Accuracy and Precision of Digital Thermometer in Neonatal Temperature Measurement

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ABSTRACT: Objective: The purpose of this study was to determine the accuracy and precision of digital thermometer for axillary and rectal thermometry in neonates. Study Design: A prospective study was conducted. One hundred infants, 0 to 28 days old, weighing 860 to 3750 gm with a gestational age of 26 to 43 weeks were measured by a gold standard mercury-in-glass thermometer and then a digital thermometer for axillary and rectal temperatures, respectively. The accuracy was analyzed by the accepted difference between mercury-in-glass versus digital thermometer of 0.1°C and 0.2°C. Results: For rectal thermometry, accuracy of ±0.1°C and ±0.2°C was 68% (95%CI=58.3%, 76.3%) and 87% (95%CI=79%, 92.2%), respectively. For axillary thermometry, accuracy was 64% (95%CI=54.2%, 72.7%) and 78% (95%CI=68.9%, 85%) for ±0.1°C and ±0.2°C, respectively. The precision of the digital thermometer was 86% (95%CI=77.9%, 91.5%) and 75% (95%CI=65.7%, 82.5%) for rectal and axillary digital thermometry, respectively. Conclusions: The digital thermometer could be used instead of the mercury-in-glass thermometer in relatively healthy neonates who could accept a wider range of temperature fluctuation within ±0.2°C. But for sick or critical neonates, the mercury-in-glass thermometer is still the recommended thermometer.

Key words: neonates, temperature measurement, digital thermometer

Temperature measurement is one of the fundamental monitoring parameters in general pediatric practice, especially for neonates. Both extrinsic factors, such as environmental temperature or clothing, and intrinsic factors such as infection or metabolic disturbances can cause temperature instability in newborn infants. Furthermore, neonates as a group are much more susceptible to developing abnormal temperature which can be manifested by various signs or symptoms. Therefore, temperature regulation reflects very basic neonatal well-being and its accurate assessment is one of the most important tasks of newborn care.

Measurement of temperature in neonates can be obtained either through the rectal or axillary route. The gold-standard of such methods is the mercury-in-glass thermometer. However, according to a review done by Craig (2000), as well as the study of Jirapet (2000), such a device must be held in place for a relatively long time in order to achieve accurate temperature measurement. During such periods, the method necessitates that each neonate is subjected to cold exposure. Moreover, mercury contamination is a true concern should the glass thermometer break, as well as intestinal perforation from glass splinter injuries. In the past decade, various techniques have been proposed as an alternative to the mercury-in-glass thermometer, such as electronic digital thermometry and infrared tympanic thermometry. The infrared tympanic membrane thermometry has been deemed limited in accuracy and reliability in the neonatal population due to the specific ear canal anatomy. Most electronic digital thermometers require that the temperature measuring sensor reads the temperature at the equilibrium point, thus achieving accurate temperature reading in a shortened amount of time when compared to the conventional glass thermometer. Electronic digital thermometry is available in oral (sublingual), axillary and rectal routes but, according to difficulties in placement, the oral route is impractical for use in neonates.

Although rectal and axillary measurements are widely accepted routes of temperature measurement in neonates, determination of accuracy of the digital thermometer specific for newborn infants is limited. OBJECTIVE

This study’s objective was to evaluate the accuracy and precision of digital electronic thermometry in rectal and axillary temperature measurements in neonates compared to the standard mercury-in-glass thermometry. The primary function of the study was to test the accuracy of the digital thermometer compared to the gold-standard mercury-in-glass thermometer when the accepted difference between the digital and the mercury-in-glass thermometer is not more than 0.1°C and 0.2°C. The secondary outcome was to test the precision of the digital thermometer.

STATISTICAL ANALYSIS

The sample size was calculated with a two-sided 95% confidence interval for a single proportion, using the large sample normal approximation, extending 0.050 from the observed proportion to an expected proportion of 0.950. The calculated sample size was 73.

SUBJECTS

One hundred term and preterm neonates aged 0-28 days admitted to the nursery, intermediate care unit and NICU at the Department of Pediatrics, Siriraj Hospital participated in the study. The criteria for inclusion included:

1. Newborn infants who had signs or symptoms that suggested NEC.
2. Newborn infants who had anal fissure.
3. Newborn infants who had congenital malformations of the lower gastrointestinal tract.
4. Newborn infants who had a serious illness with signs or symptoms of cardiovascular instability.

MATeRIALS AND METHODS

Prior to the study, four mercury-in-glass thermometers were standardized in a water bath (set at 37 °C). The technique for taking temperatures using the mercury-in-glass thermometer was based on routine practice in our division and findings from the literature. Recordings were made in the Celsius scale and timed with a stop clock.

The electronic digital thermometer used in this study was the Sure Temp Plus 690 (Welch Allyn). The manufacturer’s operating instructions were used as the accepted technique for the electronic thermometer and calibrated by technicians prior to beginning the study.

