



98.6°F  
37.0°C  
102.3°F  
101.6°F  
36.8°C  
98.2°F  
37.9°C  
38.6°C

# GETTING A BETTER READ ON THERMOMETRY

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# GETTING A BETTER READ ON THERMOMETRY

*Knowing the ins and outs of modern thermometry—and putting thermometers to a scientific test—will help you assess whether the temperature you've just taken is accurate or not.*

Mrs. Perry is scheduled for coronary artery bypass graft surgery in the morning. During a routine temperature check, her nurse, Sharon Smith, obtains a reading of 101.6° F (38.7° C) with a tympanic thermometer. Wanting to verify this febrile reading, she takes another temperature, this time using an electronic oral thermometer; the reading is normal, 98.2° F (36.8° C).

If the nurse assumes that the tympanic thermometer is correct, surgery will have to be postponed. Mrs. Perry would need to undergo lab tests such as blood cultures and possibly be put on antibiotics—actions that would be needless and costly if it turns out Mrs.

Perry doesn't have a fever. If, on the other hand, the nurse relies on the electronic reading and it is incorrect, she would have missed an important diagnosis and might be endangering her patient by letting her go to surgery.

Because temperature readings affect key treatment decisions, you need to know whether you can rely on the thermometers you're using. Of course, all manufacturers test their products extensively for accuracy and performance before putting them on the market. But how well does that same thermometer hold up under actual, clinical conditions?

To find out, many hospitals are doing small clinical studies to

determine which thermometers are most useful in their setting. And nurses are helping to conduct this research. Here's how we conducted a study to assess thermometers and what we learned.

(Since user error will skew the results of even the best instrument, the right way to take and interpret a temperature is reviewed in the box on page 4.)

## **Mercury-in-glass is out, modern thermometers are in**

Over the past few decades, technological advances have led to far more sophisticated and reliable thermometers. In the clinical setting, mercury-in-glass instru-

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ments have largely been replaced by electronic oral or rectal thermometers and tympanic thermometers. One reason is that modern thermometers improve infection control. Disposable probe covers for tympanic, oral, and rectal thermometers, for example, reduce the risk of transmitting germs from one patient to another. And tympanic thermometers virtually eliminate exposure to bodily fluids.

Speed is another benefit. Glass thermometers must be held in place for three to five minutes to register a reading, while some newer thermometers give readings in seconds.

Given these benefits, we set our sights on studying two modern thermometers: A new and fast electronic thermometer, the Diatek SureTemp™4—now called the Sure Temp® (Welch Allyn Company, San Diego). And a widely used tympanic thermometer, First-Temp Genius® Tympanic Thermometer (Sherwood-Davis & Geck, St. Louis).

The study was conducted at two facilities—a 32-bed ICU at Hamilton General Hospital in Ontario, Canada, and a 28-bed ICU/CCU at St. Joseph Medical Center in Burbank, Calif. The subjects in the study were all ICU patients 12 years of age or older. All had indwelling pulmonary artery thermistor catheters already in place. They had no contraindications to oral or tympanic temperature measurement—such as trauma or recent surgery to the lips, tongue, or oral or ear cavities, or discharge in or around the ear. Intubated patients who were able to tolerate an oral temperature measurement were included, as well.

Four ICU nurses—three volun-

teers at the Canadian hospital, and one at the U.S. facility—collected the data. Each of the nurses reviewed the study's protocol and the manufacturer's instructions, were comfortable using the thermometers, and were specially trained to collect the data.

One nurse at each site was assigned to check the calibration of all the instruments each week to ensure that the thermometers were within the manufacturer's specifications for accuracy. This was also done *prn* if there was any reason to suspect a problem. The infrared lens on the Genius was cleaned every 24 hours with a dry swab and *prn* with an alcohol swab if debris was noted on the lens.

### **Putting the study in motion**

Our objective was to compare temperatures recorded by an electronic thermometer in the oral mode and a tympanic thermometer against the temperature that was measured by a PA thermistor catheter. PA temperature is considered the most accurate clinical measurement of a person's core temperature.

According to our protocol, the nurses would collect four temperatures from the subjects within five minutes. Data could be obtained from each subject more than once—but no more than three times—in a 24-hour period. If a subject was used more than once, each set of temperatures had to be taken at least 30 minutes apart.

First, a four-second oral temperature was taken on each subject with the electronic (SureTemp4) thermometer in the normal mode. This mode allows the thermometer

to "predict" oral temperature quickly by preheating the probe to 93° F (34° C).

Second, a stopwatch-timed, three-minute measurement was made using the same thermometer and without changing the position of the probe tip. The difference was the operating mode; it was switched to "monitor," which obtains actual—as opposed to predicted—temperatures.

Next, temperature was taken with the tympanic (Genius) thermometer in the core (tympanic) mode—a process that took about a second. Finally, the temperature from the PA thermistor was recorded.

