THE IMPACT OF PREWARMING ON THE PREVENTION OF INADVERTENT PERIOPERATIVE HYPOTHERMIA

by

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ABSTRACT

EXIE DIANNE EARNHARDT. The impact of prewarming on the prevention of inadvertent perioperative hypothermia.
(Under the direction of DR. DAVID LANGFORD)

This DNP scholarly project was implemented to evaluate the impact of prewarming on the incidence of inadvertent perioperative hypothermia (IPH) in adult patients undergoing surgical hip procedures (SHP) with combined sedation and neuraxial anesthesia. IPH affects up to 90% of surgical patients across the United States every year. The adverse effects of IPH include increased mortality, cardiac events related to shivering, poor blood clotting, poor wound healing, decreased patient satisfaction and increased cost for the patient and the surgical facility. A pretest and posttest was used to measure of the effects of prewarming on the incidence of IPH during the perioperative period. Fifty-six patients were selected by a convenience sample and randomized with computer generated randomization. Twenty-eight patients were selected from the randomized sample and matched to a comparison group that did not receive prewarming. Matching was based on body mass index (BMI), gender, age and, surgical procedure. Descriptive statistics were reported. The paired *t*-test was utilized for the analysis of continuous data and the McNamar's test was utilized for analysis of categorical data between the implementation and comparison groups. Twenty-eight paired subjects (n = 56) consisting of one subject in the implementation group and 1 subject in the comparison group were divided into 4 groups for analysis.

- Group 1: Hypothermia occurred in both implementation and comparison groups.

- Group 2: Hypothermia occurred in neither implementation nor comparison group.
- Group 3: Hypothermia occurred in the implementation group only, (The implementation subject became hypothermic but the matched comparison subject did not).
- Group 4: Hypothermia occurred in comparison group only.

The results were statistically significant for the intraoperative phase with a *p*-value of <0.001 (McNemar's test). There was no statistically significant differences found between the groups for postoperative care unit length of stay ($p = 0.841$). This project supports current literature that prewarming patients prior to surgical procedures reduces the incidence of IPH.

DEDICATION

I would like to dedicate this work to Dr. Karen Lucisano for her encouragement and support during my academic career.

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I would like to offer my sincere appreciation to my Chair Dr. David Langford for his leadership, support and patience during the progression of this project. I would also like to thank all of my committee members; Dr. Robert Algozzine, Dr. Charlene Whitaker-Brown, Dr. Karen Lucisano, and Dr. Michal Moore. I would also like to especially thank Dr. Tom Norton and Dr. Robert Algozzine for their help during data analysis and the nurses, technicians and CRNAs at the facility where the project took place.

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CHAPTER 1: INTRODUCTION

Background

The incidence of inadvertent perioperative hypothermia (IPH) is a preventable condition that frequently occurs in the perioperative period, affecting up to 90% of surgical patients per year (Burns, