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Original Article

Warmed intravenous infusion for controlling intraoperative hypothermia[1]

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Objective: to verify the effectiveness of warmed intravenous infusion for hypothermia prevention in patients during the intraoperative period. Method: experimental, comparative, field, prospective and quantitative study undertaken at a federal public hospital. The sample was composed of 60 adults, included based on the criteria of axillary temperature between 36°C and 37.1°C and surgical abdominal access, divided into control and experimental groups, using the systematic probability sampling technique. Results: 22 patients (73.4%) from both groups left the operating room with hypothermia, that is, with temperatures below 36°C (p=1.0000). The operating room temperature when patients arrived and patients' temperature when they arrived at the operating room were statistically significant to affect the occurrence of hypothermia. Conclusion: the planning and implementation of nursing interventions carried out by baccalaureate nurses are essential for preventing hypothermia and maintaining perioperative normothermia.

Descriptors: Hypothermia; Perioperative Nursing; Operating Rooms.

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Introduction

During the intraoperative period, hypothermia affects 70% of the patients and can be associated with several factors, including anesthetic agents, room temperature, time of exposure to low temperature rooms, administration of cold intravenous infusions, systemic disorders, and the presence of some risk factors, such as too old or too young patients, and the appearance of metabolic illnesses or neurological disorders[1-2].

Hypothermia is determined by body temperatures below 36°C, and can be considered light, medium or moderate and serious or severe. It consists of a medical status of body temperature below the normal one, in which the body is unable to generate sufficient heat to carry out its functions[3-5]. Normothermia occurs when the body temperature is between 36 and 38°C[4-7].

In 2009, the American Society of periAnesthesia Nurses (ASPAN) published the second edition of the guide that promoted perioperative normothermia, in accordance with evidence-based medical practice. In its recommendations, it reports the existence of evidences that alternative active measures of heating, when solely used or in combination with forced air heating, can maintain normothermia. These warming measures include the warmed intravenous infusion, warmed irrigation fluid, warmed water circulation mattresses and radiant heating[6].

In most cases, active warming has better results, in particular through heated air blanket, as it keeps the body temperature close or equal to normothermia. Concerning passive warming, some studies state that it is possible to keep normothermia, since this method operates by isolating patients from the low temperatures often found in surgical rooms, keeping the air layer disposed close to the skin and reducing body heat loss through radiation and convection[8].

In a systematic review, the authors concluded that there is moderate evidence to state that the use of carbon fiber blankets is as effective as the forced air warming system in avoiding hypothermia, and that the use of circulating-water garment would be the most effective method to preserve normothermia[9].

Although the active forced air warming and the use of carbon fiber blankets have presented the best results, this type of prevention of intraoperative hypothermia is limited due to the financial investment required.

ASPAN reports the existence of evidence about the effectiveness of alternative active warming measures, including the administration of warmed intravenous infusion, in order to maintain intraoperative normotherapy, by itself or in combination with another warming method. Based on the above, the following question arises: does the warmed intravenous infusion prevent intraoperative hypothermia?

Therefore, based on the need to investigate effective ways to prevent intraoperative hypothermia, this study is aimed at verifying the effectiveness of the warmed intravenous infusion in preventing patients' hypothermia during the intraoperative period.

Methods

The methodological approach was quantitative and it had an experimental, comparative, field and prospective design.

The study was undertaken in the surgical center of a public, general and large hospital located in the capital city of the state of Minas Gerais. The surgical center has 16 operating rooms (OR) designed for care delivery in all areas. Two ORs were selected for the study, since they had similar features in relation to bioengineering and environmental temperature, as follows: temperatures between 19°C and 24°C and relative air humidity level between 45% and 60%, in accordance with the Ministry of Health's recommendations[10].

The research project received approval from the Research Ethics Committee of *Universidade Federal de Minas Gerais*, in compliance with National Health Council Decree 196/96, under registration number ETIC 310/09.

All participants signed the Informed Consent Form after the researcher had provided information about the study and its objectives. These clarifications and signatures took place in the patients' rooms, on the day of surgery, before administration of pre-anesthetic medication, when required.

The sample inclusion criteria were: to have signed the Informed Consent Form, to be an adult over 18 years of age, to be having an elective surgical procedure, to have a conventional or minimum abdominal surgical access, to have taken general anesthetic with anesthetic time of at least one hour, to be under physical classification I to III of the American Society Anesthesiologists (ASA) and to have axillary body temperature between 36°C and 37.1°C when entering the OR[3].

Patients with predisposition to temperature changes were excluded, such as thyroid and neurological disorders, extreme weight, ASA classification IV to VI and axillary body temperature under 36°C or over 37.1°C when entering the OR.

