Perioperative Warming to Decrease Inadvertent Hypothermia in the Adult Surgical Patient

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ABSTRACT

Inadvertent perioperative hypothermia occurs in many patients during surgery and can lead to adverse outcomes including myocardial events, impaired drug metabolism, impaired wound healing, increase risk of surgical site infection, and reduced oxygen perfusion. Passive and active warming measures can minimize the incidence of inadvertent perioperative hypothermia. However, passive warming alone is not sufficient. Active warming using a forced-air warming device for at least 30 minutes preoperatively has been shown effective to decrease the risk of inadvertent perioperative hypothermia. A systematic review was performed to assess how perioperative active and passive warming decrease the risk for inadvertent perioperative hypothermia in an adult patient undergoing surgery. Research databases were utilized for specific articles regarding the topic of study. Relevant articles were included in the systematic review. A total of 15 studies were critiqued. Overall, active warming methods, alone or in conjunction with other warming methods, at least 30 minutes before entering the operating room can decrease the risk of inadvertent perioperative hypothermia. Although each patient will experience a bout of hypothermia after induction of anesthesia medication, it is easier or a pre-warmed patient to return to normothermia. As nurse practitioners, collaboration and education with the perioperative team and patient advocation regarding the effects and risk of inadvertent perioperative hypothermia are essential topics and can be addressed by a surgical nurse practitioner.

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INTRODUCTION AND BACKGROUND

Introduction

Inadvertent perioperative hypothermia (IPH) can occur preoperatively and impact the patient's recovery. As defined by the American Society of Peri Anesthesia (ASPAN), normothermia is a core body temperature between 36℃ to 38℃ (Giuliano, 2017). Any unintended decrease in the patient's core temperature during the perioperative period is considered IPH. The contributing factors of IPH are the hospital's cold environment, administration of cold intravenous fluids, and the anesthetic medication used during surgery that causes inhibition of temperature regulation and redistribution of the body's core temperature to the periphery (Koh et al., 2021). In the first hour under general anesthesia, a drop in the body's core temperature is caused by 81% primarily by redistribution and less than 19% due to environmental factors (Koenen et al., 2017).

Under anesthesia, heat loss occurs in a triphasic pattern of hypothermia: Phase 1, redistribution, Phase 2, metabolic loss, and Phase 3, the end of the linear phase and plateau begins (Riley and Andrzejowski, 2018). The first phase of the triphasic pattern of hypothermia is redistribution. This happens when the patient experiences the first decline in body temperature due to the vasodilation from the administration of anesthetic medication and gases. Vasodilation occurs by sending warm blood to the peripheries, and cool blood is sent back to the body's core from the peripheries. Once this happens, Phase 2 occurs and the metabolic rate decreases because heat loss surpasses heat produced from metabolism resulting in a negative heat balance and eventually hypothermia Radiation, convection, evaporation, and conduction are causes of heat loss. In Phase 3, the triphasic pattern of hypothermia occurs when the plateau begins and the linear phase ends. Maximal vasoconstriction is the primary culprit in this phase because any heat loss is balanced metabolically (Riley and Andrzejowski, 2018).

Significance

According to Bilgin (2017), the prevalence of inadvertent perioperative hypothermia is between 50% and 90%, with an estimate of 70% in surgical patients. The complications associated with IPH can prolong a patient's recovery and hospital stay. Adverse patient outcomes include reversible coagulopathy, myocardial events, decreased drug metabolism, increased postanesthesia care unit (PACU) length of visit, shivering, reduced oxygen perfusion, poor wound healing, increased risk for surgical site infection, increased need for blood transfusion, and mortality (Link, 2020). Comorbidities that increase the patient's risk of IPH are hypothyroidism and other endocrine disorders, peripheral vascular disease, paralysis, hypoglycemia, cardiac conditions, arthritis, head or spinal cord injuries, and intoxication (Giuliano, 2017). The surgical risk factors that increase the incidence of IPH are extensive blood loss, low body core temperature preoperatively, burn injuries, preoperative fasting, fluid dehydration before anesthesia, prolonged surgery duration, cold IV and irrigation administration, and large surface area of the patient's body or cavity exposed during surgery (Giuliano, 2017).

Despite an increase in evidence-based perioperative temperature management in the surgical patient, Studies performed throughout Europe, Australia, and China revealed insufficient compliance with perioperative temperature management guidelines (Koh et al., 2017). Specific barriers preventing compliance to perioperative temperature management guidelines include accessibility to the necessary equipment and financial constraints.

IPH can be prevented, treated, and managed through the collaboration of the perioperative team. Preventions strategies include pre-warming the patient before entering the operating room, use of warmed intravenous and irrigation fluids, and active and passive warming methods. Active and passive warming examples include forced-air warming devices (FAW), warmed fluids, an electric warming blanket, thermal garments, warmed cotton blankets, and surgical drapes (Link, 2020). Management of IPH is accomplished by monitoring the patient's temperature throughout the entire perioperative phase.

Purpose

Because the recommended care of the patient in the perioperative phase is inconsistent in hospitals nationally and worldwide, a review of existing studies and literature exploring the importance of preoperative warming is crucial to prevent IPH. This paper will analyze the evidence presented in the existing literature and propose evidence-based recommendations that can be integrated into nursing practice. In particular, this paper will address the following question: How does perioperative active and passive warming decrease the risk for inadvertent perioperative hypothermia in an adult patient undergoing surgery?

METHODS

A systematic review of the literature was performed using the following databases, PubMed, CINAHL, Cochrane Data Bases, and Science Direct to identify studies on preoperative warming to prevent inadvertent perioperative hypothermia. Key terms include Perioperative phase, Perioperative Warming, Inadvertent hypothermia in conjunction with Surgery, Temperature, and Adult. The search was filtered by English full-text and a publish date within the last five years.

The search yielded 20 research articles. Abstracts and titles were reviewed for each and selected based on their relevance. Articles involving prewarming methods, and prevention and management of perioperative hypothermia were included. Fifteen articles were selected and evaluated using. The John Hopkins Nursing Evidence-Based Practice Appendix C: Evidence Level and Quality Guide. Additionally, the following National organization guidelines were reviewed: The National Institute for Health and Care Excellence (NICE), Association of periOperative Nurses (AORN), and The American Society of Post Anesthesia Nurses' (ASPAN).

