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PERIOPERATIVE HYPOTHERMIA PREVENTION IN BURN PATIENTS

Evidence Based Medicine Guideline

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SUMMARY
Perioperative hypothermia is associated with serious morbidity including blood loss, myocardial ischemia, delayed recovery, surgical wound infections, and death. Maintaining euthermia in the burn patient is especially challenging due to the need for significant and prolonged skin exposure to facilitate debridement and skin grafting. Thermoregulation in the operative setting can be accomplished through environmental warming (adjusting the room temperature), cutaneous warming (blankets, forced-air and warm-water circulating devices), and internal warming (intravascular catheters and esophageal warming catheters).

RECOMMENDATIONS

- **Level 1**
  - **None**
- **Level 2**
  - **Burn operating rooms should be pre-warmed to 26°C and adjusted throughout the procedure according to the patient's core body temperature, total body surface area (TBSA), and procedure length.**
  - **All adult burn patients should receive warmed intravenous fluids, especially if larger volumes will be administered or prolonged procedure times are anticipated.**
  - **Preoperative warming for at risk patients should begin 10-30 minutes prior to the procedure.**
- **Level 3**
  - **Esophageal warming devices should be considered for patients who:**
    - **Have greater than 20% TBSA partial and/or full thickness burns**
    - **Have an anticipated operative time greater than 3 hours**
  - **Esophageal warming devices can be set to a maximum of 42°C and should be used in conjunction with other warming strategies.**
  - **Fluidized warming blankets should be set at 40°C and placed for maximum skin contact, such as beneath patient for temperature maintenance and active warming intraoperatively.**
  - **Forced-air warming blankets, though associated with increased risk for surgical site infections in non-burn populations, are indicated for preoperative warming and intraoperative temperature maintenance.**

INTRODUCTION

Perioperative hypothermia is associated with significant morbidity (including increased blood loss, delayed recovery, triggered myocardial ischemia, and surgical wound infections) and potential mortality. Maintaining euthermia in the burn patient is especially challenging due to the need for perioperative skin antisepsis, anesthetic agents and prolonged, extensive skin exposure to facilitate debridement and skin grafting (1). Thermoregulation in the operative setting can be accomplished through a variety of techniques including environmental warming (adjusting the temperature of the operating room), cutaneous warming (blankets, forced-air and warm-water circulating devices), and internal warming devices (intravascular catheters and esophageal warming catheters).

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Supported by multiple, prospective randomized clinical trials or strong prospective, non-randomized evidence if randomized testing is inappropriate.
- **Level 2:** Supported by prospective data or a preponderance of strong retrospective evidence.
- **Level 3:** Supported by retrospective data or expert opinion.

BACKGROUND

The hypothalamus normally regulates temperature through afferent, central, and efferent responses. Behavioral responses are cited as exerting the most control over thermoregulation requiring a conscious state not possible during general anesthesia. Autonomic responses can lead to vasoconstriction or perspiration which may be significantly altered during general anesthesia. Interference results from the vasodilatory effects of anesthesia opposing normal thermoregulatory mechanisms (2). Primary hypothermia is caused by convective heat loss, environmental exposure to cold, and conductive heat loss due to water. Secondary hypothermia results from inadequate physiological heat production. Mild hypothermia is described as 34-36°C, moderate is 32-34°C, and severe hypothermia at temperatures falling below 32°C (3).

Burn-injured patients are at increased risk for hypothermia due to prolonged body surface exposure and loss of protective thermoregulation provided by normally intact skin (4). The risk for hypothermia increases exponentially during the resuscitation phase and surgical intervention. Hypothermia can lead to increased wound infection, coagulopathy with increased transfusion requirement, altered medication metabolism, prolonged hospital length of stay, and worsened post-operative discomfort (4). Post operative myocardial morbidity may occur with only mild hypothermia. Burn patients undergoing excision of large burn wounds are at risk for increased blood loss, coagulopathy and death. Maintaining euthermia aids in the emergent phase and decreases the risk of shivering (5). This morbidity does not end with the operating room as patients may remain hypothermic post-operatively and require ongoing monitoring and treatment in a critical care setting. Elderly patients and those with low body mass index are at increased risk for hypothermia due to altered central nervous system regulation and less subcutaneous fat (5,6).

