

RESULTS

The study findings are the result of analyzing the data of 151 burn patients meeting the inclusion criteria. The majority of patients were male (67.5%). The mean and standard deviation of the individuals' age was 36.44 (13.58) years. The lowest BSA was 20%, the highest was 100%, and the mean and standard deviation of the BSA was 47.04 (20.96) (Tab. 1, 2).

The thermometer present in the pre-hospital area was of mercury type and did not have the ability to measure the CBT. About half of the patients (47%) were hypothermic upon admission (Tab. 3).

CBT of burn patients upon admission showed no significant association with the quantitative variables of age (r = –0.063, p = 0.443), BSA (r = –0.086, p = 0.294), arterial oxygen percentage (r = 0.052, p = 0.529), the volume of fluids received (r = 0.055, p = 0.503), the response time (r = –0.015, p = 0.853), the transfer time (r = 0.026, p = 0.753), hospitalization days (r = 0.057, p = 0.485), and ICU hospitalization days (r = –0.012, p = 0.882) (Tab. 4).

CBT upon admission showed no significant association with qualitative variables such as cooling at the scene (p = 0.79), degree of burn (p = 0.75),

Table 1. Patients' characteristics

Individual and burn-related variables		Number	Percentage
Gender	Male	102	67.5
	Female	49	32.5
Underlying disease	Yes	113	74.8
	No	38	25.2
Place of burn	Home	81	52.6
	Out of home	64	42.4
	Out of the city	6	4
Type of burn	Thermal	116	76.8
	Inhaler	23	15.2
	Electrical	5	3.3
	Chemical	7	4.6
Burn degree	Grade 2	54	35.8
	Grade 3	22	14.6
	Grade 2 and 3	75	49.7
Burn site	Head, face and neck	9	6
	Organs	18	11.9
	Combined	124	82.1
Cooling at the scene	Yes	54	35.8
	No	97	64.2
Level of consciousness (GCS)	Conscious	136	90.1
	Lack of consciousness	15	9.9
Intubation	Yes	12	7.9
	No	139	92.1
CPR at the scene	Yes	1	0.7
	No	150	99.3
Taking warm IV fluids	Yes	68	45
	No	83	55
Taking medication	Yes	17	11.3
	No	134	88.7

CPR — cardiopulmonary resuscitation; GCS — Glasgow Coma Scale;

Table 2. Frequency distribution of some quantitative variables of patients

Variable	Mean	Standard deviation	Minimum	Maximum	Number
Age	36.44	13.58	12	75	151
Burn percentage (BSA)	47.04	20.96	20	100	151
Response time	20.23	6.168	6	40	151
Transfer time	20.66	6.43	7	38	151
Ambient temperature upon admission	23.58	1.1	21	27	151
CBT upon admission	36.61	0.62	35	39.3	151

BSA — body surface area; CBT — core body temperature

Table 3. Frequency distribution of patients with normal temperature and hypothermia

CBT	Number	Percentage
Hypothermia (equal to and less than 36°C)	71	47
Normothermia (more than 36°C)	80	53

CBT — core body temperature

Table 4. Correlation of quantitative variables with CBT of burn patients upon admission

Variable	CBT		
	Pearson correlation coefficient	p-value	Number
Age	–0.063	0.443	151
Burn percentage (BSA)	–0.086	0.294	151
Blood oxygen saturation	0.052	0.529	151
Volume of IV fluids received	0.055	0.503	151
Response time	–0.015	0.853	151
Transfer time	0.026	0.753	151

BSA — body surface area; CBT — core body temperature

type of burn ($p = 0.23$), and gender ($p = 0.45$). CBT upon admission showed a significant association with the level of consciousness ($p = 0.009$), and intubation ($p = 0.002$) (Tab. 5).

Fifteen independent factors (ambient temperature of the emergency ward upon admission, level of consciousness in the pre-hospital stage, type of burn, degree of burn, age, gender, transfer time, cooling at the scene, underlying disease, percentage of arterial oxygen, volume of fluids received, time response, drug intake, BSA, and airway type) were entered into the regression model with the CBT of the patient upon admission as a dependent variable. In the multiple linear regression analysis, among the 15 independent or predictive variables included in the backward model at the 14th stage, only the two variables of airway type ($\beta = -0.296$, $p < 0.001$) and the volume of fluids received ($\beta = 0.144$, $p = 0.08$) were identified as effective in triggering hypothermia and played a role as independent predictors of hypothermia upon admission of burn patients (Tab. 6).

