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AST Standards of Practice for Maintenance of Normothermia in the Perioperative Patient

Introduction

The following Standards of Practice were researched and authored by the AST Education and Professional Standards Committee, and are AST approved.

AST developed the following Standards to support healthcare delivery organizations (HDO) reinforce best practices as related to the role and duties of the Certified Surgical Technologist (CST®), the credential conferred by the National Board of Surgical Technology and Surgical Assisting (NBSTSA), in assisting the surgical team in avoiding inadvertent perioperative hypothermia (IPH, also referred to as unintended or unplanned perioperative hypothermia) in the surgical patient as well as maintaining patient's normothermia throughout the perioperative course of treatment. The purpose of the Standards is to provide information for OR managers/supervisors, risk management, and surgical team members to use in the development and implementation of policies and procedures for maintaining normothermia in the surgical patient. The Standards are presented with the understanding that it is the responsibility of the HDO to develop, approve, and establish policies and procedures for the CST regarding surgical patient normothermia according to established HDO protocols.

Rationale

The following are Standards of Practice related to maintaining normothermia in the surgical patient. Normothermia is defined as a body's core temperature of 36°C - 38°C, and hypothermia is defined as a core temperature below 36°C.[3,30,40,48] It is estimated that IPH occurs in more than 50% of U.S. surgical patients including those undergoing a short procedure (1 ½ hours or less).[48] The commonly accepted levels of hypothermia are:[61]

- Mild 34° - 36°C
- Moderate 32° - 34°C
- Severe <32° C

Hypothermia with a patient core temperature of <32°C has a mortality rate of 21%.[33, 61]

The American Society of Anesthesiologists (ASA) considers the use of aggressive perioperative thermal management to maintain normothermia in the surgical patient is imperative to positive surgical outcomes.[4,31] The following information provides an outline of the pathologies associated with IPH in order to stress the importance of the surgical team being an advocate for the patient by taking proactive, rather than reactive, measures to prevent IPH. The optimal approach to hypothermia is to prevent it from occurring starting in the preoperative phase of care.

Anesthetic-induced impairment of the thermoregulatory control is the primary cause of IPH in the non-emergent patient; this impairment combined with the exposure of tissues and major organs in body cavities for a length of time in the cool environment of the OR can increase the severity of IPH.[4,33,36,58] The OR's cool environment is, obviously, maintained for the comfort of the members of the sterile surgical team that is wearing a hair cover, mask, gown, and double gloves, sometimes under stressful conditions for an extended period of time. The Facility Guidelines Institute and American Society for Healthcare Engineer recommends an OR temperature of 20°C - 23°C.[13]

The body temperature is controlled by the neurons in the hypothalamus.[14,50] The administration of anesthesia eliminates the body's physiological response to cold and impairs the thermoregulatory heat-preserving functions of the hypothalamus and autonomic nervous system.[33] During the first 30 – 40 minutes of anesthesia the patient's temperature can drop to below 35°C.[44] The induction of anesthesia causes a three-phase decrease in core temperature. Initially, anesthesia causes peripheral vasodilation causing redistribution of the blood flow away from the core to the periphery through arteriovenous shunts which are anastomoses that link arterioles and veins.[14,33,48,50,55] After redistribution the core temperature slowly decreases over the next 2 – 4 hours (assuming the surgical procedure lasts that long) primarily from heat loss that is greater than metabolic heat production.[50] After that period of time the core temperature plateaus and remains about the same for the duration of the procedure. The plateau is thought to represent heat loss that is equal to heat production.[50]

Piloerection also occurs in hypothermic patients.[14] The erect hairs over the surface of the body prevents air from escaping and aids in the retention of body heat.[14]

Regional anesthesia is just as much of a risk factor for IPH as general anesthesia.[36,58] The physiological mechanisms of how regional anesthesia impairs the body's thermoregulatory system, but one mechanism is the prevention of afferent cutaneous input in response to cold.[49] Additionally, patients that receive neuraxial anesthesia may report they are warm when actually they are hypothermic leading the team to believe no action is necessary, in particular if the patient's temperature is not being monitored.[49]

Besides anesthesia, there are several medical conditions and traumatic injuries that predispose the patient to IPH including adrenal insufficiency, basilar skull fractures, brain tumors, hypoglycemia, hypothalamic injuries, hypothyroidism, malnutrition, spinal cord injuries, and subdural hematomas.[36,55,58] (See Table 1)

Table 1
Risk Factors for IPH

Patient-Specific Risk Factors	Factors That Contribute to Body Heat Loss
• Shock • Alcohol • Head injury • Bacterial toxins • Extremes of age • Spinal cord injury • General anesthesia • Epidural & spinal anesthesia • Medical conditions: adrenal diseases, cardiac dysfunctions, diabetes, hepatic diseases, malnutrition, thyroid diseases • Surgical procedures that have an increased risk for IPH: long, complex invasive procedures including cardiac, thoracic, organ transplant, total hip and knee arthroplasty[19]	• Burns • Exposure

Research studies have also linked an association between IPH and multiple perioperative complications including:[4,15,21,24,36,43,49]

