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Original Article

Anaesthesia Section

Accuracy of Nasopharyngeal Temperature in Comparison to Oesophageal Temperature for Core Body Temperature Measurement: A Cross-sectional Observational Study

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ABSTRACT

Introduction: Temperature monitoring intraoperatively is standard of care for almost all surgical cases and is necessary due to the important role that temperature plays in maintaining body homeostasis, anaesthetic drug metabolism, and recovery. However, invasive and user-unfriendly methods like measuring temperature in the oesophagus, tympanic membrane, or rectum have limitations. An alternative site for measuring core body temperature could be the nasopharynx, as its mucosa is supplied by branches of the internal carotid artery.

Aim: To determine the accuracy of the nasopharyngeal probe in comparison to oesophageal temperature probe and to identify appropriate insertion depths for measuring core body temperature.

Materials and Methods: Sixty patients scheduled for elective non-cardiac surgery under general anaesthesia lasting 60 minutes or more. A nasopharyngeal probe was inserted past the nares to a depth of 20 cm, and an oesophageal temperature probe was inserted to a depth of 40 cm past the incisors. The nasopharyngeal probe was gradually pulled out after induction, and temperatures at various depths were recorded at regular intervals. The observed depths of the nasopharyngeal probe that correlated with the oesophageal temperature were considered as the endpoints. Data was entered into Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) version 25.0.

Results: The study population consisted of 60 patients, with 31 males and 29 females, a mean age of 50 years, mean body mass index of 26 kg/m^2, American Society of Anaesthesiologists (ASA) (physical status) of 1 (n=27) and 2 (n=33). The insertion depths of 10 to 20 cm for the nasopharyngeal probe showed a mean temperature difference of ±0.3°C compared to the reference oesophageal temperature. This difference fell within the clinically acceptable accuracy range of 0 to 0.3°C (temperature mean difference ±1.96 SD) for both probes.

Conclusion: The nasopharyngeal probe offers a minimally invasive method for measuring body temperature and is easily accessible for probe placement. However, the optimal depth of insertion past the nares has not been well established. Based on the results, which showed that the mean temperature difference between the two probes fell within the specified accuracy range when the nasopharyngeal probe was inserted to a depth range of 10 to 20 cm from the nares, it is advisable to use this depth range for core body temperature measurement in non cardiac surgeries.

Keywords: Anaesthesia, Hypothermia, Intraoperative, Monitoring

INTRODUCTION

Humans are homeothermic but become poikilothermic under anaesthesia, wherein body temperature is determined by the environment. Temperature measurement and maintenance are now the standard of care intraoperatively [1]. General anaesthesia, especially volatile anaesthetics, impairs central thermoregulatory control [2]. Inadvertent hypothermia occurs in 6-90% of surgical patients [3]. Hypothermia is defined as a core temperature below 36°C [4,5]. There are guidelines and recommendations for perioperative temperature monitoring to prevent unplanned perioperative hypothermia in anaesthetised patients [6]. General anaesthetics like volatile anaesthetics, hypnotics, analgesics, and neuraxial anaesthetic drugs act both in the Central Nervous System (CNS) and peripheral tissues. The vasodilation properties of general anaesthesia drugs cause a core-to-peripheral redistribution of body heat. Perioperative hypothermia causes coagulopathy, increases the risk of wound infection, myocardial ischaemia, and prolongs the duration of action of drugs [7]. There are many monitoring sites that represent core temperature well, namely the pulmonary artery, distal oesophagus, nasopharynx, and tympanic membrane (when measured using a contact thermometer). However, in all cases, one cannot use invasive temperature monitoring sites for temperature recording [8]. As a central venous catheter or pulmonary artery catheter is not routinely used, a nasopharyngeal probe can be easily inserted by anaesthesiologists, and it is the best site for core temperature monitoring. Additionally, the temperature in the nasopharynx is thought to accurately reflect core temperature because of its proximity to the brain (internal carotid artery) [4,5]. Nasopharyngeal probes are typically inserted through one nostril. There are inadequate resources to show how deep the temperature probe can be inserted from the nasal approach to serve as a substitute for the oesophageal approach for core body temperature measurement [9-11]. In a study by Lee J et al., temperature probes were blindly inserted at different depths and into one of the nares in different patients, with a reference probe inserted into the oesophagus. Approximately 40-43% of their patients received proper probe placement, as justified by finding good correlation between two different nasally inserted probes (upper nasopharynx and mid nasopharynx; 34% and 7%, respectively) and the oesophagus [12]. This study was designed to find the range of depths of the nasopharyngeal probe in measuring core temperature compared to the reference core temperature measured in the distal oesophagus. Superficially inserted probes may be affected by ambient air, and deeply inserted probes may be influenced by the gases used for ventilation [12]. Therefore, the present study aimed to determine the accuracy of the nasopharyngeal temperature probe and its insertion depths by comparing measurements with the reference core temperature measured in the distal oesophagus.

