RAPID AXILLARY TEMPERATURES IN CHILDREN AGE THREE AND UNDER

Abstract

Axillary temperature measurements were obtained from one hundred and eighty-six children, age birth to three years, at five medical centers in the United States and Canada using the rapid predictive axillary software from a new thermometer (Welch Allyn™ SureTemp®). The results indicate that this specialized software is highly accurate in determining axillary temperatures in children under four years of age. Temperature measurements ranged from 96.5°F to 105.7°F (35.8°C to 40.9°C) and had a bias of 0.05°F (0.03°C). The standard deviation was 0.46°F (0.26°C).*

Definitions

Monitor Temperature: A function or mode of an electronic thermometer used to continuously monitor temperature until it reaches the thermal steady state (unchanging). The thermal steady state is achieved in the axilla in approximately five minutes.

Predicted Temperature: Thermometers that render a temperature reading before steady state is achieved are classified as Predictive Thermometers. Predictive Thermometers reduce the time required for measurement by using algorithms to "predict" what the temperature would be if the probe were left in place until steady state is achieved.

Introduction

Temperature measurement in children presents clinicians with many challenges. Although accuracy is the most important factor when fever is suspected, many clinicians consider patient comfort and convenience to be very important in this population also. In this age group however, clinicians have had to choose between using a thermometer that is very accurate or one that is more comfortable and convenient but may be less accurate. No other area of vital signs' collection has required clinicians to make choices of this nature.

Many pediatric clinicians who believe that accuracy is most important choose rectal thermistor thermometers. Critics of the rectal technique point out that this site introduces significant risks of bowel perforation as well as infection control issues. Those considering patient comfort, convenience, and speed, tend to migrate toward tympanic thermometers. Detractors argue that many studies show that infrared tympanic thermometry is least accurate in children.

Because of these problems, many pediatric settings are now using axillary thermometry exclusively in children under the age of 3 or 4 years. While convenient, there are those who believe that this method produces chronically low temperature readings, or when performed properly, takes too much time (five minutes).

Given this environment, the objective of this research was to determine if the axillary site and a new rapid axillary thermometer (SureTemp®) could produce sufficiently accurate estimates of body temperature in a large pediatric population. If the results of this research were positive, the authors felt this technique and instrument could present clinicians with an alternative method of temperature measurement that would meet the clinical requirements of accuracy, speed, convenience, and patient comfort.

Background

Modern use of clinical electronic thermometers began approximately twenty-five years ago with the introduction of the first **predictive** thermometers. These instruments were designed to predict oral or rectal temperature in approximately forty seconds based on a mathematical formula derived from time temperature studies of many hundreds of patients.

Infrared (IR) tympanic thermometry was introduced approximately seven years ago and has become widely used in adults and children. Primary reasons for the acceptance of IR technology were speed, convenience, and the theoretical consideration of obtaining temperature measurements from a site that closely reflected core temperature. In practice however, many clinicians have become

dissatisfied with IR because they feel that accuracy may be sacrificed in favor of speed. This appeared especially true in pediatric populations.

Accurate IR temperature measurement is largely dependent on several factors that are problematic in pediatrics. The close proximity of the tympanic membrane to the surface in children allows ambient temperature to greatly influence tympanic temperature. A child's small caliber ear canal does not allow tympanic thermometer probes to seal out ambient air properly. Other factors influencing accuracy include the clinicians' technique in using the instrument, cleanliness of the IR lens, and instrument calibration.

Axillary use of predictive thermometers has been common in pediatrics and inpatient newborn units for many years. However, the algorithms in these thermometers were designed for use in the mouth or rectum. As a result, they typically under-estimate body temperature when used in relatively cooler environment such as the axilla. These inaccuracies are magnified as the child's body temperature reaches the febrile state, where accuracy is even more clinically important.

Because of the accuracy concerns with the use of tympanic and older technology predictive axillary thermometers, no practical alternative has been readily available to pediatric clinicians. The new rapid axillary thermometer has several major clinical advantages which prompted this research. These include speed, more accurate axillary temperature measurements, and FDA approval.

Relevant Literature Review

Safety
A major consideration in using an alternative to the rectal site are the published accounts of colon perforations by thermometers in young children [1 2 3]. These studies cited the high mortality rate in the reported cases of perforation by thermometers. Each study either strongly urged caution when taking rectal temperatures in this age group, or stated that rectal temperatures were contraindicated in small children.

