Clinical Nursing Research
1–8

DOI: 10.1177/1054773814557481
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Temporal Artery Thermometry to Detect Pediatric Fever

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Abstract

This research investigated effectiveness of temporal artery thermometry (TAT) to detect high rectal fever in children ≥91 days and ≤4 years old. Rectal temperature was initially evaluated immediately followed by TAT. As expected, the difference between mean rectal (38.05 ± .99 °C) and mean TA (37.55 ± .8 °C) temperatures in subjects (N = 239) was significant (p < .0001). Linear regression revealed TAT underestimated rectal thermometry with greater frequency at higher temperatures. This observation provides probable explanation for the disparity between these thermometry methods. A TAT sensitivity of 75% and specificity of 85% were determined for detecting high fever (39 °C)—a finding clinically unacceptable. In contrast, among the small number of injured subjects enrolled, TAT detected high rectal fever with 100% sensitivity and specificity. This finding, if confirmed, suggests TAT screening for well and injured children has potential for clinical practice by diminishing rectal measurements and their associated risks in the acute care and/or ambulatory practice setting.

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Keywords
temporal artery thermometry, rectal thermometry, Emergency Department, pediatric patients, fever

Introduction

Fever is often the indication to parents that their child is ill and frequently leads to a visit to the doctor. In fact, fever is one of the most common clinical symptoms managed by pediatricians (Sullivan & Farrar, 2011). The gold standard for temperature assessment in children, unable to comply with oral thermometry, has been the rectal route because of its perceived accuracy. Despite this, rectal thermometry does not come without disadvantages. Among the alternatives to rectal assessment, temporal artery thermometry (TAT) has become popular in clinical practice. Due to lack of temperature agreement, research has shown that TAT cannot be substituted for rectal thermometry in young children (Greenes & Fleisher, 2001; Holzhauer, Reigh, Sawin, & Yen, 2009; Schuh et al., 2004; Siberry, Diener-West, Schappell, & Karron, 2002). However, TAT has been studied as a potential screening mechanism to detect pediatric fever with inconclusive results (Greenes & Fleisher, 2001; Hoffman, Etwaru, Dreisinger, Khokhar, & Husk, 2013; Holzhauer et al., 2009; Schuh et al., 2004; Siberry et al., 2002; Titus, Hulsey, Heckman, & Losek, 2009). Further research is warranted to evaluate use of TAT to detect pediatric fever providing the basis for this study.

Problem

As inaccurate temperatures can result in delayed diagnoses or unnecessary, often expensive and potentially invasive testing and/or procedures, accurate temperature assessment is imperative. Even though TAT is not interchangeable with rectal thermometry, its use as a screening tool for fever detection could result in fewer rectal assessments and their associated risks including patient discomfort. Studies evaluating TAT as a screen to detect rectal fever, defined by the American College of Emergency Physicians (ACEP; 2003), as ≥38 °C, do not support its use (Greenes & Fleisher, 2001; Hoffman et al., 2013; Holzhauer et al., 2009; Schuh et al., 2004; Siberry et al., 2002). In addition, several studies have investigated its potential to detect moderate rectal fever at 38.3 °C and 38.5 °C (Schuh et al., 2004; Siberry et al., 2002; Titus et al., 2009). Yet, there is no clinical significance for moderate fever detection as it does not guide care. However, the presence of high rectal fever, ≥39 °C, does generally direct clinical decision making (ACEP, 2003). At the time this

study was initiated, two published studies had evaluated the ability of TAT to detect high fever in children ≤24 months of age (Greenes & Fleisher, 2001; Siberry et al., 2002). Siberry et al. (2002) report a clinically acceptable TAT sensitivity of 95% (TAT cutoff: 38.3 °C), whereas Greenes and Fleisher (2001) did not find TAT screening sufficient to detect high rectal fever (94% sensitivity; TAT cutoff: 38 °C). Given lack of consensus and the desire to avoid rectal assessment if possible, this study investigated the effectiveness of TAT to detect high rectal fever in children ≥91 days and ≤4 years old.

Design

This prospective evaluation of rectal and temporal artery (TA) temperatures was conducted in a 28-bed Emergency Department (ED) in a Magnet community hospital in the Southeastern United States averaging more than 50,000 ED visits annually. During the 17-month study interval (December 2008-April 2010), 3,183 visits were recorded for children ages 91 days to 4 years. The study was approved by the facility's Institutional Review Board (IRB). Parents or guardians gave written informed consent. The IRB waived assent due to subject age and inability to comprehend the research.

