Original contribution

Core temperature measurements through a new airway device, perilaryngeal airway (CobraPLA)

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Abstract

Study Objective: The aim of this study was to test the hypothesis that the intraoperative pharyngeal temperatures obtained on the perilaryngeal airway (PLA), a novel airway device with a larger pharyngeal cuff (when inflated) than the laryngeal mask airway, are similar to tympanic membrane core temperatures.

Design: This study is a prospective, simultaneous device comparison.

Setting: This study was set at a university hospital.

Patients: The study patients included 14 adults with American Society of Anesthesiologists physical statuses I and II, scheduled for minor gynecological or orthopedic surgery.

Interventions: A PLA was inserted into the pharynx after induction of general anesthesia. Thermocouples were positioned at 3 sites on the PLA: (1) posterior portion of the head of the airway (tip), (2) midposterior portion of the cuff, and (3) left and right lateral-posterior portions of the cuff. Tympanic membrane thermocouples were inserted.

Measurements: Temperature readings from the airway and the tympanic membrane thermocouples were recorded every 15 minutes throughout surgery.

Keywords:
Airway;
Temperature;
Core;
Pharynx
Main Results: Temperatures recorded from the lateral-posterior cuff were found to be virtually identical to tympanic membrane temperatures, with 97% of the values differing by less than 0.5°C. Readings from the other 2 sites on the cuff differed considerably more from tympanic membrane values.

Conclusions: These data suggest that the PLA can be adapted to monitor core temperature reliably.

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1. Introduction

The core thermal compartment is composed of highly perfused tissues whose temperatures are uniform and high compared with those of the rest of the body. Temperature in the core compartment can be evaluated in the pulmonary artery, distal esophagus, tympanic membrane, or nasopharynx. The distal esophagus is generally the most convenient location for core temperature monitoring during general anesthesia with endotracheal intubation.

However, a large fraction of ambulatory patients who undergo general anesthesia do not require tracheal intubation. Instead, they get supraglottic airways of which the most common is the laryngeal mask airway (LMA; The Laryngeal Mask Co, San Diego, CA) [1]. We previously demonstrated that core temperatures measured on the LMA or cuffed oropharyngeal airway (COPA; Mallinckrodt Inc, Anesthesiology and Respiratory Devices Division, St Louis, MO) cuff correlated well with both nasopharyngeal and tympanic membrane temperatures [2].

The CobraPLA is a new supraglottic airway device. Our group recently demonstrated that the perilaryngeal airway (PLA) maintains an airway as well the LMA but provided better airway sealing [2]. In this study, we test the hypothesis that the intraoperative pharyngeal temperature obtained on the PLA accurately estimates core temperature during general anesthesia with tracheal intubation.

2. Materials and methods

With the approval of the University of Louisville Institutional Review Board and written informed consent, we recruited 14 patients into the study. Participating patients were of American Society of Anesthesiologists physical status I or II, older than 18 years, with Mallampati class I or II airways, and with mouth opening greater than 6 cm, a thyromental distance greater than 6 cm, and a body mass index of less than 35 kg/m². All study patients were scheduled for minor gynecological or orthopedic surgery.

Patients were excluded from the study when an LMA was contraindicated or if they had a sore throat, gastroesophageal reflux disease, pulmonary disease, cervical spine disease, pregnancy, dysphonia, or dysphagia at the time of the study. Patients in this study also participated in a larger study that evaluated functional characteristics of the PLA [2].

2.1. Protocol

We measured core temperature at the tympanic membrane using Mon-a-therm thermocouples (Tyco-Mallinckrodt Anesthesiology Products, Inc, St Louis, MO). The aural probes were inserted while the patients were awake. They were thus able to tell when they felt the thermocouple touch the tympanic membrane; appropriate placement was confirmed when patients easily detected a gentle rubbing of the attached wire. The aural canal was occluded with cotton and was secured in place with a tegaderm.

After application of routine anesthetic monitoring, general anesthesia was induced by bolus intravenous administration of propofol (2-3 mg/kg). The airways were then inserted. Size no. 3 PLA was used in most women and a size no. 4 in most men. Airways were lubricated with a water-based lubricant before intubation. No muscle relaxants were administered before airway insertion. The cuffs of airway devices were inflated to 60 cm H₂O. A low-pressure monitor (VBM, Sulz, Germany) was used to measure cuff pressure. This cuff pressure has been shown to provide safe mucosal tissue pressures [3,4].

Anesthesia was maintained with 60% nitrous oxide, fentanyl, and sevoflurane. Patients in whom the estimated duration of anesthesia was less than 1 hour were allowed to breathe spontaneously. Otherwise, rocuronium (0.5 mg/kg) was given, and patients were mechanically ventilated with a tidal volume of 8 mL/kg, at a rate sufficient to maintain end-tidal carbon dioxide near 40 mm Hg. The fresh gas flow was 2 to 3 L/min, and we used a closed breathing circuit for all patients.

2.2. Measurements

Demographic and morphometric characteristics, airway classification, type of surgery, airway device size, and duration of anesthesia were recorded. Airways were classified with a modified Mallampati score by asking patients to maximally protrude their tongues from a fully open mouth while sitting upright [5,6]. Thyromental distance was measured, as described by Tse et al [7].

We measured temperatures with Mon-a-therm thermocouples (Tyco-Mallinckrodt Anesthesiology Products, Inc) attached to the tip, midposterior, and lateral-posterior parts of the PLA cuff (Fig. 1). Tympanic membrane temperature

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1 Sessler DI. CME course on thermoregulation. 2003.
2 LMA is a trademark of The Laryngeal Mask Co, Ltd, and all references therein to LMA are to this trademark.
measured by a Mon-a-therm thermocouple was used as the reference core temperature.

