ELSEVIER

International Journal of Pediatric Otorhinolaryngology
65 (2002) 39–43

INTERNATIONAL JOURNAL OF Pediatric Oto Rhino Laryngology

www.elsevier.com/locate/ijporl

Infrared tympanic thermometer can accurately measure the body temperature in children in an emergency room setting

Hasan Kocoglu [a,*], Sitki Goksu [a], Memet Isik [b], Zekeriya Akturk [c], Yildirim A. Bayazit [d]

[a] *Department of Anesthesiology and Reanimation, Faculty of Medicine, University of Gaziantep, Gaziantep, Turkey*
[b] *Private Practice, Istanbul, Turkey*
[c] *Department of Family Medicine, Faculty of Medicine, University of Trakya, Edirne, Turkey*
[d] *Department of Otolaryngology, Faculty of Medicine, University of Gaziantep, Gaziantep, Turkey*

Received 21 November 2001; received in revised form 24 April 2002; accepted 29 April 2002

Abstract

Objective: The objective in this study was to compare the accuracy of the tympanic membrane infrared thermometer with the other conventional temperature measurement options. *Methods:* One hundred and ten randomly selected pediatric patients who admitted to our emergency room were included in the study. Each child underwent simultaneous temperature measurement via rectum, axilla, and external auditory canal. The rectal and axillary measurements were performed using conventional mercury in glass thermometers. The aural measurement was performed using the non-contact infrared thermometer (Braun ThermoScan IRT 1020, Germany). *Results:* On aural measurement, the results of both ears as well as the first, second and third measurements were similar ($P < 0.01$). The mean results of the axillary, rectal and tympanic temperature measurements were 37.46 ± 1, 38.18 ± 1, and 38.01 ± 1.1, respectively. The mean axillary temperature was 0.72 °C lower than the mean rectal temperature, and 0.55 °C lower than the tympanic temperature. The difference between the mean tympanic and rectal temperatures was 0.17 °C. The results of measurements via rectum, axilla and ear were similar ($P < 0.01$). *Conclusion:* In conclusion, it is apparent that each of the temperature measurement options has some advantages and disadvantages. An optimal thermometer should have the following features; accurate temperature measurement; ease of application in a short while; safety and absence of potential risks; and tolerability by the patient. Since the aural infrared thermometer meets these criteria, its use in the routine clinical practice appears to be advantageous rather than or complementary to the conventional methods.

Keywords: Infrared tympanic thermometer; Mercury in glass thermometer; Core temperature; Rectal temperature

1. Introduction

The body temperature varies in different parts of the body [1] though the measurement and monitoring of the core temperature are important in the clinical practice [2,3].

* Corresponding author. Tel./fax: +90-342-360-2244.
E-mail address: hkocoglu@hotmail.com (H. Kocoglu).

0165-5876/02/$ - see front matter
PII: S0165-5876(02)00129-5

The core temperature can be measured from the mouth, rectum, axilla, esophagus, urinary bladder, pulmonary artery, or tympanic membrane. Each monitoring site has advantages and disadvantages [4].

Temperature can be measured by several techniques. The mercury in glass thermometer is one of the most frequently used temperature measurement tools [5]. Nowadays, electronic thermometers have replaced the mercury in glass thermometers in the clinical practice. The infrared tympanic membrane thermometer is another alternative [2,3]. These electronic ear thermometers measure the radiant heat emitted from the tympanic membrane [6]. The accuracy of the infrared tympanic thermometer has been studied in the pediatric patients [7]. The tympanic membrane has a good blood supply, and it seems possible to measure the temperature accurately by tympanic thermometers [8].

For the purpose of this study, we compared the accuracy of the tympanic membrane infrared thermometer with the other conventional temperature measurement options.

2. Materials and methods

One hundred and ten randomly selected pediatric patients who admitted to our emergency room in 1999 were included in the study. The randomization was made according to the days that the physician who performed the temperature measurements worked in the emergency room. The same physician performed all of the measurements. An oral informed consent was obtained from the parents of the children after explaining the purpose of temperature measurement.

