

Comparison of Non-Contact Forehead Infrared Thermometry with Axillary Digital Thermometry in Neonates

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Abstract :

Introduction: Accurate temperature measurement is an important aspect of newborn care. Axillary thermometry is the accepted method in neonates. Forehead infrared thermometry, a newer non-contact method which is simple, fast and with minimal risk of cross infections could be a useful alternative in neonates. **Objective :** To determine the agreement between non-contact forehead infrared thermometry and axillary digital thermometry in neonates. **Materials and Methods :** A prospective study was conducted in neonates admitted in the neonatal intensive care unit and the postnatal ward of a tertiary care hospital. Body temperature of the neonates was measured by both the methods and the results analyzed by Bland-Altman method. **Results :** The mean difference of axillary and forehead infrared readings was -0.56°C and the 95% limits of agreement were $-1.58, 0.46$ which were greater than the values considered clinically acceptable. Agreement was similar in patients with and those without radiant warmer care. **Conclusion :** Non-contact forehead infrared and axillary digital thermometer measurements did not agree well. Forehead infrared thermometry is not accurate enough and cannot replace axillary thermometry for body temperature measurement in neonates.

Key words: Infrared Thermometer, Neonate, Temperature

Introduction :

Body temperature is an important vital sign in neonates. Accurate body temperature measurement is important for detecting not only hyperthermia but also hypothermia which is more common in neonates and associated with significant morbidity and mortality, especially in the developing countries. The ideal temperature measurement technique should be safe, easy to perform, non-invasive, time efficient, should accurately reflect the core body temperature and should not be influenced by external factors. Measurement of rectal temperature has been widely considered the gold standard in neonates because it correlates well with the core body temperature.⁽¹⁾ However it is slower, more invasive and associated with the risk of rectal perforation and transmission of microorganisms.⁽¹⁾ Therefore, the American Academy of Pediatrics (AAP) and National Institute for Health and Care Excellence, United Kingdom (NICE) guidelines recommend the use of axillary temperature in neonates.^(2, 3) According to the World Health Organization, axillary thermometry is

better because of hygiene, safety and ease.⁽⁴⁾ Digital thermometers have replaced mercury glass thermometers as they are safe and more convenient.

Recently newer non-invasive methods of thermometry have been introduced among which non-contact forehead infrared thermometry has become quite popular in health care facilities. In this method a sensor probe measures the amount of thermal radiation (infrared) emitted from the forehead which has rich blood flow from the temporal artery. It is simple, fast and convenient compared to the conventional methods. Due to its non touch technique and negligible risk of cross infections, it appears to be a promising method of thermometry in neonates where minimal handling is advocated. We therefore conducted this study to compare the temperature readings taken by a non-contact forehead infrared thermometer with those taken by an axillary digital thermometer in neonates. Our aim was to determine the agreement between the two methods and whether forehead infrared thermometry could replace axillary thermometry in neonates.

Materials and Methods :

A prospective comparative study was carried out in a tertiary care hospital in Ahmedabad, Gujarat, India from August to November 2015. Approval of the Institutional Ethics Committee was obtained and informed consent of parents of the neonates enrolled for the study was taken.

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All neonates in the NICU (Neonatal Intensive Care Unit) and postnatal ward, irrespective of their gestational age and diagnosis were included in the study. 1000 readings each by axillary thermometer and forehead infrared thermometer were taken and compared. Gibson Non-contact infrared thermometer (SJD-IR-401) was used to measure the forehead temperature and Rossmax TG120 digital thermometer was used to measure the axillary temperature. All the readings were taken by doctors as per product specific instructions of the manufacturer. The infrared thermometer was held 1-2 cm away from the forehead at the glabella. The measurement button was pressed, the position and distance of measurement adjusted by the tracking light and the readings were recorded. Axillary temperature was taken after wiping the underarm with a dry towel. The tip of the probe of the thermometer was placed high in the axilla and the arm held closely to the neonate's side. The temperature was recorded after a beep sound from the thermometer.

In the NICU, the neonates were kept under open care servocontrolled radiant warmers with the skin probe set at a temperature of 36.5°C. In the postnatal ward, the neonates were in rooming care beside their mothers with no warming device used, and the environment temperature was between 25° C to 30°C. A single reading by the infrared thermometer, followed immediately by a single reading by the axillary digital thermometer was recorded every 6 hourly in neonates aged 1-28 days in the NICU and postnatal ward. 1000 pairs of readings were taken in celsius unit (°C) in 64 neonates. 500 pairs each were recorded in neonates in the NICU (under radiant warmer) and in the postnatal ward (without radiant warmer).

