Own the Zone:
Bring visibility to a critical vital sign with continuous core temperature monitoring

INTRODUCTION:

Nearly all clinicians know that maintenance of normothermia during surgery can be associated with improved perioperative outcomes. More than 30 years of clinical research support the practice of normothermia management, and numerous clinical practice guidelines now emphasize hypothermia prevention as a recommended practice.

Despite this wealth of knowledge regarding the significance of normothermia in surgical patients, one related topic is too often overlooked—the measurement of core body temperature. While temperature is recognized as a vital sign, it is frequently thought of as being less important than the other vital signs clinicians must monitor during anesthesia.

Downplaying the importance of temperature, combined with the challenges associated with the placement of invasive thermometers within the patient's body and a potential distrust of the reliability associated with less invasive monitoring methods, means many patients undergoing anesthesia do not have their core temperature continuously and accurately monitored during surgery. This is especially true in shorter surgeries or those under neuraxial (spinal/epidural) anesthesia.

Proactively monitoring temperature with a consistent, accurate and non-invasive system is the only true way to own the normothermic temperature zone (36.0°C - 37.5°C)[1] and with that knowledge help you protect patients from perioperative hypothermia. Fortunately, a non-invasive technique known as zero-heat-flux thermometry can provide accurate measurements of core body temperature that have been shown to be equivalent to invasive methods.[2]

Proactively monitoring core temperature can give clinicians clear insight into the patient's thermal state, allowing for more effective use of warming interventions (particularly preoperatively) which can lead to better patient outcomes.

The importance of maintaining normothermia

During the first hour of general or regional anesthesia, a patient's core temperature can drop by an average of 1.6°C[3] leaving the patient at risk of hypothermia. Unintended hypothermia can develop at any stage of surgery and is not limited only to longer procedures.

While small changes in core temperature do not generally have immediate consequences, the potentially adverse effects of even mild perioperative hypothermia, defined as a core body temperature of less than 36.0°C (96.8°F)[4], are numerous and well-documented. (Fig. 1)

Risk of SSI

Studies of the impact of hypothermia on the incidence of wound infection have shown that the hypothermic patient is at an increased risk for wound infection than a normothermic patient.[5-7]

Increased blood loss

Even mild hypothermia significantly increases blood loss by 16 percent and the risk for transfusion by approximately 22 percent.[8] A 1.6°C reduction in core body temperature can increase blood loss by 30 percent and significantly augment allogenic transfusion requirement.[9]

Morbid cardiac events
Hypothermia can increase the incidence of cardiac events.[5,10,11] A study by Scott et al. found that maintaining normothermia was associated with a reduction in ischemic cardiovascular events and mortality.[5]

Extended recovery time
Unintended hypothermia alters the effects of many classes of drugs, including muscle relaxants and intravenous anesthetic agents.[12-14] By decreasing drug metabolism, even mild hypothermia can lead to delayed awakening and require a longer PACU stay.[15-16]

Patient discomfort
Patients often report shivering as the worst part of their hospitalization, sometimes rating it worse than surgical pain.[4]

Knowing these potentially harmful outcomes, and understanding that unintended hypothermia is a very common but also highly preventable phenomenon, it stands to reason that healthcare professionals should introduce the evidence-based preventive measures to proactively monitor and maintain a patient's core temperature before, during, and after surgery.

The importance of temperature monitoring
Perioperative hypothermia is by far the most common thermal consequence of anesthesia. Because of the effect anesthesia has on the thermoregulatory system, intraoperative temperature monitoring is essential to help detect significant core temperature changes. People having surgery under regional or general anesthesia are at risk of developing hypothermia, which can occur before, during and after surgery.

When patient temperature is closely monitored and measured, clinicians will have an easier time knowing what needs to be done to maintain a patient's normothermic temperature. They'll know if a patient is trending towards hypothermia and would be able to proactively respond, before their temperature reaches the lower end of the spectrum. The more accurate temperature monitoring is today, the more effective normothermia management becomes.