Each child was undressed, and exposed to a constant environmental temperature for 10 min before the simultaneous temperature measurements, which were performed via rectum, axilla, and external auditory canal.

The rectal and axillary measurements were performed using conventional mercury in glass thermometers. To ensure accurate results, the axillary region was dried using a towel before the measurement. The mercury in glass thermometer was shaken before each recording to decrease its temperature below 35 °C. The thermometers were left in place for 5 and 2 min for axillary and rectal temperature readings, respectively.

Briefly, the measurement of temperature over the tympanic measurement was performed as follows; the probe of the non-contact infrared thermometer (Braun ThermoScan IRT 1020, Germany) was inserted into the external auditory canal by pulling the pinna backward, and the probe was directed toward the eye. The probe was held in this position until the device bleeped, which usually took a few seconds. The cover of the probe was changed after each measurement.

The measurements performed from the both ears were repeated three times at 3-min interval. The first two measurements were performed simultaneously with the axillary and rectal measurement. After the second measurement, the patients were laid down on their right ear for 30 min, and a third measurement was performed from both ears. This was done in order to understand whether this kind of occlusion of the ear, or position of the body would impact on the tympanic temperature measurement.

Paired t-test was used to compare, and assess the correlation between the data using SPSS (Statistical Package for the Social Sciences) 8.0 for Windows.

3. Results

There were 44 girls and 66 boys with ages ranging from 5 to 10 years (mean, 7.7 ± 2.2). The mean height and weight of the children were 124.3 ± 13.4 cm and 25.2 ± 5.3 kg, respectively.

On aural measurement, the results of both ears as well as the first, second and third measurements were similar ($P < 0.01$). Therefore, the result of the second tympanic measurement was used to perform statistical comparisons with the results of the axillary and rectal measurements. The mean results of the axillary, rectal and tympanic temperature measurements were 37.46 ± 1, 38.18 ± 1, and 38.01 ± 1.1, respectively (Table 1).

The mean axillary temperature was 0.72 °C lower than the mean rectal temperature, and

Table 1
The mean temperatures measured in 110 children.

Measurement site	Mean (°C) ± S.D.
Axillary	37.46 ± 1
Rectal	38.18 ± 1
Tympanic	38.01 ± 1.1
1st right	37.9 ± 1.1
1st left	38.0 ± 1.2
2nd right	38.0 ± 1.1
2nd left	38.0 ± 1.1
3rd right (ear occluded)	38.1 ± 1.1
3rd left	37.9 ± 1.1

0.55 °C lower than the tympanic temperature. The difference between the mean tympanic and rectal temperatures was 0.17 °C. Despite these subtle differences, the results of rectal versus axillary ($t = 2.091$, $df = 10.9$, $P < 0.01$), rectal versus tympanic ($t = 0.419$, $df = 10.9$, $P < 0.01$), and axillary versus tympanic ($t = 1.377$, $df = 10.9$, $P < 0.01$) measurements were similar (Table 2).

A rectal temperature above 38.3 °C was considered the presence of fever. Accordingly, 33 (30%) of 110 children had fever. The presence of fever could be diagnosed by all of the modalities (axillary, rectal, aural) in 27 (90%) of 30 children. The fever was diagnosed only by rectal measurement in five (16.7%) children as the other modalities failed. In one (3.3%) patient, the aural thermometer was the only tool that helped to diagnose the fever.

4. Discussion

The measurement of a patient's temperature is probably the most common of all clinical investigations. Despite this fact, presence of differences between the results of the various temperature measurement modalities is likely. Recently, concerns have been raised about the accuracy of temperatures measured by infrared tympanic thermometers.

Infrared tympanic thermometers have many documented benefits, including speed (1–2 s), ease of use, and non-invasiveness [7,9]. The tympanic temperature reflects the core temperature accurately [10,11]. This was demonstrated by comparing the temperature measurements made in the pulmonary artery and esophagus [11]. The tympanic thermometers were demonstrated to give higher temperature readings than the oral thermometers [12]. It was also reported that tympanic thermometers provide more variable measurements than the oral thermometers [13]. According to some investigators, however, measurements from the tympanic membrane by infrared thermometry do not reflect the core temperature accurately [9].