- Cardiac abnormalities and complications[18]
- Post-anesthetic shivering that can increase pain and considerably increases oxygen consumption by the muscle cells[20,55]
- Impaired wound healing and susceptibility to surgical site infection (SSI)[36,56,61]
- Slowed drug metabolism that causes prolonged drug action that delays recovery and other metabolic disorders
- Coagulopathies that are associated with an increase in blood loss leading to transfusion requirements

Hypothermia affects the myocardium including decrease in the strength of left ventricular contraction with a reduction in cardiac output of up to a third, and atrial and ventricular arrhythmias.[33] The initial arrhythmia that will be recognized on the electrocardiograph is sinus tachycardia.[55] As the core temperature decreases a co-related progressive bradycardia occurs.[55] Furthermore, hypothermia decreases the release of oxygen from hemoglobin to the tissues, further impairing the delivery of oxygen which can result in a life-threatening complication particularly for the patient with multiple traumatic injuries who is already experiencing a lowered circulating oxygen level.[61]

Moderate to severe shivering can occur between 34° C - 36°C core temperature that results in an increase in oxygen demand by as much as 400%, and an increase in myocardial work load and blood pressure.[33,55,61] In the postoperative patient, shivering can increase the level of pain due to the overall body movement. By preventing shivering obviously the patient's level of pain and need/demand for analgesia may be lowered.[33] Independent of shivering, oxygen consumption increases by 92% with a decrease of 1.5°C core temperature.[61]

Hypothermia has been shown to be a contributor to complications that promote SSI; studies have shown that following surgery IPH triples the risk for bacterial SSI.[14,33] The complications include significant peripheral vasoconstriction, impaired function of neutrophils and macrophages, decrease of tissue oxygen levels, decrease in collagen deposition, and delayed wound healing.[50,55,61] IPH causes thermoregulatory vasoconstriction that decreases the level of oxygen in the tissues thereby lowering the surgical patient's immune system to fight infections.[56] One study showed that the incidence of SSI in patients that had experienced mild IPH was three times higher as compared to the normothermic perioperative patient.[31] A reduction in core temperature of 1.9°C has been shown to triple the occurrence of SSI after colon resection and increase the hospital stay by 20%.[55,56] The Association for Professionals in Infection Control and Epidemiology (APIC) has consistently referred to the Centers for Disease Control and Prevention's (CDC) *Guideline for the Prevention of Surgical Site Infection* that states excellent surgical technique contributes to a reduction in SSI, and these techniques include the prevention of IPH.[37] Additionally, the avoidance of tissue ischemia by the use of intraoperative warming has been shown to significantly reduce the risk of pressure sores.[33] Obviously, reducing the risk of SSI in surgical patients contributes to lower antibiotic use.

Drug metabolism and elimination is affected by core temperature; drugs can remain in the circulatory system longer than usual in the hypothermic patient.[61] The duration and increased effect of the action of drugs such as benzodiazepines and neuromuscular blockers can be extended by 40 – 50%.[50,61] Hypothermia affects the body's metabolism of propofol and increases the duration of action of atracurium.[48] Hypothermia increases the solubility of inhaled anesthetics.[52] This combination of increased duration of muscle relaxants and solubility of inhaled anesthetics explain how hypothermia may be a contributing factor for the delay of emergence and recovery from general anesthesia.[16,52]

When rewarming a hypothermic patient it can cause additional serious metabolic complications due to blood that was pooled in the peripheral vascular beds of the body that now returns to the body's core.[21,24,43] Along with the transport of the blood, acid metabolites are also released resulting in cardiac instability.[55] The signs and symptoms of hemodynamic instability include hypotension, myocardial depression, and release of metabolic acids.[55]

One of the most researched and documented effect of hypothermia is coagulopathy and blood loss. Hypothermia effects hemostasis through three primary factors: impaired platelet function, coagulation cascade, and initiation of fibrinolysis.[50,61] In one study, life-threatening coagulopathy occurred in trauma patients who required a massive transfusion with a temperature below 34°C along with a co-morbid increase in metabolic acidosis.[7,55] Prothrombin time is significantly increased at core temperature of <35°C which implies that the primary mechanism of hypothermia-induced coagulopathy is due to altered enzymatic activity.[61] Lastly, hypothermia increases blood viscosity creating the risk for the development of blood clots and emboli with diminished blood flow.

Hypothermia has been estimated to increase blood loss by up to 30% and up to a 70% probability of the need for transfusion during surgery.[33,49] Even a core temperature reduction of 0.5°C has been shown to have a physiologic effect on blood loss.[42] In one study 150 patients undergoing a total hip arthroplasty were randomly assigned to be either warmed to 36.5°C or 36°C. Several outcomes were better in the group warmed to 36.5°C including the amount of blood loss.[63] The authors concluded that aggressive intraoperative warming can reduce blood loss in total hip arthroplasty patients; this was further supported by another study in which FAW was applied for total hip arthroplasty patients.[40,63]

These complications cause prolonged recovery and hospital stay that contributes to loss of work and wages, increased treatment costs for the patient, and an increase in the risk of healthcare acquired infection (HAI).[2,20,26,33] Studies have shown that hospital stays can be 20% - 65% longer for the IPH patient.[33] In positive terms, the prevention of IPH clearly benefits the patient through reduced morbidity and mortality that is correlated to reduced hospitalization costs and faster recovery. See Table 2.

