Comparison of Rectal, Axillary, Tympanic, and Temporal Artery Thermometry in the Pediatric Emergency Room

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Background: Accurate measurement of temperature in the emergency room is important for diagnosis as well as investigating a patient. Various noninvasive methods thermometry are available today, but there is no consensus on the most accurate method of thermometry.

Study Objective: The present study was conducted to compare different methods of temperature measurement available in the emergency room, that is, rectal, axillary, and temporal artery and tympanic membrane.

Design: This was a cross-sectional observational study

Patients: Fifty febrile and 50 afebrile children aged 2 to 12 years attending the pediatric emergency room of a tertiary care hospital were included. Temperatures were measured using rectal, axillary, tympanic (right and left), and temporal artery thermometers and were compared.

Results: All the temperatures correlated well with rectal temperature, with temporal artery temperature showing the best correlation (correlation coefficients, 0.99 in the febrile and 0.91 in the afebrile group).

Conclusions: Temporal artery thermometry has the potential to replace rectal thermometry in a busy emergency room setting.

Key Words: temporal artery thermometry, rectal thermometry, correlation

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Accurate measurement of temperature carries great importance in the pediatric emergency room. Wrong temperature measurements may lead to delay in diagnosis as well as unnecessary investigations. While measuring temperature, one should be as close as possible to the core body temperature. The methods used for measuring core body temperature such as pulmonary artery (PA), distal esophageal, bladder, and nasopharyngeal are invasive and hence cannot be used in routine clinical practice.[1–5] Rectal thermometry is supposed to be the criterion standard for predicting core body temperature, but it carries its own drawbacks.[3,6] It is unacceptable for an older patient to get rectal thermometry done in a busy emergency room. Also, it carries a theoretical risk of rectal perforation, cross contamination, and HIV transmission. Measurement of temperature over the axillary artery is an acceptable method, but it shows a wide variation and is not reliable.[7] Temporal artery and tympanic membrane thermometries are newer noninvasive modalities for measuring temperature. These thermometers have infrared radiation emission detectors, which measure the thermal radiation emitted. Some of the tympanic thermometers have an in-built offset that predicts rectal or core body temperature from the tympanic temperature. Temporal artery thermometer carries the advantage of being safer, as blind introduction of the instrument in one of the body part is not required. The previous studies have shown equivocal results with both methods.[8–12] There is no consensus on the method for temperature measurement that can accurately predict core temperature and is relatively easy, safe, and noninvasive. Hence, the present study was conducted to compare different methods of temperature measurement available in emergency room among children aged 2 to 12 years, that is, rectal, axillary, temporal, and tympanic, and to find the method that predicts rectal temperature best in both febrile and afebrile patients in this age group.

SUBJECTS AND METHODS

The study was conducted in the emergency room of the Department of Pediatrics at University College of Medical Sciences and Associated Guru Teg Bahadur Hospital, Delhi, India, after approval from the institute ethical committee has been obtained. It was a cross-sectional observational study including children aged 2 to 12 years, both febrile and afebrile, attending pediatric emergency. Written informed consent was taken from parents/guardians of the patients. Temperature was measured at 5 sites in each patient, namely, rectal, axillary, right tympanic, left tympanic, and temporal. Rectal temperature was measured first using rectal mercury thermometer (Hicks; Hicks Thermometers Ltd, Aligarh, India) for 3 minutes. Axillary temperature was measured using axillary digital thermometer (Omron MC-106; Omron, India) for 5 minutes, as per the Integrated Management of Neonatal and Childhood Illnesses guidelines.[13] Tympanic membrane temperature was measured by tympanic thermometer according to the manufacturer's guidelines (both right and left ear). Equinox infrared ear thermometer (EQ ET 99; Equinox Overseas Private Ltd, New Delhi, India) was used. Temporal artery temperature was measured by temporal thermometer according to the manufacturer's guidelines using Exergen Temporal Scanner (TAT-2000C; Exergen Corporation, Watertown, Mass). Patients with abnormal anorectal or ear anatomy, thermoregulatory disturbances, family history of malignant hyperthermia, diaphoresis, hemoglobin less than 8 g/dL, severe undernutrition, and severe wasting according to the World Health Organization classification; uncooperative or crying; and unconscious were excluded. Diagnosis of fever was made, when rectal temperature was greater than 38°C, at first temperature recording in the emergency room.[14] Hypothermia was defined as rectal temperature less than 35°C.[15]

Sample Size and Data Analysis

To detect the mean difference of 0.4°C with SD of 0.8°C and 95% confidence interval, 90% power, and 5% α error, the sample size calculated for each group was 43.[16] Thus, 50 children in each group (febrile and afebrile) were enrolled in the study. SPSS version 13.0 (SPSS Inc, Chicago, Ill) software was used to analyze the data.

