Prevention of Unplanned Perioperative Hypothermia
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Perioperative nurses are all too familiar with the consequences of unplanned perioperative hypothermia and must take charge to avoid this surgical complication. Collaboration between the perioperative nursing team, surgeon, and anesthesia care provider ensures that preplanning occurs and multiple interventions are implemented to prevent unplanned hypothermia in the surgical patient. This article reviews the physiology of thermoregulation, the causes of hypothermia, and adverse patient outcomes that occur as a result of unplanned perioperative hypothermia. Recommendations for nursing interventions that can be provided during each phase of perioperative care to improve postoperative patient outcomes also are given.

Physiology of Thermoregulation
A normothermic core temperature ranges between 36° C to 38° C (96.8° F to 100.4° F). Although the term hypothermia is defined as core temperature less than 36° C (96.8° F), hypothermia can be classified as mild, moderate, or severe.

- Mild hypothermia is a core body temperature of 34° C to 35° C (93.2° F to 95° F).
- Moderate hypothermia is a core body temperature of 30° C to 34° C (86° F to 93.2° F).
- Severe hypothermia is a core body temperature less than 30° C (86° F).

Thermoregulation is the balance between heat loss and heat gain, which determines the body’s core temperature. The body is divided into two thermal compartments: the core (ie, head and trunk) and the periphery (ie, extremities). Core temperature is regulated hormonally by the hypothalamus, which often is referred to as the body’s thermostat. Central thermoreceptors in the hypothalamus, spinal cord, abdominal organs, and other central locations and peripheral thermoreceptors in the skin send information to the hypothalamus regarding core and peripheral temperatures.

Mechanisms of heat loss include radiation, convection, conduction, evaporation, peripheral vasodilation, decreased muscle tone, and increased respiration. Intraoperative heat loss occurs via
- radiation,
- convection,
- conduction, and
- evaporation.

Radiation and convection account for 85% of total heat loss from the patient to the environment.

ABSTRACT
HYPOTHERMIA is one of the most common complications experienced by surgical patients. Better postoperative patient outcomes are achieved when normothermia is maintained.

PERIOPERATIVE NURSES should understand how to maintain normothermia, the causes of hypothermia, and adverse patient outcomes that result from hypothermia. Nursing interventions to help prevent hypothermia can be implemented during each phase of perioperative care. AORN J 88 (September 2008) 358-364. © AORN, Inc, 2008.

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the environment via anterior surfaces of the body. Radiation is a form of heat loss through electromagnetic waves, which involves heat transfer from one object to another without physical contact. Convection is the process of losing heat as air or water molecules move across the skin. Conduction and evaporation account for less than 15% of total heat loss. Conduction is the process of heat loss via physical contact with another object or body (eg, the OR bed mattress). Evaporation is the process of losing heat through the conversion of water to gas (eg, evaporation of sweat).

**Causes of Unplanned Perioperative Hypothermia**

Unplanned or inadvertent hypothermia is one of the most common complications experienced by surgical patients. Typically, this occurs intraoperatively and during the immediate postoperative period. There are many causes cited for hypothermia. A primary cause is the cold temperature maintained in most ORs (ie, less than 21° C [69.8° F]). Other causes include open body cavities in abdominal and chest surgery, infusion of cold IV fluids and blood products, use of cool irrigating solutions and skin preparations, and length of surgery. General anesthesia causes heat loss from

- the lungs via inhaled gases,
- medication-induced vasodilation,
- decreased metabolic rate,
- decreased tissue perfusion, and
- redistribution hypothermia.

Patient characteristics that may influence hypothermia include

- preoperative thermal status; body morphology;
- patient age;
- electrolyte status; oxygen saturation; and
- preexisting medical conditions, such as hypothyroidism, hypoglycemia, malnourishment, burns, and trauma.

**Adverse Effects of Unplanned Perioperative Hypothermia**

Hypothermia increases the risk of surgical site infections (SSIs); increases hospital length of stay and subsequent costs; can decrease reimbursement (ie, because of risk of economic penalties for noncompliance); and increases morbidity and mortality. To prevent these problems, perioperative nurses must understand how general anesthesia affects the phases of hypothermia and how hypothermia

- affects the cardiovascular system,
- increases the risk of SSI,
- increases blood loss and transfusion requirements, and
- affects pharmacokinetics and pharmacodynamics.