Another challenge is some patients undergoing a particular procedure are simply difficult to keep warm. Patients undergoing open cardiothoracic procedures or complicated spinal procedures have a limited surface area to which the warming device can be applied. Preoperative temperature is of utmost importance for these patients.

The last part of this discussion involves a brief review of the physiology of body heat loss in order to fully understand the mechanism of hypothermia and frame the importance of maintaining normothermia in the patient.

Heat loss occurs through four mechanisms: conduction, convection, evaporation, and radiation. Conductive heat loss occurs when the skin, or tissue, has direct contact with colder objects such as when the patient is positioned on the cold mats of the OR table. Convective heat loss often occurs when air currents are present and there is a continual removal of the warm air. The rate of convective heat loss depends on the velocity of the air currents; additionally, this increases the conductive heat loss.[55,61] Conductive heat loss also occurs when cold IV fluids and blood products are administered; the infusion of a large amount of ambient or cold fluids can quickly decrease the temperature of the circulating blood. Heat loss from evaporation occurs from the patient’s airway, and exposure of the tissues and organs in the major body cavities, i.e. thoracic and abdominal cavities. Lastly, radiant heat loss occurs when the skin and viscera are warmer than the environment; exposed patients can rapidly experience radiant heat loss as compared to the surgical patient that is covered by sterile drapes.

Table 2
Effects of IPH on Body Systems

Body System	Effects of IPH
Cardiovascular Disorders	• Bradycardia • Arrhythmias • Metabolic acidosis • Myocardial ischemia • Blood viscosity increased • Peripheral vasoconstriction • Impaired tissue oxygen delivery
Coagulopathy	• Impaired platelet function • Impaired coagulation factors • Impaired clotting enzyme function
Decreased Metabolism of Drugs	• Decreased renal circulation • Decreased hepatic functions
Gastrointestinal	• Decreased motility
General Metabolic Disorders	• Shivering • Acidosis
Increased Risk of SSI	• Sepsis • Decrease of WBC • Impaired immune response • Impaired function of neutrophils
Neurological	• Confusion

Standard of Practice I
The patient and patient's family should be provided preoperative education on maintaining the warmth of the patient.

1. Maintaining normothermia begins in the home; the night before surgery and the morning of surgery when travelling to the HDO the patient should be kept warm.
    A. During the preoperative interview the patient and patient's family should receive verbal and written instructions for maintaining normal body temperature at home, in particular during the winter months.
        (1) The patient and family should be informed that staying warm before surgery will lower the risk of postoperative complications.[44]
        (2) The patient and family should be advised to bring extra clothing such as slippers and nightwear since the HDO environment may be colder as compared to home.
    B. It is recommended the patient take his or her temperature before going to bed the night before surgery and the morning of surgery.
        (1) The patient should try to maintain a normal body temperature as close to 37°C as possible.

2. The patient and family should be provided discharge teaching and instructions regarding methods to maintain normothermia at home such as the use of blankets, increased clothing, socks, and increased room temperature.

Standard of Practice II
The anesthesia provider is ultimately responsible for assessing the patient for the risk of IPH.

1. All non-emergent surgical patients should have their risk for IPH assessed and documented preoperatively by the anesthesia provider.
   A. Patients are at a higher risk of IPH if any of the following two apply:[20,36,44,58]
      (1) Major surgery will be performed.
      (2) Perioperative temperature below 36°C.
      (3) At risk for cardiovascular complications.
      (4) Extremes of age – very young or elderly.
      (5) Combined neuraxial and general anesthesia.
      (6) ASA patient grade of 2 – 5 (the higher the grade, the greater the risk)
   B. The risk assessment should include review of the patient's medical chart, interview and physical examination of the patient, and discussing the anesthesia plan and surgical procedure with the patient.[48]
      (1) The patient should be assessed for the risk of shivering.
      (2) The patient's preoperative baseline temperature should be measured and documented.[23]
      (3) The risk assessment should consider the age of the patient.
         (a) Neonates and infants are more susceptible to IPH than adults due to a high ratio of body surface area to weight that causes more heat loss.[36,58] Neonates are also at an increased risk because of disproportionately larger heads and thinner skulls and scalps allowing a greater heat loss from the brain as compared to adults.[58]

             The anesthesia plan for pediatric patients should include the use of equipment to humidify warm anesthetic gases as an adjunct to other warming methods such as FAW. The OR should be prewarmed above 26°C and maintained at that temperature.[54] One study of pediatric patients reported an increased risk of IPH by 1.96 times in an OR temperature of less than 23°C. Warm IV fluids and irrigation fluids at body temperature (37°C) should be used.
         (b) The thermoregulatory mechanisms of the elderly are often not optimal requiring the surgical team to be diligent in the provision of warming methods.[21,24,43] Elderly patients often have less subcutaneous tissue, and

the thermoregulatory mechanisms of vasoconstriction and shivering are less effective.[48]