MATERIALS AND METHODS

A cross-sectional observational study was conducted at the Department of Anaesthesia, JJM Medical College, Davangere, Karnataka, India, for a period of one year from April 2021 to March 2022. Institutional Ethical Committee (IEC) clearance was obtained (ECR/731/Inst/KA/2015 RR-18) and written informed patient consent.

Inclusion criteria: Sixty patients of the ASA (physical status) Grade-1 and 2, aged between 20 to 60 years, who were scheduled for elective non cardiac surgery in the supine position and lasting for more than 60 minutes under general anaesthesia with endotracheal intubation and controlled ventilation, were included in this study.

Exclusion criteria: Patients with pre-existing nasopharyngeal diseases, upper airway abnormalities, planned nasopharynx/throat surgery, oral surgery, epistaxis, coagulopathy, or oesophageal disease, except GERD, were excluded from the study.

Sample size: Analysis: A priori: Compute required sample size

Input: Tail(s)=One

Effect size d=0.45

α error prob=0.05

Power (1-β error prob)=0.95

Output: Non-centrality parameter δ=3.3372893

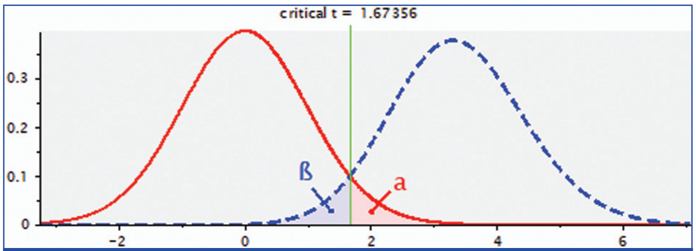
Critical t=1.6735649

Degrees of freedom (Df)=54

Total sample size=55

Actual power=0.9505469

Therefore, adjusting for attrition (10%) and adding a minimum of five samples to 55, therefore, 60 patients were enrolled in the study [Table/Fig-1].



[Table/Fig-1]: α and β probability.
t-tests- Means: Difference from constant (one sample case)

After thorough preanaesthetic evaluation, patients who met the inclusion criteria were explained about the study procedure, and written informed consent was obtained. Nil per oral (NPO) guidelines were followed. On the day of surgery, after securing an appropriate-sized intravenous cannula and attaching ASA standard monitors, patients received premedication with Inj. glycopyrrolate 0.01 mg/kg intravenously, Inj. midazolam 0.5 mg/kg intravenously, and Inj. fentanyl 2 mcg/kg intravenously. Patients were then induced with Inj. propofol 2 mg/kg intravenously and relaxed with Inj. vecuronium 0.1 mg/kg, followed by intubation with an appropriate-sized endotracheal tube. Anaesthesia was maintained with O_2+N_2O+IPPV+intermittent Inj. vecuronium 0.05 mg/kg intravenously and Isoflurane with a targeted Minimum Alveolar Concentration (MAC) of 1. The operating room temperature was maintained at 22°C to 24°C. The oesophageal probe was marked at 5 cm intervals upto a length of 40 cm from the tip. The nasopharyngeal probe was marked from 2 to 20 cm at 2 cm increments from the tip. The probes were then connected to the preassigned oesophageal and nasopharynx temperature consoles of the clinical monitor in their respective operating rooms. Any difference in baseline readings between the probes was observed and noted. The oesophageal temperature probe (T1) was inserted orally into the oesophagus to a depth of 40 cm and fixed at the angle of the mouth. After that, the nasopharyngeal probe (T2) was inserted into the nasopharynx to a depth of 20 cm from the nares. At 10 minutes after intravenous induction, the baseline temperature was recorded from both probes and labeled as T1 and T2. The nasopharyngeal probe alone was gradually pulled out by a length of 2 cm every five minutes. Eight sets of such readings were taken from both probes. Both temperature probes were removed at the end of the surgery, followed by extubation after adequate reversal with Inj. neostigmine 0.05 mg/kg intravenously and Inj. glycopyrrolate 0.01 mg/kg intravenously after thorough oral suctioning.