Temperatures were taken by both mercury-in-glass thermometry and digital thermometry. Each infant was placed in a supine position; one side of the axillary thermometer was first measured using the mercury-in-glass thermometer, followed immediately by the digital thermometer. The mercury-in-glass thermometer was placed in the interaxillary fold; the temperature was read after 7 minutes in term and 5 minutes in preterm infants. When using the digital thermometer, the axillary probe was covered with a disposable probe-cover shield before placing in the same position of each infant. The temperature was read after 10 to 15 seconds as indicated by the ready-tone of the thermometer. After completing one side of the axillary measurement, temperature measurement on the other side was done, following the same process.

After completing the axillary temperature measurement, rectal temperatures were measured in the same order. First, using the mercury-in-glass thermometer inserted 2.5 cm for preterm infants and 3 cm for term infants rectally after lubrication with petroleum gel, the temperature was read after 3 minutes. When using the digital thermometer, after the rectal probe was covered with a disposable probe-cover and lubricated, we inserted the probe 2 cm rectally. The temperature was read after 10 to 15 seconds as indicated by the ready-tone.

RESULTS

One hundred infants were enrolled in the study between October 2004 and December 2004 from the neonatal nursery, intermediate care unit and NICU at the Department of Pediatrics, Siriraj Hospital. Demographic details are shown in Table 1. The majority of the popula-

<table>
<thead>
<tr>
<th>TABLE 1: Demographic data</th>
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<tr>
<td>Mean ± SD</td>
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<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
</tr>
<tr>
<td>GA ≤37 weeks(n=66)</td>
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<tr>
<td>32.4 ± 3.06 (26-36)</td>
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<tr>
<td>GA ≥37 weeks(n=34)</td>
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<tr>
<td>38.4 ± 1.58 (37-43)</td>
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<tr>
<td>Birth weight (g)</td>
</tr>
<tr>
<td>1591.82 ± 516.67 (860-3400)</td>
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<tr>
<td>2674.65 ± 625.03 (1490-3750)</td>
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<tr>
<td>Postnatal age (days)</td>
</tr>
<tr>
<td>8.71 ± 4.1 (1-28)</td>
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<tr>
<td>Weight (g)</td>
</tr>
<tr>
<td>1592.58 ± 542.07 (670-3550)</td>
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<tr>
<td>2660.44 ± 643.66 (1470-3900)</td>
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tion were preterm infants (66%). The sex distributions of these infants are shown in Table1. Their mean birthweight was 1,950.80 ± 747.11 g (range 860-3,750g), mean gestational age of 34.25 ± 3.99 weeks (range 26-43 weeks) and mean postnatal age of 8.15 ± 7.57 days (range 0-28 days).

The accuracy was analyzed for accepted differences between the mercury-in-glass and the digital thermometer of 0.1°C and 0.2°C. For rectal thermometry, the accuracy of |0.1°C and |0.2°C was 68% (95% CI= 58.3%, 76.3%) and 87% (95% CI= 79%, 92.2%), respectively. For axillary thermometry, the accuracy was 64% (95% CI= 54.2%, 72.7%) and 78% (95% CI= 68.9%, 85%) for |0.1°C and |0.2°C, respectively.

The precision of digital thermometry was 86% (95% CI= 77.9%, 91.5%) and 75% (95% CI= 65.7%, 82.5%) for rectal and axillary digital thermometry, respectively. Precision of rectal and axillary thermometers is shown in Figure 1.

DISCUSSION

Glass thermometers have been considered the gold standard method of temperature measurement in newborn infants. However, anal perforation, accidental breakage and mercury contamination are risks associated with this method, in addition to being time-consuming and exposing neonates to room temperature which can cause hypothermia.

For these as well as other reasons, digital thermometry has been used instead of the traditional mercury-in-glass thermometer. It has a thermistor at the tip that measures the peak temperature reached in the surrounding tissue and converts it to a digital display. However, most published literatures that supported the use of this type of thermometer was done beyond the
neonatal period\textsuperscript{11-19}. There were only a few studies where neonates, especially in preterm infants, were the selected patient group. Leick-Rude and Bloom (1998) found that the digital thermometer had the highest correlation with the glass thermometer for axillary temperature\textsuperscript{2}. Dollberg et al (2001) studied electronic digital thermometer in term and near-term infants. The study accepted the accuracy and precision of the instrument with a difference of ±0.2°C\textsuperscript{21}. Our specific interest was having an understanding of the accuracy and reliability of axillary and rectal thermometry. The British Standards Institution accepted the accuracy for the mercury-in-glass thermometer of ±0.1°C and -0.15°C\textsuperscript{22}. It is generally presumed that a temperature difference from standard mercury-in-glass thermometer within 0.2°C is acceptable for clinical practice. If a particular neonate is in the sensitive area of temperature instability, such as preterm infants, the difference should not be more than 0.1°C. So we consider the difference of 0.1°C and 0.2°C as the acceptable level in this study.

