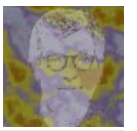

Noninvasive Measurement of Body Temperature in Critically Ill Patients

Q What is the most accurate means of measuring body temperature noninvasively in an adult critical care patient, assuming the patient does not have a pulmonary artery catheter or a temperature-sensing bladder, rectal, or esophageal probe?

A Elizabeth Bridges, RN, PhD, CCNS, and Karen Thomas, RN, PhD, reply:

When evaluating the accuracy and precision of any temperature measurement method, the method should be compared against a "gold standard." In intensive care patients, the pulmonary artery (PA) temperature, which reflects the core temperature, is considered the standard for comparison. Table 1 summarizes studies evaluating the agreement of various noninvasive temperature measurement methods (oral, ear-based, temporal artery, and axillary) with the PA temperature. In previous research,[7,9] a thermometer was considered accurate if the mean difference from the PA temperature was ±0.3°C and precise with a standard deviation ranging from 0.3°C to 0.5°C. As demonstrated in Table 1, the oral, ear-based, and temporal artery measurements are generally equivalent with regard to accuracy, whereas the axillary temperature is an underestimate of the PA temperature. However, the precision varies across methods (oral, SD = 0.24-0.6°C; ear-based, SD = 0.4-0.57°C; temporal artery, SD = 0.5-1.1°C; and axillary, SD = 0.16-0.6°C).

The difficulty in comparing 2 alternative temperature measurement methods (eg, oral, temporal artery, ear-based) is that each measurement has its own error. For example, in a recent review on the evaluation of new fever in critically ill adults, O'Grady et al[17] stated that after invasive methods (PA, esophageal, or bladder), the following methods should be used in this order: rectal, oral, and tympanic. Axillary, temporal artery, and chemical dot thermometers are not recommended. In a subsequent series of letters to the editor,[18] the author stated that temporal artery measurements were not recommended because Lawson et al[9] found that 20% of the temporal artery temperature measurements were greater than ±0.5°C different from the concurrent PA temperature. However, as summarized in Table 1, the bias and precision of the oral and temporal artery methods were similar, and 19% of the oral measurements were also greater than ±0.5°C different from the concurrent PA temperature, suggesting that the 2 methods are comparable.

Similarly, Fetzer and Lawrence[19] recently compared ear-based and temporal artery temperature measurements and reported that the bias between the 2 methods was -0.4 ± 0.64°C (95% CI, -1.29 to 1.21), which is less accurate and precise than either method compared with PA temperature measurement (Table 1). Unlike the studies outlined in Table 1, the difference between the ear-based and temporal artery methods reflects the error in both measurements, and we cannot say

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Table 1 Accuracy and precision of noninvasive temperature measurements compared with pulmonary artery temperature in adult patients in the intensive care unit[a]