The studies critiqued took place in a perioperative setting, either in the hospital or outpatient surgery center. Inclusion criteria for articles critiqued are patients who had American Society of Anesthesiologists (ASA) physical status I-III, undergoing elective surgery with general anesthesia for a specific length of time. The patients were divided into two separate groups receiving two different rewarming methods.

LITERATURE REVIEW

The National Institute for Health and Care Excellence [(NICE) 2009], Association of periOperative Nurses [(AORN) 2020], and American Society of Post Anesthesia Nurses' [ASPAN (2010)] guidelines recommend maintaining normothermia throughout the perioperative phases. AORN, NICE, and ASPAN support strong evidence-based recommendations addressing temperature measuring and monitoring and implementation for preventing or treating hypothermia for all perioperative patients. However, they do not precisely determine the best method and site of measurement. Instead, these organizations recommend the perioperative team members collaboratively decide on the same location and method throughout the entire perioperative phase. These three organizations strongly recommend identifying a patient at risk for hypothermia and initiating warming interventions before surgery to prevent inadvertent perioperative hypothermia.

Lau et al. (2018) evaluated the effect of the use of FAW intraoperatively to decrease the patient's risk of IPH. In this study, the pre-warmed group received active warming for 30 minutes via a full-body forced warming air gown with warmed blankets. The control group was dressed in standard hospital gowns and warmed with flannel blankets. At baseline, 12/100 individuals in the control group and 11/99 individuals in the pre-warmed group presented hypothermic. However, intraoperative hypothermia was lower in the pre-warmed group (Lau et al., 2018).

A systematic review of patients undergoing surgery with neuraxial anesthesia was performed by Shaw et al. (2017). It was determined that active warming did not consistently prevent IPH in patients undergoing surgery with neuraxial anesthesia. Although preoperative active warming decreased the temperature gradient between the core and peripheral tissues when general anesthesia is administered, researchers found it difficult to maintain active warming measures during anesthesia induction (Shaw et al., 2017). Xiao et al. (2020) determined recovery time was drastically reduced in the pre-warmed group versus the warmed group (17.37 minutes versus 26.73 minutes). In this randomized controlled trial, patients were divided into two separate groups. After the erector spinal plane block was performed on pre-warmed patients, a forced-air warming device was applied to the patient for 30-minutes before entering into the operating room. A forced-air warming device was used on the patient in the warmed group after entering the operating room. The incidence of inadvertent perioperative hypothermia was significantly decreased in the pre-warmed group compared to the warmed group [(12.24% vs 32.65%, *P* =.015 (Xiao et al., 2020)].

According to Tyvoid (2019), preoperatively heat loss was less in the underbody forced-air warming group compared to the self-warming blanket group. However, both methods were insufficient to prevent hypothermia despite measures of increased environment temperatures, fluids pre-warmed, and passive methods with blankets and surgical draping. Researchers endorsed active warming methods had a better outcome than passive methods. However, neither technique prevented inadvertent perioperative hypothermia.

Summary of Research Literature

IPH occurrence in the perioperative patient is relatively common, regardless of measures taken in the preoperative phase of care (Chen et al., 2019, Koh et al., 2021, Simegn et al., 2021, Xiao et al., 2020, Yoo et al., 2021). IPH causes delayed metabolism of anesthetic drugs and gases, increased risk for surgical site infections, prolonged recovery and hospitalization, and poor wound healing (Chen et al., 2019, Koh et al., 2021, Simegn et al., 2021, Xiao et al., 2020, Yoo et al., 2021).

Although prewarming measures are taken preoperatively, a slight decrease in the patient's body temperature occurs. This phenomenon, core-to-periphery body heat redistribution, occurs commonly after the induction of anesthetic medication due to anesthetic-induced vasodilation and impaired autonomic temperature regulation. However, pre-warming patients for at least 30 minutes before surgery decreases their risk of perioperative hypothermia postoperatively (Guiliano, 2017, Hooper et al., 2010, Lau et al, 2018, Link, 2020, Riley, 2018, Simegn et al., 2021). Active warming, alone or in conjunction with another active or passive warming method, is shown to be the best way to decrease the patient's risk for IPH (Guiliano, 2017, Hooper et al., 2010, Lau et al, 2018, Link, 2020, Riley, 2018, Simegn et al., 2021).

Of the 13 articles reviewed, all 13 articles confirmed a decrease in the patient's body temperature after anesthesia medication administration, 7 articles found forced-air warming units were the best mechanism for preoperative warming, 1 article found prewarming for less than 30 minutes was sufficient, 3 articles found prewarming for at least 30 minutes prevented IPH. Lau et al. (2018) confirmed normothermia in the patient's body core temperature by pre-warming.

The researchers determined preoperative pre-warming for at least 30 minutes with a full-body forced-air warming unit combined with warming intraoperatively is the best method to prevent IPH.

Common noticeable patterns in these 13 research articles include patients in ASA class I-III, the type of temperature measuring tool, and the timing of temperature measurement. A limitation found commonly in the research is the small sample size. Objective data was utilized and was considered to determine the outcome of the study rather than using subjective data from the patients participating in the trials. Researchers mainly focused on outpatient surgical centers rather than a hospital setting. Because of this, results were unable to be generalized due to the limited patient selection.

These 13 research articles discovered bouts of inadvertent perioperative hypothermia in patients undergoing surgery with general anesthesia due to heat redistribution caused by anesthetic medications. It was determined even with active warming methods before arriving at the operating suite, the patient’s temperature will drop after the initiation of general anesthetic medication (Chen et al., 2019, Connelly et al., 2017, Giuliano, 2017, Granum et al., 2019, Koenen et al., 2017, Koh et al., 2021, Lau et al., 2018, Link, 2020, Shaw et al., 2017, Tyvoid, 2019, Simegn et al., 2021, Xiao et al., 2020, Yoo et al., 2021). Because of the level of uncertainty on the effect on the patient, the researchers were able to determine that pre-warming was the best method of management in the early stages of IPH. Perioperative warming methods helped patients have a shorter time in recovery and metabolize anesthetic gases quicker (Chen et al., 2019, Connelly et al., 2017, Giuliano, 2017, Granum et al., 2019, Koenen et al., 2017, Koh et al., 2021, Lau et al., 2018, Link, 2020, Shaw et al., 2017, Tyvoid, 2019, Simegn et al., 2021, Xiao et al., 2020, Yoo et al., 2021).