When is temperature monitoring needed?
Working together, the perioperative team should measure and monitor the patient's temperature in all phases of perioperative care.

Preoperative monitoring will determine if the patient's thermoregulatory system is normal and the patient is cleared for surgery. Temperatures outside the normothermic zone may indicate systemic infection, inflammation, or other thermoregulatory issues.[17]

Once in the OR, the patient requires continuous monitoring to determine the existence or severity of hypothermia or hyperthermia during anesthesia. While rare, life-threatening hyperthermia (due to malignant hyperthermia) can develop rapidly. Continuous

The importance of measuring and monitoring core temperature

Inadvertent perioperative hypothermia is defined as a core body temperature of less than 36.0°C, which can:

Increase the rate of SSI[5-7]

Increased surgical blood loss[8,9]

Lead to increased mortality[5,10,11]

Extend recovery time[12-16]

Cause patient discomfort[4]

Fig. 1

temperature monitoring substantially improves survival when malignant hyperthermia occurs.[18,19]

Temperature monitoring is equally important after surgery, when decisions are made whether a patient is warmed for comfort or clinical necessity. Monitoring temperature post-operatively can also give clinicians confidence that when their patients leave the PACU they are truly normothermic, a requirement for discharge, and have a lower chance of experiencing surgical complications associated with hypothermia.

In one growing segment of the surgical population, patients who have neuraxial anesthesia, the importance of temperature monitoring is even more pronounced.[20,21] With neuraxial anesthesia, the patient's nerve input that informs the brain whether the patient is warm or cold is disrupted. Even if the patient is hypothermic, the patient may still feel comfortable and warm.[20,21] This could lead clinicians to reduce or discontinue warming therapy and lead to hypothermia-related complications.

