Preoperative Warming for Inadvertent Perioperative Hypothermia

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Abstract

Inadvertent perioperative hypothermia (IPH) is a significant contributor to adverse patient outcomes, and ultimately translates to increased hospital expenditures. Evidence strongly supports the efficacy of prewarming surgical patients to reduce risk of IPH. While various surgical facilities have successfully implemented different methods of warming to reduce the frequency of IPH at their respective sites, the Veterans Affairs Medical Center (VAMC) does not currently have a standardized protocol for prewarming. With input and discussion from site stakeholders and project leaders, the authors developed a data collection tool to record temperatures at five pre/intra/postoperative intervals in 30 patients undergoing robotic procedures. The intervention was a minimum of 10 minutes of forced-air warming prior to surgery. More than half the patients (63%) experienced IPH. These findings suggest that IPH occurrence in a modest-sized patient group exposed to prewarming is not different than the national occurrence of IPH when compared to the national IPH frequency.

Keywords: inadvertent perioperative hypothermia, warming, temperature, robotic, forced-air, evidence-based practice

Preoperative Warming for the Prevention of Perioperative Hypothermia

Inadvertent perioperative hypothermia (IPH) is a critical problem among surgical patients (Roberson, Dieckmann, Rodriguez, & Austin, 2013). IPH is defined as a core temperature less than 36 degrees Celsius at any point within the perioperative period (Roberson et al., 2013). Inadvertent hypothermia is one of the most common perioperative complications (Matika, Ibrahim, & Patwardhan, 2016). The percentage of unintended perioperative hypothermia is reported to be 50% to 90% and impacts approximately 70% of surgical patients (Bilgin, 2017). IPH is caused by many factors such as the administration of fluids, exposure to a cold operating room, and impaired thermoregulation secondary to anesthetic induction (Zhang, Chen, & Xiao, 2018). As little as a 0.5-degree Celsius decrease in core body temperature is associated with harmful physiologic effects (Jun et al., 2018).

Adverse conditions associated with IPH include, but are not limited to, decreased cardiac output, increased postoperative surgical site infections, and bleeding (Roberson et al., 2013). Impaired blood clotting may result from hypothermia due to decreased platelet aggregation and a disturbance of coagulation cascade enzymes (Sessler, 2016). Hypothermia is associated with a 20% increase in duration of hospitalization (Koc et al., 2017). It is estimated that preventing hypothermia can reduce hospital costs by $2,500 to $7,000 per surgical patient (Roberson et al., 2013). The goal of the project was to investigate if preoperative warming prevented IPH in patients undergoing robotic surgery.

Problem Statement

Robotic surgery patients at a Veterans Affairs Medical Center are not receiving preoperative warming as a preventative measure of IPH.

Problem Significance

General anesthesia and anesthetic drugs impede thermoregulation and increase the occurrence of shivering up to 60% (Tie, Su, He, Liang, Yuan, & Mou, 2014). This mechanism is attributed to systemic vasodilatory redistribution of body heat from the core to periphery that occurs within the first 30 minutes of anesthetic exposure (Gustafsson, Elmqvist, From-Attebring, Johansson, & Rask, 2017). The initial redistribution is difficult to treat and the return of cooled blood to the internal core further exacerbates hypothermia (Gustafsson et al., 2017). General anesthesia itself decreases core body temperature and in the presence of hypothermia, the metabolism of anesthetic drugs is significantly hindered, contributing to patient morbidity and an increased post-anesthesia care unit (PACU) and hospital length-of-stay (Roberson et al., 2013).

While anesthetic agents play a major role in IPH, there are also environmental and surgical factors that contribute to loss of body heat. Through radiation and conduction, the combined effects of being in a cold operating room (OR) and body contact with cold surfaces increase the risk of IPH (Roberson et al., 2013). Although heat redistribution is the most significant cause of perioperative hypothermia, surgical factors also increase the risk of systemic heat loss (Jun et al., 2018). For example, evaporation from exposed viscera during surgery and contact with cold intravenous or irrigation fluid further perpetuate heat loss (Emmert et al., 2018). While general anesthesia places a patient at a significant risk for hypothermia, the nature

of the surgery as well as the body's reaction to the OR surroundings can further augment the likelihood of IPH occurrence.

Postanesthetic shivering can occur as a result of inadvertent perioperative hypothermia and is associated with several adverse effects. Surgical patients report feeling cold during the perioperative period and as a mechanism to maintain core body temperature, shivering occurs, which can increase a patient's metabolic rate two to three-fold (Tie et al., 2014). Postanesthetic shivering leads to increased oxygen demand and oxygen consumption up to 100%; arterial hypoxia, increased cardiac output, and surgical incisional stretch accompanies shivering which can lead to pain or rupture, and raised intraocular and intracranial pressures (Bindu, Bindra, & Rath, 2017). When perioperative normothermia is maintained, the risk of postanesthetic shivering is reduced, thereby lessening the likelihood of associated complications and improving patient comfort (Hooper et al., 2010).

