PERIOPERATIVE HYPOTHERMIA PREVENTION IN BURN PATIENTS

SUMMARY

Perioperative hypothermia is associated with serious morbidity including blood loss, 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 at least 24.2°C (76°F) and adjusted according to the patient's total body surface area (TBSA), patient response, and procedure length.**
  - **All adult burn patients should receive warmed intravenous fluids if >500 mLs is administered.**
  - **All adult burn patients with injuries greater than 10% TBSA should be placed on a water-fluidized warming blanket.**
- **Level 3**
  - **Esophageal or intravascular 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 may be considered EXCEPT in patients with esophageal pathology or with extensive head/neck edema that interferes with safe esophageal intubation for 5 days post-operatively**
  - **Esophageal warming devices can be set to a maximum of 42°C**
  - **Intravascular warming catheters should be considered for placement the day prior to planned surgery and removed as soon as no longer clinically indicated.**
  - **Intravascular warming devices can be set to a maximum of 42°C**
  - **Forced air warming devices should not be placed directly on burn wounds**

INTRODUCTION

Perioperative hypothermia is associated with significant morbidity (including increased blood loss and surgical wound infections) and potential mortality. Maintaining euthermia in the burn patient is especially challenging due to the need for prolonged and sometimes extensive skin exposure to facilitate debridement and skin grafting. Thermoregulation in the operative setting can be accomplished through a variety of techniques including environmental warming (adjusting the temperature of the operating room), cutaneous

EVIDENCE DEFINITIONS

- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

warming (blankets, forced-air and warm-water circulating devices), and internal warming (intravascular catheters and esophageal warming catheters). This guideline details the morbidity associated with hypothermia in burn patients with the specific focus of preventing hypothermia in the perioperative setting.

BACKGROUND

The hypothalamus normally regulates temperature through efferent responses. Behavioral responses require a conscious state not possible during general anesthesia. Autonomic responses can lead to vasoconstriction or perspiration which may be significantly altered during general anesthesia. This occurs primarily due to the vasodilatory effects of anesthesia opposing normal thermoregulatory mechanisms (1,2).

Primary hypothermia is caused by environmental exposure to cold, whereas secondary hypothermia results from inadequate physiologic heat production. Advanced Trauma Life Support (ATLS) classifies core temperature hypothermia as mild (32–35°C), moderate (30–32°C), or severe (<30°C). In contrast to severe environmental hypothermia, which is associated with a mortality rate of <25%, even moderate hypothermia associated with severe traumatic injury is associated with a nearly 100% mortality risk (3).

Burn patients are at increased risk for hypothermia due to unprotected and prolonged body surface exposure and loss of protective thermoregulation provided by normally intact skin (2). The risk for hypothermia increases exponentially during the resuscitation phase and surgical intervention. Hypothermia can lead to increased wound infections, prolonged hospital length of stay, and worsened post-operative discomfort. 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 (1). Maintaining euthermia aids in the extubation process and decreases the risk of shivering (4). This morbidity does not end with the operating room as burn patients may remain hypothermic post-operatively and require ongoing monitoring and treatment in a critical care setting (5).

The morbidity and mortality associated with hypothermia necessitate aggressive intervention, most especially during the critical operative phase of burn treatment. Williams et al. described three warming categories. First, maintaining a warm environment allows for endogenous heat production. Second, active cutaneous warming of the body's surface can be accomplished through multiple modalities. Third, internal rewarming of the body's core is possible using intravascular warming catheters and esophageal heat exchange devices (EHED) (5,6). Regardless of the modality selected, accurate monitoring of core temperature is essential (7).

LITERATURE REVIEW

The massive inflammatory response to a major burn leads to increased oxygen consumption, catabolism, and resting energy expenditure. Burn-induced hypermetabolism leads to ineffective thermoregulation. Anesthesia administration exacerbates this response and intensifies the heat loss through redistribution of circulating volume. Hypothermia adds further to the metabolic stress. Burn injuries result in increased evaporative losses and often require extended operative times (8).

The first approach in preventing intraoperative hypothermia is to warm the environment. Unfortunately, there is extensive heterogeneity within the literature addressing warming of the operating room. Research involving orthopedic surgery suites heated to 25°C and general surgery suites heated to 24°C reveal decreased vasoconstriction and better maintenance of core body temperature. Increasing ambient temperature in the operating room is a common practice in burn surgery. Temperature settings are based on the age and severity of the burns and range between 26.4°C and 37.4°C. The effects of these temperatures are exacerbated when donning surgical garb and are oppressive for the staff, creating an environment that hinders performance. Despite the challenges of warming the operating room and maintaining the heated environment for the duration of the case, the benefit to burn patients makes this an important, and cost effective, intervention (8,9).