To ensure that we had a valid sample, temperature data were collected from febrile patients—those with an oral temperature greater than 100° F (38° C)—and those with normal temperatures (see the box on page 60 for normal temperature ranges by body site). Over approximately a one-month period in the Canadian hospital and a three-month period in the U.S. facility, a total of 261 sets of temperatures (all four measurements) were collected.

### **Analyzing the results**

According to our analysis of the data, which is shown in the chart on page 5, temperature readings from both the electronic and tympanic thermometers came very close to those obtained from the PA thermistor catheter. Overall, both thermometers missed the mark by no more than a half a degree—a small range of error for most patient populations.

When used on febrile patients, the tympanic thermometer aver-

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# Taking a temperature—the right way

Measuring temperature is such a basic nursing function that many nurses take for granted that they know how to do it. That assumption increases the odds of human error. Here's an overview of the right way to take a temperature using the new technology and how to avoid false readings.

**Electronic thermometry.** First, set the operating and site modes correctly. Most temperatures taken with the electronic thermometer are set in the faster "normal" mode. For example, the electronic thermometer used in our study can predict oral temperatures in about four seconds and rectal temperature in about 15 seconds. A thermometer placed in the "monitor" mode will obtain actual oral or rectal temperatures in three minutes.

Make sure, too, that you use the right probe at the correct site; using an oral probe at the rectal site, for example, will produce a distorted reading.

Misplacement of the thermometer's probe tip is the most common error when taking an oral temperature. The probe tip should be placed in the sublingual pocket yourself. (Hold it there yourself, since the patient may not be able to keep the probe steady or may place the probe tip right behind the teeth—both of which can cause false low readings.) See Figure 1.

Always consider patient-related factors when interpreting readings. Low oral measurements are typically found in patients who breathe mainly through their mouth, are unable to seal their lips around the thermometer, or are receiving oxygen through a face mask. If the patient has had a cold drink within the last 20 minutes, the reading may be falsely low. Conversely, the temperature of a patient who has had a hot drink or smoked a cigarette within the last 20 minutes may be falsely high.

**Tympanic thermometry.** A tympanic thermometer does not need to touch the ear's tympanic membrane to obtain an accurate temperature reading. Instead, it calculates temperature by detecting the highest level of infrared energy, or heat rays, within the ear canal.

Using a mathematical formula, it converts temperatures obtained from within the ear canal into predicted readings at various body sites—core (tympanic), oral, rectal, or surface (actual skin). For that reason, you always need to be aware

of the mode the thermometer's set on. A reading of 100.5° F (38.1° C) would indicate a fever if the thermometer is set in the oral mode, but would be considered normal if obtained in the rectal mode.

Again, proper placement of the probe tip is essential to obtain readings that most closely resemble the body's core temperature. As shown in Figure 2, direct the tip toward the tympanic membrane, occluding the ear canal. This will eliminate the effect of ambient air, which can skew readings by as much as 5° F.

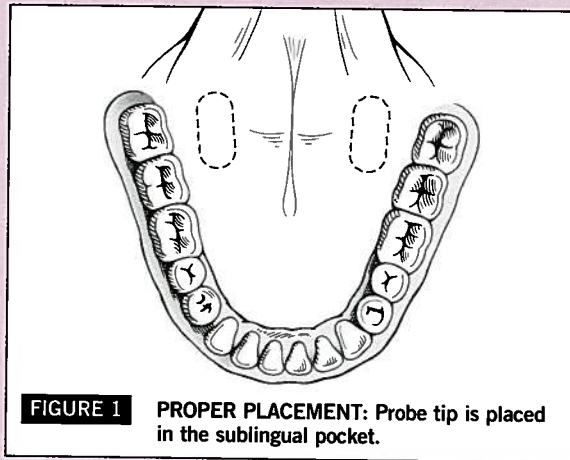
Vigorous exercise and intense emotions can alter readings, too. Objects that cover the ear—such as hearing aids, hats, and pillows—or direct sunlight and heat lamps can cause artificial warming and falsely elevate readings. If you suspect that's the case, remove the object or heat source.

Finally, be sure that the sensor lens of the thermometer is clean. Dust or ear wax on the lens obstructs the ability of the sensor to read the infrared energy from the tympanic

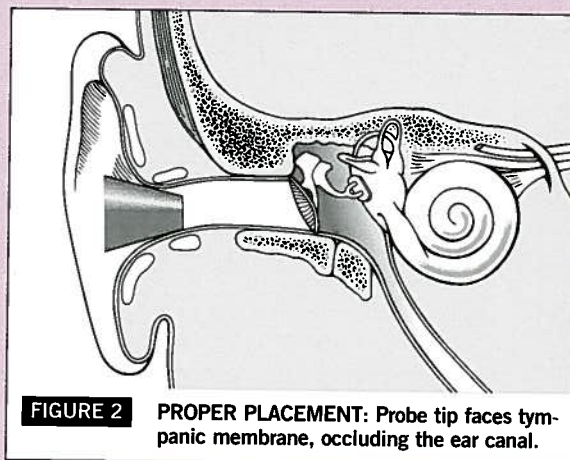
membrane, resulting in false-low readings. As directed by the manufacturer, clean the lens with a dry cotton swab or lens wipe at least once daily. Most manufacturers also allow the use of alcohol to clean heavily soiled lenses, but be sure to allow the lens to dry thoroughly for approximately 30 minutes before use.

