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FACTORS ASSOCIATED TO THE DEVELOPMENT OF HYPOTHERMIA IN THE INTRAOPERATIVE PERIOD[1]

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This study aimed to assess factors associated to body temperature changes intraoperatively in patients undergoing elective surgery. A prospective study including 70 patients was carried out in a charity hospital. A data collection instrument was developed and its face and content validity was established. The variables measured were operating room temperature and humidity and patient body temperature at different times. In the multivariate linear regression, the variables type of anesthesia, duration of anesthesia, body mass index, and operating room temperature were directly associated to mean body temperature. Nurses are responsible for planning and implementing effective interventions that can contribute to minimize costs and most importantly reduce hypothermia complications.

DESCRIPTORS: hypothermia; perioperative nursing; research

FACTORES RELACIONADOS AL DESARROLLO DE HIPOTERMIA EN EL PERÍODO INTRAOPERATORIO

La investigación tuvo como objetivo analizar los factores relacionados a las alteraciones de la temperatura corporal del paciente sometido a cirugía electiva en el período intraoperatorio. Para esto, se realizó un estudio de correlación, prospectivo, en un hospital filantrópico. Fue elaborado un instrumento y sometido a validación aparente y de contenido, el cual fue utilizado para recolectar datos de 70 pacientes. La temperatura y humedad de la sala de operación y la temperatura corporal del paciente, en diferentes momentos, fueron las variables mensuradas. En la regresión linear multivariada, las variables: tipo de anestesia, duración de la anestesia, índice de masa corporal y temperatura de la sala de operación estaban directamente relacionadas a la temperatura corporal promedio de los sujetos investigados. Es el enfermero quien debe planificar e implementar intervenciones efectivas que contribuyan para minimizar los costos y principalmente reducir las complicaciones asociadas a la hipotermia.

DESCRIPTORES: hipotermia; enfermería perioperatoria; investigación

FATORES RELACIONADOS AO DESENVOLVIMENTO DE HIPOTERMIA NO PERÍODO INTRA-OPERATÓRIO

A pesquisa teve como objetivo analisar os fatores relacionados às alterações da temperatura corporal do paciente submetido à cirurgia eletiva no período intra-operatório. Para tal, realizou-se estudo correlacional, prospectivo, em um hospital filantrópico. Foi elaborado um instrumento e submetido à validação aparente e de conteúdo, o qual foi utilizado para a coleta de dados de 70 pacientes. A temperatura e umidade da sala de operação, a temperatura corporal do paciente em diferentes momentos foram as variáveis mensuradas. Na regressão linear multivariada, as variáveis tipo de anestesia, duração da anestesia, índice de massa corporal e a temperatura da sala de operação estavam diretamente relacionadas à temperatura corporal média dos sujeitos investigados. Compete ao enfermeiro o planejamento e implementação de intervenções efetivas que contribuam para minimizar custos e principalmente reduzir as complicações associadas à hipotermia.

DESCRITORES: hipotermia; enfermagem perioperatória; pesquisa

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BACKGROUND

Hypothermia is a common event that affects more than 70% of patients undergoing anesthesia/ surgery and it may cause major complications[1]. This event occurs mainly due to anesthetic agent actions on thermoregulation and reduced patient metabolism[2].

Another major contributing factor to hypothermia is patient exposure to the operating room's (OR) cold environment, at temperatures ranging from 18ºC to 23ºC. In addition to preventing microorganism proliferation, at this temperature range, the team of providers feels comfortable wearing surgical clothing. However, surgical patients are usually naked in the OR and will be submitted to several situations that lead to heat loss, such as application of cold skin antiseptics, exposure of large skin areas, thoracic or abdominal cavity opening, administration of cold solutions, and inhalation of cold anesthetic agents[3].

