Preventing Inadvertent Hypothermia in Patients Undergoing Major Spinal Surgery

A Nonrandomized Controlled Study of Two Different Methods of Preoperative and Intraoperative Warming

Granum, Mia N.; Kaasby, Karin; Skou, Søren T.; Grønkjær, Mette

Published in:
Journal of PeriAnesthesia Nursing

DOI (link to publication from Publisher):
10.1016/j.jopan.2019.03.004

Publication date:
2019

Document Version
Accepted author manuscript, peer reviewed version

ABSTRACT

Purpose: To evaluate if a Full Access Underbody blanket (FAU) used pre- and intraoperatively in patients undergoing major spinal surgery prevents hypothermia compared to current practice and to explore patients' experiences of comfort.

Design: A non-randomized controlled trial.

Method: Sixty patients were included, 30 in each group. Temperature was assessed at arrival, after connecting to the bladder catheter, at the start and end of surgery. In the FAU group, comfort was evaluated at arrival and after ten minutes of prewarming.

Findings: The risk of hypothermia at the start of surgery was significantly lower (Relative Risk (95% CI) of 0.28; (0.13 to 0.59). Before prewarming, 77% felt comfortable, 20% cold and 3% hot. After prewarming 60% felt comfortable, 37% hot and 3% very hot.

Conclusions: Patients using FAU had a 72% lower risk of hypothermia at the start of the operation. Attention to thermal comfort during surgery is important.

Keywords:

Inadvertent hypothermia, prewarming, Forced Air warming (FAW), Thermal Comfort

INTRODUCTION

Hypothermia is defined as a core temperature of < 36 ^{0} C. [1] Inadvertent hypothermia of only 1^{0} C increases the intraoperative blood loss and the need for blood transfusions due to a reduced formation of a platelet plug and a reduced clot formation, leading to a combination of platelet and enzyme impairment increasing blood loss by about 20 %. [2,3] Vasoconstriction occurs when the patient is mildly hypothermic and results in reduced oxygen perfusion, reduced systemic immune activation and reduced tissue healing and thus triples the infection rate.[2,3,4] Mild hypothermia is defined as a core body temperature between 34^{o}C and 36^{o}C [5, 6]. Previous research has indicated that intraoperative hypothermia influences the risk of myocardial ischemia and triples the risk of morbid cardiac output. [2]. Anesthetics inhibit thermoregulatory control and affect the vasoconstriction potentially causing inadvertent hypothermia and shivering [7]. Although hypothermia is used deliberately in some surgical procedures to preserve cells, hypothermia is associated with several adverse effects for patients ranging from thermal discomfort to increased morbidity and mortality.[1]

Major spinal surgery tends to be lengthy with an increased risk of hypothermia. Patients operated for spinal deformities have an increased risk of hypothermia due to length of operation, degree of exposed skin surface and positioning. [8] This emphasizes that length of operation, exposed skin surface, positioning, incision length and theatre temperature are considered predictors of hypothermia. [9, 10, 11] Post-operatively, patients can experience physical discomfort due to hypothermia during surgery. [2,3] Years after their operation, patients identify the feeling of being cold as their worst hospital experience. [2,3] Being warm is a substantial factor that influences the patient's experience of care during surgery. A survey among nurse anesthetists on patients' major concerns showed that 71% of the nurses found that being cold was a comfort problem. [12] Physical comfort needs include physiologic mechanisms that are disrupted such as thermoregulation. Preemptive warming is one technical comfort measure that has shown effectiveness in reducing inadvertent hypothermia [13], and at the same time increased the patient's thermal comfort [14].

Prewarming is defined as warming of peripheral tissues or skin surface before anesthetic induction. [1,15] Forced air warming (FAW) prevents intraoperative hypothermia effectively and thermal comfort provided by FAW is superior to other warming methods. [9, 11] Prewarming is effective in preventing redistribution hypothermia, especially one hour after induction of anesthesia. [2,3,12] It is not known whether the use of a Full Access Underbody (FAU) blanket can prevent hypothermia during major spinal surgery pre- and intraoperatively. For that reason, the aims of this study were to evaluate if a FAU blanket used pre- and intraoperatively can reduce the number of patients having inadvertent hypothermia when undergoing major spinal surgery, as compared to current practice, and to evaluate the thermal comfort of patients using the FAU blanket. The hypothesis is that the FAU blanket will decrease the risk of hypothermia <36ºC and increase the patient's experience of thermal comfort.

