Temporal Artery Thermometry in Children Younger Than 5 Years
A Comparison With Rectal Thermometry

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Background: Temporal artery (TA) thermometry has come as one of the new methods for temperature measurement, especially in children in whom accurate temperature monitoring can save lives. The device which is convenient and simple to use is yet to gain popularity in several parts of the world, as there are conflicting reports of its accuracy. This study compares the accuracy of the TA thermometry in children younger than 5 years using the rectal thermometry as the gold standard.

Methods: Temperature was measured simultaneously in eligible children younger than 5 years from the forehead and rectum using the TA thermometer (TAT-2000C Exergen, USA) and standard mercury in glass rectal thermometer, respectively. The difference between the mean temperatures obtained by the 2 thermometry methods was tested using the paired t test. Pearson correlation coefficient, linear regression, and Bland-Altman plot were also used to test the relationship and agreement between the 2 instruments. The sensitivity, specificity, and positive and negative predictive values were also calculated.

Results: Overall, the mean TA temperature (37.80°C ± 1.07°C) was significantly lower than the mean rectal temperature (38.07°C ± 0.95°C), P < 0.001. In neonates, however, the mean difference was not significant, 0.02 ± 0.59 (P = 0.810). There was a significant positive correlation between the rectal and the temporal temperatures (r = 0.80, P < 0.01). The Bland-Altman plot showed wide variation in the limit of agreement between the rectal and the TA temperatures which ranged from −1.02°C to +1.56°C. The sensitivity of the TA thermometer was 64.6% and 83.5%, respectively, at a TA fever cutoff of 38.0°C and 37.7°C.

Conclusions: Temporal artery thermometry is not accurate enough for the measurement of core body temperature in children younger than 5 years. However, it may be used as a tool for screening for fever in very busy clinics and emergency room at a fever cutoff of 37.7°C.

Key Words: thermometer, thermometry, temporal artery, rectal

Monitoring of temperature in children is one of the important procedures in pediatric practice as many disease conditions in children younger than 5 years present with fever. The temporal artery (TA) thermometer has come as one of such devices. It is a simple, noninvasive device that uses infrared technology to detect the heat emitted from the skin surface, then through an arterial heat balance system it adjusts for the effects of the skin temperature and thus provides a TA temperature (TAT).

The mercury in glass thermometer, which is still widely used in the country, although cheap and simple to use is fraught with several drawbacks. These include its slowness to reading which makes it unsuitable for a busy clinic or emergency room and also the risk of mercury poisoning on breakage or perforation when used in the rectum. Other newer device like the tympanic thermometer, although simple, safe, and convenient is faced with reports of inaccuracy. In clinical setting, rectal thermometry has been considered the gold standard, but many mothers resent the idea of inserting a thermometer into the children's rectum.

This study compares the accuracy of the TA thermometry in children younger than 5 years using the rectal thermometry as the gold standard.

METHODS

This was a cross-sectional study conducted at the Department of Paediatrics, Federal Medical Centre, Owerri, Nigeria, during a 6-month period; from July to December 2012. Approval was obtained from the hospital research and ethics committee before commencement. Children younger than 5 years presenting to the emergency pediatric and special care baby units of the hospital were enrolled into the study. The children were recruited based on the convenience of the lead author, who did all the temperature measurements. There was no categorization based on presence or absence of fever. Informed consent was obtained from each caregiver before enrolment. Children who were judged to be critically ill or whose mothers declined consent were excluded from the study.

Eligible children had their temperature measured simultaneously from the forehead and rectum using the TA thermometer (TAT-2000C Exergen, USA) and standard mercury in glass rectal thermometer (which is still widely used in Nigeria), respectively. The rectal thermometer was first lubricated and inserted into the rectum to a depth of 3 cm and left for 3 minutes. The TAT was measured just before removing the rectal thermometer. The TA thermometer probe was placed at the center of the forehead while pressing and holding the scan button and then gently slid toward the right to the hairline while keeping the sensor flat and in contact with the skin for the entire duration. The scan button was released once the probe got to the hairline and the display temperature read. This process took about 3 seconds and was in conformity with the manufacturer’s guide. Any perspiration present on the forehead was wiped before the procedure.

