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Comparison of infrared tympanic and non-contact temporal artery thermometer in determining the body temperature of patients in cardiovascular surgical intensive care

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Abstract

Accurate measurement of body temperature is crucial post-cardiovascular surgery, given the intricate and high-risk nature of cardiovascular procedures. In this prospective observational study, the safety and efficacy of infrared tympanic thermometers (ITT) and non-contact infrared temporal artery thermometers (NCTAT) were assessed in intensive care patients recovering from cardiovascular surgery. Conducted at a state hospital in Istanbul from April to July 2016, the study included 60 eligible patients meeting the specified criteria. Results indicated a slightly higher body temperature measurement with ITT (36.42±0.72) compared to NCTAT (36.02±0.79). NCTAT and ITT values were found (right ear: bias =0.39°C, limits of agreement: -1.99°C to 1.21°C; left ear: bias =0.29°C, limits of agreement: -1.59°C to 1.01°C) in the statistical evaluation by Bland and Altman analysis method. Repeatability, intragroup correlation and scatter plots of both measuring devices did not show a significant difference. In conclusion, within the cardiovascular surgical intensive care unit, both types of thermometers prove suitable for body temperature measurement. Healthcare professionals can make informed choices between the two based on the distinct advantages and disadvantages associated with each device.

Keywords: Infrared tympanic, non-contact temporal artery thermometer, body temperature, intensive care, cardiovascular surgery

Introduction

Body temperature includes core temperature and body surface temperature. It was defined by Carl Reinhold in 1868 as internal temperature exceeding 38°C. In 1999, the Society of Intensive Care and Infectious Diseases defined fever as a body temperature of ≥38.3°C (≥101°F) [1-3]. The normal value of body temperature is 37±1°C and is affected by age, physical activity, hormonal factors, clothing, daily temperature cycle, stress, daytime and environment [4,5]. Interventional methods for measuring body temperature through catheters placed in the artery, nasopharynx or bladder are considered the gold standard. However, in parallel with technological developments, single measurement with easier methods such as digital, infrared tympanic thermometer (ITT), non-contact infrared temporal artery thermometer (NCTAT) and non-invasive methods such as disposable plastic thermometers are more widely preferred. The ideal method for measuring body temperature should reflect body core temperature well and provide rapid results, and should also be easy to apply, safe and cost-effective. It is stated in the literature that noninvasive methods for measuring body temperature are more advantageous in infection control than invasive methods [3,5,6].

Since the eardrum shares the same blood with the hypothalamus, which is the heat center, body temperature measurement values made with ITT are considered to be closest to reality [7,8]. It is thought that non-contact infrared thermometers may be an ideal measurement method or alternative in intensive care units, as NCTAT does not require sterilization before use in different individuals or does not have disposable apparatus [2,9-11]. As a matter of fact, since the World Health Organization declared the COVID-19 pandemic on March 11, 2020, interventions that reduce contact, prevent the development of infection, and prevent device selection have gained more priority and their use has increased [12].

Measurement of body temperature is very important in patients

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hospitalized in the intensive care unit after cardiovascular surgery, which involves complex, risky and major surgical intervention. Body temperature must be monitored to ensure safe and effective care. Appropriate body temperature measurement and timely response to fever or hypothermia are necessary to evaluate the effectiveness of treatment [1-3]. When studies comparing NCTAT and ITT in body temperature measurement are examined, it is seen that most of them were conducted at home in healthy children and newborn infants [9,13-17], and studies were conducted on adult patients treated in intensive care units, but these studies are quite limited [4,18-22]. Our aim in this study is to compare NCTAT and TIT in body temperature measurements of patients treated in the cardiovascular surgery intensive care unit, to enrich professional practice and knowledge, to increase the existence of evidence-based practices, and to facilitate the body temperature evaluation process.

Material and Methods

Design and study population

This study was conducted in a prospective observational type in the cardiovascular surgery intensive care unit of a training and research hospital affiliated to the Ministry of Health in Istanbul between April 2016 and July 2016. In the calculation of the study sample, a two-sided hypothesis was established using Power (G-Power) analysis and it was found including 53 patients in each groups should be included in the study with 80% power, 0.05 type 1 error and moderate effect size (0.40). The inclusion criteria comprised unconscious, non-intubated patients beyond the first postoperative day, without ear discharge or infection, and devoid of interventions like blood transfusion or antipyretic treatment. Excluded were patients undergoing hot-cold applications during measurements. The gold standard for temperature comparison was determined as the closest measurement to the body core temperature using the ITT.