The relationship between increased risk of surgical site infections (SSI) and perioperative hypothermia remains controversial. Study results range from three times increased risk for SSI linked to perioperative hypothermia to lower rates when intraoperative hypothermia is present. Surprisingly, meta-analyses conducted by Bu et al. and Ju et al. did not find a correlation between increased risk of SSI and perioperative hypothermia (1,7). Despite these findings, both studies concluded that complex relationships exist between SSI and hypothermia and the numerous variables potentially impacting outcomes, supporting ongoing research (1,7).

Early and aggressive surgical management remains the hallmark of successful treatment for significant burn injuries. Intraoperative hypothermia has led to delay or termination of essential surgical intervention. While general anesthesia alone is known to lead to hypothermia with an incidence of 24-90 %, open burns further contribute to overall risk. Mai et al. report that total body surface area greater than 20% and operative time greater than three hours compounded by intraoperative hypothermia are associated with increased of death (8). Acute respiratory distress syndrome and venous thromboembolism also occur more frequently in this population (8)

The massive inflammatory response to major burns potentiates increased oxygen consumption, catabolism, and resting energy expenditure. Burn-induced hypermetabolism leads to ineffective thermoregulation (9). Anesthesia administration exacerbates this response and intensifies the heat loss through redistribution of circulating volume (3). Burn injuries represent an independent risk factor for hypothermia due to increased evaporative losses and extended operative times (9).

LITERATURE REVIEW

Potential Complications of Perioperative Hypothermia (2)
1. Increased cardiovascular complications **2. Increased blood loss, transfusion requirements, perioperative hemorrhage** **3. Increased risk for surgical site infection** **4. Altered drug metabolism** **5. Delayed anesthesia emergence** **6. Prolonged intensive care unit (ICU) length of stay** **7. Decrease perioperative patient comfort and satisfaction** **8. Increased hospital mortality** **9. Immune impairment** **10. Increased healthcare costs**

The World Health Organization has prioritized perioperative euthermia. Temperature must be accurately monitored to detect impending hypothermia (3). Peripheral tissues, such as arms and legs, may be up to 4°C cooler (5). Core temperatures should be measured 1-2 hours before the start of the case. Continuous measurement is recommended intraoperatively, or at least every 15 minutes (3). Pulmonary artery, esophageal, tympanic membrane, nasopharynx, rectal and urinary temperature monitoring all provide accurate core temperature measurements. Bladder and rectal temperature trends are delayed, when compared to intravascular monitors. The accuracy of esophageal monitors is predicated on correct placement, in the lower third of the esophagus (5).

The first approach to preventing intraoperative hypothermia is to ensure the patient has an adequate body temperature before the case begins. Skin surface warming is a well-studied intervention to prevent intraoperative hypothermia. Active cutaneous warming is accomplished using water-circulating, resistive and radiant heat, and forced-air warming (FAW). Applying layers, such as reflective hats, blankets or surgical drapes, offers passive cutaneous warming through insulation. Under body warming devices are not as effective as over body devices due to the reduced efficiency of perfusion to dependent areas. Unfortunately, intraoperative vasoconstriction reduces the efficacy of all cutaneous warming therapies (3,5)

The use of FAW preoperatively is a well-studied and common method for accomplishing active warming. Several models are available with different size and shape disposable blankets. FAW are composed of an intake system for floor-level air, with an intake filter, blowers, and connecting hoses. These devices are either placed directly over the patient or over a blanket, gown or sheet on top of the patient. They can be secured in place with ties or tape. They are preheated to avoid inadvertent cooling. This modality does not raise core temperature directly but is effective through increasing the temperature in the peripheral tissue. The body surface area covered by the FAW often depends of the perioperative phase of care in which it is placed and planned operative procedure. Additionally, starting temperature varies with reports of 40-47°C (6). The recommendations for "pre-warming" are that it begin between 10 and 60 minutes prior to the procedure, which can be difficult to arrange. Lau et al. conducted a randomized clinical trial with results supporting the decreased intraoperative hypothermia with FAW provided for 30 minutes prior to operative procedures lasting greater than 120 minutes (10,11). Whether with a self-warming blanket or FAW, preoperative warming has been shown to facilitate temperature maintenance through induction, avoiding the complications associated with perioperative hypothermia (12).

