Sensitivity and Specificity of Temporal Artery Thermometer to Detect Fever in Older Adults in the Emergency Department

by

Emily R. Latimer

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Abstract

Introduction: Detection of fever in geriatric patients in the emergency department (ED) is a critical assessment parameter. However, immune responses become less robust with increasing age. Therefore, it is important to determine if a new method for measuring temperature (i.e., temporal artery thermometer [TAT]) is as accurate as rectal thermometer (RT) in older patients. The purposes of this study were to: compare agreement between RT and TAT readings in younger (i.e., 65-74 years of age, n=50) versus older (i.e., ≥75 years of age, n=75) geriatric patients seen in the ED and compare the sensitivity and specificity of the TAT to detect fever between these two groups.

Methods: A convenience sample of patients ≥65 years of age had TAT and RT taken on arrival to the ED. Descriptive statistics were calculated; Fisher's Exact and Mann-Whitney U tests were used to evaluate for gender differences and ESI distributions between the groups. Analysis of variance was used to evaluate the effect of age group on TAT and RT differences. Logistic regression was used to determine sensitivity and specificity of TAT.

Results: The two groups were 69.5 (±3.6) and 82.7 (±5.8) years of age. No statistically significant differences were found in mean RT and mean TAT measurements between the younger and older geriatric patients. Sensitivity to detect fever was 53.8% in the younger group and 50.0% in the older group, and specificities were 95.8% and 95.3%, respectively.

Discussion: TAT yields a false negative rate that is too high to be used to evaluate for fever in geriatric patients in the ED. TAT's low sensitivity suggests that RT needs to remain the primary method of temperature assessment in geriatric patients who cannot provide reliable oral temperatures.

Key words: temporal artery thermometer; rectal thermometer; emergency department; triage; geriatric; fever

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Introduction

With aging, immune responses to illness and injury change (Shaw & Bandaranayake, 2017). These immunosenescence-driven alterations and associated decreases in the vigor of homeostatic responses may explain why many geriatric patients have atypical presentations for common illnesses (High, 2017; Kuchel, 2017; Shaw & Bandaranayake, 2017). For example, when fevers occur, geriatric patients have lower basal temperatures at baseline and less robust febrile responses (High, 2017). In addition, fever at initial presentation of an illness seems to be lower with each increasing decade of life (Roghmann, Mackowiak, & Warner, 2001).

Screening for temperature abnormalities occurs very early in a patient's emergency department (ED) visit, as part of the initial triage process, and aids in the determination of acuity (Gilboy, Tanabe, Travers, & Rosenau, 2011). The presence of a fever may alter the plan of care in the ED, particularly for a geriatric patient. While oral thermometers are frequently used during the triage process, many factors present in ED patients, including the inability to follow commands, facial trauma, and rapid or mouth breathing, that render these readings unreliable. The temporal artery thermometer (TAT) became a preferred method to assess for fever in the ED because it offered a more convenient, rapid, and tolerable method than an oral or axillary thermometer (Opersteny et al., 2017).

TAT was introduced into clinical settings in the early 2000s with the promise of replacing more invasive thermometry methods, particularly in patients who required core or rectal temperatures (Calonder et al., 2010). The TAT works by measuring skin temperature over the temporal artery 1000 times per second for the duration of time the button is depressed. Then the peak temperature measured during the assessment, which theoretically approximates the temperature of blood flowing through the temporal artery, is reported ("Model TAT-5000 Reference Manual," n.d.). The manufacturer of the widely used TAT-5000 (Exergen Corporation, Watertown, MA) reports that this arterial temperature is more rapidly responsive to changes in both the development of fever and defervescence ("Model TAT-5000 Reference Manual," n.d.). Initial validation of this device was primarily done in the pediatric and perioperative settings. Of the 53 publications cited in the manufacturer's materials as of 2017, approximately half focused on pediatric patients; less than 20% were associated with ED, critical care, or acute care settings; and none were specific to geriatric patients ("Exergen Temporal Scanner TAT-5000 Benefits Overview," n.d.).

Since its initial introduction, the sensitivity and specificity of TAT readings have come into question across many patient populations and settings. Of note, studies reported problems with the ability of TAT to detect both fever and hypothermia, especially in acutely ill adults (Geijer, Udumyan, Lohse, & Nilsagard, 2016; Mason et al., 2017; Singler et al., 2013), as well as poor inter-rater reliability even under ideal conditions (Bahr, Alysson, Linda, & Polly, 2010).

