

## A comparison of axillary and tympanic membrane to rectal temperatures in children

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### Abstract

**Background** Core body temperature measurement is not commonly done in pediatric populations because it is invasive and difficult to perform. Therefore, axillary and tympanic membrane temperature measurements are preferable, but their accuracy is still debatable.

**Objective** To compare the accuracy of axillary and tympanic temperatures to rectal temperature in children with fever, and to measure the cut-off point for fever based on each temperature measurement method.

**Methods** A diagnostic study was conducted among feverish children aged 6 months to 5 years who were consecutively selected from the Pediatric Outpatient Clinic, Pediatric Emergency Unit, and the inpatient ward in the Department of Child Health, Cipto Mangunkusumo Hospital (CMH), from December 2014 to January 2015. Subjects underwent three measurements within a two minute span, namely, the axillary, tympanic membrane, and rectal temperature measurements. The values obtained from the examination were analyzed with appropriate statistical tests.

**Results** The cut-off for fever on axilla was 37.4°C and on tympanic membrane was 37.4°C, with sensitivity 96% (95%CI 0.88 to 0.98) and 93% (95%CI 0.84 to 0.97), respectively; specificity 50% (95%CI 0.47 to 0.84) and 50% (95%CI 0.31 to 0.69), respectively; positive predictive value/PPV 90% (95%CI 0.81 to 0.95) and 85% (95%CI 0.75 to 0.91), respectively; and negative predictive value/NPV 83% (95%CI 0.61 to 0.94) and 69% (95%CI 0.44 to 0.86), respectively. The optimal cut-off of tympanic membrane and axilla temperature was 37.8°C (AUC 0.903 and 0.903, respectively).

**Conclusion** Axillary temperature measurement is as good as tympanic membrane temperature measurement and can be used in daily clinical practice or at home. By increasing the optimum fever cut-off point for axillary and tympanic membrane temperature to 37.8°C, we find sensitivity 81% and 88%, specificity 86% and 73%, PPV 95% and 91%, and NPV 95% and 91%, respectively. [Paediatr Indones. 2017;57:47-51. doi: 10.14238/pi 57.1.2017.47-51].

**Keywords:** children; axillary temperature; tympanic temperature; rectal temperature; fever

Fever is defined as a rectal temperature  $\geq 38^\circ\text{C}$ , axillary temperature  $\geq 37.4^\circ\text{C}$ , and tympanic membrane temperature  $\geq 37.6^\circ\text{C}$ .<sup>1,2</sup> Previous studies reported that axillary temperature is 0.72 to 0.85°C lower than rectal temperature, and 0.55°C lower than tympanic membrane temperature; in addition, tympanic membrane temperature is 0.17 – 0.49°C lower than rectal temperature.<sup>3,4</sup> Another study reported 0.2 – 0.6°C differences between axillary and tympanic membrane temperatures.<sup>5</sup>

Currently, there are no data nor studies comparing the accuracy of tympanic membrane and axillary temperature to rectal temperature as the gold standard of core body temperature in children and adults. Therefore, we aimed to determine the accuracy of axillary and tympanic membrane temperatures compared to rectal temperature, in feverish children aged 6 months to 5 years who visited the Pediatric Outpatient Clinic, Pediatric Emergency Department,

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and the inpatient Pediatrics Ward at Dr. Cipto Mangunkusumo Hospital, Jakarta.

## Methods

This diagnostic study was performed to determine the accuracy of axillary and tympanic membrane temperature results compared to rectal temperature in feverish children aged 6 months to 5 years, who visited the Pediatrics Outpatient Clinic, Pediatrics Emergency Unit, and the inpatient Pediatrics Ward in the Department of Child Health, Dr. Cipto Mangunkusumo Hospital, from December 2014 to January 2015. The temperature of the tympanic membrane was measured using infrared thermometers (OMRON Gentle Temp 510), while the axillary and rectal temperatures were measured with digital thermometers (OMRON MC 246). The temperature measurement was done by trained doctors. The minimum required sample size was 90 subjects, who were consecutively selected. This study was approved by the Research Ethics Committee of the University of Indonesia Medical School, and subjects' parents provided informed consent.

Room temperature was measured with a GEA thermometer 10 minutes before the patient's body temperature measurement, and insulation was put around the subject's bed. Thermometers were calibrated and cleaned beforehand. Disposable probe covers for the infrared thermometer were used for each patient. Before taking measurements, the six steps of hand washing were performed followed by wearing clean latex gloves. Subjects underwent

three measurements within a two minute span, namely, the axillary, tympanic membrane, and rectal temperature measurements. The values obtained from the examination were analyzed with appropriate statistical tests.

