Accidental Hypothermia and Related Risk Factors among Trauma Patients Admitted to the Emergency Department

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Abstract

Background: Early detection and management of hypothermia are determinants in the consequences of the injury. Various factors are involved in the progress of accidental hypothermia in these patients.

Objectives: This study was done to determine the prevalence of accidental hypothermia and its related factors in trauma patients admitted to the emergency department (ED).

Methods: In this prospective observational study, 123 trauma patients, who were transferred to the ED of Ayatollah Mosavi hospital, Zanjan, Iran by emergency medical technicians during November 2018, were selected. The patients' core body temperature (CBT) was measured through a calibrated tympanic thermometer on admission, 30 minutes after admission, and at the time of leaving the ED. Personal, clinical, environmental, and caring variables were evaluated as factors associated with hypothermia. Data were analyzed using descriptive statistics and multiple linear regression by SPSS16. The significance level was considered to be 5%.

Results: The prevalence of accidental hypothermia in the ED was 43.1%. The patient's arrival CBT (β: 0.333, P-value <0.001), the length of stay in the ED (β: - 0.174, P-value =0.011), arrival ambient temperature (β: 0.165, P-value =0.039), and Glasgow coma scale (GCS) (β: 0.413, P-value <0.001) were the risk factors identified as predictors of hypothermia.

Conclusion: A significant proportion of trauma patients were hypothermic on admission to the ED. Arrival CBT, length of stay in the ED, arrival ambient temperature, and GCS had a significant role in the development or exacerbation of hypothermia. The results of this study highlight the need for giving special attention to the early detection and management of accidental hypothermia among trauma patients in the ED.

Keywords: prevalence; accidental hypothermia; injury; core body temperature (CBT); emergency department (ED)

Introduction

Hypothermia is common among trauma patients [1-4]. Hypothermia is observed in up to two-thirds of the patients with severe trauma [5]. Accidental hypothermia refers to a core body temperature (CBT) below 35 ° C [6]. Accidental hypothermia among trauma patients is defined as a drop in the CBT below 36 °C. Based on CBT, hypothermia is classified as mild (34-36 °C), moderate (32-34°C), and severe (less than 32 °C) [5,7,8]. This phenomenon can be caused by trauma, infection, or other illnesses; hypothermia in trauma can occur due to exposure to the environment or conditions that reduce thermoregulatory responses. Also, it can occur during resuscitation at the time of emergency situations [9,10].

Hypothermia in the hospital setting may occur following prolonged resuscitation and surgical procedures, general anesthesia, spinal anesthesia, burns, and cold intravenous fluid infusions. Exposure to environments that do not take appropriate measures to maintain the normal body temperature is also involved in the development of hypothermia [5,11]. It initiates the lethal triad in trauma patients and provides conditions for the development or exacerbation of metabolic acidosis and coagulopathy [12,13]. Hypothermia is associated with exacerbated injury and increased mortality [14,15]. It induces coagulation, and cardiovascular, neurological, and renal problems, leading to increased morbidity and mortality [5,16].

Epidemiologic study of trauma is essential to prevent mortality among trauma patients. Analysis of treatment outcomes and causes of trauma-related mortality can improve the treatment and prevention of mortality among trauma patients [17]. Although the mechanism of the deleterious effects of hypothermia is well known, the causes of hypothermia are unclear. Most information on patients with hypothermia comes from hospital records or retrospective studies and pre-hospital patient information is scarce [18,19]. Hypothermia, besides causing problems in the patient's health, imposes high costs on the health system due to prolonged hospitalization and more diagnostic tests [20]. Studies have shown that the trauma care team is unaware of the presence of this phenomenon in the initial assessment and management of trauma patients [3,5,7,21].

