Temperature Recording In Neonates by Non-Contact Thermometer Versus Routine Digital Thermometer - The Best Modality?

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Abstract of the Study

Introduction: Measurement of temperature in neonates should be accurate, reliable and reproducible, considering that they have a limited ability to regulate their own temperature. There is no ideal thermometer to measure temperature, however, there has been a constant endeavour to find more accurate and non-invasive means of measurement. The present study was conducted to find whether Non-Contact Infrared thermometers were as accurate as Digital Axillary thermometers in measuring temperatures in neonates.

Methodology: This was a comparative diagnostic study, carried out in the maternity unit of a tertiary care hospital over a period of 6 weeks. A total of 154 neonates were recruited in the study through consecutive sampling and their temperatures recorded using Non-Contact Infrared Thermometer (NCIT) on forehead and Digital Axillary Thermometer (DAT) on axilla simultaneously.

Results: The average temperature recording on forehead using NCIT and axilla using DAT, was in the range of 36 – 37^{o}C, with the NCIT showing a higher recording as compared to the DAT. The mean difference between the two modalities was –0.46^{o}C. A Bland-Altman plot analysis was done, in which majority of readings had wide variation, falling beyond the upper (0.57^{o}C) and lower (–1.49^{o}C) limits. A linear regression plot also showed a positive correlation between NCIT on forehead and DAT on axilla, with absolute R value = 0.2, which showed a weak correlation between the two.

Conclusion: It was concluded that NCIT measurements on forehead are not as accurate as DAT measurements on axilla. However, a larger study, is needed to extrapolate these findings to the general population.

Keywords: Temperature, Neonates, Non-Contact Infrared Thermometer (NCIT), Digital Axillary Thermometer (DAT)

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Introduction and Background

One of the significant components of the holistic care in hospitals for all neonates is Temperature management. Body temperatures above or below normal ranges may indicate some underlying diseases or clinical deterioration and it should be identified within a timely manner. Maintaining a normal body temperature assists in optimizing metabolic processes and bodily functions.[1]

The estimated rate of heat loss in a newborn is approximately 4 times that of an adult. The main reason for the elevated rate of heat loss is evaporation of amniotic fluid from the surface of the skin once the wet newborn moves from the consistently warm uterine environment to a cooler, drier labour room. Under the usual delivery room conditions (20–25°C), an infant's skin temperature falls approximately 0.3°C/min, and core body temperature decreases approximately 0.1°C /min during the period immediately after delivery; these rates generally result in a cumulative loss of 2–3°C in deep body temperature (corresponding to a heat loss of approximately 200 kcal/kg). The heat loss occurs by 4 mechanisms: convection of heat energy to the cooler surrounding air, conduction of heat to the colder materials touching the infant, heat radiation from the infant to other nearby cooler objects, and evaporation from skin and lungs. This heat loss leads to hypothermia, which has been defined by the WHO as body temperature below the normal range (36.5°C–37.5°C) and has been sub-classified into three grades: mild (36.0°C–36.5°C), moderate (32.0°C–35.9°C), and severe (<32.0°C) hypothermia.[2,3,4]

Hence, measurement of temperature in neonates should be accurate, reliable and reproducible, considering that they have a limited ability to regulate their own temperature. It should be simple and as non-invasive as possible.

The rectal method using digital thermometers is generally considered the "gold standard". Digital devices, which are placed in the axilla, remain a common option for use in neonatal units. The main disadvantage of these devices is the time it takes to obtain an accurate reading: up to three minutes, depending on the device.

Dante A et al evaluated the interchangeability of forehead, tympanic and axillary thermometers in 433 children. Comparing the measurements of each type of thermometer with the overall average of the three measurements recorded as the virtual gold standard, Bland Altman analysis highlighted that tympanic thermometer more closely resembled the reference temperature, indicating its preferential use in paediatric clinical practice.[12]

Smith J et al tried to establish if using a non-contact thermometer would be in agreement with the axilla method of temperature taking by undertaking a comparative design used to evaluate level of agreement between Infrared (IR) non-contact thermometer and digital thermometer (via axilla) in term and preterm infants admitted to the neonatal unit, where the limits of agreement of Infrared (IR) non-contact thermometer with Axilla measurements were found wider and therefore its use in the neonatal population was not recommended.[13]

However, a study conducted by Sugawara S et al concluded that the non-contact infrared thermometer using in the neonatal room of obstetrics was not only practical but also very useful. This method was hygienic, had a short measurement time and did not disturb the quality of daily life of the newborns.[11]

Sener S et al, on the contrary suggested that easy application may lead non-contact thermometry to be the preferable method for healthcare providers but large agreement limits with axillary thermometry should be considered to bring it into clinical practice.[14]

With so much ambiguity in the process of assessment of the vital sign, there is no ideal thermometer yet present in the clinicals for recording temperatures. Hence there has been a constant endeavour to find more accurate and non-invasive means of measurement.