## Results

During the study period, of 280 patients who came to the Pediatric Outpatient Clinic with complaints of fever, 78 were aged over 5 years, 91 were in a state of neutropenia or thrombocytopenia, 18 experienced emergency situations (shock, tachypnoea, or tightness), and 3 had anorectal anatomical abnormalities or were surgical. Hence, a total of 90 infants and children were enrolled. Subjects underwent axillary, tympanic membrane, and rectal body temperature measurements and consisted of 42% males and 58% females. They comprised the following age ranges: 6 months - 1 year (19%), >1 year - 3 years (38%), and >3 years - 5 years (43%). Initial fever detection was done by measuring body temperature using a thermometer (67%) and palpation (29%), prior to the study. Types of thermometer used by parents were digital (62%) and mercury (6%). Treatments given to manage fever were antipyretics (42%), warm water compresses (6%), and nothing (2%). Antipyretics used was paracetamol (100%) syrup (87%). Ninety-six percent of parents were aware of the dangers due to fever.

Diagnostic results comparing axillary (37.4°C) and rectal temperature measurements had a sensitivity of 96% (95%CI 0.88 to 0.98), specificity of 50%

**Table 4.** Summary of diagnostic results of axillary and tympanic membrane temperatures at various cut-off points compared to rectal temperatures

Diagnostic results	Cut off temperature				
	37.4 °C	37.5 °C	37.6 °C	37.7 °C	37.8 °C
<b>Axillary temperature</b>					
Sensitivity, %	96	93	90	88	81
Specificity, %	50	68	73	77	86
PPV, %	90	90	91	92	95
NPV, %	83	75	70	68	60
<b>Tympanic membrane temperature</b>					
Sensitivity, %	95	94	93	91	88
Specificity, %	36	50	50	60	73
PPV, %	84	85	85	87	91
NPV, %	56	73	69	68	66

(95%CI 0.47 to 0.84), PPV of 90% (95%CI from 0.81 to 0.95), NPV of 83% (95%CI 0.61 to 0.94), positive likelihood ratio (PLR) 3 (95%CI 1.52 to 5.92), and negative likelihood ratio (NLR) 0.06 (95%CI 0.02 to 0.2). Diagnostic results of tympanic membrane temperature (37.6°C) compared to rectal measurements were sensitivity of 93% (95%CI 0.84 to 0.97), specificity of 50% (95%CI 0.31 to 0.69), PPV of 85% (95%CI 0.75-0.91), NPV of 69% (95%CI 0.44 to 0.86), PLR 1.85 (95%CI 1.13 to 3.04), and NLR 0.15 (95%CI 0.06 to 0.38) (Table 1).

The ROC curve of axillary and tympanic membrane temperature showed good AUC value of 0.903 for axillary temperature and 0.885 for tympanic membrane temperature.

## Discussion

In this study, subjects' fever was first detected by parents' temperature measurement with thermometers (67%) or by palpation (29%). Of the 67% of parents who had thermometers at home, 92% had digital, 8% had mercury, and none had infrared thermometers at home. In developing countries, including Indonesia, not all families have thermometers, so fever assessment may be reliant on the perception of mother/caregiver by palpation. Thermometer prices play a role in the availability of thermometers at home. Infrared thermometer prices range from Rp 400,000 to Rp 1,500,000 with the probe cover price of Rp 350,000 / 20 probe covers. Hence, infrared thermometers are about 8-15 times the price of digital thermometers, and 40-150 times the price of mercury thermometer. Studies have found that although the temperature assessment by palpation is good enough to detect fever (sensitivity 89.2 to 96.3% and specificity 23 to 64.3%), the assessment is influenced by subjectivity, technique, and environmental factors.<sup>8-11</sup> Banco *et al.* reported that detection of fever by mothers without using a thermometer had a sensitivity of 73.9% and a specificity of 85.6%.<sup>12</sup>

As many as 90% of children aged  $\leq 2$  years with temperature  $\geq 38.9^\circ\text{C}$  were diagnosed as having fever, and 52.3% of children who complained of suffering from a fever were actually proven to have fever when the temperature measurement was taken with thermometer. A previous study found that 82%

of 264 caregivers of children taken to the ER were very worried by the presence of fever, with one-third of the caregivers deciding that the child needed to be treated even if the measured temperature was less than  $37.9^\circ\text{C}$ .<sup>13-16</sup> In our study, 96% of parents were aware of the dangers of fever and gave antipyretic drugs if the body temperature was  $>37.5^\circ\text{C}$  (90%). Also, one-third (31%) of parents gave antipyretic drugs a few hours before the child was brought for treatment (mean 3.7 hours). The prevailing parental perception was that the child's body temperature should be within the normal range ( $36.5 - 37.5^\circ\text{C}$ ). Many parents and caregivers had a phobia of fever, although fever is actually the body's physiological mechanism against infection. Thus, counseling and education for parents are needed to explain that the primary purpose of fever management was not only to lower the body temperature to normal limits, but also make the child more comfortable and ensure adequate intake of fluids and nutrients. Parents also need to be educated on the proper storage of antipyretic drugs.