Accuracy
In 1974 a study by Eoff, Meier, and Meier [4] of 30 infants, it was concluded that axillary and rectal temperatures were closely related. These authors also pointed out that axillary temperature measurements are non-invasive and do not involve the risk of bowel perforation to the infant.

Eoff and Joyce[5] studied 25 toddlers (ages 1 to 3 years) and 25 pre-schoolers (ages 3 to 6 years) and concluded that there was no clinically important difference between axillary and rectal temperature in this population. Schiffman found a significant positive correlation between rectal and axillary temperatures in 46 neonates[6].

The American Academy of Pediatrics recommended in 1977, that the axilla be considered as a site for temperature measurement[7]. In 1988, the American Academy of Pediatrics and the American College of Obstetricians and Gynecologists expressed their confidence in the axillary site because it accurately reflects rectal temperature in neonates, and because of the safety of the site[8].

Numerous studies, including those by Kunnel et al, Schiffman, and Eoff et al, recommended the axilla as the best or most appropriate choice for temperature measurement in stable neonates.[1,3,9]

In a controlled study of 200 temperature readings, Weiss and Richards[10] concluded that predictive axillary temperatures offer an accurate, safe, and rapid alternative to axillary **monitor mode** and rectal temperature measurements.

Materials and Methods

Study Design
In clinical practice, temperature readings from predictive thermometers are often compared to those from glass mercury thermometers to assess accuracy. In non research conditions routinely encountered by clinicians, the methodology used for this comparison has lacked control causing inaccurate and somewhat distorted results.[2] For example, glass-mercury thermometers are

not checked for accuracy prior to obtaining temperature readings. A number of studies have shown that glass-mercury thermometers can vary by 0.1°F to 0.5°F (.05 to .28° C).[3] A study by Terndrup and Allegura documented the fact that electronic thermometers used in the monitor mode are more accurate and reliable than glass- mercury thermometers.[7] Another common error is the failure to place the probe tip as deep as possible in the axilla. This oversight can produce inaccurately low temperature readings. Inconsistent probe placement can also cause significant variations in temperature readings.

This study was designed to make direct comparisons of five minute and predicted axillary temperature readings from a new rapid predictive thermometer (Welch Allyn™ SureTemp®, Welch Allyn Inc., San Diego, CA.), using a multi center, non-randomized methodology. Each of the potential errors related to using the axillary site were controlled by the development of a precise protocol and technique standardization. Individual training and observation of each study clinician was performed prior to the start of this study. Technique standardization included placing the thermometer probe in the highest anatomical position in the axilla, and avoiding probe movement, especially during the predict cycle by:

- Trapping the probe between the arm and thorax.
- Holding the arm firmly at the subjects side.

Each data set included the prediction time (in seconds), the predicted axillary temperature and a five minute monitor temperature measurement from the same anatomical site by the same study instrument.

Clinicians at individual centers were required to collect a minimum of twenty percent febrile data (>100°F or 37.8 °C).

Each study instrument was checked in a calibrated water bath at 106°F (41.1°C) in the monitor mode at the beginning and at the conclusion of the study. All instruments were within ± 0.1° F.

Study Population

Axillary temperature measurements were obtained from three hundred and four children and neonates at five inpatient and outpatient settings in the United States and Canada*. The neonatal population consisted of one hundred and fifty newborns up to age 47 days, pre-discharge from NICU's and normal newborn nurseries. The remainder of the one hundred and fifty four subjects were age 10 weeks to three years.

Temperatures ranged from 96.5°F to 105.7°F (35.8°C to 40.9°C). Centers were selected based on their volume of pediatric subjects, availability, their willingness to participate, and proximity to the individual study clinicians.

Analysis

Data from this study was analyzed by comparing the predicted axillary temperature from the SureTemp thermometer to the five minute axillary temperature. Prediction time was calculated and expressed as the average of all readings. Outliers were not removed because practicing clinicians include all temperatures obtained by their thermometer to form an overall opinion of the accuracy of an instrument or technology.

Results

The scatter charts illustrate the predicted versus five minute temperatures.

Neonates

The mean bias (error) for neonates was 0.02°F (0.01°C) with a standard deviation of 0.4°F (0.2°C).

