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Original Article

Investigation of inadvertent hypothermia incidence and risk factors

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ABSTRACT

Objective: This study was conducted to determine the incidence of inadvertent hypothermia in operative patients and the risk factors that are involved in the development of hypothermia.

Material and Methods: This prospective, descriptive, cross-sectional study was conducted from January 2016to August 2016 with 144 patients who over the age of 18 years, underwent general surgery, orthopedic surgery, urologic surgery, neurosurgery, and plastic and reconstructive surgery. Data was collected with the "Hypothermia Data Collection Form." Body temperature was measured by the tympanic membrane in the waiting room, operating room, and PACU.

Results: Overall, 89% of the patients (n=129) were normothermic in the preoperative phase; 74.30% of the patients (n=107) in intraoperative phase and 75.70% of the patients (n=109) in postoperative phase were hypothermic. American Society of Anesthesiologist (ASA) score, preoperative body temperature, operating room temperature, and using heating method at operation were found to be effective in the development of inadvertent hypothermia during the operating period. It was determined that premedication, preoperative and postoperative body temperature, and the operating room temperature were effective for inadvertent hypothermia in the postoperative period.

Conclusion: As a result of the study, it was determined the rate of inadvertent hypothermia was high during and after surgery. Preoperative and intraoperative patient body temperature and operating room temperature were found to be effective in preventing inadvertent hypothermia.

Keywords: Inadvertent hypothermia, Incidence, Risk factors, Operating room

INTRODUCTION

Providing and maintaining normothermia in the preoperative, intraoperative, and postoperative periods is highly important in terms of patient safety, positive surgical results, and patient satisfaction (1, 2). Inadvertent hypothermia can cause complications such as postoperative myocardial events, surgical site infections, and prolonged durations of hospitalization and recovery (3-6). It has been reported that the maintenance of normothermia decreases the length of hospitalization by approximately 40% and the risk of surgical site infection by 64% (7). Every year, about 24%–90% of surgical patients suffer from inadvertent hypothermia (8). Hypothermia is defined as the decrease in patient's core body temperature below 36.0°C (9, 10). In the guideline for the management of inadvertent hypothermia in adults published by the National Institute for Health and Care Excellence (NICE), inadvertent hypothermia is examined in three phases: (1) *the preoperative phase*, which is defined as the hour before induction of anesthesia when patient is prepared for surgery; (2) *the intraoperative phase,* which covers the administration of anesthesia; and (3) *the postoperative phase*, which is defined as the 24 hours beginning with the entry into the recovery unit (9).

Surgery and general anesthesia affect the normal balance between heat production and heat loss. Anesthetic agents, opioids, and sedatives suppress behavioral and autonomic responses by influencing patient's thermoregulation feature that can change depending on the environmental temperature (7). Inadvertent hypothermia results from anesthesia, temperature of the operating room, and the use of cold intravenous solutions and cold blood products (7, 10). When anesthesia is administered, the factors increasing the risk of hypothermia are the application of a large and moderate-degree surgical intervention, inclusion in the American Society of Anesthesiologist (ASA) II-IV group, female gender, preoperative body temperature below 36°C, administration of sedation and premedication, the presence of coexisting cardiac and vascular diseases, application of combined regional and general anesthesia, age over 70 years, and systolic blood pressure above 140 mmHg (11).

This study aimed to determine the incidence of inadvertent hypothermia and the risk factors affecting the development of hypothermia in patients undergoing a surgery.

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MATERIAL AND METHODS

This prospective, descriptive, and cross-sectional study was conducted in the surgical clinics and operating unit of a university hospital. The study included all patients who were operated in the departments of general surgery, orthopedics, urology, neurosurgery, and plastic and reconstructive surgery in our hospital between January and August 2016. The patients who were planned for emergency surgery needed to be applied therapeutic hypothermia, and they were followed in the intensive care unit after operation. The patients whose body temperature could not be tympanically measured during operation were not included in this study. The study consisted of 144 patients who met these inclusion criteria. The patients whose body temperature was below 36°C were accepted to be hypothermic. Data were collected by measuring patients' body temperatures three times: in waiting unit before surgery, during operation, and in the recovery room after surgery. The power of the study was calculated over its own sampling through GPower 3.1, and it was found to be 0.94.