There are three phases of hypothermia: the redistribution phase, the linear decrease phase, and the thermal plateau phase. Redistribution hypothermia develops immediately after induction of general anesthesia as a result of internal core-to-peripheral redistribution of body heat, an example of convective heat loss. This occurs because of anesthesia-induced vasodilation and reduced thermoregulatory vasoconstriction. Core temperatures can drop 0.5° C to 1.5° C (0.9° F to 2.7° F). The linear decrease phase of hypothermia occurs during the second and subsequent hours of anesthesia, during which heat loss exceeds the body’s ability to metabolically produce heat. The thermal plateau phase occurs approximately three to five hours into surgery. The patient’s core temperature plateaus and remains constant, even during prolonged surgery.

**Effects of Hypothermia on the Cardiovascular System.** A mild drop in temperature (0.5° C to 1.5° C
[0.9°F to 2.7°F]) has been shown to trigger sympathetically mediated hypertension, which occurs as a result of profound increases (eg, 100% to 700%) in serum norepinephrine concentrations, thus increasing systemic vascular resistance (ie, cardiac afterload) and generalized systemic vasoconstriction.\textsuperscript{8,10} This can further perpetuate problems for patients with existing coronary artery disease. Hypothermia can induce a vigorous shivering response as the body endeavors to increase metabolic heat production up to 600% above the patient’s basal level.\textsuperscript{11}

Some patients report that shivering and being cold are worse than surgical pain.\textsuperscript{11} Furthermore, shivering increases oxygen consumption up to 400% to 500% and markedly increases carbon dioxide production.\textsuperscript{8} Hypothermia decreases the patient’s metabolic rate and also may decrease tissue perfusion from a catecholamine response.\textsuperscript{6} Research by Nesher et al\textsuperscript{10} indicated that maintenance of normothermia decreased myocardial ischemic injury as demonstrated by improved hemodynamic variables and reduced levels of serum cardiac markers.

**Increased Risk of Surgical Site Infections.** The primary line of defense against infection is intact skin. A surgical incision exposes the body to exogenous and endogenous pathogens. The primary defense against surgical pathogens is oxidative killing by neutrophils. Hypothermia triggers vasoconstriction, which decreases tissue oxygenation and perfusion, thus significantly increasing the risk for SSIs.\textsuperscript{8,9} Increased infection rates have been associated with surgical procedures that last longer than four hours.\textsuperscript{9}

**Increased Blood Loss and Transfusion Requirements.** Mild hypothermia significantly increases blood loss by approximately 16% (range 4% to 26%) and increases the relative risk for transfusion by approximately 22% (range 3% to 37%).\textsuperscript{12,13} Hypothermia impairs platelet function by blocking the release of thromboxane A2, which is responsible for developing the initial platelet plug. Hypothermia impairs the coagulation cascade enzymes, which prolongs prothrombin and partial thromboplastin times. This can be overlooked clinically because coagulation tests are performed at 37°C (98.6°F)\textsuperscript{12,13} and not at the patient’s core temperature. According to Raja-gopalan et al, “when various in vitro tests are performed at various temperatures, however, impairment is obvious.”\textsuperscript{12(p71)}

**Effects on Pharmacokinetics and Pharmacodynamics.** The effects of hypothermia on the pharmacokinetics and pharmacodynamics of medications used during and after surgical procedures are not fully understood. Anesthesia care providers and postanesthesia care unit (PACU) nurses must be prepared to carefully monitor patients who are suffering from hypothermia because dosing can unexpectedly progress from subtherapeutic to toxic. Hypothermia causes decreased hepatic blood flow and metabolism as well as decreased renal flow and clearance.\textsuperscript{14} The enzymes that moderate organ function, primarily the liver and kidneys, and metabolize most medications are very temperature sensitive, which makes them very susceptible to hypothermia.\textsuperscript{14}

**Midazolam.** Midazolam levels were measured in 15 traumatically brain-injured patients with a Glasgow coma scale score of 7.3.\textsuperscript{15} Eight patients’ core temperatures were lowered to 32°C to 34°C (89.6°F to 93.2°F) for 48 hours. Seven patients’ core temperatures were maintained at normothermia. Midazolam plasma concentration levels showed a five-fold increase in the hypothermic patients compared to the normothermic patients. A remarkable decrease in midazolam plasma concentration levels occurred, however, when a patient’s core temperature rose above 35°C (95°F). A limitation of this
Preventing hypothermia improves postoperative patient outcomes; therefore, nurses must take charge and proactively implement nursing interventions to keep patients warm during all phases of perioperative care.