There are several characteristics that place patients at a higher risk for hypothermia during the perioperative period. The most commonly noted risk factors are separated into demographic and surgery-related categories. Individuals aged 60 and older are at higher risk for hypothermia during the perioperative period due to decreased thermoregulation (Akers et al., 2019). Length of surgical time plays a role in hypothermia risk as the patient is exposed to the cold operating room environment for a longer period of time. For robotic cases specifically, the procedure duration is commonly greater than two hours, therefore increasing the risk of IPH. Types of surgery associated with perioperative hypothermia include open and laparoscopic abdominal procedures as well as total knee and hip arthroplasties (Akers et al). Other independent predictors of IPH include neurologic disorders, low BMI, high American Society of

Anesthesiologist (ASA) Physical Status Classification, anemia, and preoperative severe illness (Akers et al.; Riley, & Andrzejowski, 2018).

Inadvertent perioperative hypothermia is a preventable perioperative complication. Many studies highlight the benefits of preoperative warming, or prewarming, and suggest intraoperative warming alone does not prevent IPH. Prewarming is defined as warming patients' skin and peripheral tissues prior to the induction of anesthesia (Torossian et al., 2016). While heat loss in surgical patients is inevitable, preoperative warming increases peripheral tissue temperature and total body heat content, thereby decreasing the core-to-periphery temperature gradient after anesthetic induction (Rosenkilde, Vamosi, Lauridsen, & Hasfeldt, 2017). Preoperative warming with a forced-air warmer reduces complications such as surgical site infections, PACU length-of-stay, blood loss, and the associated costs (Conway et al., 2019).

Forced-air warming devices provide temperature-controlled air to the patient via an inflatable blanket. This method of preoperative warming attempts to mitigate temperature shifts by inhibiting heat loss to the environment caused by radiation (Horosz & Malec-Milewsk, 2014). Moreover, Akhtar et al. (2016) states that active prewarming increases peripheral tissue temperature, ameliorating redistribution hypothermia effects. Torossian et al. (2016) reported a 43% occurrence of perioperative hypothermia in patients who received forced-air prewarming as compared to a 68% occurrence for those who did not ($p < 0.001$). Horn, Bein, Bohm, Steinfath, Sahili, & Hocker (2012) suggest that even 10 minutes of prewarming can aid in the prevention of inadvertent perioperative hypothermia.

Wartigg, Alderson, Campbell, and Smith (2014) found preoperative forced-air warming, as compared with warming by cotton blankets, reduced the amount of time patients were hypothermic within the perioperative period. Intraoperative warming alone was found to be ineffective in the prevention of IPH. Core temperatures of individuals in the prewarmed groups were higher in relation to participants in the control groups who were warmed intraoperatively only. The results of this study suggest prewarming contributes to an overall reduction in hypothermia at the end of surgery (Perl et al., 2014).

Studies suggest the duration of surgery should direct providers to identify which patients are most likely to benefit from prewarming. Nieh and Su (2018) reported a study in which prewarmed patients undergoing laparoscopic abdominal surgery, with procedure times ranging from 90 to 330 minutes, experienced higher temperatures as compared to the control group. Similarly, Lau et al. (2018) reported that surgeries lasting greater than 2.5 hours, resulted in 24.2% of the control group becoming hypothermic versus only 2.3% of the prewarmed group. The results of these studies emphasize the importance of prewarming patients expected to be in surgery for greater than two hours. Koc et al. (2017) explained that the optimum amount of time for prewarming prior to anesthetic induction to reduce IPH is unknown. However, studies in which patients received 30 to 60 minutes of prewarming prior to induction of anesthesia suggested a significant increase in core temperature when prewarming with a forced-air warming device was used (Perl et al., 2014).

After reviewing these findings, the focus of the quality improvement project is to provide prewarming for 10-60 minutes utilizing a forced-air warming device to patients scheduled for

robotic surgery expected to last greater than two hours in an effort to prevent hypothermia (Torossian et al., 2016).

Project Aim

Robotic surgery patients at a VAMC who receive preoperative warming via a forced-air warmer applied in the preoperative holding area will have a lower occurrence of IPH as compared to the national frequency of IPH in surgical patients who did not receive preoperative warming.

Method

Setting

VAMC is a general medical and surgical teaching facility that provides health care to Veterans in one region of Pennsylvania and the surrounding counties. The facility has 142 acute care beds, along with eleven operating rooms. VAMC provides a wide variety of surgical services, including robotics within the specialties of gynecology, urology, thoracic, and general surgery. VAMC perioperative services currently employs approximately fifty registered nurses and twenty-one anesthesia providers. In 2018, 3,345 surgeries requiring anesthesia were provided in the VAMC operating rooms with approximately five robotic surgeries per week. The utilization of the robot for surgery at VAMC has continued to expand in the last two years.