The data obtained were analyzed using the statistical package for social sciences (SPSS) version 20. The difference between the
mean temperatures obtained by the 2 thermometry methods was tested using the paired t test. A P value less than 0.05 was considered significant. The relationship between rectal temperature (RT) and TAT was tested using the Pearson correlation and simple linear regression at 99% and 95% confidence intervals, respectively. An equation to predict TAT from RT was also derived. The agreement between the 2 temperatures was assessed using the Bland-Altman plot. The sensitivity, specificity, and positive and negative predictive values were calculated using RT cutoff value of 38.0°C or higher as the definition of fever.

RESULTS

The temperatures of a total of 156 children younger than 5 years were measured during the 6 months the study was conducted. These comprised 81 males and 75 females giving a male/female ratio of 1.1:1. The children ranged from 1 day to 59 months, with a mean age of 10.8 ± 13.6 months.

The RTs ranged from 35.7°C to 40.5°C, whereas the TATs ranged from 36.0°C to 41.8°C. There were 79 (50.6%) febrile and 77 (49.4%) afebrile children. Although 6 (3.8%) of the children had subnormal temperatures (<36.5°C), no child had temperature in the range of hypothermia (<35.0°C). The mean TAT (37.8°C ± 1.1°C) was significantly lower than the mean RT (38.1°C ± 0.9°C), P < 0.001. However, when the children were stratified into age groups; there was no significant difference between the mean RTs and TATs in the neonatal group. Table 1 shows the mean temperatures and the mean temperature differences in the different age groups. Post hoc power calculation indicated that our study had a power of 0.87 for detecting a statistically significant difference between the 2 thermometry methods.

There was a significant positive correlation between the rectal and the temporal temperatures (r = 0.80, P < 0.01) (Fig. 1).

Linear regression analysis yielded the following equation to predict TATs from RTs:

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TAT (°C) = 0.903 \times RT(°C) + 3.443.
\]

Applying the formula, an RT of 38.0°C which was used to define fever corresponded to a TAT of 37.7°C.

The Bland-Altman plot showed most of the points lying within the 95% confidence interval (±2SD), with only approximately 5.8% outlying points. However, there was a wide variation in the limit of agreement between the RTs and the TATs which ranged from -1.02°C to +1.56°C (Fig. 2).

The sensitivity, specificity, and positive and negative predictive values of the TA thermometer are shown in Table 2. Adjusting the TAT cutoff of fever as 37.7°C for RT equivalent of 38°C (as predicted by the regression equation), the sensitivity increased to 83.5%, whereas specificity dropped to 88.3% (Table 2).

DISCUSSION

Monitoring of temperature in children has been a very dynamic process with different devices and sites evolving to replace the available ones. By implication, the ideal instrument and site is yet to be found. Since the introduction of the TA thermometry, several studies, mostly from the developed countries, have tried to evaluate its accuracy in different groups of children with conflicting results. Although, one study tried to compare the device among children of different ethnicity without finding any significant difference, there was no comparison to a standard temperature measuring device and there was great disparity in the number of the children from the different ethnic groups.