The complications associated to the development of hypothermia include changes in drug metabolism and protein metabolism that can compromise tissue healing, changes in serum potassium levels, chills, increased metabolic demand postoperatively, peripheral vasoconstriction, reduction of subcutaneous oxygen tension, inhibition of cascade enzymatic reactions of coagulation, and coagulation and platelet function abnormalities, thus increasing intraoperative bleeding and the need for postoperative transfusions. In addition, heart arrhythmia and ischemia and organ dysfunctions may occur and increase post-anesthesia care unit (PACU) and hospital stay, surgical site infection, pressure ulcers and mortality. Thermal discomfort is also remarkable during surgery, which lowers patient satisfaction with the anesthesia/surgery experience[1,4-5].

Besides being associated to hypothermia complications, prolonged PACU stay increases overall hospital costs because, additionally to intensive care, transfusions, supplementary drugs and laboratory tests, among others, are required[6].

Maintenance of perioperative normothermia can reduce bleeding intraoperatively, reduce surgical site infection and PACU stay, and provide thermal comfort to patients and thus greater satisfaction, as well as lower hospital costs. This is a challenge nurses practicing in Brazil have to face, as they usually work in settings with minimum support for maintenance of intraoperative patient body temperature. Allied to that, there are scarce Brazilian studies investigating hypothermia-related issues, as well as effective methods for prevention and treatment of this complication. Further studies are needed to provide input to better understand this issue, which can contribute to better perioperative nursing care[7].

Since hypothermia is recognizably a harmful event for surgical patients, the objective of the present study was to assess factors associated to body temperature changes intraoperatively in patients undergoing elective surgery.

METHODS

A prospective, descriptive, correlational study was conducted using a quantitative approach. The study was carried out in a 109-bed charity hospital in the interior of the State of São Paulo, southeastern Brazil.

It was approved by the Research Ethics Committee of Universidade de São Paulo Ribeirão Preto Nursing School and authorized by the selected hospital. All subjects signed a free and informed consent form after the investigator had explained the study procedures.

Inclusion criteria included: patients aged 18 years or more undergoing elective surgery; at least one-hour duration of anesthesia. Patients with body temperatures equal to or above 38ºC and below 36ºC upon entrance in the OR were excluded.

A data collection instrument was developed and its face and content validity was established by three judges. The instrument's final version included information on patient characteristics, anesthesia/ surgery, and room temperature and patient body temperature.

Patient body temperature was measured at different times: upon the patient's arrival at the operating area, upon entrance in the OR, at the start of anesthesia, and then every 20 minutes throughout the entire anesthesia/surgery. Temperatures were measured using an infrared tympanic thermometer (ProCheck®, Canada) with ±0.2ºC precision. It is a reliable non-invasive method recommended by the American Society of PeriAnesthesia Nurses (ASPAN)[8].

OR temperature and humidity were measured using a thermohygrometer (Minipa®, Brazil) with ±1ºC precision for indoor temperature and ±8% for room relative humidity (RH). This equipment was positioned about one meter away from the patient's head and on the same side where the tympanic temperature was measured. Measures were taken upon the patient's entrance in the OR, at the start of anesthesia and then every 20 minutes throughout the entire anesthesia/surgery.

One of the researchers collected all data and performed all measures using the same equipment between August 2006 and June 2007.

Results were presented as means, standard deviations (SD), medians, and minimum and maximum values. Multiple regression analysis was performed to evaluate percentage variance of the model explained by each predictive variable (described below) for mean patient body temperature variability.

Bivariate analysis through parametric statistics was carried out for the selection of variables to be included in the final model. Student's t-test was used in the analysis of differences between mean body temperatures by gender, chronic conditions (if any or not), and blood transfusion (if any or not).

Pearson's correlation coefficient was used to assess the correlation between mean patient body temperature and the following variables: duration of anesthesia, duration of surgery, body mass index (BMI), mean OR temperature and age.

ANOVA was used to assess differences between mean patient body temperature by type of anesthesia (general, regional or combined).

Variables with p-value equal to or lower than 0.20 (conservative model) were included in the model and then multiple regression analysis was carried out.