Sample

Thirty adult patients scheduled for robotic surgery of greater than two hours in duration were included in the project. The sample was limited by the availability of the project leaders to implement the intervention. Therefore, not every patient who received robotic surgery during the 6-month project period received preoperative warming.

Procedure

The VAMC Institutional Review Board deemed the project as a Quality Improvement (QI) project on October 4th, 2018. The University of Pennsylvania Quality Improvement clearance was obtained on October 11th, 2018. The project team implemented and oversaw all parts of the project. Key stakeholders included the OR nurse manager and clinical nurse specialist, nurse anesthetists, and perioperative nursing staff. In preparation for project implementation, an information sheet describing the purpose and goal of the project was provided to key stakeholders (Appendix A). Multiple meetings and an in-service were held for the stakeholders during which the project team discussed the project purpose, the logistics of project implementation, and the evidence addressing IPH and preoperative warming. All key stakeholders were invited to participate in the project.

Measurement of Outcome

The data collection tool was developed by the project team with input from the OR clinical nurse specialist and institutional team lead (Appendix B). The American Society of PeriAnesthesia Nurses Clinical Guideline for the Prevention of Unplanned Perioperative Hypothermia was also used to guide the development of the project data collection tool (Hooper et al., 2010). A pre-implementation pilot test of the data collection tool was conducted in December 2018 on a single patient and tool modifications were made accordingly. Prewarming start and end times were recorded. For the robotic patients selected to receive warming, recording of temperatures occurred at five intervals: (1) immediately pre-, (2) and post-intervention, (3) post-induction of general anesthesia, (4) last temperature recorded in operating room, (5) and in PACU. Figure 1 explains the significance of each of the five time points. The

outcome criterion for IPH was any temperature during these five different measurement intervals that was less than 36 degrees Celsius. To reduce risk of measurement error with data collection, temperature measurements pre- and post-intervention were obtained using oral thermometers from the same manufacturer. While intraoperative temperature is routinely monitored, providers have different options (i.e. nasopharyngeal, esophageal) to obtain such measurements. For this reason, route of temperature monitoring was also recorded as this was unable to be controlled for intraoperatively.

Intervention

A designated forced-air warming device was used for the intervention. A multi-position, upper-body inflatable blanket provided by VAMC was placed vertically, covering the patient's entire body, along with one non-warmed blanket covering the inflatable blanket. The forced-air warming device was then turned on to inflate the blanket to a temperature of 43 degrees Celsius. The length of prewarming varied, depending on patient preference and the duration of the patient's stay in preoperative holding prior to surgery. The project team leaders were regularly present in the preoperative holding area and PACU to answer questions from staff and patients pertaining to the project. The desired duration of prewarming for the selected robotic patients was a minimum of 10 minutes. Those who did not meet this minimum requirement of prewarming were excluded from the sample.

Data Management

Project leaders reviewed recorded information on the data collection tool for completeness on a weekly basis. Any missing data was obtained by one project lead from the electronic medical record. All data were then de-identified. Completed data collection for the

week was then uploaded to a database. After all data were collected and uploaded to a database, the data were then verified twice against the data collection tool to ensure accuracy by another project lead. Upon review and confirmation of an accurate database, analysis was performed by one project lead.

Analysis

The occurrence of IPH was calculated as follows: the total number of patients who were "ever" cold, or experienced IPH, defined as a temperature < 36 degrees Celsius, at least once in the perioperative period was divided by thirty, which was the total number of patients in the project, and then multiplied by 100. A chi-square test was used to examine the association between becoming hypothermic at any time point after the warming period and total amount of time spent warming (e.g., less than 30 minutes compared to 30 minutes or longer). Given the repeated temperature recordings per subject, a Friedman's test was used to examine if differences in temperature existed across time points. Post-hoc pairwise multiple comparison test using the Nemenyi approach was conducted following a universal significant P-value from the Friedman's test (Pohlert, 2014). This post-hoc test approach was developed to control for family-wise Type I error inflation during multiple comparisons and is a conservative test (Nemenyi, 1963). Wilcoxon signed-ranks tests were used for post-hoc pairwise comparisons. A temperature difference of 0.5 degrees was considered clinically meaningful based on Jun et al. (2018). Statistical significance was set to $P<0.05$. All analyses were conducted in RStudio (RStudio, 2018).

Results

Thirty patients were included in the project, 28 of which were male (93.3%) and two females (6.7%; see Table 1). The median age of participants was 66 years. Robotic surgical procedures included gynecology, urology, thoracic, or general cases (see Table 1). Thirteen out of 30 (43%) were thoracic cases, while 10 out of the 30 (33%) were urology cases. The surgery duration range was 4.15 and 5.49 hours with a median of 4.88, or approximately 5 hours in duration. The median duration of prewarming was 20.5 minutes [IQR: 14.25, 30.00] and an average of 20 minutes specific to the hypothermic group. There was no association between length of warming and ever having a temperature less than 36 degrees Celsius based on the results of the chi-square test (see Table 2).