**Clinical Nursing Interventions and Patient Outcomes**

Preventing hypothermia improves postoperative patient outcomes. Research has indicated that hypothermia contributes to morbid cardiac events,8,10 SSIs,8,9 coagulopathies and the need for transfusions,12,13 and altered medication metabolism.14-16 For these reasons, nurses must take charge and proactively implement nursing interventions to keep patients warm during all phases of perioperative care: the preoperative holding area, the OR, and the PACU/ICU.

**Preoperative Holding Area.** Preoperative assessment begins at the preadmission testing (PAT) appointment for outpatients or the preoperative visit the day before surgery for inpatients. The patient’s physical assessment includes age; body morphology (e.g., height, weight, body surface area); current vital signs; laboratory findings; preexisting medical conditions; and the proposed surgical procedure. The assessment provides the nurse with the opportunity to implement nursing interventions specific to the patient to prevent hypothermia. The PAT nurse may suggest that the patient wear a pair of socks and a head covering to stay warm during surgery.1,2 The nurse should discuss with the patient the physiologic benefits of staying warm, and if the facility has forced-air, temperature-regulating gowns, the nurse should explain that the patient is able to control the temperature of the gown to his or her comfort level.

Fentanyl is metabolized in the liver. Human and animal studies have indicated that fentanyl metabolism increases plasma concentration levels approximately 25% as a result of decreased hepatic blood flow at a temperature of 32°C (89.6°F).16 This observation is consistent with other medications with a high hepatic extraction ratio, such as propofol and propranolol.16

Research by Vanni et al4 indicates that one hour of preoperative skin-surface warming combined with intraoperative skin-surface warming prevented redistribution hypothermia study was the small sample size.

**Fentanyl.** Fentanyl is metabolized in the liver. Propofol concentrations were 28% higher at 34°C (93.2°F) than at 37°C (98.6°F). Hepatic blood flow decreased 23% with a standard deviation of 11% in normothermic volunteers compared to 33% with a standard deviation of 11% in hypothermic volunteers. Hepatic blood flow was assessed by a continuous IV infusion of indocyanine green. Hypothermia caused a decrease in hepatic blood flow, which then impaired the clearance of propofol.

**Vecuronium.** Vecuronium is a neuromuscular blocking agent that can be used to prevent shivering in the intensive care unit (ICU). Muscle strength is reduced during hypothermia, both in the presence and absence of neuromuscular blocking medications. A 2°C (3.6°F) reduction in body temperature may double the duration of neuromuscular blockade.18 Central body and muscle temperatures decline in parallel, as long as peripheral vasoconstriction does not occur.19 In a human study where central body temperature was allowed to decrease gradually from 36.5°C to 34°C (97.7°F to 93.2°F), the plasma concentration of vecuronium increased gradually with time.18 Therefore, as patients transition between normothermic and hypothermic states, frequent monitoring of medication effects is required.
during the first two hours of surgery in adult elective abdominal procedures. Forced-air, temperature-regulating blankets were used in the study for skin-surface warming.

Physical warmth and comfort also decreases anxiety.19 According to a study by Wagner et al, the treatment group [ie, using patient-controlled warming gowns] experienced a significant decrease in anxiety compared to the control group [ie, using traditionally warmed blankets]. This effect demonstrated that the patient-controlled warming gown had psychological effects in addition to providing thermal comfort.19(p443)

For an inpatient, warming gowns can be provided on the nursing floors 45 to 60 minutes before the patient arrives in the preoperative holding area.4 At some facilities, the preoperative nurse applies a circulating fluid garment on cardiac patients;3,20 the patient wears the circulating fluid garment to the OR and to the ICU postoperatively rather than a forced-air, temperature-regulating gown.3,20 The circulating fluid garment covers the patient’s back and to the mid-axillary line in the front, allowing for full-chest exposure. Nurses monitor the patient’s temperature every 30 minutes when the patient is wearing the circulating fluid garment.

OR. The OR nurse has the ability to control the environment, supplies, and equipment and implement procedures to keep the patient warm. Surgeons and scrubbed personnel stand for extended periods under hot surgical lights. Surgeons frequently ask the circulating nurse to decrease the room temperature. A delicate balance is necessary to keep the patient warm and the surgeons and scrubbed personnel comfortable. The optimal OR temperatures for the patient should be no less than 20° C (68° F).6 Even that temperature can be very cold for a patient, particularly if body cavities are exposed, so the circulating nurse should keep the patient’s head and feet covered.

