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A Comparison of Different Methods of Temperature Measurements in Sick Newborns

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Summary

We aimed to compare the accuracy of digital axillary thermometer (DAT), rectal glass mercury thermometer (RGMT), infrared tympanic thermometer (ITT) and infrared forehead skin thermometer (IFST) measurements with traditional axillary glass mercury thermometer (AGMT) for intermittent temperature measurement in sick newborns. A prospective, descriptive and comparative study in which five different types of thermometer readings were performed sequentially for 3 days. A total of 1989 measurements were collected from 663 newborns. DAT and ITT measurements correlated most closely to AGMT ($r = 0.94$). The correlation coefficent for IFST and RGMT were 0.74 and 0.87, respectively. The mean differences for DAT, ITT, RGMT and IFST were +0.02°C, +0.03°C, +0.25°C and +0.55°C, respectively. There were not any clinical differences (defined as a mean difference of 0.2°C) between both mean AGMT&DAT and AGMT&ITT measurements. Our study suggests that tympanic thermometer measurement could be used as an acceptable and practical method for sick newborn in neonatal units.

Key words: Temperature, newborn, thermometers, axillary, rectal, tympanic, digital, infrared.

Introduction

Maintainance and monitoring of the thermoregulation of newborn infants is a basic requirement of good neonatal management and play a key role for neonatal nursing care in the neonatal intensive care unit (NICU). Determining accurate measurement of temperature is very important because abnormal temperature is strongly associated with a serious condition [1, 2]. Temperature of newborns may be measured in a variety of sites, including rectum, tympanic membrane, forehead and axilla and using a number of different tools, including glass mercury, digital, electronic and infrared thermometers.

Temperature measurement by the axillary method has become the accepted neonatal nursing care [3, 4]. Because of the greater surface vasculature, increased body fat and thermal uniformity, temperature measured in the axillary area is considered reliable and is used as a standard measurement site in newborns. No significant differences have been noted between left and right axillae [5].

Glass mercury thermometers are historically the most acceptable standard methods of temperature measurement. However, glass mercury thermometers has some disadvantages such as danger of breakage, potential harm and toxic vapor effects to health workers and the patients. Therefore, glass mercury thermometers are now used rarely in developed countries and studies are conducted to understand the efficacy of the various types of equipment available to measure temperature [6].

The aim of this study was to compare the accuracy of digital axillary thermometer (DAT), rectal glass mercury thermometer (RGMT), infrared tympanic thermometer (ITT) and infrared forehead skin thermometer (IFST) measurements with traditional axillary glass mercury thermometer (AGMT) for intermittent temperature measurement in the NICU.

Methods

This study was performed between 1 December 2008 and 1 April 2009 in the NICU of the Diyarbakir Children Hospital, in Turkey. During the study period, the newborns who were hospitalized in NICU of the Diyarbakir Children Hospital, were included in the study. The patients with unstable conditions such as dysmorphic appearance, congenital anomaly, septic shock and circulatory problem that would effect measurement were excluded from the trial. This was a prospective, descriptive and

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comparative study in which three temperature readings were performed sequentially 3 days from each newborn in incubator by the same neonatal nurse. A health worker helped the nurse for stabilization of the patients. Prior to the onset of data collection, the data collector nurse was instructed for correct temperature measurements procedures utilizing the five methods. An oral informed and written consent were obtained from the parents of the infants.

Temperature was measured using the following: glass mercury thermomether (for axillary and rectal tools separately), digital thermometer (Microlife digital thermometer, model MT 3001, Microlife AG Swiss Corp., Widnay, Switz), tympanic thermometer (First Temp Genius, Tyco Healthcare Kendall, Mansfield, Massachusetts) with disposable probe covers and infrared skin thermometer (Thermoflash LX-26, Visiomed France, Mountreuil, France).

The glass mercury thermometers and the tympanic thermometer were supplied by hospital's central service. The infrared skin thermometers and digital thermometers were provided by the authors of the study. The glass mercury thermometer (GMT) and digital thermometer were used separately for each patients.

Bilateral axillae were utilized for glass and digital thermometers, and right ear was chosen for tympanic thermometer. Infrared skin temperature was obtained on the central part of forehead. Axillary and forehead region were dried using a towel before the measurement. The GMT was shaken before using in order to decrease the reading below 35°C. Infrared skin thermometer was put in incubator or it was kept at room temperature for 15 min before using. First, digital and glass mercury thermometers were randomly placed in bilateral axillas separately in supine position at the same time. Patients were stabilized by a health worker. Simultaneously tympanic thermometer was inserted into the right external auditory canal by pulling the pinna straight back and the probe was directed toward the eye. The prob was held in the ear canal until a beep was heard. After this procedure according to principles and precautions of manufacturer, infrared skin thermometer readings were recorded three times by placing the device approximately 5–15 cm above forehead skin (mean value was accepted). Immediately after IFST measurement, a rectal glass thermometer was inserted upwards to a depth of 3 cm in a term and 2 cm in a preterm baby.