Nineteen out of 30 patients (63%) experienced hypothermia at least once throughout the perioperative period. The median age among those recorded to be hypothermic at least once during their perioperative period (n=19) was 68 years (see Table 3). The highest proportion (57.9%) of patients with hypothermia by surgical procedure occurred in thoracic cases (n=11), followed by 26.3% in urology cases (n=5). The lowest temperatures were recorded at ‘Time 3’, which is the temperature measurement in the operating room after anesthetic induction (see Table 5). The median temperature at ‘Time 3’ for the hypothermic group was 35.76 versus 36.35 for the non-hypothermic group ($p<0.001$). There was a statistically significant difference in the distribution of participants’ temperatures across time points measured in the perioperative period (Friedman’s $\chi^2 = 35.48$, $p<0.001$). Post hoc pairwise comparisons indicated a significant decrease in the median baseline temperature from ‘Time 1’ to ‘Time 3’ ($p<0.001$) (see Table 6). Additionally, the median temperature decreased from ‘Time 2’, immediately post-warming, to

'Time 3' ($p<0.001$) as well as from 'Time 2' to 'Time 4' ($p=0.049$) (see Table 6). The difference in median temperature from 'Time 1' to 'Time 3' was 0.8 degrees Celsius. Median temperatures significantly improved by 0.7 degrees Celsius from 'Time 3' to 'Time 5' ($p<0.001$). However, no significant difference was observed in temperatures between 'Time 1' and 'Time 5' (see Table 6).

Discussion

There is no literature describing the widespread presence of IPH in robotic surgical patients. The occurrence of IPH in robotic surgical patients at VAMC who do not receive prewarming is unknown. On examination of the data, the calculated 63.33% occurrence of IPH in the project falls within the 50-90% national frequency of IPH in individuals who did not receive preoperative warming. The range of IPH in surgical patients reported in the literature is wide and specific surgical types in studies of IPH are often not reported. The national frequency is compared to a relatively small sample of patients in this evidence-based practice implementation project. In a Cochrane Review evaluating the effectiveness of active prewarming to prevent the occurrence of IPH, authors concluded preoperative warming for a minimum period of 30 minutes had an added protective benefit (Madrid et al., 2016). Prewarming time in our sample was controlled by the time the patient presented to the holding area prior to entering the operating room. As a result, the median prewarming time of this project sample was 20 minutes, which was less than the commonly reported prewarming recommendation in the literature of 30 minutes. Other major project findings included the absence of a formal perioperative temperature collection process prior to the implementation of this project, a project implementation barrier related to perioperative geographical layout, the essential value of stakeholder engagement, the

potential connection between prewarming and patient comfort, and the importance of available baseline population data prior to project implementation.

For over fifteen years, there has been evidence suggesting a linkage between perioperative hypothermia and serious adverse outcomes such as surgical site infections, coagulopathies, and cardiac events. The current published research demonstrates that intraoperative heat loss is inevitable, specifically after the induction of anesthesia. Prewarming has been shown to reduce the risk of IPH in surgical patients. This evidence has been used to formulate guidelines for the prevention and management of IPH. Prewarming initiatives have been recommended by perioperative groups such as the Association of Operating Room Nurses (AORN) and the American Society of PeriAnesthesia Nurses (ASPAN) as a way to prevent IPH (Hooper et al., 2010; Bashaw, 2016). Many facilities have adopted prewarming practices as a result of AORN and ASPAN recommendations. Despite the demonstrated need to prevent hypothermia, the number of individuals affected by IPH remains high. The overwhelming body of evidence that addresses the prevention and management of IPH provides an opportunity to translate research into evidence-based practice.

Barriers

Implementation of this preoperative warming project was influenced by external factors, such as the absence of a consistent perioperative temperature collection process. The facility utilized both paper and electronic documentation, which at times made it difficult to locate preoperative and/or postoperative temperatures. On occasion, a temperature was not documented, or was documented in a different area of the electronic health record than is common practice. The identification of inconsistent or missing documentation of temperatures

was an unintended finding that highlights how the project facilitated the development of a standardized process for measuring and recording routine perioperative temperatures. Prewarming implementation thus served to ensure documentation of patient temperatures across the perioperative continuum at this site.

