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Patient Safety Tip of the Week

June 2, 2020 Perioperative Hypothermia

Perioperative hypothermia is a common complication of orthopedic surgery that is associated with increased morbidity, including increased risk for surgical site infections, sepsis, increased bleeding risk, cardiac and other complications, mortality and prolonged length of stay.

A 2018 review of almost 7,000 orthopedic cases (Kleimeyer 2018) found hypothermia in 72.5% of patients intraoperatively and 8.3% postoperatively. Risk factors for postoperative hypothermia included intraoperative hypothermia (odds ratio 2.72), lower preoperative temperature (OR 1.46), female sex (OR 1.42), lower body mass index (OR 1.06 per kg/m2), older age (OR 1.02 per year), adult reconstruction by specialty (OR 4.06), and hip and pelvis procedures by anatomic region (OR 8.76).

Another 2018 review (Boddu 2018) noted risk factors that can contribute to inadvertent perioperative hypothermia can be subdivided into 3 groups: patient-related risk factors, anesthesia-related risk factors, and procedure-related risk factors.

Patient-related risk factors identified were a high severity of illness on admission (OR 2.81), presence of a neurological disorder such as Alzheimer's disease (OR 1.71), male sex (OR 1.65), age >65 years (OR 1.61), recent weight loss (OR 1.60), anemia (OR 1.49), and chronic renal failure (OR1.43).

They note that the effects of general and regional anesthesia on perioperative core temperature are significantly different, both in terms of intraoperative thermoregulation and postoperative recovery. Core body temperature drops during the first 2 hours of general anesthesia, due to loss of thermoregulatory cutaneous and peripheral vasoconstrictive responses resulting in heat loss exceeding metabolic heat production but then plateaus during the subsequent 3 hours due to the return of the thermoregulatory responses. Notably, postoperative recovery from the hypothermia induced by general anesthesia is significantly faster than from that induced by regional anesthesia.

The effects of regional anesthesia and regional hypothermia are complex and depend upon whether a tourniquet is used or not. The extent and rate of development of peripheral/limb hypothermia and core body temperature during surgery depends on several factors, including the operating room ambient temperature, duration of tourniquet application, and temperature of any irrigation fluid. They note that postoperative recovery from the hypothermia induced by regional anesthesia takes longer than from that induced

by general anesthesia because of the prolonged period of loss of vasoconstrictive response.

Procedure-specific risk factors for inadvertent perioperative hypothermia during arthroscopic surgery include prolonged operating time, low blood pressure during the procedure, and low temperature of the irrigation fluid.

The authors note that ambient operating room temperature has traditionally been considered a risk factor for inadvertent hypothermia in perioperative patients, but that evidence for that was scant or even contradictory.

They discuss both active and passive interventions to avoid hypothermia. Passive methods decrease heat loss by radiation (eg, reflective blanket), conduction (eg, layered cotton blankets and padding the operating table), or convection (eg, heat and humidity exchanger in the breathing circuits) to the surrounding environment. Active patient heating methods are generally more successful and aim to bring in heat from the source to the patient's body using conduction (eg, Hot Dog® [Eden Augustine Temperature Management]) or convection (eg, Bair Hugger® [Arizant Healthcare]) techniques.

Simpson et al. (Simpson 2018) found that, at the time of incision, 60 of 179 (34%) total knee arthroplasty (TKA) patients and 80 of 204 (39%) total hip arthroplasty (THA) patients were hypothermic. In THA patients, 65% remained hypothermic for the duration of anesthesia compared to 33% of TKA patients. The largest drop in core body temperature in both THA and TKA patients occurred between preoperative holding and induction of anesthesia. In THA patients, spinal anesthesia had a significantly higher occurrence of PH. No significant patient factor was found to increase risk. The authors suggested that emphasis on preoperative holding protocols, decreasing time from operating room entry to incision, and increasing ambient room temperature could reduce risk of hypothermia in this patient population.

Though not confined to orthopedic cases, another study (Akers 2019) found 7 of 298 surgical patients at a single hospital site in the midwestern United States were hypothermic in the post-op period. Older adults (ie, more than 60 years old) were significantly more likely to experience hypothermia and that abdominal procedures posed a greater risk for hypothermia than other procedures. In addition, perioperative hypothermia was significantly associated with postoperative anemia, sepsis, and mortality.

