Body temperature of patients in critical care units can be monitored with a variety of devices and at a variety of body sites. In recent years, monitoring of urinary bladder temperature has become more common. Temperature-sensing indwelling urinary catheters allow continuous drainage of urine and continuous measurement of body temperature. This article provides a comprehensive and critical review of research undertaken in intensive care units to compare body temperatures measured in the urinary bladder with temperatures measured at a core site, the pulmonary artery. The studies support the use of urinary bladder temperature as a reliable index of core temperature during times of thermal stability. For critically ill patients who are already under considerable stress and whose condition necessitates the use of an indwelling urinary catheter, bladder temperature monitoring is an easy and convenient method that eliminates the need to use alternative sites. Further studies on the effects of shivering and urinary flow rate on temperatures measured in the bladder in critical care patients are needed. The economics of monitoring urinary bladder temperature also should be studied. (American Journal of Critical Care. 2001;10:38-47)
A database search revealed that no systematic review of the literature on monitoring of urinary bladder temperature had been published. In this article, I provide a comprehensive and critical review of research undertaken in ICUs to compare body temperatures measured in the urinary bladder with temperatures measured at a core site, the pulmonary artery. The ICU is an ideal clinical area for this comparison. Many ICU patients require a pulmonary artery catheter for hemodynamic monitoring and an indwelling catheter for urine drainage. In critically ill patients, insertion of a urinary catheter is considered justified, and continued catheterization is justified when close monitoring of urine output is required. Further, critically ill patients often provide a wide range of temperature measurements, particularly immediately after open heart surgery.

**Criteria for Selection of Articles**

Before undertaking the review, I selected criteria to delimit the literature search. Publications had to be in English, and the subjects studied had to be adults with temperature-sensitive urinary bladder catheters in place. Further, subjects had to be in an intensive care setting, and temperatures at the bladder site had to be compared with core temperatures measured in the pulmonary artery. Unless otherwise noted, reported values are means, with the associated SDs in parentheses.

Temperature-sensing bladder catheters were initially described in the literature approximately 2 decades ago, so only publications from 1980 and later were sought. Various databases were used to locate relevant published and unpublished studies. These included MEDLINE, Current Contents, Cumulative Index for Nursing and Allied Health (CINAHL), and Pro Quest Digital Dissertation Abstracts. The reference sections of relevant articles provided additional sources. Key words used in the search were bladder temperature, pulmonary artery temperature, body temperature, intensive care, and critical care. In total, 8 studies met the just-described criteria, and all were included in the review.

**Background**

Urinary production is the result of continuous filtration of plasma through the kidneys, which receive approximately 20% to 25% of the cardiac output. Normally, less than 1% or approximately 1500 mL of the 180 L of plasma filtered daily leaves the body as urine. However, this quantity can vary between 600 and 2500 mL/d. Urine leaving the kidney flows through the ureters, which are approximately 30 cm long, before entering the bladder. Although micturition is the normal process through which urine is eliminated from the body, in many hospitalized patients, this process is aided by means of an indwelling urinary catheter. The addition of a thermistor or thermocouple within an indwelling catheter results in a device that serves a dual purpose. The catheter tip floats in the urine contained within the bladder, providing a urine temperature that is displayed continuously on a bedside monitor. Simultaneous urine drainage and body temperature measurements are thus provided.

**Urinary Bladder Temperature: Advantages and Disadvantages**

Urinary bladder temperature has characteristics similar to those of rectal temperature, perhaps because of the proximity of the bladder to the rectum. When core temperature changes, a delay occurs before bladder temperature also changes, although the delay is not as pronounced as the delay before rectal temperature changes. These delays are particularly apparent when core temperature is changing rapidly. The low blood flow in the pelvis and the thermal insulation in this region may account for these characteristics. Consequently, bladder temperature is not considered a true measure of core temperature, but rather an intermediate measure, responding to changes in core temperature faster than rectal and skin temperatures respond, but slower than esophageal and nasopharyngeal temperatures do.

