Difference in thermodynamics between two types of esophageal temperature probes: Insights from an experimental study

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BACKGROUND Luminal esophageal temperature monitoring is performed with a variety of temperature probes, but little is known about the relationship between the structure of a given probe and its thermodynamic characteristics.

OBJECTIVE The purpose of this study was to evaluate the difference in thermodynamics between a 9Fr standard esophageal probe and an 18Fr esophageal stethoscope.

METHODS In the experimental setting, each probe was submerged in a constant temperature water bath maintained at 42°C. In the patient setting, we monitored the temperature with both probes at the same time.

RESULTS The time constant of the stethoscope was higher than that of the probe (33.5 vs 8.3 seconds). Compared to the probe, the mean temperature measured by the stethoscope at 10 seconds was significantly lower (22.5°C ± 0.4°C vs 33.5°C ± 0.3°C, $P < .0001$), whereas the time to reach the peak temperature was significantly longer (132.6 ± 5.9 seconds vs 38.8 ± 1.0 seconds, $P < .0001$). Even in the ablation cases we observed that when the esophageal probe reached a peak temperature of 39.6°C ± 0.3°C, the esophageal stethoscope still displayed a temperature of 37.3°C ± 0.2°C (mean 2.39°C ± 0.3°C lower, $P < .0001$), showing a <0.5°C increase in temperature half of the time.

CONCLUSION The 18Fr esophageal stethoscope has a significantly slower time response compared to the 9Fr esophageal probe. In the clinical setting, this might result in a considerable underestimation of the luminal esophageal temperature with potentially fatal consequences.

KEYWORDS Esophageal luminal temperature monitoring; Esophagus; Atrio-esophageal fistula; Thermodynamics; Temperature probe

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Introduction

Luminal esophageal temperature (LET) monitoring using esophageal temperature probes has been used as a strategy to decrease the risk of esophageal thermal injury/atrio-esophageal fistulas by guiding energy delivery during ablation for more than a decade.[1–3] To be effective, LET must accurately reflect the esophageal tissue temperature. Accuracy can be affected not only by the position of the probe relative to the ablation catheter but also by its structural characteristics.[4] many different types of esophageal temperature probes are commercially available, varying in size (7–18Fr), sensor cover (metallic vs plastic), and number of sensors (single vs multiple). Given the widespread availability and low cost of the probes, LET is commonly performed with disposable, single-sensor, plastic-covered