The sample was composed of 60 patients, and defined according to the number of predictive variables initially proposed, using five patients in relation to each of the variables from the multiple regression model[11].

The study groups were constituted by using the systematic random sampling technique, that is, a draw was held to determine the group of the first patient of the sample, whether it was the Experimental Group (EG) or the Control Group (CG), who was selected for the EG, and from this, the second patient was selected for the CG, and so forth, successively intercalated until 30 patients were selected for each group.

The EG participants received warmed intravenous infusion during the whole anesthetic-surgical procedure and the CG's participants did not receive any specific care to prevent hypothermia, in accordance with the institution's procedures. All participants received passive warming provided by a cover sheet.

The venous infusion warming was done through a Fanem incubator, line 502, version A, with electronic thermostats and kept at 40°C, thereby providing that the infusions were maintained at temperatures between 37°C and 38°C. Tests were applied for adjusting the incubator temperature with the venous infusion temperature, for the purpose of controlling the venous infusion temperature, based on the upper body temperature limit considered normal.

For data collection, an instrument was developed and submitted to content validation by four judges, being two baccalaureate nurses providing assistance at the surgical center, and two university professors in charge of study subjects that approach contents related to perioperative care.

Patients' data collected were related to the group they belonged to (CG or EG), gender, age, comorbidities, ASA classification, body temperature at the time of entry and exit from the OR. Concerning the anesthetic-surgical procedure, the data collected was related to the type of surgery performed, contamination potential[12], and duration of surgery and anesthesia. The environmental data collected were temperature and relative air humidity level in the OR, both at the time of entry and exit of the patient, using a thermometer of the brand Thermometer, which was positioned at one meter from the head of the operating table.

The measurement of patients' axillary temperature was done both at the time of entry and exit from the OR, by using the digital medical thermometer Pro Check TH186. One of the researchers collected the data between May 2011 and April 2012.

The software used for data analysis was R, version 2.13.1. The Mann-Whitney test was used to verify the homogeneity between the CG and the EG, which was applied to compare the quantitative variables, presenting the results in arithmetic averages, median, maximum and minimum values, standard deviation with significance level of 5%.

The Chi-squared test was used for the quantitative variables, and Fisher's Exact test was used for the qualitative variables, when the expected values in the contingency table were less than five.

In order to select the variables that significantly affect the occurrence of hypothermia, the selection method Stepwise was used, through logistic regressions. As the entry criterion ("Forward") in the multi-varied logistic regression, the significance level was 20%, and as the exit criterion ("Backward"), the significance level was 5%.

Concerning the variables that significantly affect the occurrence of hypothermia, it was verified through multi-varied logistic regression whether there were significant differences between the control and the experimental groups, thus controlling for possible confusing factors.

Results

The results are shown with data relating to patients' features, anesthetic-surgical procedure, body and room temperature.

Patients' features

With regards to gender, there were similarities between the groups, with predominance of females, being 23 (76.6%) and 22 (73.3%) female, and 7 (23.4%) and 8 (26.7%) male, in the CG and EG respectively (p=0.7660).

The average age of patients in the CG was 45.4, the median was 45.5, and the standard deviation was 2.48, showing a minimum age of 18 and a maximum of 69. In the EG, the average age was 49.6, the median 54.0, the standard deviation was 2.74, showing a minimum age of 20 and a maximum of 81 (p=0.2608).

The most frequent comorbidities were: systemic arterial hypertension, followed by Diabetes Mellitus. In the CG, 14 (46.6%) and in the EG, 9 (30.0%) patients had systemic arterial hypertension (p=0.1840). As for Diabetes Mellitus, both groups had 4 (13.3%) patients (p=1.0000).

The ASA assessment of physical condition was similar, with predominance of ASA II in both groups,

being 20 (66.6%) in the CG and 18 (60.0%) in the EG. Only one patient in the EG was classified under ASA III (p=0.793).

Features of anesthetic-surgical procedure

An inclusion criterion for the sample was an abdominal access in the surgical procedure. The procedures performed showed similarities between the groups in relation to the type and classification of the potential contamination.

The most frequent procedure in both groups was laparoscopic cholecystectomy, due to cholelithiasis, with 8 (26.6%) in the CG and 6 (20.0%) in the EG, followed by videolaparoscopy, due to disorders such as endometriosis, uterine fibroids, ovarian cysts, among others, with 5 (16.6%) in the CG and 8 (26.6%) in the EG.

Concerning the potential for contamination, the procedures classified as clean were 22 and 21, potentially contaminated 4 and 6, contaminated 3 and 3, infected 1 and zero, in the CG and the EG respectively (p=0.911).