Although bladder temperature shows inertia during times of dynamic thermal changes, the bladder has distinct advantages and uses. Measurement of bladder temperature is convenient, reliable, and safe and is a good estimate of core temperature. Measuring bladder temperature is useful during intensive care management and as a substitute for measuring pulmonary artery temperature. Because of the frequency of hypothermia in the operating room during anesthesia and surgery, measurement of bladder temperature is also useful as an indicator of rewarming, particularly in cardiac surgery patients.

A distinct advantage of using the bladder for temperature measurement, when an indwelling catheter has been inserted for continuous urinary drainage, is that doing so causes no additional discomfort for the patient. Insertion of a temperature-sensitive indwelling catheter eliminates the need to use other sites for temperature measurement and allows both an exact measurement of urine output and a continuous measurement of body temperature. Measurement of bladder temperature is particularly useful in critically ill patients such as...
those with extensive burns\textsuperscript{19} or severe head injuries and in patients who have undergone neurosurgery or surgery for head and neck cancer.

Disadvantages include the need to use a special catheter and monitoring system, which often are not available outside the ICU or operating room.\textsuperscript{16,17} The additional cost of these special catheters\textsuperscript{13} also is a drawback. The decreased need for alternative temperature-taking methods and the nursing time saved may outweigh this cost; however, these factors have not been investigated.

### Bladder Temperature Compared With Pulmonary Artery Temperature

The pulmonary artery is the site of mixed venous blood coming from the warm viscera and the generally cool skin. In clinical studies, pulmonary artery temperature is often used to represent core body temperature, and in thermally dynamic states, pulmonary artery temperature responds faster than esophageal or nasopharyngeal temperatures to changes in core temperature.\textsuperscript{14,20,21} Because pulmonary artery temperature is considered the optimal representation of internal body temperature,\textsuperscript{11,22} or the reference standard for measurement of core temperature, urinary bladder temperature was compared with pulmonary artery temperature for this review. However, as discussed later, shivering\textsuperscript{23} and urinary flow rate\textsuperscript{8} may influence the relationship between bladder and pulmonary artery temperatures.

### Bladder Temperatures in the ICU

Eight studies that compared urinary bladder and pulmonary artery temperatures in critical care patients were reviewed. Each study was reviewed for its sampling method, sample size and demographics (age, sex), procedure, and results, including the results of instrument testing. The conclusions drawn by the author or authors were noted, as were the limitations of the study. In several studies, temperature in the urinary bladder was compared with temperature in the rectum, no doubt because of the anatomic proximity of the 2 sites and their similar temperature responses. If rectal temperature measurements were provided, and if inclusion of this information was pertinent to the understanding of bladder temperature performance, it was reported in the review. A synthesis of the information from the 8 studies follows the review and critique of each study. Summary information also is provided in the Table.

Ilsley et al,\textsuperscript{22} who studied a small sample of vascular surgery patients in the immediate postoperative period, reported a nonsignificant difference between bladder and pulmonary artery temperatures. Although Ilsley et al recommended the bladder as a site suitable for temperature measurement because of the consistent gradients between bladder temperature and pulmonary artery temperature, their report did not include the range of temperature differences between the bladder and the reference pulmonary artery. Limitations of this study include the extremely small sample size, the minimal demographic information, the limited procedural information (eg, the timing and frequency of measurements per subject were not reported), and the use of multiple nurses as data collectors. Because of these limitations, the results of this study must be viewed with caution.

In another study, Moorthy et al\textsuperscript{9} evaluated bladder temperature as an indicator of core body temperature. The number of data collectors was not reported. Using repeated-measures analysis of variance, Moorthy et al noted a nonsignificant difference between mean pulmonary artery temperature and bladder temperature. Although they concluded that bladder temperature was representative of core temperature in the steady state, they did not report the range of patients’ body temperatures or, more importantly, the range of differences between the pulmonary artery and bladder temperatures. A larger sample size and the testing of catheters after their removal from patients would have enhanced the validity of the study findings.