Although some facilities place circulating fluid mattresses under patients, it has been determined that these mattresses are ineffective at minimizing the risk of hypothermia and that in combination with the patient’s body weight, the heat of the fluid mattress increases the risk of pressure ulcers or necrosis.21

Temperature-regulating blankets are effective at minimizing convective heat loss. The circulating nurse should cover the patient with an upper-body or lower-body temperature-regulating blanket, depending on the surgical procedure. Active patient warming requires frequent monitoring with an appropriate device depending on the surgical procedure (eg, pulmonary artery catheter, esophageal temperature probe, indwelling urinary catheter with temperature probe). The anesthesia care provider may use two temperature-monitoring devices to correlate core temperatures in different locations of the body.

Frequently, the pharmacy premixes antibiotic irrigation solutions that are then stored in the OR refrigerator. The circulating nurse should allow the premixed antibiotic irrigation solution to warm to room temperature before it is used or should mix it with warm saline solution if dilution of the antibiotic concentration is acceptable. Other irrigation fluids should be warmed to near 37° C (98.6° F).6 The anesthesia care provider should warm IV fluids, blood, and blood products to near 37° C (98.6° F) with fluid warmers.4

The anesthesia care provider also can add a heated humidifier to the anesthetic circuit when high gas flow rates are required. This warms and humidifies inspired gas, minimizing evaporative heat loss from the lungs. Temperatures, however, must be kept below 41° C (105.8° F).14

PACU or ICU. Because some patients report that shivering and being cold are worse than
surgical pain, the circulating nurse or anesthesia care provider should report the patient’s baseline temperature to the PACU nurse. The nurse should ask the patient whether he or she feels cold and also should observe for signs and symptoms of hypothermia (eg, shivering, piloerection, cold extremities). Average postoperative warming times are 45 to 60 minutes, and the nurse should monitor the patient’s temperature every 30 minutes during postoperative warming. The PACU nurse should ensure that the patient’s head remains covered and that socks are placed on the patient’s feet as passive warming measures. The PACU nurse should continue active postoperative warming with the forced-air, temperature-regulating gown or full-body blanket covered by a single cotton blanket until the patient’s core temperature reaches 36°C (96.8°F). Cardiac patients continue to wear the circulating fluid garment in the ICU.

The nurse should maintain ambient room temperatures of 20°C to 24°C (68°F to 75°F).

Case Study

Ms Z is a 40-year-old woman diagnosed with rectal bleeding and a right colon mass for which she is scheduled to undergo an exploratory laparotomy and colon resection. The circulating nurse notes on a review of the medical history that the patient is a practicing Jehovah’s Witness. The patient’s baseline hematocrit and hemoglobin are 26.8% and 8.4 g/dL with a platelet count of 376,000/mm³. The patient states that she does not want any blood or blood products, including topical fibrin sealants.

Before transporting the patient to the OR, the circulating nurse notes that the patient’s admission tympanic temperature is 37.3°C (99.1°F); therefore, no prewarming is required. The patient is wearing a head covering and socks on her feet. After helping the patient transfer to the OR bed, the circulating nurse places an upper-body temperature-regulating blanket on the patient and then secures the safety strap. After induction of anesthesia, the anesthesia care provider inserts an esophageal temperature probe and monitors the patient’s core temperature continuously throughout the procedure. The anesthesia care provider adjusts the temperature-regulating blanket settings based on the patient’s thermal response. The anesthesia care provider warms and humidifies inspired gas by adding a heated humidifier to the anesthesia circuit and administers IV fluids that have been warmed to near 37°C (98.6°F) with fluid warmers. The circulating nurse mixes antibiotics in saline warmed to near 37°C (98.6°F) and then delivers them to the sterile field. The circulating nurse maintains the OR room temperature at 21.1°C (70°F).

The patient’s initial vital signs in the PACU reveal a tympanic temperature of 36.2°C (97.1°F). Her estimated blood loss is 50 mL. The patient is discharged two hours later from the PACU with a tympanic temperature of 37°C (98.6°F). The patient has successfully maintained normothermia throughout her exploratory laparotomy and right hemicolectomy procedure as a result of proactive nursing interventions.

Summary

Hypothermia is one of the most preventable surgical complications, and nurses can proactively take charge to prevent it by implementing a variety of nursing interventions. Maintaining normothermia in the surgical patient improves patient outcomes. Adverse outcomes, such as

- redistribution hypothermia,
- myocardial ischemia,
- postoperative shivering,
- SSI,
- blood loss,
- need for transfusion, and
- altered medication metabolism

can be prevented with simple nursing interventions. Nursing interventions in the preoperative phase range from applying socks and a head covering to prewarming patients with forced-air, temperature-regulating gowns or circulating water garments for cardiac surgical patients. Intraoperative interventions include using heated and humidified anesthesia gas circuits, fluid and blood warmers, forced-air temperature-regulating blankets, and active patient monitoring throughout the surgical procedure. The biggest intraoperative obstacle is achieving an ambient room temperature that keeps the surgeon comfortable and ensures a
safe patient temperature. Postoperative nurses provide ongoing use of warming devices and monitoring of the patient’s temperature to achieve normothermia.

