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Comparison of Core Temperature by Noninvasive Method vs Invasive Method in Infants and Young Children

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Abstract

Context: Temperature is a vital parameter for monitoring under anesthesia. Induction of anesthesia leads to impairment of thermoregulatory center and results in redistribution of body heat from core to periphery. Hypothermia especially in children may results in increased morbidity and mortality. Sites of measurement of core body temperature are invasive and are not easily accesible. The purpose of this study is to evaluate the performance of skin temperature probe applied over the carotid artery in comparison to the nasopharyngeal, axillary, forehead temperature recordings. So that a better, safe and appropriate alternative to invasive temperature monitoring in pediatric age group can be used. *Aim:* To compare core temperature measured with invasive nasopharyngeal probe and noninvasive surface temperature measured with probe over axilla, forehead and skin over carotid artery. *Settings and Design:* The present study was a prospective, randomized and comparative study. We included 150 patients of age between 1 month and 60 months of ASA Grade 1 and 2, posted for elective abdominal and inguinoscrotal surgeries lasting more than 1 hour. *Methods and Materials:* Patients were randomly divided in 3 groups with 50 patients in each group. Group 1: Axillary vs nasopharyngeal temperature. Group 2: Forehead vs nasopharyngeal temperature. Group 3: Skin over carotid artery vs nasopharyngeal temperature. Standard General Anesthesia protocol was followed in all patients. We evaluated differences by monitoring and comparing invasive and noninvasive methods of temperature monitoring at above sites. *Statistical analysis used:* Software named statistical package for the social sciences (SPSS version 21.0, IBM Corporation, USA) for MS Windows. *Results:* Temperature noted throughout the surgery in Group 1 i.e. Axillary temperature v/s nasopharynx, temperature and we found that axillary temperature was lower by 1–1.5°C than nasopharynx temperature which was statistically significant (p-value being <0.05). Whereas in Group 2 i.e. Forehead temperature was lower by 2–3°C than nasopharynx temperature which was also statistically significant (p-value being < 0.05). However, in Group 3 we found that the temperature at skin over carotid artery (noninvasive) was almost equivalent to temperature at nasopharynx (invasive) with minimum difference of 0.2–0.3°C (p-value being >0.05), which was statistically not significant. This shows that temperature on skin over carotid artery almost equals to core, i.e. nasopharyngeal temperature in paediatric patients. *Conclusions:* We conclude that instead of using conventional invasive method of temperature monitoring, we can use equally reliable method of monitoring i.e. skin over carotid which is noninvasive, easily accessible with higher accuracy of estimating near core temperature.

Keywords: Hypothermia; Paediatric; Anesthesia; Core Temperature; Invasive; Noninvasive.

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Introduction

Temperature is a vital parameter for monitoring under anesthesia especially in infants and young children. They are more prone to develop hypothermia due to less insulating subcutaneous fat and higher surface area to volume ratio. They loose more heat through conduction and radiation than adults. Hypothermia especially in children may results in increased morbidity and mortality.[1]

Induction of anesthesia leads to impairment of thermoregulatory center and results in redistribution of body heat from core to periphery. Most commonly used sites for core temperature measurement are invasive like nasopharynx, distal esophagus, tympanic membrane, rectum and bladder. Non-invasive sites like axilla, forehead, skin over chest are easy to record but precision and accuracy of measurements may vary. Hence the measurement of core temperature is clinically more important.[2]

Nasopharyngeal temperature monitoring is used most oftenly in the operating room as it is easily accessible as compared to other invasive sites and gives more reliable core temperature. But this site also carries risk of injury to nasal mucosa, olfactory bulb, turbinates and readings may be affected by inspired anesthetic gases. Axillary temperature, among noninvasive techniques is used most extensively. However, axillary temperature monitoring is an unreliable method for measuring core temperature because the probes are often misplaced within the axilla.[3]

Skin temperature should correlate with changes in the core temperature. We hypothesize that skin over carotid artery temperature measurement may be an alternative method which provides rapid, easy and painless recording.

In this study, our aim is to evaluate the performance of skin temperature probe applied over the carotid artery in comparison to the nasopharyngeal, axillary, forehead temperature recordings. So that a better, safe and appropriate alternative to invasive temperature monitoring in pediatric age group can be used.