Using pulmonary artery temperature as a reference, Mravinac et al\textsuperscript{25} compared temperatures at that site with bladder and rectal temperatures in hypothermic patients after cardiac surgery. Multiple data collectors recorded the temperatures. Repeated-measures analysis of variance indicated a significant difference between temperatures measured at the 3 sites over time ($P<.001$). The higher correlation at each time point between pulmonary artery and bladder temperatures ($r = 0.78$ to $0.94$, $P<.01$) than between pulmonary artery and rectal temperatures ($r = 0.49$ to $0.82$, $P<.01$) led to the conclusion that bladder temperature provided a better representation of core temperature than did rectal temperature. Further, bladder and pulmonary artery temperatures varied similarly. The sample size is a strong point of this study. Additional statistical testing to determine which temperature site in particular differed from the pulmonary artery site would have been beneficial. Whether patients were shivering when cool was not reported. Shivering, if it was present, may have accounted for the change in the relationship between pulmonary artery and bladder temperatures observed once normothermia was reached.\textsuperscript{23} Omission of tests of interrater reliability and catheter accuracy are limitations of this study.
Table 1  Studies comparing pulmonary artery and urinary bladder temperatures in intensive care patients

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Procedure</th>
<th>Results</th>
<th>Instrument testing</th>
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<tbody>
<tr>
<td>Ilsley et al (1983)&lt;sup&gt;24&lt;/sup&gt;</td>
<td>N=5 Patients after vascular surgery Age and sex not reported</td>
<td>PAT and UBT compared for 24 hours after normothermia reached*</td>
<td>Mean UBT higher than PAT by 0.27°C (SD, 0.18°C) Range of differences, -0.5°C to +0.9°C</td>
<td>Catheters tested upon removal Accuracy within ±0.2°C of reference thermometer</td>
</tr>
<tr>
<td>Moorthy et al (1985)&lt;sup&gt;9&lt;/sup&gt;</td>
<td>N=12 6 men (mean age, 55 years), 6 women (mean age, 59.7 years) Patients after cardiac surgery 10 patients with measurements in postoperative period</td>
<td>Data collected hourly for first 6 hours and then every 2 hours for 10 hours* 11 measures per subject</td>
<td>Mean PAT, 37.2°C (SD, 0.1°C) Mean UBT, 37.1°C (SD, 0.1°C)</td>
<td>Instruments calibrated by using probe simulator Accuracy of pulmonary artery and bladder catheters not assessed after removal</td>
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<tr>
<td>Mravinac et al (1989)&lt;sup&gt;25&lt;/sup&gt;</td>
<td>N=55 39 men, 16 women Hypothermic patients after cardiac surgery Age, 34-84 years (mean, 65.1 years)</td>
<td>PAT, UBT, and RT recorded every hour for up to 7 periods until normothermia reached* 4-7 measures per subject</td>
<td>Gradual increase in mean hourly PAT (33.53°C to 37.23°C) and UBT (33.52°C to 37.25°C) Mean range of differences, 0.01°C to 0.26°C for the 7 time periods (calculated) Mean PAT higher than UBT until normothermia, then UBT (37.25°C [SD, 0.29°C]) higher than PAT (37.23°C [SD, 0.31°C])</td>
<td>Recording devices calibrated before data collection Accuracy of catheters not assessed after removal</td>
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<tr>
<td>Nierman (1991)&lt;sup&gt;7&lt;/sup&gt;</td>
<td>N=15 7 men, 8 women Patients in medical ICU Mean age, 78 years (SD, 6 years)</td>
<td>PAT and UBT recorded every 4 hours from time of insertion of pulmonary artery catheter to time of removal* Temperatures for first 32 hours analyzed 9 measures per subject</td>
<td>Mean PAT, 37.69°C (SD, 0.34°C) Mean UBT, 37.74°C (SD, 0.35°C) Mean PAT-UBT difference, -0.04°C (SD, 0.27°C)</td>
<td>Instruments compared with each other but not with reference thermometer</td>
</tr>
<tr>
<td>Earp and Finlayson (1991)&lt;sup&gt;26&lt;/sup&gt;</td>
<td>N=14 13 men, 1 woman Patients after cardiac surgery Age, 40-70 years (mean, 59.4 years)</td>
<td>PAT and UBT recorded every 15 minutes for 6 hours between 11 AM and 6 PM 25 measures per subject</td>