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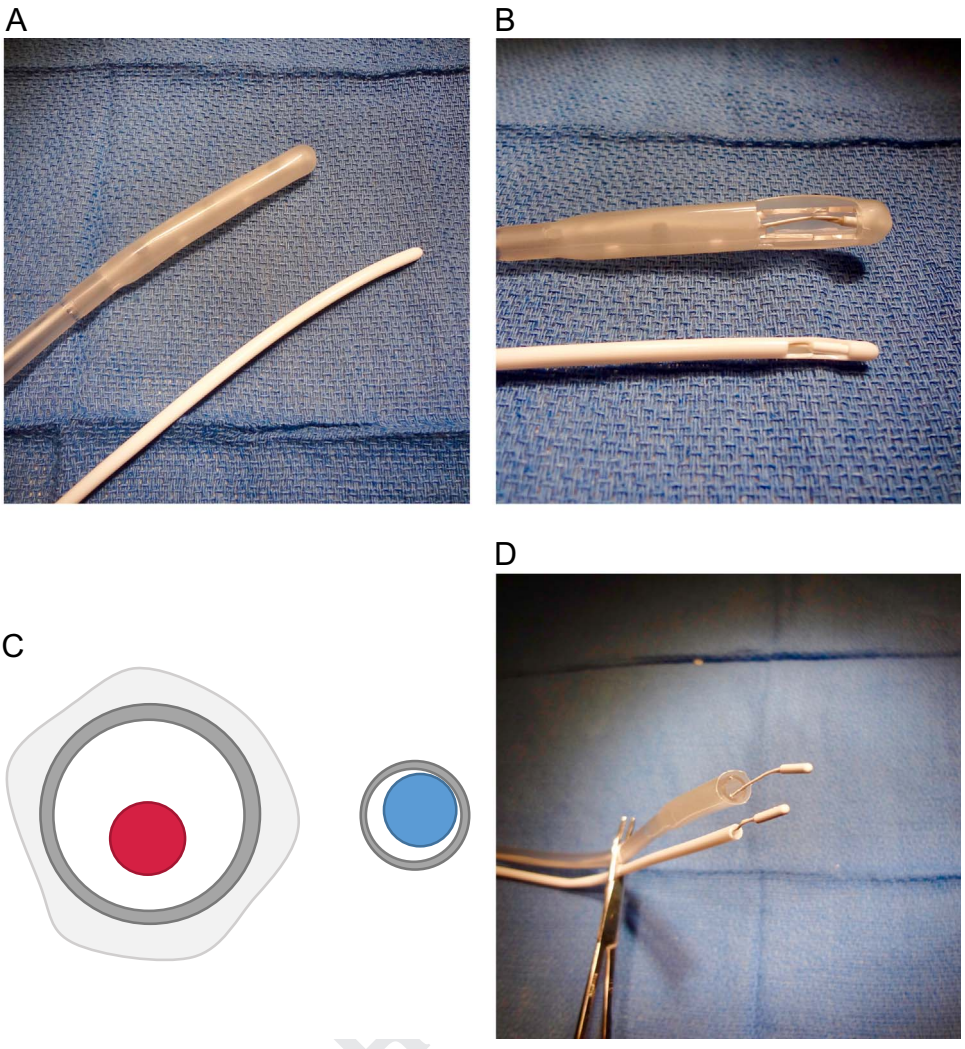

Figure 1 Esophageal stethoscope and esophageal probe. **A:** Esophageal stethoscope **(top)** and probe **(bottom). B, C:** Section of the plastic sheath removed to show the exposed thermistor. **D:** Schematic representation of the structure of the esophageal stethoscope **(left)** and probe **(right).**

probes used by anesthesiologists to monitor the core temperature at the level of the distal esophagus.[5] These temperature probes can be either standalone *(esophageal probe)* or incorporated into *esophageal stethoscopes* to allow simultaneous auscultation of heart and lung sounds even when the patient's chest is covered by surgical drapes. The latter usually has a larger diameter, with a higher air-to-plastic sheath ratio to enhance sound transmission (Figure 1). Consequently, the esophageal stethoscope is stiffer and easier to advance into the esophagus, and as such it usually is preferred by anesthesiologists. The recent occurrence of 2 cases of atrio-esophageal fistula in a short time span prompted us to investigate the esophageal stethoscope because in neither case did the measured temperature appear to be >40°C. Because we hypothesized that the esophageal stethoscope significantly underestimated LET, we sought to compare its thermodynamic characteristics to that of a standard esophageal probe.

Methods

We tested 2 types of single-sensor temperature probes (Smiths Medical, Dublin, OH): (1) *9Fr esophageal probe* (ER400-9), which consists of a thin (~0.4 mm) 9 polyvinyl chloride (PVC) tube with a 3-mm diameter; and (2) *18Fr esophageal stethoscope* (ES400-18), which consists of a thick (~0.8 mm) PVC tube with a distal perforated end (for better sound transmission) covered by a thin plastic cuff. The diameter of the PVC tube is 6 mm but up to 8.8 mm when the cuff is included.

Inside both catheters, a thermistor positioned at the distal end measures the temperature with an accuracy of ±0.2°C. Both probes were connected to a monitor (CareScape B650, General Electric, Fairfield, CT), which displayed the temperature in real time at a rate of 1/second.

In the *experimental setting,* each probe was submerged in a constant temperature water bath maintained at 42°C throughout the experiments. The exposed thermistor was used as control. The experiments were repeated 10 times for each probe. Data collected included baseline temperature, temperature values after submersion (1/second), temperature reached at 10 seconds, and temperature of the esophageal stethoscope when the esophageal probe reached the peak temperature. Moreover, given the first-order system behavior