Materials and Methods

A study of a continuous response variable from three independent study groups with 1:1:1 patient ratio in Group 1, Group 2 and Group 3 are studied. In a previously published study the response within each patient group was approximately normally distributed. If the true intra-group difference in the mean response is approximately 1.5, we will need to study minimum 45 patients in each study group (i.e. total 135 patients) to be able to reject the null hypothesis that the population means of Group 1, Group 2 and Group 3 are equal with probability (power) 0.80. The Type I error probability associated with this test of null hypothesis is 0.05.

Therefore, the sample size we studied was 50 patients in each group (Total 150).

p value < 0.05 was considered as statistically significant.

After approval by institutional ethical committee, randomized prospective comparative study was conducted in attached teaching hospital. Study includes 150 patients, with 50 patients in each group randomly divided in three equal groups.

Group 1: Axillary vs nasopharyngeal temperature

Group 2: Forehead vs nasopharyngeal temperature and

Group 3: Skin over Carotid Artery VS Nasopharyngeal temperature.

We evaluated the differences by monitoring and comparing them in particular groups. Study includes children of age group 6 months to 5 years of both sexes and posted for elective urogenital surgeries lasting more than 1h with ASA Grade I and II. Neurological conditions affecting thermoregulatory function such as cerebral palsy were excluded. All patients were evaluated preoperatively.

Written informed consent was obtained from the parents. Standard *non per os* (NPO) guidelines for pediatric patients was followed.

Uniform Standard General Anesthesia protocol was followed in all patients. Temperature monitoring was started after 10 minutes of intubation and continued till extubation with every 10 minutes interval.

For temperature monitoring, surface probe used was attached to multiparameter cardiocap – DatexOhmeda monitor.

The nasopharyngeal probe (invasive method) is introduced into nasopharynx through one of the nasal apertures to a pre-calculated depth. The depth of insertion is determined before insertion by measuring the distance externally between the tragus and the nasal aperture. Simultaneously skin surface probe was placed over the axillary artery in the pit on the arm (noninvasive method) along the mid-axillary line in patients of Group 1.

In Group 2, probe is attached on the forehead (noninvasive) covering with adhesive dressing to avoid the effect of external objects affecting the temperature reading, while comparing it with the nasopharyngeal reading.

Finally, in Group 3 skin surface temperature probe is attached to the anterior part of the neck, centered to the site of maximum intensity of carotid artery pulsation at the level of thyroid prominence (noninvasive method), comparing it again with the nasopharyngeal reading (invasive method). The skin probe is secured in place and covered with adhesive dressing.

The operating room temperature was thermostatically maintained in the range of 20–22°C and relative humidity of 50%. All the patients received pre-warmed blanket applied over the lower extremity without disturbing the monitoring site.

The entire data is statistically analyzed using Statistical Package for Social Sciences (SPSS version 16.0, Inc. Chicago, USA) for MS Windows. The inter-group comparison of categorical variable is tested using chi-square test after Bonferroni's correction for multiple group comparisons. The intra-group comparison was performed using paired '*t*' test. The normality assumption was tested before subjecting the continuous variables to ANOVA and T test.

Results

The demographic data: age, weight in the groups were comparable did not differ significantly across three intervention groups (*p*-value >0.05 for all). Distribution of sex between group I vs II and I vs III was significant, which may be due to randomization.

Temperature noted throughout the surgery in Group 1 i.e. Axillary temperature v/s nasopharynx temperature and we found that axillary temperature was lower by 1–1.5°C than nasopharynx temperature which was statistically significant (*p*-value being <0.05). We found the fall in temperature in nasopharynx group from baseline, i.e. 36.7 ± 0.38 to 35.1 ± 0.42 at the end of procedure, whereas for axillary temperature it was from baseline 35.4 ± 0.48 to 33.1 ± 0.71 at the end of procedure.

Whereas in Group 2, i.e. Forehead temperature was lower by 2–3°C than nasopharynx temperature which was also statistically significant (*p* value < 0.05). The difference in nasopharynx group from baseline, i.e. 36.6 ± 0.35 to 34.4 ± 0.0 at the end of procedure, whereas for forehead temperature it was from baseline 34.7 ± 0.66 to 32.6 ± 0.0 at the end of procedure.

