Title: ESOPHAGEAL TEMPERATURE DISTRIBUTION, IMPLICATIONS FOR CLINICAL TEMPERATURE MEASUREMENT

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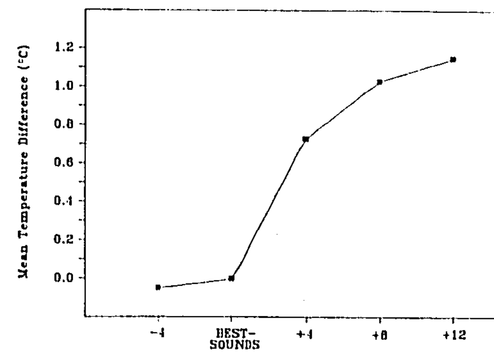
Introduction: Monitoring of body temperature has become routine. A popular monitoring technique is measurement of esophageal temperature either with separate temperature probes or esophageal stethoscopes with integral temperature probes. The question being investigated here is the size of the temperature gradient along the esophagus and its relationship to the heart and breath sounds heard through an esophageal stethoscope.

Methods: All temperatures were measured with Sheriden esophageal stethoscopes, model 5-13724, which contain a series 400 thermistor temperature probe. The thermistor was connected to a Yellow Springs Instrument Company temperature monitor which could read to ± 0.1°C. Esophageal temperatures of 15 patients undergoing total hip or total knee replacement were measured. All patients underwent tracheal intubation, with the endotracheal tube cuff palpable in the suprasternal notch. Anesthesia was maintained with oxygen 2 l/min, nitrous oxide 3 l/min, and isoflurane. End-tidal CO_2, measured by mass spectrometer, was maintained such that P_{aCO_2} remained between 35 torr to 45 torr. Following induction, an esophageal stethoscope was inserted for routine monitoring of temperature and breath and heart sounds. After the temperature had stabilized, usually at least an hour after induction, the position of best-sounds was determined. Best-sounds was defined as the best combination of breath sounds and heart sounds. Once the position of best-sounds was determined, the stethoscope was shifted to the nearest depth marking. These markings start at 22 cm, and are placed every 4 cm thereafter. All positions were measured relative to the upper central incisors. This maximum shift of 2 cm had very little effect on the sounds. The stethoscope remained at this last position until the temperature stopped drifting; this temperature was recorded. The stethoscope was then inserted to a depth of 42 cm and the temperature recorded after cessation of drift. Temperatures were measured in the same manner at 38, 34, 30, 26 and 22 cm depth, skipping the depth of best-sounds. The stethoscope was then returned to the position of best-sounds (on the nearest depth calibration) and the temperature remeasured.

Results: The Figure shows the difference in mean temperature between the position of best-sounds and the other positions along the esophagus. A positive distance corresponds to a position of greater depth relative to the position of best-sounds. The difference in temperature between the position of best-sounds and other positions ranged from -1.3°C (at -4 cm) to +2.4°C. Four patients had temperatures 1.5°C or higher than those at the position of best-sounds. Analysis of variance with repeated measures (BMDP P2V) and two-tailed Dunnett's test were used to determine the statistical significance of the temperature difference between the position of best-sounds and other positions along the esophagus. There was no statistically significant difference in temperature between the position of best-sounds and -4 cm. The temperature differences at positive positions were all significant at $p < 0.01$.



Discussion: The data as presented in the Figure are independent of the accuracy (offset) of the temperature measurements. Their validity depend only on the slope and linearity of the measuring system over a very small range of temperatures. The body temperatures of the patients were stable during the measurement period since the mean difference in temperature between the two measurements at positions of best-sounds was 0°C. In summary, 1) The coolest area in the esophagus is where the best heart and lung sounds are auscultated. 2) Accurate esophageal temperature is measured behind the heart, 12 cm to 16 cm deeper than the position of best-sounds. 3) Auscultation of esophageal sounds affords an easy method for determining correct temperature probe placement. 4) Measurement errors due to esophageal temperature probe positioning can be large enough to cause unnecessary therapeutic intervention and iatrogenic hyperthermia. 5) Esophageal stethoscopes with the temperature probe located at the auscultory cuff should not be used. 6) Temperature probes should not be arbitrarily positioned in the esophagus. 7) Measurements (or reports) of heater-humidifier effects on body temperature, as measured by esophageal temperature, are likely to be in error due to direct airway heating of the esophagus, unless the temperature probe is known to be correctly placed.