Pediatrics Age 10 weeks to 3 Years

Average error for the remainder of the pediatric population (age 10 weeks to 3 years) was 0.2°F (0.1°C), the standard deviation was 0.4°F (.26°C).

These results demonstrate excellent correlation and no clinically significant differences between the five minute monitor temperature and the predicted temperatures from the Welch Allyn SureTemp axillary software in this population.

Average predict time was 10.2 seconds (SD 6.8 seconds).

Discussion

Although temperature has been viewed as a routine task, body temperature monitoring and treatment in pediatric patients are a critical component of their care. Until now, the measurement of temperature has occupied the majority of time in collection of vital signs. Routine heart rate is usually collected over fifteen to thirty seconds, blood pressure takes approximately twenty seconds, and when properly performed, axillary temperature measurement takes five minutes. Often clinicians incorrectly used older technology predictive thermometers, which produced consistently low temperatures and took approximately one minute.

The major drawbacks of using tympanic thermometry (accuracy, repeatability, clinician technique, patient anatomy, patient compliance, and maintenance of fragile tympanic instruments) make this technology impractical in pediatric settings. The new SureTemp thermometer offers the speed advantages of tympanic thermometers, with much improved accuracy and none of the associated problems.

The major clinical benefits of this new thermometer are significantly improved accuracy and greatly increased speed.

Conclusions

This research demonstrated the following:

1. **That there were no clinically significant differences between five minute axillary temperature measurements and predicted temperatures using the rapid axillary software available with the SureTemp thermometer in children under age 4 years.**
2. **That the SureTemp axillary software provides rapid measurement of body temperature using accepted, durable, and familiar technology.**
3. **In contrast to tympanic thermometers, clinicians can utilize this new instrument with very little additional training and minimal instrument maintenance**

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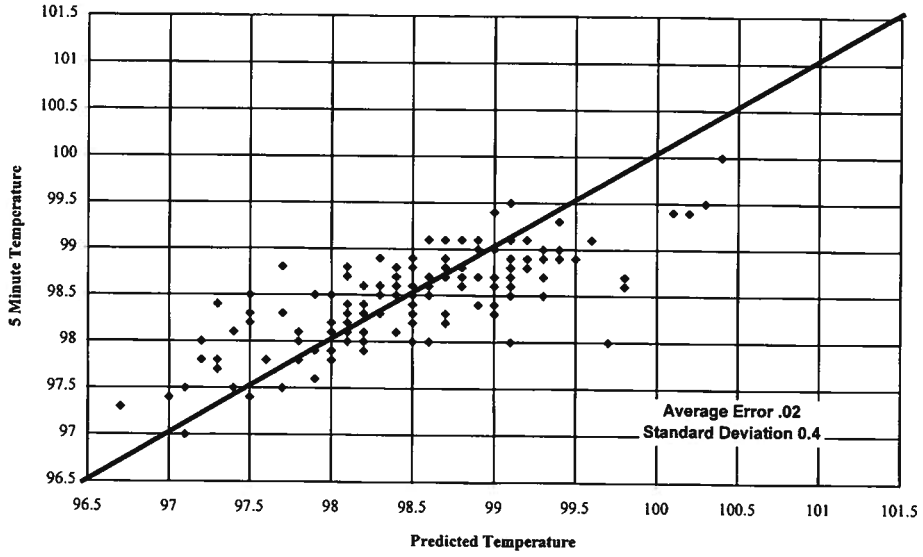
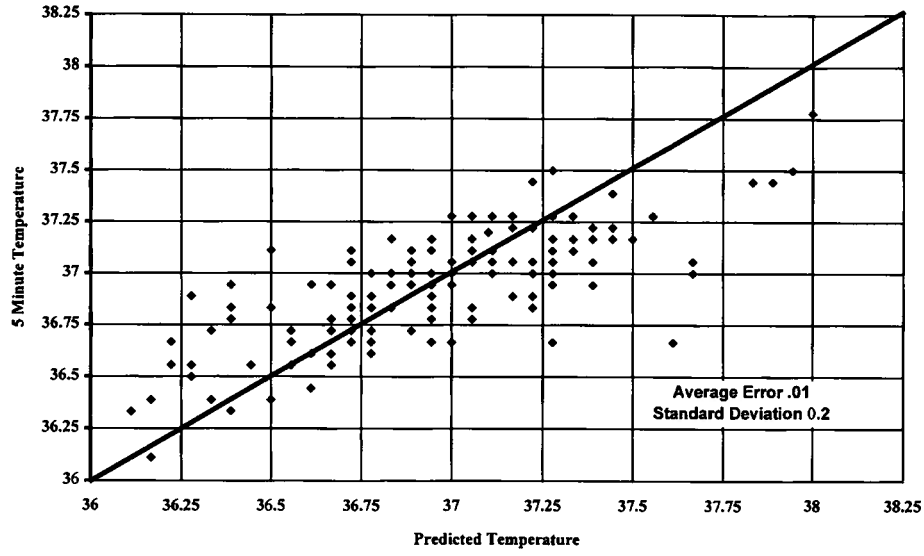
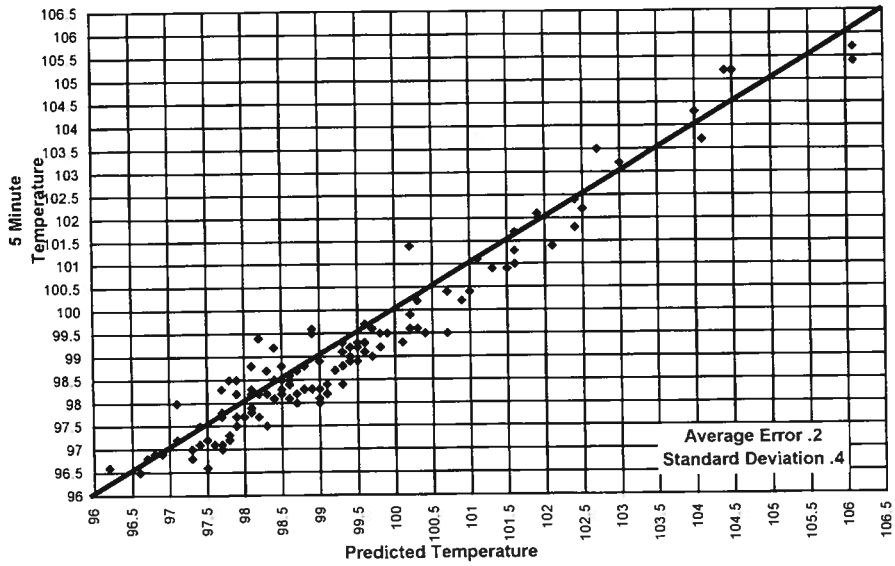
SureTemp VS 5 Minute Axillary Temperature
Neonates