Staff nurses can be the leaders in preventing hypothermic conditions in each surgical procedure. Tracking the results of hypothermia prevention interventions and posting patient outcomes for medical and nursing staff members can improve awareness and provide positive reinforcement for change. As patient advocates, nurses can help keep patients warm during surgery.

REFERENCES


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Prevention of Unplanned Perioperative Hypothermia

PURPOSE/GOAL
To educate perioperative nurses about how to prevent unplanned perioperative hypothermia.

BEHAVIORAL OBJECTIVES
After reading and studying the article on inadvertent perioperative hypothermia, nurses will be able to

1. describe the physiology of thermoregulation,
2. explain the causes of hypothermia,
3. identify the adverse patient outcomes that occur as a result of unplanned perioperative hypothermia, and
4. discuss nursing interventions that can be implemented during each phase of perioperative care to minimize the occurrence of unplanned perioperative hypothermia.

QUESTIONS

1. Moderate hypothermia is defined as a core body temperature of
   a. 34° C to 35° C (93.2° F to 95° F).
   b. 30° C to 34° C (86° F to 93.2° F).
   c. less than 30° C (86° F).

2. Core temperature is regulated hormonally by the
   a. brain stem.
   b. thyroid gland.
   c. hypothalamus.
   d. pituitary gland.

3. Intraoperative heat loss occurs via
   1. convection.
   2. conduction.
   3. evaporation.
   4. increased respiration.
   5. radiation.
   a. 2 and 3
   b. 1, 4, and 5
   c. 1, 2, 3, and 5
   d. 1, 2, 3, 4, and 5

4. The process of losing heat as air or water molecules move across the skin is called
   a. conduction.
   b. convection.
   c. evaporation.
   d. vasodilation.

5. Unplanned or inadvertent hypothermia can be caused by
   1. cold OR temperatures.
   2. infusion of cold IV fluids and blood products.
   3. length of surgery.
   4. open body cavities.
   5. use of cool irrigating solutions and skin preparations.
   a. 2 and 3
   b. 1, 4, and 5
   c. 2, 3, 4, and 5
   d. 1, 2, 3, 4, and 5

6. Hypothermia significantly increases the risk of surgical site infections by
   a. triggering vasoconstriction, which decreases tissue oxygenation and perfusion.
   b. inducing shivering, which increases patient discomfort.
   c. causing profound decreases in systemic vascular resistance, which results in peripheral vasoconstriction.
7. Hypothermia significantly increases blood loss and increases the relative risk for transfusion by impairing platelet function and impairing the coagulation cascade enzymes.
   a. true
   b. false

8. When planning perioperative interventions for preventing hypothermia, the nurse performs a preoperative assessment that includes the patient’s
   1. age.
   2. body morphology.
   3. current vital signs.
   4. laboratory findings.
   5. preexisting medical conditions.
   6. proposed surgical procedure.
   a. 1, 3, and 5
   b. 2, 4, and 6

9. Methods that preoperative nurses may employ to prewarm patients include
   1. circulating fluid garments.
   2. patient-controlled warming gowns.
   3. forced-air, temperature-regulating blankets.
   4. socks and head coverings.
   a. 2 and 3
   b. 1 and 4
   c. 2, 3, and 4
   d. 1, 2, 3, and 4

10. The biggest intraoperative obstacle to preventing unplanned hypothermia is length of procedure time.
    a. true
    b. false
Prevention of Unplanned Perioperative Hypothermia

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Prevention of Unplanned Perioperative Hypothermia

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**Purpose/Goal**
To educate perioperative nurses about how to prevent unplanned perioperative hypothermia.

**Objectives**
To what extent were the following objectives of this continuing education program achieved?
1. Explain the physiology of thermoregulation.
2. Identify the causes of hypothermia.
3. Describe adverse patient outcomes that occur as a result of unplanned perioperative hypothermia.
4. Discuss nursing interventions that can be implemented during each phase of perioperative care to minimize the occurrence of unplanned perioperative hypothermia.

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7. did this article facilitate learning?
8. were your individual objectives met?
9. did the objectives relate to the overall purpose/goal?

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