

CLINICAL EFFICIENCY OF NON-CONTACT INFRARED THERMOMETER OVER AXILLARY DIGITAL THERMOMETER AND MERCURY IN GLASS THERMOMETER WITH PARACETAMOL

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ABSTRACT

Fever is defined as rise in normal body temperature above 98.6°F. Clinical thermometer is a medical instrument for measuring human body temperature. The traditionally used mercury in glass thermometer was replaced by digital thermometer due to mercury toxicity. Non-contact infra-red thermometer is a non-invasive thermometer used for un-cooperative pediatric patients. The objective of this study is to determine the clinical efficiency of non-contact infrared thermometer over axillary digital thermometer and mercury in glass thermometer over a range of body temperature by using paracetamol in febrile patients. This descriptive hospital based cross sectional study was conducted from 5th December 2019 till 23rd August 2020 after ethical approval from Institutional Review Committee of Nepal Medical College and Teaching Hospital. Mercury in glass thermometer, axillary digital thermometer and non-contact infrared thermometer were used to measure body temperature in febrile patient. Body temperature was re-measured one hour after administration of paracetamol. Data was entered and analyzed with statistical package for social sciences version 16. Axillary digital thermometer has high predictability in the upper body temperature range (in febrile state) but its predictability is low in lower body temperature range (our normal body temperature). Non-contact infrared thermometer in comparison with axillary digital thermometer has lower predictability in both upper and lower body temperature range. Clinical efficiency of non-contact infrared thermometer is less than that of axillary digital thermometer and mercury in glass thermometer in febrile patients.

KEYWORDS

Digital thermometer; fever; mercury thermometer; non-contact infrared thermometer; paracetamol

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INTRODUCTION

Fever is when there is rise in normal body temperature¹ that is managed with paracetamol; a safe antipyretic medication that reduces fever by inhibiting cyclooxygenase enzyme in the cerebral cortex.² It is the easiest identifiable sign of illness and one of the most common reason for consultation in pediatric practice that is measured with a thermometer. The traditionally used mercury in glass thermometer (MIGT) is considered as the gold standard.³ MIGT has now been replaced by axillary digital thermometer and is considered to be accurate as MIGT.⁴ Even more trending nowadays is the non-contact infrared thermometer (NCIT) that are preferred for rapid and non-invasive technique with negligible cross infection risk.⁵ NCIT has proved to be a boon in medical sectors especially during the current scenario of covid-19 (screening of arriving traveler's for fever without causing harmful transmission among those tested). But how efficient is NCIT? There has been a surge in demand for NCIT but can it end the era of ADT? The objective of this study is to determine the clinical efficiency of NCIT over ADT and MIGT over a range of body temperature by using paracetamol in febrile patients.

MATERIALS AND METHODS

This was a hospital based cross-sectional study conducted in pediatric ward of Nepal medical college and teaching hospital (NMCTH), Kathmandu. Ethical approval was obtained from Institutional review committee of NMCTH, Kathmandu (Ref: 61-074/075). The study was conducted from 5th December 2019 till 23rd August 2020. Sample size was calculated taking reference to the study conducted by Berksoy *et al.*,⁶ as follows:

$$\text{Sample size (n)} = (Z_{\beta} + Z_{\alpha/2})^2 \times 2 \times \sigma^2 / d^2$$

$$\text{where } Z_{\beta} = 0.842; Z_{\alpha/2} = 1.96; \sigma^2 = 1.1^2 = 1.21; \\ d = 37.7 - 37 = 0.7.$$

The calculated sample size for the study was 39. However, we conducted the study in 70 subjects.

70 children above the age of five years with fever regardless of the diagnosis were enrolled in this study. However, children below five years of age were excluded due to the risk of breakage of MIGT. Other exclusion criteria included inability to access site for measuring temperature (bandage in forehead) and

