INFRARED TYMPANIC THERMOMETRY: METHODOLOGICAL CONSIDERATIONS

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INTRODUCTION

Infrared tympanic thermometers (ITT) are becoming commonplace in hospitals and laboratories for routine measurement of deep body temperature. Their appeal lies in their being non-invasive, non-traumatic, easy to use in any setting, and providing a reading within seconds rather than minutes with no risk of cross-contamination. Recent studies have investigated the absolute accuracy of these instruments (1, 2) or examined their relationship with other measures of deep body temperature (e.g. oral, oesophageal or rectal) during surgery (1, 3) or cold water immersion (4). The results from these studies are conflicting. Some authors have reported their instrument to be accurate to within 0.1°C (1) and closely related to other measures of deep body temperature (1, 3, 4), while others reported some inaccuracy (± 0.5°C; 2) and poor correlations (5). The objective of the present study was to investigate the influence of methodological factors and ear canal anatomy on the ITT readings. We hypothesized that the temperature readings obtained by a ITT depends upon the brand of the instrument used, the operator's technique, and the characteristics of the ear canal which define the field of view of the instrument.

METHOD

Sixty-six male (mean ± SE: 38.1 ± 1.3 years of age) and 29 female subjects (34.0 ± 1.8 years) had their right ear canal characterised by a physician using an othoscope (Heine micro-tip, Germany; outside diameter of the cone-tip: ~7.0 mm). The anatomical characterisation was done for the length of the ear canal, its diameter, curvature, presence of ear canal or tympanum inflammation, level of obstruction by cerumen, and percentage of the field of view covered by the tympanum (at ± 5 % accuracy). Following the ear examination, the right tympanic temperature was measured three times by each of the three investigators using one of three different ITT instruments (FirstTemp Genius model 3000A, Intelligent Medical Systems, CA, USA; Thermoscan model IR-1, Thermoscan Inc., CA, USA; Diatek model 9000, Diatek Inc, CA, USA) for a total of 27 readings per subject (3 readings x 3 investigators x 3 instruments) within a 15- min period. The sequence for operators and instruments was randomly assigned among the subjects. During the 15-min period, the oral temperature was also measured using a small thermistor (YSI 44004 series, Yellow Spring Instruments, Ohio, USA) located in a posterior sublingual pocket of the subject's mouth. The oral temperature was recorded at the end of the 15-min period. The subjects were asked to avoid ingesting any drink or food and refrain from smoking for at least 30 min before the measurements. During the 15-min measurement period, the subjects were asked to breathe through their nose and keep their mouth closed. The temperature measurements were performed at room temperature (23.0 ± 0.2°C) while the subjects were in a sitting position. The ITT instruments were checked for calibration against a calibrated quartz thermometer (Hewlett Packard 2804A) and were found to be accurate to 0.1°C. The calibration of the oral thermistors was checked to be within 0.1°C of the ITT instruments. All three ITT instruments were used at the "surface mode" setting which gave the actual temperature of the surface scanned.

RESULTS

Twenty-four of the 95 subjects (25%) had between 50 to 100% of their tympanic membrane obscured due to the curvature of the ear canal or by cerumen (8 subjects had total obstruction of the canal by cerumen), while the tympanic membrane could be entirely visualized in only 14 subjects (15%). We observed that the largest difference between any of the 3 successive readings performed by the same operator using the same instrument was less than the resolution of the ITT instruments (0.09 ± 0.02°C); those three successive readings were therefore averaged. The oral temperature (Toral) was significantly higher (by 0.92 ± 0.05°C, ranged from -0.1 to 2.2°C; $p < 0.001$) than the tympanic temperature (Ttymp) measured by the ITT instruments (Toral: 36.80 ± 0.03°C; Ttymp: 35.88 ± 0.05°C). There was a significant positive correlation ($p < 0.001$) between Toral and Ttymp but the coefficient of correlation was only 0.36 ± 0.02. No difference was observed between the temperature readings of the Thermoscan and the Diatek instruments, but both instruments were giving temperatures 0.20 ± 0.03°C higher than the Genius ($p < 0.001$), which has the largest cone-shaped head of the instruments tested (Genius: 9.0 mm; Thermoscan: 7.6 mm; Diatek: 8.0 mm). No difference was observed between the temperature readings obtained by operators 1 and 2, but both operators obtained readings on average 0.23 ± 0.03°C higher than operator 3 whose technique differed by his lighter pressure on the subject's ear canal.

Stepwise linear regression analysis using the characteristics of the ear canal as independent variables show that for the Genius ITT the curvature of the ear canal has a negative linear correlation with Ttymp ($p < 0.001$, $R = 0.35$). For the Thermoscan and Diatek ITTs, the % coverage by the tympanum and the presence of tympanic inflammation had a positive linear correlation with Ttymp, while the length of the ear canal had a negative linear correlation with Ttymp ($p < 0.001$, $R = 0.42$)

CONCLUSIONS

The infrared sensor of an ITT will register the temperature of the aural structure that it can "see" during the measurement. Several factors have been identified in this study to significantly affect the sensor's view: the diameter of the probe tip (brand of ITT), the technique of measurement (aim and pressure), and the characteristics of the ear canal (curvature, length, and tympanic inflammation). Five subjects had an ideal ear canal for tympanic temperature measurement using an ITT (short, straight, large diameter, absence of cerumen and inflammation); the average value of (Toral - Ttymp) was down to 0.15°C for those subjects compared to 0.92°C for the pool of 95 subjects. It is concluded that unless the ITT instrument has a perfect view of the tympanum (which was the case in only 5% of our subjects), it can not provide a reliable measurement of the tympanic temperature.

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