The research question that arises here is, which method of recording temperature in neonates is better and effective: non-contact infrared thermometer recording on forehead or digital axillary temperature recording.

Primary Hypothesis

H_0: There is no difference in recordings of temperature between non-contact infrared thermometer on forehead and digital axillary thermometer.

H_1: There is significant difference in recordings of temperature between non-contact infrared thermometer on forehead and digital axillary thermometer.

The aim was to compare the efficacy of non-contact infrared thermometers in measuring neonatal temperature with respect to digital axillary thermometers.

Objectives

1. To record the temperature of neonates with non-contact infrared thermometer on forehead.
2. To record temperature of neonates with digital thermometer in the axilla.
3. To compare the temperature recorded on the forehead using infrared thermometer to axillary temperature using digital thermometer in neonates.

The advantages foreseen for this study are:

1. Non-invasive method will help in less handling of the babies.
2. Prevent interruption of sleep hence aiding to promotion of health
3. Less chances of infection
4. If the accuracy is found to be compatible, it can be used in labour room, NICU, PICU and pediatric settings.

Problem Statement

A study to compare the temperature recording on forehead by a non-contact infrared thermometer vs routine digital axillary temperature recording in neonates admitted to a tertiary care center in Western Maharashtra.

Ethical Consideration

This study was formulated taking utmost care to abide by the guiding ethical principle after being thoroughly scrutinized by the Institutions ethical committee (IEC/2021/378 dt 17 Apr 2021 Armed Forces Medical college, solapur road, Pune- 411040) and the hospital staff in direct contact with the target population in the long run.

Methodology

The approach adopted for the study was quantitative with a diagnostic comparative design.

The variables included

Independent variables: Non-contact infrared thermometer (NCIT) and Digital axillary thermometer (DAT).

Dependent variables: Temperature recording of neonates using NCIT or DAT

Research variables: Age (Hours of life), Gender, Weight at birth and Mode of delivery

The study was conducted in the maternity unit of a selected tertiary care hospital where the target population were term neonates fulfilling the inclusion and exclusion criteria. During the six weeks of data collection from 1st DEC 2021 to 15th JAN 2022, the available term neonates having no complications at birth and roomed in with mothers were considered as accessible population

Sample size

Determining the appropriate sample size for this study is essential component of the study protocol. An adequate sample size ensures that the study will yield reliable information. Sample size for the present study was calculated based on the pilot study conducted by the researcher during November 2021 on 30 neonates with the same inclusion and exclusion criteria.

Sample size is calculated for Bland Altman Plot

1. Type I error (alpha) = 0.01
2. Power (1- Beta) = 0.80
3. Expected mean difference between axillary and NCIT = 0.47°C
4. Expected Std deviation of difference between the two method = 0.34°C
5. Maximum allowed difference between the two methods = 1.3°C
6. Sample Size **153.6 neonates**

However, A total of 154 neonates were chosen by consecutive sampling by Medcalc Software, based on the pilot study conducted by the researcher during November 2021 on 10 neonat The inclusion criteria was all Healthy term newborns (>37 completed POG) and exclusion criteria were Neonates with any metabolic disorders or requiring NICU admission.

Material

The instruments used in the present study were chosen after an extensive market survey for basic safety and essential performance of clinical thermometers for body temperature measurement.

1. Non Contact Infrared Thermometer (NCIT): Omron MC720 Infrared thermometer, manufactured by Omron Healthcare Co Ltd, Japan. Digital Axillary Thermometer (DAT):
2. Omron MC-246 Digital thermometer, manufactured by Omron Healthcare Co Ltd, Japan.

Reliability and validity of both the instruments were ensured for the data collection

Method of measurement: Those who fulfill the inclusion criteria and willing to participate were taken up for the study after receiving a written informed consent from their parents.after preparing the basic information sheet, One reading of axillary temperature (via DAT) and three readings of forehead temperatures (via NCIT) were taken for each neonate. The axillary temperature, which is considered the clinical standard was then compared with the maximum forehead temperature recorded by the NCIT for the neonate, for the purpose of assessing the replicability.