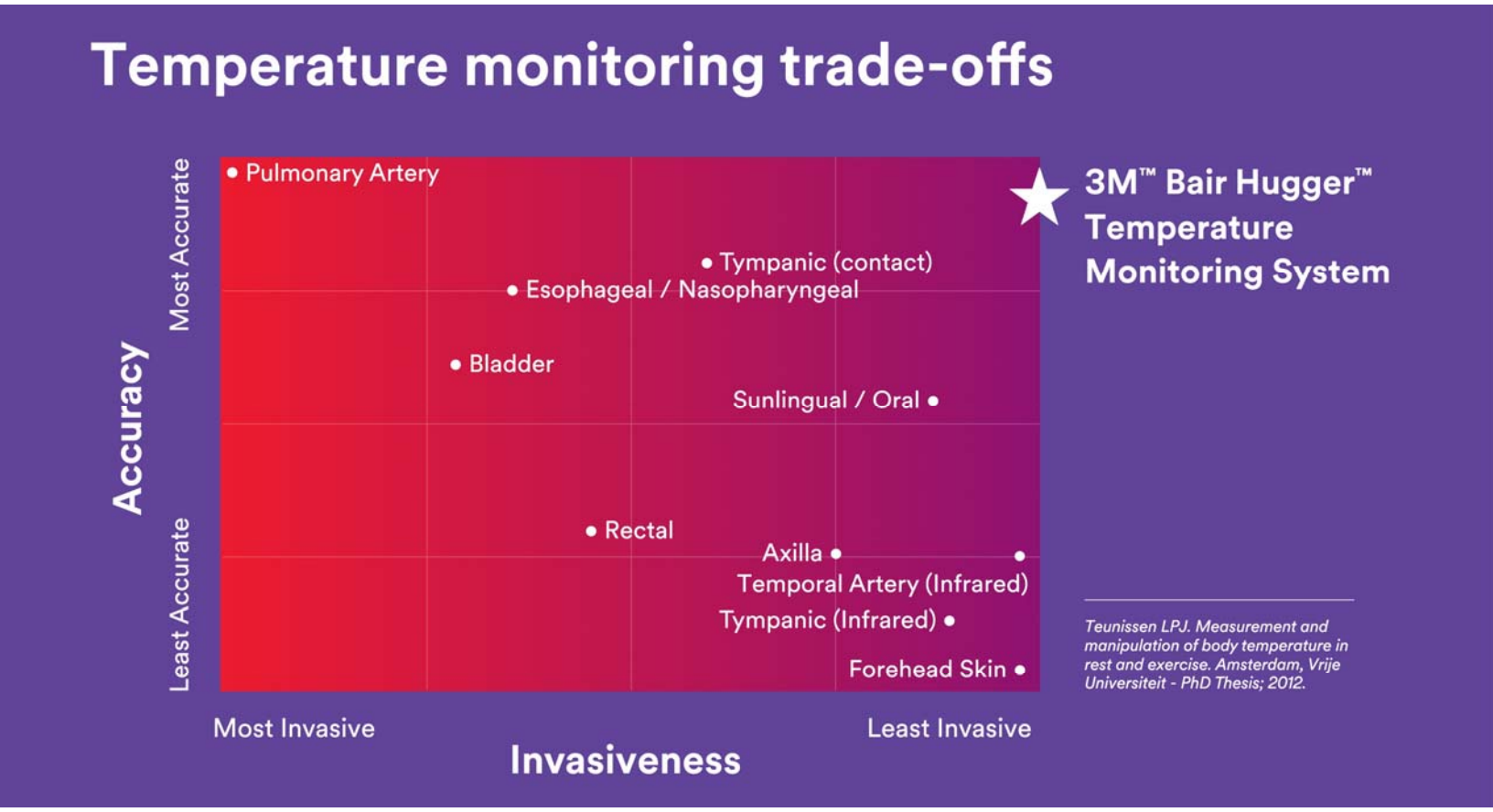

Fig. 2

Temperature Monitoring Methods

Today there are a wide variety of temperature monitoring devices in use, which can lead to inconsistency with site of measurement, user technique and monitoring frequency. These variations can impact the reliability of accurate temperature readouts, which ultimately can influence important clinical intervention decisions. (Fig. 2)

Many non-invasive thermometers currently available accurately report the temperature of the tissue they measure. However, the less invasive the measurement location, the more likely the tissue does not reflect true patient core temperature.[22] Core body, as opposed to surface

temperature, is more valuable because it is the most relevant indicator of the body's overall thermal condition.[17]

In the pre- and post-surgery periods, temperature is usually measured at intervals with minimally invasive methods such as oral thermometers or a temporal artery scanner, although tympanic thermometers may also be used. During surgery, a direct estimate of core temperature can be monitored accurately through invasive methods such as esophageal, nasopharyngeal, bladder or pulmonary artery catheters.[17]

Below, we examine the benefits and limitations of both invasive and non-invasive temperature monitoring methods.

Minimally-invasive methods

Minimally invasive temperature measurement methods only provide indirect estimates of core temperature and are typically monitored and recorded at set intervals. All minimally-invasive methods to measure body temperature have accuracy and precision variances unique to each type of method when compared to more invasive core temperature monitoring methods.[23]

Axillary thermometer

Axillary temperature is measured in the armpit near the axillary artery. The thermometer is held in place by the upper arm pressing against the chest wall. While considered safe, the variability in placement and other factors decrease the precision[24,25] and it is not recommended for clinical use.[26]

Skin sensors

Skin sensors, often in the form of a liquid crystal thermometer that changes color in relation to temperature, are single patient use and easy to use and observe. The accuracy of this method may be impacted by ambient temperature or air flow at the sensor[27-30] and accuracy decreases as core temperature decreases.[31] Skin sensors have been found unsuitable for clinical use.[31]

Temporal artery thermometer

Temporal artery thermometers measure temperature directly over the temporal artery. While quick and non-invasive, technique significantly impacts the accuracy and precision of measurements[24,32] Temporal artery thermometers also are poor at detecting fever[33,34] and hypothermia[35,36] and experience high reproducibility error.[34] Numerous studies found it insufficient for use in perioperative patients[34,35] and clinical practice.[17,33,35,37]

Oral thermometer

The oral thermometer is quick, easy, and familiar to patients while providing a reasonable estimate of core body temperature.[24,31,38] Accuracy can be impacted by technique, probe placement or even a recently consumed food or beverage. Oral thermometers are not ideal for surgical patients, unconscious or restless patients and continuous temperature monitoring is not possible.