Consideration should be given to geographical challenges which affected compliance with prewarming implementation. Due to the presence of two separate holding areas and the variable duration patients spent in either location, there were instances in which prewarming was discontinued prior to a full ten minute duration because the patient was required to enter the operating room. The designated storage area for forced-air warming devices and inflatable blankets was located in a separate location creating another barrier in establishing a streamlined flow for prewarming implementation. Ambient temperature differences between holding areas and the operating rooms were also uncontrolled, which may have potentially altered patient temperatures; though in practice implementation, this is not unexpected. A growing body of literature suggests that thermometer inaccuracy can be a barrier in implementing effective thermal care. Niven et al. (2015) suggests peripheral thermometers should not be used in clinical practice because they do not have scientifically acceptable accuracy. Given the influence of each of these factors, it would have been valuable to anticipate these extraneous circumstances prior to project initiation. Similar to a pilot test period of the data collection instrument, a pilot test period of the full practice change protocol prior to project implementation is an important consideration for minimizing the effect of specific project barriers on project implementation and results..

The engagement of stakeholders and perioperative staff was essential to successful execution of the project. Key stakeholders and perioperative staff chose prewarming as an area for practice change, but during the time of project implementation, a concurrent nursing-driven practice change project was underway. This resulted in competing staff interests and a lack of continual engagement in the implementation of the prewarming project. It would have been beneficial to involve staff in active roles, or to designate a unit-based champion for this project, to maximize the number of patients who received prewarming. More importantly, greater staff engagement may have effects on adoption and sustainment of the prewarming practice beyond the conduct of the project. For future practice, staff participation may be better facilitated by minimizing the number of concurrent practice change projects or giving a choice to staff members to participate in a project aligned with personal interests while ensuring an adequate number of staff are engaged with each project. Observations related to organizational agenda, availability and documentation of baseline data, geographical perioperative layout, and buy-in from staff were significant project findings.

Unintentional Findings

An unanticipated finding was the anecdotal reporting of patient comfort with prewarming. Patient experience is paramount to any evidence based practice change and this alone may be a significant reason to implement prewarming. Several patients made statements suggesting increased satisfaction with pre-warming such as “this is better than an electric blanket” or “it feels very comforting” and “I feel more relaxed with this blanket.” Therefore, adding a perioperative satisfaction component to any subsequent prewarming practice change project will permit evaluation of patient preferences and values.

The absence of a baseline frequency, or prevalence rate of IPH in robotic surgery patients absent prewarming, limits the ability to fully understand the implications prewarming has on this specific population at VAMC. The post-implementation occurrence of 63.33% supports that increased monitoring uncovered the high proportion of surgical patients experiencing IPH. This finding is similar to many of the studies observing IPH in adult surgical patients who had general surgical approaches but not robotics surgical procedures (Duff, Walker, Edward, Williams, & Sutherland□Fraser, 2014; Karalapillai et al., 2013). The results of this project suggest that robotics surgical procedures confer similarly high risk for IPH as seen in non-robotics surgical procedures. While intraoperative warming with a forced-air warmer has been in practice for over a century, IPH still occurs and this confirms the significant role that general anesthesia plays in IPH. A strong recommendation to future projects is to obtain baseline data of IPH in robotic surgery patients to serve as a basis for comparison.

Conclusion

Prewarming is a feasible practice to reduce IPH in the robotic surgical population at VAMC. There are noteworthy contextual factors to consider when implementing a prewarming practice change project, including the availability of forced-air warming devices and location of the devices in the perioperative area and availability and type of thermometers. Downstream effects of a prewarming practice on perioperative flow may also be observed and will necessarily affect adoption and sustainment of the practice. While the anesthetic factors that contribute to IPH may be difficult to modify, preoperative warming via a forced-air warmer is a feasible practice to prevent, or reduce, the risk of IPH. Other important key points relative to the project include, but are not limited to (1) the importance of staff education about IPH and the evidence

in support of preoperative warming, and (2) policy revision or clinical guideline development that addresses maintenance of perioperative normothermia. Moving forward, project sustainability should be facilitated by continuous staff and stakeholder engagement in the implementation of the project itself, as well as the genesis or modification of institutional perioperative normothermia guidelines.