In order to reduce the rate of trauma-related deaths and minimize its associated complications and disabilities, it is necessary to properly organize the care and treatment of these injured patients. This arrangement begins from pre-hospital care and will continue during hospitalization [22]. The ability of healthcare providers to identify risk factors and adopt appropriate interventions to prevent hypothermia is critical [20,23]. Early detection and control and management of hypothermia are determinants in the consequences of the injury, and imperative to improve patient outcomes [1,19]. Thermoregulation is an important consideration while caring for trauma patients [7]. In Iran, especially in the Zanjan province, there is insufficient evidence on the prevalence of hypothermia and its risk factors in trauma patients admitted to the EDs. Therefore, this study intended to address this gap in the evidence.

Methods
This prospective observational study was performed on trauma patients referring to the ED of one of the teaching hospitals of Zanjan University of Medical Sciences. Ayatollah Mousavi Hospital is the 540-bed trauma center in Zanjan province located in the northwestern part of Iran and accepts trauma patients referring from the whole Zanjan province and neighboring western and northwestern provinces. After the approval of the research ethics committee (IR.ZUMS.REC.1397.198), 123 trauma patients were recruited from 11 to 21 November 2018. Patients with mechanical trauma over 18 years of age, who were transported by the EMS staff to the ED, participated in this study. Patients who were resuscitated or died in the ED, as well as patients referring from other medical centers or transported by personal vehicle, were excluded. Temperature values (i.e. CBT, ambient temperature, and infusion fluid) were measured and recorded using a digital thermometer. A Beurer FT 58 Ear Thermometer made in Germany was used, which can measure CBT with an accuracy of ±0.2-0.3, ambient temperature with an accuracy of ± 2, and objects' temperature with an accuracy of ±2°C). CBT was measured and recorded on arrival at the ED, 30 minutes after hospitalization, and at the time of leaving the ED. ED ambient temperature was also measured at the time of admission and when the patient left the department. Infusion fluid temperature was also measured and recorded during the infusion.

Seven factors that were considered risk factors (age, sex, level of consciousness (GCS), CBT on arrival at the ED, ambient temperature on arrival at the ED, ambient temperature at the time of discharging from the ED, and length of stay in the ED) were analyzed by multiple linear regression. Data were described in frequencies, mean, and standard deviation and analyzed using SPSS 16. The assumptions of the linear regression analysis were established. The significance level was considered as 5%.
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Results

The findings of the study are based on the analysis of 123 trauma patients eligible for the study. The majority of the patients were male (75.6%). The average age was 37.8 ± 17.9 years. The most common mechanism of trauma was blunt trauma (74.8%), and the leading cause of trauma was motor vehicle accidents (69.6%). The mean GCS of the patients was 14.1 ± 7.3, and the average length of admission in the ED was 5.88 ± 3.49 hours. Other demographic characteristics of the patients and factors associated with hypothermia are presented in Table 1.

Table 1: Demographic characteristics and factors associated
with hypothermia in trauma patient (N=123)

Variables		N(%)
Sex	Male	93(75.6)
	Female	30(24.4)
Trauma location	Head	29(23.6)
	Chest	4(3.3)
	Abdomen	2(1.6)
	The vertebrae	5(4.1)
	Upper limb	12(8.9)
	Lower limb	20(16.3)
Mechanism	Multiple Traumas	51(41.5)
	Blunt	92(74.8)
	Penetrating	4(3.3)
	Both	27(22)
Etiology	Motor vehicle	86(69.6)
	Sharp things	2(1.6)
	Fall	25(20.3)
	Workplace accidents	8(6.5)
	Other	2(1.6)
Climate	Cold to rainy	111(90.2)
	Snowy	12(9.8)
Shift	Morning	45(36.6)
	Evening	44(35.8)
	Night	34(27.6)
Thermal care at the time of examination	Yes	55(44.7)
	No	68(55.3)
Thermal care when changing clothes	Yes	66(53.7)
	No	57(46.3)
Thermal care at the time of diagnostic and therapeutic interventions	Yes	84(68.3)
	No	39(31.7)

The results showed that 53 patients (43.1%) had a CBT below 36 ° C upon their arrival at the ED. Thirty minutes after admission to the ED, 56 patients (45.5%) showed a CBT below 36 °C. The ambient temperature and infusion fluid temperature are also given in Table 2.