Of the 13 research articles, the population selection was very similar. Patients who fell the in ASA I-III classification without chronic comorbidities and 18 years or older were selected for the studies. Many of these studies were performed in other countries and patients often did not speak any English. However, researchers provided these patients with information and documents in their native tongue.

In contrast, not all research articles used the same method of warming. Active warming with FAW devices was mostly used preoperatively in comparison to passive warming with cotton blankets or surgical drapes. In some trials, the only active warming method was the use of a forced-air warmer. However, in another trial, the researchers used different combinations of active and passive warming methods and compared those combination methods. For example, a forced-air warmer would be used in conjunction with warmed fluids and a cotton blanket over the forced-air warmer.

Analysis

The critiqued research revealed variations in the facility's practice, comparable studies, factors, and components used in each trial. Although organizations, such as AORN, recommend specific temperature ranges for the operating room, the facilities and hospitals included in the trials are international facilities. Therefore, these facilities do not follow AORN recommendations and guidelines. In some trials, researchers considered room temperature to affect the patient's temperature intraoperatively. However, some other trials did not take into consideration operating room temperature.

Many of the research articles analyzed compared their research to a similar study. However, the similar study used reported no difference between the pre-warmed and control group despite 60 minutes of pre-warming. Although the comparative analysis was used, researchers agreed that active pre-warming methods for 30 minutes preoperatively decreased the patient's risk for IPH when compared to a patient who used passive warming methods preoperatively.

Gap Analysis

Simegn et al. (2021, p. 3) recommend that "perioperative hypothermia prevention and identification should be started 1-2 hours before anesthesia administration. The intraoperative temperature should be monitored at least every 15 minutes." Although this systematic review determines different methods of management for perioperative hypothermia, this systematic review failed to review the studies statistically.

Chen et al. (2019) pointed out that although studies found significant advantages for warming perioperative patients, their studies and others failed to compare other methods of warming, such as, combined active warming strategies of forced air and warmed blanket (CAW-AB), combined active warming strategies of forced-air, fluids, and warmer blanket warming (CAW-AFB), and combined active warming strategies of fluids and warmed blanket warming (CAW-FB), due to lack of availability of these methods in other facilities.

In Yoo et al.'s (2021) study, limitations included variations in instruments used, estimated values, and lack of long-term follow-up to determine an outcome from interventions implemented during the perioperative period.

The critiqued research found many variations in anesthesia time, warming time, temperature measurement, warming temperature, and assessment time. The variations made it difficult to determine the outcome of the study. Other limiting factors that impacted the study were selection bias, limited sample size, and study bias.

CONCLUSION

Summary of Evidence

Passive warming and initiating warming methods intraoperatively were believed to be sufficient for the surgical patient. Passive warming would include the use of cotton blankets preoperatively. Intraoperatively, the draping of the patient with the sterile drapes is considered another form of passive warming. However, research literature revealed these methods helped, but were not as effective and enough to prevent IPH. Research literature strongly recommends using active warming methods, alone or in conjunction with other warming methods, at least 30 minutes before entering the operating room to decrease the risk of IPH. Evidenced-based active warming methods include forced-air warming and pre-warmed irrigation and intravenous fluids. Literature determined each patient will experience IPH after the induction of anesthesia medication, but it is easier for a pre-warmed patient to return to normothermia.

John Hopkins Nursing Evidence-Based Practice Appendix C: Evidence Level and Quality Guide was utilized to grade the quality of the research articles. The articles analyzed consists of three Level 1 systematic reviews, five Level I randomized control trials, one Level II Quasi-experimental, two Level III Quality, two Level IV clinical guidelines, and two Level V literature reviews.

The applicability of evidence into practice is significant since healthcare is driven towards following guidelines. Although professional organizations provide guidelines and recommendations, it is not required for the facilities to follow them. However, the health and betterment of the patient is the primary goal in healthcare. If the benefits outweigh the risks, more than likely, the recommendation will be implemented in practice.

The benefits of initiating active warming at least 30 minutes before surgery outweigh the risks of passive warming. Research literature has found passive warming ineffective to prevent inadvertent perioperative hypothermia in surgical patients. A facility may see passive warming as cost-effective because for active warming; the facility will need to purchase the warming device and the patient items used for pre-warming, for example, the BairPaw gown and BairPaw warming unit. However, if a patient experiences complications from inadvertent perioperative hypothermia, the patient and facility costs will most likely exceed the price of active warming. Some expenses that would accrue to care for a patient with complications from IPH include hospital stay, inpatient medication, hospital supplies, and a possible return to the operating room and anesthesia time.

When active warming devices are used, patient education will need to be performed to ensure proper use and knowledge of the active warming device. These measures can prevent patient injury and improper use of the active arming device.

Implications of EBP recommendation for nursing

Nurse practitioners work closely with the surgical team, who primarily care for and monitor patients during the perioperative phase. As nurse practitioners, it is not only our duty to empower and educate our patients about a disease process and management; it is also our duty to the patient to empower and educate the perioperative team caring for them and ways to prevent, monitor, and manage perioperative hypothermia to improve the patient' outcomes. In collaboration with each other, the nurse practitioner will have a better understanding of the surgical teams' knowledge of inadvertent perioperative hypothermia.

How EBP recommendation will change practice

The EPB recommendation from this writer will change the practice of the entire perioperative department workflow. A collaboration of care to decrease the risk of IPH in the surgical patient will need to be implemented to ensure the appropriate measures are taken. Active warming will need to be initiated by the preoperative nurse in the preoperative phase of surgery, the same temperature measuring method and location will be used throughout the entire perioperative phase, and pre-warmed and irrigation fluids will be used intraoperatively to help prevent IPH.

