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Precision, Sensitivity and Patient Preference of Non-Invasive Thermometers in a Pediatric Surgical Acute Care Setting

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ABSTRACT

Purpose: The purpose of the project was to compare the temporal artery thermometer (TAT) to the digital probe thermometer readings at axillary or oral sites, to determine the relative precision and sensitivity of the three methods of thermometry, to compare their readings to core temperature when feasible, and to survey patient and family thermometer preferences.

Design & Methods: A randomized crossover design in a 70-bed surgical unit over eight months. Two sets of temperature measurements were obtained for each patient: TAT, axillary, oral (depending on patient ability) and a bladder temperature representing core body temperature (when available). Each method was used twice on each patient, to examine within-method precision. Following measurement, patients or caregivers provided their thermometer preference. For younger/nonverbal patients, a professional observer recorded a disruption score. N = 298 patients were enrolled

Results: TAT was more precise than oral and axillary thermometers ($p < 0.001$ vs. axillary, $p = 0.001$ vs. oral). TAT measurements were higher on average than axillary and oral, by 0.7 °C and 0.6 °C respectively ($p < 0.001$). TAT's disruption score for younger patients was 0.6 points lower on average than axillary ($p < 0.001$). 84% of patients and families who indicated a clear thermometry preference chose TAT. Only 3 patients had bladder-temperature devices, and therefore accuracy could not be analyzed.

Conclusions: TAT is more precise, more fever sensitive, less disruptive to younger children, and more preferred by patients and families.

Practice Implications: TAT is an acceptable temperature measure that could be substituted for oral or axillary temperature in acute care pediatric settings.

Obtaining a reliable temperature measure is a component of routine nursing assessment in virtually all clinical pediatric settings. In order to provide high quality nursing care, it is imperative that nurses utilize temperature devices that are accurate, precise, and pose no harm to the patient. The current practice at the Seattle Children's Hospital (SCH) surgical unit includes use of oral and axillary thermometers, however there is increasing interest in exploring the use of temporal artery thermometers (TATs) within the hospital. Nurses hypothesized that the use of TATs may result in reduced patient disruption and increased patient and/or parent satisfaction. Consequently, a literature review was conducted by the SCH Surgical Unit's Evidence Based Practice Committee on the subject of clinical pediatric thermometry. This review revealed many studies comparing TAT temperatures to core temperature measurements, but only a few studies comparing TAT to axillary or oral measurements. Even fewer studies examined patient and/or family preference for different thermometry devices.

The TAT is a non-invasive device that is rarely used on the SCH surgical unit. Research on accuracy and reliability of thermometry has provided mixed to favorable results, a meta-analysis study found wide variations between axilla and core sites (Craig, Lancaster, Williamson, & Smyth, 2000), and recommended further research to study precision. One study consistently reported variation of axillary temperature compared with core (pulmonary artery) temperature, suggesting measurement concern with axillary temperature (Bridges et al., 2007).

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According to our research, the advantages that the TAT could offer over oral or axillary devices include; increased accuracy, precision, efficiency and patient satisfaction.

While our study was ongoing, several meta-analyses were published examining the accuracy of TAT and other noninvasive methods in estimating core temperatures. Niven et al. (2015) analyzed 69 studies of adults and young children, examining the accuracy of noninvasive methods (14 of the studies examined TAT), and 20 studies (7 with TAT) examining sensitivity to fever detection. Geijer, Udumyan, Lohse, and Nilsagård (2016) analyzed 37 studies of TAT accuracy, and Zhen, Xia, Long, and Pu (2014) analyzed 28 studies of tympanic thermometry accuracy. All meta-analyses indicate that no widely-used noninvasive method achieves the accepted accuracy criterion of remaining within ± 0.5 °C of core temperature 95% of the time (known as Limits of Agreement or LOA).

Among core-temperature methods, the least invasive is rectal. This method is still considered problematic or even risky for many patient populations, young or ill children. Other core methods require an invasive surgical procedure. The debate whether to institute core thermometry as the bedside standard (e.g., Niven et al., 2015; Bonzi et al., 2016) is beyond the scope of our study. As long as the policy in many pediatric departments is to use noninvasive methods, the question remains as to which of these limited-accuracy methods is preferable. However, documented evidence of patient comfort and preference is lacking in existing literature. Additionally, limited attention has been given to the comparison of TAT use to oral or axillary thermometers in acute care pediatric settings.