STATISTICAL ANALYSIS

The collected data was entered into an Excel sheet and analysed using SPSS software version 25.0. Qualitative data (categorical data) were expressed as frequencies (percentages), and quantitative data were expressed as mean.

Factors	Mean±SD
Age (years)	50±10
Height (in cm)	159±10
Weight (kg)	67±12
Body Mass Index (BMI) (kg/m²)	26.05±2.41
Gender*	
Female	31 (51.7)
Male	29 (48.3)
ASA 1:2	27 (45):33 (55)

[Table/Fig-2]: Demographic profile.
*values as n (%)

RESULTS

A total of 60 cases were studied. The demographic profile of the study population is presented in [Table/Fig-2].

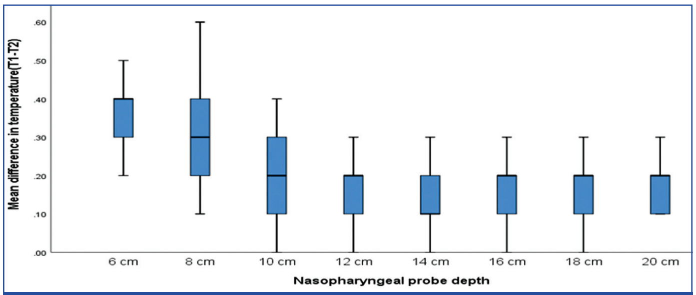
It was hypothesised that when the mean with two standard deviations for the temperature difference between both probe depths is in the range of 0 to 0.3°C, the nasopharyngeal probe shall be considered accurate enough to reflect core temperature at that depth.

The mean and standard deviation of nasopharyngeal temperature and oesophageal temperature, as well as the difference between their means at all probe depths, are presented in [Table/Fig-3]. The mean oesophageal temperature was consistently higher than the mean nasopharyngeal temperature, but the mean difference between nasopharyngeal and oesophageal temperature was small (≤0.3°C) for all depths of more than 10 cm.

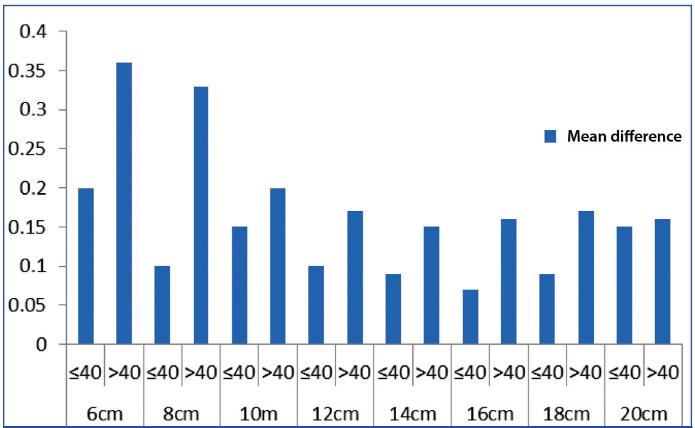
Depth (in cm)	T1 (Oesophageal temperature)	T2 (Nasopharyngeal temperature)	T1-T2 (Mean±SD)
6	36.61±0.69	36.25±0.7	0.36±0.1
8	36.76±0.47	36.43±0.33	0.33±0.14
10	36.86±0.58	36.66±0.47	0.20±0.11
12	37.08±0.67	36.89±0.58	0.19±0.09
14	36.56±0.62	36.45±0.55	0.11±0.07
16	36.7±0.7	36.52±0.64	0.18±0.06
18	36.48±0.78	36.30±0.72	0.18±0.06
20	36.79±0.63	36.60±0.58	0.19±0.05