While early studies focused primarily on the pediatric population (Hooper & Andrews, 2006), later studies that included adults in emergency and critical care units enrolled primarily younger patients (Bijur, Shah, & Esses, 2016; Lawson et al., 2007; Marable, Shaffer, Dizon, & Opalek, 2009; Mason et al., 2017). In a recent systematic review (Keikkas, Stefanopoulos, Bakalis, Kefaliakos, & Karanikolas, 2016), the authors indicated that the TAT should not be used in places where temperature disorders are relatively common. However, because of the paucity of research on the sensitivity and specificity to detect fevers in older adults, no recommendations were made on the use of this device in this high risk population.

Only two studies have evaluated for differences in core versus TAT temperatures in ED geriatric patients (Brosinski, Valdez, Riddell, & Riffenburgh, 2017; Singler et al., 2013). In one study of RT vs TAT vs tympanic membrane (TM) temperatures in hemodynamically stable geriatric patients ≥75 years of age (n=427) (Singler et al., 2013), RT and TAT were higher in patients with a fever compared to those without a fever. However, fewer fevers were detected by TAT and TM than RT. In addition, wide variability was found between RT and TAT readings, which contributed to low diagnostic accuracy. The authors recommended that when TAT is used, a lower cut off of ≥99.1°F be used to define a fever for clinical decision making (Singler et al., 2013).

In a previous report from our research team (Brosinski et al., 2017), differences in RT vs TAT in ED geriatric patients ≥65 years of age (n=125) were evaluated. Regardless of health status, while TAT had a diagnostic accuracy of 85%, even when readings were adjusted by +1°F (as is sometimes done for other noninvasive temperature readings such as axillary or oral), TAT readings produced a false negative rate of 25.9% in detecting fever. In addition, no differences were found in the accuracy of readings based on patient's Emergency Severity Index (ESI) acuity rating or gender, or the experience level or training of the individual collecting the TAT readings.

To date, no study has compared TAT vs RT in younger versus old geriatric/elderly patients, who may have different response patterns to illness and injury. Therefore, building on our previous findings (Brosinski et al., 2017), the purposes of this study were to: compare agreement between RT and TAT thermometer readings in younger (i.e., 65-74 years of age, n=50) versus older (i.e., ≥75 years of age, n=75) geriatric patients seen in the ED and compare the sensitivity and specificity of the TAT to detect fever between these two groups of older patients.

Methods

Setting

The data collection methods and the training and competency verification for this study were described in detail elsewhere (Brosinski et al., 2017). In brief, data for this analysis were collected in a 17-bed ED located in a military hospital on a remote island, with an average monthly census of 1,300 patients. Institutional review board approval waived the requirement for informed consent given the minimal risk to the patient of the study design. The patient or family caregiver provided verbal consent following an explanation of the TAT procedure and provision of an information sheet that described the purpose of the study. All patient recruitment took place during the initial triage evaluation by ED staff.

Study Protocol

All equipment was sent to the Biomedical Engineering Department for calibration and preventive and corrective maintenance prior to initiation of data collection. Initial protocol training and TAT and RT procedure refresher training were conducted during a departmental meeting, where the majority of staff verified competency in both TAT and RT measurements. Those staff who were unable to attend the meeting were trained on a one-on-one basis. New staff were trained during the orientation process (Brosinski et al., 2017).

Data were collected on patient's age, gender, ESI, and rectal and TAT temperatures during the initial triage evaluation by registered nurses (RN) and ED technicians. For this analysis, patients were included if they: were geriatric patients ≥65 years of age; were unable to provide a reliable oral temperature for any clinical reason, including altered mental status; had a suspected fever undetected by oral temperature assessment; had rapid or were primarily mouth breathing; and/or had facial/oral trauma. Patients with injuries or deformities at the TAT site were excluded, as were patients with behavioral problems who might be disturbed by the TAT assessment.

A within-patient comparison design was utilized to evaluate TAT using the TAT-5000 (Exergen Corporation, Watertown, MA) and RT using the Welch Allyn Sure Temp Plus thermometer (Welch Allyn, Skaneateles Falls, NY). Each patient underwent a single RT and three sequential TAT readings within approximately one minute of each other. Because previous analysis of these data demonstrated no clinically significant differences among the three TAT measurements, this study used only the first of the three TATs collected for comparison with RT, which is consistent with the clinical use of the TAT (Brosinski et al., 2017).

Data Analysis

The sample was divided into two age groups (i.e., 65-74 years of age and ≥75 years or age) based on commonly reported age categories in the literature (Albert, Rui, & McCaig, 2017; Zizza, Ellison, & Wernette, 2009). Data were analyzed using SPSS 24 (IBM Corporation, Armork, NY). The Fisher's Exact test was used to evaluate for gender differences between the two age groups. The Mann-Whitney U test was used evaluate for differences in the ordinal ESI score between the two age groups. Repeated measures analysis of variance (RMANOVA) was used to determine if the difference between the two temperature devices, TAT and RT, depended on age group. Logistic regression was used to determine the sensitivity and specificity of the TAT device in predicting the gold standard for this study (i.e., RT) for each age group. Sensitivity is defined as the probability of a test being positive when a disease state is present, or the ability of a test to correctly identify an individual who has a disease (i.e., "true positive"). Specificity is the probability of a test being negative when a disease state is absent (i.e., "true negative") (Parikh, Mathai, Parikh, Chandra Sekhar, & Thomas, 2008).