This literature review found strong evidence to support active warming preoperatively in adults undergoing surgery. Of the interventions reviewed, actively warming the patient with a forced-air warming device had the strongest support evidence. Perioperative teams should initiate active warming measures at least 30 minutes prior to entering the operating room to limit the risk of IPH.

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APPENDIX A

Literature Matrix

Reference list entry (APA 7th ed.)	Database/ Search Terms Type of Study	Purpose Population	Methodology	Results/Conclusion	Analysis Implication for Practice
Chen, W., Liu, C., Mnisi, Z., Chen, C., Kang, Y. (2019). Warming strategies for preventing hypothermia and shivering during cesarean section: A systematic review with network meta-analysis randomized clinical trials	ScienceDirect Inadvertent Perioperative Hypothermia Systematic review with network meta-analysis of RCT	• Identify the easiest interventions such as forced-air warming, intravenous fluid warming, conduction mattress warming, warmed blanket warming, and combined warming strategies that have the highest efficacy to prevent shivering and hypothermia in women undergoing cesarean delivery • Women undergoing cesarean delivery.	• 18 RCTs were included and researched conducted by a team of anesthesiologists and an experienced evidence-based medicine researcher. Single active warming strategies (SAW): conduction mattress warming, forced-air warming, IV fluids warming, warmed blanket warming; combined active warming strategies (CAW): CAW of forced-air and warmed blanket warming (CAW-AB), CAW of forced-air and fluids warming (CAW-AF), CAW of forced-air, fluids and warmed blanket warming (CAW-AFB), CAW of forced-air, fluids warming, and warmed gown warming (CAW-AFG) • RCTs investigating the correlation between warming strategies, hypothermia, and shivering events were considered. • Duplicates were removed. Medline, Embase, and Cochrane Library database of systematic reviews to analyze RCTs that studied warming strategies for cesarean section. • Cochrane risk of bias tool was used to assess for bisk risk. • Risk ratio with 95% confidence interval was used to report results of shivering and hypothermia. • Surface under the cumulative ranking curve was used for supporting evidence for clinical practice	• 18 RCTs were included in the study based on eligibility criteria. • Hypothermia events were reported in non-active warming conduction mattress warming, fluids warming, forced-air warming, CAW-AF, and CAW-FM	**Limitations:** Couldn't put CAW-AB, CAW, AFB, CAR-FB in meta-analysis due to lack of comparison with other studies, trials differed in warming time, anesthesia type, warming temperature, temperature measurement, and assessment time, SUCRA may not affect our outcomes because the consistency model in this study showed trends with significant findings.
Connelly, L., Cramer, E., DeMott, Q., Piperno, J., Coyne, B., Winfield, C., & Swanberg, M. (2017). The optimal time and method for surgical prewarming: A comprehensive review of the literature. *Journal of PeriAnesthesia Nursing*, *32*(3), 199–209. https://doi.org/10.1016/j.jopan.2015.11.010	PubMed Hypothermia	• To determine optimal methods and amount of time to prewarm a surgical patient to prevent perioperative hypothermia.	• Used online databases for search, words included "pre-operative," "prewarming," and "perioperative hypothermia" in PubMed, search returned 46 articles • Inclusion criteria were articles written in English, full-text articles, and articles with evidence-based prewarming recommendation • Exclusion criteria were pediatric studies and studies focusing on prewarming the surgical environment • Second search was done, words included "preoperative OR pre-operative" OR "perioperative or peri-operative" AND "prewarming OR pre-warming" in CINAHL and PubMed, search returned 35 on PubMed and 18 in CINAHL • Used Critical Appraisal Skills Programme (CASP) tool for experimental studies • Used Stetler evidence hierarchy for quantitative articles • Prewarming time and method recommendations were reviewed to determine the prewarming recommendations • Studies were conducted in the United States, United Kingdom, Germany, Belgium, Canada, and Brazil • Researchers examined temperature difference of patients prewarmed with forced-air warming vs no pre-warming, measuring tympanic or core temperatures before induction of anesthesia and throughout the surgeries	• 14 articles were included to draw conclusions and formulate recommendations • Articles studies specific type of surgeries in gynecology, orthopedic, urology, cardiac, Abdominal, colorectal, spinal, varicose veins, ENT, breast reconstruction, and joint replacement • Surgery was between 20 minutes and 5 hours • 12 articles mention length and/or type of anesthesia, most common is 1 to 3 hours, and most common type is general, spinal, and epidural • Researchers found forced-air warming provided significant difference in maintenance of normothermic temperature at 1, 2, ad 3 hours into surgery	**Limitations:** Pediatric and patients over 80 years old were excluded, ophthalmic, neurologic, and surgeries less than 20 minutes or more than 4 hours were not adequately addressed **Strengths:** • Prewarming patients helps reduce rates of perioperative hypothermia. • Forced-air warming is proven to be the most effective system • Suggests a minimum of 10 minutes of forced-air prewarming warming is sufficient to maintain normothermia