Table 1 – Features of the duration of anesthetics and surgery. Belo Horizonte, MG, Brazil, 2011

Variables	Groups	Average	Standard Error	Median	Minimum	Maximum	p-value
Duration of anesthetics (minutes)	Control	183.80	14.69	175.0	60.0	330.0	0.9646
	Experimental	183.53	15.04	165.0	80.0	400.0	
Duration of surgery (minutes)	Control	148.77	14.04	140.0	45.0	285.0	0.6253
	Experimental	139.00	13.77	102.5	60.0	340.0	

According to Table 1, the average duration of anesthetics and surgery was similar between the groups.

Features of body temperature

The median temperature of patients at the time of entry into the OR was 36.4°C in the CG and 36.1°C in the EG, and this difference was marginally significant (p=0.0562). At the time of exit from the OR, the median temperature was 34.7°C in the CG and 34.3°C in the EG, with maximum of 35.6°C in the CG and 36.2°C in the EG, which were not statistically significant (p=0.7113).

Table 2 – Features of patients' body temperature at the time of entry and exit from the operating room. Belo Horizonte, MG, Brazil, 2011

Variables	Groups	Average	Standard Error	Median	Minimum	Maximum	p-value
Patients' temperature at the time of entry into the OR (°C)	Control	36.35	0.05	36.4	36.0	36.9	0.0562
	Experimental	36.25	0.06	36.1	36.0	37.1	
Patients' temperature at the time of exit from the OR (°C)	Control	34.43	0.16	34.7	32.7	35.6	0.7113
	Experimental	34.33	0.20	34.3	32.0	36.2	

Defining hypothermia as patients' temperature below 36°C at the time of exit from the OR, 44 cases of hypothermia were observed in the two groups, being that 50.0% occurred in the CG and 50.0% in the EG.

Both in the CG and the EG, 8 (26.6%) patients showed no hypothermia and 22 (73.4%) patients left the OR with temperatures under 36°C (p=1.0000), Odds ratio 1.00 and IC 95%: 0.318 – 3.14.

Environmental features

The humidity level in the OR, both at the time of entry and exit of patients, showed a higher median in relation to the CG when compared to the EG, being this a significant difference at the time of entry (p=0.0000) and exit (p=0.0001).

Table 3 – Features of the operating room in relation to temperature and humidity level. Belo Horizonte, MG, Brazil, 2011

Variables	Groups	Average	Standard Error	Median	Minimum	Maximum	p-value
Temperature of the OR at the time of patients' entry (°C)	Control	23.69	0.11	24.0	22.2	24.8	0.1776
	Experimental	24.07	0.25	24.2	21.7	26.7	
Temperature of the OR at the time of patients' exit (°C)	Control	23.07	0.19	23.3	20.8	24.6	0.8416
	Experimental	23.64	0.38	23.1	21.4	29.5	
Humidity level of the OR at the time of patients' entry (%)	Control	55.13	0.51	55.0	45.0	60.0	0.0000
	Experimental	49.73	1.05	49.5	42.0	64.0	
Humidity level of the OR at the time of patients' exit (%)	Control	54.20	0.56	55.0	44.0	59.0	0.0001
	Experimental	48.33	1.08	47.5	38.0	59.0	

Table 4 – Proportion of patients in the CG and the EG, according to the changeable variables for the occurrence of hypothermia. Belo Horizonte, MG, Brazil, 2011