DISCUSSION

The findings of this study showed that accidental hypothermia in burn patients was highly prevalent (47%). Multiple linear regression analysis identified two factors of airway type (intubation) and volume of fluids received in the pre-hospital stage as effective factors in accidental hypothermia upon admission of burn patients.

One of the serious reasons for the drop in the CBT of burn patients in the present study seems to be the lack of serious attention to the evaluation of the CBT of burn patients and the inability to de-

Table 5. The difference in the mean CBT on admission according to the variables of cooling the burn site, burn degree, type of burn, gender, consciousness, and intubation in the pre-hospital

Variable	status	Mean (SD)	Number	F	P-value (ANOVA)
Cooling at the scene	Yes	36.60 (0.59)	97	0.06	0.79
	No	36.62 (0.69)	54		
Burn degree	Grade 2	36.65 (0.58)	54	0.25	0.75
	Grade 3	36.61 (0.84)	22		
	Grade 2 and 3	36.57 (0.59)	75		
Type of burn	Thermal	36.65 (0.62)	116	0.73	0.23
	Inhalation	36.63 (0.68)	23		
	Electrical	36.58 (0.420	5		
	Chemical	36.57 (0.61)	7		
Gender	Male	36.58 (0.61)	102	0.56	0.45
	Female	36.66 (0.65)	49		
Level of consciousness	Conscious	36.65 (0.58)	136	6.97	0.009
	Lack of consciousness	36.21 (0.84)	15		
Intubation	No	36.65 (0.61)	139	10.10	0.002
	Yes	37.07 (0.59)	12		

Table 6. Multiple linear regression analysis of independent variables with CBT at the beginning of admission of burn patients (step 14 of Backward model)

Variables	B	S.E.	t	β	Sig.	95 % CI	
						Lower	Upper
Airway type (intubated)	–0.684	0.191	–3.58	–0.296	< 0.001	–1.062	–0.307
volume of IV fluids received	0.000	0.000	1.748	0.144	0.082	0.000	0.001

CI — confidence interval

tect individuals at risk of hypothermia early. Lack of awareness or failure to follow clinical guidelines, as well as insufficient facilities and equipment for assessing CBT in patients and not reheating them, are other reasons. Failure to provide proper temperature care in the pre-hospital area and even burn emergency wards, such as not using heaters to heat injection fluids, can be one of the reasons for the high prevalence of hypothermia in the studied patients.

Numerous studies have reported the prevalence of hypothermia between 34 and 79.2%. In a retrospective study of 57 patients, Alonso et al. (2020) reported that 79.2% of patients were hypothermic during admission [17]. Ehrl et al. (2018) mentioned the prevalence of hypothermia during admission among 52 patients as 65.4 [4]. Also, Ziegler et al. (2019), in their study on 141 patients, estimated the prevalence of hypothermia at 60.3% [3]. Steele et al. (2016) reported a 42% prevalence of accidental hypothermia in patients with large burns during admission and hospitalization [5]. Based on Weaver et al.'s (2014) study, among 277 patients, about 42% were hypothermic [7]. Hostler et al. (2013) also conducted a study on 12097 patients and reported the prevalence of hypothermia to be 39.67% [18]. In a retrospective study on 301 patients, Lukusa et al. (2021) also reported the prevalence of accidental hypothermia to be 34% [6].

The main reasons for the variation in the prevalence of hypothermia in different studies seem to be related to the differences in the selection of the cut-off point for hypothermia, inclusion criteria (degree and extent of burn), temperature recording methods (peripheral or CBT recording thermometers), study times (cold and hot seasons), different geographical regions (cold or tropical), and the type of studies (retrospective or prospective).

In most studies, the cut-off point for hypothermia has been defined as less than and equal to 36°C [3, 27, 29–31] In a few studies, including Weaver et al. (2014) and Hostler et al. (2013), hypothermia has been defined as below 36.5°C [7, 18]. The results of two studies, in which hypothermia had been considered less than and equal to 35°C [19, 27] were contrary to the present study's findings. This difference can be justified according to the cut-off point of 36°C used in the present study.