Infrared tympanic thermometer

Tympanic scanners are popular because they are quick and easy to use. However, errors in measurement technique may contribute to accuracy and low reliability of measurements.[24,25] Numerous studies have evaluated the accuracy and variability of this monitoring method and have deemed infrared tympanic thermometers insufficient for clinical use.[17,24,26,31,39,40]

Invasive methods

Most temperature probes used for long-term monitoring of body temperature during the perioperative period consist of temperature sensors that are enclosed in rigid metal or flexible

plastic housings. The entire assembly may be temporarily implanted on or within a target anatomic location, such as the bladder, pulmonary artery, esophagus, or nasopharynx. After a period of equilibration, the temperature at the sensor is essentially equivalent to the temperature at the target site.

Pulmonary artery catheter

While the pulmonary artery catheter, which measures blood temperature, is considered the gold standard for measuring core temperature[23], this method is also invasive and has its share of complications related to catheter insertion and maintenance. In a study on 70 ICU patients, between 20-30 percent had significant adverse events related to the pulmonary artery catheter.[41] In addition, PA catheter use in the critically ill has not been shown to improve outcomes, and it is not recommended in the intensive care[42] for the routine management of patients or for temperature monitoring.

Nasopharyngeal catheter

A nasopharyngeal thermocouple needs to be positioned a few centimeters past the nares, above the hard palate in the nasal cavity. One study indicated fewer than half of nasopharyngeal temperature probes placed blindly by practitioners were optimally positioned.[43] Airflow also can alter the monitored temperature, so this method is not recommended for self-ventilating patients.[44] In conscious patients, the probe can cause significant discomfort making it an option reserved primarily for anesthetized, ventilated patients. Nasopharyngeal monitoring has been shown to offer adequate accuracy.[44]

Esophageal catheter

For the esophageal temperature measurement, the probe is inserted through the mouth or nose and continues down the esophagus until it is in close approximation to the heart. Not for use on conscious patients, the esophageal probe is inserted in the distal third of the esophagus, and its position needs to be confirmed by a chest X-ray.[45] While esophageal monitoring is not as accurate as a pulmonary artery catheter, it offers better accuracy than rectal or surface measurement methods.[46] Accuracy can depend on positioning and there is a risk of esophageal trauma on insertion or removal.

Bladder catheter

Bladder temperature measurement provides a reasonable estimate of core body temperature and is not impacted by a variation in technique. It can be useful in patients already requiring a bladder catheter. However, accuracy diminishes with core temperature changes[38], including hypothermia[17], and is influenced by urine output.[27]

It's essential to note that not all temperature monitoring devices measure with the same level of accuracy. Moreover, as body temperature decreases so too does the accuracy of surface temperature monitors such as skin sensor probes, liquid crystal displays and temporal artery scanners.[27,31,38]

Non-invasive temperature monitoring modalities have limited reliability to get an accurate core temperature measurement. Invasive modalities, while accurate, have contraindications for ICU patients and can present infection risks, such as catheter associated urinary tract infections (CAUTI).[47]

Ideally, clinicians would be able to use a single, non-invasive device throughout the perioperative journey, resulting in better consistency while accurately providing temperature measurement. Until recently, however, no such temperature monitoring method could easily offer the accuracy of invasive methods along with the benefits of non-invasive application.