(4) Patients that have suffered extensive burns must be carefully assessed.
   (a) Patients with burns easily lose body heat by radiation and convection, and they have lost the insulation of the skin placing them at a higher than normal risk for IPH.
   (b) The anesthesia plan should include the availability of equipment to humidify warm anesthetic gases.
   (c) Warm IV fluids and irrigation fluids at body temperature (37°C) should be used.
   (d) FAW should be used if possible; if the patient suffered burns over a large portion of the body it may not be possible to use any type of active warming method and as much of the body surface should be covered as possible.
   (e) The OR should be prewarmed above 26°C and maintained at that temperature.

(5) If a patient is on a drug therapy plan for taking antipsychotics it should be assessed and documented. Antipsychotics impair the thermoregulatory functions of the hypothalamus.[30]

(6) The assessment should include evaluation and documentation of the patient's body weight. Low body weight is a risk factor for IPH.[27] Slender patients have less insulation and a larger body-surface-area-to-weight ratio. Whereas, bariatric patients have a high weight-to-body-surface ratio and the peripheral adipose tissue is maintained at a normal to high temperature.

(7) Patients should be assessed for metabolic disorders that can interfere with normal thermoregulation. Studies have shown patients with diabetic neuropathies tend to have a low core body temperature when under anesthesia for two hours when compared to non-diabetic surgical patients.[29]

(8) The plan should include: anesthesia method(s); surgical procedure to be performed; methods to be used for pre-warming, and intraoperative and postoperative warming.
   (a) The plan should be developed based upon the specific, documented risk factors that have been identified for the patient.
   (b) If the plan includes the use of a pneumatic tourniquet, such as for a Bier block, it should be documented. Pneumatic tourniquets lessen hypothermia by blocking the exchange of blood and heat between the extremity and rest of the body.[28,42] However, the risk factor is when the tourniquet is released redistribution of the blood flow and heat from the core to the extremity occurs resulting in a sharp decrease in core temperature.[28,42]

(9) The risk factor assessment findings and plan should be shared with all members of the surgical team to allow the team the ability to plan ahead of time in making sure devices and equipment are in working order and available for the procedure.[23] Abreu developed a personalized Hypothermia Risk Index (pHRI) as a tool to identify in advance patients that are at risk for hypothermia; however, he acknowledges further studies are needed to confirm its usefulness; see Table 3.[1]

The risk assessment documentation should include the anesthesia plan, surgical procedure plan, patient assessment for risk of IPH, anesthesia diagnosis, and planned interventions for warming the patient and preventing IPH.

Table 3
Personalized Hypothermia Risk Index

Parameter	**Y/N**	**Value**	**Insert Value of Y Responses**
Autonomic Responses			
Piloerection		1	
Shivering – mild or cold hands/feet (pallor)		2	
Shivering – pronounced		3	
Behavioral response			
Cold?		1	
Hot?		0	
Neutral?		0	
Unresponsive/unable to communicate		1	
Core/brain temperature			
<34.5°C		4	
≥34.5°C to <35.5°C		3	
≥35.5°C to <36°C		2	
≥36°C to <36.5°C		1	
≥36.5°C		0	

Total:
Patients with a score of ≥4 are at increased risk for developing complications from hypothermia and should be closely monitored during and after surgery.
Abreu M. New Concepts in Perioperative Normothermia: From Monitoring to Management. Anesthesiology News. 2011; 37(10); 39-48.

2. Patient's that have sustained one or more traumatic injuries are susceptible to IPH. Up to 50% of trauma patients are unintentionally hypothermic before they reach the HDO.[21,24,43] Hypothermic trauma patients are less likely to survive their injuries when compared to trauma patients who are normothermic.[10,21,24,43,55] The "lethal triad" of hypothermia, impaired coagulation, and metabolic acidosis

significantly decreases the patient's ability to recover from traumatic injuries.[21,24,43] Trauma patients that are particularly at risk for IPH are neonates/infants, elderly, and homeless.[55] Factors that may contribute to the high incidence of IPH in the trauma patient include prolonged exposure to the weather elements, alcohol intoxication, head injury, and shock.[55] A French study conducted in 2012 confirmed that the three most significant risk factors for IPH are severity of injury, temperature of IV fluids, and temperature inside the ambulance.[32] The study reported that the severity of hypothermia is linked to the severity of the injury, such as blood loss and spine or head injuries that impair the body's internal temperature regulating mechanisms.[32]

As with all patients, cross-department teamwork is essential; emergency first-responders (Emergency Medical Technicians and Paramedics) and the surgery team must take under consideration that factors that contribute to IPH tend to be exaggerated in the trauma patient.

