

## Is the axilla the right site for temperature measurement in children by chemical thermometer?

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Although each method has its own advantages and disadvantages compared with the conservative mercury-in-glass thermometers, there are conflicting opinions about the optimal anatomic site for measuring body temperature as well about the variations in measurements with different methods. In this study, we aimed to assess the accuracy and reliability of measurements obtained from the axilla with the chemical thermometer (Tempa DOT™) compared with the classic mercury-in-glass instruments.

Sixty randomly selected pediatric patients who were admitted to our hospital were enrolled. Simultaneous temperature axillary measurements (n: 1300) were performed with the chemical thermometer and mercury-in-glass instruments.

The mean results of the axillary mercury-in-glass thermometers and axillary chemical thermometer were  $36.8 \pm 0.6$  and  $37.2 \pm 0.7$ , respectively. The Bland-Altman plot of differences suggests that 95% of the chemical thermometer (Tempa.DOT™) readings were within limits of agreement (+0.37 and -1.24°C) when mercury-in-glass thermometer is considered as the standard.

Our results showed that limits of agreement were wide (+0.37 and -1.24°C) between readings of axillary mercury-in-glass thermometers and chemical thermometers. Since approximately 20% of febrile patients with mercury-in-glass temperature were misdiagnosed as afebrile with measurements via chemical thermometer, we suggest that the axilla is not a suitable anatomic site for screening of fever with Tempa.DOT™. Further studies involving larger study groups with similar age should be done to more definitely assess its screening value in pediatrics.

**Key words:** body temperature measurement, axilla, mercury-in-glass, chemical thermometer.

Accurate body temperature monitoring in patients, especially in children, is vital and important. For all intents and purposes, though, elevation in body temperature was previously guessed at using the physician's hand until discovery of the first liquid-in-glass thermometer. For more than 200 years, the standard tool for the measurement of temperature has been the mercury-in-glass thermometer. In recent years, alternative methods including chemical and infrared tympanic thermometers began to replace conventional mercury-in-glass instruments

in emergency rooms and hospitals. Although each method has its own advantages and disadvantages compared with the conservative mercury-in-glass thermometers<sup>1</sup>, there is disagreement about the optimal anatomic site for measuring body temperature<sup>2-4</sup> as well as about the variations in measurements with different methods.

Although peripheral temperature measurements (skin or axilla) are not exact representatives of the core temperature, the axilla is the widely accepted site for daily temperature measurement. In our study, we aimed to

compare the accuracy and reliability of measurements obtained from the axilla using a chemical thermometer (Tempa.DOT™) with conventional temperature option mercury-in-glass instruments in children hospitalized for different etiologies.

### Material and Methods

Sixty-one randomly selected pediatric patients who were hospitalized in Hacettepe University Ihsan Doğramacı Children's Hospital between 1 December 2003 and 1 March 2004 were included in the study. These patients were randomly selected from the pediatric infectious disease ward. The patients with unstable conditions, including septic shock, or those with circulatory collapse were excluded from the study. An oral informed consent was obtained from the parents of the children. All the measurements were performed by the same nurse who was trained for each instrument.

Simultaneous temperature measurements were performed via the axilla with Tempa.DOT™ (3M Health Care; MN, USA) and conventional mercury-in-glass thermometer. For each method, 1,300 measurements were performed.

Axillary measurements were performed using both conventional mercury-in-glass thermometers and chemical thermometer Tempa.DOT™. To ensure accurate results with mercury-in-glass thermometer, 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 minutes for axillary readings. For chemical thermometer, Tempa.DOT™ plastic strip coated with heat-sensitive dots was held in the axilla for 3 minutes and read by the same nurse.

The data were expressed as percentages, mean and standard deviation (SD) for nominal data. Analyses of data were performed using repeated ANOVA, paired t-test, correlation and the Bland-Altman plot of difference to determine 95% limits of agreement. A significance of  $p < 0.01$  was accepted as statistically significant. Analysis was performed using SSPS 11.5 and Med Calc (MedCalc, version).

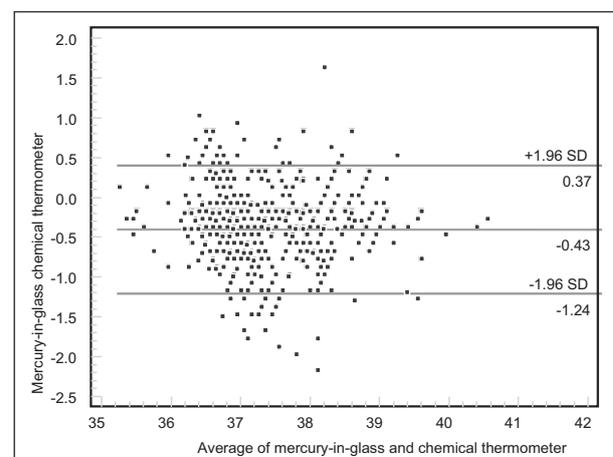
### Results

There were 31 girls and 30 boys, with ages ranging from 2 to 16 years (mean:  $7.4 \pm 3.6$ ). The study group was hospitalized due to a variety of diagnoses (Table I).

**Table I.** Underlying Disease Spectrum of the Study Group

| Disease                  | Number (rate) |
|--------------------------|---------------|
| Respiratory infections   | 24 (39.3%)    |
| Cellulites               | 12 (19.6%)    |
| Meningitis               | 9 (14.8%)     |
| Deep neck infections     | 5 (8.1%)      |
| Mumps                    | 3 (4.9%)      |
| Acute gastroenteritis    | 3 (4.9%)      |
| Neutropenic fever        | 3 (4.9%)      |
| Urinary tract infections | 2 (3%)        |
| Total                    | 61 (100%)     |

The mean results of the axillary mercury-in-glass thermometer and axillary chemical thermometer (Tempa.DOT™) were  $36.8 \pm 0.6$  and  $37.2 \pm 0.7$ , respectively. The Bland-Altman plot of differences suggests that 95% of the chemical thermometer (Tempa DOT™) readings were within limits of agreement ( $+0.37$  and  $-1.24$  °C) when mercury-in-glass thermometer is considered as the standard (Fig. 1).



