EVALUATION OF CHEMICAL DOT THERMOMETERS FOR MEASURING BODY TEMPERATURE OF ORALLY INTUBATED PATIENTS

By Patricia Potter, RN, PhD, CMAC, Marilyn Schallom, RN, MSN, CCRN, CCNS, Susan Davis, RN, MSN, BC, CS-MSCNS, CCRN, Carrie Sona, RN, MSN, CCRN, CS-MSCNS, and Maryellen McSweeney, PhD. From Barnes Jewish Hospital (PP, MS, SD, CS) and St Louis University (MM), St Louis, Mo.

• BACKGROUND Recent research indicates that oral measurement of body temperature is a reliable option in orally intubated patients. In situations such as protective isolation, where dedicated electronic thermometers are not available, are single-use chemical dot thermometers an acceptable alternative?

• OBJECTIVE To determine the accuracy of single-use chemical dot thermometers in orally intubated adult patients.

• METHODS Subjects included a convenience sample of 85 adult patients admitted to 1 of 2 intensive care units (surgical trauma and neuroscience). For each patient, oral temperatures were measured concurrently (within 5 minutes) with a chemical dot thermometer and an electronic thermometer. The sequence of temperature measurements was alternated with each subsequent patient. Both thermometers were placed in the same posterior sublingual pocket opposite the side of the endotracheal tube.

• RESULTS Measurements obtained with electronic and single-use chemical dot thermometers correlated strongly ($r = 0.937$). With the chemical dot thermometer, body temperature was overestimated in 11.8% of the measurements and underestimated in 10.8% of the measurements by 0.4°C or more. The difference between oral temperatures measured with the 2 different thermometers was not related to the patient’s age, sex, or sublingual pocket location or to the order of thermometer use.

• CONCLUSION The chemical dot thermometer is useful and reliable for measuring body temperature of orally intubated patients. When measurements of body temperature have important consequences for decisions about treatment, clinicians should use an electronic thermometer to confirm measurements made with a chemical dot thermometer. (American Journal of Critical Care. 2003:12:403-408)

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A ccurate measurements of body temperature are essential in the clinical management of critically ill patients. Clearly, the thermistor in a pulmonary artery catheter that senses the temperature of mixed venous blood provides the best measurement of core body temperature. However, a pulmonary artery catheter is used only when continuous hemodynamic monitoring is necessary.1 Thus, when a pulmonary artery catheter is not used, another method for measuring body temperature is needed. The oral method is more convenient than other methods, yet it has typically been avoided in orally intubated patients because it is thought to lead to inaccurate results, as patients who are intubated cannot close their mouths completely.2,3
Despite the general thinking that oral measurements of body temperature are inaccurate in orally intubated patients, findings from 4 different studies in which electronic thermometers were used to measure oral temperature in such patients have refuted this assumption. Using electronic thermometers, Cashion and Cason compared differences between oral and rectal temperatures preoperatively before subjects were intubated and after cardiac surgery when subjects were intubated. Although mean differences between oral and rectal temperatures were smaller during intubation than before intubation, the differences between temperatures obtained orally and rectally with and without an endotracheal tube in the oral site were not significant. Findings from the study supported use of the posterior sublingual pocket for temperature measurement in orally intubated patients. However, Cashion and Cason used a small sample size (N = 15) and did not control sequencing of oral-rectal measurements.

Fallis et al compared oral temperatures with reference temperatures obtained with a pulmonary artery catheter at 3 measurement times during a thermally dynamic 8-hour period in intubated patients. Mean oral temperatures were not statistically or clinically significantly different from mean reference temperatures at any of the times. Correlations between oral and reference temperatures were significant (r = 0.92) for each of the 3 measurement times, thus supporting the use of the posterior sublingual pocket for measurement of temperature in orally intubated patients.

A comparison of oral, rectal, axillary, and tympanic membrane temperatures obtained immediately before and after removal of an endotracheal tube also supported use of oral measurements in orally intubated patients. Differences between oral temperatures measured with and without an oral endotracheal tube in place were statistically, but not clinically, significant. Oral temperatures were generally higher with the endotracheal tube in place. Studying the relationship between the simultaneous measurements of oral temperatures and temperatures measured with a pulmonary artery catheter in orally intubated patients, Goalen found that mean oral and pulmonary artery temperatures did not differ significantly. Furthermore, measurements from the 2 sites correlated highly (r = 0.97).