METHODS

Study design

The study is a non-randomized controlled trial conforming to the TREND statement [16] for reporting non-randomized studies.

Patients and recruitment

The study included 60 patients undergoing major spinal surgery; in this study defined as spine deformity surgery. Inclusion criteria were Danish speaking in order to ensure patients understood questions related to their thermal comfort, and age ≥14 years in order to match the included patients in the former quality improvement project. A tympanic temperature < 38^0 C or >36^0 C. Patients were excluded if they weighed more than 115 kg (FAU has a 115 kg limit), had a preoperative temperature > 38 ° C or ≤ 36 ° C (Normothermia is defined as a core temperature range of 36^0 - 38^0 C), [1] or had cognitive impairment to such an extent that they were not capable of cooperating. Patients were included consecutively at the Clinic for Anesthesiology, Child Diseases, Circulation and Women, Aalborg University Hospital and divided into two groups of 30 patients depending on

time of inclusion. Patients for the control group were included as part of a quality improvement project in the period from September 2012 - February 2013. Patients for the intervention group were included from November 2015 - October 2016. The time span between the two data collection periods was caused by lack of options of how we could prevent inadvertent hypothermia effectively in this group of patients. The acquisition of the FAU blanket challenged the current warming practice and gave ideas as to how the number of patients with inadvertent hypothermia might be reduced.

Study treatments

In the control group, patients were covered with a lint free quilt and a reflective blanket before entering the operating theatre. When the patient was placed on the operating table, the quilt and reflective blanket were placed on top of the patients' legs and arms so as not to interfere with the preoperative preparations consisting of positioning of the patient, x-rays, marking of the patients' back position and ending with the sterile draping. A Full Body Blanket with surgical access (FBBSA) (Bairhugger blanket model 570 - warming unit) and cotton blankets on the upper limbs were applied and FBBSA activated shortly before the start of the operation.

In the intervention group, the FAU blanket (Bairhugger blanket Model 635 – warming unit 775) was placed upon the patient under a lint free quilt before entering the operating theatre. In the operating theatre, the patient was asked to assess his or her thermal comfort. The FAU blanket was then connected to the warming unit and started at 43^0 C. Prior to induction of anesthesia, patients once again were asked to assess their thermal comfort. The FAU blanket was switched off and placed on the operating table before placing the patient on top of it in prone position. The FAU blanket was turned on and kept running throughout the remaining preoperative preparations only to be switched off momentarily while the sterile drapings were placed. In both the intervention and the control group, the temperature of the warming unit was adjusted either in accordance with the patient's statements of thermal comfort or alterations in the bladder temperature. In both groups, the temperature of the operating theatre was set at 20^0 C. This temperature is controlled and monitored by a central heating system and

is digitally visible in the operating theatre.

Data collection procedure

The patients' tympanic temperature was measured. Anesthesia was induced and maintained with Propofol, Ultiva and Fentanyl and in some cases supplemented by a volatile anesthetic. The patient was intubated and ventilated mechanically. The patients in the control group continued with non-active warming since the FBBSA interfered with the preoperative procedures due to its placement on top of the patient. The patients in the intervention group had the FAU blanket placed beneath them; thus resuming active warming during the continuous preoperative procedures. According to current practice, all patients acquired a bladder catheter after the induction of anesthesia, thus avoiding the pain and discomfort associated with the insertion. Bladder temperature was measured and documented when the bladder catheter was connected to the monitor, at the start and end of the operation. In order to be able to alternate the temperature of the blankets, the bladder temperature was observed on the monitor and reacted upon, yet not documented with 15 minutes intervals throughout the operation and on arrival to the recovery room. Furthermore, the patient's thermal comfort was assessed when using the FAU blanket as active prewarming.