The data were collected by the researchers through face-to-face interviews with the patients. Their body temperatures were measured using a calibrated Genius 2 Infrared Tympanic Electronic Thermometer (Covidien, Mansfield, America) by the researchers in the waiting unit, operating room (before giving anesthesia and during operation), and in the recovery room. After surgery, the first measurements of patients' body temperatures were recorded in the clinic. The data of the study were collected between January and August 2016. This study was approved by the non-interventional ethics committee of the Dokuz Eylül University with the decision number 2015/28-26, dated 01.17.2015, and protocol number 2351-GOA. Necessary institutional permissions were obtained from the hospital where the study was conducted. Verbal and written informed consents were received from the patients who confirmed their participation in this study.

Data collection instruments

The data were collected using a "Hypothermia data collection form" that was developed by the researchers in accordance with literature (4, 7, 9-11). This form, which consisted of two parts within itself, included "Form for Patient Characteristics" in the first part and "Form for the Identification of Hypothermia" in the second part.

Part 1. Form for Patient Characteristics: This form was designed by the researchers in accordance with literature, and it consisted of seven items including patient's sociodemographic features: age, gender, height, weight, and clinical features: planned surgery, the department where the patient was hospitalized, and the drugs that the patient used.

Part 2. Form for the Identification of Hypothermia: This form, which was developed in accordance with literature, consisted of three parts. The first part included six items on patient-related risk factors for undesired hypothermia, age, body mass index (BMI), chronic diseases, ASA level, systolic blood pressure, and preoperative body temperature. The second part included 12 items on surgery-related risk factors for undesired hypothermia, application of premedication, type of anesthesia, type of surgery, duration of surgery, temperature of the operating room, amount of fluid given in the operating room, application and amount of blood transfusion, heating method used intraoperatively, application of a heating technique in the recovery room, room temperature of the recovery unit, room temperature in the clinic, and application of a heating method in the clinic. The third part consisted of the measurements of patients' body temperatures in the clinic and waiting room where the patients stayed before operation, just before the induction of anesthesia and during the operation in the operating room, and in the recovery room and clinic after operation.

Statistical Analysis

The collected data were analyzed using the Statistical Package for the Social Sciences Version 20,0 (SPSS) (SPSS, Inc., New York, USA). Number, percentage, and mean were used to analyze the sociodemographic features, clinical features, and the frequency of hypothermia. Univariate and multivariate linear regression analysis methods were employed to compare hypothermia risk factors and body temperature measurements, which were the independent variables of the research.

RESULTS

The descriptive features of the patients participating in the study are presented in Table 1. Of the patients, 62.50% (n: 90) were male, and 37.50% (n: 54) were female. The mean age of the patients was 53.59±15.88 years. Among the patients, 49.30% had a chronic disease, and 52.80% were evaluated to be at ASA II level. It was found that 89% of the patients (n: 129) (36.37±0.51°C) were normothermic in the waiting unit and on the operating table before the induction of anesthesia in the preoperative phase (1), in one hour when they prepared for the surgery. Inadvertent hypothermia developed in 74.30% of the patients (n: 107) (35.52±0.69°C) in the intraoperative phase (2) after the induction of anesthesia, and in 75.70% of the patients (n: 109) (35.43±0.73°C) in the 24-hour postoperative phase (3) beginning with the entry into the recovery unit.

For the predicted risk factors for inadvertent hypothermia developing preoperatively, intraoperatively, and postoperatively, the results of univariate linear regression analysis and multivariate linear regression analysis are shown in Table 2 and Table 3, respectively.

According to the results of univariate and multivariate analyses, age, gender, BMI, systolic blood pressure, and application of premedication had no effect on the preoperative development of inadvertent hypothermia ($p>0.05$).

It was found that body temperature in the waiting room, ASA level, temperature of the operating room, and the intraoperative application of a heating method positively affected the intraoperative body temperature, and this finding was statistically significant ($p<0.05$). Also in the multivariate analysis, the effects of body temperatures of the patients in the waiting room and temperature of the operating room on the intraoperative body temperature were detected to be positive and statistically significant ($p<0.05$). It was revealed that body temperatures of the patients in the waiting unit and temperature of the operating room affected the intraoperative development of inadvertent hypothermia at the rates of 60% and

37.80%, respectively (B: 0.604 95% CI: 0.375—0.833; B:0.378 95% CI: 0.237–0.552, respectively).

