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Comparison of the Specificity and Sensitivity of the Infrared Temporal Artery and Digital Axillary Body Temperature Measurements with Nasopharyngeal Method in Adult Patients

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ABSTRACT

Aims Accurate and timely determination of body temperature as one of the vital signs of the body is the key to diagnosis and treatment. Temporal artery thermometer is one of the new tools for measuring body temperature that is still unknown regarding for its accuracy and reliability. Therefore, this study aimed at comparing the specificity and sensitivity of two methods of body temperature measurement by electric subroutine thermometer and digital temporal artery in comparison with nasopharyngeal thermometer in adult patients.

Instruments & Methods This descriptive-analytical and cross-sectional study was performed on 200 adult patients over 17 years old admitted to the ICU of Shohadaye Khalije Fars Hospital, Bushehr, Iran in 2015. The samples were selected by convenience sampling method. For all samples, body temperature was measured and recorded using three methods, including nasopharyngeal (gold standard), axillary, and temporal arterial methods. Data were analyzed by SPSS 20 and STATA 11 software using Pearson correlation coefficient, chi-square test and ROC curve.

Findings The sensitivity, specificity, and accuracy of the temporal artery method with fever threshold of 37.7°C were 94.0%, 85.0% and 86.5%, respectively, and showed a good agreement between the axillary and temporal artery methods with a kappa coefficient of 0.67.

Conclusion Body temperature measurement by temporal artery method is precise, fast, comfortable and safe for patients in comparison with nasopharyngeal and axillary methods and the best threshold for fever in this method is 37.7°C.

Keywords Axillary; Thermometer; Temporal Artery; Temperature; Nasopharyngeal

CITATION LINKS

[1] Temporal artery versus bladder thermometry during perioperative and intensive care unit monitoring [2] Comparison of axillary, tympanic and rectal body temperatures using a covariate-adjusted receiver operating characteristic approach [3] A comparison of different methods of temperature measurement by mothers and physicians in healthy newborns [4] Temperature measurement in the adult emergency department: oral, tympanic membrane and temporal artery temperatures versus rectal temperature [5] Comparison of temporal artery, nasopharyngeal, and axillary temperature measurement during anesthesia in children [6] Comparison of temporal artery, mid-forehead skin and axillary temperature recordings in preterm infants< 1500 g of birthweight [7] Tympanic, infrared skin, and temporal artery scan thermometers compared with rectal measurement in children: a real-life assessment [8] Comparison of temporal artery and axillary temperatures in healthy newborns [9] Temporal artery and axillary thermometry comparison with rectal thermometry in children presenting to the ED [10] Comparison of temporal artery thermometry with axillary and rectal thermometry in full term neonates [11] Accuracy of temporal artery thermometry in neonatal intensive care unit infants [12] A practical comparison of temporal artery thermometry and axillary thermometry in neonates under different environments [13] Temperature measurement in pediatrics: a comparison of the rectal method versus the temporal artery method [14] Comparison of temporal artery to mercury and digital temperature measurement in pediatrics [15] Comparison of temporal artery to rectal temperature measurements in children up to 24 months [16] Methods and devices for measuring core body temperature [17] Agreement between temporal artery, oral, and axillary temperature measurements in the perioperative period [18] Accuracy of a noninvasive temporal artery thermometer for use in infants [19] A comparison between infrared tympanic thermometry, oral and axilla with rectal thermometry in neutropenic adults

Introduction

Body temperature is one of the vital signs that should be checked for safe and effective care [1]. Despite the remarkable advances in medical science and medical engineering in recent years, the electronic technology in clinical examinations has been used for diagnosis and treatment and follow-up of the disease. Patients' body temperature can be measured from various areas, such as the mouth, armpit, rectal, pulmonary artery, esophagus, pharynx, bladder, ear canal (tympanic) and temporal artery [2, 3]. Each method of measuring body temperature has its own advantages and disadvantages. Therefore, to choose the ideal method or area for the measurement, it should be considered to use a method that reflects the central body temperature and also the fast and convenient, hygienic, non-invasive, applicable, and cost-effective method is preferred [4]. Nasopharyngeal temperature, like the pulmonary artery and rectal temperature, reflects central body temperature as the gold standard, however, this method is difficult and requires expensive props and monitor and is used only in patients admitted to intensive care units or patients undergoing general anesthesia and hypothermia [5].

Axillary temperature measurement is used because of its convenience and safety, especially in specific groups, such as children, the elderly and critically ill patients in the intensive care unit, however, despite its many benefits; it is affected by ambient temperature and rarely remains stable [6]. The new method of measuring body temperature, the temporal artery thermometer, is a developed method, which is a noninvasive, rapid, accurate, easy and suitable method for all ages in clinical setting [7-9]. Some studies have reported temporal arterial temperature as a central body temperature index from the accessible area with the least confounding factors. It is believed that the temporal artery blood is supplied from the external carotid and directly from the heart and center of the body and has a relatively high and stable blood flow, indicating the body's central temperature. Various studies have compared temporal arterial temperature with different areas of the body and studied its accuracy and precision [10-12].