All the temperature measurements were recorded in the morning between hours of 08:00 till 12:00 during the study period. The room air temperature and relative humidity were kept constantly at 22–26°C and a relative humidity of 30–60%, respectively [7]. The temperatures of the incubators were adjusted according to the standard temperature reccommendations based on gestational age [8]. All readings were done by celcius (°C) scale. A time of 3 min was needed for axillary and 2 min for rectal thermometer, approximately 1–3 min with digital thermometer, 3 s with tympanic thermometer and 1 s with infrared skin thermometer. All measurements were terminated nearly at 8–10 min.

Five temperature measurements were obtained by data collector for each sample. Data analysis included Pearson's r coefficients (to determine the strength of the correlation), paired t-tests (to determine statistically significant difference), standard deviation, mean and range using SPSS statistical package. Scatter plot method was used in order to compare axillary glass thermometer with every other devices. Clinical signifance was defined as a mean difference of 0.2°C between axillary glass temperature and other four measurements [9].

Results

During the study period, 742 patients were hospitalized in the NICU. Seventy nine neonates who met the exclusion criteria were not included in the trial. Six hundred sixty-three newborn infants were included in this study and 1989 measurements of data were used during statistical analysis. Three hundred and forty-one of them were males (51.4%) and the average gestational age, birth weights and postnatal age during the study period were 36 ± 3.6 weeks, 2468 ± 11 g and 11 ± 7.4 days, respectively. Among the babies in the study group, 305 (46%) were preterm whereas 358 (54%) term. The study group did not include any postmature baby. Among the babies, 319 (48.1%) were found to be low birth weight (LBW) (<2500 g) whereas 344 (51.9%) had a birth weight ≥2500 g. The temperature values of the patients and mean differences according to gestational age (preterm and term) and birth weight (<2500 g and ≥2500 g) were summarized in Table 1. When all methods of temperature measurement were taken into consideration, any clinical difference which was defined as a mean difference of 0.2°C was not observed between patients regarding gestational age and birth weight. The hospitalization etiologies of patients in the study group were shown in Table 2.

The correlation between five methods were given in Table 3. DAT and ITT measurements correlated most closely to AGMT ($r = 0.94$). The correlation coefficent for IFST and RGMT were 0.74 and 0.87, respectively. The comparison of measurement of DAT, IFST, RGMT and ITT with AGMT were shown in Figs 1–4, respectively. The comparison of the temperature readings done by AGMT and DAT, and AGMT and ITT is seen in Figs 1 and 2, respectively. A significant correlation was found between comparable methods (Fig. 1, Rsq 0.886, Fig. 2, Rsq 0.885). The comparison of AGMT and RGMT temperature measurements were shown in Fig. 3. There is good correlation between these methods (Fig. 3,

TABLE 1
The temperature measurement of the patients according to gestational age (preterm and term) and birth weight (<2500 g and ≥2500 g)

Types of Thermometer[a]	Gestational age			Birthweight		
	Preterm babies ($n = 305$)	Term babies ($n = 358$)	Mean difference[b]	<2500 g ($n = 319$)	≥2500 g ($n = 344$)	Mean difference[b]
AGMT	36.71 ± 0.41	36.76 ± 0.41	−0.05	36.70 ± 0.40	36.77 ± 0.41	−0.07
DAT	36.72 ± 0.41	36.77 ± 0.40	−0.05	36.72 ± 0.40	36.78 ± 0.41	−0.06
ITT	36.73 ± 0.41	36.78 ± 0.41	−0.05	36.72 ± 0.41	36.80 ± 0.41	−0.08
RGMT	36.94 ± 0.42	36.98 ± 0.41	−0.04	36.94 ± 0.41	36.99 ± 0.42	−0.05
IFST	37.21 ± 0.47	37.24 ± 0.48	−0.03	37.21 ± 0.48	37.23 ± 0.48	−0.02

[a]Values were given as mean ± SD by celcius (°C) scale.
[b]There were no clinical differences (defined as a mean difference of 0.2°C) between patients according to gestational age (preterm and term) and birth weight (<2500 g and ≥2500 g).