Data Analysis Procedure and Disscussion

1. The data collected using the methodology is entered in an excel sheet and was imported to SPSS version 27 for the statistical analysis.
2. Frequency and percentage distribution was used for socio-demographic variables
3. Bland- Altman test was used for evaluating the replicability of NCIT with DAT.
4. Karl Pearson's correlation coefficient was used to determine the correlation between the DAT reading and the NCIT reading
5. P value of <0.01 was considered to be statistically significant

Table 1.1: Socio-demographic data of the neonates

Variables	Parameters	Total samples	
		f	%
Age (in completed hours of life)	< 24	39	25.3
	24–72	59	**38.3**
	>72	56	36.4
Sex	Male	98	**63.6**
	Female	56	36.4
	DSD	0	0
Weight (in grams)	<2500	27	27.5
	2500–3500	109	**70.8**
	>3500	18	11.7
Mode of Delivery	Normal Vaginal delivery	115	**74.4**
	Vacuum/ Forceps	0	0
	LSCS	39	25.6

The average age of neonates in the study was 24–72 hours, comprising 38% of the total samples. However, there were almost an equal number (36%) of neonates, who were more than 3 days old (Table 1.1).

Majority of the neonates were males, forming 64 % of the study population, whereas the rest 36% of the population were females. None of the neonates had ambiguous genitalia, belonging to the differences in sex development category (Table 1.1). 70.8% of the neonates had a birth weight between 2.5 to 3.5 kgs (Table 1.1). Compared to the study by Uslu S et al who had 51.4% neonates with birth weight more than 2.5 kg, this study had a greater number of neonates in the same category. This could be explained by the fact that our inclusion criteria had only term neonates, while Uslu et al included preterm neonates as well.[5]

Another variable which did not turn up on any of the search findings was that of mode of delivery.

Out of 154 neonates, 74.7% were born by spontaneous vaginal delivery, none requiring any instrumental support like vacuum or forceps, while 25.3% neonates were born via caesarean section (Table 1.1) While it was presumed that mode of delivery, especially instrumental deliveries might alter accurate forehead temperature measurements, the researcher could not find any study which had assessed this parameter.

Relationship of these research variables with the dependent variables was found to be statistically insignificant when tested with independent t test and ANOVA.

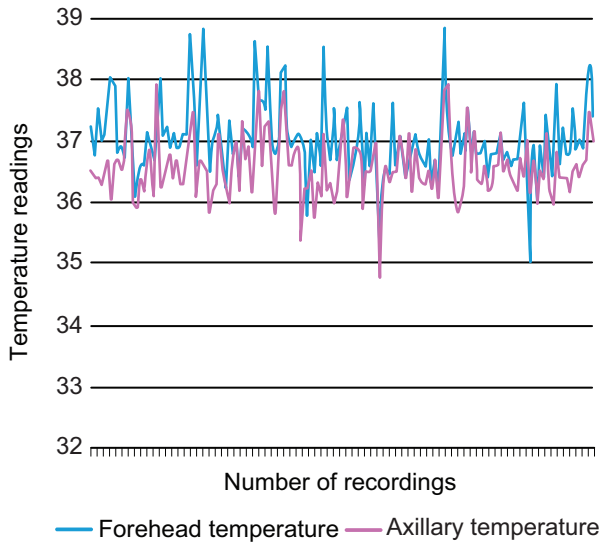

Figure 2.1. Comparison of Forehead Temperature using NCIT and Axillary Temperature using DAT

Graphically, it was seen that the forehead temperature using NCIT were approximately 1°C higher than the axillary temperature using DAT, and this difference was nearly constant (Fig 2.1).

In this study, it was found that the average range of NCIT readings was between 36–37°C, while that of DAT was in the range of 35–38°C. These readings were consistent and no clinical difference was observed between patients with different weights or gestational age. The mean difference between axillary and forehead temperatures was –0.46°C.

These findings were similar to the study done by Uslu S et al.[5] In a study conducted by Robertson-Smith J et al, the mid-forehead temperature recordings had a higher reading compared to digital axillary readings, with a clinically non-significant difference in the temperature readings between the two modalities.[6] This was in contrast to the findings of the present study

A one sample t-test was done to compare if the difference between NCIT and DAT readings was statistically significant. It was found that the t-value was more than the table value. Hence, although clinically non-significant, the difference between the two modalities was statistically significant (Table 1.2), verifying the rejection of null hypothesis at p value 0.000.

Table 1.2: One sample t test

						Test value= 0	
	t value	**df**	**Significance (2- tailed)**	**Mean difference**	**SD**	**95% CI of the difference**	
						Lower	**Upper**
Mean Difference	**6.513**	153	**0.000**	0.25130	0.4788	0.1751	0.3275