A study by Bahorski *et al.* to determine the accuracy of temporal temperature versus rectal in children showed that the right and left tympanic temperatures are highly correlated with rectal temperature as the gold standard [13]. Işler *et al.* in their study found that temporal arterial temperature was significantly higher than axillary temperature [14]. Also, Carr *et al.* reported a correlation coefficient of 0.77 between the temporal artery and rectal methods [15]. Haddad *et al.* compared the temperature of neonates using temporal and axillary methods and showed that the temporal artery temperature was higher than that of the axillary method, but they did not use the gold standard in their study [8].

Precise temperature measurement is an important step in patient care. The speed of temperature measurement is very important, especially in hospitalized children and adults who cannot keep a thermometer. Also, a method that reduces nurses' workloads, saving time and manpower is of great importance [16]. Therefore, measuring the temperature through the temporal artery instead of the central nasopharyngeal and axillary techniques, as a noninvasive procedure is helpful. Therefore, given the contradictory findings in various studies and the importance of the possibility of replacing invasive methods by temporal technique, this study aimed at measuring body temperature using temporal artery and axillary methods and comparing them with body temperature measurement using nasopharyngeal method.

Instrument and Methods

This study is a cross-sectional and descriptive-analytical research. The study population consisted of adult patients admitted to ICU of Shohadaye Khalije Fars Hospital, Bushehr, Iran in 2015. Inclusion criteria were the age of over 17 years and no diseases, scars or surgery in the frontal, temporal, nasal, pharynx and axillary areas. Patients were not feed orally during the study. The patient's room temperature was kept constant at 25°C. According to previous studies, sample size was estimated 200 individuals using PASS 11 software with 80% power and 95% confidence level. The samples were selected by convenience sampling method and enrolled in the study.

After calibration of the devices and obtaining written consent from the patient and companions, three body temperature measurements were used: axillary, temporal artery, and nasopharyngeal methods and the results were recorded in a checklist plus the patients' demographic characteristics.

Temporal arterial temperature was assessed using FT 65 Infrared device model 6-IN-1 FT65 (Beurer; Germany) by placing on the temporal artery at both right and left sides and the temperature was recorded after 3 seconds. Left and right axillary temperature measurement was done by digital device model flex temp cE 0197 (Omron; Japan). A disposable cover was placed on the tip of the thermometer and with observing the hygiene considerations, the thermometer was placed in the axilla in the midline of the axilla in a perpendicular position to the body. After turning the device on and hearing the beep sound, the number appeared on the monitor screen of the device was recorded as the axillary temperature. To measure the nasopharyngeal temperature, by placing a disposable plastic cover on the tip of the thermometer for this procedure, thermometer was placed (5-8 cm) in the patient's nose and throat and fixed. Then the number appeared on the monitor screen of the device was recorded after the heat was fixed. Thermometer mode BF (Alborz Company; Iran) was used to measure this method. To prevent the possible influence of room temperature on the obtained data, the room temperature was also measured using an ambient thermometer mounted on the room wall and kept at 25°C.

Quantitative data were expressed as mean and standard deviation. At first, normal distribution of data was verified by Kolmogorov-Smirnov test. Then, Pearson correlation coefficient was used to show the correlation of recorded body temperatures by two methods.

The area under the ROC curve and its 95% confidence interval were calculated for body temperature measurements by right and left axillary and right and left temporal artery methods. Nasopharyngeal body temperature was used as the gold standard. Chi-square test was used to compare the area under the curve of the two methods.

Youden index was used to calculate the best cut-off point for fever detection. Sensitivity and specificity of the methods were calculated using the ROC curve at the points with the highest sensitivity and specificity.

Also, to determine the similarity or differences of the results of the different measurement methods, the results were first divided into two groups: with a fever or without a fever and their accuracy were calculated and evaluated. After determining the accuracy, kappa coefficient of agreement was used to indicate the degree of agreement between the right and left axillary and right and left temporal arteries methods. Data were analyzed by SPSS 20 and STATA 11 software.

Findings

Of the 200 studied patients, 33 cases (16.5%) were female and 167 cases (83.5%) were male. The minimum age of patients was 17 and maximum was 78 years with the mean age of 37.30±17.82 years.

Mean body temperature was measured using digital axillary thermometer, infrared temporal artery thermometer and nasopharyngeal thermometer (Table 1).

Table 1) The mean body temperature of the patients by different measurement methods

Measurement method	Body temperature (°C)
Right temporal artery	37.12±0.65
Left temporal artery	37.11±0.70
Right axillary	36.78±0.85
Left axillary	36.81±0.80
Nasopharyngeal	37.04±0.83

The maximum and minimum room temperatures were 35°C and 21°C, with a mean of 27.57±2.13°C, respectively. Thirty-six patients (18.0%) were diagnosed with fever using gold standard (nasopharyngeal) method.

For the right axillary and left temporal artery methods, the maximum area under the ROC curve as an index of accuracy was 0.988±0.0052 and 0.947±0.0002, respectively. There was no statistically significant difference between the area under the ROC curve in the right and left axillary (p=0.029) and right and left temporal artery (p=0.06) measurements (Table 2).