In the univariate analysis, the effects of preoperative body temperature, intraoperative body temperature, the application of premedication, and temperature of the operating room on the postoperative body temperature were found to be positive and statistically significant ($p<0.05$). On the other hand, in the multivariate analysis, only intraoperative body temperature and temperature of the operating room were observed to have a positive effect on the postoperative body temperature, and this finding was statistically significant ($p<0.05$). It was found that temperature of the operating room and intraoperative body temperature affected the postoperative development of inadvertent hypothermia at the rates of 19.80% and 48.30%, respectively (B: 0.198 95% CI: 0.048-0.347; B: 0.483 95% CI: 0.294-0.672, respectively).

Table 1. Characteristics of the patients

Characteristics	**n: 144**	
Age*	53.59±15.88	
Body mass index*	27.16±4.57	
	n	%
Gender		
Female	54	37.50
Male	90	62.50
Department where the patient was operated		
Urology	47	32.60
General Surgery	44	30.60
Orthopedics and Traumatology	26	18.10
Brain and Nerve Surgery	14	9.70
Plastic and Reconstructive Surgery	13	9.10
Chronic disease		
Yes	71	49.30
No	73	50.70
¥ASA state		
I	56	38.90
II	76	52.80
III	12	8.30
	mean±SD (min-max)	
Body temperature in the waiting unit (n: 144) (preoperative phase)	36.46±0.46 (min: 35.00-max: 37.60)	
Body temperature before the induction of anesthesia (n: 144) (Preoperative phase)	36.37±0.51 (min: 34.60-max: 37.70)	
Intraoperative body temperature (n: 144) (intraoperative phase)	35.52±0.69 (min: 33.10-max: 37.00)	
Body temperature in the recovery unit (n:144) (postoperative phase)	35.43±0.73 (min: 33.80-max: 37.50)	
The first body temperature measured in the clinic (n: 144) (postoperative phase)	35.92±0.44 (min: 35.00-max: 37.40)	

*: mean± standard deviation
¥ASA: American Society of Anesthesiology Classification

DISCUSSION

Providing and maintaining normothermia in the preoperative, intraoperative, and postoperative periods is very important for patient safety and satisfaction (2, 12). The data obtained in our study were discussed under three headings as the preoperative, intraoperative, and postoperative phases, in accordance with the definition of inadvertent hypothermia by NICE. In many studies examining risk factors affecting the development of inadvertent hypothermia (13-21), risk factors were evaluated perioperatively, and they were not examined separately in the preoperative, intraoperative, and postoperative periods.

Preoperative period

In our study, the incidence of hypothermia in the preoperative period was found to be 11% (n= 15). The incidence of preoperative hypothermia was reported to be 4% in the study of Horn et al. (13) and 2.40% in the study of Aksu et al. (14). Compared to these two studies, the higher incidence in our study might have resulted from non-application of any heating method preoperatively and taking the patients into the operating room without checking their body temperatures.

It was found that age, gender, BMI, systolic blood pressure, and ASA level did not have any effect on preoperative inadvertent hypothermia. This result is considered to be associated with the fact that the development of hypothermia has a multifactorial etiology.

Intraoperative period

In our study, the incidence of intraoperative hypothermia was found to be 74.30% (n=107). Similar to our results, the incidence of intraoperative hypothermia was reported as 74% in a study conducted in Australia (22). Different from the results of our study, it was detected to be 39.90% in a study performed in China (15) and 28% in another study performed in the Netherlands (16). The difference between the incidences of inadvertent hypothermia in the studies might have resulted from the differences in the interventions performed for providing normothermia in the institutions where the studies were conducted. In literature, the preoperative use of a heating method and taking patient into operation after having provided normothermia are known to be important for the prevention of inadvertent hypothermia development (12). The higher incidence in our study might have been due to non-application of preoperative heating to the patients and intraoperative application of a heating method at a low rate as 27.80% (n=40) (Table 2).

The results of univariate and multivariate linear regression analyses revealed that temperature of the operating room and preoperative body temperature affected the development of inadvertent hypothermia (Table 3). The results of our study are consistent with those in literature. In the studies conducted to determine the incidence of postoperative hypothermia and risk factors, temperature of the operating room and preoperative body temperature were reported to be associated with the development of inadvertent hypothermia (14, 23).

In the studies of Belayneh et al. (24) and Monzón et al. (25), ASA level was found to affect the development of hypothermia. On the other hand, in some studies, no effect of ASA level

was reported on the development of hypothermia (17, 26). In our study, although ASA score was found to be an effective risk factor in the univariate analysis, it was found to have no effect in the multivariate analysis (Table 2).