Measurements

Preoperatively, demographic and morphometric characteristics were documented including age, gender, weight, ASA and tympanic temperature. Ear canal temperature (Braun Welch Allyn Thermoscan Pro 4000 ± 0,2 ^{o} C for the thermometer at 35.5 -42.0 ^{o} C) [17] was measured upon arrival due to its unobtrusive nature and ease of management, [18] although it is considered inferior compared to other temperature sites. [3,19,20] The accuracy of this measurement was, however, of less importance since it was used to in- or exclude patients in the study. A Foley bladder catheter measured the bladder temperature with a temperature sensor (Smiths Medical level 1FC 400/ 12-14). The bladder temperature is considered suitable for clinical use providing an adequate urine flow. [3] Hypothermia was defined as temperature <36^{o}C. Patients thermal comfort was assessed with a modified 5-point

Likert visual scale consisting of 5 points: 1: very cold, 2: cold, 3: comfortable, 4: hot, 5: very hot. The Likert scale is a psychometric scale of five point that allow individuals to express how much they agree or disagree to a particular statement.[21] For the purpose of this study, the Likert scale was modified and included digits and smileys so it was easier for patients to see and make the grade.

Data analysis

Potential between-group differences in demographics and treatment-related variables were compared using the two-sample t-test, Pearson's Chi squared test or Fischer's exact test depending on data type and cell numbers. Relative risk (95% CI) and Pearson's Chi squared test or Fischer's exact test were used to compare hypothermia (temperature <36ºC) between groups. Thermal comfort was numerically calculated and presented in a diagram. The significance level was set at $P<0.05$ and all analyses were performed in IBM SPSS Statistics Version 24 (IBM Corporation, Armonk, NY).

Ethics and registration

The study was registered at ClinicalTrials.gov (NCT03193905) and was carried out in accordance with The Helsinki Declaration. [22]. The patients (and their legal guardians if under 18), were informed about the study prior to surgery and informed about their rights to withdraw from the study at any time. Confidentiality and anonymity was ensured. In accordance with Danish legislation, formal ethics approval of the study was not required since the study was an analysis of current practice and thus had no implications for the treatment of the patient. Authorization by the regional Danish Data Protection Agency Identity number 2015-135 was obtained.

Findings

Table 1 presents the demographic and morphometric characteristics and treatment-related variables of the patients included. Length of stay in the operation theatre ($P=0.003$) and length of operation ($P=0.002$) were significantly shorter in the intervention group compared to the control group. There were no other statistically

significant differences found between the two groups in demographic or treatment-related variables. When connecting to the bladder catheter, no significant between-group difference was found (RR (95%CI) of 0.20 (0.03 to 1.61); Table 2) in the risk of hypothermia with mean (SD) temperatures of 36.3 (0.5) ^{0}C in the control group and 36.5 (0.4) ^{0}C in the intervention group. At the start of the operation, the risk of hypothermia (<36^{0}C) was significantly lower in the intervention group compared to the control group (RR (95%CI) of 0.28 (0.13 to 0.59); Table 2) with mean (SD) temperatures of 35.8 (0.5) ^{0}C in the control group and 36.3 (0.3) ^{0}C in the intervention group. At the end of the operation, no significant between-group difference was found (RR (95%CI) of 0.33 (0.04 to 3.03); Table 2) in the risk of hypothermia with mean (SD) temperatures of 36.8 (0.7) ^{0}C in the control group and 37.1 (0.4) ^{0}C in the intervention group. When asked, 77% (23) of the patients in the intervention group indicated that they felt thermally comfortable, 20% (6) cold and 3% (1) hot before prewarming, while 60% (18) felt thermally comfortable, 37% (11) hot and 3% (1) very hot after prewarming.

Discussion

We found that inadvertent hypothermia at the start of the operation was lowered by 72% when using the FAU blanket pre- and intraoperatively compared to the use of passive prewarming and active warming with the FBBSA commencing at the start of the operation. This corresponds partly with Pu et al. who found that significantly less patients with intraoperative hypothermia were observed in a group of patients who were actively warmed with an underbody warming system intraoperatively compared to a passively warmed group of patients. [23] Also, they found no significant alteration in the temperature at the beginning of surgery until 30 minutes later, despite differences in warming methods**.** [23] We found no significant difference in the number of patients with inadvertent hypothermia between the control group and the intervention group when the patients' bladder catheters were connected to the monitor. However, both our groups experienced a small decrease in bladder temperature at the start of the operation. This corresponds with Akhtar et al. who found only a small redistribution hypothermia in patients who were not prewarmed, thus supporting our findings. [24] Sessler argues that the initial reduction in core temperature is difficult to treat since it is caused by redistribution of heat from