If oral measurement of temperature is an appropriate method for assessing body temperature in intubated patients, what is the reliability of alternative devices? Oral temperature can be measured by using mercury-in-glass thermometers, electronic thermometers, and single-use chemical dot thermometers. The hazards of mercury in the workplace have been a driving force to seek alternatives to mercury-in-glass thermometers. Electronic thermometers are an acceptable alternative to the reference standard mercury-in-glass thermometers. Single-use chemical dot thermometers are an easy-to-use, compact, and disposable alternative to electronic thermometers. Mazur et al found that chemical dot and electronic thermometers are clinically similar. The use of an electronic thermometer may become a problem when patients require protective isolation. Unless an electronic thermometer is dedicated to a patient’s room, it must be cleaned between uses. Often, clinical areas do not have a sufficient number of electronic thermometers for all patients’ rooms. The question becomes whether single-use chemical dot thermometers are accurate when used to measure the body temperature of orally intubated patients.

Erickson et al reported that single-use chemical dot thermometers provide rough temperature estimates in nonintubated critically ill adults and children. When compared with electronic thermometers, single-use chemical dot thermometers led to underestimation of oral temperature by 0.4°C or more in 48% of adult subjects. This finding was disturbing because the accuracy of electronic thermometers has been established in numerous studies. Because use of the chemical dot thermometers resulted in underestimation of body temperature, Erickson et al recommended that these thermometers be used only for screening. To date, the accuracy of single-use chemical dot thermometers in measuring the body temperature of orally intubated patients has not been investigated.

### Methods

#### Subjects and Setting

After approval was received from the appropriate institutional review board, a convenience sample of 86 orally intubated adult patients was recruited from 2 critical care units (surgical trauma and neuroscience) at Barnes Jewish Hospital in St. Louis, Mo. Inclusion
criteria were oral intubation, age 18 years or greater, and admission to 1 of the 2 critical care units designated for the study. Exclusion criteria included oral surgery, oral trauma, and body temperature greater than 40.4°C (as determined with an electronic thermometer). For 21 days, patients were enrolled each day when the clinical specialists made rounds.

**Instruments**

The chemical dot thermometer used in the study (Tempa.DOT Single-Use Clinical Thermometer, 3M Health Care, Borken, Germany) has 50 dots (temperature sensors) on the distal end of a flexible polystyrene plastic strip; each dot represents a temperature increment of 0.1°C over a range of 35.5°C to 40.4°C. The device registers a temperature within 60 seconds and can be read after waiting an additional 10 seconds for a stable measurement; the last dot to turn blue constitutes the body temperature. All of the chemical dot thermometers used in the study were from the same product lot.

The electronic thermometer used as a reference standard for comparison (SureTemp, model 678, Welch Allyn, San Diego, Calif) was calibrated according to the recommendations of the manufacturer before each day’s use. The electronic thermometer was certified to National Institute of Safety Testing accuracy to 0.0015°C. The body temperature determined by the electronic thermometer appears as a digital display; temperatures are recorded in single-degree increments in tenths of a degree Celsius.

**Procedure**

Three clinical nurse specialists who consult on selected intensive care units and had no direct responsibilities for patients’ care collected data for the study. Each was taught the correct use of the thermometers. All subjects had body temperatures measured by the oral route, with both an electronic thermometer and a single-use chemical dot thermometer. All temperatures were measured at least 20 minutes after oral care had been provided to ensure the most accurate readings from both thermometers. The sequence of temperature measurement (first electronic and then chemical dot or first chemical dot and then electronic) was alternated with each subsequent patient. In each patient, both thermometers were placed in the same posterior sublingual pocket opposite the side of the endotracheal tube.11 Measurements were obtained for 1 minute with the chemical dot thermometer and for 20 seconds with the electronic thermometer. After removal of the chemical dot thermometer and a wait of 10 seconds for the color change to stabilize, the value of the last dot to turn blue was recorded. A delay of 5 minutes between the 2 measurements ensured that the sublingual pocket was not physiologically affected by the previous temperature measurement. This delay was a recommendation of researchers from Welch Allyn. Placement of the thermometer in either the right or left posterior sublingual pocket was recorded for each measurement.

**Data Analysis**

Data were analyzed by using a series of correlations and paired t tests. Differences (lack of agreement) between the 2 methods were calculated as the electronic readings minus the chemical dot readings, so that values would be negative when chemical dot readings were higher and positive when they were lower. Temperature differences were reported as means and SDs. The 95% CI was calculated to indicate the range most likely to include the true population mean. Power analysis indicated that a sample size of 38 patients on each intensive care unit was needed for an approximately 96% chance to detect a 0.3°C temperature difference at the .05 level of significance. For the combined sample of 85 patients, there was a 99% chance to detect a 0.3°C temperature difference at the .05 level of significance. The 0.3°C temperature difference was determined to be clinically significant.9 The correlations between temperature differences and order of thermometer measurement, sublingual pocket location, subject’s age, and subject’s sex were determined.