Zero Heat Flux

Zero-heat-flux thermometry is a method for measuring core temperature from the surface of the skin. It is non-invasive, agrees closely with invasive measurements such as pulmonary artery blood temperature[2], is unaffected by ambient conditions, may be deployed as a single patient use probe, and is inexpensive. Moreover, zero heat flux thermometry enables a consistent measurement technique to be used during the entire perioperative period, thereby eliminating variability caused by compounding instrument and measurement technique errors.

Zero heat flux thermometry makes it possible to estimate perioperative core temperature on nearly all surgical patients and may improve perioperative temperature management, especially for those patients who are scheduled for surgical procedures using regional anesthesia in whom conventional monitoring thermometry is not usually or cannot be employed.

Fig. 3

How it works

Zero heat flux thermometry, utilized in the 3M™ Bair Hugger™ temperature monitoring system, measures core temperature with a thermal insulator applied to the skin.[48] The temperature of uninsulated skin depends greatly on ambient conditions; however, if a small area of skin can be perfectly insulated, its surface temperature would eventually closely approximate the tissue temperature directly beneath it.[48] (Fig. 3)

The creation of a zone of perfect insulation is the basic principle of zero heat flux thermometry, and it is accomplished by applying just enough heat to the skin surface to exactly oppose the heat transfer.

Applying a small amount of heat within the sensor, the system actively warms the site of measurement until the heater and the skin temperature are equal and an "isothermic pathway" to the patient's core is established. (Fig. 4)

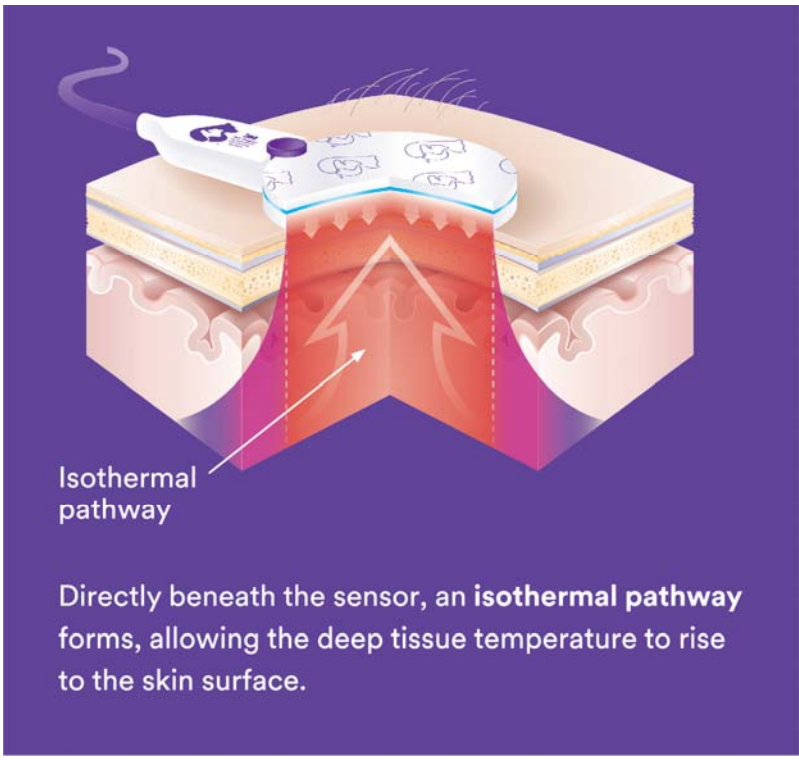

Fig. 4

The sensor needs to be placed on the forehead. This method has been shown to be accurate and comfortable for patients in comparison studies.[49]

The 3M™ Bair Hugger™ temperature monitoring system

The 3M Bair Hugger temperature monitoring system is a noninvasive, easy-to-use, accurate temperature monitoring system that continuously measures patients' core body temperature. The system helps clinicians effectively monitor and manage patient temperature to help improve patient outcomes.