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TABLE 1. Mean and SD of Temperatures Measured by Different Methods in Febrile and Afebrile Group

Method Used	Afebrile Group, Mean (SD)	Febrile Group, Mean (SD)
RT	37.27 (0.40)	39.43 (0.94)
AT	36.86 (0.42)	38.50 (0.63)
RTMT	36.89 (0.38)	38.87 (1.02)
LTMT	36.91 (0.36)	38.89 (0.91)
TAT	37.30 (0.38)	39.43 (0.95)

AT indicates axillary temperature; LTMT, left tympanic membrane temperature; RT, rectal temperature; RTMT, right tympanic membrane temperature; TAT, temporal artery temperature.

Bland and Altman statistical method was used to assess the level of agreement between rectal temperature and other methods of temperature measurement, that is, axillary, temporal artery, and right tympanic and left tympanic. Pearson correlation coefficient was calculated to assess the degree of correlation between 2 methods. Paired Student *t* test was applied to compare the difference between mean rectal temperature and mean temperature measured by other methods. Simple linear regression analysis was used to predict rectal temperature from axillary temperature, temporal artery temperature, and right and left tympanic membrane temperature, and linear regression equation was also derived.

RESULTS

A total of 50 patients were enrolled in the 2 groups, febrile and afebrile. We did not find any patient with hypothermia in our study. The mean age of patients in the febrile and afebrile groups was comparable (6.1 and 6.15 years, respectively). There were 20 females (40%) in the afebrile group and 26 (52%) in the febrile group. The mean temperature and SDs in the 2 groups are shown in the Table 1.

It was found that the temperatures measured by all the methods correlated well with rectal temperature with correlation coefficient of greater than 0.9 in the febrile group and greater than 0.7 in the afebrile group (Tables 2 and 3). The best correlation was seen with temporal artery temperature with correlation coefficient of 0.99 in the febrile and 0.91 in the afebrile group. Axillary temperature correlated better in both groups as compared with tympanic temperature. There was good correlation between right and left tympanic membrane temperatures with correlation coefficient of 0.95 in the febrile and 0.94 in the afebrile group. The Bland-Altman plots of differences between the temporal artery–rectal temperature suggest that 95% of values lie between −0.24 to 0.26 in the febrile and −0.36 to 0.30 in the afebrile group, showing good agreement (Fig. 1).

Sensitivity, specificity, positive predictive value, and negative predictive value of temporal artery, tympanic membrane, and axillary thermometers for detecting fever (rectal temperature >38°C) were calculated as shown in Table 4.

Abilities of individual methods to accurately predict rectal temperature within ±0.2°C, ±0.2 to 0.4°C, and greater than ±0.4°C were calculated. All the thermometers were able to predict rectal temperature within greater than ±0.4°C. Temporal artery thermometer was able to predict rectal temperature in 49 of 50 febrile patients and 45 of 50 afebrile patients within the range of 0.2°C (Table 5).

DISCUSSION

The present study was conducted in the pediatric emergency room on 50 febrile and 50 afebrile children between 2 and 12 years of age, to compare different methods of thermometry, namely, rectal, axillary, temporal artery, and tympanic membrane temperatures. Our aim was to find the method correlating best with the core temperature, which was taken as rectal temperature in our study.

In the present study, temporal artery temperature correlated best with core temperature in both febrile and afebrile patients. These results are consistent with the findings of Greenes and Fleisher.[9] They also concluded temporal artery thermometry to be more accurate and acceptable than tympanic membrane and axillary thermometry in predicting rectal temperature. Titus et al[17] reported temporal artery thermometry as an effective screening tool for identifying fever in children between 1 and 4 years of age. These results are in contrast with the previous

TABLE 2. Comparison of Rectal, Axillary, right Tympanic, Left Tympanic and Temporal Artery Temperatures in Febrile Group

Groups Compared	Correlation Coefficient (*P*)	Regression Equation	Limits of Agreement (95% CI) Using Bland-Altman Test
AT vs RT	0.96 (<0.001)	RT = −15.744 + 1.433 AT	0.19 to 1.68
RTMT vs RT	0.92 (<0.001)	RT = 6.867 + 0.838 RTMT	−0.24 to 1.37
LTMT vs RT	0.93 (<0.001)	RT = 2.270 + 0.956 LTMT	−0.15 to 1.24
TAT vs RT	0.99 (<0.001)	RT = 1.077 + 0.973 TAT	−0.24 to 0.26