According to the results of our study, intraoperative heating affected the intraoperative development of inadvertent hypothermia (Table 2). Our result is consistent with that in literature (8, 13, 14). In the study performed by Horn et al. (13) to deter-

Table 2. Univariate linear regression analysis of risk factors and body temperature values

	Preoperative				Intraoperative				Postoperative			
Parameters	**B**	**95% CI**		**p**	**B**	**95% CI**		**p**	**B**	**95% CI**		**p**
Age	-0.002	-0.007	0.003	0.352	-0.001	-0.008	0.006	0.761	0.000	-0.008	0.008	0.991
Gender	-0.116	-0.273	0.041	0.146	-0.166	-0.403	0.070	0.166	-0.093	-0.345	0.159	0.467
Body mass index	0.009	-0.008	0.026	0.289	0.017	-0.008	0.042	0.181	-0.005	-0.032	0.021	0.690
ASA	-0.057	-0.182	0.068	0.367	0.186	0.001	0.371	0.049*	0.141	-0.055	0.337	0.157
Systolic blood pressure	-0.056	-0.185	0.073	0.390	0.087	-0.106	0.280	0.374	0.063	-0.140	0.266	0.541
Application of premedication	-0.114	-0.533	0.305	0.591	0.384	-0.242	1.009	0.228	0.728	0.078	1.378	0.028*
Preoperative body temperature					0.686	0.464	0.908	0.000*	0.511	0.260	0.761	0.000*
Type of anesthesia					0.112	-0.102	0.326	0.303	0.085	-0.141	0.310	0.460
Type of surgery					0.024	-0.128	0.176	0.753	-0.061	-0.220	0.099	0.454
Duration of surgery					0.012	-0.026	0.051	0.534	-0.008	-0.048	0.033	0.716
Temperature of the operating room					0.367	0.243	0.491	0.000*	0.392	0.261	0.523	0.000*
Amount of fluid given during operation					0.095	-0.119	0.309	0.381	0.002	-0.223	0.228	0.984
Application of a heating method in the operating room					0.355	0.104	0.605	0.006*	0.128	-0.144	0.400	0.354
Intraoperative body temperature									0.630	0.488	0.771	0.000*
Application of a heating method during recovery									0.098	-0.263	0.459	0.591

R^2: 0.071; Corrected R^2: 0.022 R^2: 0.286; Corrected R^2: 0.212 R^2: 0.437; Corrected R^2: 0.363
ASA: American Society of Anesthesiology Classification
CI: Confidence interval
*p<0.05

Table 3. Multivariate linear regression analysis of risk factors and body temperature values

	Preoperative				Intraoperative				Postoperative			
Parameters	**B**	**95% CI**		**p**	**B**	**95% CI**		**p**	**B**	**95% CI**		**p**
Age	-0.001	-0.006	0.005	0.864	-0.003	-0.011	0.006	0.499	0.000	-0.008	0.008	0.957
Gender	-0.130	-0.295	0.036	0.124	-0.195	-0.403	0.041	0.104	0.020	-0.207	0.246	0.864
Body mass index	0.009	-0.008	0.026	0.318	0.022	-0.003	0.046	0.078	-0.015	-0.038	0.009	0.212
ASA	-0.042	-0.188	0.105	0.573	0.003	-0.223	0.229	981	0.070	-0.147	0.286	0.526
Systolic blood pressure	-0.016	-0.158	0.126	0.820	0.025	-0.193	0.243	0.823	-0.046	-0.252	0.161	0.664
Application of premedication	-0.108	-0.528	0.312	0.611	0.248	-0.349	0.844	0.413	0.519	-0.052	1.090	0.074
Preoperative body temperature					0.604	0.375	0.833	0.000*	0.179	-0.085	0.443	0.182
Type of anesthesia					0.086	-0.118	0.289	0.407	-0.015	-0.209	0.178	0.875
Type of surgery					0.012	-0.178	0.202	0.901	0.001	-0.179	0.180	0.992
Duration of surgery					0.016	-0.028	0.060	0.471	-0.003	-0.045	0.039	0.887
Temperature of the operating room					0.378	0.237	0.520	0.000*	0.198	0.048	0.347	0.010*
Amount of fluid given during operation					0.077	-0.179	0.333	0.554	-0.019	-0.264	0.225	0.876
Application of a heating method in the operating room					0.196	-0.073	466	0.152	-0.183	-0.442	0.077	0.167
Intraoperative body temperature									0.483	0.294	0.672	0.000*
Application of a heating method during recovery									0.101	-0.212	0.415	0.523

R^2: 0.071; Corrected R^2: 0.022 R^2: 0.286; Corrected R^2: 0.212 R^2: 0.437; Corrected R^2: 0.363
ASA: American Society of Anesthesiology Classification
CI: Confidence interval
*p<0.05

mine the effect of heating on the prevention of the occurrence of inadvertent hypothermia, it was reported that the rate of hypothermia development was lower in patients undergoing intraoperative active heating. In a study conducted by Aksu et al. (14), less hypothermia was reported in patients undergoing heating during operation. As recommended in the guidelines for the prevention of inadvertent hypothermia, intraoperative heating prevents the development of inadvertent hypothermia (2, 9, 12, 27).