The probes were connected to Mallinckrodt Model 6510 2-channel electronic thermometers. These thermometers require no user calibration and have a precision of 0.1°C when used with Mon-a-therm disposable thermocouples. All temperatures were measured at 15-minute intervals throughout surgery.

2.3. Data analysis

Assuming the SD of the temperature differences to be approximately 0.6°C, 14 independent measurements provide 82% power for detecting a difference of 0.5°C. In addition, 39 independent data pairs would provide 99.9% power for detecting a difference of 0.5°C. We have 39 measurements in 14 patients, and because all 39 measurements are not independent, our study power is less than 99.9% but at least 82%. We considered differences less than 0.5°C to be clinically unimportant; thus, our study population provided adequate power for evaluating the ability of thermocouples positioned on the PLA to record body temperature accurately.

Perilaryngeal airway temperatures and the reference tympanic temperatures were compared using the bias (the mean difference between the methods) and the mean temperature difference. As in previous studies, temperatures differing less than 0.5°C from tympanic membrane values were considered clinically acceptable [2]. Bias was calculated as the average

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<th>Table 1 Temperature monitoring: tympanic membrane vs PLA</th>
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<td>Tip (1)</td>
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<td>Midposterior cuff (2)</td>
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Values are presented as mean ± SD or proportions. The numbers in the left-hand column refer to the labels in Fig. 1.

a The average of the perilaryngeal airway temperature minus tympanic membrane temperature for the individuals.

b The average of the absolute value of tympanic membrane temperature minus the perilaryngeal airway temperature for the individuals.

c The proportion of perilaryngeal airway temperatures that were within 0.5°C of the tympanic membrane temperature.

Fig. 1 Mon-a-therm thermocouples (Tyco-Mallinckrodt Anesthesiology Products, Inc) were placed on the posterior of the head portion (1), midposterior portion of the cuff (2), and on the midlateral portions (3 and 4) of the PLA cuff. The thermocouples were covered with bio-occlusive dressing.

Fig. 2 Bland-Altman analysis comparing the temperatures recorded at 3 PLA monitoring sites to those recorded at the tympanic membrane. The bias is the average of the PLA temperature reading minus the tympanic membrane temperature for the individuals expressed in degrees Celsius. The average of the absolute value of tympanic membrane temperature minus the PLA temperature is plotted on the x-axis. The centerline marks the bias or mean difference. The upper and lower lines are the boundaries for 2 SDs from the differences.
of the differences between the PLA temperatures and tympanic membrane temperatures for each recorded temperature. The mean temperature difference, however, was the average of the absolute value of tympanic membrane temperature minus the airway temperature for each recorded temperature. Results are presented as mean ± SD.

3. Results

We took measurements in 7 men and 7 women patients. They were, on average, 38 ± 10 years old and 169 ± 8 cm tall, and they weighed 79 ± 18 kg (body mass index, 28.5 ± 7.5 kg/m²). Ten of the patients were undergoing orthopedic surgery; 4 were undergoing gynecologic procedures. The average duration of anesthesia was 59 ± 36 minutes. All patient airways were scored as Mallampati class I (n = 8) or II (n = 6). All airway insertions were problem-free.

The temperatures at the tympanic membrane ranged from 35.9°C to 37.8°C. There were 39 data pairs analyzed from the 14 patients. Temperatures measured at the tip of the PLA differed considerably from the reference tympanic membrane temperature. However, temperatures recorded from the midposterior cuff differed considerably less. Temperatures recorded from the lateral-posterior cuff were virtually identical to tympanic membrane temperatures, with 97% of the values differing by less than 0.5°C (Table 1). As seen in Fig. 2 and Table 1, the bias (average of the PLA temperature reading minus the tympanic membrane temperature reading for each individual) became progressively better (nearer 0), going from the tip, to the midposterior, to the lateral-posterior positions on the cuff.

4. Discussion

Nearly all patients undergoing ambulatory surgery with general anesthesia in cold rooms become hypothermic [8]. Core hypothermia of even 1°C to 2°C is associated with numerous serious complications, including morbidity, cardiovascular outcomes [9], coagulopathy and increased transfusion requirement [10], surgical wound infection and prolonged hospitalization [11], reduced drug metabolism [12-14] and delayed postanesthetic recovery [15], and thermal discomfort [16]. Maintaining perioperative normothermia has thus become standard practice [17].

In this study, we concluded that core temperature can be monitored reliably by thermocouples placed on the cuff of PLA. The most reliable measurements were obtained through thermocouples positioned on the airway’s cuff rather than on the airway’s head. This positioning ensured that the thermocouples were near highly perfused oropharyngeal tissues and were insulated from respiratory gases by still air trapped within the cuff. The key element here was identifying a site on the PLA that positioned the thermocouple adjacent to well-perfused oropharyngeal tissues. Once appropriate positioning was ensured, it was unsurprising that the resulting temperatures were fairly accurate because carefully performed oral temperatures usually are accurate.

A limitation of our study is that most of the patients we studied were nearly normothermic (36°C-37°C). It therefore remains possible that accuracy is worse at lower or higher temperatures. A wide range of temperatures needs to be tested to confirm the accuracy at these measurements. However, supraglottic airways are usually used in patients having relatively small and short operations and who presumably are kept normothermic. In addition, our sample size was only 14 patients. However, even with this relatively few subjects, our power for detecting a 0.36°C temperature difference was 95%.

In summary, we compared tympanic membrane temperatures with those obtained from thermocouples positioned on 3 different sites of the cuff of PLA. Temperatures obtained from the lateral-posterior part of the cuff of PLA correlated well with the tympanic membrane temperatures. The other sites rarely differed by more than 0.5°C. We thus conclude that temperatures monitored from the cuff of PLA can be used intraoperatively.

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