However, in Group 3 we found that the temperature at skin over carotid artery (non-invasive) was almost equivalent to temperature at nasopharynx (invasive) with minimum difference of 0.2–0.3°C (*p* value being >0.05), which was statistically not significant as shown in graph 3.

The mean nasopharynx temperature (from baseline 36.6 ± 0.42 to 35.7 ± 1.27 at the end of procedure) didn't differ significantly compared to temperature at skin over carotid artery (baseline 36.3 ± 0.55 to 35.5 ± 1.27). Thus temperature at skin over carotid closely resembles to that nasopharynx.

The intra-group comparison of temperature at each time interval throughout the surgery is almost equivalent in Group 3 compared to Group 1 and Group 2 as shown in Table 2.

This shows that temperature measured on skin over carotid artery almost equals to core temperature, i.e. nasopharyngeal temperatures in pediatric patients.

Discussion

Children loose more heat through conduction and radiation than adults, due to less insulating

Table 1: Distribution of Demographic Data of Cases Between Three Groups

Parameter	Group I	Group II	Group III	Gr I v II	Gr I v III	Gr II v III
Age – Yrs	1.58 ± 1.09	1.86 ± 1.25	1.83 ± 1.34	0.644 NS	0.502 NS	0.873 NS
Wt – Kg	10.06 ± 2.77	10.54 ± 3.25	9.80 ± 3.16	0.189 NS	0.098 NS	0.816 NS
Sex M:F	48 : 02	39 : 11	37 : 11	0.015*	0.004*	0.815 NS

NS: non-significant

Table 2: Comparison of Temperature at each Time Interval between group

Time (min)	Group 1 (N=50)			Group 2 (N=50)			Group 3 (N=50)		
	Nasopharynx	Axillary	*p*-value	Nasopharynx	Forehead	*p*-value	Nasopharynx	Skin over carotid artery	*p*-value
10	36.7 ± 0.38	35.4 ± 0.48	0.001*	36.6 ± 0.35	34.7 ± 0.66	0.001*	36.6 ± 0.42	36.3 ± 0.38	0.001 NS
20	36.5 ± 0.37	35.4 ± 0.49	0.001*	36.4 ± 0.42	34.5 ± 0.67	0.001*	36.3 ± 0.59	36.2 ± 0.37	0.061 NS
30	36.4 ± 0.42	35.3 ± 0.48	0.001*	36.2 ± 0.36	34.5 ± 0.76	0.001*	36.1 ± 0.72	36.1 ± 0.42	0.848 NS
40	36.1 ± 0.47	35.1 ± 0.52	0.001*	36.1 ± 0.31	34.4 ± 0.78	0.001*	35.9 ± 0.63	36.0 ± 0.47	0.744 NS
50	35.9 ± 0.56	34.9 ± 0.52	0.001*	36.0 ± 0.33	34.3 ± 0.82	0.001*	35.9 ± 0.56	35.9 ± 0.56	0.742 NS
60	35.9 ± 0.55	34.9 ± 0.54	0.001*	35.9 ± 0.31	34.3 ± 0.83	0.001*	35.8 ± 0.56	35.8 ± 0.55	0.959 NS
70	35.8 ± 0.65	34.8 ± 0.65	0.001*	35.9 ± 0.37	34.0 ± 0.95	0.001*	35.7 ± 0.63	35.7 ± 0.65	0.601 NS
80	35.7 ± 0.45	34.6 ± 0.68	0.001*	35.9 ± 0.35	34.1 ± 0.99	0.001*	35.6 ± 0.69	35.7 ± 0.45	0.195 NS
90	35.7 ± 0.45	34.5 ± 0.69	0.001*	35.7 ± 0.31	33.9 ± 0.98	0.001*	35.5 ± 0.73	35.5 ± 0.45	0.753 NS
100	35.7 ± 0.50	34.4 ± 0.77	0.001*	35.5 ± 0.34	33.6 ± 0.97	0.001*	35.3 ± 0.75	35.4 ± 0.50	0.191 NS
110	35.7 ± 0.55	34.3 ± 0.89	0.001*	35.3 ± 0.26	33.3 ± 0.96	0.001*	35.2 ± 0.74	35.3 ± 0.55	0.074 NS
120	35.6 ± 0.56	34.4 ± 0.97	0.001*	35.2 ± 0.44	33.6 ± 0.97	0.001*	35.1 ± 0.86	35.2 ± 0.56	0.401 NS
130	35.5 ± 0.61	34.2 ± 1.05	0.001*	34.9 ± 0.07	32.8 ± 1.28	0.001*	35.3 ± 0.72	35.3 ± 0.61	0.524 NS
140	35.5 ± 0.60	34.3 ± 1.22	0.007*	34.6	32.6	–	35.2 ± 0.85	35.2 ± 0.60	0.563 NS
150	35.5 ± 0.67	34.4 ± 1.36	0.0026*	34.4	32.6	–	34.9 ± 0.73	34.9 ± 0.67	0.111 NS
160	35.4 ± 0.51	34.4 ± 1.47	0.001*	–	–	–	35.1 ± 1.00	35.2 ± 0.51	0.580 NS
170	35.3 ± 0.38	34.5 ± 1.72	0.001*	–	–	–	35.2 ± 1.32	35.2 ± 0.38	0.999 NS
180	35.1 ± 0.42	33.9 ± 1.71	0.001*	–	–	–	35.7 ± 1.27	35.5 ± 0.42	0.999 NS