[Table/Fig-3]: Mean temperatures of oesophageal probe (T1) and nasopharyngeal probe (T2) across varying probe depths and difference between them.

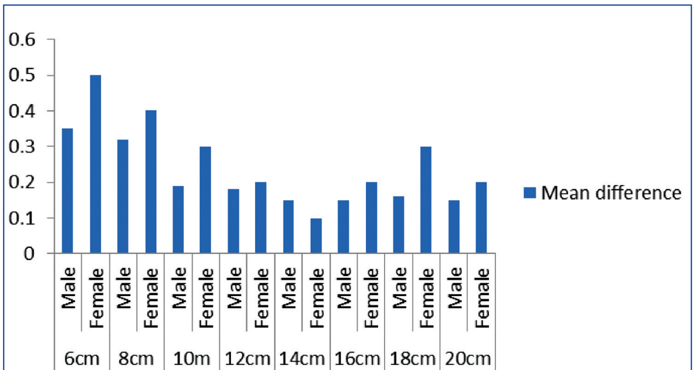
The range of depths of the nasopharyngeal probe that showed accuracy is depicted in [Table/Fig-4]. It was shown that nasopharyngeal probe depths starting from a depth of 10 cm and further beyond had a mean difference ± 2 SD values falling between 0 to 0.3°C. The accuracy of nasopharyngeal temperatures did not vary appreciably as a function of age, gender, and BMI [Table/Fig-5-7].



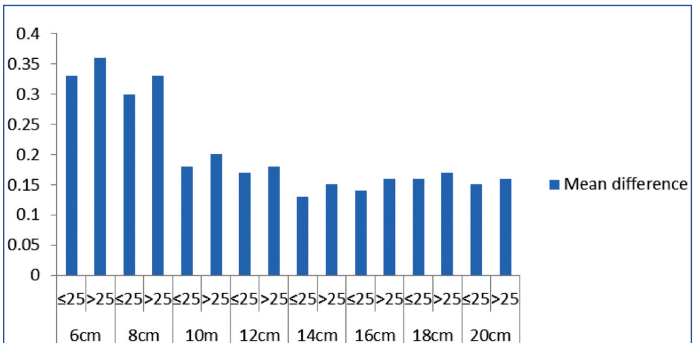
[Table/Fig-4]: Box whiskers plot showing temperature mean difference with 2sd between the nasopharyngeal probe and oesophageal probe plotted against varying nasopharyngeal probe depths.



[Table/Fig-5]: Bar chart showing age at various depths (x axis) against mean temperature difference (y axis) between T1-T2.



[Table/Fig-6]: Bar chart showing gender at various against mean temperature difference between T1-T2.



[Table/Fig-7]: Bar chart showing BMI at various against mean temperature difference between T1-T2.

DISCUSSION

It was found in this study that the nasopharyngeal temperature probe inserted to a depth of 10 to 20 cm past the nares correlated well with oesophageal temperature, which is known to reflect core body temperature. The core thermal compartment is composed of highly perfused tissues whose temperature is uniform and high compared to the rest of the body, and sites like the oesophagus, nasopharynx, pulmonary artery, and tympanic membrane help in measuring the same [2]. The nasopharynx has the added advantage of ease of insertion, even in cases where supraglottic airway devices are used. Intraoperative temperature should be measured atleast every 15 minutes [13,14]. Hypothermia can lead to complications such as surgical wound infections, coagulopathy, increased allogenic transfusions, negative nitrogen balance, delayed wound healing, delayed post-anaesthetic recovery, prolonged hospitalisation, shivering, and patient discomfort [7]. Therefore, it is recommended to monitor body temperatures in patients undergoing general anaesthesia for longer than 30 minutes or surgeries lasting more than one hour [2].