The type of anesthesia did not significantly differ between the hypothermic and normothermic groups. Although multiple combinations of anesthesia (eg, general anesthesia used in conjunction with spinal anesthesia) were noted in the total sample, general anesthesia was used exclusively for most procedures and all seven patients who experienced perioperative hypothermia received general anesthesia only. Some previous studies had suggested hypothermia was more common in patients undergoing combination anesthesia. Also, contrary to some other studies, duration of surgery did not appear to correlate with hypothermia.

Another recent study (Nordgren 2020) compared the efficacy of four treatment interventions to prevent hypothermia in patients undergoing total knee or hip arthroplasty. The interventions included convective warming (ie, forced air warming or FAW) with prewarming (group 1), conductive warming with prewarming (group 2), reflective and convective warming without prewarming (group 3), and convective warming only (group 4). There were 30 patients in each group. They also standardized anesthetic agents and delivery methods, administering spinal anesthetic blocks of 15 mg of bupivacaine with 45 μg of clonidine or general anesthesia. They also agreed to avoid the use of sedating agents whenever possible, but if sedation was required, they administered 1 to 2 mg of midazolam.

The mean temperature decreased in all groups upon arrival in the OR and after the administration of anesthesia. At the beginning of surgery, the mean temperature fell below the hypothermic limit for all patients in groups 2, 3, and 4. During surgery, there was an increase in core temperature for all interventions. However, upon the patient's arrival to the PACU, the mean temperature fell below the hypothermic limit for all interventions.

The average number of inadvertent perioperative hypothermia (IPH) episodes for group 1 was significantly lower compared with the number of IPH episodes for groups 2, 3, and 4.

There was no difference in the perception of cold or warmth between groups and, interestingly, none of the patients felt uncomfortable. This point further emphasizes the need to measure core temperature objectively in such patients.

Patients using a FAW gown who began prewarming on the nursing unit had a significantly higher core temperature throughout the perioperative period. These patients had a lower rate of IPH than patients who received the other three interventions.

The authors felt that, although the active self-warming blanket was less effective than FAW at preventing IPH, the active self-warming blanket may still be beneficial because it can be used during patient transport without a control unit.

Many patients using the handheld controller for the FAW expressed a positive feeling of control over something preoperatively and postoperatively; this seemed to be an additional patient benefit.

The study confirms that inadvertent perioperative hypothermia is common in patients undergoing THA or TKA. It suggests that convective warming (ie, FAW) with prewarming appears to reduce hypothermia in patients. Prewarming with an active self-warming blanket (ie, conductive warming) was less effective. An important finding that merits further research is that patients' temperatures typically drop after they leave the OR and arrive in the PACU

Our January 23, 2018 Patient Safety Tip of the Week "Unintentional Hypothermia Back in Focus" discussed three articles showing that unintentional hypothermia is very common in obstetrics, but lamented the relative lack of proven interventions to prevent or treat hypothermia in obstetrical patients.

Note that a previous Cochrane review (Cochrane 2014) found that active warming, particularly forced air warming, appears to offer a clinically important reduction in mean time taken to achieve normothermia in patients with postoperative hypothermia, but that high-quality evidence on other important clinical outcomes is lacking. It concluded that it is unclear whether active warming offers other benefits and harms. High-quality evidence on other warming methods is also lacking; therefore, it is unclear whether other rewarming methods are effective in reversing postoperative hypothermia.

So, are there harms associated with various warming interventions? Several of our prior columns on iatrogenic burns (listed below) cited cases of burns caused by warming blankets and other warming devices. In particular, our December 23, 2014 Patient Safety Tip of the Week "Iatrogenic Burns in the News Again" gave details on the additional risk factors that may have predisposed such patients to burns, such as poor tissue perfusion, sensory loss, etc. It also discussed the dangers of "**hosing**" or "**free-hosing**" (using the hose of the warming device without the blanket attachment and allowing the hot air to blow directly onto the patient, forcing the hot air onto one focused area of the body).