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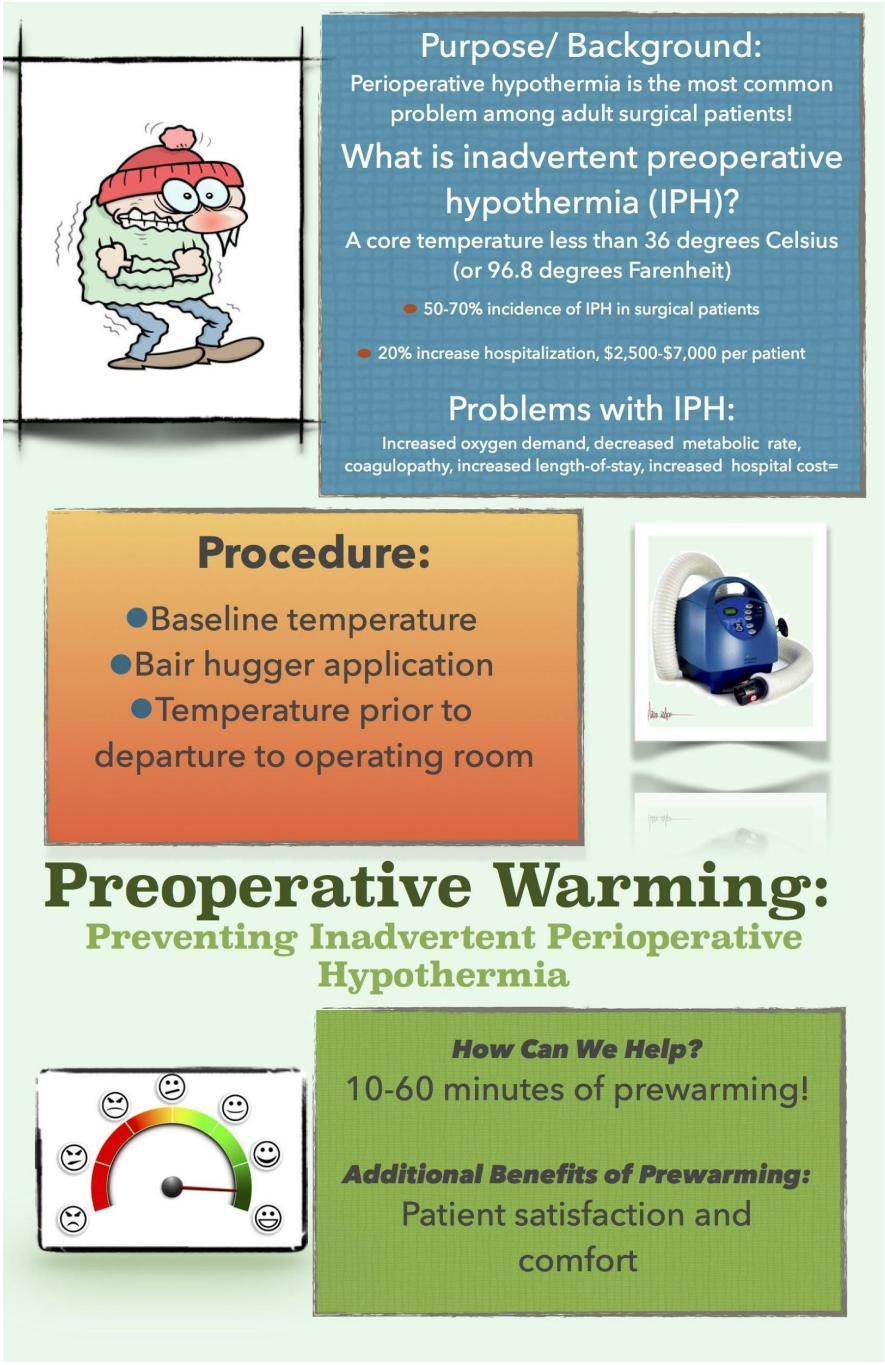
Appendix A

Information Sheet



Appendix B

Data Collection Tool

Preoperative Warming Project
ID Number:

Date of Surgery: _____

DEMOGRAPHIC AND OUTCOME DATA COLLECTION FORM

Instructions: Each statement is followed by a choice of responses. Please circle/check off choices provided with blue or black ink only. For applicable questions, please circle **C°** or **F°**. Please do not write any identifying marks on the form as participants are meant to be anonymous. All information will be kept confidential. Please not designated sections to be filled out by appropriate personnel as indicated on form. Thank you for your time and cooperation.

(Questions 1-9 to be filled out by Perioperative RN)

1. **Gender:**
   1) Male ☐
   2) Female ☐

2. **Age: _____ years**

3. **Surgical robotic procedure:**
   1) Gynecology ☐
   2) ENT ☐
   3) Urology ☐
   4) Thoracic ☐
   5) General ☐
   6) Other: _____

4. **Baseline temperature in SPU:**
   _____ C° /F°
   Time temperature was taken: _____

5. **Temperature monitoring device used in holding:**
   1) Oral (electronic) ☐
   2) Unknown/ not specified ☐
   3) Other: _____

6. **Was Bair Hugger implemented for prewarming in holding area?**
   1) Yes ☐
   2) No ☐
   3) Unknown ☐

If yes, to what temperature was Bair Hugger set to? High (43°C) ☐ Med (38°C) ☐ Low (32°C) ☐
Start time (Bair Hugger turned on):
End time (Bair Hugger turned off):
Total time: _____ (min)

7. Were warm cotton blankets used in addition to the Bair Hugger in holding area?
   1) Yes ☐
   2) No ☐
   3) Unknown ☐

8. **Was prewarming stopped/reduced/started again prior to entering OR?**
   1) Yes ☐
   If *reduced*, reduced to what setting on Bair Hugger? Med (38°C) ☐ Low (32°C) ☐
   2) No ☐
   3) Unknown ☐

If stopped, how long was warming stopped prior to reimplementation? _____ (min)

9. **Temperature prior to departing SPU to the operating room: _____ C° /F°**

Time the temperature was taken: _____

(Questions 10-14 to be filled out by Anesthesia)