unwilling patients. All three thermometers were calibrated before use. Mode of use, calibration, cleaning and disinfection (cotton swab with alcohol 70% concentration) were followed as recommended by manufacturer's manual. The study procedure was explained to the patient verbally providing all information and ample opportunity was giving to the subject to ask questions. The patient was provided with study information (body temperature) if requested. Informed consent was taken from each patient. The patient was asked to rest for 2 minutes before measuring the body temperature. MIGT was placed sublingually for 5 minutes to measure temperature.⁷ Similarly, ADT was placed under the arm pit to measure axillary temperature and NCIT was used over the temple area of the forehead (keeping a distance of less than 5 cm – following the instruction in the manual) to measure temperature of the forehead. The NCIT was not used in the direct sunlight and environmental temperature of 16-40°C was preferred. The test area to be scanned was clean, dry and not blocked. The NCIT was kept in proper position and a proper distance was maintained. The sensor area of the NCIT was also kept clean and dry. NCIT displays two types of temperature reading. In the default setting, NCIT convert the temple temperature to display its "oral equivalent" whereas in object mode it displays the temperature of the targeted site. The NCIT was kept in default setting. The three thermometers were kept in stationary position when temperature was being measured. Temperature was recorded by MIGT, ADT and NCIT. The data collected was entered and analyzed in statistical package for social sciences (SPSS) version 16. The reading of the MIGT was considered as the standard for comparison. The febrile patients were given paracetamol (15mg/kg orally) and temperature was remeasured after an hour to check the clinical efficiency of the thermometers at lower range of the body temperature. Rossmax HA500 NCIT, Rossmax TG100 ADT and Simca MIGT were used in this study.

RESULTS

The body temperature was recorded in 70 patients. The mean, standard deviation, minimum and maximum temperature recorded by MIGT, ADT and NCIT are shown in table 1.

Before administration of paracetamol, MIGT reading showed 100% (70 patients) of the patients were febrile, ADT showed 100% (70

Table 1: Summary of measured body temperature

Before administration of paracetamol					
Thermometer	Observations	Mean °F	Standard deviation	Min °F	Max °F
MIGT	70	100.51	1.10	98.90	104.80
ADT	70	100.76	1.07	99.00	103.60
NCIT	70	100.50	1.20	98.10	103.60
After administration of paracetamol					
Thermometer	Observations	Mean °F	Standard deviation	Min °F	Max °F
MIGT	70	98.67	0.76	96.3	100.4
ADT	70	98.97	0.84	99.00°F	101.2
NCIT	70	98.83	0.83	98.10	100.6

Table 2: Table showing Pearson correlation between temperature measured by MIGT, ADT and NCIT.

Before administration of paracetamol	N	Pearson correlation	p value
MIGT and ADT	70	0.853	<0.001
MIGT and NCIT	70	0.691	<0.001
After administration of paracetamol	N	Pearson correlation	p value
MIGT and ADT	70	0.762	<0.001
MIGT and NCIT	70	0.655	<0.001

patients) were febrile and NCIT showed 94.2% (66 patients) were febrile. Therefore, NCIT was not able to detect fever in all the patients. After administration of paracetamol, there was reduction in body temperature in all the patients as shown in table 1. MIGT readings demonstrated 55.7% (39 patients) of the patients were afebrile, ADT showed 42.8% (30 patients) were afebrile and NCIT showed 50% (35 patients) were afebrile. NCIT was able to detect afebrile state more accurately than ADT.

Statistical analysis of the temperature recording by MIGT, AGT and NCIT was done using Pearson correlation scatter plot which is shown in table 2. The Pearson correlation revealed that temperature recorded by ADT showed a strong positive correlation with MIGT in febrile state (before paracetamol consumption) and moderate positive correlation in afebrile state (one hour after paracetamol consumption). NCIT showed moderate positive correlation with MIGT in febrile and afebrile state.

Table 3: variation among ADT and NCIT with MIGT

Before administration of paracetamol	N	R2	p value
MIGT and ADT	70	0.728	<0.001
MIGT and NCIT	70	0.478	<0.001
After administration of paracetamol	N	R2	p value
MIGT and ADT	70	0.580	<0.001
MIGT and NCIT	70	0.429	<0.001

Regression line was plotted to illustrate how well the ADT and NCIT predicted MIGT. The model showed R² in table 3. In the fitted model, 72.8% and 58% of the variation was recorded by ADT in febrile and afebrile state respectively. Similarly, 47.8% and 42.9% of the variation was observed by NCIT in febrile and afebrile state respectively. ADT has high predictability in the upper body temperature range (in febrile state) but its predictability is less in lower body temperature range (our normal body temperature). In comparison to ADT, NCIT has lower predictability in both upper and lower body temperature range.

