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Validation of Electronic Rectal Thermometry

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Electronic rectal thermometry is performed routinely in most medical centers. While electronic thermometry has been validated at the oral site, rectal measurement has not. We performed a controlled study on 84 children comparing mercury-in-glass and electronic thermometry at the rectal site. No significant difference occurred in temperatures between the two methods. We conclude that the electronic thermometer is a valid instrument to measure rectal temperature. (Henry Ford Hosp Med J 1988;36:207-8)

Clinical thermometry is an essential part of patient evaluation. Temperature can be measured clinically at various sites using various techniques. Each site and technique has advantages and disadvantages, and the temperature recorded should be interpreted according to how and where it is measured.

Electronic thermistor thermometry has recently replaced the standard mercury-in-glass (SMIG) method in many centers. Electronic thermometry has been received favorably by most health care workers because of its convenience to both patient and nurse, cost-effectiveness, and greater reliability (1,2). However, accuracy of electronic thermometers depends on routine maintenance including regular calibrations and inspection for faulty connections (1,3,4). Studies have shown a strong correlation between electronic and SMIG thermometry at the oral site (1). However, since young children are unable to cooperate with the oral temperature method, either the rectal or axillary site is substituted.

Rectal temperature is an accurate approximation of core temperature when performed properly (5). Current electronic thermometers measure the rate of rise in temperature over a brief period of time. A predictive endpoint temperature is then displayed. Thus, the steady-state temperature is not measured directly. Rectal mucosal heat is absorbed into the cooler thermistor probe, its cover, and lubricant. We hypothesized that this small amount of heat loss may produce an incorrect low reading. The higher the body temperature, the greater the potential may be for inaccuracy. We found no published studies that compared electronic and SMIG thermometry at the rectal site. Therefore, we undertook the following study to assess the validity of the electronic technique.

Materials and Methods

The subjects were patients from a general pediatric inpatient service and pediatric intensive care unit at a large community hospital. Approval for the study was obtained from the institutional review board. All children aged 3 to 48 months were considered potential subjects. Exclusion criteria were 1) a bleeding diathesis, 2) an immunocompromised state, 3) recent abdominal or pelvic surgery, and 4) recent perineal trauma. Because each subject served as his own control, a convenience sample was chosen. Subjects were distributed among seven groups according to age: 3 to 6 months, 7 to 9 months, 10 to 12 months, 13 to 18 months, 19 to 24 months, 25 to 36 months, and 37 to 48 months.

The SMIG devices were water bath-tested thermometers measured in accordance with the National Bureau of Standards with a maximum error of ± 0.2°F at 98°F and ± 0.3°F at 102°F and 106°F. Each thermometer was used once. The Diatek Model 600 Digital Thermometer (Diatek Inc, San Diego, CA) was the electronic thermistor thermometer used. The unit was calibrated externally immediately prior to the study and checked at the end of the study. This thermometer also tests calibration internally with each use, with a maximum allowable error of ± 0.2°F at 100.5°F. Standard probe covers and water-soluble lubricant were used. All equipment was kept between 72°F and 78°F until the moment of use. In all patients the thermometers were inserted 3 cm into the rectum over approximately ten seconds. The SMIG thermometer remained in the rectum exactly five minutes and was read immediately when withdrawn and recorded to the closest 0.1°F. The electronic probe was left in place until the temperature was displayed digitally. Time between removal of one instrument and insertion of the second was less than 30 seconds.

Fever was defined as a SMIG temperature of 100.4°F. Each age group had four subgroups of three subjects each: 1) febrile with SMIG temperature taken first, 2) febrile with electronic
temperature taken first, 3) afebrile with SMIG temperature taken first, and 4) afebrile with electronic temperature taken first. A quota system was used in which subjects were tested until all subgroups were filled. No subject was excluded from data analysis.

The paired t test was used to determine if electronic and SMIG temperatures were different. Analysis of variance was used to examine the effect of fever, age, and order of thermometry method on temperature differences.

**Results**

The study was performed without any adverse effect on the patients or equipment malfunction.

Using SMIG thermometry, the mean temperature in the afebrile groups was 98.9°F ± 0.64°F (SD). In the febrile groups, the mean was 101.4°F ± 0.95°F.

The mean difference of the electronic minus the glass thermometer temperatures was 0.18°F ± 0.288°F. The paired t test examined if the mean difference between temperatures taken by each device was different than zero. For all but one age group (25 to 36 months), the electronic temperature was significantly higher than the SMIG temperature (P < 0.05). In the 25 to 36 month age group this difference approached but did not achieve statistical significance (P = 0.09).

Analysis of variance showed no effect of fever or age on the difference between the two temperature measures. Thermometer order (glass or electronic first) was also assessed. The mean difference in temperatures when the electronic device was used first was 0.224°F, while that with the SMIG thermometer used first was 0.136°F. The P-value for order effect was 0.09. While this is suggestive of an effect, it is not statistically significant.

**Discussion**

Electronic thermometry has displaced SMIG thermometry in many medical centers because of simplicity, efficiency, and patient comfort. Previous studies have validated electronic oral thermometry (1,6,7). We were unable to find similar studies for electronic rectal thermometry. We hypothesized that this method might be invalid because of heat absorption from the rectal mucosa into the probe, probe cover, and lubricant, with rectal blood flow unable to compensate for this heat loss, especially in the smallest and sickest patients. This hypothesis was disproven.

Electronic thermometry uses a probe thermistor that receives electronic pulses many times during a temperature measurement. A ratiometric calculation is used to compute the probe resistance from its pulse width relative to those provided by two standardized internal resistors. The probe temperature is computed using the probe resistance value. The temperature displayed is the sum of the actual probe temperature and a computed correction factor. This factor is dependent on the ambient probe temperature and the rate of fall in probe resistance. The Diatek Model 600 (Diatek Inc, San Diego, CA) measures predicted steady-state temperature every 1.5 seconds. When this value is stable for several seconds, the result is displayed. At this point, the correction factor is from 0°F to 2.3°F with a typical value of about 1°F (8).

A statistically significant but clinically insignificant difference was observed between SMIG and electronic rectal temperatures. A number of factors may account for the higher results using the electronic instrument. First, while a near steady-state temperature is achieved between three and five minutes using SMIG thermometry, a clinically insignificant rise occurs for at least ten minutes (9-11). If the electronic device were perfectly accurate, the SMIG temperature at five minutes would be expected to be slightly lower. Second, the patient may have cooled during the measurement. Using analysis of variance, there is a strong suggestion that the mean electronic temperature was higher when taken first (0.224°F versus 0.136°F higher, P = 0.09). This supports the possibility that a trivial drop in temperature occurred while the patient was undressed during the five minutes for SMIG thermometry. Third, the SMIG thermometer could have absorbed enough heat from the rectum to depress the result of subsequent electronic thermometry.

This study validates electronic thermometry for rectal temperatures. The slight differences between electronic and SMIG thermometry techniques are not clinically significant.

**References**