The method suggested by Bland and Altman was used to study the agreement between the two methods of

temperature measurement.⁽⁵⁾ The mean difference of temperature (bias) between the two methods was calculated. In a manner consistent with previous research,^(6, 7) a mean difference of $\leq \pm 0.5^\circ\text{C}$ was considered clinically acceptable. The number of data pairs outside the $\pm 0.5^\circ\text{C}$ limits were analyzed. The Bland-Altman graph displaying the difference between the two measurements plotted against their average was constructed and the scatter of data from the mean difference or bias (solid line) was studied. The scatter was quantified by calculating the upper and lower limits of agreement (dotted lines). The upper limit was computed as bias +1.96 SD (Standard Deviation of the bias) and the lower limit as bias -1.96 SD. The limits of agreement represent the range of values in which agreement between the two methods lie for 95% of the sample. The narrower the range between the two limits, the better the agreement between the two methods.

Results :

The mean, range, mean difference and 95% limits of agreement of the temperature measurements are shown in Table 1. Considering all the 1000 pair of readings, the mean axillary temperature was 36.92°C and the mean infrared temperature was 37.49°C. Therefore, the mean infrared temperature recorded was significantly higher than the mean axillary temperature (p value <0.0001). The mean difference (bias) of the axillary and infrared forehead readings was -0.56°C (standard deviation = 0.52°C). This is more than the clinically acceptable value set at $\leq \pm 0.5^\circ\text{C}$. Infrared readings tend to be greater than the axillary readings. The lower and upper limits of agreement by the Bland-Altman method were -1.58 and 0.46, respectively (Figure 1). This range of the limits of around 2°C is too wide to be clinically acceptable. In 601(60.1%) of the comparisons, the difference between

Table 1: Mean, range, mean difference and limits of agreement of the temperature measurements

Variable	Axillary temperature in °C		Infrared temperature in °C		Mean difference in °C	Lower limit of agreement	Upper limit of agreement
	Mean	Range	Mean	Range			
All neonates	36.92	35.2-38.6	37.49	35.3-39.4	-0.56	-1.58	0.46
NICU neonates (with warmer)	36.87	35.2-38.3	37.44	35.4-39.2	-0.58	-1.60	0.44
Postnatal ward neonates (without warmer)	36.98	35.5-38.6	37.52	35.3-39.4	-0.54	-1.57	0.48

the axillary and infrared forehead readings were greater than acceptable limit of $\pm 0.5^{\circ}\text{C}$. In 190 (19%) pairs, the difference was greater than $\pm 1^{\circ}\text{C}$. Therefore, the forehead infrared temperature measurements did not agree well with the axillary measurements.

Comparing the results recorded in the NICU neonates with radiant warmer (Figure 2) and those recorded in the postnatal ward neonates without radiant warmer (Figure 3), the mean difference of the axillary and infrared temperature readings was -0.58°C and -0.54°C , respectively. The limits of agreement in the two groups ($-1.60, 0.44$ and $-1.57, 0.48$, respectively) were also similar with a negligible difference.

Figure 1 : Bland-Altman plot of temperature measurements by axillary digital and forehead infrared methods of all the neonates

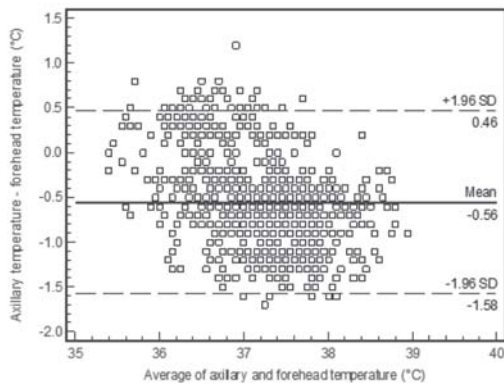


Figure 2: Bland-Altman plot of temperature measurements by axillary digital and forehead infrared methods of NICU neonates (with warmer)

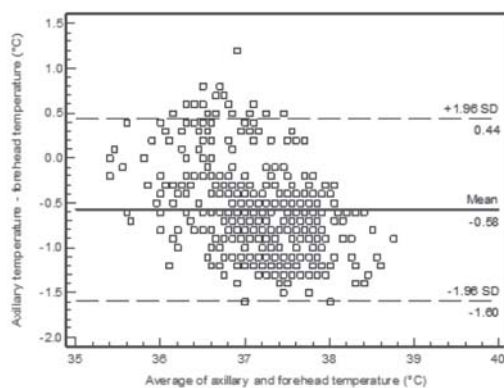
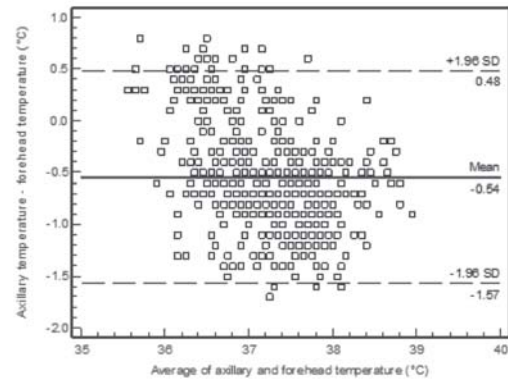


Figure 3: Bland-Altman plot of temperature measurements by axillary digital and forehead infrared methods of postnatal ward neonates (without warmer)



Discussion:

Forehead infrared thermometry is a new method which is rapid and easy to use compared to conventional methods of temperature measurement. Due to the non contact technique and negligible risk of cross infections it appears to be very suitable for use in neonates.