Inclusion and exclusion criteria: Patients who were unconscious and not intubated, who were not on the first postoperative day, who did not have any ear discharge or infection, and who did not receive any interventions such as blood transfusion, antipretic treatment, hot-cold application during the measurement constituted the inclusion criteria. Patients who did not meet these criteria were excluded from the study. ITT closest to body core temperature was considered the gold standard. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist [23].

Instruments

Administration of thermometers used to measure body temperature

The study employed the infrared thermometer, a preferred and reliable choice in intensive care units, considering healthcare professionals' experiences. To ensure standardization, the thermometer underwent verification by the manufacturer's technical staff, and researchers received training. The "Patient Observation Form," crafted by reviewing relevant literature [13,15,19,22,24], included questions about patient characteristics (surgical intervention type, gender, age, surgery duration, body mass index (BMI)), and factors influencing measurements (room temperature, position). Subsequently, all measurements were documented on the "Patient Observation Form."

Data collection

Simple random sampling method was used in the sample selection of the study. The sample consisted of patients who were hospitalized in intensive care on Wednesdays and Thursdays every week and met the inclusion criteria. Data were collected by the researchers. To maintain measurement accuracy, the ambient temperature was consistently regulated at 23-24°C through the central air conditioning system, ensuring a humidity range of 40-60%. During ear measurements, the infrared tympanic membrane was positioned in the outer 1/3 of the ear, with the auricle pulled up toward the forehead until the signal sound was audible. All measurements were conducted on patients in a supine position for a minimum of 15 minutes. ITT took one or two seconds, while the NCTAT was set for a one-second duration. To ensure consistency, a single researcher conducted all measurements.

Statistical analysis

In the study's findings analysis, the Statistical Package for Social Sciences (SPSS) for Windows 17.0 program and MedCalc 9.6.2.0 program were utilized for statistical analysis. Data statistics were assessed using frequency, percentage, mean, and standard deviation. The Student's t-test was applied for paired groups, and one-way analysis of variance was employed for comparisons involving more than two groups in quantitative data analysis. To examine method fit, the concordance correlation coefficient was used, and correlation coefficients, including Pearson ρ, were calculated. The Bland Altman graph was drawn for assessing the relationship between measurements in the comparison between methods [25]. Results were interpreted within a 95% confidence interval (CI), with a P value <0.05 considered significant.

Ethical considerations

The study was approved by the ethics committee of Istanbul Medipol University (12.12.2014-Number: 10840098-325) and necessary institutional permissions (22.04.2015-Number: 28001928-501.07.01) were obtained from Health Sciences University Dr. Siyami Ersek Thoracic Heart and Vascular Surgery Training and Research Hospital. Patients were informed by the researcher using a “Voluntary Information Form” and those who agreed to participate in the study gave written and verbal consent. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Table 1 shows the descriptive characteristics of the patients and the comparison of the measurement values of infrared thermometers. It was determined that 50% (n=30) of the patients were between

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the ages of 50-65 years (54.2±13.5) and male. In the study, no significant difference was found when the descriptive features and measurement values of both thermometers were compared (P>.05). It was determined that the mean measurement value from the right ear with ITT was 0.10 units higher than that from the left ear (right ear: 36.42±0.72; left ear 36.32±0.67). It was also determined that the mean value of the measurement made from the right ear with ITT (right ear: 36.42±0.72) was 0.40 units higher than the measurement made with NCTAT (36.02±0.79).