After dividing the data into two groups of with a fever or without a fever, the highest agreement was found between the right and left axillary method with kappa coefficient of 71 and the lowest agreement between the right axillary and left temporal artery methods with the coefficient of 59.

The highest correlation was observed between the nasopharyngeal and right axillary methods and the least correlation between the nasopharyngeal and the left temporal artery methods (p=0.0001; Table 3).

Table 2) ROC curve results for sensitivity and specificity of different temperature measurement methods compared with nasopharyngeal method

Measurement method	Fever threshold (°C)	Sensitivity (%)	Specificity (%)	Positive predictive value	Negative predictive value	Accuracy (%)
Right temporal artery	37.5	94.4	75.0	58.1	97.2	86.5
Left temporal artery	37.7	84.0	85.0	56.3	96.5	85.5
Right axillary	37.6	88.8	94.5	78.4	97.4	93.5
Left axillary	37.6	91.6	94.5	78.5	98.1	94.0

For all cases: p=0.0001

Table 3) Pearson correlation coefficients between different body temperature measurement methods

Measurement method	Nasopharynx	Right temporal artery	Left temporal artery	Right axillary
Nasopharyngeal	1			
Right temporal artery	0.864	1		
Left temporal artery	0.855	0.923	1	
Right axillary	0.903	0.867	0.865	1
Left axillary	0.859	0.798	0.780	0.890

Discussion

Findings of correlation between body temperature measurement by temporal artery and nasopharyngeal methods showed a good correlation between these two methods. There was also a high correlation between nasopharyngeal and axillary methods. In the study by Carr *et al.* on the central and temporal artery temperature, this correlation coefficient was reported 0.77 [15]. Barringer *et al.* compared temporal and axillary body temperature measurements and reported a good agreement between these two methods, which despite their small sample size, their results are consistent with the present study [17]. Another study by Bahorski *et al.* reported Spearman's correlation of 0.85 between the two methods of temporal and rectal artery in neonates [13], which is consistent with the results of the present study in adults.

The results of this study showed that the mean body temperature difference is 0.2°C between nasopharyngeal method with axillary and temporal artery methods. In Carr *et al*. study, there was no difference between the mean rectal temperature and the temporal artery in children [15]. Also, in the study by Işler *et al*. on comparing temporal artery and axillary methods using a mercury glass thermometer in children, there was no statistically significant difference between the mean results of the two temporal artery and nasopharyngeal methods [14], indicating the similarity of the results between these two methods. According to the results, the right and left arteries can be selected to measure body temperature. However, in the Lee *et al*. study to determine the accuracy of the temporal arterial method as a noninvasive thermometer, there was a statistically significant difference between the temporal and rectal artery temperature results. The mean rectal temperature was also significantly lower than the temporal artery method, which is not consistent with our findings, which may be due to the difference between the infants and adults [11].

In the present study, the temporal artery approach with a fever threshold of 38°C had a low sensitivity and specificity, but after shifting the threshold to 37.5°C, sensitivity and specificity were significantly increased. Therefore, this change in threshold can lead to diagnose some patients with a fever using temporal artery method who already were diagnosed using nasopharyngeal method, as well. Greens and Fleischer in 2001 determined temporal arterial method accuracy as a noninvasive body temperature measurement method and reported a sensitivity of 66% and specificity of 96%, which are consistent with the results of the present study [18]. No relevant study was found reporting the sensitivity, specificity, and cut-off point in the temporal artery method.

In the present study, the kappa coefficient of agreement between the temperature of the temporal artery and the nasopharyngeal methods was 62%. Carr *et al*. reported an agreement of 94.5% between the temporal artery and rectal methods, which is inconsistent with the results of the present study, which may be due to differences in the methods used in the two studies [15]. Dezarr *et al*. compared the accuracy of tympanic, axillary, oral and rectal techniques on 60 adult patients and suggested that the correlation between the temperature measured by the axillary and rectal methods was very low with a coefficient of 43 due to the used small sample size. Therefore, the present study has controlled this error using larger sample size [19].

Considering the results of the present study and comparing these results with other studies and also regarding the patient's characteristics and the used area to measure body temperature, as well as providing the safety, comfort and convenience of the patient and the treatment team, the use of the temporal artery thermometer in clinical care of patients is recommended.

It is recommended to provide more evidence using other relevant studies on adults and new tools to measure body temperature.

Conclusion

All three body temperature measurements, including the nasopharyngeal, temporal artery, and axillary are sensitive to body temperature changes and exhibit an increase or decrease in central body temperature. Therefore, in cases with limitation to control temperature through the nasopharynx, using a digital axillary and temporal artery thermometer can be used as an alternative. Temporal artery temperature measurement is a non-invasive, fast, healthy, and cost-effective way to measure body temperature in 2-3 seconds and is also more practical than invasive methods; therefore, it can be used as an alternative.

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Ethical Permission: This study was extracted from a Master's thesis of the Bushehr University of Medical Sciences (Ethics code: 32356).

Conflict of interests: there is no conflict of interests.

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