TABLE 3. Comparison of RT, AT, RTMT, LTMT, and TAT in Afebrile Group

Groups Compared	Correlation Coefficient (*P* Value)	Regression Equation	Limits of Agreement (95% CI) Using Bland-Altman Test
AT vs RT	0.77 (<0.001)	RT = 10.730 + 0.720 AT	−0.14 to 0.96
RTMT vs RT	0.74 (<0.001)	RT = 8.325 + 0.785 RTMT	−0.17 to 0.92
LTMT vs RT	0.72 (<0.001)	RT = 7.568 + 0.805 LTMT	−0.20 to 0.91
TAT vs RT	0.91 (<0.001)	RT = 1.203 + 0.967 TAT	−0.36 to 0.30

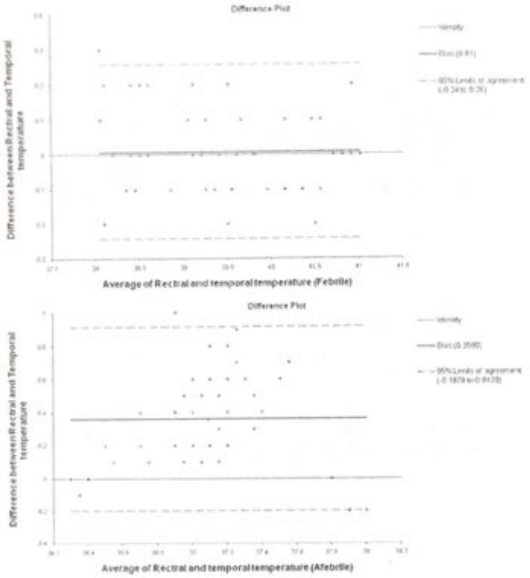

FIGURE 1. Bland-Altman plot of difference between mean temperature difference and 95% limits of agreement.

study by Siberry et al,[8] where TA temperature was found to be an inaccurate predictor of fever, with only 66% sensitivity. Brennan et al[18] also reported poor sensitivity of TA thermometry in detecting rectal fever in children between 6 months and 6 years of age.

Tympanic membrane thermometry is limited to children older than 2 years because of narrow ear canal, and hence we included the patients older than 2 years in our study. In our study, TM temperatures also correlated well with core temperatures, but when compared with the correlation coefficients of temporal artery versus rectal temperatures, the method was inferior to the temporal artery thermometer. In a meta-analysis of 44 studies by Craig et al,[10] the agreement between TM temperatures and rectal temperatures was low, and the differences were in either direction. Even when the device was used in rectal mode, it was not found to be an approximation of rectal temperature. Hooker[19] and Muma et al[20] have also shown poor sensitivity of TM thermometry in detecting fever. Their results were in line with the results of our study. Axillary temperature correlated better than tympanic temperature, although difference in mean temperatures was not clinically significant. The correlation was seen to be better in the febrile group than in the afebrile group with all the methods, the reason for which is not clear.

TABLE 4. Sensitivity and Specificity of Axillary, Tympanic Membrane, and Temporal Artery Thermometer in Detecting Fever

Method of Thermometry Used	Sensitivity, %	Specificity, %
Axillary thermometer	80	100
Tympanic membrane thermometer	98	98
Temporal artery thermometer	80	98

TABLE 5. Accuracy of Axillary, Tympanic Membrane, and Temporal Thermometers in Predicting Rectal Temperature

Range of Temperature	Axillary Temperature		Tympanic Membrane		Temporal Artery	
	Febrile	Afebrile	Febrile	Afebrile	Febrile	Afebrile
±0.2°C	0	10	4	18	49	45
±0.4°C	4	29	23	31	50	49
±>0.4°C	50	50	50	50	50	50

The limitation of our study was use of rectal temperatures as a measure of core temperature. Pulmonary artery and distal esophageal temperatures correlate best with core temperature, but these are invasives methods and cannot be used in routine emergency care practice. Rectal temperature was found to correlate best with PA among noninvasive methods.[21] In a study of 20 patients in a pediatric intensive care unit, Romano et al[22] found that rectal thermometry had less bias and variability than tympanic or axillary thermometers in predicting PA temperature. Similar results were shown in adult patients by Milewski et al.[23]

Our study did not include patients with hypothermia, and hence these findings cannot be extrapolated to newborns and patients with hypothermia. Further studies including these groups should be conducted for wider use of temporal artery thermometers.

CONCLUSIONS

We conclude that temporal artery thermometry has the potential to replace rectal thermometry in busy emergency room setting among children aged 2 to 12 years. It correlates better with rectal temperatures when compared with tympanic and axillary temperatures, in both febrile and afebrile children.

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