A. Emergency first-responders must be aware that the infusion of cool isotonic solutions such as normal saline contributes to IPH and complicates the ability of the surgical team to achieve normothermia.[21,24,32,43] Additionally, when the trauma patient is in shock hypoperfusion can also further exacerbate IPH.[20,22,39]
    (1) Warming trays should be used in the ambulance to keep IV fluids warm.[21,24,43]
    (2) It is recommended that only enough IV fluids should be administered to maintain the systolic blood pressure at 85-90 mmHg.[32,43]
    (3) Emergency first-responders and the surgery team must be aware of the signs and symptoms of metabolic acidosis, and be prepared to treat the condition.
B. Other risk factors that should be addressed and treated in the trauma patient are:
    (1) Shivering: Trauma patients should be covered as best as possible as soon as possible at the scene and when being transported; emergency foil blankets are effective in retaining body heat. Wet clothing should be removed, but if not wet as little clothing should be removed as possible that still allows access to the traumatic injuries. The compartment heater of the ambulance should be turned on to make the patient area as warm as possible.[10,32]
    (2) Coagulopathy: The challenge for the surgery team is the trauma patient's coagulation laboratory test results may be reported as normal since the blood sample(s) are heated to 37°C before being tested.[61]
C. If the trauma patient is hypothermic and all other immediate measures have been completed such as covering the patient, the next step is to verify the core temperature. See Standard of Practice IV for sites where the temperature is taken and recorded.

Standard of Practice III
100% of patients should be adequately covered on the ward and during transfer to the preoperative holding area.[20]

1. The patient should be adequately covered on the ward or any other units such as the ICU before and after surgery.
    A. The patient should be encouraged to communicate to healthcare providers and/or family if he/she is not warm enough.
2. During transfer from the ward or other unit such as the ICU, the patient should be adequately covered to prevent IPH.
    A. It is recommended that the patient be covered with one sheet and at least two warm blankets prior to transfer.
        (1) If a CST is responsible for transporting the patient, he/she should visually confirm that as much of the surface area of the patient is covered including arms.
        (2) The CST should verbally confirm with the patient that he/she is warm and provide additional blankets if the patient expresses being cold.
3. While waiting in preoperative holding the patient must be kept warm by providing additional warm blankets, in particular if the patient has been administered premedications.[44] Shivering by the patient must be prevented.
    A. If a patient has been preoperatively assessed for being at-risk for IPH it is recommended that forced-air warming be implemented in preoperative holding.

Standard of Practice IV
The body temperature of the patient should be recorded throughout the perioperative period.

1. Body temperature is just as important of a vital sign as the blood pressure or pulse.[20]
    A. 100% of non-emergent patients should have a temperature of 36°C or above prior to transport to the OR and before the start of anesthesia.[20]
    B. It is recommended that the body temperature be recorded a minimum of one hour before transfer from the ward or other unit such as the ICU to preoperative holding.
        (1) If a CST is responsible for transporting the patient, he/she should confirm that the body temperature has been recorded in the patient's record.
    C. The body temperature should be recorded at the same frequency as other vital signs throughout the perioperative period including up to a minimum of the first 24 hours postoperatively.[20]
        (1) The patient's temperature should be measured and documented before the induction of general or neuraxial anesthesia.[44]
        (2) It is recommended that all surgical patients should have their core temperature recorded every half-hour during anesthesia.[2]
        (3) A consistent measuring site and technique should be used throughout the perioperative period for every patient in order to

detect changes of temperature from the baseline and obtain comparative results.[23]

(4) Adult patients receiving FAW are unlikely to become hyperthermic due to sweating that cools the body. However, neonates, infants, and adolescents quickly become warm and require close monitoring.[50]

D. Temperature measurement is divided into two categories: core temperature and near-core.[23] Clinical research literature reports that the sites that most accurately provide core temperature readings are the distal esophagus, nasopharynx, pulmonary artery and tympanic membrane via thermocouple.[19,23,50,61] Near-core sites include the bladder, oral chemical dot thermometers, temporal artery, and tympanic membrane with infrared sensor.[23]

(1) Bladder temperature can be measured with a urinary catheter that contains a temperature transducer.[35] Bladder temperatures provide a good calculation of the core temperature as long as the urine flow is good; if the urine flow is low the accuracy of the bladder temperature monitoring decreases.[34,35,50] Therefore, obtaining an accurate bladder temperature relies on a third factor, urine flow, making the bladder a less than optimal site.

(2) Distal esophageal temperature accurately reflects core temperature, but the reading is affected by the use of humidified gases if the probe is not positioned far enough and may be affected during open cardiothoracic procedures since the cavity is exposed to ambient air.[34,35] However, the site is easy to use and minimally invasive.[19]

(3) Nasopharyngeal temperature is measured by placing the esophageal probe superior to the soft palate; this positions the probe close to the brain to obtain an accurate core temperature.[48] But the temperature measurement can be affected by inspired gases.[34,35]

(4) Pulmonary artery catheters measure the central blood temperature which directly measures the core temperature.[35] However, pulmonary artery catheter use is usually for patients that require close hemodynamic monitoring due to their invasiveness and high cost of the catheters.[34,35]