Univariate logistic regressions	β	S(β)	p-value	Odds ratio	LI	LS
Intercept	1.010	0.413	0.014	-	-	-
Group=Experimental	0.000	0.584	1.000	1.00	0.32	3.14
Intercept	1.870	0.760	0.014	-	-	-
Gender=Female	-1.080	0.825	0.192	0.34	0.07	1.71
Intercept	-0.755	1.010	0.455	-	-	-
Age (Years)	0.039	0.022	0.077	1.04	1.00	1.08
Intercept (ASA=I)	0.693	0.463	0.134	-	-	-
ASA=II	0.477	0.600	0.427	1.61	0.50	5.22
Intercept	0.860	0.360	0.017	-	-	-
Systemic Arterial Hypertension=Yes	0.421	0.620	0.498	1.52	0.45	5.14
Intercept	0.903	0.306	0.003	-	-	-
Diabetes Mellitus=Yes	1.040	1.110	0.348	2.83	0.32	24.92
Intercept	1.190	0.345	0.001	-	-	-
Other comorbidities = Yes	-0.716	0.666	0.283	0.49	0.13	1.80
Intercept (CPCC=Clear)	1.070	0.350	0.002	-	-	-
CPCC=Potentially contaminated	-0.221	0.774	0.776	0.80	0.18	3.65
CPCC=Contaminated	-0.375	0.934	0.688	0.69	0.11	4.29
Intercept	0.856	0.728	0.240	-	-	-
Anesthetics duration (hours)	0.051	0.221	0.816	1.05	0.68	1.62
Intercept	0.996	0.631	0.114	-	-	-
Surgery duration (hours)	0.006	0.234	0.978	1.01	0.64	1.59
Intercept	79.500	35.100	0.023	-	-	-
Patients' temperature at the time of entry into the OR (°C)	-2.160	0.964	0.025	0.12	0.02	0.76
Intercept	17.600	7.360	0.017	-	-	-
Temperature of the OR at the time of patients' entry (°C)	-0.692	0.304	0.023	0.50	0.28	0.91
Intercept	9.050	4.330	0.037	-	-	-
Temperature of the OR at the time of patients' exit (°C)	-0.342	0.183	0.062	0.71	0.50	1.02
Intercept	-2.390	2.910	0.412	-	-	-
Humidity level in the OR at the time of patients' entry (%)	0.065	0.056	0.244	1.07	0.96	1.19
Intercept	-3.040	2.650	0.251	-	-	-
Humidity level in the OR at the time of patients' exit (%)	0.080	0.052	0.127	1.08	0.98	1.20

Table 4 shows the variables analyzed with the purpose of verifying the factors that affect hypothermia in a univariate manner, and selecting potential predictors to participate in the multivariate model. The inclusion criterion for the multivariate regression was to have a p-value under 0.20.

It can be noted that the variables selected to compose the multivariate model with p-value under 0.20 were: age, gender, patients' temperature at the time of entry into the OR, temperature of the OR at the time of patients' entry, temperature of the OR at the time of patients' exit and relative air humidity in the OR at the time of patients' exit.

It can also be noted that patients' temperature at the time of entry into the OR significantly affects (p=0.025) the occurrence of hypothermia, with each 1°C increase in this temperature meaning a reduction of 0.12 times in the risk of hypothermia. It is interesting to observe that the maximum extent of patients' temperature was 1.1°C.

The temperature in the OR at the time of patients' entry significantly affects (p=0.023) the occurrence of hypothermia, being that each 1°C increase in this temperature reduces by half the risk of hypothermia.

Table 5 – Distribution of variables selected for multivariate logistic regressions for the occurrence of hypothermia. Belo Horizonte, MG, Brazil, 2011

Multivariate logistic regression	β	S(β)	p-value	Odds ratio	LI	LS
Intercept	99.76	40.86	0.0146	-	-	-
Patients' temperature at the time of entry into the OR (°C)	-2.23	1.05	0.0341	0.11	0.01	0.85
Temperature of the OR at the time of patients' entry (°C)	-0.74	0.35	0.0342	0.48	0.24	0.95

A multivariate regression was performed with all the selected factors. Through the use of the Backward procedure at 5% significance level, it could be noted that either the patients' temperature at the time of entry into the OR or the temperature of the OR at the time of patients' entry were significant, concerning the effect it had over the occurrence of hypothermia.

For each 1°C increase in the patients' temperature at the time of entry into the OR, the risk of hypothermia is decreased by 0.11 times, or for each 1°C that is added to patients' temperature at the time of entry into the OR, the chance of hypothermia not occurring increases by 8.33 times.

For each 1°C increase in the temperature of the OR at the time of patients' entry, the risk of hypothermia is decreased by 0.48 times, or for each 1°C that is added to the temperature of the OR at the time of patients' entry, the chance of hypothermia not occurring increases by 2.08 times.

Discussion

The results showed that, in the CG as well as in the EG, 22 (73.4%) patients were hypothermic when they left the OR, with body temperatures under 36°C, and that the statistically significant variables to affect hypothermia were the patients' temperature at the time of entry into the OR and the temperature of the OR at the time of the patients' entry.

Patients' temperature at the time of entry into the OR was a controlled variable in this study, ranging between the maximum and minimum values of 1.1°C. The statistic tests showed that, for each 1°C increased to patients' temperature at the time of entry into the OR, the risk of hypothermia is reduced and the chance of hypothermia not occurring is increased.

Based on the above, the need for interventions to prevent hypothermia and maintain normothermia is noted, both in the intraoperative and pre-operative periods.