Table 2: CBT, ambient temperature, and infusion fluid temperature of trauma patients (N=123)

	Temperature values	N(%)
Arrival CBT at the ED	Hypothermia (overall)	53(43.1%)
	Normal (36- 38 ° C)	69(56.1%)
	Mild (34- 36 ° C)	51(41.5%)
	Moderate (32- 34 ° C)	3(2.4%)
	Severe (less than 32 ° C)	0(0%)
CBT 30 minutes after hospitalization in the ED	Hypothermia (overall)	56(45.5%)
	Normal (36- 38 ° C)	67(54.5%)
	Mild (34-36 ° C)	54(43.9%)
	Moderate (32-34 ° C)	1(0.8%)
	Severe (less than 32 ° C)	1(0.8%)
CBT in discharge	Hypothermia (overall)	55(44.7%)
	Normal (36- 38 ° C)	68(55.3%)
	Mild (34- 36 ° C)	50(40.7%)
	Moderate (32- 32 ° C)	4(3.3%)
	Severe (Less than 32 ° C)	1(0.8%)
Ambient temperature of the ED	Arrival ambient temperature (Less than 22 ° C)	31(25.2%)
	Discharge ambient temperature (Less than 22 ° C)	22(17.9%)
Infusion fluid temperature	Liquid temperature (Less than 37 ° C)	43(35%)

Observations showed that the ED ambient temperature and patients CBT were not assessed upon the arrival to or during the hospitalization in the ED. The thermometer available in the ward was a mercury-in-glass and could not measure the CBT. Moreover, infusion fluid was not warmed before infusion.

Of the seven factors included in the multiple linear regression through Enter model, the patient's arrival CBT (β: 0.333, P-value <0.001), the length of stay in the ED (β: -0.174, P-value=0.011), arrival ambient temperature (β:0.165, P-value =0.039), and GCS (β: 0.413, P-value <0.001) as predictive factors, showed no statistically significant effect (Table 3).

Table 3: Multiple linear regression (enter model) of trauma patients' hypothermia (N=123).

Model	B	SE	Beta	t	Sig	95% Confidence Interval	
						Upper	Lower
Arrival temperature	.460	.098	.333	4.683	.000	.265	.654
Arrival ambient temperature	.142	.068	.165	2.088	.039	.007	.277
GCS	.343	.058	.413	5.891	.000	.228	.459
Gender	.061	.180	.023	.336	.738	-.297	.418
Age	.002	.004	.034	.485	.628	-.006	.011
Length of Stay (Hr.)	-.056	.022	-.174	-2.593	.011	-.099	-.013
Discharge ambient temperature	.049	.072	.054	.688	.493	-.093	.192
F=16.374, P=0.000, R2=0.499, Adjusted R2=0.415							

Discussion

The results showed that a significant proportion of trauma patients (43.1%) were hypothermic upon arrival to the ED, and showed no improvement even 30 minutes after admission to the ED. Conversely, the proportion of hypothermia

increased to 45.5%. This finding indicates that hypothermic patients do not receive adequate thermal care in the ED. Some studies have reported the prevalence of 12% to 66% for hypothermia [1,3,8,23-26].

Based on the evaluation of the factors associated with accidental hypothermia in trauma patients, 7 factors were analyzed by the multiple linear regression. Four factors, including arrival CBT of the patients, length of stay in the ED, GCS, and arrival ambient temperature were identified as predictive factors.

Vincent-Lambert et al. (2018) also reported that 51% of the patients had a body temperature below 36 ° C on arrival to the ED, which increased to 56%, 30 minutes after their admission to the ED [25], which is in line with the present study. Ireland et al. (2011) also noted that the number of hypothermia patients had a recurrent decrease in temperature after being admitted to the ED [1]. In this study, the lack of special attention to the assessment of CBT as well as early detection of patients at risk of hypothermia is considered the leading cause of hypothermia. Patients did not receive adequate thermal care during transferring from the ambulance to the ED. Warmer was also not used to warm infusion fluids. Another important finding of this study was the positive relationship between the length of ED stay and the severity of hypothermia. Hsieh et al (2018) showed that long hospital stay was associated with hypothermia [8]. In the study conducted by Ireland et al. (2011), hypothermic patients also had a longer hospital stay [1]. Also, Pirnes and Ala-kokko (2017) demonstrated that patients with long-term hospitalization had a lower initial temperature [27]. These findings were in line with the results of the present study.