SureTemp vs 5 Minute Axillary Temperature
Neonates



SureTemp vs. Five Minute Axillary Temperature
Ages 10 Weeks to 3 Years



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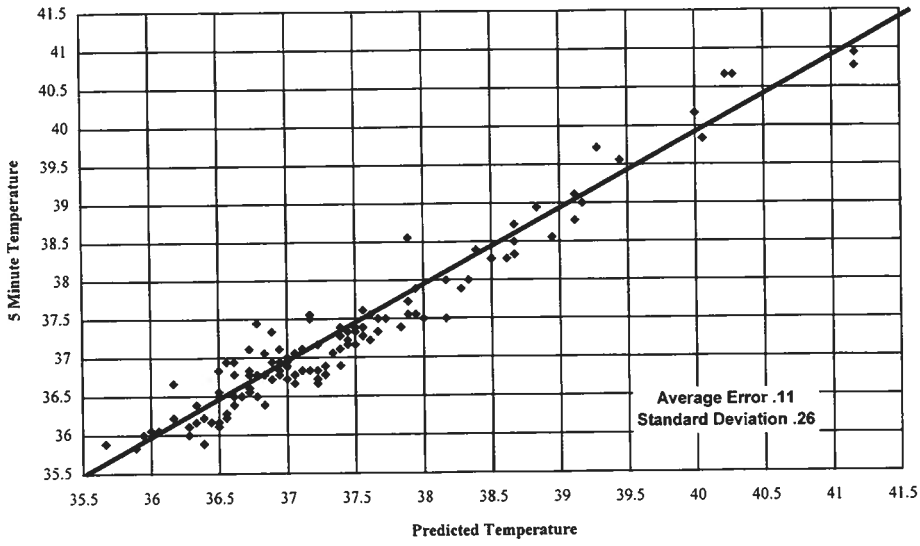

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