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Tympanic, Infrared Skin, and Temporal Artery Scan Thermometers Compared with Rectal Measurement in Children: A Real-Life Assessment

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ABSTRACT

Introduction: Body temperature measurement in children is of clinical relevance. Although rectal measurement is the gold standard, less invasive tools have become available. We aimed to describe the accuracy of tympanic, infrared skin, or temporal artery scan thermometers compared with rectal measurement to reflect core temperature.

Methods: Rectal (Filac 3000; Covidien, Mechelen, Belgium), tympanic (AccuSystem Genius2 Typmanic Infrared Ear Thermometer, Covidien, Mechelen, Belgium), temporal artery scan (Exergen, Exergen Corp, Watertown, Massachusetts), and infrared (ThermoFlash Contactless Medical Electronic Thermometer, Visiomedlab, Paris, France) body temperature measurements were randomly performed and readings were collected once. Temperature readings were described as median and range, and observations were compared with rectal temperature readings (using Wilcoxon, Bland-Altman, sensitivity, and specificity tests). The child's comfort was assessed by the child, parent, and nurse (using Likert scales) and ease of use was assessed by nurses (using visual analog scale).

Results: Based on observations in 294 (median age = 3.2 years, range = 0.02–17 years) children, the mean difference was 0.49°C (tympanic scan; $P < 0.0001$), 0.34°C (infrared skin scan; $P < 0.0001$), and 0°C (temporal artery scan; $P = 0.9288$), respectively, when compared with rectal temperature readings. Based on visual inspection of Bland-Altman plots, all tools overestimated the temperature at lower body temperature and underestimated the temperature at higher body temperature, resulting in a sensitivity of 22% to 41% and a specificity of 98% to 100% for rectal temperatures above 38°C. The Likert scale scores and the visual analog scale scores for rectal measurement were only slightly higher when compared with the other methods.

Conclusions: All noninvasive techniques underperformed compared with rectal measurement. The temporal artery scan deviations were smallest, but all noninvasive techniques overestimate lower temperatures and underestimate higher temperatures compared with rectal measurement. In our hands, temporal artery scan measurement seems to be second best, but not yet ideal.

Introduction

Medical decisions related to diagnosis, planning of investigations, or subsequent pharmacologic treatment in children are in part driven by body temperature measurement.[1–3] In pediatrics, the gold-standard reference to measure core body temperature is by measurement of rectal temperature because this reflects central core temperature. Although this is considered to be the gold standard in many health care systems, it carries its own drawbacks. This includes discomfort, emotional distress, and—although very rare—possible complications such as perforation or transmission of micro-organisms. In a systematic review, axillary instead of rectal recordings resulted in a pooled difference of 0.85°C (−0.2°C to 1.9°C).[4,5] In an attempt to avoid the disadvantages of rectal measurement, a range of alternative devices and less noninvasive methods have been introduced, including tympanic,[6–11] infrared skin scan,[6,12–15] and temporal artery scan[16,17] temperature measurement.

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A popular alternative for rectal measurement is the tympanic scan thermometer.[6–11] This device measures the amount of infrared heat produced by the tympanic membrane of the ear by means of a sensor probe. The tympanic membrane shares its blood supply with the hypothalamus, the thermoregulatory center of the human body. However, this necessitates appropriate application and access to the tympanic membrane. Consequently, the probe needs to be positioned in the auditory external duct in the appropriate angle to the tympanic membrane, which makes it more difficult in young infants or in cases of suspected otitis media, but has indeed been very well validated in, for example, sedated patients or during anesthesia. The infrared skin thermometer is another tool to measure body temperature.[6,12–15] A sensor probe measures the amount of infrared emitted heat. Consequently, temperature can be measured without direct contact with the child. Specific advantages of the no-touch technique relate to cross-infections or the possibility to measure without disrupting sleep. Finally, temporal artery scan techniques have been developed.[16,17] Temperature is hereby registered by slow scanning the forehead in the temporal artery region and behind the ear by direct skin contact. The thermometer thereby measures the naturally emitted infrared heat form the temporal arterial supply.

Several comparative studies have been performed in either sedated patients[9,12] or in specific pediatric subpopulations,[9,10,14] commonly by comparing 2 devices.[4–6,8,11,13,15–17] In contrast, investigator-driven studies that simultaneously compare different available assessment tools in a heterogeneous group of pediatric populations commonly admitted in a pediatric hospital is limited. In our study, we aimed to evaluate the accuracy and performance of 3 newer tools when compared with what is considered to be the gold standard; that is, rectal temperature measurement, within a real-life clinical setting. Besides the measurement, we also collected some subjective impressions about the child's comfort (evaluated by the nurse, parent, and child) and the device-specific ease of use (evaluated by the nurse).