Sample

Male and female children, aged ≥91 days to 4 years, of any race or ethnicity, were eligible to participate in the study if their parent or guardian understood English. Exclusion criteria included children arriving by emergency medical services, those presenting with life threatening conditions, rectal anomalies, facial trauma, malformation of the temporal area, and the mentally challenged. In addition, children birth to 90 days old were excluded given the temperature assessment recommendation of the Emergency Nurses Association (Barnason et al., 2011). Utilizing mean temperature data previously published (Greenes & Fleisher, 2001), a desired sample size of 252 subjects was determined a priori (anticipated Cohen's $d = .315$, $\alpha = .05$, power = .80). Of the 257 subjects enrolled in the study, 18 were excluded. Reasons included incomplete data ($n = 14$) and age <91 days ($n = 4$). Post hoc power analysis revealed an observed power of 98.9% (Cohen's $d = .556$, $\alpha = .05$, sample size = 239).

Procedures

Subject temperature was first measured rectally using an Alaris® digital thermometer (Alaris Medical Systems, Inc., San Diego, CA). Immediately

following rectal thermometry, his or her TA temperature was taken using an Exergen® Temporal Scanner (Exergen Corporation, Watertown, MA). Five triage nurses served as data collectors after receiving training, as per manufacturer guidelines, on both devices. Thermometers were routinely maintained by the facility's clinical technology department over the course of the study. Gender, age, and presenting complaint (illness or injury) were also collected.

Data Analysis

Temperatures were recorded in degrees Fahrenheit and converted to degrees Celsius for analysis. Descriptive statistics included mean, *SD*, and frequency. A linear model was generated using regression analysis, and the correlation coefficient was calculated for the relationship between TA and rectal temperature. For sensitivity and specificity calculations, a TAT cutoff of 38 °C was utilized to detect rectal fever, defined as ≥38 °C, and high rectal fever, defined as ≥39 °C. The intraclass correlation coefficient (ICC) was used to estimate interrater reliability. Significance was determined at $p \leq .05$ for all statistical analyses.

Findings

Mean subject age was 1.5 ± 0.77 years. More male subjects were recruited (53%; 139/239), but this gender distribution was similar to the ED pediatric census at the facility during the study period ($\chi^2 = 2.78$, $df = 1$, $p = .095$). Subject mean rectal temperature was 38.05 ± 0.99 °C, while mean TA temperature (37.55 ± 0.8 °C) was 0.5 °C less. As demonstrated in Figure 1, the linear regression model ($r = .606$) confirmed the expectation that TA and rectal temperature measurements were not interchangeable as demonstrated by substantial deviation from unity. The higher the rectal temperature, the more frequently TAT underestimated rectal values.

The prevalence of rectal fever was 41% (98/239) and the majority of febrile subjects were less than 2 years old (75/98). TAT demonstrated a sensitivity of 56% and a specificity of 93% as a screen for rectal fever (Table 1). For high rectal fever detection, TAT screening demonstrated 75% sensitivity and 85% specificity. Narrow confidence intervals were observed for all determinations (Table 1).

Further analysis of subjects presenting with injury ($n = 27$), for example, falls, lacerations, and so on, was done. In this subset of the study population, TAT was ineffective as a screen for rectal fever (sensitivity: 67%, specificity: 100%). Conversely, TAT detected high rectal fever with 100% sensitivity and 100% specificity in these subjects (Table 1).

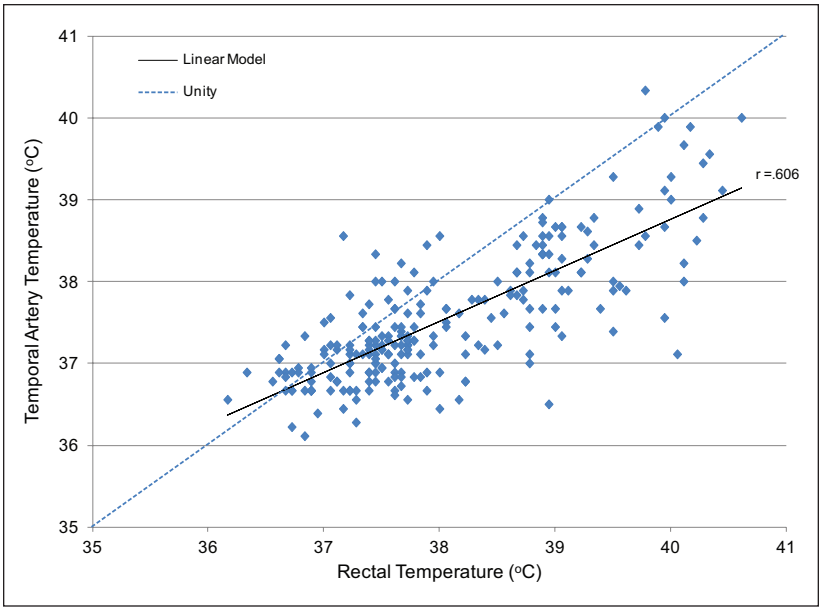

Figure 1. Linear regression model of all subjects' rectal and TA temperatures.
Note. The reference line of unity represents equivalent rectal and TA values at all temperatures between 35 °C and 41 °C. The model (r = .606) shows poor agreement between the two thermometry methods. TA = temporal artery.