Author	Population of patients	No.	Temperature mean or range, °C	Thermometer mode (brand)	Bias (SD), °C	Limits of agreement, °C	
						Lower	Upper
Bock et al[1]	Cardiac surgery	26	33.6-37.6	Ear-based (Exact-Temp)	0.1 (0.3)	-0.4	0.6
Carroll et al[2]	Intensive care unit (ICU)	300	98.6 (1.3)	Oral (model not specified)	1.4 (1.6)	-1.6	4.5
				Temporal artery (Exergen LXTA), forehead	1.0 (1.2)	-1.3	3.3
				Temporal artery (Exergen LXTA), behind ear	0.1 (1.1)	-2.1	2.3
				Temporal artery (Exergen LXTA), forehead plus behind ear	-0.2 (1.1)	-2.3	2.0
Erickson and Kirklin[3]	ICU	38	34.4-38.8	Oral (Temp Plus II, model 2080A, predictive mode)	0.1 (0.3)	-0.5	0.6
				Ear-based (Core Check 2090)	0.1 (0.4)	-0.7	0.9
				Axillary (Temp Plus II, model 2080A, steady state)	-0.7 (0.6)	-1.9	0.5
Erickson and Meyer[4]	ICU	50		Oral (Temp Plus II, model 2080A)	-0.2 (0.6)	-1.4	1.0
				Ear-based (Core Check 2090, First Temp Genius 3000A, ThermoScan PRO-1 IR1, Octotemp 3000)	-0.7 (0.5)	-1.7	0.3
				Axillary (Temp Plus II, model 2080A)	-0.7 (0.6)	-1.9	0.5
Farnell et al[5]	ICU	25	35.0-39.3	Axillary (Tempa.DOT)	0.2 (0.36)	-0.5	0.9
				Ear-based (First Temp Genius 3000A)	0.0 (0.6)	-1.2	1.2
Fullbrook[6]	ICU	60		Axillary (Tempa.DOT)	-0.5 (0.5)	-1.6	1.2
				Ear-based (Diatek 9000 InstaTemp Thermometer)	0.4 (0.3)	-1.2	1.3
Giuliano et al[7]	ICU	102		Oral (Welch Allyn 670)	-0.2 (0.4)	-0.9	0.6
				Ear-based (First Temp Genius 3000A, core)	-0.1 (0.6)	-1.2	1.0
				Ear-based (First Temp Genius 3000A, oral)	-0.5 (0.5)	-1.6	0.5
Henker and Coyne[8]	After cardiac surgery	24	36.2-37.7	Ear-based (Core Check)	0.1 (0.4)	-0.7	0.9
				Ear-based (First Temp Genius)	0.1 (0.5)	-0.9	1.1
				Oral (Temp Plus II, model 2080A)	0.2 (0.2)	-0.3	0.7
				Oral (Tempa.DOT)	0.4 (0.5)	-0.5	1.3
Lawson et al[9]	ICU	60	35.3-39.4	Oral (SureTemp Plus)	-0.1 (0.4)	-0.9	0.8
				Ear-based (First Temp Genius 3000A)	0.4 (0.6)	-0.7	1.5
				Axillary (SureTemp Plus, axillary mode)	-0.2 (0.4)	-1.1	0.6
				Temporal artery (Exergen Temporal-Scanner)	0.02 (0.5)	-0.9	0.9
Lefrant et al[10]	ICU	42		Axillary (gallium in glass)	-0.3 (0.5)	-1.2	0.6
Moran et al[11]	ICU	110	34.3-39.3	Ear-based (First Temp)	-0.4 (0.5)	-1.3	0.6
				Axillary (glass, mercury)	-0.3 (0.4)	-1.0	0.4
Myny et al[12]	ICU	57	37.1 (0.87)	Temporal artery (Exergen LXTA)	-0.1 (0.5)	-1.1	0.8
				Axillary (Hartmann Digital Classic)	-0.5 (0.4)	-1.2	0.3
Rotello[13]	ICU	16	<37 or >38	Ear-based (ThermoScan HM-1, oral mode)	0.2 (0.5)	-0.8	1.1
				Ear-based (ThermoScan PRO-1)	0.1 (0.4)	-0.7	0.9
				Ear-based (ThermoScan PRO-LT)	-0.2 (0.5)	-1.2	0.8
Smith[14]	After cardiac surgery	35	37.1 (0.53)	Oral (SolarTherm)	-0.6 (0.3)	-0.5	-0.4
				Axillary (DataTherm)	-0.5 (0.2)	-0.4	-0.15
				Axillary (DataTherm)	-0.7 (0.3)	-0.8	-0.6
Stavem et al[15]	ICU	16		Ear-based (First Temp 2000A)	0.5 (0.4)	-0.3	1.2
Suleman et al[16]	After cardiac surgery	15	>37.8	Temporal artery (SensorTouch)	-1.3 (0.6)	-2.5	-0.1

[a] The bias and limits of agreement reflect the test method (eg, oral, ear-based) minus pulmonary artery temperature. A positive number means the test method overestimates the pulmonary artery temperature, and a negative number means the test method underestimates pulmonary artery temperature.

that one method is more accurate than the other, only that they are not interchangeable.