(5) Studies have indicated tympanic membrane via thermocouple (also called thermistor) measurements are highly reliable and consistent, and are the preferred perioperative method.[19,48,50,61] The tympanic membrane is close to the carotid artery and hypothalamus allowing for an accurate measure of core temperature, and taking the measurement is noninvasive.[34,35]

However, infrared tympanic thermometry and temporal artery thermometers do not provide an accurate temperature measurement during the perianesthesia period.[19,23]

E. CSTs should complete training in the use, care and handling of temperature recording devices.
   (1) On the day of the surgical procedure, the CST should collaborate with the anesthesia provider and other members of the surgical team in confirming the availability of the temperature recording device that has been documented to be used in the patient's anesthesia plan.
   (2) The CST should complete training in how to test the temperature recording device prior to use on the patient. The CST should test and use the temperature monitoring device according to manufacturer's instructions for use (IFU).
   (3) The training should include how to clean and store the devices according to manufacturer's IFU.

Standard of Practice V
Forced-air warming (FAW), circulating-water device, and energy transfer pads are recommended methods for perioperative warming of the surgical patient and prevention of IPH.

1. Methods for maintaining normothermia are categorized as passive or active. It is recommended the surgical team employ both methods to prevent IPH.[19]
   A. Passive warming refers to decreasing heat loss by insulation, i.e. covering exposed skin surfaces to the extent possible. This is accomplished through the use of warm blankets, foil blankets, sterile drapes, and plastic bags, e.g. anesthesia provider covers the head of the patient with a plastic bag.
      (1) Rubber warming bottles or warm IV fluid bags should never be used to warm patients, in particular pediatric patients. The temperature of the bags cannot be controlled and can result in patient burns.
   B. Active warming involves the use of a device.
2. FAW is an effective method active warming.[3,64] FAW utilizes the mechanisms of convection and radiation.[56] The movement of the warm air transfers heat to the surface of the patient's skin; this allows FAW blankets to transfer more heat at a lower temperature.[56,64] However, in hypothermic patients, particularly trauma patients, peripheral vasoconstriction can limit the efficacy of FAW and other methods such as the heated water blanket may be more efficient.[61,53] For a summary of the available methods see Tables 4 and 5.
3. Circulating-water devices use convective heating to warm the patient.[12] The method has been confirmed to be effective for both adult and pediatric patients, and reported to transfer more heat to patients than FAW.[59]
   A. Several studies have confirmed the effectiveness of circulating-water devices with a focus on its use during pediatric and adult cardiac surgery, and major open surgery such as liver transplant. The results of the research consistently showed that circulating-water devices were more effective than FAW during cardiac and major open surgery.[26, 42, 50, 59, 56]
      (1) Due to a decrease in the surface area for effective cutaneous heat transfer, FAW has been shown to be insufficient during cardiac

surgery and major open surgery.[51] However, the circulating-water garment allows the surgical team to cover a much larger surface area with the ability to position it under the patient and wrap around the anterior surface to cover the torso, legs and upper arms.[51] Three studies showed that the mean core temperature of patients was significantly higher with the use of the circulating-water garment as compared to the control group in which FAW was used.[38, 43,56]

(2) In a study that used nine volunteers the conclusion is the circulating-water garment transferred more heat than FAW with the difference resulting mainly from posterior heating.[51]

(3) Orthotopic liver transplants (OLT) present multiple factors that contribute to IPH including massive fluid administration, convective and evaporative losses from lengthy exposure of the abdominal cavity, decrease in hepatic energy production, and implantation of the cold liver allograft.[23] The results of the study showed that the mean core temperature during incision, one hour after incision, and during skin closure were significantly higher in the circulating-water garment group of patients as compared to the FAW control group.[23] Additionally, the core temperature was also significantly higher during the placement of the cold liver allograft.[23] The conclusion of the authors of the study is the circulating-water garment results in better maintenance of intraoperative normothermia than FAW due to the ability to cover a greater percentage of the body surface.[23]

4. A newer system for preventing IPH is the energy transfer pads (ETP). Studies have been performed in the use of ETPs primarily during off-pump coronary artery bypass (OPCAB) surgery and pediatric procedures. The conclusion of the studies is consistently that ETP is significantly more effective than FAW and other conventional methods, e.g. higher room temperature, heated IV fluids.[17, 22, 45, 46, 51, 62] It is shown to significantly maintain higher core body and skin temperatures, and in some instances even raise the core body temperature when necessary.[17, 22, 45, 46, 51, 62]
5. It is recommended patients should be pre-warmed a minimum of 30 minutes immediately prior to the administration of general or neuraxial anesthesia.
   A. When the periphery is pre-warmed, the core to periphery flow of heat can be greatly reduced.[50,53] This is especially important for patients undergoing a short or complicated procedure.
   B. It is recommended that active warming methods, defined as forced-air warming (FAW) or circulating water device, be used throughout the intraoperative period to achieve the target temperature of 36°C within 30 minutes immediately before or 15 minutes after the discontinuation of anesthesia.[2,23] The measure applies to all patients including pediatrics that undergo a non-emergency surgical procedure in which the patient is under general or neuraxial anesthesia for 60 minutes or longer.[4,20]

C. It is recommended that the temperature setting of the warming device be set as high as possible according to the manufacturer's IFU and adjusted to the level at which the patient's temperature is maintained at 36°C.[11,44]
D. CSTs that perform the assistant circulating role should complete training on the use of warming devices used in the surgery department.