<td>Mean PAT range, 35.19°C (SD, 0.82°C) to 37.46°C (SD, 0.58°C) Mean UBT range, 35.40°C (SD, 0.80°C) to 37.60°C (SD, 0.54°C) Range of differences, 0.00°C to 0.22°C (SD not reported)</td>
<td>Accuracy of catheters not assessed after removal</td>
</tr>
<tr>
<td>Author</td>
<td>Sample</td>
<td>Procedure</td>
<td>Results</td>
<td>Instrument testing</td>
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<tr>
<td>Earp and Finlayson</td>
<td>N=37</td>
<td>PAT and UBT recorded every 15 minutes for 6 hours between 11 AM and 6 PM for 25 measures per subject</td>
<td>Range of temperatures on admission: PAT, 35.33°C to 35.85°C UBT, 35.52°C to 36.15°C At end of 6 hours: PAT, 36.80°C to 37.59°C UBT, 36.70°C to 37.44°C</td>
<td>Accuracy of catheters not assessed after removal</td>
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<td></td>
<td>32 men, 5 women</td>
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<td>Shivering (n=28) and nonshivering (n=9) patients after cardiac surgery</td>
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<td>Age, 40-73 years (mean, 59.9 years)</td>
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<tr>
<td>Erickson and Kirklin</td>
<td>N=38</td>
<td>PAT and UBT recorded every 20 minutes for 4 hours* for 12 measures per subject</td>
<td>Mean UBT, 0.03°C (SD, 0.23°C) higher than PAT Range of differences, -0.7°C to +0.8°C In normothermic patients (&gt;37°C), mean UBT, 0.14°C (SD, 0.20°C) higher than PAT In cool patients (&lt;36.5°C), mean UBT 0.11°C (SD, 0.19°C) lower than PAT</td>
<td>Samples (3) of each catheter used in study tested Mean error of: standard and fiber-optic pulmonary artery catheters, 0.03°C to 0.07°C and -0.10°C to 0.02°C respectively; bladder catheters, -0.04°C to 0.05°C</td>
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<tr>
<td></td>
<td>27 men, 11 women</td>
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<td>ICU patients, 28 with temperature-sensing bladder catheters</td>
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<td>Age, 30-78 years (mean, 64.4 years; SD, 9.4 years)</td>
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<tr>
<td>Erickson and Meyer</td>
<td>N=50</td>
<td>PAT and UBT recorded on one occasion* for 10 measures per subject</td>
<td>Range of PAT, 34.2°C to 38.8°C Mean difference between the 2 sites, 0.02°C (SD, 0.18°C) Range of differences -0.6 to + 0.3°C In cool patients (&lt;36°C), PAT higher than UBT by mean of 0.14°C (SD, 0.20°C) In patients with temperatures between 36.0°C and 36.9°C, PAT was lower than UBT by 0.01°C (SD, 0.12°C) In patients with temperatures between 37.0°C and 37.9°C, PAT was lower than UBT by 0.11°C (SD, 0.17°C) In patients with temperatures between 38.0°C and 38.8°C, no difference between PAT and UBT (mean, 0.00°C; SD, 0.00°C)</td>
<td>Samples (3) of each catheter used in study tested Mean error of: standard and fiber-optic pulmonary artery catheters, 0.04°C (SD, 0.05°C) and -0.03°C (SD, 0.09°C), respectively; bladder catheters, -0.00°C (SD, 0.05°C)</td>
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<td></td>
<td>36 men, 14 women</td>
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<td>ICU patients (hypothermic and febrile patients included) 21 patients with temperature-sensing bladder catheters</td>
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<td>Age, 27-83 years (mean, 58.2 years; SD, 13.4 years)</td>
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ICU indicates intensive care unit; PAT, pulmonary artery temperature; RT, rectal temperature; UBT, urinary bladder temperature. *Temperatures also recorded at additional sites.
Nierman compared pulmonary artery and bladder temperatures in patients admitted to a medical ICU. Using Bland and Altman’s technique for assessing agreement between methods of measurement, he found good agreement between temperatures measured at these 2 sites throughout the monitoring period. Nierman concluded that pulmonary artery and bladder thermometer catheters provided consistent and highly reliable measures of core temperature in ICU patients. A larger sample size and measures of interrater reliability would have enhanced the validity of the findings.