**Results**

Of the 86 subjects originally enrolled, 1 had a body temperature of 42.1°C and thus was excluded from the study because the chemical dot thermometer cannot register a body temperature greater than 40.4°C. As a result, the sample consisted of 85 adult patients from 17 to 91 years old. Fifty-six percent of the subjects were male. The predominant medical conditions for which the patients were hospitalized included aortic aneurysm, bowel obstruction, abdominal trauma, intracerebral hemorrhage, and closed head injury.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intensive care unit</th>
<th>Pooled sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of subjects</td>
<td>Surgical</td>
<td>Neuroscience</td>
</tr>
<tr>
<td>Correlation</td>
<td>0.908</td>
<td>0.957</td>
</tr>
<tr>
<td>Mean difference, °C</td>
<td>0.0128</td>
<td>-0.0132</td>
</tr>
<tr>
<td>Paired t</td>
<td>.267</td>
<td>-.263</td>
</tr>
<tr>
<td>P</td>
<td>.79</td>
<td>.79</td>
</tr>
</tbody>
</table>

**Table 1 Comparison of temperature measurements obtained with single-use chemical dot and electronic thermometers**
A comparison of the performance of the 2 thermometers is given in Table 1. The differences between measurements ranged from 1.2°C to -0.50°C (Table 2). The temperature readings of the patients sampled provided sufficient variability outside the range of 36°C to 38°C. The temperatures measured were from 35.7°C to 40.4°C for the chemical dot thermometer and from 35.9°C to 41°C for the electronic thermometer. The true upper range of body temperatures for the chemical dot thermometers is unknown because the thermometer cannot detect temperatures that exceed 40.4°C. The mean of the differences was 0.001°C (SD = 0.318°C; \( t_{84} = .034, P = .97; 95\% \text{ CI }, -0.061°C \text{ to } +0.070°C \)). Both the test and the 95% confidence interval indicate no significant difference between the chemical dot and electronic thermometers at the .05 level of significance. The correlation between the measurements obtained with electronic and single-use chemical dot thermometers was high (\( r = 0.937 \)) at the .01 level of significance. Results for the separate units showed similarly high correlations and no statistically significant differences between the 2 types of measurements (Table 2). However, almost 25% of all chemical dot thermometer readings either were over- or underestimates (11.8%) or underestimates (10.8%) by 0.4°C or more relative to the electronic readings. In one instance, the measurement obtained with the chemical dot thermometer was an underestimate of 1.2°C because chemical dot thermometers cannot detect temperatures greater than 40.4°C. The magnitude of differences between measurements obtained with the 2 thermometers was not associated with any measured variable, including patient’s age, patient’s sex, sublingual pocket location, order of thermometer measurement, or nurse specialist who measured the temperature.

**Discussion**

Measurements of body temperature of orally intubated patients obtained with the single-use chemical dot thermometer correlated strongly with measurements obtained with the electronic thermometer. The single-use chemical dot thermometer is a practical option for measuring body temperature in intubated patients. It is compact, easy to use, and has negligible risk of infection. However, the tendency for body temperature to be both overestimated and underestimated when a chemical dot thermometer is used suggests that the device may lack specificity for detecting fever. The risk of potentially false-positive readings could trigger the initiation of unnecessary antibiotic therapy. False-negative readings could delay treatment response. The problem of temperature underestimation is potentiated by the fact that the upper limit of the chemical dot thermometer may be exceeded by patients who are critically ill. This scenario occurred in 3 patients (2 excluded initially from the study, 1 excluded after enrollment in the study) whose temperatures exceeded 40.4°C. Lack of specificity in detecting fever can interfere with appropriate decisions about treatment.

**Table 2** Differences between electronic and chemical dot thermometer readings*

<table>
<thead>
<tr>
<th>Differences (electronic - chemical), °C</th>
<th>Frequency</th>
<th>% difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.50</td>
<td>6</td>
<td>7.1</td>
</tr>
<tr>
<td>-0.40</td>
<td>4</td>
<td>4.7</td>
</tr>
<tr>
<td>-0.30</td>
<td>11</td>
<td>12.9</td>
</tr>
<tr>
<td>-0.20</td>
<td>6</td>
<td>7.0</td>
</tr>
<tr>
<td>-0.10</td>
<td>13</td>
<td>15.3</td>
</tr>
<tr>
<td>0.00</td>
<td>8</td>
<td>9.4</td>
</tr>
<tr>
<td>0.10</td>
<td>14</td>
<td>16.5</td>
</tr>
<tr>
<td>0.20</td>
<td>9</td>
<td>10.6</td>
</tr>
<tr>
<td>0.30</td>
<td>5</td>
<td>5.9</td>
</tr>
<tr>
<td>0.40</td>
<td>3</td>
<td>3.6</td>
</tr>
<tr>
<td>0.50</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>0.60</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>0.70</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>0.80</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>1.20</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Negative value indicates overestimation; positive value, underestimation.