ASPAN makes recommendations in relation to the maintenance of perioperative normothermia during pre, intra and post-operative periods. The recommendations in the pre-operative period of patients' assessment include evaluating risk factors for patients in relation to perioperative hypothermia, measuring patients' temperatures at hospital admission, determining the level of thermal comfort, evaluating signs and symptoms of hypothermia such as tremors, piloerection and cold extremities, and documenting and communicating the entire evaluation of risk factors to all members of the anesthetic and surgical teams[6].

The pre-operative interventions include implementing passive measures of thermal care, maintaining the room temperature at 24°C or over, establishing active heating for hypothermic patients, considering pre-operative heating to reduce the risk of intraoperative and post-operative hypothermia, and it also mentions evidences suggesting that pre-heating for at least 30 minutes can reduce the risk of subsequent intraoperative hypothermia[6].

The implementation of methods to maintain patients' normothermia at the perioperative period is essential. In this context, it is the nurses' responsibility to implement effective measures that promote prevention or treatment of hypothermia and consequently the reduction of complications associated to this event[13].

In passive heating, one single layer can reduce heat loss by 30%; however, the use of an active skin surface heating system is proven more effective to maintain patients' normothermia during the perioperative period[14-15].

A study involving adults undergoing elective abdominal surgeries showed that warming the skin surface for an hour during the pre-operative period, in combination with heating the skin surface during the first two hours of surgery, stops the redistribution of hypothermia[16].

Prevention of hypothermia improves patients' post-operative outcomes[17-18]. Nurses should lead and proactively implement nursing measures aimed at maintaining patients warm during all stages of the perioperative period. During the pre-operative period, nurses may suggest to patients using a pair of socks and a head covering, and explain the benefit of keeping warm[17].

In this research, the surgeries had abdominal access. Hypothermia can also be associated with patients undergoing abdominal cavity surgeries because of the exposure, generally long, of the large visceral surface to the operating room temperature when the conventional approach is used[19].

Measures to prevent hypothermia and to maintain normothermia should be the responsibility of nurses from the healthcare unit where patients are first assisted, who should promote measures for patients to arrive to the OR with body temperatures close to the higher limit of normothermia.

The temperature of the OR at the time of patients' entry was another significant variable in the development of intraoperative hypothermia. This variable was controlled in accordance with the Ministry of Health's recommendations, which is between 19°C and 24°C[10]. The statistical tests showed, within this temperature range, a reduction in the risk of hypothermia and an increase in the chance of hypothermia not occurring for each 1°C that is increased to the temperature of the OR at the time of patients' entry.

Among the results shown in a study involving 70 patients aimed at analyzing the factors related to the changes of body temperature in patients undergoing elective surgery, during the intraoperative period the temperature of the OR was one of the significant variables directly related to the average body temperature of these patients[13].

In a literature review, it was indicated that the temperature of the OR is a factor that affects patients' heat loss, since the reduction of room temperature leads to an increase in heat loss through transference from the patient to the room[20].

The intraoperative interventions recommended by the ASPAN to all patients, among others, is to maintain room temperature between 20°C and 25°C, in accordance with the recommendations of the Association periOperative Room Nurse (AORN)[6].

Sufficiently high room temperature, over 23 ºC, will maintain or restore normothermia during anesthesia; however, it causes thermal discomfort for the anesthetic-surgical team, thus negatively affecting their cognitive performance. Consequently, active or passive warming strategies should be employed[15].

The variables shown to affect thermoregulation in another study were the position of patients on the operating table, the control of room temperature, the warming of fluids and the use of blankets. That study also highlighted the need for studies to explore variables such as drugs and anesthesia in relation to body temperature[21].

Conclusion

The results of this research allowed to conclude that the use of heated intravenous infusion on its own in patients during the intraoperative period does not prevent hypothermia, showing that the same number of patients from the CG and the EG left the OR with body temperatures below 36°C.

The variables selected to compose the multivariate model that were related to body temperature were gender, age, patients' temperature at the time of entry into the OR, temperature of the OR at the time of entry and exit of patients and humidity level in the OR at the time of patients' exit.

The variables that were statistically significant in the development of intraoperative hypothermia were patients' temperature at the time of entry into the OR and the temperature of the OR at the time of patients' entry.

Measures should be planned and implemented by nurses, starting from the pre-operative period, which include passive warming with a sheet and blankets and minimum possible exposure of body surface, so that patients arrive warm at the OR.

Room temperature should also be controlled and the results allowed to conclude that the temperature of the OR, even within the normal limits, for each 1°C increase in room temperature, the risk of patients developing hypothermia decreases.

It can also be concluded in this research that the use of heated intravenous infusion on its own does not prevent perioperative hypothermia, and this should be associated with patient warming measures during the

pre-operative period and control of room temperature in the operating room.

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