Table 1. Comparison of patients' descriptive characteristics and measurement values of infrared thermometers (N=60)

Descriptive characteristics		Infrared tympanic thermometer right ear (°C)			Infrared tympanic thermometer left ear (°C)			Non-contact temporal artery thermometer (°C)		
	n (%)	Mean (SD)	F / t	P	Mean (SD)	F / t	P	Mean (SD)	F / t	P
Age										
18-33	6 (10.0)	35.87 (0.74)			35.98 (0.58)			35.88 (0.53)		
34-49	14 (23.3)	36.46 (0.49)			36.43 (0.62)			36.10 (0.56)		
50-65	30 (50.0)	36.60 (0.74)	2.06	.09*	36.35 (0.72)	.54	.71*	36.06 (0.96)	.15	.96*
66 -72	6 (10.0)	35.98 (0.62)			36.18 (0.60)			35.87 (0.87)		
73 ↑	4 (6.7)	36.35 (0.74)			36.40 (0.91)			35.95 (0.53)		
Gender										
Female	30 (50.0)	36.33 (0.74)	-.93	.35**	36.35 (0.58)	.42	.67**	35.98 (0.61)	-.41	.68**
Male	30 (50.0)	36.50 (0.71)			36.28 (0.77)			36.07 (0.95)		
BMI										
Normal (20-24.9)	17 (28.3)	36.21 (0.71)			36.13 (0.61)			35.83 (0.53)		
Overweight (25-29.9)	24 (40.0)	36.16 (0.54)			36.31(0.64)			36.02 (0.85)		
Moderately obese (30-34.9)	14 (23.3)	36.59 (0.65)	1.72	.13*	36.59 (0.82)	1.37	.25*	36.34 (0.97)	.92	.45*
Severely obese (35 -39.9)	3 (5.0)	36.83 (1.12)			35.90 (0.30)			35.70 (0.66)		
Morbid (40≤)	17 (28.3)	36.21 (0.71)			36.70 (0.42)			36.10 (0.71)		
Room temperature										
23	7 (11.7)	36.56 (0.79)			36.14 (0.54)			35.59 (0.63)		
24	21 (35.0)	36.41 (0.55)	.15	.86*	36.39 (0.63)	.36	.702*	36.04 (0.70)	1.28	.28*
25	32 (53.3)	36.39 (0.82)			36.31(0.74)			36.11 (0.87)		
Duration of surgical intervention (hours)										
≥5	25 (42.4)	36.45 (0.79)	.19	.84**	36.43 (0.68)	.94	.34**	36.12 (0.87)	.67	.50**
5<	34 (57.6)	36.42 (0.68)			36.26 (0.66)			35.98 (0.74)		
					Mean (SD)	**Range**				
Infrared timpanik thermometer (n=60)										
Right ear					36.42 (0.72)	35.0-38.0				
Left ear					36.32 (0.67)	35.2-37.8				
Non-contact temporal artery thermometer (n=60)					36.02 (0.79)	36.32-38.0				
Age (year) Mean (SD) (n=60)					54.2 (13.5)					

BMI: body mass index, SD: standart deviation, *One-way analysis of variance (Anova) F test, ** Student t test

The agreement and repeatability coefficients of NCTAT and ITT measurement values are given in Table 2. The repeatability coefficient value for the right ear with ITT was .61 (P>.05) and .64 (P>.05) for the left ear. The repeatability coefficient value of the measurement values made with NCTAT was .68 (P>.05) It is not possible for two different methods used to measure the same parameter to give exactly the same results for all subjects. However, when the difference between the two methods was evaluated as twice the standard deviation of the differences between the reproducibility coefficient suggested in the Bland and Altman article [24], it was found that there was no statistically significant difference between the measurement methods used (P>.05).

Table 3 shows the intra-group correlation coefficients of NCTAT and ITT. The intra-group correlation of the two measurements made with ITT in the right ear was .94 and .93 for the left ear. The intra-group correlation of the two measurements made with NCTAT was .94.

Table 4 shows the comparison of the limits of agreement of the measurement values made with NCTAT and ITT with the Bland

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and Altman method. When the mean difference and limits of agreement of the measurement pairs were analyzed, it was found that although the values of the measurements made with ITT from the right and left sides were higher than the values made with NCTAT, there was no statistically significant difference (P>.05). NCTAT and ITT could be 1.99 units lower or 1.21 units higher than the values measured from the right side (bias=.39°C, limits of agreement (LOA): -1.99°C to 1.21°C; t=.76; P>.05) It was also found that the values measured with NCTAT could be 1.59 units lower or 1.01 units higher than the values measured with ITT on the left side (bias=.29°C, limits of agreement (LOA): -1.59°C to 1.01°C; t=1.55; P>.05 In general, NCTAT and ITT measurement methods were found to be agreement.