The results of multiple linear regression analysis showed that the volume of injected fluids in the pre-hospital stage was related to hypothermia upon admission. Of course, this relationship is such that with an increase in the volume of injected fluids, the CBT of the patients also increases. In many studies, hypothermia is usually aggravated by increasing the volume of intravenous fluids in patients, while this study showed contradictory results.

Ehrl et al.'s (2018) study showed that hypothermia enhanced with the increased volume of injected crystalloid fluids [4]. Steele et al.'s (2016) study also reported the association of excessive administration of intravenous fluids in the pre-hospital phase with exacerbation of hypothermia [5]. In Reynolds et al.'s (2012) study, the prevalence of hypothermia in massive transfusions was also high [32].

However, some studies, including Lim et al. (2016), Lapostolle et al. (2012), and Ziegler et al. have not reported any relationship between the volume of fluids received and causing hypothermia [3, 31, 33].

The discrepancy between the finding of the present study and other existing studies can be argued for various reasons. One of the specific reasons for this study is to provide low volumes of intravenous fluids in the pre-hospital stage for burn patients in such a way that the average volume of fluids received by these patients was about 780.46 ± 335.50 mL, which does not seem to be enough to reduce the CBT of patients significantly. The second reason can be related to the relatively fast time (20.66 minutes with a standard deviation of 6.428) of transferring burn patients by ambulance to the medical center, which is not enough to cause temperature changes due to receiving the volume of intravenous fluids. Of course, the temperature of the injected fluids is also an important factor, which in the present study was not possible to check accurately in the pre-hospital stage. The temperature of intravenous fluids is a risk factor for hypothermia [7, 21, 34] and has negative effects [35].

Another independent risk factor for the prevalence of hypothermia in the present study was the airway type so that the body temperature upon admission was lower in intubated than in non-intubated patients, and this difference was statistically significant. Many studies have reported the association between tracheal intubation and the prevalence of hypothermia [3, 4, 7, 20, 33, 36, 37]. However, Lukusa et al.'s (2021) study was inconsistent with the present study, showing that intubation in children is not a suitable indicator of hypothermia [6].

Since patients with tracheal tubes are often unconscious or have a low level of consciousness, lose the ability to regulate their body temperature, and their intubation at the scene is also a factor in wasting time in transportation, and they will have more opportunity to lose temperature. In addition, changing the natural path of breathing and replacing it with artificial tracheal tubes distorts the possibility of warming the breathing air temperature.

Among other findings of the present study was the exacerbation of hypothermia with a decrease in the level of consciousness, although this finding was not identified as an effective factor in multiple linear regression analysis. Studies have also shown that hypothermia increases with a decreased level of consciousness [7, 38–40]. This phenomenon can be due to the non-observance of temperature care protocols for burn patients in the pre-hospital stage, such as not heating the injection fluids, insufficient coverage of patients, and patients' prolonged intubation at the scene. In addition, temperature regulation mechanisms are disturbed in unconscious or low-consciousness patients.

The pre-hospital field information recorded in the datasheet may not have sufficient validity. Another limitation of the study was the investigation in different seasons (cold and hot), which was considered a confounding factor. Recording the body temperature of some patients inside the ambulance cabin with a mercury thermometer was another limitation of the study. The present study was conducted only in a burn center and on patients referred by ambulance. In order to accurately check the prevalence of hypothermia, it is better to conduct other studies on patients who are referred from other hospitals and by private vehicles as well.

CONCLUSIONS

In the present study, nearly half of the burn patients were hypothermic. Among the numerous variables evaluated as risk factors related to hypothermia in this study, patients with endotracheal intubation and the volume of fluids received effectively contributed to creating or aggravating hypothermia. One of the different findings of this study was the correlation of CBT in patients upon admission with the volume of fluids received, which contradicted the existing research evidence and therefore needed further study and exploration. The role of factors such as lack of assessment or inappropriate assessment of core body temperature, neglect of temperature care instructions, and weakness of diagnostic and interventional equipment for managing accidental hypothermia in burn patients should not be ignored. Empowering the pre-hospital and hospital care team and improving their knowledge and skills in evaluating burn patients and early diagnosis, prevention, and optimal management of accidental hypothermia is expected seriously. Also, the application of research evidence and clinical guidelines on how to manage accidental hypothermia in burn patients in emergency wards and the commitment to evidence-based practice along with the optimization of temperature care in the pre-hospital field and burn centers can be effective in the management of accidental hypothermia and related consequences.

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Conflict of interest

The authors declare no conflicts of interest.

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