The sample size was defined according to the first proposed number of predictive variables. i.e., five to 10 subjects for each predictive variable included in the multiple regression model, which yielded a final sample size of 70 subjects[9].

The distribution normality of each variable was analyzed in the Kolmogorov-Smirnov test[10-11].

Data were double entered and analyzed using the Statistical Package for the Social Sciences (SPSS 10.0). A 5% level of significance was adopted.

RESULTS

Description of the sample, patient body temperature, OR temperature and humidity

Of all 70 subjects, mean age was 53.6 years (SD: 15.4 years); of them, 46 (65.7%) were females and 24 (34.2%) were males (Table 1).

Mean and median BMI were 25.3 and 24.9 kg/m^2, respectively. Based on medical records and anesthesiology reports, most subjects (49 patients; 70%) were classified as ASA 2, 13 patients (18.5%) as ASA 1, seven (10%) as ASA 3, and one unknown (Table 1).

Table 1 – Categorical variable distribution of 70 subjects studied. Jacareí, Brazil, 2006–2007

Variables	N	%
Gender		
Female	46	65.7
Male	24	34.2
ASA Classification*		
ASA 1	13	18.5
ASA 2	49	70
ASA 3	7	10
Unknown	1	1.4

* American Society of Anesthesiologists

Table 2 – Characterization of duration of anesthesia and type and duration of surgery in the study sample. Jacareí, Brazil, 2006–2007

Variables	N (%)	Mean±SD*	Median	Range
Duration of anesthesia (minutes)		158.2±53.7	150	75-280
Type of anesthesia				
General	54 (77.1)	151±54.2	140	75-280
Regional	7 (10)	167.1±59.9	170	80-270
Combined	9 (12.9)	194.4±29	195	150-250
Duration of surgery (minutes)		111±48.1	100	40-230

* Standard deviation

Table 2 shows that mean and median duration of anesthesia were 158.2 and 150 minutes (SD: 53.7 minutes). Of 70 subjects studied, 54 (77.1%) underwent general anesthesia, nine (12.9%) combined anesthesia (general + spinal), and seven (10%) regional anesthesia (spinal or epidural). Duration of anesthesia was greater among those undergoing combined anesthesia, with a mean duration of 194.4 minutes (SD: 29 minutes).

Surgical procedures had mean and median duration of 111 and 100 minutes, respectively (SD: 48.1 minutes), ranging from 40 (minimum) to 230 minutes (maximum).

The most common surgical procedures performed were laparoscopic cholecystectomy (18 subjects; 25.7%), followed by laparoscopic hiatal hernia repair (7 subjects; 10%), and prostatectomy (6 patients; 8.6%).

As for body temperature, upon the patient's arrival in the OR, mean and median body temperature were 36.4ºC, then it dropped to 36.2ºC at the start of anesthesia, and mean and median temperatures were 35.6ºC at the start of surgery. By the end of anesthesia/surgery, mean patient body temperature was 33.6ºC and median 33.7ºC (SD: 0.2ºC).

Mean OR temperature upon the patient's arrival was 24.6ºC, against 22.4ºC in the fourth hour of anesthesia/surgery. Mean OR humidity upon the patient's arrival was 48.6%, against 49.3% in the fourth hour.

Association between patient body temperature and the study variables

The following results were obtained in the statistical analyses including the study variables.

The distribution normality of body temperature in males (variable: gender) among those receiving blood transfusions (variable: blood transfusion) and those receiving regional and combined anesthesia (variable: type of anesthesia) was verified using the Kolmogorov-Smirnov test.

Pearson's correlation test showed statistically significant negative correlations between mean patient body temperature and duration of anesthesia ($r=-0.45$; $p\cong0$) and duration of surgery ($r=-0.43$; $p\cong0$), i.e., the longer the anesthesia or the surgery, the lower the patient body temperature.