The preliminary and completed findings of a study of the relationship between pulmonary artery and bladder temperatures during the rewarming phase in patients in the ICU after hypothermic cardiac surgery were reported in 2 separate publications. In the preliminary study by Earp and Finlayson, data were collected by one data collector, and participants’ hemodynamic status was stable. Mean bladder temperatures were generally higher than pulmonary artery temperatures except for 3 measurement times when bladder temperature was lower by 0.03°C to 0.04°C. Significant differences (P<.05) occurred at 11 time points; 24 of the 25 measures had differences of 0.17°C or less. The authors found a strong positive relationship, as indicated by correlation coefficients of 0.94 to 0.99, between the measurements at these 2 sites. Both pulmonary artery and urinary bladder temperatures were recommended as effective measures for evaluating body temperature during rewarming of patients after cardiac surgery, and it was suggested that both be used in order to provide a better index of core temperature. Unfortunately, the omission of catheter testing after removal makes it impossible to determine whether the differences in temperature detected in the study are true differences or are due to catheter error.

In the final results presented by Earp and Finlayson, the thermal gradient between pulmonary artery and urinary bladder temperatures in shivering and nonshivering patients was assessed. Shivering was recorded by using both an electromyogram and a 4-point observational scale. Interestingly, for the nonshivering group (24%), bladder temperature generally stayed higher than pulmonary artery temperature. This relationship was reversed in the shivering group (76%), resulting in pulmonary artery temperatures that were significantly higher than bladder temperatures (P<.03). Shivering occurred from 75 minutes to 5 hours after admission, with between 1 and 13 patients shivering at each measurement time. The authors concluded that urinary bladder temperature is a reliable index of core temperature for hypothermic patients and suggested that it also could serve as an adjunct to pulmonary artery temperature. Unfortunately, catheters were not tested for accuracy after removal; rather, the investigators relied on manufacturers’ reports. Further, although 1 of the study’s purposes was to determine whether urinary bladder and pulmonary artery temperature gradients were related to shivering, the ratio was reported, but the gradients were not reported. Moreover, it is unclear which shivering scale was used in the analysis of the shivering data. The use of a single data collector in this and the authors’ earlier study decreases the variation in measurement and procedure that may occur with multiple data collectors.

Bladder temperature generally corresponded well to reference pulmonary artery temperature in the 2 final studies reviewed. Using 2 experienced critical care nurses as data collectors, Erickson and Kirklin compared temperatures measured at 4 routine sites with pulmonary artery temperature. When compared with mean pulmonary artery temperature, bladder temperature was significantly higher (P<.01). Much like Mravinac et al, Erickson and Kirklin noted that when patients were normothermic (>37°C), mean bladder temperature exceeded pulmonary artery temperature. However, this relationship was reversed when patients were cool (<36.5°C), with mean bladder temperature lower than pulmonary artery temperature. The presence or absence of shivering was not reported. The possible effect of time on measurements of bladder and pulmonary artery temperatures was not examined.