The system's disposable sensor is placed on the patient's forehead helping to reduce temperature variation associated with clinician technique and the utilization of multiple device types. The control unit continuously displays core body temperature, trends two hours of patient temperature data and can be connected to the patient monitor by a simple cable connection.

Standardize on a single solution

On average, a facility will stock five different temperature monitoring devices to meet the varying clinical needs of the perioperative patient.[50] Standardization with one temperature monitoring product eliminates the hassle and costs associated with purchasing, stocking and managing multiple products for the same use.

The 3M Bair Hugger temperature monitoring system also streamlines the number of steps in each perioperative area—no need for multiple forehead swipes, ear insertions or invasive probes. Consolidating to one accurate, consistent core temperature monitoring device provides the temperature data needed to get the most out of warming product investments at each stage of the perioperative process.

Conclusion

While active warming perioperatively is important, it is equally important not to overlook monitoring core body core temperature in perioperative patients and optimize any measures of perioperative temperature management. Each method and location of temperature measurement has its advantages and limitations, so it is essential to choose the appropriate method of temperature measurement depending on the patient, the procedure, and the type of anesthesia.

Knowing a patient's core temperature at a glance can enable clinicians to respond quickly to

Help prevent and avoid complications associated with unintended hypothermia. The 3M™ Bair Hugger™ temperature monitoring system offers an accurate, noninvasive, continuous method to easily measure core temperature throughout the perioperative journey.

3M can help clinicians Own the Zone

Unsure of whether your facility is ready to Own the Zone? 3M can help. We will work together with you to understand your warming needs, identify your clinical challenges and evaluate your practice requirements so that we can recommend proven, cost-effective solutions to advance your patient warming goals.

3M offers a simple, concise Temperature Review Program designed to provide the data you need to address the hypothermia rate within your facility. Through this program you'll learn:

- The percentage of your patients who are normothermic vs. hypothermic
- How 3M's expertise can help establish (or improve) your warming protocol, including prewarming
- An innovative way to continuously monitor core body temperature before, during & after surgery

For additional resources on the importance of patient warming, temperature monitoring, and how to Own the Zone, visit BairHugger.com/OwntheZone.

To learn more about 3M's scientific approach to help fight SSIs from every angle, click here.

AUTHOR:

Troy Bergstrom, 3M Patient Warming Business

References:

1. Schroeck H, Lyden AK, Benedict WL, Ramachandran SK. Time Trends and Predictors of Abnormal Postoperative Body Temperature in Infants Transported to the Intensive Care Unit. *Anesthesiology Research and Practice*. 2016:7318137.

2. Eshraghi Y, Nasr V, Parra-Sanchez I, Van Duren A, Botham M, Santoscoy T, Sessler DI. An Evaluation of a Zero Heat Flux Cutaneous Thermometer in Cardiac Surgical Patients. *Anesth Analg*. 2014;119(3):543-549.

3. Matsukawa T, Sessler DI, Sessler AM, Schroeder M, Ozaki M, Kurz A, Cheng C. Heat flow and distribution during induction of general anesthesia. *Anesth*. 1995 Mar;82(3):662-73.

4. Sessler DI. Current concepts: Mild Perioperative Hypothermia. *New Engl J Med*. 1997; 336(24):1730-1737.

5. Scott AV, Stonemetz JL, Wasey JO, Johnson DJ, Rivers RJ, Koch CG, et al. (2015) Compliance with Surgical Care Improvement Project for Body Temperature Management (SCIP Inf-10) Is Associated with Improved Clinical Outcomes. *Anesthesiology*. 123: 116–125.

6. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. *NEJM*. 1996 May 9;334(19):1209-16.

7. Melling AC, Ali B, Scott EM, Leaper DJ. Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. *The Lancet*. 2001 Sep 15;358(9285):876-80.

8. Schmied H, Kurz A, et al. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. *The Lancet*. 1996;347(8997):289-292.

9. Rajagopalan S, et al. The Effects of Mild Perioperative Hypothermia on Blood Loss and Transfusion Requirement. *Anesth*. 2008; 108:71-7.