TABLE 2
The hospitalization etiologies of patients in the study group

Etiologies	Infants ($n = 663$) n (%)
Respiratory diseases	273 (41.2)
Perinatal asphyxia	109 (16.4)
Sepsis	91 (13.7)
Prematurity	78 (11.8)
Hyperbilirubinemia	41 (6.2)
Surgical diseases	23 (3.5)
Other diseases	48 (7.2)

TABLE 3
Correlation coefficents for temperature measurements between axillary glass thermometer and other four methods

Types of Thermometer	Pearson's correlation coefficents
AGMT	1.0000
DAT	0.94
ITT	0.94
RGMT	0.87
IFST	0.74

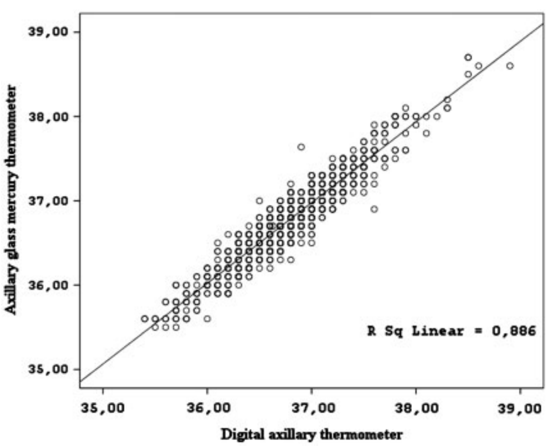

FIG. 1. Scatter plot of the difference between temperatures measured by AGMT and DAT.

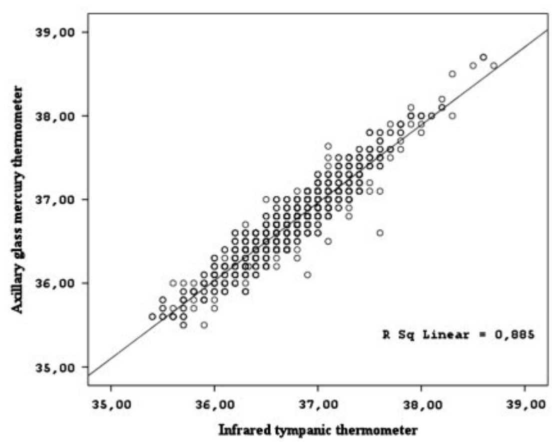

FIG. 2. Scatter plot of the difference between temperatures measured by AGMT and ITT.

Rsq 0.758). Poor correlation between AGMT and IFST temperature measurements is seen Fig. 4 (Rsq 0.596).

The mean temperature measurements were given in Table 4. The DAT had the smallest range (35.4–38.6°C). The IFST had the widest range (35.9–39.6°C). Mean AGMT measurement (36.74 ± 0.41°C) was compared with DAT (36.75 ± 0.40°C), ITT (36.76 ± 0.42°C), RGMT (36.97 ± 0.42°C) and

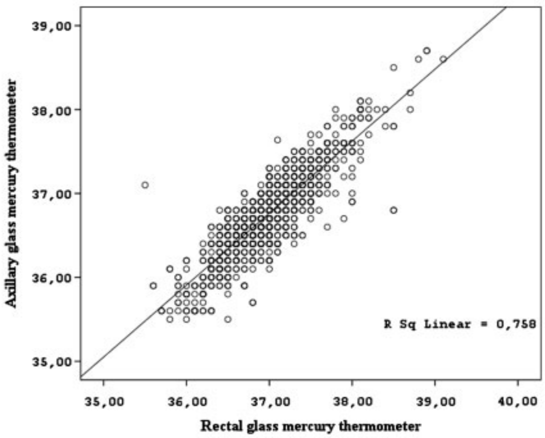

FIG. 3. Scatter plot of the difference between temperatures measured by AGMT and RGMT.

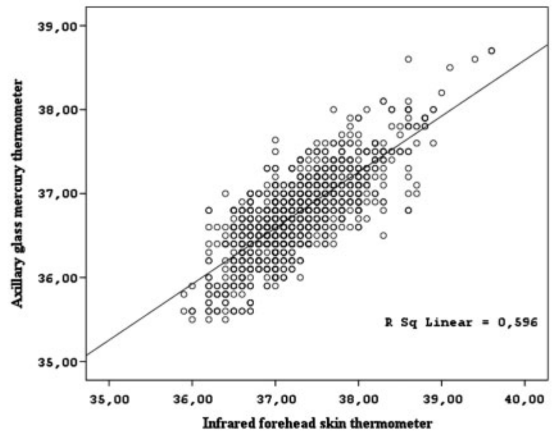

FIG. 4. Scatter plot of the difference between temperatures measured by AGMT and IFST.