Values are Mean ± Standard Deviation. *p*-values for Intra-group comparisons by paired sample = '*t*' test. **p* value < 0.05 is considered to be statistically significant.

NS : statistically Non- Significant

subcutaneous fat and higher surface area to volume ratio. Hence, temperature monitoring is an integral part of management of anesthesia during surgeries, especially in infants and young children who are more prone to hypothermia.

A more severe loss of temperature, inability to generate heat inside the body and lack of thermoregulatory response, in children, make them more susceptible to hypothermia than adults. Therefore, correct and continuous measurement of the core body temperature, during surgery, is very important for controlling temperature conditions in patients, especially children.

Hypothermia can occur in up to 20% patients who undergo major surgeries. It is also accompanied by various symptoms that can increase the clinical consequences especially high-risk patients. These consequences include respiratory disorders, apnea, hypoxia, carbon dioxide retention, metabolic acidosis, hypoglycemia, left shift of oxygenation curve, heart disorders, platelet dysfunction, dysfunction of coagulation enzymes, increased bleeding, increased surgical site infection, change in drug metabolism and thermal discomfort.[4]

As core body temperature measurement sites (e.g. tympanic membrane, pulmonary artery, distal esophagus and nasopharynx) are not easily accessible, usually near core sites are used for monitoring. These sites include the mouth, axilla, bladder, skin surface, and rectum. The above mentioned core temperature measurement sites advocated as the most pertinent are relatively invasive and present as an elevated health risk to a varying degree. For example, probes in the nasopharynx can cause mild-to-severe epistaxis while rectal probes can occasionally cause trauma.

In some situations, none of the true core temperature sites are readily accessible such as during the immediate perioperative period with procedural sedation, or in patients with congenital malformations.

Replacing a malfunctioning invasive probe in a patient can also be challenging once a surgical procedure is underway. Furthermore, the risk of cross-infection among patients will be elevated in low resource settings due to the repeated use of a given invasive probe. A need therefore exists for a sufficiently accurate noninvasive form of thermometry.

Hence, we conducted a prospective randomized study by comparing invasive and noninvasive methods of temperature monitoring, to avoid such complications in children.

We compared mean nasopharyngeal and mean axillary temperatures (Group 1) and found that the difference between mean nasopharyngeal temperatures and axillary temperatures were around 1–1.5°C.

