THE ESOPHAGEAL TEMPERATURE GRADIENT IN ANESTHETIZED CHILDREN

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Abstract

Objective. Our objective was to study the effect of the temperature of the anesthetic gas mixture (AGM) on esophageal temperature measurements made in children whose tracheas had been intubated for anesthesia. We also sought to establish the optimal site for the temperature sensor in the esophagus and to find a way to accurately place the sensor.

Methods. Special esophageal temperature probes with thermistors located at 1-cm intervals were used for data collection on a multiplex system. Esophageal temperature measurements were made every 15 minutes for a period of 120 minutes in anesthetized children receiving heated (n = 30) and unheated (n = 30) anesthetic gases.

Results. The temperature of the AGM (p < 0.001), the site of measurement (p < 0.001), and the interaction between AGM temperature and site of measurement (p < 0.007) all had a significant effect on esophageal temperature measurements. This effect was greatest at a point 3 cm distal to the level of the tip of the endotracheal tube when AGMs were not heated.

Conclusion. We conclude that best results are obtained when care is taken to place the thermistor in the lower quarter of the esophagus. (We provide a simple formula for calculating this placement in pediatric patients of varying ages.) Placing the probe by acoustic criteria cannot consistently be relied on to provide good thermometry.

temperature measurements made in the esophagus. We studied intubated pediatric patients who were receiving either warmed or unwarmed AGMs to define the magnitude and the extent of this effect, to locate the level in the esophagus at which temperature measurements by a thermistor would correlate most closely with those made by a nasopharyngeal probe, and to find a convenient method whereby the thermistor could be accurately placed.

MATERIALS AND METHODS

We studied 60 patients (Table). Written informed consent was obtained from each patient’s parent and from the patient when pertinent. Patients were randomly assigned to receive AGMs warmed to 37.37 ± 0.8°C (n = 30) or AGMs not warmed or humidified. Gases were warmed by a Fisher Paykell heated humidifier, and we assumed that the AGMs were saturated with water vapor at the delivered temperature. All patients were classified as either ASA I or II. Those who were scheduled for thoracotomy, who had tracheal or esophageal disease, or who received less than 120 minutes of anesthesia were excluded from the study. This study was approved by the Institutional Review Board of Duke University Medical Center.

Anesthesia for all patients consisted of general orotracheal anesthesia through a Jackson Rees modification of Ayre’s T-piece. Ventilation was controlled and fresh gas flow rates were adjusted to achieve an end-expired CO₂ tension of between 25 and 35 mm Hg. The agents used were halothane, nitrous oxide, and oxygen; fentanyl when indicated; and either atracurium or vecuronium for muscle relaxation. The ETT was positioned so that the distal end was located 2 cm above the carina. This position was achieved by advancing it into a main stem bronchus and, while auscultating over the nonventilated lung, withdrawing the ETT to the carina, then withdrawing it 2 cm more [2]. The ETT was secured at this level if a gas leak occurred when the pressure in the circuit was between 12 and 25 cm of water.

Starting at the level of the end of the ETT in the trachea, we made temperature measurements along the esophagus at 1-cm intervals with specially constructed esophageal temperature probes. They were of the same thickness (12 French) and length as the probes that we routinely use in clinical practice. Each probe had nine thermocouple sensors spaced at 1-cm intervals along its length, the first located 8 cm from the probe’s distal tip. We knew the level of the distal end of the ETT [2], so it was possible to position the probe in the esophagus with the proximal thermocouple lying directly opposite the end of the ETT in the trachea. With the probe in this position, the multiplex system simultaneously recorded temperature by all thermocouple sensors every 15 minutes. We considered the simultaneous collection of data important because of the differing response and equilibration times seen at different levels in the esophagus [3].

The measurements obtained from the two groups of patients were compared with each other and also with nasopharyngeal temperature data [4]. Because we found that the recommended depth of placement of the nasopharyngeal probe sometimes resulted in the tip of this probe lying in the oropharynx, it was inserted to a depth equal to 1.5 to 2 cm less than the distance from the tragus of the ear to the nostril. A pack was then placed in the oropharynx to isolate the probe from the ETT and from any gases escaping above the trachea during positive pressure ventilation.

When appropriate, t-tests and analysis of variance with repeated measures of variance was used for comparison between groups. Pearson’s product correlation coefficient was also used. A probability value of <0.05 was considered to be statistically significant. Results are given as mean ± 1 standard deviation (SD).

RESULTS

There were no statistical differences between patients receiving warmed and patients receiving unwarmed AGMs with respect to age, weight, height (Table), or the duration of anesthesia, nor did the nasopharyngeal temperatures differ between the two groups and during the 120 minutes of study period. However, in both groups there was a slight increase in nasopharyngeal temperature over the period; the mean temperature in patients receiving warmed AGMs increased from 36.8 ± 0.7°C to 37.2 ± 1.0°C and in patients receiving unwarmed AGMs it increased from 36.8 ± 0.5°C to 37.2 ± 0.8°C.

Demographic Data

<table>
<thead>
<tr>
<th>Anthropometric Data</th>
<th>Group Iᵃ (n = 30)</th>
<th>Group IIᵇ (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>3.07 ± 2.4</td>
<td>3.3 ± 2.5</td>
</tr>
<tr>
<td>(0.1–8.0)</td>
<td>(0.4–9.0)</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>14.7 ± 8.3</td>
<td>15.1 ± 5.7</td>
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<tr>
<td>(4.0–9.0)</td>
<td>(7.0–23.0)</td>
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</tr>
<tr>
<td>Height (cm)</td>
<td>90.1 ± 23.1</td>
<td>95.1 ± 19.4</td>
</tr>
<tr>
<td>(25.0–141.0)</td>
<td>(63.5–129)</td>
<td></td>
</tr>
<tr>
<td>Incisors to LES</td>
<td>27.1 ± 5.1</td>
<td>21.1 ± 6.6</td>
</tr>
<tr>
<td>distance (cm) (9)</td>
<td>(19.1–36.8)</td>
<td>(26.1–36.0)</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD; ranges are given in parentheses.

ᵃPatients in group I received warmed AGMs.
ᵇPatients in group II received unwarmed AGMs.
LES = lower esophageal sphincter.