10. Frank SM, Fleisher LA, Breslow MJ, et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. *JAMA*. 1997;277:1127-1134.

11. Bush H Jr., Hydo J, Fischer E, et al. Hypothermia during elective abdominal aortic aneurysm repair: The high price of avoidable morbidity. *J Vasc Surg*. 1995;21(3): 392-402.

12. Leslie K, Sessler DI, Bjorksten AR, Moayeri A. Mild hypothermia alters propofol pharmacokinetics and increases the duration of action of atracurium. *Anesth Analg*. 1995;80(5):1007–1014.

13. Fritz HG, Bauer R, Walter B, Moertiz KU, Reinhart K. Effects of hypothermia (32°C) on plasma concentration of fentanyl in piglets (abstract). *Anesthesiology*. 1999;91(3A):A444.

14. Heier T, Caldwell JE, Sessler DI, Miller RD. Mild intraoperative hypothermia increases duration of action and spontaneous recovery of vecuronium blockade during nitrous oxide-isoflurane anesthesia in humans. *Anesthesiology*. 1991;74(5):815–819.

15. Bissonnette B, Sessler DI. Mild hypothermia does not impair postanesthetic recovery in infants and children. *Anesth Analg*. 1993;76(1):168–172.

16. Lenhardt R, Marker E, Goli V, et al. Mild Intraoperative Hypothermia Prolongs Postanesthetic Recovery. *Anesth*. 1997; 87(6):1318-1323.

17. Sessler DI. Temperature Monitoring and Perioperative Thermoregulation. *Anesthesiology*. 2008;109(2):318-338.

18. Larach MG, Brandom BW, Allen GC, Gronert GA, Lehman EB. Malignant Hyperthermia Deaths Related to Inadequate Temperature Monitoring, 2007–2012: A Report from The North American Malignant Hyperthermia Registry of the Malignant Hyperthermia Association of the United States. *Anesthesia & Analgesia*. 2014;119(6):1359-1366.

19. Shafer SL, Dexter F, Brull SJ. Deadly Heat: Economics of Continuous Temperature Monitoring During General Anesthesia. *Anesthesia & Analgesia*. 2014;119(6):1235-1237.

20. Glosten B, Sessler DI, Faure EA, et al. Central temperature changes are poorly perceived during epidural anesthesia. *Anesthesiology*. 1992;77:10-16.

21. Joris J, Ozaki M, Sessler DI, et al. Epidural anesthesia impairs both central and peripheral thermoregulatory control during general anesthesia. *Anesthesiology*. 1994;80:268-277.

22. Kimberger O. Temperature monitoring in the OR – State of the art and a 2012 update. Trends in *Anaesthesia and Critical Care*; 2012;3(1): 8-12.

23. Bridges E, Thomas K. Noninvasive measurement of body temperature in critically ill patients. *Crit Care Nurse*. 2009 Jun; 29(3): 94–97.

24. Lawson L, et al. Accuracy and precision of noninvasive temperature measurement in adult intensive care patients. *Am J Crit Care*. 2007; 16(5):485-96.

25. Lefrant JY, et al. Termperature measurement in intensive care patients: comparison of urinary bladder, oesophageal, rectal, axillary, and inguinal methods versus pulmonary artery core method. *Intensive Care Med.* 2003;29:414-18.

26. Hooper VD, Andrews JO. Accuracy of noninvasive core temperature measurement in acutely ill adults: the state of the science. *Biol Res Nurs*. 2006; 8(1):24-34.

27. Holtzclaw BJ. Monitoring body temperature. AACN Clin Issues *Crit Care Nurs*. 1993;4:44–55.

28. Ikeda T, et al. Influence of thermoregulatory and ambient temperature variation on the accuracy of core-temperature estimates by cutaneous liquid-crystal thermometers. *Anesth*. 1997; 86:603-12.