Results

Sample Characteristics

Descriptive statistics are listed in Table 1. No between group differences were found in gender distribution or ESI scores.

Rectal versus TAT mean temperatures

In the younger geriatric group (i.e., 65-74 years of age), mean TAT was 99.2°F ± 2.7 and RT was 100.5°F ± 2.5, a difference of 1.3°F. In the older geriatric group (≥75 years of age), the measurements were TAT 98.9°F ± 2.5 and RT 100.0°F ± 2.2, a difference of 1.1°F. Using RMANOVA, no statistically significant differences were found in the mean RT and mean TAT measurements ($p=0.602$) (Figure 1).

Sensitivity and Specificity

Using the widely accepted clinical definition of a fever as ≥100.4°F(Bijur et al., 2016; Brosinski et al., 2017; Mason et al., 2017), the sensitivity and specificity of TAT to detect fever were calculated within each age group. In the younger geriatric group, TAT sensitivity was 53.8% (95% Confidence Interval [CI] 34.7-73.0) and TAT specificity was 95.8% (95% CI 87.8-100.0). In the older geriatric group, TAT sensitivity was 50.0% (95% CI 32.7-67.3) and TAT specificity was 95.3% (95% CI 89.1-100.0).

Discussion

This study is the first to compare RT and TAT readings in younger vs older geriatric patients. For both older age groups, the mean differences between RT and TAT measurements, as well as the sensitivity and specificity were very similar, which suggests that the accuracy of TAT is consistent. While immune function does decline with increasing age (Shaw & Bandaranayake, 2017; Wilber, Gerson, & McQuown, 2017), TAT and temporal perfusion may not reflect this change in immune responses during an illness.

Consistent with previous reports (Bijur et al., 2016; Brosinski et al., 2017; Geijer et al., 2016), we found high specificity and low sensitivity across both age groups. However, in our study, the sensitivities of 53.8% and 50.0% were lower than the sensitivities of 70% to 75% reported in previous studies that included geriatric patients (Bijur et al., 2016; Brosinski et al., 2017; Geijer et al., 2016). These inconsistent findings may be related to our inclusion of patients with all levels of hemodynamic stability. Previous studies in the ED restricted the sample to patients who were hemodynamically stable (Bijur et al., 2016; Geijer et al., 2016; Singler et al., 2013). Because hemodynamic variability caused by illness affects peripheral perfusion, variations in TAT readings may occur (Keikkas et al., 2016). In addition, in the primary analysis by our research team of the aggregated geriatric group, patients were excluded whose TAT readings appeared to be outliers (Brosinski et al., 2017). These two ESI level 1 patients, one in each of our age groups, had very low body temperature readings. However, they were included in our analysis to reflect actual clinical practice. Of note, in an analysis that excluded these patients, the sensitivity and specificity findings did not change for either group.

Despite variations in the sensitivity of TAT across various studies, our conclusions are consistent with previous reports (Brosinski et al., 2017; Keikkas et al., 2016; Mason et al., 2017; Singler et al., 2013), namely that TAT does not have the requisite sensitivity to be used to assess for fever in geriatric patients. Because it is critical to identify even small temperature changes in geriatric patients, and because the TAT readings vary by more than 1°F from the gold standard, this measure yields a false negative rate that is too high to be a reliable measure of temperature for the evaluation of geriatric patients in the ED.

Several limitations need to be acknowledged. As a single-site study in a remote location, these findings may not generalize to other EDs. However, the wide age, temperature, and acuity distribution of our sample mitigates this limitation to some extent. The sample size for this study was relatively small (n=125). However, the findings are strengthened by the lack of differences in gender distribution and ESI scores and approximately equal sizes of each geriatric age group. Convenience sampling was used, which may introduce the possibility of selection bias because some patients who met our inclusion criteria were missed. To mitigate this possibility, staff were frequently reminded to screen all patients for eligibility and collect data on all eligible patients who consented to participate (Brosinski et al., 2017). Additionally, we did not investigate TAT as a measure to detect hypothermia, another important clinical indicator of severe illness in geriatric patients.