Our results indicated that if we accept the difference of not more than 0.2°C, the accuracy of both rectal and axillary digital thermometers was acceptable compared with the mercury-in-glass thermometer. On the other hand, the accuracy of a difference of less than 0.1°C was not acceptable. These results were similar when we separately analyzed them in term and preterm infant groups.

In consideration of precision, the rectal digital thermometer is precise but the axillary digital thermometer is not. Digital thermometry is not a perfect device to be used instead of the standard mercury-in-glass thermometer in all neonates. It depends on the acceptable range of accuracy shown in the study. Hence, we might use it for relatively healthy infants who have an acceptable wider range of temperatures but not for sick or preterm infants. In addition, the relatively low number of samples in this study limited our ability to assess the correlation of the two methods of measurements.

Apart from considering it as a less time-consuming device, the digital thermometer is use in general nursing care should be of concern about its possible role as a vector in the transmission of nosocomial infections. There were reports of an outbreak of \textit{Enterobacter cloacae} in the NICU related to disinfected thermometers\textsuperscript{7-9}. Others have reported outbreaks in which the thermometer transmit \textit{Clostridium difficile} and \textit{Salmonella spp}\textsuperscript{10-26}. Replacement with a disposable probe cover is one suitable way to prevent problems but we have to be concerned about the common digital device and its technique. However, the disposable probe cover is relatively expensive; the cost-effectiveness should be taken into account that should be considered for use in general care.

CONCLUSION

Precise assessment of temperature measurement is one of the fundamental care for either healthy or sick neonates. It is essential in determining the appropriate course of action for treatment. For this reason, the study indicated that, for temperature measurement of relatively healthy infants who had an acceptable range of measured temperature of 0.2°C, rectal digital thermometry could be an appropriate device instead of the mercury-in-glass thermometer in order to decrease disturbance time during measurement and decrease the work load of care givers. In sick or critically-ill patients, the mercury-in-glass thermometer should be the standard device. Moreover, factors of cost effectiveness, understanding the equipment and infectious control have to be considered in each situation.

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REFERENCES

บทเด็ดย่อ

การศึกษาความถูกต้องและความแม่นยำของเครื่องวัดอุณหภูมิระบบติดล้อในการวัดอุณหภูมิอากาศ

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วัตถุประสงค์การศึกษา

เพื่อศึกษาความถูกต้องและความแม่นยำของเครื่องวัดอุณหภูมิระบบติดล้อในการวัดอุณหภูมิอากาศและทารุณมีการกลมในการเก็บ

รายละเอียด: ศึกษาในรอบ 100 วัน อยู่ 0 ถึง 28 วัน ที่อุณหภูมิระหว่าง 26 ถึง 43 องศาเซลเซียส น้ำหนักของฝักตั้ง 860 ถึง 3750 กรัม ระหว่างผ่านกระบวนการวัดอุณหภูมิระบบติดล้อ อุณหภูมิวัดได้รับการวัดอุณหภูมิระบบติดล้ออุณหภูมิต่ำกว่าโดยใช้เครื่องวัดอุณหภูมิระบบติดล้อที่ต่ำกว่าอุณหภูมิระบบติดล้อ ปริมาณที่เก็บเก็บขึ้นที่วัดได้จากผลการวัด อุณหภูมิระบบติดล้อ อุณหภูมิต่ำกว่าโดยใช้เครื่องวัดอุณหภูมิระบบติดล้อ

ผลการศึกษา: ความถูกต้องของเครื่องวัดอุณหภูมิระบบติดล้อในการวัดอุณหภูมิอากาศทดลองเพียงต่ำกว่า 68% (95%CI=58.3%, 76.3%) และ 87% (95%CI=79%, 92.2%) สำหรับการวัดอุณหภูมิระบบติดล้อ อุณหภูมิต่ำกว่าโดยใช้เครื่องวัดอุณหภูมิระบบติดล้อ ปริมาณที่เก็บเก็บขึ้นที่วัดได้ต่ำกว่า 64% (95%CI=54.2%, 72.7%) และ 78% (95%CI=68.9%, 85%) สำหรับการวัดอุณหภูมิระบบติดล้อ อุณหภูมิต่ำกว่าโดยใช้เครื่องวัดอุณหภูมิระบบติดล้อ ปริมาณที่เก็บเก็บขึ้นที่วัดได้ต่ำกว่า 86% (95%CI=77.9%, 91.5%) และ 75% (95%CI=65.7%, 82.5%) ตามลำดับ

สรุป: สามารถทำการวัดอุณหภูมิระบบติดล้อได้เท่านั้นก็เพียงแค่ในการวัดอุณหภูมิทางอากาศและทารุณมีการกลมได้ในทางที่ไม่ผู้ในภาวะที่ป่วยหรือสุขภาพที่ไม่ดี แต่ต้องมีการเตรียมการป้องกันการเกิดอุณหภูมิอากาศที่ต่ำกว่ากรอบที่เหมาะสมกับการทำงานของเครื่องวัดอุณหภูมิระบบติดล้อ