ORIGINAL ARTICLE

Monitoring Temperature in Children Under General Anesthesia: Nasopharynx Versus Carotid Artery Surface

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Abstract- Continuous body temperature monitoring during anesthesia in children is very important. Hypothermia in children may lead to higher morbidity and mortality. Measurement points to detect the temperature of core body are not simply accessible. In this study we measured the skin temperature over the carotid artery and compared it with the nasopharynx. Totally, 84 children of 2-10 years undergoing elective surgery were selected. Temperature over the carotid artery and nasopharynx was measured during anesthesia. Mean temperature of these points was compared which each other, and the effects of age, sex, and weight change of temperature during anesthesia were evaluated. The mean age of patients was 5.4±2.6 years s. 37% of patients were female, and 63% were male. The mean weight was 20±7 kg. The mean duration of surgery was 60.45±6.65 min. The temperature of the skin and nasopharynx was decreased during surgery as after 60 min, the deference between skin over the carotid artery and the nasopharyngeal area was 1° C. The bodyweight has a significant effect on carotid skin temperature in regression model. Skin temperature over the carotid artery, with a simple correction factor of+1° C, provides a viable noninvasive estimate of nasopharyngeal temperature in children during elective surgery with a general anesthetic.

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Introduction

Continuous monitoring of body temperature during anesthesia is essential, postoperative hypothermia happens due to inhibition of thermoregulation during anesthesia or when the patients are exposed to a cold environment. To detect malignant hyperthermia all patients should be monitored (1-3).

During general anesthesia the temperature gap between core and peripheral is reduced. After reaching a stable constant anesthesia that is around 10-15 minutes (min) from the beginning of anesthesia, this gap stay constant (4). In most patients, the early reason of hypothermia is Impairment of normal thermal control due to anesthesia and consequent redistribution of body heat from the core to peripheral (5). Hypothermia in pediatrics is defined as a core body temperature less than 36° C, that leads to higher morbidity and mortality (6,7). Ggeneral anesthesia increases the risk of hypothermia in children and it may cause severe symptoms. During hypothermia, while vasoconstriction of the skin is impaired, the body's basal metabolism reduces up to 30% (8,9). The association of increased perspire thresholds and lessen vasoconstriction augment the inter threshold span ten-time, from its normal range of 0.2-0.4° C to almost 2-4° C. thermoregulatory defense mechanisms are not stimulated within this temperature range, and patients are poikilothermic in this range (5). Surgery can also reduce body temperature by three to four times (10). Hypothermia can happen in patients undergoing major

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operations up to 20%, with a variety symptoms which can increase the clinical outcomes, especially in high-risk patients (11). These outcomes include respiratory and heart disorders, apnea, hypoxia, carbon dioxide retention, metabolic acidosis, hypoglycemia, left shift of oxygenation curve, platelet or coagulation enzymes' dysfunction, increased bleeding, increased transfusion requirements, increased lesion infection, change in drug metabolism and thermal discomfort (12-16). children are unable to generate heat inside the body, and they do not have thermoregulatory response; Thus, if severe loss of temperature happens, they would be more vulnerable to hypothermia than adults (13). Accordingly, continuous monitoring of the core body temperature in the time of operations is essential especially in children. Because central body temperature measurement points (e.g. tympanic membrane, pulmonary artery, distal esophagus and nasopharynx) are not comfortably accessible, points close to the core are used.

The purpose of this study is comparing the measured skin temperature on the carotid artery and nasopharynx in children and finding a correlation coefficient between these two areas.

Materials and Methods

This study is approved by the Ethic Committee of Anesthesiology Department of Tehran University of Medical Sciences (TUMS). This observational study was conducted on 84 elective pediatric patients (2-10-year-old) in Children's Medical Center, TUMS, Tehran, Iran. Inclusion criteria were ASA I-II and non-head and neck surgery. Exclusion criteria were any abnormality or pathology in aria of probe attachment, coagulopathy and taking any antipyretic drug before surgery.

After obtaining informed consent from parents or legal guardians of children aged 2 to 10 years who require surgery under general anesthesia, premedication including ketamine 5 mg/kg, atropine 0.1 mg/kg and midazolam 0.5 mg/kg were given orally to all patients.

After beginning of the sedation and installing the monitoring equipment and taking peripheral IV line, induction of anesthesia was conducted with fentanyl (1 µg/kg), thiopental sodium 5mg/kg, and atracurium 0.5 mg/kg.

Anesthesia was continued by isoflurane anesthetic inhalation and oxygen. The respiratory system is regulated so that blood carbon dioxide (CO_2) is equal to 40-35 mm Hg at the end of exhalation. The flow rate of fresh gas was set at three liters per minute. Intravenous fluids were at room temperature, and the prescribed ringer lactate serum followed the 3-5 ml/kg rule.