The axillary measurement may not reflect the body temperature accurately [14]. By contrast, rectal temperature measurement is considered to reflect the core temperature accurately [15]. It was reported that the electronic rectal temperature measurement is the most accurate, and the tympanic, oral, or axillary measurements are not recommended [16]. There may be unacceptable differences in body temperature between measurements recorded with an infrared tympanic thermometer and a rectal mercury thermometer [17]. In our study, the results of the aural measurement was comparable to the results of the rectal measurement. The aural thermometers are as reliable as the rectal thermometers, and seem to give more

Table 2
The confidence intervals and statistical significance of the temperatures measured with different modalities

Temperatures compared	Mean difference	Standard deviation	95% confidence interval		Standard Error Mean
			Lower	Upper	
Rectal versus axillary	0.72	0.36	0.65	0.79	0.03
Axillary versus tympanic	0.55	0.4	−0.48	−0.63	0.04
Rectal versus tympanic	0.17	0.37	0.09	0.23	0.03

accurate results than the axillary measurements. Our results are further supported by the finding that there is a better correlation of the tympanic membrane temperature with the urinary bladder temperature than the axillary temperature [9].

In one study, it was proposed that there was no statistically significant difference between the temperatures in the ear and the axilla [8]. However, the rectal temperature is generally considered to reflect the body temperature better than the axillary temperature. In our study, the rectal temperature was 0.72 °C higher than the axillary temperature. However, the difference between the results of the rectal and aural temperatures was only 0.17 °C. Although there was no statistically significant difference between the results of three temperature measurement modalities, the mean difference 0.72 °C between the axillary and rectal temperature, and 0.55 °C between the axillary and tympanic temperature is significant in the clinical practice. The 0.17 °C difference between the rectal and tympanic pressure is not that high to cause misdiagnosis of fever in the clinical practice.

Despite the similarities between the results, the presence of fever could be diagnosed only by rectal thermometer in 16.7% of the patients versus only in 3.3% by the tympanic thermometer. This condition may be ignored because of the presence of significant statistical correlation between rectal and tympanic measurements. However, when there is a high index of suspicion for the presence of fever on physical examination, both of the aural and rectal measurements can be used as complementary options.

Despite its low accuracy, the axillary temperature measurement is safe and lacks potential complications. Despite its high accuracy, there may be some problems or complications on rectal temperature measurement such as rectal perforation, increase in blood pressure and decrease in PaO_2, and inaccurate results because of feces in the rectum [18]. On the other side, the aural measurement takes the advantage of accuracy as in the rectal measurement, and is a safe technique as the axillary measurement. In addition to that, surgical procedures on the tympanic membrane do not affect the results of the measurement of the temperature by infrared thermometry [19]. An ear infection, a crying baby, effusion and cerumen in the ear do not affect the result as well [20,21]. However, use of the ear thermometers as the ears are cold may give unreliable results, because the environmental temperature may also affect the tympanic membrane temperature [8].

According to a study performed in a private practice setting, the infrared thermometer is unreliable compared with conventional methods of temperature determination [22]. Our study was performed in an emergency room setting, more patients were included, and a different model of infrared thermometer was used. Each patient was assessed using three measurement modalities, and paired samples correlation was used in the statistical analyses. These differences between the studies might have caused the contradictory results.

On aural thermometry, the results of both ears were similar. Therefore, it is not important which ear was used for the temperature measurement. The position of the body and occlusion of the ear to some extent (the patients were laid down on their right ear for 30 min) does not impact on the measurement as well. The results of the first, second and third readings were also similar which makes repetitive measurements unnecessary and the results of aural measurement reproducible. Therefore, single measurement is enough to learn the core temperature in the clinical practice.

In conclusion, it is apparent that each of the temperature measurement options has some advantages and disadvantages. An optimal thermometer should have the following features; accurate temperature measurement; ease of application in a short while; safety and absence of potential risks; and tolerability by the patient. Since the aural infrared thermometer meets these criteria, its use in the routine clinical practice appears to be advantageous rather than or complementary to the conventional methods.

References

[1] G. Pocock, C.D. Richards, Human Physiology the Basis of Medicine, Oxford University Press, New York, 1999, pp. 539–546.