Since its introduction various studies have been conducted to compare its accuracy with other methods of temperature measurement. Most of the studies have been conducted in children and adults. Chiappini et al⁽⁸⁾ reported good agreement (mean difference of 0.015°C and 95% limits of agreement $-0.62, 0.76$) between forehead infrared thermometry and axillary thermometry using mercury in glass thermometer in pediatric population. On the other hand, Apa et al⁽⁹⁾ recorded a higher mean difference of -0.38°C between axillary and infrared temperatures in children. While comparing rectal and forehead infrared thermometry, Teran et al⁽¹⁰⁾ noted a mean difference of only 0.029°C and so found infrared thermometry reliable while Teller et al⁽¹¹⁾ reported wide limits of agreement (range of almost 3°C) and so concluded that it was not accurate enough for use in children. Fortuna et al⁽¹²⁾ and Allegaert et al⁽¹³⁾ in their studies in children, noted that compared with rectal thermometers, forehead infrared thermometers overestimated the temperature at lower body temperatures and underestimated the temperature at higher body temperatures.

Studies done in neonates also show conflicting results. De Curtis et al⁽¹⁴⁾ compared infrared thermometry with rectal thermometry in 107 newborns and found a mean difference of -0.052°C and 95% limits of agreement as $-0.682, 0.578$. They concluded that the difference between the two methods being modest and limits of agreement acceptable, infrared thermometry could be used in neonates. Among the studies comparing axillary and forehead infrared thermometry, Placidi et al⁽¹⁵⁾ recorded a mean difference of 0.35°C with 95% limits of agreement as $-0.45, 1.17$. Uslu et al⁽¹⁶⁾ noted a bias of -0.55°C and Can et al⁽¹⁷⁾ found the limits as being $-0.4, +1.54$. They all concluded that infrared non contact thermometers cannot be recommended for the measurement of body temperature in neonates in an intensive care setting where accurate temperature measurement is required. Sethi et al⁽¹⁸⁾ noted a mean difference of -0.5°C and limits of agreement as $-2.3, 1.2$ in their study comparing axillary and forehead infrared thermometry. Patel et al⁽¹⁹⁾ found a very high mean difference of -1.5°C and 95% limits of agreement as $-2.7, -0.3$ with infrared values higher than the axillary values in all the pairs of readings.

In our study, a high value of bias and wide limits of agreement were noted. The mean difference was -0.56°C which was greater than the set clinically acceptable limit. The limits of agreement encompassed a range of 2°C which, though narrower than the range of 3.5°C recorded by Sethi et al⁽¹⁸⁾ and 3°C recorded by Patel et al⁽¹⁹⁾, is still too wide to be acceptable for use in neonates in whom the normal body temperature range is narrow ($36.5^{\circ}\text{C} - 37.5^{\circ}\text{C}$). Inaccurate temperature measurement would lead to a wrong diagnosis of hypothermia and hyperthermia in neonates.

Oncel et al⁽²⁰⁾ reported that while infrared thermometers were not accurate enough to be recommended for use in hospitalized neonates, they could be used for determining body temperature of newborns at home by caretakers because they are safe, time efficient, non-invasive and easy to use.

In our study, the mean difference and limits of agreement of the readings in neonates with and without radiant warmer care were similar. A similar observation was also reported by Sethi et al⁽¹⁸⁾ in their study. However, Teller et al⁽¹¹⁾ found infrared forehead readings to be affected by external factors like radiant warmers.

There are some limitations in our study. Only one model for each type of thermometer was analyzed. Therefore our results cannot be generalized to other models. We did not evaluate the reproducibility of measurements recorded by each thermometer. However, the large number of readings in the study should have minimized the impact of measurement imprecision. Also, interoperator differences were not studied. Therefore, larger studies need to be conducted to compare the accuracy of non contact infrared thermometers with different temperature measuring devices and to study of the effect of various external factors on the temperature readings.

Conclusion :

Non-contact forehead infrared thermometry is a new method which is simple, rapid, non-invasive and hygienic compared to conventional methods of body temperature measurement. However, in our study, temperature readings by forehead infrared thermometry did not agree well with those by axillary digital thermometry in neonates. Therefore, forehead infrared thermometry cannot replace axillary thermometry and is not recommended for body temperature measurement in neonates.

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