Axillary temperatures were found less than nasopharyngeal temperatures and the result was statistically significant. Androkites *et al.* conducted a similar study "On comparison of axillary and infrared tympanic membrane thermometers in a pediatric oncology outpatient setting. There results showed that the tympanic membrane site of temperature monitoring results in significantly higher temperature reading than the axillary method.[5]

In Group 2 we compared mean nasopharyngeal and mean forehead temperatures and found that the difference between the mean nasopharynx temperatures compared to mean forehead temperatures were around 2–3°C i.e. temperature on forehead is less than nasopharynx. This difference was statistically significant ($p < 0.05$).

In Group 3 we compared mean nasopharynx temperature and mean temperature of skin over carotid artery in study population and found that the difference between mean nasopharyngeal temperatures and mean temperatures at skin over carotid artery were around 0.2–0.3°C ($p > 0.05$), which was statistically not significant.

Similar studies was conducted by Imani *et al.* to measure skin temperature over the carotid artery and compare it with the rectum temperature, in order to propose a model for accurate estimation of near core body temperature.[6]

Selvaraj *et al.* also did a prospective double-blinded study to compare the correlation of skin temperature over carotid artery in the neck to that of simultaneously measured nasopharyngeal temperature in adult patients undergoing surgical procedures under general anesthesia.[7]

They also found that skin temperature over the carotid artery in the neck was strongly correlated to the nasopharyngeal temperature in adult patients.

We did similar study in pediatric patients comparing skin over carotid artery to nasopharynx as well as comparison with other sites and the results were almost equivalent to above study.

Skin over carotid is more reliable technique of temperature monitoring as compared to other peripheral sites, because of its close proximity to larger artery. This may be explained as there is thin layer of skin over the artery in children.

Nasopharyngeal temperature monitoring is considered as the primary indicator of intraoperative thermal status due its proximity to internal carotid artery. But nasopharyngeal temperature monitoring has its limitations because of the risks involved in it.

As oppose to this temperature measured on skin over carotid artery provides accurate, safe temperature measurement and without potential risks.

In conclusion, skin temperature measured over the carotid artery, provides an accurate noninvasive estimate of nasopharyngeal temperature in infants and young children undergoing elective surgery. This method completely eliminates risks (e.g., epistaxis, infection, etc.) associated with invasive core temperature measurements and also presents a reliable alternative.

The only limitation of our study is that we have included all types of surgeries more than 1 hour. In future, we can study this in specific type of surgeries where risk of hypothermia is more.

Conclusion

We conclude that instead of using conventional invasive method of temperature monitoring, we can use equally reliable non-invasive method of monitoring, i.e. Skin over carotid artery which is easily accessible and is devoid of complications.

Key Messages: Temperature monitoring over skin over carotid is reliable for core temperature.

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References

1. Mance MJ. Keeping infants warm: challenges of hypothermia. Adv Neonatal Care. 2008;8:6–12.
2. Sessler DI. Temperature monitoring and perioperative thermoregulation. Anesthesiology. 2008;109(2):318–38.
3. Luginbuehl I, Bissonnette B, Davis PJ. Thermoregulation: Physiology and Perioperative Disturbances. In: Motoyama EK, Davis PJ, editor. Smith's Anesthesia for Infants and Children. 7th ed. Philadelphia: Mosby, an imprint of Elsevier, Inc.; c2006.pp.154–76.
4. Stephen CR, Dent Sara J, Hall KD, *et al.* Body

Temperature Regulation During Anesthesia in Infants and Children Constant Monitoring of Body Temperature Helps to Prevent Complications Associated with Hypothermia and Hyperthermia. JAMA. 1960;174(12):1579–85.

5. Androkites AL, Werger AM, Young ML. Comparison of axillary and infrared tympanic membrane thermometry in a pediatric oncology outpatient setting. J Pediatr Oncol Nurs. 1998 Oct; 15(4):216–22.
6. Imani F, Karimi Rouzbahani H, Goudarzi M, Tarrahi M, Ebrahim Soltani A. Skin Temperature Over the Carotid Artery, an Accurate Non-invasive Estimation of Near Core Temperature. Anesth Pain Med. 2016 Jan 17;6(1):e31046.
7. Selvaraj V, Gnanaprakasam PV. Evaluation of skin temperature over carotid artery for temperature monitoring in comparison to nasopharyngeal temperature in adults under general anesthesia. Anesth Essays Res. 2016 May-Aug;10(2):291-6.