Figures 1 and 2 show the scatter plots of the NCTAT and ITT right and left ear measurement agreement according to the Bland and Altman method. The graph shows that the differences do not show a systematic distribution around zero and that there is no clear relationship between the mean differences. This is supported by the fact that the slope parameter of the regression curve is not significant. When the mean differences and measurement limits of agreement are examined in Tables 3 and 4, it is clearly seen that this is supported. It is seen that the measurement methods used in both ways are agreement.

Table 2. Agreement and repeatability coefficients of infrared tympanic and non-contact infrared temporal artery thermometers (N=60)

Temperature measurement methods (°C)		Agreement coefficient	95% CI	Pearson p	Repeatability coefficient
ITT	**Right ear**	.86	.79–.90	.91	.61
	Left ear	.84	.75–.90	.87	.64
NCTAT		.86	.74–.91	.90	.68

ITT: infrared tympanic thermometer, NCTAT: non-contact infrared temporal artery thermometer, CI: indicates confidence interval

Table 3. Intra-group correlation coefficients of infrared tympanic and non-contact temporal artery thermometers (N=60)

Temperature measurement methods (°C)		Intra-group correlation	%95 CI
ITT	**Right ear**	.94	.90-.96
	Left ear	.93	.88-.96
NCTAT		.94	.90-.96

ITT: infrared tympanic thermometer, NCTAT: non-contact infrared temporal artery thermometer, CI: indicates confidence interval

Table 4. Comparison of the measurement agreement of ınfrared tympanic and non-contact temporal artery thermometers with the Bland and Altman analysis method (N=60)

		Mean difference BIAS±SE (95% CI)	Lower agreement limit (95% CI)	Upperagreement limit (95% CI)	t	P
NCTAT	**Right ear**	-.39	-1.99	1.21	.76	.45
ITT (°C)		-.60±-.18	-2.35 to -1.63	.84 to 1.57		
NCTAT	**Left ear**	-.29	-1.59	1.01	1.55	.12
ITT (°C)		-.46±-.12	-1.88 to -1.29	.71 to 1.30		

ITT: infrared tympanic thermometer, NCTAT: non-contact infrared temporal artery thermometer, CI: indicates confidence interval, SE: standard error

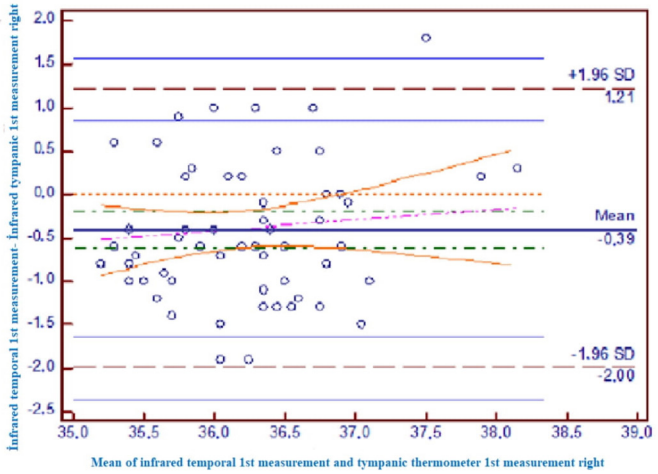

Figure 1. Scatter plot of NCTAT and ITT right ear measurement agreement according to Bland and Altman analysis method

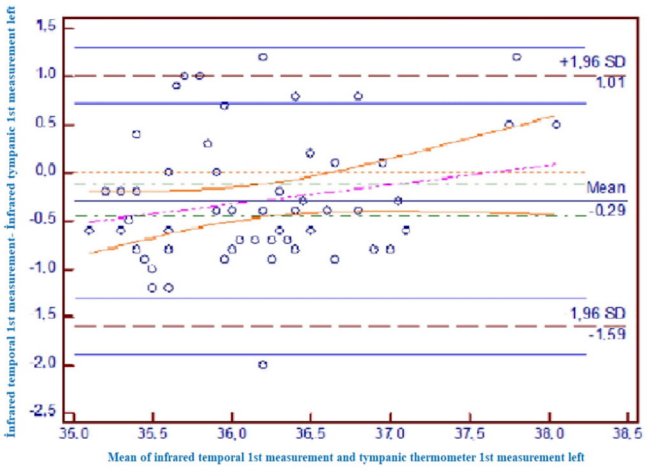

Figure 2. Scatter plot of NCTAT and ITT right ear measurement agreement according to Bland and Altman analysis method