For every patient, to detect the temperature, a probe was put inside the nasopharynx, and the other was put on the skin surface, above the point with maximum carotid artery pulse, because at this point, the carotid artery has the minimum distance from the skin on it and the possibility of heat transfer to the skin on it will be increased.

In the supine position, the common carotid artery is usually located on the outside of the trachea, and the jugular vein is on the outside of the artery. However, the temperature of these two vessels affects each other, and due to the rapid blood flow in them and their relationship to the body's central blood flow, both will almost be indicative of the body's central temperature.

Temperature was continuously monitored in the time surgery. The thermometers, Temperature Channel 2 Probe Type YSI 400 (Pooyandegan Rah Saadat Co. Ltd., Tehran, Iran) had the following characteristics: compatible range 0-50° C, accuracy±0.2° C, alarm sources error messages. The patients reached the steady anesthetic state in 30 minutes, and we started documenting the temperatures from the 30th minute. However, we only recorded its average every 10 minutes. All the data were measured and recorded under steady anesthetic conditions. The temperature of the operating room was constantly set at 23±1° C by a central thermostat. The patients' clothing, during the operation, was the conventional disposable operating room clothing.

The results of other studies (Ollie Jay study) were used to calculate the sample size so that based on a similar study, the mean difference and standard deviation between the measurement of nasopharynx and carotid artery were 0.52 and 0.32, respectively. According to the sample size of 28 people, the standard deviation was 1.69. Power and sample size software was used to calculate the sample size to design these matched studies.

Sample Size Assumptions: Type I error: 0.05, Study power: 0.80, Average difference: 0.52, Standard deviation: 1.69; finally, the calculated sample size was 84 individuals.

Data analysis

Mean (standard deviation) and frequency (percent) were used to describe quantitative and qualitative variables. The mean temperature difference of the nasopharynx and skin over carotid artery will be measured by paired t-test. Significance level of tests will be considered 0.05.

Results

In this study, 84 children aged 2 to 10 years with a mean of 5.4±2.6 years were studied. 37% of patients were female and 63% were male. Demographic data are presented in Table 1.

The mean skin temperature of the carotid and nasopharyngeal area and differences between them with correlation factors are shown in Table 2.

Table 1. Demographic data

	Mean	SD
Age (year)	5.4	2.6
Height (cm)	109	17
Weight (kg)	20	7
Surgery duration(min)	60.45	6.65

SD: standard deviation

Table 2. Comparing carotid skin and nasopharyngeal temperature during surgery

Times (min)	T.S	T.NP	T.S-T.NP	95% interval	Correction factor
0	36.94±0-46	36.64±0.45	1.67±0.22	1.72-1.63	1.4
20	35.12±0.45	36.52±0.46	1.39±0.26	1.45-1.34	1.4
40	35.28±0.46	36.37±0.46	1.09±0.22	1.14-1.05	1.3
60	35.27±0.47	36.32±0.49	1.05±0.23	1.1--1	1.2

T. S=temperature skin
T.NP=temperature nasopharynx

The variables including: The mean nasopharyngeal temperature, mean carotid temperature, age, sex, and weight, were used for the regression model. The body weight had a significant effect on carotid skin temperature.

Discussion

The most important finding of this study was that temperature measurement on the skin of the carotid artery, which is a non-invasive method than estimating nasopharynx temperature, accurately reflects near core temperature among children undergoing elective surgery with general anesthesia.

Immediately after induction of anesthesia, we apply one probe on the skin of the carotid artery and the other through the nose in the nasopharyngeal space. At this time, due to the coldness of the neck area, the probe was cold, and it may take some time to show the actual temperature on the carotid artery skin. Therefore, over time this temperature rises to the actual temperature of the carotid artery skin.

In addition, due to the effects of anesthesia on central body temperature and the effects of operating room temperature, the nasopharyngeal temperature decreases over time.

In Imani *et al.*, study rectum temperature and skin over the carotid artery in children within the age range 2-6 years during general anesthesia was compared. The results show that skin over the carotid artery with a correlation factor near one degree can indicate core temperature (17).

Jay *et al*., compare skin over the carotid artery and nasopharynx in children lower than three years and found that skin temperature over the carotid artery, with a simple correction factor of +0.52° C, provides a viable noninvasive estimate of nasopharyngeal temperature in young children during elective surgery with general anesthesia (18). The difference between our study and Jay's research was the age of children. As we evaluated older children and probably due to thicker skin and subcutaneous tissue, the correction factor in our study was near 1° C.

In our study, there is a constant temperature on the skin of the carotid artery and the nasopharyngeal area after about 40 minutes elapsed time, and the approximate temperature difference of these two regions is about 1° C.

In 40 and 60 minutes, the effect of age, sex, and weight on the temperature difference of the skin and the nasopharyngeal area was evaluated. The only factor that was effective was weight, and during anesthesia, as the weight increased, the temperature difference between these two areas increased.

Temperature over the carotid artery is a safe method with easier access and higher accuracy for estimating near body core temperature.

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