Several avenues for additional research warrant consideration. An important question for future research is to evaluate the sensitivity and specificity of TAT to detect hypothermia in geriatric patients, which in other patient populations has demonstrated high specificity but low sensitivity (Keikkas et al., 2016; Lawson et al., 2007). In a larger sample, the accuracy of TAT could be compared across ESI categories. This study would provide useful information on the accuracy of TAT in ill and non-ill patients. Given TAT's mechanism for measuring blood flow through the temporal artery, additional studies that compare the accuracy of TAT based on comorbidities that affect peripheral circulation (e.g., diabetes, peripheral vascular disease, hyperlipidemia) would provide important clinical information. Finally, a continued search for novel non-invasive, non-oral, and accurate methods of temperature assessment to detect both fever and hypothermia, will provide increased comfort and efficiency in temperature measurement for geriatric patients.

Conclusions

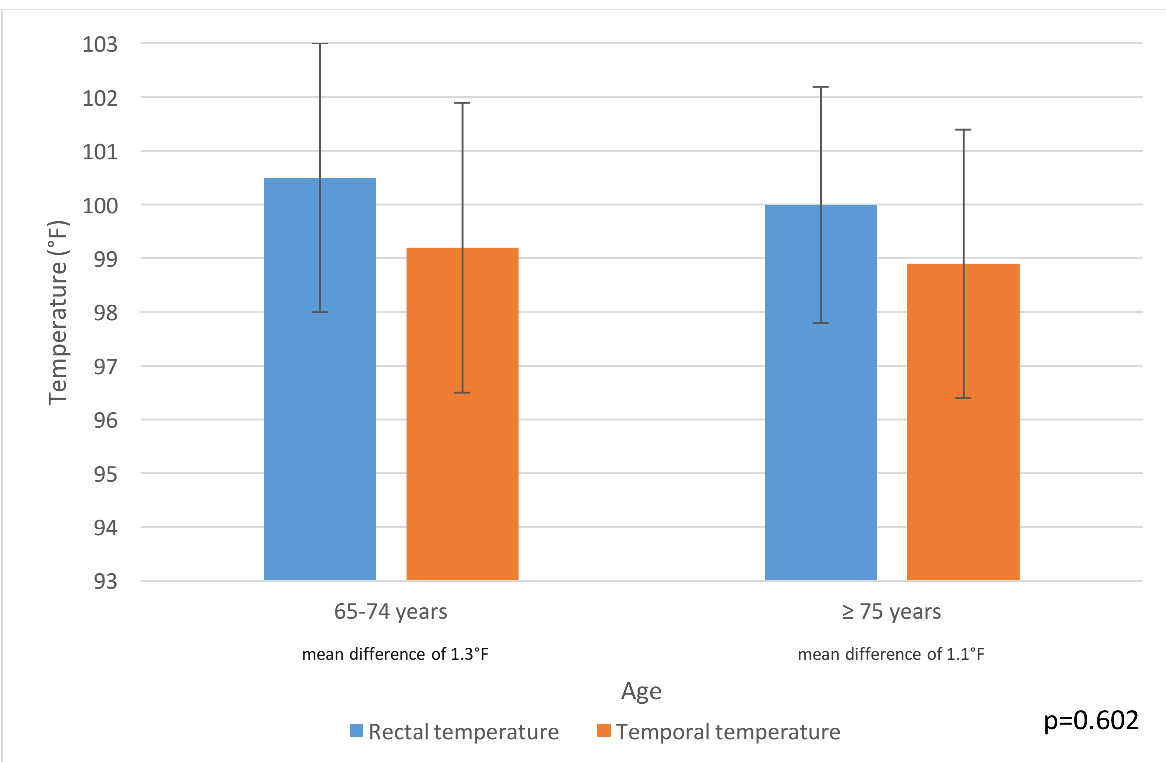
TAT appears to be useful only for "ruling in" but not "ruling out" a fever in geriatric patients of all ages. The accuracy of TAT does not appear to change with increasing age. Our findings suggest that it is not an acceptable substitute for RT in geriatric patients of any age who cannot provide a reliable oral temperature when detection of fever is a primary concern. We recommend that RT continue to be the primary method of temperature assessment in geriatric patients who cannot, for whatever reason, obtain reliable oral temperature readings during ED triage.

Table 1. Differences in sample characteristics between the two age groups

Characteristic	Younger Old 65-74 years old 40% (n=50)	Older Old ≥ 75 years old 60% (n=75)	Statistic
Age	Mean (SD)	Mean (SD)	p < 0.001
	69.5 (3.56)	82.7 (5.83)	
Gender	% (n)	% (n)	p=0.711
Male	62 (31)	57.3 (43)	
Female	38 (19)	42.7 (32)	
ESI	% (n)	% (n)	p=0.988
1	4 (2)	5.3 (4)	
2	60 (30)	58.7 (44)	
3	34 (17)	32 (24)	
4	2 (1)	3 (4)	

Abbreviations: ESI = Emergency Severity Index; SD = standard deviation

Figure 1. Rectal vs TAT mean temperatures by age



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