Giuliano, K. K., & Hendricks, J. (2017). Inadvertent perioperative hypothermia: Current nursing knowledge. *AORN Journal*, *105*(5), 453–463. https://doi.org/10.1016/j.aorn.2017.03.003	PubMed Hypothermia	• To evaluate the current level of nurses' knowledge regarding perioperative hypothermia and compare it with the knowledge of nurses surveyed approximately 10 years ago after AORN developed and disseminated "Guideline for prevention of unplanned patient hypothermia" • Nursing and medical staff members	• Survey to assess depth of knowledge and understanding concerning inadvertent hypothermia and effect on trauma patients • existing data collection: years of practice as perioperative nurse, level of education, participation in post-graduate, training in perioperative nursing, primary work setting, and clinical setting	• 69% both nurses and physicians were unsure of definition of hypothermia • all participants were able to identify two or more factors contributing to hypothermia, at least list one rewarming strategy, define normothermia 36℃ to 37 • nurses able to identify two or more complications associated with hypothermia: delayed recovery, postoperative shivering, hypotension, increased postoperative pain, and delayed incision healing	**Limitations**: • Study discovers lack of awareness of evidence-based definition for hypothermia and normothermia • nurses were unfamiliar with guideline-recommended values for hypothermia and normothermia • knowledge gaps about thermal regulation, normothermia, and hypothermia are needed to promote awareness
Granum, M. N., Kaasby, K., Skou, S. T., & Grønkjær, M. (2019). Preventing inadvertent hypothermia in patients undergoing major spinal surgery: A nonrandomized controlled study of two different methods of preoperative and intraoperative warming. *Journal of PeriAnesthesia Nursing*, *34*(5), 999–1005. https://doi.org/10.1016/j.jopan.2019.03.004	ScienceDirect Inadvertent Perioperative Hypothermia Quasi-Experiment	• To evaluate if a Full Access Underbody (FAU) blanket used for operatively and intraoperatively in patients undergoing major spinal surgery prevents hypothermia compared with current practice and to explore patients' experiences of comfort	• Two groups: control and intervention group. Control group were covered with a lint-free quilt and reflective blanket before entering operating suite. • Once patient was position on the operating bed, patient was given a full body blanket with surgical access before the start of the operation. • Intervention group had the FAU placed on top of them under a cotton blanket before entering the operating suite. Bair hugger unit was left on during surgery. • Temperature was taken via tympanic temperature. • However in the operating suite, the bladder temperature was measured.	<u>**60 participants**</u> - 30 in control, 30 in intervention. IAH was lowered 72% when FAU was used preoperative and intraoperatively compared with passive and FBBSA starting intraoperatively	**Limitations**: • 72% lower risk of IAH in patients with the FAU blanket at start of operation (pre and intraoperatively). • Validity would have be strengthened if the study was RCT it would've eliminated selection bias, standardization of practical treatments between each group would have prevent inconsistencies
Hooper, V. D., Chard, R., Clifford, T., Fetzer, S., Fossum, S., Godden, B., Martinez, E. A., Noble, K. A., O'Brien, D., Odom-Forren, J., Peterson, C., Ross, J., & Wilson, L. (2010). ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia: Second edition. *Journal of PeriAnesthesia Nursing*, *25*(6), 346–365. https://doi.org/10.1016/j.jopan.2010.10.006	PubMed Perioperative Hypothermia	• Used Stelter and colleagues evidence rating scale for evaluation of the strength and quality of evidence for all ASPAN evidence-based clinical practice guidelines • **Temperature Measurement Recommendations supported by strong evidence:** Near-core measures of oral temperature best approximate core, same route or temperature measurement should be used throughout the perianesthesia period for comparison purposes, caution should be taken in interpreting extreme values from any site with near-core temperature • **Temperature Measurement Recommendations supported by weak evidence:** Temporal artery measurement approximate core temperature at normothermic temperature but not extremes outside of normothermia, infrared tympanic thermometry does not provide accurate temperature measurements during the perianesthesia period • **Preadmission/Preoperative Recommendations:** *Assessment*: Assess for risk factors for perioperative hypothermia, measure patient temperature on admission, determine patient's thermal comfort level, assess for signs and symptoms of hypothermia (shivering, piloerection, and/or cold extremities), document and communicate all risk factor assessment findings to all members of the anesthesia/surgical team, *Interventions*: Implement passive thermal care measures, maintain ambient room temperature at or above 24 Celsius, institute active warming for patients who are hypothermic, consider preoperative warming to reduce the risk of intra/postoperative hypothermia (evidence suggests prewarming for a minimum of 30 minutes may reduce the risk of subsequent hypothermia • **Preadmission Testing/Preoperative Admission Expected Outcomes:** Patient will express thermal comfort, nonemergent patients should be normothermic prior to transfer to the OR/procedure area (emergent patients should be warmed as soon as clinically appropriate) • **Intraoperative Recommendations:** *Assessment*: Identify patient's risks factors for unplanned perioperative hypothermia, frequent intraoperative temperature monitoring should be considered in all cases, assess for signs and symptoms of hypothermia, determine patient's thermal comfort level, document and communicate all risk factor assessment findings to all members of the anesthesia/surgical team *Interventions:* Limit skin exposure to lower ambient environmental temperature, initiate passive warming measures, passive warming interventions include: cotton blankets, surgical drapes, plastic sheeting and reflective composites, maintain ambient room temperature from 20-25 Celsius based on AORN and architectural recommendations, forced-air warming should be implemented for patients undergoing a procedure with an anticipated anesthesia time greater than 30 minutes, alternative active warming measures: warmed IV fluids and irrigation fluids, circulating water garments, circulating water mattress, radiant heat, gel pad, resistive heating • **Intraoperative Admission Expected Outcomes:** Patient will be normothermic on discharge from the OR/procedure area • **Phase I/II PACU Postoperative Patient Management Recommendations**: *Assessment:* Identify the patient's risk factors for perioperative hypothermia, document and communicate all risk factors assessment findings to all members of the health care team, measure the patient temperature on admission, (if normothermic, continue to measure temperature at least hourly, at discharge and as indicated by patient condition, if hypothermic, measure temperature at a minimum of every 15 minutes until normothermia is achieved), determine patient's thermal comfort level, assess for signs and symptoms of hypothermia, *Interventions*: If patient is normothermic, provide comfort measures: implement passive thermal care measures, maintain ambient room temperature, assess patient thermal comfort level on admission discharge, and more frequently as indicated, observe for signs and symptoms of hypothermia, reassess temperature if patients thermal comfort level changes and/or signs or symptoms of hypothermia occur, implement active warming measures as indicated, measure patient's temperature prior to discharge, if patient is hypothermic, in addition to normothermic interventions, initiate active warming measures, apply forced-air warming systems, consider adjunctive measures, warmed IV fluids, humified warm oxygen, and assess temperature and thermal comfort level every 15 minutes until normothermia is achieved.			