6. The OR table mattress and linens should be pre-warmed as an adjunct to preventing conduction heat loss.
7. To assure patient safety, the manufacturer's IFU for the use of a warming device should be followed.
    A. Only U.S. Food and Drug Administration (FDA) approved warming devices should be used.
    B. Only the blanket and hose that were delivered with a FAW device upon purchase should be used; the items should not be replaced by a blanket or hose from another device even if it is the same model.
    C. The hose should never be disconnected from the warming blanket when in use; the hose alone should not be used to deliver the warm air which has resulted in patient injuries.[38,39]

Table 4
Methods to Maintain Normothermia in the Surgical Patient

External Methods	Internal Methods
• Fluid warmer • Force-air warming • Heated water blanket • Heated water mattress • Warm blankets; foil blanket • Increase temperature in OR • Heated humidified anesthetic gases • Remove patient from cold environment	• Cardiopulmonary bypass • Hemodialysis with warm fluids • Peritoneal lavage with warm fluids • Continuous arteriovenous warming (CAVR)[47]

Standard of Practice VI
The pharmacologic agent of choice for the treatment of shivering is meperidine.

1. Based upon clinical studies, the ASA recommends that meperidene should be used for the treatment of patient shivering during emergence and postoperatively. **(ASA)**
    A. Clinical research literature supports the effectiveness of meperidine when compared to other opioid agonists or agonist-antagonists for reducing shivering. **(ASA)**
    B. The CST in the assistant circulator role should be familiar with meperidine including actions, side-effects and uses.

Table 5
Advantages and Disadvantages of Specific Methods of Patient Warming

Method of Warming	Advantages	Disadvantages
Forced-air warming	• Immediately produces warm air; quickly warms the patient • Low risk of patient burns	• Warms the OR making it uncomfortable for the surgical team • No cooling option except to turn off unit • Disposables increase cost of use • Patient must be padded to prevent pressure sores
Water mattress	• Risk of pressure sores alleviated • Does not warm the OR • Low risk of patient burns • Can cool and heat	• Water leakage if mattress damaged • Heavy; transporting, handling, and positioning mattress difficult • High-use of electrical power
Fluid Warmer	• Direct warming of IV fluids and blood products before they are infused • Easy and fast to set-up portable fluid warming units	• Only use is for warming IV fluids and blood products

Standard of Practice VII
Intravenous (IV) fluids and blood products should be warmed prior to transfusion to aid in preventing IPH.

1. It is recommended that IV fluids should only be warmed when it is anticipated that more than 2 liters per hour will be administered in adults.[44,48] When less than 2 liters per hour will be administered warm IV fluids have little effect on the patient's core temperature.[44,48]
   A. Studies support the warming of IV fluids as an adjunct to FAW to decrease the risk for IPH.[35,52]
   B. The IV bags should be warmed according to manufacturer's IFU.
      (1) The CST should collaborate with the anesthesia provider and other members of the surgical team in confirming there is an adequate number of warm IV bags available prior to the start of the surgical procedure.

(2) The IV bags should be warmed to a temperature of approximately 37°C.[44,48]

2. Blood products must be warmed prior to transfusion.[7]
    A. The CST can collaborate with the anesthesia provider in obtaining the portable blood-warming unit and assist in preparing it for use, e.g. attach to IV pole, plug electrical cord into outlet, start the unit, assist anesthesia provider with placing tubing inside the unit.[7]

Standard of Practice VIII
Warm skin preparation antiseptics should be used when performing the patient skin prep.

1. Warm antiseptic solutions will help to prevent cooling of the surface of the skin. However, the manufacturer's IFU should be consulted to confirm if it is safe to warm the antiseptic solution, what temperature the solution can be warmed, and the storage temperature.[8]
2. Some antiseptic solutions are flammable; heating the solution is a fire hazard.
3. To the extent possible, expose only the skin necessary for the patient skin prep to prevent convection heat loss.
4. The sterile drapes should be placed as soon as possible after the patient skin prep is completed to prevent evaporation heat loss.

Standard of Practice IX
The CST in the first scrub role must provide warm irrigating fluids for use by the surgeon to aid in preventing IPH in the surgical patient. (ST for the ST)

1. Warm irrigation fluids support the use of other warming methods to prevent IPH.
    A. A study of patients that underwent a shoulder arthroscopy concluded that core temperature may be effected by irrigation fluid temperature and recommended that the fluid be warmed to 36°C.[9]
    B. The irrigation fluids should be warmed to a temperature of approximately 37°C. However, the irrigation fluids should be warmed according to the manufacturer's IFU.
    C. The CST should confirm there are an adequate number of warm containers of irrigation fluids available prior to the start of the surgical procedure.

Standard of Practice X
The patient's perioperative record should include documentation of the measures taken by the surgical team to prevent IPH and maintain normothermia in the patient.