TABLE 4
Measurement ranges of five methods

Types of Thermometer	Mean (°C)	Standard deviation	Range (°C)
AGMT	36.74	0.41	35.5–38.7
DAT	36.75	0.40	35.4–38.6
ITT	36.76	0.42	35.4–38.7
RGMT	36.97	0.42	35.5–39.1
IFST	37.22	0.47	35.9–39.6

IFST (37.22 ± 0.47°C). When we evaluated the correlation between AGMT and the other methods, the mean differences for DAT, ITT, RGMT and IFST were +0.02°C, +0.03°C, +0.25°C and +0.55°C, respectively. The mean differences were significant ($p = 0.001$, $p = 0.001$, $p < 0.001$, $p < 0.001$, respectively). But there were no clinical differences (defined as a mean difference of 0.2°C) between mean AGMT and DAT measurement, and mean AGMT and ITT measurement.

Discussion

Accurate and practical temperature monitoring is essential for clinical neonatal care and time management in neonatology units. Glass mercury thermometers and axillary region have been considered the gold standard method of temperature measurement in newborns [6, 10]. Although glass mercury thermometers have been used for a long period of time, this procedure had also some important disadvantages such as danger of breakage, potential harm and toxic vapor effects; difficulties in reading the values on the device; and possible role in spread of hospital acquired infections [2, 6]. Therefore, several studies have been conducted to determine the most accurate and practical device.

Digital thermometers have been shown to be a valuable method for neonatal temperature measurements. Sganga [6], Smith [11] and Leick-Rude *et al.* [12] found that the digital thermometer had a high correlation with the AGMT. In our study, the mean difference between AGMT and DAT was statistically significant, but not clinically significant. We demonstrated a good correlation between AGMT and DAT.

ITT is useful for clinical temperature measurement as long as moderately variability between patients is acceptable [13]. There are studies supporting the use of ITT among various age groups including newborns [14–16]. Weiss *et al.* [17] and Weiss [18] found that mean ear and axillary temperatures were highly correlated in newborns. However, its accuracy has been questioned for newborns in some studies [6, 19]. In our study, we found a high correlation between AGMT and ITT measurements. Although the mean difference of temperature measurements was statistically significant, a clinical significance was not found.

Rectal temperature measurement with glass mercury thermometer was reported to be the accurate method compared with the axillary measurements in newborns [20, 21]. Fulbrook *et al.* [22] stated that rectal temperatures to be consistently higher than temperatures taken at other sites possibly due to increased metabolic activity or bacteria. Hissink *et al.* [23] showed a wide variation of the mean difference between axillary and rectal temperature in newborns. In a systematic review, Craig *et al.* [24] concluded that the difference between temperature reading at the axilla and rectum using glass mercury thermometer showed wide variation across studies. Our study had same result also. There was a statistical and clinical significance between AGMT and RGMT.

Kemp *et al.* [25] compared AGMT and infrared axillary skin temperature and found good correlation between two devices but the measurements were from the different regions. Can *et al.* [26] concluded that the noncontact infrared thermometer could not be recommended for assessment of body temperature in newborns admitted to NICU. Similarly, we found a less correlation between AGMT and IFST results. The mean difference of measurements was significant both statistically and clinically. According to our study results, IFST measurement does not seem to be suitable and accurate for sick newborns.

This study has some limitations. Measurements were performed from the different body region by the same neonatal nurse. Different body regions have separate surface vasculature, metabolic activity and body fat composition. This condition might affect the measurements of the temperature. However, Kunnel *et al.* [20] found no difference in temperatures taken rectally, femorally, from the axilla or skin. Another limitation of our study was that we did not have a true measure of core body temperature to use as a criterion standard. In the literature, esophageal or pulmonary artery temperatures are generally considered to be true measures of core body temperature [27]. But both methods are invasive procedures.

The ideal measuring device should be a noninvasive, with a rapid result, accurate and practical to use. We measured temperature using five different devices and different sites in the same baby three times to find an ideal tool. We found statistically significant differences between measurements, but concluded that the differences between AGMT and DAT or ITT seen (0.01–0.02°C) were not clinically significant. Both of them were noninvasive, but ITT had more rapid results.

Conclusion

Good correlation with glass mercury thermometer, rapid result delivery, improved patient comfort, being an easy and noninvasive procedure and lacking the disadvantages of glass mercury thermometer are the advantages of tympanic thermometer. Our study suggests that tympanic thermometer measurement could be used as an acceptable method for sick newborns in the neonatal units.

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