		• **Phase I/II PACU Postoperative Patient Management Expected Outcomes**: Patient achieves normothermia, before discharge from Phase I and/or Phase II PACU, patient verbalizes thermal comfort			
Koenen, M., RN, Passey, M., PhD, Rolfe, M., PhD. (2017). "Keeping Them Warm" - A Randomized Controlled Trial of Two Passive Perioperative Warming Methods. *Journal of PeriAnesthesia Nursing, 32*(3), 188-198.	ScienceDirect Perioperative Hypothermia Randomized Controlled Trial	• To determine if reflective blankets are more effective than cotton blankets in reducing the core-peripheral temperature gradient and increasing heat content during the perioperative phase among adult patients undergoing elective surgery of less than 1 hour • Adult patients 18 years or older undergoing surgery less than 1 hour, ASA classification 1-3, with general anesthesia	• Patients were randomly placed into two groups: 1) reflective blanket group received a reflective blanket close to the skin and one cotton sheet on top to contain the lightweight reflective blanket, 2) cotton blanket group received a cotton sheet to the skin and a cotton blanket on top of the sheet. • Temperature was taken in the perioperative holding area, anesthetic bay, operating room, and postanesthesia care unit on the patient's right or left temporal artery and right or left sole of the foot	**320 participants**, 179 in reflective blanket, 141 patients in cotton blanket group. Foot temperature in both groups increased from preoperative area to anesthetic bay. No significant difference observed between the two groups with respect to the lowest intraoperative temperature or the time at which patients reached their lowest temperatures	**Strengths:** Demonstrated passive warming with reflective blankets provides appropriate intervention, active warming should be considered as a preoperative warming method for patients with an increased risk of developing hypothermia **Limitations:** Results can't be generalized to patients with serious medical conditions, patients undergoing emergency surgery, and patients who arrive hypothermic
Koh, W., Chakravarthy, M., Simon, E., Rasiah, R., Charuluxananan, S., Kim, T.-Y., Chew, S. H., Bräuer, A., & Ti, L. (2021). Perioperative temperature management: A survey of 6 asia–pacific countries. *BMC Anesthesiology*, *21*(1). https: //doi.org/10.1186/s12871-021-01414-6	ScienceDirect Perioperative Experimental	• To evaluate the prevalent practices and attitudes to perioperative temperature management in the Asia-Pacific region, as well as determine the individual and institutional factors that lead to noncompliance • Six countries in Asia-Pacific: Singapore, Malaysia, Philippines, Thailand, India, and South Korea	• Cross-sectional study on anesthesiologists and anesthesia trainees in the 6 countries listed • Written informed consent waived, return of anonymous completed questionnaires over a 1.5 year period • 40 anonymous online questionnaires shared via weblink, used self-reported format, encouraged participation and completion by lucky drawing prizes for each country for air purifiers, lucky draw was made separate from questionnaire • Survery monkey was utilized for the creation and hosting of questionnaire • Questionnaire was used to examine current practice and perceptions and limitations that may exist that prevent the and/or adoption of best practices, best monitoring, and best interventions for perioperative temperature management • Questions were based on currently published literature, authors' personal experience • Participants current practice inpatient warming and temperature measurement across perioperative department was examined • Participants were queried regarding influencing factors and personal opinions with regards to perioperative temperature management • Participants were asked regarding the availability of patient warming options and temperature measuring equipment in their hospital	**1259 unique survey responses**, over a 1.5 year period between Oct 2017 to Feb 2019, representing a response rate of 14.9%, 1154 responses were valid • A proportion of questionnaires were large empty, more than 50% incomplete • Most responses from India, then Philippines, Singapore, and Malaysia • 531 respondents measure temperatures • 279 respondents perform prewarming • 203 respondents perform prewarming for neuraxial anesthesia • Intraoperatively, 767 measure temperature "often" to "always" during general anesthesia compared to 291 during neuraxial anesthesia • 508 respondents for perform intraoperative active warming • Postoperatively, 953 respondents measure temperature versus 486 perform postoperative active warming for majority of patients • When respondents were asked about their perspectives on compliance, a commonly cited barrier to effective perioperative temperature management was the lack of equipment for perioperative temperature monitoring (34.3%), prewarming (34.2%), intraoperative warming (31.6%) and postoperative warming (33.5%). 729 (63.2%) respondents were keen for more active warming devices, and 577 (50.0%) respondents were keen for more temperature measurement devices	**Limitations:** Environmental/resource limitations is the single largest contributor to noncompliance