10. **First temperature in operating room:**
    _____ C° / F°
    Time the temperature was taken:_____

11. **Last temperature in operating room:**
    _____ C° / F°
    Time the temperature was taken: _____

Preoperative Warming Project
ID Number:

12. Intraoperatively, which of the following were in place as warming techniques?

1) Fluid warmer ☐
2) Bair hugger ☐ If yes, specify the location of Bair Hugger placement: _____
3) Warm cotton blankets ☐
4) Unknown/ not specified
5) None ☐
6) Other: _____ ☐

Time Bair Hugger turned on: _____

13. Was the warming technique(s)/temperature *stopped/reduced* at any point intra-operatively?

1) Yes ☐
If *reduced*, reduced to what setting on Bair Hugger? Med (38°C) ☐ Low (32°C) ☐
2) No ☐
3) Unknown ☐

If yes, what was the patient's documented temperature at that time? _____C° / F°

Time the temperature was taken: _____

14. Temperature monitoring device used in operating room:

1) Nasopharyngeal ☐
2) Esophageal ☐
3) Bladder ☐
4) Skin ☐
5) Axillary ☐
6) Oral ☐
7) Other: _____

(Questions 15-16 to be filled out by PACU RN)

15. First temperature in PACU: _____ C° / F°

Time the temperature was taken:_____

14. Temperature monitoring device used in PACU:

1) Oral (electronic) ☐
2) Unknown/ not specified ☐
3) Other: _____

Procedure Start: _____
Procedure End: _____

Time out of OR: _____

Anesthesia Start: _____
Anesthesia End: _____

ADT Discharge Time: _____

Additional Comments:

_____
_____
_____

Thank you for your time and cooperation.

Appendix C

Data Label	Project Measurement Interval
Time 1	Baseline temperature
Time 2	Temperature immediately following preoperative warming, prior to OR transfer
Time 3	First recorded temperature in OR after anesthetic induction
Time 4	Last temperature recorded in the OR prior to PACU transfer
Time 5	Temperature recorded upon PACU admission

Figure 1. Recording of temperatures at five intervals: (1) immediately pre-, (2) and post-intervention, (3) post-induction of general anesthesia, (4) last temperature recorded in operating room, (5) PACU

Table 1

Sample characteristics

Characteristic	Variable	Frequency (N [%]) or Median (Q1, Q3)
Gender	Female	2 (6.7%)
	Male	28 (93.3%)
Age	Years	66.00 (62.00, 71.75)
Surgery type	Gynecology	2 (6.7%)
	Urology	10 (33.3%)
	Thoracic	13 (43.3%)
	General	5 (16.7%)
Preoperative temp device	Oral	30 (100.0%)
Bair hugger setting	43°C	26 (86.7%)
	38°C	3 (10.0%)
	32°C	1 (3.3%)
Cotton blanket	No	5 (16.7%)
	Yes	25 (83.3%)
Total warming time	Minutes	20.50 (14.25, 30.00)
Intraoperative temp device	Nasopharyngeal	5 (16.7%)
	Esophageal	24 (80.0%)
	Unknown	1 (3.3%)
Intraop warming device(s)	Unknown	1 (3.3%)
	Lower body warmer	9 (30.0%)

Note. Q1 = 25th quartile or interquartile lower bound; Q3 = 75th quartile or interquartile upper bound; C = Celsius.

Table 1

Sample Characteristics

Characteristic	Variable	Frequency (n [%]) or Median (Q1, Q3)
	Lower body warmer + cotton blankets	2 (6.7%)
	Upper body warmer + fluid warmer	1 (3.3%)
Intraop warming stopped/setting reduced to	No	27 (90.0%)
	Unknown	1 (3.3%)
	Yes	2 (6.7%)
PACU temp device	Oral	28 (93.3%)
	Tympanic	2 (6.7%)

Note. Q1 = 25th quartile or interquartile lower bound; Q3 = 75th quartile or interquartile upper bound; C = Celsius.

Table 2

Comparison of Length of Prewarming to Hypothermia [a]

Duration of Prewarming	Never Hypothermic	Hypothermic
<30 minutes	8	13
≥30 minutes	3	6

Chi-square (χ^2) = 0.06, p=0.891

[a]Hypothermic = any single or more times temperature <36°C was identified.