Low GCS was another factor that was determined as the independent variable in predicting hypothermia among trauma patients. Lapostolle et al. in two sequential studies proved that a low GCS and a low air temperature are independent factors associated with hypothermia [3,26]. Some other studies also revealed that hypothermic patients had a significantly lower GCS compared with normothermic patients (8,27,28].

Ambient temperature was another factor that significantly was related to hypothermia in the patient. Numerous studies have confirmed our findings. They showed ambient temperature as an independent factor in predicting hypothermia among trauma patients in pre-hospital scene, ED, and operating room areas [3,29-33]. The ambient temperature in the ED, operation room, and critical care units is kept between 21°C and 24°C to make sure a decrease in convective heat loss [34]. Vincent-Lambert et al. (2018) stated that the ambient temperature in the triage area is varied and was documented as less than the recommended 21°C in 68% of the cases [31]. In contrast, Inaba et al. (2012) showed that a lower ambient operation room temperature was not associated with a drop in the patient's CBT [35]. This lack of association may be related to the setting of the two studies. Their study was conducted in the operation room and they paid attention to the aggressive use of active warming measures in maintaining normothermia than ambient temperature regulation.

In the present study, other factors related to hypothermia using multiple linear regression showed no statistically significant effect on hypothermia. Concerning age and gender, as risk factors associated with hypothermia, the results were consistent with some studies [1,4,36], while gender was identified as a risk factor in the study conducted by Hsieh et al. (2018) [8].

The data collection in this study was done in the autumn; thus, the findings cannot be generalized to trauma patients admitted in the other seasons. In addition, Zanjan province has a cold climate and it is expected that the hypothermia prevalence and its associated risk factors in this province will be different from other provinces in the country. It is suggested that similar studies be prospectively designed with sampling in all seasons in other provinces to obtain a more accurate estimation of the hypothermia prevalence and its related factors.

Conclusion
In the present study, about half of the patients admitted to the ED were hypothermic. Thirty minutes after hospitalization, not only their hypothermia did not improve but also it got worse. This indicates that trauma patients did not give thermal care in the ED. There are various reasons for the development and exacerbation of hypothermia, which have been mentioned in the trauma care literature. Arrival CBT, length of stay in the ED, arrival ED ambient temperature, and GCS had a significant role in the development or

exacerbation of hypothermia. However, the role of other factors, such as lack of attention to the early assessment of CBT, lack of thermal care protocols in the ED, and poor warming devices for the management of accidental hypothermia should not be overlooked.

To effectively manage hypothermic trauma patients in ED, some proper measures must be taken into account:

• Routine assessment of CBT using tympanic thermometers.

• The ambient temperature in the ED should be kept at 21°C - 24°C.

• Active warming must be initiated for any patient with a CBT of less than 36°C.

• Routine use of external warming devices for all trauma patients is recommended. These devices should be used in association with fluid warmers, heat-moisture exchange (HME) filters in breathing circuits, and other methods to prevent heat loss.

Applying clinical guidelines on how to manage accidental hypothermia in trauma patients in EDs and commitment to evidence-based practice can address these risk factors. Also, equipping EDs with digital thermometers that can accurately detect CBT, as well as external body heaters and intravenous fluid warmers smooth the management of this phenomenon.

Author Contributions:
Study concept and design (MD, RH, MR); obtaining fundings (MD); acquisition of the data (MD, RH); analysis of the data (MD, RH); drafting of the manuscript (MD, RH); critical revision of the manuscript (MD); approval of final manuscript (MD).

Conflict of interest
The writers report there is no conflict of interest in this study.

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