1. The documentation should include the type of temperature measurement device used and settings; temperature measurements recorded during the surgical procedure; type of active warming device used and setttings; use of warming device for blood and blood products if infused; any other thermoregulation methods or devices.

Standard of Practice XI
Incidences of IPH and device malfunctions should be documented and reviewed in order to identify measures that can be taken to improve surgical outcomes.

1. An incidence of IPH that occurs during the perioperative period should be documented and assessed by the surgical team.
    A. The surgical team should evaluate to the extent possible the reason(s) for the occurrence of IPH including if there was a lapse in applying the policies and procedures, and make the necessary adjustments to prevent further incidences.
    B. The HDO’s normothermia policies and procedures should be reviewed at least biannually.
        (1) The policies and procedures should be available in the surgery department for the surgical personnel.
2. Incidences involving warming devices and temperature monitoring devices should be documented according to the HDO’s adverse event reporting policies and procedures, and in compliance with the Safe Medical Devices Act of 1990.[57]
    A. A patient device injury is required to be reported to the FDA and device manufacturer within 10 days; the report should include the type of device, identifying information such as serial number and date of manufacture, inspection dates performed by biomedical equipment technicians, and description of the adverse event.[57]

Standard of Practice XII
CSTs should better familiarize themselves with the clinical subject of normothermia and IPH by completing continuing education on the adverse effects of IPH, and methods for preventing and treating IPH.

1. Given its critical importance to positive surgical outcomes, literature has recognized that regulation of normothermia has been inconsistent and often ignored.
    A. The following have been identified as barriers for establishing a national standard of care for normothermia:[50]
        (1) Lack of clear, evidence-based guidelines on warming techniques that are most successful. It has been identified that an evidence-based approach to thermoregulation is needed for HDOs to use as guidance in developing policies.
        (2) Inconsistent practice within HDOs; some patients are monitored and others are not monitored.
        (3) Inconsistent practice from one HDO to another; 100% of patients monitored and hypothermia prevented, whereas an HDO may report hypothermia in the PACU as being common.
        (4) Staff turnover can contribute to inconsistent practices; one or more advocates for preventing IPH leave and efforts to monitor patients decreases.
        (5) The benefits of warming the patient are not immediately noticeable. Surgery personnel are more accustomed to seeing immediate results, such as a drug taking effect or stopping

bleeding with electrocautery. Surgery personnel may not be aware of the long-term benefits to the patient of maintaining normothermia and preventing IPH. Operating room staff that do not follow patients postoperatively will not have the experience of observing the benefits and positive outcomes of warming. Continuing education that stresses the evidence-based benefits of patient thermoregulation is important for getting the message out to surgery personnel.

(6) The warming methods used by the surgery department may be ineffective causing the surgery personnel to disregard the effects of IPH. The department may only be relying upon passive warming methods combined with a lack of awareness of other available technologies.

(7) The increased focus and pressure by HDO administration on fast OR turnovers can contribute to ignoring the use of warming measures and monitoring the patient's temperature. A FAW device takes time to set-up and position on the patient as well as transportation issues when the patient is transported from preoperative holding to the OR and then the PACU. Additionally, the anesthesia provider may feel the pressure to not take the time to establish a base core temperature prior to the administration of anesthesia as well as upon emergence in the OR.

2. Educational efforts on patient warming and IPH should be provided to all surgery team members in order to better understand the correlation between hypothermia and adverse outcomes.[50]
   A. The continuing education should include up-to-date, outcomes-based information on the ways IPH can be prevented and treated.
   B. The CST should periodically complete continuing education on normothermia, IPH, temperature measurement technology up-dates, and methods for preventing IPH.[5]
   C. The completion of continuing education and annual competency assessment of the CST in the prevention of IPH, and safe use of temperature measurement and warming devices should be documented by the HDO.

Competency Statements

Competency Statements	Measurable Criteria
1. CSTs have the knowledge and skills to provide patient care by reviewing the anesthesiologist's risk factors assessment in order to participate with the surgical team in implementing the thermoregulatory plan for the surgical patient. 2. CSTs have the knowledge and skills to perform patient care by participating in assembling, testing and applying thermoregulatory devices in the perioperative setting. 3. CSTs have the knowledge and skills to perform patient care by applying passive methods of warming patients in the perioperative setting. 4. CSTs can serve on as well as participate in the work of a committee assigned to assess incidences of IPH and adverse events related to device malfunction.	1. Educational standards as established by the *Core Curriculum for Surgical Technology*.[6] 2. The didactic subject of thermoregulatory care of the patient is included in an accredited surgical technology program. 3. Students demonstrate knowledge of thermoregulatory care of the patient in the lab/mock OR setting and during clinical rotation. 4. CSTs perform patient care by implementing the thermoregulatory plan in coordination with the surgical team members. 5. CSTs participate on the HDO's patient normothermia committee. 6. CSTs complete continuing education to remain current in their knowledge of normothermia, preventing IPH, and safe use of temperature monitoring and warming devices.[5]

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