Erickson and Meyer, in a complex study using a cross-sectional repeated-measures design, compared multiple ear-based temperatures with temperatures measured at various sites, including the pulmonary artery and the bladder. Three critical care nurses collected data. Bladder temperature was nearly identical to pulmonary artery temperature at each measurement time, and high correlations (r=0.99) were noted. Patients in the coolest range of temperature (<36°C) had pulmonary artery temperatures that were higher than bladder temperatures. In comparison, patients with temperatures between 36.0°C and 37.9°C had pulmonary artery temperatures that were lower than bladder temperature (P<.01). For patients in the 38.0°C to 38.8°C range, temperatures measured at the 2 sites did not differ. The prevalence of shivering was not reported. Although randomized order of measurement was used to eliminate order effect, the multiple sequences possible when 10 measurements are taken but only 50 subjects are used does not provide equal
representation to all the orders. Testing of catheters after removal and reporting of interrater reliability would have enhanced the validity of the findings in both this study and the study undertaken earlier by Erickson and Kirklin.

Discussion

Bladder temperature was compared with pulmonary artery temperature among ICU patients in 8 studies. Patients were from 27 to 84 years old, and both sexes were included in each study. In addition, measurements of bladder temperature from close to 34°C to almost 39°C were assessed. All studies used convenience sampling and natural circumstances; none were experimental in design. In all but 1 study, repeated measurements of temperature were collected over time, with data collection varying from 4 hours to 24 hours and 32 hours. The possible effect of circadian rhythm was not addressed in the studies of extended duration. Only half of the studies had more than 30 subjects; sample sizes of 15 or fewer were used in the remaining studies. Small sample sizes limit the use of inferential statistics and generally result in a nonnormal distribution of data. Some studies, however, had large data sets resulting from multiple measurements of subjects.

In general, the instruments (catheters and monitors) used to measure pulmonary artery and bladder temperatures were not well described. In 2 studies, the manufacturers’ reports of the instruments’ accuracy was relied upon, and although this practice is common in the clinical area, it is generally not acceptable in research. In order to determine if the temperature differences between measurement sites reflect true differences or are due to error, at a minimum, information about the instrument’s accuracy and resolution, the smallest increment in a quantity that can be measured with certainty, is required. It is not feasible to pretest disposable pulmonary artery and bladder catheters, which must be sterile when inserted. However, accuracy of catheters can be assessed after they are removed. In only 1 study were catheters tested after removal. When instrument validity is not assessed, the validity of the study’s findings is open to question.

Although sites that both accurately reflect core temperature and have minimal variability are the ideal, Erickson and Kirklin note that some variability is to be expected with clinical measurements. This variability may be due to the patient or the environment, or it may be a result of factors related to the measurement technique. Further, the accuracy of temperature measurements does not have to be absolute but must be sufficient for detection of clinically important changes in core temperature. Although empirical studies to determine what

is a clinically significant change in temperature have not been done, temperature differences between ±0.2°C and ±0.5°C have been suggested. With temperature differences of that size, the mean differences (including the SDs) between pulmonary artery and urinary bladder temperatures reported in all 8 studies, except for the second study by Earp and Finlayson, would not be considered clinically significant. The second study by Earp and Finlayson was the only study in which shivering of patients was reported.

Overall, bladder temperature was similar to or slightly higher than pulmonary artery temperature when patients were normothermic. This relationship, however, generally was reversed when patients were shivering or cool, resulting in pulmonary artery temperatures that exceeded bladder temperatures. The most likely explanation of this disparity is that shivering and its subsequent production of thermal energy resulted in a transient rapid increase in core temperature that had yet to be reflected in the urinary bladder temperature. Shivering in postoperative patients can produce dramatic increases in oxygen consumption, from 65% to 220%.