Table 1. Characteristics of a 38 °C TA Cutoff to Identify Rectal Fever (≥38 °C) and High Rectal Fever (≥39 °C) in the Study Population and the Subset of Subjects Presenting With Injury.

Rectal fever	Sensitivity (95% CI)	Specificity (95% CI)
All subjects		
≥38 °C	0.56 [0.54, 0.58]	0.93 [0.92, 0.96]
≥39 °C	0.75 [0.73, 0.77]	0.85 [0.83, 0.87]
Injured subjects		
≥38 °C	0.67 [0.65, 0.69]	1.0 [0.98, 1.02]
≥39 °C	1.0 [0.98, 1.02]	1.0 [0.98, 1.02]

Note. TA = temporal artery; CI = confidence interval.

Discussion

Like Greenes and Fleisher (2001), we report a TAT sensitivity less than the clinically acceptable standard of 95% to screen for high fever in pediatric

patients. Even though Siberry et al. (2002) recommend utilizing TAT to detect high rectal fever, their sensitivity and specificity calculations were based on the small number of study subjects with high rectal fever (21/275; 7.6%). A strength of our study was the proportion of febrile subjects having high rectal fever (47/239; 19.7%), which was similar to that (49/304; 16%) reported by Greenes and Fleisher (2001).

Our findings confirm that TAT assessment cannot be substituted for rectal thermometry in young children unable to comply with oral thermometry (Greenes & Fleisher, 2001; Holzhauer et al., 2009; Schuh et al., 2004; Siberry et al., 2002). Interestingly, regression analysis revealed TAT consistently underestimated rectal temperature. Furthermore, the frequency of TA underestimation increased as rectal values increased. This observation provides a probable explanation for why TAT does not adequately detect high rectal fever. Although not explicitly stated, scatterplots in previous studies demonstrate the underestimation phenomenon (Greenes & Fleisher, 2001; Hoffman et al., 2013). Due to our facility standard of care, each subject's temperature was first measured rectally. The lack of randomization in temperature assessments could have introduced bias into the data.

There was good interrater reliability (ICC = .933) observed among the data collectors. In contrast to a seasoned researcher, research assistant, or fewer data collectors, the five triage nurses collecting temperature measurements in this study reflect the realistic ED practice setting in which TAT would be used and is, in fact, being used.

A recent study by Hoffman et al. (2013), published after this study was conducted, reported that TAT failed to detect both rectal fever (53% sensitivity) and high rectal fever (28% sensitivity) in children ≤36 months old. Importantly, their study population contained more subjects with high rectal fever than previous studies (76/263; 29%). However, the rectal and TA temperatures were assessed in two different areas of their hospital resulting in non-sequential measurements. The time delay was limited to 30 min for study eligibility. A strength of our study was simultaneous rectal and TAT assessments.

Herein, TA temperatures predicted high rectal fever among subjects presenting with injury 100% of the time. To our knowledge, no other researchers have specifically evaluated TAT as a screen to detect high fever in injured subjects. In fact, this population was not actively recruited in one study (Holzhauer et al., 2009). Although TAT effectively detected high rectal fever in all injured subjects, this subset of our study population was small limiting generalizability. Therefore, additional research with a larger sample size of injured children with high rectal fever is necessary to substantiate our preliminary finding. If reproduced, TAT screening for high fever in injured children holds promise for adoption in clinical practice.

Application

The number of rectal temperatures and their associated risks could be reduced by utilizing TAT to detect high fever in injured children. This finding adds to the body of knowledge, and has potential for impacting clinical practice if substantiated by further research. The well child, much like the injured child that presents in the emergent setting, is not expected to have high fever. Thus, if our finding is confirmed, TAT screening for high fever could diminish rectal measurements for well child visits in the ambulatory setting.

As use of TA thermometers vary among practitioners (Siberry et al., 2002), proper TAT technique regardless of whether the child is well, ill, or injured is imperative. Therefore, nurses must use the devices according to manufacturer guidelines to ensure reliable temperature assessment. As suggested by Holzhauer et al. (2009), our study results further demonstrate the role for research in guiding adoption of new technology in clinical practice.

Acknowledgments

The authors thank the following nurses for their support in facilitating the project: Susan Hesterberg, Anita Herman, Karen Drum, Cherie Turney, Nancy Lawrence, Amanda Lyerly, Sue Patton, Tracy Bombenger, and Van Haygood. The services of medical librarians Karen L. Martinez, MLS, and Janice Moore, MLS, Northwest Area Health Education Center, and Dr. Bjarne Berg, Professor of Mathematics and Computing Science, Lenoir-Rhyne University, are most appreciated.

Authors' Note

Parties interested in additional information regarding study sample and/or facility comparison data should contact the corresponding author.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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