BMI and mean OR temperature were positively correlated to mean patient body temperature ($r=0.30$; $p=0.014$ and $r=0.43$; $p\cong0$, respectively), i.e. the higher the patient BMI or the room temperature, the higher the patient body temperature.

A total of 14 (20%) subjects received blood transfusions. A statistically significant difference ($t=2.41$; $p=0.019$) in mean body temperatures was found between those who received transfusions and those who did not.

Although Student's t-test did not show any statistically significant difference between mean patient body temperature and gender ($t=1.83$; $p=0.07$), this variable was included in the final model, as it was established in the methods that those variables with p-value equal to or lower than 0.20 (conservative model) would be included in the multiple regression analysis.

With regard to type of anesthesia, a statistically significant difference between mean body temperatures and type of anesthesia (general, regional, and combined) ($F_{(2;67)}=8.221$; $p=0.01$) was found through ANOVA, and those undergoing combined anesthesia had lower mean body temperatures.

The statistical significance values for age and chronic conditions were above 0.20 ($r=-0.07$; $p=0.55$ and $t=-0.31$; $p=0.75$, respectively) and, thus, these variables were not included in the final model.

The following predictive variables were included in the multivariate linear regression model: gender, blood transfusion, type of anesthesia, duration of anesthesia, duration of surgery, BMI, and mean OR temperature.

In the complete model including all predictive variables, 53.8% variance was found, defined by mean room temperature ($\beta=0.45$; $p\cong0$), BMI ($\beta=0.34$; $p\cong0$), duration of anesthesia ($\beta=-0.61$; $p=0.03$), and type of anesthesia ($\beta=-0.23$; $p=0.01$). In a second, third, and fourth model, after the exclusion of the least significant variables, that is, gender in the first model, blood transfusion in the second and duration of surgery in the third, the same results were found with the expected b and p-value changes, i.e. mean OR temperature ($\beta=0.43$; $p\cong0$), BMI ($\beta=0.35$; $p\cong 0$), duration of anesthesia ($\beta=-0.37$; $p\cong0$), and type of anesthesia ($\beta=-0.22$; $p=0.014$) explained 55.3% of total variance in the model.

It was thus verified that type of anesthesia, duration of anesthesia, BMI and mean OR temperature were directly associated to mean body temperature of the subjects studied.

DISCUSSION

In the present study, duration of surgery had a negative significant correlation with mean patient body temperature, i.e. the longer the duration of surgery, the lower the patient's body temperature. These findings are consistent with ASPAN guidelines, which point out type and duration of surgery as risk factors for hypothermia[8].

Some authors have shown that hypothermia is more commonly seen in long surgical procedures because body temperatures drop more markedly within the first 40 to 60 minutes after the start of anesthesia[1].

In the present study, a statistically significant difference was found between blood transfusion and mean patient body temperature.

In a meta-analysis of 18 studies investigating adverse effects to patients due to hypothermia, the authors pointed to increased bleeding and, consequently, need for blood transfusions, as well as longer intensive care and hospital stay. These studies also showed significant increase in the number of whole blood, plasma, and platelet units required for surgical patients with hypothermia(12).

Most subjects in the present study underwent general anesthesia (54 patients; 77.1%) and a negative statistically significant correlation was found between duration of anesthesia and mean patient body temperature, i.e. the longer the anesthesia, the lower the patient's body temperature. A statistically significant difference was also evidenced between the different types of anesthesia and mean patient body temperature, that is to say, those undergoing combined anesthesia had lower mean body temperatures. These findings corroborate the literature, indicating that the combination of general and regional anesthesia poses higher risk of hypothermia. Impaired core thermoregulation allied to inability to produce a thermoregulatory response in the legs can produce more severe hypothermia than when either general or regional anesthesia is administered separately(2-3).