In that column we made the following recommendations to avoid thermal injuries from warming blankets and related devices:

- Never use the hose alone without the blanket
- If you anticipate your patient might need active warming during surgery, you should apply the disposable warming blanket before surgical draping
- Ensure any restraint straps are underneath the warming blanket or "gown" rather than in a position that might compress the blanket or "gown"
- Don't place instruments on top of the blanket or "gown" or the patient (that's what stands are for!)
- Make sure the temperature sensor is in contact with the appropriate target and not up against any other objects
- Measure the body temperature regularly (eg. every 10 to 20 minutes) and if the expected rise in patient temperature does not occur look for a reason
- Check the function of the warming device itself, ensuring free inflow and egress of air from the warming blankets and gowns
- Monitor the cutaneous response in patients who are under anesthesia, unable to communicate, or have loss of skin sensation
- Beware of any pressure on the warming blanket/gown, whether from instruments or personnel leaning on it
- Don't use warming blankets designed for awake patients for patients who are not awake, are insensate, or unable to communicate (these devices generate higher temperatures)
- The "high" settings should be used sparingly, especially in infants
- The patient's skin should be checked periodically for thermal injury

- If used in patients with impaired tissue perfusion, skin must be checked frequently for signs of thermal injury
- If used in patients with impaired sensation, skin must be checked frequently for signs of thermal injury
- Make sure all your OR staff are familiar with the correct use of each warming device
- If the expected response fails to occur (i.e. the patient's temperature fails to rise in the expected fashion) use this as a red flag and investigate whether the equipment and setup are functioning properly
- In your pre-op huddle/briefing discuss potential contingencies related to warming blankets or related devices
- Remember foremost: your patient under anesthesia is unable to fend for him/herself and is vulnerable to many potential bodily insults

Our own interest in unintentional hypothermia was related to occurrence of an unusual phenomenon in patients undergoing spinal anesthesia using morphine. These were cases (most often obstetrical) in which **spinal anesthesia with morphine** is used and patients develop **hypothermia with paradoxical sweating**. See our Patient Safety Tips of the Week for December 4, 2012 "Unintentional Perioperative Hypothermia: A New Twist" and January 23, 2018 "Unintentional Hypothermia Back in Focus" for details. The proposed mechanism is that enough of the morphine ascends in the subarachnoid space to reach the hypothalamus where it interacts with receptors important in thermoregulation. Essentially this leads to **alteration of the hypothalamic thermoregulatory set point** causing the body to feel hot and sweat in attempt to adapt to heat. The main reason to recognize that phenomenon is that some cases appear to respond to benzodiazepines. Benzodiazepine receptors are also found in the hypothalamus and are probably also involved in thermoregulation. Naloxone and atropine have also been noted to produce improvement in case reports. You probably should amend your hypothermia management protocols to take this phenomenon into account. Specifically, there should be **a prompt to consider the phenomenon** if the expected improvement in hypothermia is not occurring within a reasonable amount of time after conventional warming procedures have been instituted. Perhaps even a prompt at the beginning of your protocol to look for signs you would not expect with hypothermia (i.e. sweating, hot feeling, vasodilation) might suggest this unusual etiology for the hypothermia. The presence of nausea and pruritis might be an additional clue. In either case the prompt should remind you to consider a trial of either low dose benzodiazepine or naloxone.

Your facility should have a formal protocol to follow for prevention and management of perioperative hypothermia. The AORN Guideline for Prevention of Hypothermia (AORN 2020) was also discussed in a recent review (Link 2020), stressing use of a consistent temperature measurement method through all phases of perioperative care, assessing risk for hypothermia in all patients, and prewarming perioperative patients. Other guidelines and resources on perioperative hypothermia are available from the Pennsylvania Patient Safety Authority (PPSA 2008), the American Society of PeriAnesthesia Nurses (ASPAN 2010), and the National Institute for Health and Care Excellence (NICE 2017).

Our prior columns on inadvertent perioperative hypothermia:

- December 4, 2012 "Unintentional Perioperative Hypothermia: A New Twist"
- January 23, 2018 "Unintentional Hypothermia Back in Focus"

Our prior columns on iatrogenic burns:

- March 2009 "Risk of Burns during MRI Scans from Transdermal Drug Patches"
- June 1, 2010 "Iatrogenic Burns"
- October 5, 2010 "More Iatrogenic Burns"
- December 23, 2014 "Iatrogenic Burns in the News Again"
- March 2015 "Another Source of Iatrogenic Burns"
- September 5, 2017 "Another Iatrogenic Burn"
- June 5, 2018 "Pennsylvania Patient Safety Authority on Iatrogenic Burns"

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