Only 1 study was specifically designed to assess shivering. However, shivering may have occurred in other studies as well, in which the sample or subgroups of the sample were reported to be cool. Shivering would account for the change in relationship between pulmonary artery and bladder temperature that occurred when temperatures increased and near normothermia. A lag of bladder temperature behind pulmonary artery temperature in cardiac surgery patients during rapidly induced temperature changes has been reported and may have occurred in these studies when pulmonary artery temperature was increasing quickly because of the thermal energy produced by shivering. Shivering also may have accounted for the range of differences between pulmonary artery and bladder temperatures noted by Erickson and Kirklin, Erickson and Meyer, and Earp and Finlayson. The smaller gradient noted in Earp and Finlayson’s earlier study may have been due to the smaller sample size in that study.

In the studies reviewed, urinary flow rate was not reported. The gradient between bladder and pulmonary artery temperatures may vary with rates of urine flow. Horrow and Rosenberg in a study of patients undergoing cardiac surgery, found that temperature differences between the 2 sites were significantly greater when the urine flow rate was low than when the urine flow rate was high. The occurrence of this phenomenon has not been investigated in ICU patients.

Last, although differences between bladder and core site measurements of body temperature and the variability associated with these measurements are important,
the degree of association between pulmonary artery and bladder temperatures also is noteworthy. Moderate to high correlations of 0.78 to 0.99 between pulmonary artery and urinary bladder temperatures were found in several studies.\textsuperscript{17,23,25} Correlation coefficients, however, do not provide information about the gradient or temperature difference between variables, but only about the strength and direction of the association. Further, the association depends on the range of measurements. The wider the range of the true quantity in the sample, the greater will be the correlation coefficient.\textsuperscript{27}

**Conclusion**

The optimal site for temperature monitoring depends on the goal of monitoring.\textsuperscript{26} and this site may differ depending on the circumstances.\textsuperscript{26} For many patients, temperature plays a prominent role as an indicator of thermal stability or the effectiveness of therapeutic treatments. Frequent or continuous temperature measurement is an important assessment tool in many clinical areas, including the ICU.

Development of a temperature-sensing indwelling catheter has enabled measurement of temperature in the urinary bladder.\textsuperscript{21} In critical care areas, measuring bladder temperature has become a common method of estimating core temperature.\textsuperscript{17} Results of the studies reviewed here support the use of bladder temperature as a reliable index of core temperature in patients who are normothermic (>36.5°C) and in patients with elevated body temperatures (up to 38.8°C). Further, although the relationship between pulmonary artery and urinary bladder temperature reversed when patients were cool (<36.5°C), mean temperature differences between these 2 sites remained clinically insignificant.\textsuperscript{16,17,23,25}

Because many ICU patients have indwelling bladder catheters to assist in management of their acute illness,\textsuperscript{3} the ability to use this device to measure both urine output and continuous body temperature is a distinct advantage. For patients in the ICU who are already under considerable stress and do not have a pulmonary artery catheter in place, using a temperature-sensing bladder catheter eliminates the need to measure temperature at other sites, reducing disturbance of the patient and freeing nursing time as well. Therefore, use of this device for continuous measurement of temperature or for assessing a patient’s response to treatment is suggested for ICU patients who require an indwelling urinary catheter.

Further research is needed to determine what roles shivering and urine flow rate play in the accuracy of measuring urinary bladder temperature in the ICU. Investigation into the cost-effectiveness of temperature-sensing bladder catheters also is required.

**ACKNOWLEDGMENTS**

Sincere appreciation is extended to Dr Karen Thomas, Dr JoAnne Whitney, and Dr Eleanor Bond from the University of Washington School of Nursing for their early review of this manuscript.