**Fig. 1.** Bland-Altman plots of difference (95% limits of agreement), when measurement with mercury-in-glass is considered as the standard. A scatter of mean differences (mercury-in-glass and chemical thermometry, respectively) for each subject plotted against the average of two related temperatures measured by the two methods is shown. The upper (mean+1.96 SD) and lower (mean-1.96 SD) limits of agreement for two different comparisons were found to be (0.37 and -1.24) for mercury-in-glass and chemical thermometer.

If an axillary temperature above 38.3°C with mercury-in-glass temperature was considered as fever, there were 350 (39%) axillary measurements greater than 38.3°C. In our study group, 4.1% of the patients were

misdiagnosed as febrile and 19% of febrile patients were misdiagnosed as afebrile with chemical thermometer when compared to mercury-in-glass thermometer results from the axilla.

## Discussion

The measurement of a patient's temperature is probably the most common and important of all clinical investigations, especially in children. The method for measurement of fever should be accurate and reproducible since it has a great influence in decision making by parents or doctors. The measurement of temperature should be simple and non-invasive. Although axillary measurements with mercury-in-glass thermometers have advantages such as low cost, availability and wide usage in every clinic, they also carry some disadvantages. First, the clinician must wait at least 5 minutes for the measurement, and furthermore, control of cross-infection in hospitals could be an important problem. In addition, environmental mercury pollution due to accidental breakages has become an important issue<sup>5,6</sup>. Some investigators have also suggested that axillary measurements with mercury-in-glass thermometer or the digital thermometer may not reflect the body temperature accurately<sup>7</sup>.

Tempa.DOT™, as a chemical thermometer and a non-invasive method, enables reading via the axilla in 3 minutes and has promising practical usage and no risk of contamination, which was especially a problem with the mercury-in glass thermometers. Despite its advantages and some studies suggesting the accuracy of the chemical thermometer (Tempa.DOT™)<sup>8,9</sup>, some articles suggest that axillary measurements with Tempa.DOT™ are not as accurate as expected<sup>6</sup>. In our study, the overall difference between the axillary temperature measured with mercury-in-glass thermometer and Tempa.DOT™ was  $-0.43^{\circ}\text{C}$  (SD=0.4) and statistically significant. Our results showed that limits of agreement were wide ( $+0.37$  and  $-1.24^{\circ}\text{C}$ ) between readings of axillary mercury-in-glass thermometers and chemical thermometers (Tempa.DOT™).

In our group, 4.1% of the patients were misdiagnosed as febrile and 19% of febrile patients were misdiagnosed as afebrile when

measured with chemical thermometer when compared to mercury-in glass thermometers, meaning that approximately 20% of patients would not be accepted and treated as having fever. Although the sensitivity of detection of fever was reported to be higher (92%) when compared to mercury-in glass thermometers in Morley's study<sup>10</sup>, the sensitivity of Tempa.DOT™ in our study was 81%. Aside from our study, others have also revealed a wide spectrum of measurements with Tempa.DOT™. In our study, the mean difference was  $0.43^{\circ}\text{C}$ , while in another study this difference was  $0.29^{\circ}\text{C}$ <sup>11</sup>, and was statistically and clinically significantly important.

In conclusion, we would like to state that the axilla is not a suitable anatomic site for measurement of temperature with the chemical thermometer, especially in a child with low-grade fever. Our results should be supported with results of a larger study group of similar age, before claiming definitively that the chemical thermometer is not suitable for axillary measurements in pediatrics.

## REFERENCES

1. Pocock G, Richards CD. Human Physiology The Basis of Medicine. New York: Oxford University Press; 1999: 539-546.
2. Lorin M. Measurement of body temperature. *Semin Pediatr Infect Dis* 1993; 4: 4-8.
3. Fulbrook P. Core temperature measurements in adults: a literature review. *J Adv Nurs* 1993; 18: 1451-1460.
4. Dominguez EA, Musher DM. Clinical thermometry. In: Mackowiak PA (ed). *Fever: Basic Mechanisms and Management*. New York, NY: Raven Press; 1991: 71-81.
5. Benzinger M. Tympanic thermometry in surgery and anesthesia. *JAMA* 1969; 209: 1207-1211.
6. Zengya ST, Blumenthal I. Modern electronic and chemical thermometers used in the axilla are inaccurate. *Eur J Pediatr* 1996; 155: 1005-1008.
7. Holtz JB. Determining cold-stress in full-term newborns through temperature site comparisons. *Schl Inq Nursing Pract* 1991; 5: 113-123.
8. Rogers M. A viable alternative to the glass/mercury thermometer. *Ped Nursing* 1992; 4: 53-55.
9. Pontius SL, Kennedy A, Chung KL. Accuracy and reliability of temperature measurement in the emergency department by instrument and site in children. *Ped Nursing* 1994; 20: 58-63.
10. Morley C, Murray M, Whybrew K. The relative accuracy of mercury, Tempa-DOT and FeverScan thermometers. *Early Hum Dev* 1998; 53: 171-178.
11. Payne D, Johnson A, McKenzie A, et al. Chemical and glass thermometers for axillary temperatures: how do they compare? *Arch Dis Child* 1994; 71: 259-260.