### TABLE 1. Comparison of Mean Rectal and Temporal Temperatures by Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>n</th>
<th>Mean RT (°C)</th>
<th>Mean TAT (°C)</th>
<th>Mean Temperature Difference (°C)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤28 d</td>
<td>50</td>
<td>37.36 ± 0.69</td>
<td>37.34 ± 0.83</td>
<td>0.02 ± 0.59</td>
<td>-0.24</td>
<td>0.810</td>
</tr>
<tr>
<td>29 d–11 mo</td>
<td>58</td>
<td>38.36 ± 0.86</td>
<td>37.95 ± 0.97</td>
<td>0.42 ± 0.66</td>
<td>-4.80</td>
<td>0.000</td>
</tr>
<tr>
<td>12–59 mo</td>
<td>48</td>
<td>38.46 ± 0.88</td>
<td>38.12 ± 1.24</td>
<td>0.34 ± 0.62</td>
<td>-3.74</td>
<td>0.001</td>
</tr>
<tr>
<td>Total</td>
<td>156</td>
<td>38.07 ± 0.95</td>
<td>37.80 ± 1.07</td>
<td>0.26 ± 0.65</td>
<td>-5.13</td>
<td>0.000</td>
</tr>
</tbody>
</table>

FIGURE 1. Scatter diagram showing the relationship between rectal and TA thermometry.
In this study, which to best of our knowledge is the first from Nigeria, there was a strong correlation between TATs and the RTs. Like in our study, other studies also demonstrated significant correlation between RTs and TATs. This, however, only demonstrated a good linear relationship between the 2 temperatures such that as RT increased, the TAT also increased. Bland and Altman had proposed “agreement” as a better method of comparing 2 different measuring instruments. In this study, there was a wide variation in the limit of agreement between the RTs and TATs. This is similar to the findings by several authors who also obtained variations that ranged from higher than −1°C to higher than +1°C. It, however, differed from the findings by Batra and Goyal whose limit of agreement in their study ranged from −0.24 to +0.26. Al-Mukhaizeem et al also recorded good agreement between TAT and esophageal and also between RTs and esophageal temperatures.

The wide variation in limit of agreement was also reinforced by a statistically significant difference between the 2 thermometry methods. However, when the children were stratified into age groups, TATs were similar to RTs in the neonatal age group. This may be an indication that the TA thermometry can sufficiently replace rectal thermometry in this age group. The finding, however, contrasts with the observation of Lee et al, who documented a significant difference between TA and RT in neonates.

The poor sensitivity of the TA thermometer may be another reason that will discourage its use. With fever as RT of 38.0°C or higher, more than 35% of children with fever will be missed. This is unacceptable because missed fever may have severe consequences for this group of children. Greenes and Fleisher also obtained similar poor sensitivity in their study of infants using the same fever cutoff of 38.0°C or higher. A TAT equivalent of 37.7°C for an RT of 38.0°C as obtained from the linear regression equation should actually be regarded as the more appropriate cutoff for fever when using the TA thermometer. If the TAT cutoff for fever is assumed to be 37.7°C, the sensitivity may just be acceptable as a screening tool for fever.

In conclusion, the TA thermometer is not accurate enough for the measurement of core body temperature in children younger than 5 years. However, it may serve as a tool for screening for fever in very busy clinics and emergency rooms but the fever cutoff has to be at 37.7°C for rectal fever cutoff of 38.0°C to achieve a better result.

REFERENCES


FIGURE 2. The Bland-Altman plot showing the agreement between RTs and TATs. The continuous line indicates the mean, whereas the broken lines indicate the 95% limit of agreement.

TABLE 2. Comparison of the Sensitivity, Specificity, Positive Predictive Value, and Negative Predictive Value at the Various Temperature Cutoff Points

<table>
<thead>
<tr>
<th>Temperature Cutoffs</th>
<th>Parameter</th>
<th>RT 38.0°C, TAT 38.0°C</th>
<th>RT 38.0°C, TAT 37.7°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity, %</td>
<td>64.6</td>
<td>83.5</td>
<td></td>
</tr>
<tr>
<td>Specificity, %</td>
<td>94.8</td>
<td>88.3</td>
<td></td>
</tr>
<tr>
<td>PPV, %</td>
<td>92.7</td>
<td>88.0</td>
<td></td>
</tr>
<tr>
<td>NPV, %</td>
<td>72.3</td>
<td>84.0</td>
<td></td>
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NPV indicates negative predictive value; PPV, positive predictive value.