No differences were found between temperatures taken with the 2 thermometers.

**Chemical dot thermometers are useful and reliable screening tools for orally intubated patients.**

Chemical dot thermometers are useful and reliable screening tools for orally intubated patients.

If chemical dot thermometers are to be introduced to a clinical area, the risk of user variability increases as more clinicians measure body temperature. Six data collectors were used in the study by Erickson et al. in which 52% of the subjects had temperature variations of ±0.4°C. Our study involved only 3 data collectors. With the widespread use of chemical dot thermometers within a care unit, greater user variability is likely. This caveat applies to the use of any type of ther-
mometer, but this factor must be considered when chemical dot thermometers are chosen as an alternative and in planning for appropriate staff education.

The correlation between measurements obtained with the electronic and chemical dot thermometers provides confidence in using the chemical thermometer in orally intubated patients when more accurate methods are impractical because of concerns about infection control or safety. The chemical dot thermometer can be a useful screening tool. However, when temperature values have important consequences for decisions about treatment, clinicians should use an electronic thermometer to confirm the measurements obtained with a chemical dot thermometer. If chemical dot thermometers are chosen for use in a clinical site, nursing and medical staff must understand the limitations of the device and should receive training on proper thermometry technique.

This study was the first to investigate use of chemical dot thermometers in intubated patients, so further investigation in a variety of intensive care settings would be valuable. Because no attempt was made to measure patients’ body temperature by way of mixed venous blood via a pulmonary artery catheter, a study comparing chemical dot, electronic, and pulmonary artery catheter measurements of body temperature would also be useful.

ACKNOWLEDGMENTS

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REFERENCES

Study Synopsis: This study examined the accuracy of the single-use chemical dot thermometer in orally intubated adult patients. In a convenience sample of 85 adult ICU patients, temperature readings were measured concurrently with an oral chemical dot thermometer and an electronic thermometer and then compared. Results revealed a high correlation between the temperature readings ($r = .937$). However, there was an overestimation of body temperature in 12% of the chemical-dot thermometer readings and an underestimation of 0.4°C in 10% of the readings. The results of the study demonstrate that the chemical dot thermometer is useful and reliable in screening body temperatures of orally intubated patients; however, confirmatory readings should be obtained using an electronic thermometer when temperature readings have direct consequences for clinical treatment decisions.

Information From the Authors: Patricia Potter, PhD, RN, lead author of this journal club article, provided additional information about the study. Potter explained that the impetus for conducting the study was based on previous research conducted at their hospital. Potter shares, “Our hospital conducted a study comparing chemical dot thermometers with electronic thermometers in adult medical-surgical patients. That study showed a correlation between the 2 instruments but found overestimation and underestimation of measures. As a result, recommendations were made to use the chemical dot thermometer for screening. Our ICU clinical nurse specialists had read the article by Fallis on using oral thermometers with intubated patients. So, there was a natural leap of logic to test the disposable thermometers in intubated patients.”

According to Potter, there were no real difficulties encountered in conducting the study. Potter explains, “An in-service was conducted for the 3 data collectors. Emphasis was placed on the wait time to ensure accurate recording of the chemical dot thermometer. Guidelines outlining the steps for temperature measurement were provided to the data collectors and reviewed.” Potter relates that all data were collected over a 3- to 4-week period and that “the age range was 17 to 91 years and the average age of subjects was 54 years.”

Implications for Practice: According to the study results, the disposable chemical dot thermometer offers a reliable option for measuring body temperature in orally intubated patients. Potter explains, “The device can be extremely useful for patients on protective isolation who may not have a dedicated electronic thermometer available for use.” However, Potter stresses that the chemical dot thermometer should only be used for screening purposes since the study found overestimations and underestimations of body temperature when using the thermometer. Potter shares, “It is important to assess all clinical symptoms of a patient. If a patient is at high risk for febrile or hypothermic conditions or demonstrates clinical signs of a temperature alteration, an electronic thermometer is probably the best choice for temperature measurement.” Highlighting that additional research is needed, Potter concludes: “Replication of the study would be valuable in other critically ill patient populations.”

Journal Club feature commentary is provided by Ruth Kleinpell.