the core to the peripheral tissue due to anesthetic induced vasodilatation and impaired autonomic temperature regulation. [2] Moola and Lockwood argue that prewarming is effective in preventing redistribution hypothermia, especially one hour after induction of anesthesia. [25] Sessler found that prewarming for as little as 30 minutes probably prevents considerable redistribution, [2] whereas Horn et al. comparing three periods of prewarming at 10, 20 and 30 minutes respectively, suggest that prewarming for only 10 or 20 minutes in most cases prevents hypothermia. [26] Connelly et al. suggest that 10 minutes prewarming is sufficient in reducing intraoperative hypothermia. [27] In our study, patients in the intervention group were actively prewarmed between 2 – 20 minutes and significantly maintained their bladder temperature ≥36 ^{o} from start and throughout surgery in contrast to the control group. According to Leslie & Sessler, one hour of active forced air warming with 43 ^{0} C prior to anesthesia is sufficient to counter act a redistribution core temperature drop, but may result in sweating and discomfort for the patient. [28] We found that 40 % of the patients felt hot and very hot after between 2 – 20 minutes of prewarming with 43^{o}C. The National Institute for Health and Care Excellence (NICE) recommends that active warming be maintained throughout the intraoperative phase. [29] In our study, active warming of the patients in the intervention group were resumed immediately after positioning and draping; thus minimizing the heat loss before the start of the operation in contrast to the patients in the control group where active warming was initiated just prior to the start of the operation. That might suggest active warming to be continued during further preparation of the patient before the start of the operation.

Length of operation and length of stay in the operating room were significantly lower in the intervention group than in the control group. Length of operation and length of stay in the operating room could have contributed to the significantly lower heat loss in the intervention group. Journaux suggests in a review that patients undergoing longer procedures are in increased risk of hypothermia. [30] Lynch et al. argue that to prevent hypothermia in procedures lasting more than one hour it might be advisable to increase the operating room temperature. [11] However, a recent study showed that the operating room ambient temperature has a negligible effect on core temperature when patients are warmed with forced air. [31] The effect is larger when the patient is passively

insulated, but with a small magnitude. [31] Wagner et al problematized the lack of research on the benefits of prewarming as a comfort intervention or anxiolytic mean to decrease patient anxiety. [32] Fossum et al. indicated that application of forced warm air preoperatively provides positive feelings of comfort. [33] However, thermoregulation also presents a nursing care challenge. [10] We found that 20 % of the patients felt cold arriving to the operating theatre. This correlates with Wagner's study where patients often mentioned that they felt cold in the preoperative phase of the surgery. [32] Most of the patients in our study, however, felt comfortable. After prewarming, the patients no longer felt cold (37% felt hot; 3% felts very hot adding risk of discomfort). This underlines the need for nurses to intervene successfully and effectively pre- and intraoperatively to increase thermal comfort, be aware of, and control the thermal environment. It is possible to adjust the active warming device from 43^{0} C to either 38^{0} C. or 32^{0} C. Further research on patient experiences of thermal comfort is needed.

Limitations

The validity of this study would have been strengthened if the study was a randomized controlled trial as this would have eliminated selection bias and ensured that any known and unknown confounders would have been balanced between groups [34]. Alongside further standardization of the practical methods applied during surgery between treatment groups, this would have ensured that any potential inconsistencies in time of prewarming and preparation after induction of anesthesia, clothing worn when the patients arrived at the operation theatre and differences in time uncovered during for example catheterization and positioning would have be equally distributed between groups. However, as this were individual and not systematic differences between groups, we have no reason to believe that they would significantly affect the results. Finally, as we did not conduct a sample size calculation a priori, we cannot rule out that significant between-group differences in hypothermia would have also been found when connecting the bladder catheter or at the end of the operation, had we included more patients.

Conclusion

Patients using FAU blanket were at a 72% lower risk of hypothermia at the start of the operation, suggesting that this might be an appropriate pre- and intraoperative warming method in major spinal surgery. When using the FAU blanket, the time and amount of skin surface receiving forced air warming was extended because the blanket allowed all the preoperative procedures to go on due to its placement underneath the patient; thus minimizing the loss of heat to the environment leaving heat production to exceed heat loss. The comfort scores indicate that nurses should pay careful attention to the patient's thermal comfort and adjust accordingly.

Declaration of interest & funding

The authors declare that there is no conflict of interest.

Funding: Søren T. Skou is currently funded by the Independent Research Fund Denmark (DFF – 6110-00045) and the Lundbeck Foundation (both grants are for another project unrelated to the current work).

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