[2] D.I. Sessler, Temperature Monitoring, in: R.D. Miller (Ed.), Anesthesia, fifth ed., Churchill Livingstone, Philadelphia, 2000, pp. 1366–1389.
[3] C.G. Cattaneo, S.M. Frank, T.W. Hesel, H.K. El-Rahmany, L.J. Kim, K.M. Tran, The accuracy and precision of body temperature monitoring methods during regional and general anesthesia, Anesth. Analg. 90 (2000) 938–945.
[4] G.E. Morgan, M.S. Mikhail, Clinical Anesthesiology, Appleton and Lange, Stamford, 1996, pp. 73–108.
[5] R.S. Atkinson, G.B. Rushman, N.J.H. Davies, Lee's Synopsis of Anesthesia, Butterworth-Heinemann Ltd, Oxford, 1993, pp. 339–356.
[6] G. Edge, M. Morgan, The genius infrared tympanic thermometer, Anaesthesia 48 (1993) 604–607.
[7] R.D. Kenney, J.D. Fortenberry, S.S. Surratt, B.M. Ribbeck, W.J. Thomas, Evaluation of an infrared tympanic membrane thermometer in pediatric patients, Pediatrics 85 (1990) 854–858.
[8] C. Childs, R. Harrison, C. Hodkinson, Tympanic membrane temperature as a measure of core temperature, Arch. Dis. Child. 80 (1999) 262–266.
[9] R.S. Erickson, S.K. Kirklin, Comparison of ear-based, bladder, oral, and axillary methods for core temperature measurement, Crit. Care Med. 21 (1993) 1528–1534.
[10] M. Yoran, S.R. Lowenstain, J. Koziol McLain, Measuring the accuracy of the infrared tympanic thermometer, J. Emerg. Med. 13 (1995) 617–621.
[11] K. Stavem, H. Saxholm, N.S. Erichsen, Accuracy of infrared ear thermometry in adult patients, Intensive Care Med. 23 (1997) 100–105.
[12] S.M. Irvin, Comparison of the oral thermometer versus the tympanic thermometer, Clin. Nurse Spec. 13 (1999) 85–89.
[13] K.K. Giuliano, A.J. Giuliano, S.S. Scott, E. MacLachlan, E. Pysznik, S. Elliot, et al., Temperature measurement in critically ill adults: a comparison of tympanic and oral methods, Am. J. Crit. Care 9 (2000) 254–261.
[14] J. Bliss-Holtz, Determining cold-stress in full-term newborns through temperature site comparisons, Schl. Inq. Nursing Pract. 5 (1991) 113–123.
[15] B. Holtzcloiw, Monitoring body temperature, AACN Clin. Issues 4 (1993) 44–45.
[16] B.N. Jensen, F.S. Jensen, S.N. Madsen, K. Lossl, Accuracy of digital tympanic, oral, axillary, and rectal thermometers compared with standard rectal mercury thermometers, Eur. J. Surg. 166 (2000) 848–851.
[17] P.C. Valle, O. Kildahl-Andersen, K. Steinvoll, Infrared tympanic thermometry compared to mercury thermometers, Tidsskr. Nor. Laegeforen. 20 (2000) 15–17.
[18] J. Bliss-Holtz, Comparison of rectal, axillary, and inguinal temperatures in full-term newborn infants, Nursing Res. 38 (1989) 85–87.
[19] A. Tomkinson, Tympanic thermometry and minor ear surgery (short communication), J. Laryngol. Otol. 110 (1996) 454–455.
[20] O. Kahyaoglu, I. Babka, C. Demirci, Effect of crying on infrared tympanic temperature measurement in pediatrics, Clin. Pediatr. 36 (1997) 487–488.
[21] P.J. Robb, R. Shahab, Infrared transtympanic temperature measurement and otitis media with effusion, Int. J. Pediatr. Otorhinolaryngol. 59 (2001) 195–200.
[22] G.L. Freed, J.K. Fraley, Lack of agreement of tympanic membrane temperature assessments with conventional methods in a private practice setting, Pediatrics 89 (1992) 384–386.