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9. Schuhmann MU, Suhr DF, v Gisseln H, Brauser A, Jantzen JP, Samii M. Moderate to high correlations of 0.78 to 0.99 between pulmonary artery and urinary bladder temperatures also is noteworthy. Moderate to high correlations of 0.78 to 0.99 between pulmonary artery and urinary bladder temperatures were found in several studies.\textsuperscript{17,23,25} Correlation coefficients, however, do not provide information about the gradient or temperature difference between variables, but only about the strength and direction of the association. Further, the association depends on the range of measurements. The wider the range of the true quantity in the sample, the greater will be the correlation coefficient.\textsuperscript{27}
CE Test Instructions

To receive CE credit for this test (ID# A021101), mark your answers on the form below, complete the enrollment information, and submit it with the $12 processing fee (payable in US funds) to American Association of Critical-Care Nurses (AACN). Answer forms must be postmarked by January 1, 2004. Within 3 to 4 weeks of AACN receiving your test form, you will receive an AACN CE certificate.

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CE Test Form
Monitoring Urinary Bladder Temperature in the Intensive Care Unit: State of the Science

Objectives
1. Describe how urinary bladder temperature is measured
2. Identify advantages of using bladder temperature in critically ill patients
3. Discuss the correlation of bladder temperature to core site measurements in critically ill patients

Mark your answers clearly in the appropriate box. There is only one correct answer. You may photocopy this form.


Program evaluation
Objective 1 was met
Objective 2 was met
Objective 3 was met
The content was appropriate
My expectations were met
This method of CE is effective for this content
The level of difficulty of this test was:
[ ] easy [ ] medium [ ] difficult
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Form expires: January 1, 2004
Contact hours: 2.0
Passing score: 8 correct (73%)
Test writer: Ruth Kleinpell-Nowell, RN, PhD, CS, CCNS
Category: A
Test Fee: $12
CE Test Questions
Monitoring Urinary Bladder Temperature in the Intensive Care Unit: State of the Science

1. Continuous measurement of core temperature can be provided by all of the following except which method?
   a. Pulmonary artery thermistor catheters
   b. Esophageal probes
   c. Ear probes
   d. Indwelling urinary catheters

2. The thermistor of an indwelling urinary catheter measures temperature at which anatomical location?
   a. Ureter
   b. Bladder
   c. Urethra
   d. Ureter junction

3. Urinary bladder temperature has characteristics similar to temperatures at which other site?
   a. Rectal
   b. Esophageal
   c. Pulmonary artery
   d. Nasopharyngeal

4. Bladder temperature is considered to be which type of temperature?
   a. Core
   b. Superficial
   c. Intermediate
   d. Local

5. Delays in bladder temperature changes are seen in what temperature change pattern?
   a. Slow
   b. Rapid
   c. Elevated
   d. None of the above

6. Which one of the following factors will influence the relationship between bladder and pulmonary artery temperature?
   a. Shivering
   b. Hypothermia
   c. Hyperthermia
   d. Hypotension

7. Research comparing pulmonary artery with bladder temperature readings has found what type of relationship between the two?
   a. Weak positive
   b. Strong positive
   c. Varying
   d. Inverse

8. In patients with cooler temperature ranges (<36°C), how do pulmonary artery temperatures compare with bladder temperatures?
   a. Identical
   b. Higher
   c. Lower
   d. Similar but not equal

9. Temperature differences between bladder and pulmonary artery temperatures have been found to be greater with what type of urine flow rate?
   a. High
   b. Low
   c. Constant
   d. Fluctuating

10. What is not considered a clinically significant change in temperature differences?
    a. Between +0.1°C and +0.3°C
    b. Between +0.2°C and +0.5°C
    c. Between +0.5°C and +0.8°C
    d. Between +0.8°C and +1.0°C

11. Adequate evidence on the advantages of urinary bladder temperature is available on all of the following parameters except which one?
    a. Ease of use
    b. Convenience
    c. Cost-effectiveness
    d. Need for alternative temperature site monitoring
Monitoring Urinary Bladder Temperature in the Intensive Care Unit: State of the Science
Wendy M. Fallis

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