As evident from [Table/Fig-5], the mean temperature difference from all age groups beyond the probe insertion depth of 10 cm was ≤±0.3°C. However, at 6 and 8 cm depth and in age groups of more than 40 years, the mean temperature difference was more than 0.3°C. Therefore, age does not affect the accuracy of temperature recordings and further objective analysis in this study. Similarly, other demographic parameters such as gender and BMI did not affect the accuracy study of the nasopharyngeal temperature probe [Table/Fig-5,6]. This finding was similar to the study by Wang M et al., where the accuracy of nasopharyngeal temperatures did not vary appreciably as a function of age, BMI, or gender [15].

In another study by Lee J et al., contrast CT imaging of the head and neck showed that the upper or mid-portion of the nasopharynx was in close proximity to the internal carotid artery, which was quoted as the optimal position for probe placement for core body temperature measurement. In sagittal CT images of their study population, it was shown that the mean distance from the nares to the upper 1/3rd of the nasopharynx and middle 1/3rd of the nasopharynx was in the range of 9.1-12.8 cm (females:males) and 11-12.8 cm (females:males), respectively, which did not significantly affect their study outcome [12].

As evident from this study, the mean nasopharyngeal temperature was lower than the mean oesophageal temperature at all depths. The difference between the mean nasopharyngeal temperature and the mean oesophageal temperature was ≤0.3°C in the insertion depth range of 10 to 20 cm of the nasopharyngeal temperature probe. This finding was comparable to a study by Wang M et al., where they found that a nasopharyngeal probe inserted 10 to 20 cm deep past the nares reflected core body temperature, as the mean temperature differences between the probes were ≤0.5°C (within the accuracy range) as specified by the authors [15].

There was a significant difference between nasopharyngeal and oesophageal temperature values in the depth range of 6 to 10 cm, which was consistent with a study by Lim H et al., who found that the average depth of the upper nasopharynx corresponded to a depth of approximately 10 cm as confirmed by fiberscope [16]. The correlation between probes inserted to depths less than 10 cm and the oesophagus was poor, suggesting that superficially placed temperature probes may show false low readings due to the influence of ambient air. Lee J et al., mentioned in one of their studies that CT scan images of the head showed that the mucosa in the upper nasopharynx is closest to the territory of the internal carotid artery, and the average distance from the nares to the upper nasopharynx was 9.4 cm and 16 cm in females and males, respectively [12]. Duggappa AK et al., suggested that temperature measured by either inserting a nasopharyngeal probe to the fossa of Rosenmuller at an average depth of 10 cm from the nares or using the philtrum tragus distance at a mean depth of 15 cm from the nares showed good correlation with oesophageal temperature [17]. During general anaesthesia, the oesophagus and nasopharynx are typically the most reliable locations to monitor temperature. They are both genuine core sites that are resistant to artifacts. In addition to the zero-heat flux forehead temperature, other options appropriate for neuraxial anaesthesia and postoperative care include oral and axillary temperatures [18].

Limitation(s)

The exact location of the nasopharyngeal probe tip corresponding to the 10 to 20 cm insertion depth was not confirmed using a flexible fiberoptic scope to visualise the internal anatomical structures. A similar study could be conducted on the paediatric population to determine the accurate depth range of nasopharyngeal temperature measurement for core body temperature.

CONCLUSION(S)

Oesophageal temperature monitoring is considered a standard method for measuring core body temperature. However, as it is semi-invasive and requires expertise, this study aimed to find an alternative site with the appropriate insertion depth that could serve as a substitute. Based on the findings of this study, which showed a smaller mean temperature difference between oesophageal and nasopharyngeal temperatures at an insertion depth of 10 to 20 cm, it was concluded that the nasopharynx can be considered as an alternative site for measuring core body temperature when the probe is inserted beyond 10 cm past the nares.

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