We report here our comparative study of three non-invasive approaches to temperature measurement in the pediatric acute care population: oral, axillary and TAT. None of these three devices directly measure core body temperature, making it impossible for us to ascertain the true accuracy of each device. Consequently, we examined the following endpoints: 1) precision; evaluated by the correlation and normalized difference between two successive measurements on the same patient, 2) the relationship between the different measurement methods, in particular the degree of agreement regarding actionable fever, and 3) patient experience; evaluated with a patient and caregiver questionnaire or a level of disruption scored by a professional observer.

Materials & Methods

Design, Setting, and Subjects

The study was carried out at the 70-bed surgical care units of SCH, a 323 bed, tertiary regional pediatric medical center with approximately 15,000 admissions yearly, to the surgical care unit, cover a broad range of surgical procedures across medical specialties. Eligible participants were pediatric patients aged 0–17 years admitted inpatient to the surgical units at SCH. Including both pre-operative and post-operative patients, as well as those admitted for medical therapies. The SCH surgical units' specialties include general surgery, cardiac-surgery, cardiology, solid organ transplant, gastroenterology, nephrology, urology, orthopedics, plastic and oral surgery, otolaryngology, and neurosurgery. Patients with head bandages or hardware that did not allow a TAT to be taken were excluded, otherwise all remaining patients on the unit were considered eligible participants. After the SCH institutional review board (IRB) approval, trained registered nurses who were members of this research group approached and consented eligible participants. Once participants were appropriately enrolled, data collection commenced until approximately 300 patients were enrolled.

Instruments

We used two non-invasive thermometers to compare the precision and correlation between two sets of measured temperatures per patient. In addition, we used a survey question and a Likert-scale questionnaire to measure patient preferences.

The TAT; Temporal Scanner TAT 5000 (Exergen Corporation, Watertown, MA, USA) was used for the temporal artery temperature. The TAT measures the body temperature within 1–2 s, by scanning the infrared emission across the patient's forehead.

The digital probe thermometer; Sure Temp Plus 692 (Welch Allyn, Louisiana, MO, USA) was used for oral and axillary temperature. A digital probe measures temperature by heat conduction from the area of the body that the device has contact with (axillary – under the patient's arm; oral - under the patient's tongue). Oral measurement takes approximately 4–6 s, and axillary approximately 10–12 s.

To measure device preference each type of device had on each participant and their family, we asked the participants with verbal abilities a survey question to allow participants to express device preference. The planned survey questions for verbal patients (developmentally preschool age and older) and for their parents were “Which thermometer did you like?”, “Which one is your favorite?” or “Which one would you want to use again?”

For the nonverbal participants, patients with developmental delays or patients too young to verbalize preference (typically newborn to around two years of age) we assessed the level of disruption utilizing a 5-point Likert scale instrument. A search conducted found no other validated tool that would elicit the data we were seeking. Therefore, the team developed and named the Myking Disruption Scale (Table 1). The disruption level reflects the time it took for the patient to calm down or regain their baseline state prior to the thermometer assessment. For example, if a 12-month old patient took 2 min to calm down from being disturbed by the assessment of an axillary temperature device, that assessment would receive a disruption score of 2 (Table 1).

Data Collection

For each enrolled participant, data were collected on three to four items: a TAT measurement, an oral, and/or axillary temperature (depending on patient age) and device preference determined by survey question or disruption score. Oral temperatures were not collected on participants unable to follow directions due to actual or developmental age per surgical unit standard of care. In the same encounter, the temperature-measurement sequence was repeated within 5–10 min by the same professional. The order in which the devices were used was randomized to neutralize a potential order effect. For patients fitted with a bladder temperature device, a pair of bladder temperature reading was recorded as a closer proxy to core body temperature. Data were collected during standard-of-care scheduled times of the day and night shifts to most accurately represent the 24-hour inpatient setting. The team of direct care nurse investigators entered data to a password-protected, secure Excel 2007 spreadsheet (Microsoft, Redmond WA), on an enterprise desktop.

Analysis

Descriptive statistical summaries (mean, standard deviation and range) were calculated for each device's measurements, and for pair

Table 1
MyKing Disruption Scale.

Behavioral observations	Points
Patient, no change in behavior	0
Patient, awakened/returned to pre-assessed state within 1 min	1
Patient, awakened/returned to pre-assessed state within 1–5 min	2
Patient, awakened/returned to pre-assessed state within 5–10 min	3
Patient, awakened/returned to pre-assessed state, >10 min needed to settle	4

Table 1 ascribes a score for disruption level by measuring the time occurred to regain a pre-assessed state.