DISCUSSION

Body temperature is a very important tool in diagnosis of a disease. Correct temperature can determine the need for medication. Use of MIGT in oral and axillary site are convenient⁵ but rectal site is the most accurate.⁸ MIGT has become obsolete now due to risk of mercury toxicity. When mercury thermometer was being replaced by digital thermometer; various researches have pointed out the benefit of banning mercury. Mercury is toxic to the human body as well as the surroundings. Some research has also pointed out that the amount of mercury in thermometer (0.5-3 grams) is sufficient to contaminate a lake. Mercury from thermometer when released into air can remain in the atmosphere for a year. Due to this mercury were recategorized from biomedical waste to hazardous waste.⁷ On the contrary, digital thermometer were environment friendly. But digital thermometers were time consuming and risk of cross infection was high. Periasami V *et al*⁷ in his study concluded that the average time taken by ADT was 88 seconds which can be time consuming when examining large number of patients and problematic in uncooperative patients. On the other hand, NCIT promises to perform the task avoiding these drawbacks. NCIT has created its own scope from its use in industrial sector (measure temperature of moving parts), chemical labs (measure temperature of solid, liquid, gas and even chemical reactions), volcanology (to measure temperature of volcano), pediatric department (uncooperative patients) and at the time of epidemic of diseases causing fever (Ebola virus, SARS corona). They are easy to use, clean and disinfect; measure temperature and display reading rapidly and provide ability to retake a temperature quickly.⁶ But can NCIT work equivalent to ADT and MIGT? A study

conducted by Sollai S *et al*⁹ concluded good performance of NCIT.

In our study, before administration of paracetamol; we observed, MIGT and ADT readings showed 100% patient were febrile whereas NCIT showed 94.3% were febrile. NCIT was found to be less efficient in determining febrile body temperature in comparison to MIGT and ADT. Improper use of NCIT could be a reason for inaccurate temperature readings. Chen H *et al*¹⁰ concluded that NCIT may be used only for screening purpose as they cannot represent the actual body temperature. A study conducted by Berksoy A *et al*⁶ concluded that temperature recorded with NCIT and ADT were diverse and this variation in their readings could be due to use of ADT rather than MIGT. Therefore, in our study we included MIGT and observed that temperature measured by NCIT and MIGT were different.

Paracetamol is a non-steroidal anti-inflammatory drug with good anti-pyretic action. It is easily absorbed orally and highly efficacious. The onset of action is 30 minutes following oral administration.¹¹ Following one hour of paracetamol administration, we observed reduction in fever of all the patients; some were afebrile whereas some were still febrile. MIGT reading showed 55.7% of the patients were afebrile, ADT reading showed 42.8% were afebrile and NCIT reading showed 50% patient were afebrile. Both ADT and NCIT readings were in febrile range in afebrile patients. NCIT considered 5.7% of the afebrile patients to be febrile while ADT considered 12.9% of the afebrile patients to be febrile. In afebrile patient, the possibility of false positive reading by ADT was found to be more than NCIT. Therefore, NCIT was more efficient than ADT in determining body temperature in afebrile patients. We found similar studies in which ADT under-reads lower body temperature. Mukoro GD *et al*¹² concluded that ADT can be used in clinically febrile patients but not in afebrile healthy patients as ADT was less sensitive in lower body temperature.

Pearson correlation test between NCIT and MIGT demonstrated moderate association through a range of body temperature. Although the readings did not match, the variation between the readings was similar in febrile and afebrile state. However, this was not the case with ADT. We observed stronger association between ADT and MIGT readings during febrile state and only moderate association during afebrile state. This indicates less variation between the

reading of MIGT and ADT in febrile state more variation in afebrile state which explains why ADT under-read low body temperature.

We also observed that ADT predicted more of MIGT readings. The use of ADT in febrile state would mean 27.2% of the febrile children would be missed and the use of NCIT in febrile state would mean 52.2% of the febrile children would be missed. Therefore, ADT was more efficient than NCIT in determining body temperature in febrile patients. Due to this reason we recommend clinician to use ADT more often to measure fever and not rely on NCIT. Franconi I *et al*¹³ in his study concluded that ADT and NCIT should not be used interchangeably. Teller J *et al* in their study reported that NCIT should not be used in pediatric practice because they were inconsistent, extremely dependent on external variable. However, NCIT can be used under the following circumstance i.e. measure body temperature in afebrile patient or when

patient is not comfortable with ADT. However, there are other studies that conclude NCIT can measure body temperature accurately and reproducibly at various body site.¹⁴ But we recommend more studies and encourage on development of advanced thermometer in the days to come as fever remain one of the first symptoms of infections.

Although NCIT is an attractive tool for measuring body temperature in healthy patients our study suggests that clinical efficiency of NCIT is less than that of ADT and MIGT in febrile patients. Therefore, NCIT should not be used on regular basis or as an alternative to ADT.

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