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A quality improvement project incorporating preoperative warming to prevent perioperative hypothermia in major burns

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ABSTRACT

Background: Patients with extensive burn injuries are susceptible to a host of accompanying adverse effects should they develop perioperative hypothermia, which occurs in up to 1/4 of all major burn cases. This quality improvement project aimed to reduce the incidence of perioperative hypothermia to below 10% of cases in patients with major burn (Total Body Surface Area [TBSA] >15%), within a one year period.
Methods: A baseline diagnostic phase was undertaken to provide a greater understanding of the incidence, natural history and risk factors of perioperative hypothermia. We also reviewed and reinforced intraoperative measures in current use, including preemptive adjustment of the ambient temperature, underbody warming mattress use, warming blanket application over areas not operated, regular temperature monitoring, and discussion at the WHO surgical checklist. Preoperative forced air warming with a 'Bair Hugger'™ was identified as a sound change initiative, a strategy applied to good effect in other surgical settings. The primary outcome measure was the percentage of cases of perioperative hypothermia (<36 °C), utilizing a time series design for the period between 1 November 2016 and 31 October 2017.
Results: 53 patients with burn greater than 15% TBSA were admitted over the one year period. Of these, 40 patients required 127 operative procedures. Their mean age was 48.23 years, their mean TBSA was 27.65% (range 15–75%), and their mean length of hospital stay was 31.2 days. After the introduction of pre-warming, the proportion of cases of inadvertent hypothermia reduced to 13.77% (n = 14/102), with special cause variation, from 24% (n = 6/25) in the baseline data collection period. The final temperature correlated with the lowest temperature recorded in only 32% of cases. Based on stakeholder feedback and consensus from the literature, an algorithm was developed which forms the basis for a medical directive for preoperative warming for eligible patients. No significant balancing measures were identified, nor any undue costs incurred.
Discussion: The inevitable drop in temperature is ameliorated by sound perioperative practices, rather than just intraoperative ones. This initiative demonstrated the potential benefits of, and motivates for, the broad application of preoperative warming in the context of major acute burn surgery. Further investigations include PDSA cycles to determine whether the duration or degree of intraoperative hypothermia is more virulent. To

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consolidate the pre-warming initiative, we have introduced a standard order within our admission order sets to include preoperative warming for all eligible patients.

1. Background

Burn remains a prominent global health burden, with over 11 million burn injuries requiring medical attention annually, and is a leading cause of traumatic mortality and morbidity [1]. For full thickness and deep partial thickness burns, the widely-accepted practice, after initial critical care assessment and fluid resuscitation, is early excision and autografting [2–11]. While outcomes are undoubtedly improved because of this approach, early aggressive debridement exposes susceptible patients to the sequelae of hypothermia in the perioperative period [12–14]. A recent review highlighted the scarcity of literature on the sequelae of perioperative hypothermia, and challenged the burn community to "re-evaluate current dogma" regarding surgical principles and practice [12].

Hypothermia, a core temperature under 36°C, is known to have a host of accompanying adverse effects, manifesting as morbid cardiovascular events, infections, a propensity for greater blood loss, prolonged drug metabolism, as well as delays in obtaining definitive wound healing. These, in turn, may necessitate greater periods of mechanical ventilation, antibiotics, inotropes, opiate analgesics, sedatives and blood products, as well as further operative interventions [15–35]. These ill effects have been described in a wide variety of elective and emergency surgical settings, and notably, in the field of trauma surgery [15,16], its inclusion in the 'lethal triad' added impetus to 'damage control' surgery [36–42].

Even without burn injury, patients undergoing major surgery have as much as a 46% chance of developing hypothermia in an operating facility where the ambient temperature is between 20 and 25°C [18,19]. The additional challenge specific to the practice of major burn surgery is the deficient epidermal barrier which compromises thermoregulation. During 'prepping and draping' for surgery, the patient has the dressings removed, and the burn wounds are washed with antiseptic solutions. Donor sites for autograft harvest, if required, are also prepared, and large cutaneous areas may be left exposed while the operating team scrub and gown. The induction of general anaesthesia itself impairs one's autonomic means of regulating, distributing and conserving heat [32,43–45]. Patients are susceptible to three phases of hypothermia during anaesthesia, including a drop of 1–1.5°C during the first 60min, a slower linear decline in temperature from one to three hours after induction of general anaesthesia, and a subsequent plateau in core temperature at about 3–4h of anaesthesia. The nadir temperature, therefore, is likely a function of defective thermoregulation, a low ambient environmental temperature, heat redistribution from anaesthesia, the administration of relatively cool intravenous fluids and inhaled gases, and exposure of cutaneous surfaces and wounds [32,43–45].

Recent research from this unit demonstrated that those patients with major burn injury (greater than 20% TBSA) who had surgical durations over four hours, as well as intraoperative hypothermia, had significantly increased rates of postoperative infectious and non-infectious complications when compared to a low risk cohort [32]. More than a quarter of all operative interventions for major burn injury had temperatures recorded below 36°C, many of these even prior to the initiation of surgery itself. While burn surgeons are generally well informed of the manifestations of hypothermia, strategies to ameliorate its impact have been applied in an *ad hoc* fashion. The practice of limiting excisions to specific maximum body surface areas [13], or operative times, for example, are generally adhered to principally because of anecdotal experience and convenience, instead of a scientific evidence-base or according to a standardized protocol [32].

The purpose of this quality improvement project was to reduce the incidence of perioperative hypothermia (Temperature <36°C) to below 10% of cases (i.e. by at least a half) in patients with major burn injury (Total Body Surface Area [TBSA] >15%), within a one year period.

2. Methods

This quality improvement initiative was undertaken at the regional American Burn Association verified burn centre in Ontario, Canada. The unit serves a population of over 10 million people, admitting 350 patients a year, with approximately 30% resident in the Greater Toronto Area, and 70% from other areas of Ontario and beyond.

Frequent reference is made to a retrospective chart review, undertaken in this unit and published in this journal, of 1111 patients who underwent 2171 surgeries for acute burn injury over a 10-year period. In addition to the statistically significant association noted between hypothermia and complications, it was discovered that as many as 29% of operative cases for major burn injury (TBSA >20%) had temperatures recorded below 36°C, and many of these occurred even before the onset of surgery itself [32]. Root cause analysis based on the above data, with a group of stakeholders, including representation from the surgical, anaesthetic, burn unit nursing and operating room nursing staff teams, identified prominent reasons for perioperative hypothermia. These included the impact of anaesthetic induction, prolonged 'prepping and draping', failure to adjust the ambient operating room temperature timeously, and pre-existing hypothermia in the unit. A fishbone diagram of these reasons is demonstrated graphically (Fig. 1). Potential interventions were then considered which might most effectively target the prominent causes. We hypothesized that a few simple change concepts, iteratively introduced and tested via PDSA cycles, in addition to the dissemination of awareness of the impact of perioperative hypothermia on outcomes, might eliminate the nadir temperature commonly recorded intra-