Though one of the most frequently employed perioperative warming devices, there are specific risks attributed to the use of FAWs including fire, contamination, burn injury, interference with anesthesia monitoring equipment, and worsening hypothermia due to water vaporization occurring on the moist surface of larger open burns (3,5). FAWs have been associated with increased SSIs. One suspected cause is the potential for bacteria to collect in hoses and the warming unit intake. Additionally, the forced air emission creates airflow disturbances within the operating suite. This interruption of filtered air may permit unwanted dust particles to settle on wounds. Lange et al. found that there is a risk for both airborne and surface contamination resulting from the use of FAWs and recommended against use of the device (13). Patients being treated with FAWs are at risk for hyperthermia (6).

Unfortunately, there is extensive heterogeneity within the literature addressing warming of the operating room (OR). Available literature examines the OR warming primarily in trauma and orthopedic settings with a paucity specific to burns. There is no consensus and the practice remains controversial. Increasing ambient temperature in the operating room is common practice in burn surgery. Temperature goals range from 26°C to as high as 40°C (mean of 26°C). Temperature settings are based on patient age and past medical history, severity of the burns and surgical plan. The effects of these temperatures are exacerbated when donning surgical garb and are oppressive for the staff, creating an environment that hinders performance. Infrastructure shortcomings can impair control of operative ambient temperature. Despite the challenges of warming the operating room and maintaining the heated environment for the duration of the case, the anecdotally reported benefit to burn patients makes this an important, and cost effective, intervention (2,9).

Anesthesia administration presents new challenges to maintaining euthermia. Anesthetics directly impact the autonomic nervous system with induction redistributing heat away from the core. Several medications may decrease core temperature, including first- and second-generation anti-psychotics, propofol, clonidine, certain opioids, and benzodiazepines. Anesthesia providers direct fluid administration. Fluid warming is recommended for all intraoperative intravenous fluid administration when boluses or larger volume infusions are anticipated and provides direct core warming. Efficacy of fluid warming is impacted by the method selected, rate of administration, and length of tubing. Following induction, patients are prepped with liquid antiseptic, causing further cooling.

Patients undergoing burn surgery may be placed on a heated fluidized warming blanket as yet another adjunct in to promote temperature maintenance (3,5,14).

First described in 1993, esophageal heat exchange devices (EHED) were first exclusively indicated for cooling during cardiac procedures. EHEDs have been found to be useful for avoiding perioperative hypothermia. Esophageal warming depends on the natural insulation of the esophagus, fluid temperature and flow rate (15). EHEDs are 60 cm long, flexible, non-sterile silicone tubes inserted into the esophagus and connected to a closed system water circulation device for patient warming and cooling. The device has three ports: one for water infusion, one for water recirculation, and one for gastric emptying (14). They are inserted in a manner similar to an orogastric tube, through the mouth and into the esophagus. The EHED is felt to be superior to intravenous heat exchange devices because of the risks for infection and injury associated with invasive catheters. However, it was noted to be insufficient when used alone and is suggested to be used in conjunction with surface warming (15).

The most invasive method for prevention and treatment of perioperative hypothermia is the intravascular rewarming catheter. It is a unique tool utilized in both the OR and the ICU setting. It has the advantage of warming or cooling the patient from the inside out. Several different types of catheters are on the market and most systems warm the patient through a closed loop system within a balloon that sits within a central venous catheter. The catheter is connected to a regulation system which remotely senses changes in a patient's core temperature and automatically adjusts the temperature to the set target temperature (16). Most systems pump normal saline through the catheter and balloon. As venous blood passes over the balloon, blood is either warmed or cooled. Femoral vein placement is recommended. Though these devices have demonstrated superiority in active warming and maintenance of euthermia, the risk of thromboembolic events (around 30%), and known catheter-related complications, such as those related to insertion and increased risk for infection, limit their wide-spread inclusion in perioperative hypothermia prevention and treatment standards. Intravascular warming catheters are not currently being utilized in our center's adult burn population (4,16).

CONCLUSIONS

Burn injuries place patients at increased risk for perioperative hypothermia due to exposed body surface area, prolonged operative times, and the underlying hypermetabolic response to the injury itself. Prevention is key, with planning beginning at admission. This requires a choreographed interprofessional plan including surgeons, nurses, nutritionists, and operative staff. Coordination to ensure easy access to equipment for active warming and communication for ambient temperature regulation is crucial. Strategic planning is needed to attenuate the impact of perioperative hypothermia when it does occur should be developed and included in institutional guidelines

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