***'t' table value- 1.96 (df= 153)**

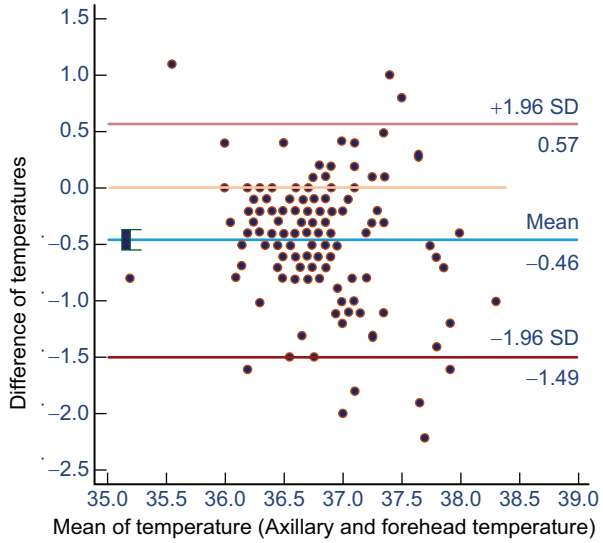

Figure 2.2. Bland Altman plot for agreement of forehead temperature recordings and axillary temperature recordings

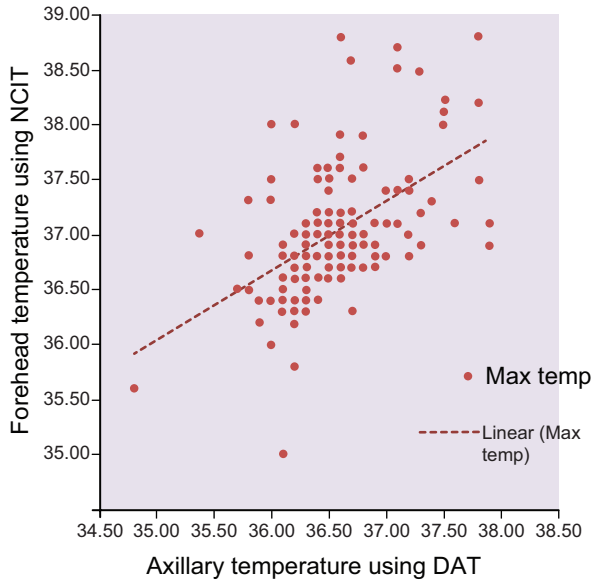

Figure 2.3. Linear Regression between Forehead temperature using NCIT and Axillary temperature using DAT

The Bland Altman graph was plotted to find a large number of observations to be outliers. As the observations showed a wide scatter, going beyond the limits of 0.57 and 1.49, it was suggestive of the fact that there is a significant difference between the measurements of the temperature by the two methods (Fig 2.2).

These findings were similar to the study conducted by Apa H et al, which mentioned that the NCIT was found as a useful tool for screening of fever, but had a higher degree of variation from axillary temperature.[7]

However, other studies by Uslu et al, Robertson-Smith et al, Thiagarajan S et al, in their study also conducted a Bland-Altman analysis to show a moderate agreement between NCIT and axillary temperatures by Bland-Altman analysis . Chiappini E et al also undertook both Bland-Altman analysis and receiver operating characteristic curve to determine the best threshold limits for both axillary and NCIT. Their results showed good sensitivity and specificity of NCIT.[5,6,8,9]

The present study also undertook a Pearson's correlation where the analysis showed a consistent linear correlation between DAT and NCIT measurements (Fig 4.3.1). A similar correlation was also found in a study by Sugawara S et al and Hayward G et al.[10,11]

Linear regression was also done in the study to predict the value of forehead temperature with the help of axillary temperature, after the correlation was established. A weak regression coefficient was found in the study (Fig 2.3).

Findings of the Study

The findings in the study suggests that NCITs may not be interchangeable with digital axillary thermometers for measuring temperature in neonates given the wide limits of agreement and poor replicability.

Implications of the Study

Nursing Practice

The NCIT cannot replicate the DAT (clinical standard). Hence routine monitoring of axillary temperature using DAT should be continued for ensuring quality care in neonatal population.

Nursing Administration

The nurse administrator's is responsible to restrict the replacement of DAT by NCIT and ensure standard practices in nursing neonates in maternity and neonatal wards, unless proven otherwise.

Nursing Education

Students can be educated about the various modalities of thermometry available, and to use the appropriate method depending on the clinical scenario faced.

Limitations of the Study

A non-randomised method of sample collection was applied in the study due to the short span of data collection, which may limit the generalizability of the findings to other populations and settings.

Furthermore, this study did not account for potential confounding variables, such as ambient temperature and humidity, which could impact the accuracy of NCIT

Recommendations from the Study

The researcher found that while the findings correlate with most of the other studies in saying that NCIT is not as accurate as DAT, a larger study with more subjects and a longer time duration for data collection is recommended to extrapolate and generalize the findings of the study.

The target population can be broadened to find the accuracy of thermometers on different age groups of children.

Modifying the research design to a mixed method, to identify other factors affecting temperature measurements can also be considered.

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