Methods

Ethics, enrollment, and clinical study

The study protocol (S 53071) was approved by the ethics board of University Hospitals, Leuven, Belgium. Pediatric patients admitted to different pediatric wards of University Hospitals were included in the study after informed consent of the patients and/or their legal representatives when body temperature assessment was scheduled.

The study protocol had the explicit aim to reflect a real-life assessment. Measurements were collected in every single patient in random order. Using an at-random approach, a rectal body temperature measurement device (Filac 3000; Covidien, Mechelen, Belgium), a tympanic scan thermometer (AccuSystem Genius2 Tympanic Infrared Ear Thermometer; Covidien, Mechelen, Belgium), an infrared skin scan thermometer (ThermoFlash Contactless Medical Electronic Thermometer; Visiomedlab, Paris, France), and a temporal artery scan thermometer (Exergen; Exergen Corp, Watertown, Massachusetts) were used. Measurements were collected consecutively at 1 single time point with a time interval to collect all readings of <5 minutes to avoid physiologic fluctuations.

Measurements were performed according to the product-specific instructions, and nurses were trained before the study on the appropriate use of the different devices. These trainings were formal teaching sessions explaining product-specific issues for appropriate and safe use of the different devices. The presentations and written handout documents were subsequently provided to the nurses and compliance was intermittently verified by a dedicated study nurse (I. van Gorp). Temperature readings in every individual patient were collected at 1 time point, every child was only included once, and device-specific readings were only performed once in every patient. To reflect the heterogeneous character of the study population, children were included at the emergency department, at the outpatient clinic, at the pediatric day surgery unit and on the medical wards.

In addition to the temperature readings, subjective impressions about the child's comfort (as assessed by the nurse, parent, and child) and the ease of use (assessed by the nurse) were collected. These subjective impressions were quantified based on a Likert scale score (child's comfort, assessed by the child, parent, and nurse, where 1–5 = very well, well, neutral, poor, and very poor comfort, respectively) or a visual analog scale (VAS) score (ease of use, assessed by the nurse, where 0–10=very good to very poor). The choice for different scores (Likert or VAS) for the assessments of the nurses was to stress the differences between both questions (child's comfort vs ease of use). These data were collected immediately following temperature readings.

Data analysis and statistics

Temperature readings and Likert scale or VAS scores were reported by median and range. Temperature readings as collected with the different measurement tools were compared (using Wilcoxon test). Considering rectal temperature readings as the reference value, temperature readings were compared with this reference value (differences) and graphed according to the Bland-Altman method. Finally, sensitivity, specificity, positive predictive values, and negative predictive values to detect raised body temperature (37.8°C) and fever (38°C) were calculated based on the same rectal reference measurements. Statistics were analyzed using MedCalc (MedCalc Software, Ostend, Belgium), and P values <0.05 were considered significant.

Results

In total, 294 children with a median age of 3.2 years (range = 0.02–17 years) were included. Temperature readings as recorded for the different measurement tools are listed in Table I. Compared with rectal measurement, the mean differences were 0.49°C

Table I
Temperature readings* and subjective evaluation by nurses, parents, and children related to the child's comfort or ease of use.

Temperature measurement device	Median	Range	
Rectal measurement	37.1	35.1–39.5	
Tympanic thermometer	36.6	34.7–39.5	
Infrared skin scan thermometer	36.7	35.0–39.7	
Temporal arterial scan thermometer	37.1	35.6–39.8	
	Nurse	Parent	Child
Subjective evaluation, child friendly†			
Rectal measurement	2 (0-5)	2 (0-5)	2 (0-5)
Tympanic thermometer	1 (0-3)	1 (0-5)	1 (0-5)
Infrared skin scan thermometer	1 (0-5)	1 (0-5)	1 (0-5)
Temporal arterial scan thermometer	1 (0-5)	1 (0-5)	1 (0-5)
Subjective evaluation, ease of use‡			
Rectal measurement	3 (0-7)		
Tympanic thermometer	2 (0-6)		
Infrared skin scan thermometer	1 (0-9)		
Temporal arterial scan thermometer	2 (0-6)		

*Values are given in °C.
†Based on Likert score of 0–5. Values are given as median (range).
‡Based on visual analog scale score of 0–10. Values are given as median (range).