Lau, A., MD, Lowlaavar, N., MD, MPH, Cooke, E., BSc, West, N., MSc, German, A.M BA, BSc, Morse, D., MSc, Gorges, M., PhD, Merchant, R., MD, FRCPC. (2018). Effect of Preoperative Warming on Intraoperative Hypothermia: a Randomized-Controlled Trial. *Canadian Journal of Anesthesia, 65,* 1029-1040.	ScienceDirect Intraoperative Hypothermia Randomized Controlled Trial	• To evaluate the effects of perioperative forced-air warming on intraoperative hypothermia • Adult aged 18- to 85-year-old undergoing elective non-cardiac surgery under general anesthesia at Royal Columbia Hospital in Westminister, BC, Canada	• Patients were randomly placed in two separate groups: 1) control group -- received additional warmed flannel blankets on request in preoperative period for at least 30 min per institution's practice, or 2)prewarmed group -- received active pre-warming for at least 30 minutes via disposable BairPaw full-body forced-air convection warming gowns, in addition to requested warmed blankets. Intraoperatively, FAW was initiated at the discretion of the anesthesiologist. • SpotOn thermometer was placed on patients' forehead in both groups and utilized to measure the patients' temperature throughout the perioperative period	**191 participants**, • 97 patients in the control group, and 94 patients in the prewarmed group. • Pre-warmed participants were warmer than control patients at then end of the pre-warming period, prewarmed patients were also warmer than control group on arrival to PACU	**Limitations:** • Trial limited to a single hospital, unable to generalized to other hospitals with different ambient room temperatures, forced-air warming devices, and variations • Unfamiliarity with SpotOn thermometer
Link, T. (2020). Guidelines in practice: Hypothermia prevention. *AORN Journal*, *111*(6), 653–666. https://doi.org/10.1002/aorn.13038	ScienceDirect Perioperative Hypothermia	• Revised hypothermia guideline includes only Recommendation and Conditional Recommendation Levels • Article provides guidance readers can use to identify gaps in practice, evaluate risks associated with gaps, and implement recommendations, using examples from revised prevention of hypothermia guideline • AORN recommends measuring and monitoring the patient's temperature during all phases of perioperative care • However, researchers have not identified a specific site or method that is applicable in all clinical situations.4,7,8 Therefore, AORN recommends that the perioperative team members collaboratively determine the temperature measurement site and method to be used throughout all perioperative phases • AORN does not recommend a specific frequency for temperature measurement because clinical practice guidelines and low-quality evidence do not provide consistent guidance for temperature monitoring frequency based on procedure duration • AORN recommends implementing methods for preventing or treating hypothermia for all patients during all phases of perioperative care.6 Perioperative team members should collaborate to select the methods to be used based on patient- and procedure-specific risk factors identified during the preoperative patient assessment.6 Because of preexisting health conditions, some patients are at increased risk for developing hypothermia, and identifying these conditions is a part of the perioperative nursing patient assessment. AORN also recommends that when active warming is indicated, the team members should prewarm the patient with the selected warming method • The perioperative team may decide to use a combination of active warming methods or a combination of active warming and passive insulation methods • The team members should determine the best warming methods to use based on the patient's needs and the procedure requirements. • Determining the amount of time for prewarming is a conditional recommendation, meaning that the team should make an informed decision based on the available evidence and the facility's policies. • Researchers have tested varying durations for prewarming, but moderate- and high-quality evidence supports prewarming the patient for a minimum of 10 minutes.			
Riley, C., & Andrzejowski, J. (2018). Inadvertent perioperative hypothermia. *BJA Education*, *18*(8), 227–233. https://doi.org/10.1016/j.bjae.2018.05.003	ScienceDirect Perioperative Hypothermia Literature Review	• Defined as core body temperature < 36℃ • Heat and cold sensors in the peripheral skin and deep tissue, and centrally in the spinal cord, brain stem, and hypothalamus triggers thermoregulation; heat balance describes process of thermoregulation, "heat is produced by metabolism and basal metabolic rate is independent of thermoregulatory feedback, ¾ of body's head is loss by convection, radiation, conduction – remaining by evaporation mostly in respiratory tract • Heat is lost during anesthesia – occurs in triphasic pattern of hypothermia: 1) redistribution causes rapid decline in temperature when vasodilation causes warm blood to reach the peripheries and cool blood from peripheries enter into core circulation, 2) vasodilation occurs by direct effect of anesthetic agents and indirect consequence of lowered vasoconstriction threshold, 3) linear phase 2 occurs because heat loss exceeds heat produced from metabolism • Regional anesthesia decreases shivering and vasoconstriction threshold below level of the block – possibly due to decreased afferent input from peripheral thermal centers, greatest risk of heat loss is during combined regional and general anesthesia • Neonates = higher risk of IPH, children lose heat faster due to higher surface area to volume ration and less insulation subcutaneous adipose tissue, risk factors for IPH in pediatrics patients: young age, length of surgery > 30 min, major surgery and temperature < 36.5℃ before induction of anesthesia • Other risk factors for IPH: age, duration of surgery, environmental temperature • Consequences of IPH impact morbidity, mortality and length of hospital stay, increased risk of SSI • Temperature should be recorded every 30 minutes in patients undergoing general anesthesia, including regional anesthesia, invasive techniques that measure core temperature should be used: distal esophageal, intravesical, or nasopharyngeal – if not infrared tympanic and temporal artery thermometer • NICE guidelines assist in prevention and thermometers treatment of IPH at each perioperative phase: preoperatively, patients shall be prewarmed 30 mins, intraoperatively, patients shall have a forced air warming device placed during surgery and IV fluids/irrigation should be warmed • Pediatrics: kids should be kept warm with blankets and encouraged to walk to the operating room, preemies should be nursed in an incubator, operating room shall be warmed			

Shaw, C., BSN, Steelman, V., PhD, DeBerg, J., MLS, Schweizer, M., PhD (2017). *Journal of Clinical Anesthesia, 38*, 93-104.	ScienceDirect Inadvertent Perioperative Hypothermia Systematic review with network meta-analysis of RCT	• Does the type of warming intervention influence the frequency or severity of IPH in surgical patients receiving neuraxial anesthesia? • Adult patients undergoing surgery with neuraxial anesthesia, such as a spinal, epidural, or combined spinal-epidural	• Preferred reporting items for systematic reviews and Meta-analysis (PRISMA) was used. • Duplicates were removed. • Data extraction was verified by one investigator and another investigator verified the accuracy of the first investigator. • Random-effects model was used to calculate risk ratio for dichotomous data and mean differences in continuous data with 95% confidence intervals. • Cochrane collaboration's tool for assessing risk bias was used to investigate each study	• **25 studies with 2048 patients** were included for systematic review. • Outcomes for the studies were heterogeneous. • 7 out of the 25 studies tried to blind the study staff measuring and recording temperatures; other studies had difficulty in hiding the warming intervention from hospital staff -- according to the Cochrane collaboration studies, this was an unclear risk of bias. • For passive warming, all the studies showed low temperatures, large temperature decreases, or high percent of patients with IPH that used reflective blankets/suits, cotton blankets, and FAW without warmed forced-air. • Active warming with FAW had lowest and highest reported mean temperatures when patients received FAW were 35.3 ± 0.5 [26] and 37.1. • Active warming with a conductive heat mat had the lowest and highest reported mean temperature at the end of surgery had was used were 35.1 ± 0.6 °C [26], and 36.9 ± 0.4 °C	**Limitations**: Potential bias for authors of included studies, lack of standardization temperature measurement and site
Simegn, G., Bayable, S., Fetene, M. (2021). Prevention and management of perioperative hypothermia in adult elective surgical patients: A surgical review. *Annals of Medicine and Surgery, 72*, 1-7	ScienceDirect Inadvertent Perioperative Hypothermia Systematic Review	• To improve management of perioperative hypothermia for adult elective surgical patients. To design clear institutional guidelines for managing perioperative hypothermia in elective adult surgical patients. • Elective adult surgical patients	• The evidence was collected and the appraisal and evaluation of the study quality followed the WHO 2011 level of evidence and degree of recommendation. • The selection of studies chosen were the original articles, systematic reviews, meta-analysis, and RCT about perioperative hypothermia management for the adult undergoing elective surgery, inadvertent perioperative hypothermia, complication of hypothermia occurrence, and management studies written in English.	• There is no clear working protocol for perioperative hypothermia prevent and management regarding evidence discussing room temperature IV fluids versus warmed IV fluids. • Other hypothermia management techniques such as using forced-air warming devices versus resistive heating is more effective in preventing inadvertent hypothermia.	**Strength**: Develops optional management of perioperative hypothermia. Uses the latest PRSMA2020 diagram to find illegible studies. **Limitations**: Bias of study is not statistically assessed. Only free full access articles are included in this study.
Tyvoid, S. (2019). Preventing hypothermia in outpatient plastic surgery by self-warming or forced-air-warming blanket. *European Society of Anesthesiology, 36,* 843-850.	Cochrane Inadvertent Perioperative Hypothermia Randomized Controlled Trial	• To evaluate which of our current active warming measures, self-warming blanket or forced-air blanket, was the most effective in preventing perioperative heat loss. • Outpatient surgical patients with ASA 1-3	• Patients were randomly placed into two separate groups: 1) self-warming blankets and 2) forced-air-warming blanket group. • The temperature was taken preoperatively, every 10 min from start to end of general anesthesia, and postoperatively using 3M SpotOn forehead temperature sensor. • Prewarmed IV fluids and local anesthetic solutions were used.	• **112 patients** were included in the study; 47 in self-warming blanket group and 65 in the forced-air warming blanket group. • Incident of hypothermia while under general anesthesia was higher in the self warming blanket group 22 out of 4 versus the forced-air-warming blanket group, 16 out of 65. • Postoperative incidence of hypothermia during the first assessment was higher in the self-warming blanket group 16 out of 47, versus forced-air-warming group 9 out of 65.	**Limitations:** Method of randomization could have been design to limit unequal numbers in each group even though this was compensated for in power analysis