29. Fiedler MA. Thermoregulation: Anesthetic and perioperative concerns. *AANA J*. 2001;69(6):485-91.

30. Cattaneo CG, et al. The accuracy and precision of body temperature monitoring methods during regional and general anesthesia. *Anesth Analg.* 2000; 90(4):938-45.

31. Langham GE, et al. Noninvasive temperature monitoring in postanesthesia care units. *Anesth*. 2009; 111:90-6.

32. Carroll D, et al. A Comparison of Measurements From a Temporal Artery Thermometer and a Pulmonary Artery Catheter Thermistor. *Am J Crit Care*. 2004;13(3):258.

33. Suleman MI, et al. Insufficiency in a new temporal-artery thermometer for adult and pediatric patients. *Anesth Analg*. 2002;95:67-71.

34. Kimberger O, et al. Temporal artery versus bladder thermometry during perioperative and intensive care unit monitoring. *Anesth Analg*. 2007; 105(4):1042-47.

35. Hannenberg AA, Sessler Di. Improving Perioperative Temperature Management. *Anesth Analg*. 2008;107(5):1454-56.

36. Winslow EH, et al. Unplanned perioperative hypothermia and agreement between oral, temporal artery, and bladder temperatures in adult major surgery patients. *J Perianseth Nurs*. 2012; 27(3):165-80.

37. Greenes DS, et al. Accuracy of a noninvasive temporal artery thermometer for use in infants. *Arch Pediatr Adolesc Med*. 2001;155:376-81.

38. Frank SM, et al. Temperature monitoring practices during regional anesthesia. *Anesth Analg*. 1999;88:373–7.

39. Modell JG, Katholi CR, et al. Unreliability of the infrared tympanic thermometer in clinical practice? A comparative study with oral mercury and oral electronic thermometers. *South Med J*. 1998;91:649-54.

40. Frommelt T, Ott C, Hays V. Accuracy of different devices to measure temperature. *MedSurg Nursing*. June 2008;17(3):171-82.

41. Fein AM, Goldberg SK. Is pulmonary artery catheterization necessary for the diagnosis of pulmonary edema? *Am Rev Respir Dis*. 1984;129:1006–1009.

42. Harvey S, Young D, Brampton W. Pulmonary artery catheters for adult patients in intensive care. *Cochrane Database Syst Rev.* 2006;(3):CD003408.

43. Lee J, Lim H, Son KG, Ko S. Optimal nasopharyngeal temperature probe placement. *Anesth Analg*. 2014 Oct;119(4):875-9.

44. Chacko B, Peter JV. Temperature monitoring in the intensive care unit. *Indian J Respir Care.* 2018;7:28-32.

45. Whitby JD, Dunkin LJ. Temperature differences in the oesophagus. Preliminary study. *Br J Anaesth.* 1968;40:991-5.

46. Robinson S, Spady. Comparison of oesophageal, rectal, axillary, bladder, tympanic, and pulmonary artery temperatures in children; *J Pediatr*. 1998;133:553-556.

47. Schell-Chaple HM, Liu KD, Matthay MA, Puntillo KA. Rectal and Bladder Temperatures vs Forehead Core Temperatures Measured With SpotOn Monitoring System. *Am J Crit Care*. 2018;27(1), 43-50.

48. Eshraghi Y, Nasr V, Parra-Sanchez I, et al. An evaluation of a zero-heat-flux cutaneous thermometer in cardiac surgical patients. *Anesth Analg*. 2014;119:543-549.

49. Iden T, Horn EP, Bein B, et al. Intraoperative temperature monitoring with zero heat flux technology (3M SpotOn sensor) in comparison with sublingual and nasopharyngeal temperature: an observational study. *Eur J Anaesthesiol*. 2015;32:387-391.

50. AORN 2012 Survey of AORN Nurses. Data on file with 3M.

Medical Solutions Division
3M Health Care
2510 Conway Avenue
St. Paul, MN 55144-1000
USA

1-800-228-3957
www.3M.com/Medical