During general anesthesia, after anesthetic induction, body temperature first drops due to internal redistribution of heat from the core to the peripheral compartment of the human body, and then temperatures falls linearly (0.5 to 1ºC per hour). This linear phase lasts as long as there is a difference between metabolic production and heat loss to the environment. Below a certain temperature, vasoconstriction and reduced heat flow occur between the core and peripheral compartments, resulting in reduced internal heat redistribution and loss to the environment (plateau phase). A new thermal equilibrium is attained between the core and peripheral compartments but at lower temperatures(2-3).

During regional anesthesia, internal heat redistribution is limited to the lower limbs and therefore less significant. The linear phase of hypothermia occurs at higher temperatures and at a lower rate since the metabolic heat production is close to normal. In contrast, due to the extent of sympathetic and motor blocks, this linear phase is not discontinued because nerve block prevents thermoregulatory vasoconstriction(2-3).

Monitoring and maintaining body temperature perioperatively are key for patient care regardless of the type of anesthesia selected, because patients have a major risk of developing hypothermia and their body temperature should be carefully managed(13).

Mean (25.3 kg/m^2) and median (24.9 kg/m^2) BMI of the study subjects showed they were either overweight or normal weight, respectively(14) This variable had a positive correlation, i.e., the greater the BMI the higher the patient body temperature.

A study tested the hypothesis whether core temperature was associated to body fat or BMI during the phase of internal heat redistribution. These authors investigated 40 patients undergoing colon resection elective surgery. They found that the reduction of core temperature during the first hour of surgery was inversely proportional to body fat percentage or BMI. Obese patients require shorter warming period with an active skin warming system compared to non-obese patients, especially in short-duration surgery, when hypothermia is often caused by internal heat redistribution(15).

In the present study, mean OR temperatures showed slight variations, ranging between 22.4 and 24.1ºC intraoperatively. These findings are consistent with ASPAN guidelines, suggesting that OR temperature should be between 20ºC and 24ºC(8). This variable had a statistically significant positive association with mean patient body temperature, i.e. the higher the OR temperature, the higher the patient body temperature.

The Association of PeriOperative Registered Nurses (AORN)(16) appoints that patient heat loss through skin, by radiation and convection, as well as evaporation due to the use of antiseptic skin solutions, will be determined by OR temperature.

A literature review showed that OR temperature is a major factor of intraoperative heat loss because low room temperatures lead to increased heat loss by radiation from the patient's skin to the environment(17).

Besides avoiding complications for surgical patients, prevention of perioperative hypothermia can reduce hospital costs. The maintenance of patient normothermia in OR can lead to cost savings between $2,500 to $7,000 per patient(12). It usually requires two to five hours to restore normothermia in patients depending on hypothermia severity and patient age. The cost of one hour of care at PACU is estimated at

$100, which means an additional cost between $200 to $500 for normothermia recovery of hypothermic patients[18].

CONCLUSION

Based on the present study findings, it can be concluded that:

- No statistically significant difference was found between mean patient body temperature and the variables gender, age, and chronic condition;
- A statistically significant difference was found between mean patient body temperature and the variables duration of anesthesia, type of anesthesia, duration of surgery, OR temperature, BMI, and blood transfusion;
- In the multivariate linear regression analysis, the variables type of anesthesia, duration of anesthesia, BMI, and OR temperature were directly associated to mean body temperature of the subjects studied.

Nurses play a crucial role in the prevention or treatment of perioperative hypothermia. Maintaining normothermia can reduce costs to the hospital and patients and, more importantly, reduce risk of complications. The implementation of protective actions against hypothermia may have a strong impact on patient safety and nurses should lead the surgical team to eliminate this complication[19].

Better understanding of factors associated to the development of hypothermia in Brazilian settings provides evidences to support nurses' decision making to implement interventions for hypothermia prevention or treatment. Nurses should also bear in mind that passive warming measures (cotton sheets or blankets) are not sufficient; active warming systems are required (e.g., forced-air warming system), as well as other adjuvant measures, such as warming IV fluids and solutions to be flushed into abdominal, pelvic or thoracic cavities[16,20].

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