**The drawdown effect.** When temperature measurements are repeatedly taken at the same body site—say, the same ear or the same sublingual pocket—subsequent measurements will be slightly lower than the initial measurements, typically by 0.2°–0.3° F. This phenomenon, known as the "drawdown effect," occurs because the probe—which is initially cooler than the body—conducts heat away and retains some of the body's warmth when it's placed in contact with tissue.

To avoid this effect, wait about two minutes between taking temperatures at the same site. Or, take the temperature in the opposite ear or sublingual pocket. Don't expect the measurements to be exactly the same, though: It's normal for the temperature in the right ear to differ slightly from that of the left ear; the same holds true when measuring temperature in the sublingual pockets.



**FIGURE 1** PROPER PLACEMENT: Probe tip is placed in the sublingual pocket.



**FIGURE 2** PROPER PLACEMENT: Probe tip faces tympanic membrane, occluding the ear canal.

## Understanding the study results

As the analysis of the data below shows, the SureTemp4 set in monitor mode performed the best in our clinical trial. We measured several factors: *Overall accuracy* refers to how close the thermometer came to matching the reading from the PA thermistor catheter. A *false positive* reading occurs when the thermometer indicates a fever in a patient who is afebrile; a *false negative* reading occurs when the thermometer fails to detect a

fever in a patient who is febrile.

The rate of false positives directly correlates with *specificity*—the thermometer's ability to correctly identify patients without fevers. Similarly, the rate of false negatives directly correlates with *sensitivity*—the thermometer's ability to correctly detect a fever. A desirable thermometer is one that has low rates of false positives and false negatives, and high rates of specificity and sensitivity.

Thermometer	Overall accuracy		False positive (Specificity)	False negative (Sensitivity)
	In all patients	In febrile patients		
Diatek SureTemp4 Normal mode (electronic)	+0.5°	+0.5°	15.84% (84.16%)	11.11% (88.89%)
Diatek SureTemp4 Monitor mode (electronic)	+0.3	+0.5	10.40 (89.60)	6.67 (93.33)
FirstTemp Genius (tympanic)	-0.4	-1.0	16.75 (83.25)	53.33 (46.67)

## Temperature differs according to body site

The normal range for an oral temperature in adults is 1° F above or below 98.6° F—the "norm" for body temperatures. Rectal temperatures are about 1° F higher than oral measurements. Core temperatures—such as those obtained with a pulmonary artery catheter or a tympanic thermometer set in "core" mode—fall about midway between oral and rectal measurements.

Body site	Normal temperature range
Oral	97.6° - 99.6° F (36.5° - 37.5° C)
Core (Tympanic)	98.2° - 100.2° F (36.8° - 37.9° C)
Rectal	98.6° - 100.6° F (37.0° - 38.1° C)

aged one degree lower than the core temperature read by the PA thermistor. The readings from the electronic thermometer—in both normal and monitor modes—averaged a half degree higher than the core temperature.

The rate of false positives—the

number of times the thermometer indicated a fever when there was none—ranged from about 10% for the electronic thermometer in monitor mode, to about 17% for the tympanic thermometer. However, there was a big difference when it came to false negatives: 53% of the

time, the tympanic thermometer failed to detect a fever in patients who had one—a rate nearly five times higher than that of the electronic thermometer in normal mode.

Other studies have shown tympanic thermometers to be more accurate than ours did, perhaps because of differences in study protocols. But even our findings do not mean that the thermometer isn't useful. Although it may not be the instrument of choice for certain patients in whom very precise temperature readings are critical, it's still accurate enough to be used in many clinical settings. It can monitor temperature trends and detect important changes and it's quick and convenient.

In the case of Mrs. Perry, the tympanic thermometer turned out to be right. After checking the mode settings on both thermometers to make sure they were set correctly, nurse Sharon Smith interviewed the patient. Mrs. Perry told her that she was thirsty even though she had had a glass of ice water just five minutes before.

Knowing that drinking cold liquids can result in false low readings with an electronic oral thermometer, the nurse waited half an hour and then took Mrs. Perry's temperature again. This time, the electronic thermometer read 100.8° F (38.2° C)—confirming the tympanic thermometer's initial finding.

Because of Smith's good judgment and a thorough understanding of the factors affecting her thermometer's accuracy, she was able to identify Mrs. Perry's fever. The surgery was delayed and treatment was rendered. And a potentially harmful situation was avoided. □

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