Hyperthermia or Hypothermia

Limited research has addressed whether the thermometer correctly identifies patients with hyperthermia or hypothermia. In a study[20] in 13 febrile patients, the oral thermometer was most accurately for detecting fever (>38.3°C), whereas the ear-based measurement had the lowest chance of a false-negative reading. In 2 additional studies,[15,21] researchers evaluated the utility of ear-based temperature measurements for detecting fever (variably defined as a body temperature >38°C-38.5°C). In these studies, the ear-based thermometers also showed high specificity (0.92-1.00), indicating accuracy in identifying patients *without* a fever; but lower sensitivity (0.50-0.80) indicating accurate identification of only 50% to 80% of patients *with* a fever. Limited research has been done on temporal artery temperature measurement in febrile patients. In the study by Lawson et al,[9] 11 measurements were obtained from 3 patients where the PA temperature was 38°C or greater. The temporal artery measurement allowed correct characterization of the patient as febrile in 10 of 11 cases, and the oral and axillary temperatures allowed correct detection in 7 of 11 cases; whereas none of the fevers were detected with the ear-based measurement.

In another study[22] in which the temporal artery thermometer (Exergen Temporal Scanner TAT-5000A, Watertown, Massachusetts) was compared with a bladder probe, the temporal artery thermometer had a sensitivity of 0.71 and specificity of 0.97 (area under curve, 0.95) to detect a temperature greater than 37.8°C, and in patients with a bladder temperature less than 35°C, the temporal artery thermometer had a sensitivity of 0.3 and a specificity of 0.95. In the only study[16] to evaluate the SensorTouch temporal artery

Table 2 Factors that affect the accuracy and precision of various temperature measurement methods

Method	Factors	Steps to correct
Oral	Endotracheal tube	Place probe on side opposite endotracheal tube because the tube may increase the measured temperature[3,9,23]
	Incorrect positioning of the probe	Place probe in the posterior sublingual pocket—not the front of the mouth
	Mode	Set the thermometer in the "core" mode[7,24]
	Drinking hot/cold fluids	Wait 30 minutes after consumption of any amount of liquids[25]
	Oral mucositis/stomatitis	General contraindication—anecdotally reported to increase temperature
Temporal artery	Diaphoresis	SCAN button remains depressed and an additional temperature measurement is taken directly behind the ear (consider this method for all patients)
	Vasopressor medications	Limited research
	Dirty lens	Clean at least every 2 weeks[2]
	Air flow across face	Limited research
Ear-based	Excessive cerumen	Lowers temperature by 0.13ºC to 0.3°C. Consider removal of cerumen as appropriate
	Ear against pillow	Do not take measurement in ear on which the patient has been recently lying (causes overestimation of temperature)
	Repeat temperatures	Allow at least 2 minutes between repeat measurements to avoid tissue cooling after contact with the probe
	Using opposite ear	Do not reach across the patient's body to use the contralateral ear
	Dirty lens	Clean according to manufacturer's recommendations
Axillary	Incorrect positioning of probe	Lift the patient's arm so the entire axilla can be seen
		Place the probe as high as possible in the axilla with the probe tip not coming into contact with the patient until the probe is at the measurement site and axillary tissue completely surrounds the probe tip
		Place the patient's arm snugly at the patient's side and hold the patient's arm in this position during the measurement cycle

thermometer, the sensitivity was 0 (ie, the device failed to detect any fevers) and the specificity was 1. In total, these studies indicate that noninvasive temperature measurements are accurate for ruling out hyperthermia and hypothermia but may fail to detect hyperthermia and hypothermia, depending on the thermometer used. Further research is needed in this area. Finally, it is important to recall that therapeutic decisions should not be made on the basis of a single vital sign.

Factors Affecting Accuracy and Precision of Measurements

A critical issue to consider when using any thermometer is whether you are controlling the factors that affect the accuracy and precision of the measurement (Table 2). These factors must be addressed when educating staff on the use of the various temperature measurement methods and when critiquing the literature about a specific method and device. CCN

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Financial Disclosures
None reported.

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