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Discussion

Measurement of a patient's temperature in the cardiovascular surgery intensive care unit is a performance indicator as outlined by the Cardiovascular Surgery Intensive Care Nursing Association. [1-4]. When the relationship between the measurement results with the thermometer is examined, age, gender, type of surgical intervention, room temperature and duration of surgical intervention, measurement results found to be statistically insignificant.

The clinical accuracy of non-contact infrared thermometers has been extensively investigated in the pediatric field and their use in the clinical field is recommended [13,14]. However, very little research has been conducted on the use of these thermometers in adults. In the studies we encountered, it was reported that the mean values of NCTAT measurements in healthy adult patients were 0.3°C lower [18] or the same [26] than the mean values of ITT measurements. The opposite was found in pediatric patients [9,13,14,16]. In the literature review, only one study examined the measurement result between the right and left ear and the difference was found to be 0.07°C units [15]. In this study, the difference between NCTAT and ITT from the right ear was 0.40°C units. The difference between the results of the measurements made with ITT from the right and left ears was found to be 0.10°C units and was found to be agreement. Although the results in this study support the limited literature, the reason for the difference between the measurement results is not explained. It is pleasing that the results in this study are consistent with each other.

It has been reported that there is no significant difference between the body temperature measurements of patients in cardiovascular surgical intensive care unit using NCTAT and ITT with oral and axillary thermometers. However, it is recommended that invasive measurement methods should be preferred primarily in patients with fever [20,22,27-29]. Asadian et al. found that measurements with NCTAT and ITT were safer [20]. Again, in the post-anesthesia care unit [30,31], colorectal-gynecological [23], rehabilitation period of patients with spinal cord and brain trauma [32] or in patients undergoing major surgical intervention [11,19,31], it is stated that the results of measurements made with NCTAT and ITT are agreement and that invasive measurement method should be used as a reference [11,19,30]. In a meta-analysis of 11 studies in 1764 patients, Geijer et al. emphasized that NCTAT is more reliable than ITT and may replace ITT in the future [10]. Studies have also reported that NCTAT has significant advantages in terms of sleep quality and comfort in patients [10,26,32]. Although the lack of reference to one of the invasive measurement methods in body temperature measurement was a shortcoming of the study, ITT closest to the body core temperature was accepted as the gold standard. In addition, statistical evaluation was performed with the Bland Altman analysis method. In the study, when the intragroup correlations, repeatability, agreement and scatter plots were statistically analyzed, it was found that they were compatible with each other and there was no significant difference between the measurement methods. Our study result supports the literature information.

Although the reliability of a method of measuring body temperature in clinical practice has not yet been defined, studies [27,33] indicate that a temperature measurement method is reliable when the standard deviation ranges between 0.3°C and 0.5°C. Gejer et al. found that the limits of agreement of the reference thermometer with NCTAT (-.92 to -.79) and ITT (-1.15 to -.57) were close [10]. In this study, the limits of agreement of the NCTAT and ITT values measured from the right and left sides were similar to the limits of agreement.

Limitations of study

The results cannot be generalized because the limitations of this study were that it was single-center, the sample was small and it was not a randomized controlled study.

Conclusion

When comparing ITT and NCTAT, which are the most preferred noninvasive methods in clinical practice, there is no significant difference between the measurement values. Both thermometers can be used to measure the body temperature of patients being treated in the cardiovascular surgical intensive care unit. Healthcare professionals may consider the advantages and disadvantages of the thermometers they use to measure body temperature.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The article was produced from the master thesis. There are traces of ethics and institutions.

This study was produced from a master's thesis and presented as an oral presentation at the 1st International Health Sciences Congress held in Van on 27-29 October 2022.We thank the patients who participated in the study

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