The accuracy of axillary and tympanic membrane temperature measurement results remain inconclusive. In our study, mean axillary temperature was  $0.5^\circ\text{C}$  lower than mean rectal temperature and  $0.3^\circ\text{C}$  lower than mean tympanic membrane temperature. Mean tympanic membrane temperature was  $0.2^\circ\text{C}$  lower than the mean rectal temperature. Similarly, previous studies reported that axillary temperature was  $0.25 - 1^\circ\text{C}$  lower than rectal; axillary temperature was  $0.18 - 0.55^\circ\text{C}$  lower than tympanic membrane temperature; and the tympanic membrane temperature was  $0.17 - 0.49^\circ\text{C}$  lower than rectal temperature.<sup>2-4,17-23</sup>

A systematic review by Craig *et al.* reported a  $0.25^\circ\text{C}$  difference between axillary temperature - measured with a rectal mercury thermometer and  $0.85^\circ\text{C}$  with digital thermometer. Mean differences of axillary-rectal temperatures were  $0.17^\circ\text{C}$  for neonates and  $0.92^\circ\text{C}$  for children and adolescents.<sup>24</sup> Variations in temperature can be caused by different types and brands of thermometers, malposition of the digital thermometer tip at the time of measurement, and improper ear tug technique.

Diagnostic values obtained with the fever cut-off of  $37.4^\circ\text{C}$  (axilla) and  $37.6^\circ\text{C}$  (tympanic membrane) were: sensitivity of 96% (95%CI 0.88 to 0.98) and 93% (95%CI 0.84 to 0.97), specificity of 50% (95%CI 0.47 to 0.84) and 50% (95%CI 0.31 to 0.69), PPV of

90% (95%CI 0.81 to 0.95) and 85% (95%CI 0.75 to 0.91), and NPV of 83% (95%CI 0.61 to 0.94) and 69% (95%CI 0.44 to 0.86). In our study, if the fever cut-off of axillary and tympanic membrane temperature was raised to 37.8°C or 37.7°C (Table 1) diagnostic values obtained were: sensitivity of 81% (95% CI 0.7-0.8) and 88% (95%CI 0.78 to 0.94), specificity of 86% (95%CI 0.67 to 0.95) and 73% (95%CI 0.52 to 0.87), PPV of 95% (95%CI 0.86 to 0.98) and 91% (0.82 to 0.96), and NPV of 60% (95%CI 0.42 to 0.74) and 67% (95%CI 0.47 to 0.82).

A previous study reported that the results of axillary temperature measurements were as good as tympanic membrane temperature results, with a sensitivity 94% and 70%, respectively, and specificity of 92% and 94%, respectively.<sup>25</sup> Other studies reported that the temperature of the tympanic membrane had a 67-76% sensitivity for detecting fever in children aged 6 months - 6 years and there was no significant difference between the results of temperature measurements between the right and left ear (0.019 – 0.2 °C).<sup>3,28-30</sup>

To minimize measurement errors, axillary skin must be dry. The precision of axillary temperature measurement for detecting fever is affected by peripheral vasoconstriction at the initial onset of fever, sweating, and evaporation resulting in lower skin temperature compared to the actual body temperature. Tympanic membrane temperature accuracy is affected by the technique of ear tugging and probe position so the infrared thermometer probe needs to be appropriately-sized for the the diameter of the ear canal. Differences in brand, variation, and type of thermometer used contributed to the variations in measurement results generated from this study compared to previous studies, therefore, to avoid bias, temperature measurements in this study were conducted by a research assistant (physician) who had previously been trained and undergone validation tests. In addition, the thermometer battery was replaced every day and disposable probe covers were replaced for each subject.

In conclusion, the optimum cut-off point for diagnosing the presence of fever measured by axillary and tympanic membrane temperatures was 37.8°C, with fair sensitivity, specificity, and PPV (axillary: 81%, 86%, and 95%, respectively, and tympanic membrane of 88%, 73%, and 91%, respectively).

Axillary temperature measurements were equally comparable to that of the tympanic membrane for detecting fever and can be used in everyday clinical practice or at home.

We suggest that clinicians use a fever cut-off point of  $\geq 37.8^{\circ}\text{C}$  for clinicians and  $\geq 37.5^{\circ}\text{C}$  for parents. Pediatricians should be able to explain the definition of fever and the appropriate time to give antipyretic drugs to parents.

## Conflict of Interest

None declared.

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