Xiao, Y., Zhang, R., Lv, N., Hou, C., Ren, C. (2020). Xiao, Y., Zhang, R., Lv., N. Hou, C., Ren, C., & X., H. (2020). Effects of Preoperative Forced-Air Warming System for Patients Undergoing Video-Assisted Thoracic Surgery. *Medicine Open Journal*, 1-9.	PubMed Perioperative Hypothermia Randomized Controlled Trial	• To investigate the effects of prewarming for 30 minutes combined with a forced-air warming system on intraoperative hypothermia in patients undergoing VATS under general anesthesia combined with ESPB • Patients undergoing VATS under general anesthesia combined with ESPB: 45 to 60 years old, ASA classification 1-3, surgery duration 1 to 3 hours, surgery 12/2016 to 6/2019	• Computer-generated randomization table was used for patient placement. • A sealed envelope was opened the day of surgery and the patient was randomly placed in prewarming group or warming group. • Anesthesiologist and surgeon was also blinded to study conditions. • Anesthesia management was followed. • Prewarming group was warmed for 30 after ESPB using full-body FAW blanket and warming group was warmed with upper body FAW once they entered into the operating room. • Both groups received warmed IV and irrigation fluids. • Patient's temperature was measured using two different thermometers: infrared tympanic thermometer preop and esophageal probe after induction of anesthesia	• **98 patients** were randomly placed. Prewarming group had a significantly shorter recovery time. • Prewarming had a higher core temperature and IPH was significantly reduced	**Limitations:** • did not record the incidence of infection, only included patients with ASA classification I or II • two different types of temperature measurement • limited sample size
Yoo, J.H., Ok, S. Y., Kim, S.H., Chung, J.W., et al. (2021). Efficacy of Active Forced Air Warming During Induction of Anesthesia to Prevent Inadvertent Perioperative Hypothermia in Intraoperative Warming Patients. *Medicine Open Journal,* 1-9.	PubMed Inadvertent Perioperative Hypothermia Randomized Controlled Trial	• To evaluate the efficacy of peri-induction warming for prevention of perioperative hypothermia, defined as a reduction in body temperature to <36℃ during the perioperative period during a major surgery lasting >120 minutes. • 130 patients with ASA classification of 1-3, scheduled for elective surgery under general anesthesia, last more than 120 minutes	• Computer-generated number block randomization using excel into two different groups: 1) peri-induction warming group & 2) control group with allocation rate of 1:1. • Anesthesiologists were not blinded, but the study nurse was blinded. 30 minutes before anesthesia warmed IV fluids were started, forced-air warming was immediately started after arrival to the OR in preinduction group. • In the control group, passive warming with a warmed cotton blanket was started. Standard anesthesia induction protocol was followed. • Patient's temperature was taken using tympanic membrane sensor in pre-anesthetic holding and PACU area every 10 minutes. • Intraoperatively, it was taken via nasopharyngeal probe recorded every 15 minutes. • Operating room temperature was taken upon arrival and departure	• Data from **126 patients** were analyzed: 63 in peri-induction, 63 in the control group. • The peri-warming duration in the peri-induction warming group was 20.2±8.7minutes; the duration of unwarming (time from arrival in the operating room or end of peri-warming to resumption of continuous warming) was significantly reduced in the peri-induction warming group. P < .001). • The last intraoperative nasopharyngeal temperature was higher in the peri-induction warming group than in the control group. • The incidence of intraoperative hypothermia was significantly lower in the peri-induction warming group than in the control group (19.0% vs 57.1%; mean difference [95% confidence interval, CI]: 0.381 [0.2159–0.5261], P<.001), and the effect of peri-induction warming was moderate (phi=0.392). incidence of first-hour-onset hypothermia was also significantly lower in the peri-induction warming group than in the control group	**Limitations:** • Results doesn't apply to surgeries lasting less than 120 minutes, pre- and postoperative temperatures differed from intraoperative nasopharyngeal core temperature because tympanic thermometer was used pre and postoperative, peri-induction • warming method used in this study focused on the process performed during the induction of anesthesia • heat content and peripheral temperature were estimated because the values were not measured directly, • the association with perioperative complications is unknown because the power was small to prove it and no long-term follow-up was performed after patients exited PACU

APPENDIX B

Posterboard Presentation