In various studies in literature, no statistically significant difference was found between the development of intraoperative inadvertent hypothermia and some parameters such as age, gender, BMI, ASA score, systolic blood pressure, preoperative body temperature in the clinic, type of surgery, duration of surgery, and temperature of the operating room (15, 17, 19, 28). On the other hand, in some studies, age, gender, ASA level, type of surgery, and duration of surgery were found to have an effect on the development of intraoperative hypothermia (19-21). The risk factors affecting the occurrence of intraoperative hypothermia vary. In our study, the results of univariate and multivariate regression analyses demonstrated that the variables of age, gender, BMI, systolic blood pressure, premedication, type of anesthesia, type of surgery, duration of surgery, and amount of fluid given during operation did not affect the intraoperative development of inadvertent hypothermia.

Postoperative period

In our study, the incidence of postoperative inadvertent hypothermia was detected to be 75.70% (n= 109). The incidence rates differ in the studies on hypothermia. The incidence was reported to be 13.50% in a study performed in Australia (29), 32% in a study conducted in Portugal (17), and 47.50% in a study performed in Turkey (14). It is thought that the differences among the incidence rates of inadvertent hypothermia are associated with the variations in the applications.

Preoperative body temperature affects postoperative body temperature (11, 15). Our study revealed that preoperative body temperature affected the development of inadvertent hypothermia (Table 2). In a study performed to determine the incidence of inadvertent hypothermia and risk factors, it was found that the risk of hypothermia was lower in patients having high body temperature before surgery (15). Mehta and Barclay conducted a study on patients undergoing colorectal surgery, and they reported that the development of hypothermia was 20 times higher in patients with low body temperature before surgery (22). Therefore, it is important to provide normothermia in patients before surgery and to use heating methods when needed.

It was found that the application of premedication had an effect on the development of inadvertent hypothermia (Table 2). The results of studies conducted by D'AngeloVanni et al. (30) and Matsukawa et al. (31) are consistent with ours. With other risk factors causing hypothermia, premedication leads to vasodilatation and inhibits patients to preserve their body temperatures (32).

In our study, the results of multivariate analysis showed that temperature of the operating room affected the occurrence of postoperative inadvertent hypothermia (Table 2, 3). Similar to these results, Yi et al. found a statistically significant difference between the temperature of the operating room and inadvertent hypothermia (15). In the study of Poveda et al., temperature of the operating room was reported to be associated with the development of hypothermia (33). Different from the results of our study, another study demonstrated no statistically significant difference between the temperature of the operating room and inadvertent hypothermia in patients undergoing emergency operation (34).

According to the results of univariate and multivariate regression analyses, intraoperative body temperature was found to be effective in the development of postoperative inadvertent hypothermia (Table 2, 3). In the studies that were conducted to determine the risk factors for the development of postoperative undesired hypothermia, the rate of postoperative inadvertent hypothermia was reported to be higher in patients having low body temperature during surgery (15, 24, 28). In our study, age, gender, BMI, ASA score, premedication, type of surgery, duration of surgery, amount of fluid given during operation, and the application of a heating method in the operating room and in the recovery room were found to have an effect on the development of postoperative inadvertent hypothermia.

A limitation of this study is that the body temperatures of the patients were not measured before taking them into the operating room and in the clinic after operation.

CONCLUSION

In our study, in which the incidence of inadvertent hypothermia and risk factors were examined, the incidence of hypothermia was found to be quite high. It was detected that preoperative body temperature, temperature of the operating room, and the intraoperative application of a heating method affected the development of inadvertent hypothermia.

Health staff has great responsibilities toward patients undergoing surgery in the preoperative period, in the operating room, and in the postoperative period to protect them from inadvertent hypothermia and its effects. The body temperature of patient should be checked and evaluated preoperatively, intraoperatively, and postoperatively.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Dokuz Eylül University School of Medicine (2015/28-26 - 01.17.2015).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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