Skin surface warming is another well-studied intervention to prevent intraoperative hypothermia. Active cutaneous warming is accomplished using water-circulating, resistive and radiant heat, and forced-air

warming (FAW). This modality does not raise core temperature directly, but is effective through increasing the temperature in the peripheral tissue. Applying layers, such as 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 (1).

FAW devices are used to prevent and treat hypothermia through surface warming (2). FAW is the most commonly employed modality for skin surface warming (1). Several models are available with different size and shape disposable blankets (7). FAW are composed of an intake system for floor-level air, with an intake filter, blowers, and connecting hoses. This modality has been widely studied and remains the most commonly used. More recently, FAW devices have been criticized due to concern for contamination inside the equipment that can subsequently be emitted, placing patients at risk for infection (10). Furthermore, Williams et al. proposed that FAW systems worsen hypothermia due to water vaporization occurring on the moist surface of larger open burns (6).

There are specific risks associated with the use of FAW to include fire, contamination, burn injury, and interference with anesthesia monitoring equipment (7). Additionally, there is increasing concern that air flow may also increase the risk of surgical site infections (SSI). 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. Some surgeons delay using these warming devices until the patient is completely prepped and draped, while others no longer utilize them at all. The creator of the Bair Hugger™ FAW device himself indicated that more recent studies directly correlate use of the FAW and surgical implant contamination. He recommended to discontinue all use of these devices in implant surgery until further studies can be completed (11).

A critical literature review by Kellam et al. identified numerous methodological inconsistencies in the available literature leading to a lack of convincing scientific evidence to support the elimination of FAW devices in the perioperative phase (2). Even though bacteria were located within the hoses and intake systems, a causal link between this method and an increase in SSIs was not established. The Federal Drug Administration (FDA) investigated health care provider safety concerns by collecting data from a variety of sources. They were unable to identify a valid correlation between FAW devices and SSIs. Therefore, the FDA continues to recommend FAW as an intervention for preventing hypothermia (12).

Fluid warming is recommended for all intraoperative intravenous fluid administration in a volume of greater than 500 ml and provides direct core warming (4). There are several types of fluid warmers to include dry systems, countercurrent exchange, water bath, convective air, and insulator systems (1). Efficacy of fluid warming is impacted by the method selected, rate of administration, and length of tubing (1).

Esophageal heat exchange was first described in 1993, but regulating temperature using the gastrointestinal tract was described as far back as the 1950's. Esophageal temperature is not affected by environmental temperature or any surface warming (13,14). Instead, esophageal warming depends on the natural insulation of the esophagus, fluid temperature and flow rate (13). Esophageal heat exchange devices (EHED) 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 exit for recirculation, and one for gastric emptying (6).

EHEDs can be used for warming in the operative and critical care settings with response monitored by core temperature probes. They are inserted in a manner similar to an orogastric tube, through the mouth and into the esophagus (15,16). 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 is felt to be insufficient when used alone and is suggested to be used in conjunction with surface warming. Though described more extensively for the induction of hypothermia, research describing its use for preventing or treating hypothermia is limited to a few small case studies (6,13,16,17)**.**

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 (5). Most systems pump normal saline through the catheter and balloon. As venous blood passes over the balloon, the blood (and patient) is either warmed or cooled. Catheters are placed in either the femoral, internal jugular, or subclavian vein (18-21).

Intravascular catheter placement is performed much like a central venous catheter. Once in place, the balloon is inflated to the manufacturer's recommendations. Catheter diameter ranges from 8.5 Fr to 9.3 Fr and length ranges from 20 to 50 cm. Most catheters have 1 to 3 lumens and some include a lumen for fluid and drug administration. Once in place, the thermal regulation system can warm or cool from 0.10 -0.65 ºC per hour. Desired temperature is usually achieved within 60 minutes. Certain systems such as the Zoll Thermogard XP® have monitoring capabilities that can track patient and system data and electronically transfer it to the patients' medical record (19-21). Catheters can stay in place for up to 7 days, but, as with any central venous catheter, should be removed as soon as they are not needed clinically (19-22).

Intravascular catheters are placed within the venous system and do not require arterial access. They are placed just like a central venous catheter and do not require additional training for insertion. The system is a closed circuit with sensors located within the balloon if the balloon was to malfunction. The machines are portable and can be moved from the OR to the ICU or vice versa (20). Risks of insertion are much the same as a central venous catheter insertion including misplacement, infection, catheter-related venous thrombosis, hematoma, pneumothorax, and risk to surrounding structures (21-23). There are distinct benefits for the burn patient (and the burn surgery staff) including decreased risk of complications associated with hypothermia, decreased operative times and improved outcomes (21-23).

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