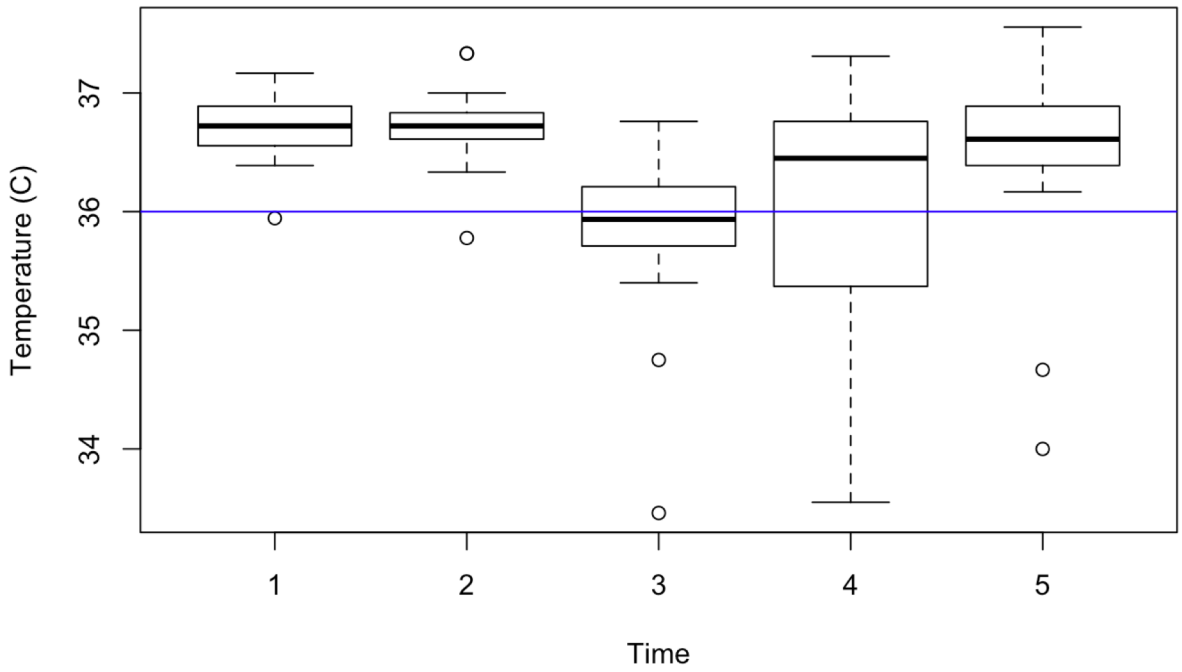


Figure 2. Median temperatures at different time measurement intervals of the perioperative period. Time 1-baseline temperature, Time 2-temperature immediately following preoperative warming or prior to OR transfer, Time 3-first recorded temperature in OR after anesthetic induction, Time 4-last temperature recorded in the OR prior to PACU transfer, Time 5-temperature recorded upon PACU admission. C = Celsius.

Table 3

Proportion of Patients with Temperature <36°C

Time	N	Frequency n (%)
1	30	1 (3.3%)
2	30	1 (3.3%)
3	30	17 (56.7%)
4	29	12 (41.4%)
5	29	2 (6.9%)

Note. C = Celsius; N = 30
Time 1-baseline temperature, Time 2-temperature immediately following preoperative warming or prior to OR transfer, Time 3-first recorded temperature in OR after anesthetic induction, Time 4-last temperature recorded in the OR prior to PACU transfer, Time 5-temperature recorded upon PACU admission

Table 4

Proportion of Hypothermic Patients (<36°C)

Temp Status	Frequency n (%)
Never Hypothermic	11 (36.6%)
Hypothermic Once	8 (26.7%)
Hypothermic Twice	8 (26.7%)
Hypothermic ≥ 3 times	3 (10.0%)

Note. C = Celsius; n = 30
Time 1-baseline temperature, Time 2-temperature immediately following preoperative warming or prior to OR transfer, Time 3-first recorded temperature in OR after anesthetic induction, Time 4-last temperature recorded in the OR prior to PACU transfer, Time 5-temperature recorded upon PACU admission

Table 5

Temperatures by Time

Time	N	Median (Q1, Q3)
1	30	36.72 (36.56, 36.88)
2	30	36.72 (36.61, 36.83)
3	30	35.94 (35.72, 36.18)
4	29	36.45 (35.37, 36.76)
5	29	36.61 (36.39, 36.89)

Note. Q1 = 25th quartile or interquartile lower bound; Q3 = 75th quartile or interquartile upper bound

Table 6

Post-hoc Pairwise Comparison of Temperatures at Different Time Measurement Intervals [a]

Time (median temp)	1 (36.72°C)	2 (36.72°C)	3 (35.94°C)	4 (36.45°C)
2 (36.72°C)	0.992	-	-	-
3 (35.94°C)	**<0.001**	**<0.001**	-	-
4 (36.45°C)	0.149	**0.049**	0.093	-
5 (36.61°C)	0.998	0.938	**<0.001**	0.286

Friedman's $\chi^2 = 35.48$, $p<0.001$

[a]Time 1-baseline temperature, Time 2-temperature immediately following preoperative warming or prior to OR transfer, Time 3-first recorded temperature in OR after anesthetic induction, Time 4-last temperature recorded in the OR prior to PACU transfer, Time 5-temperature recorded upon PACU admission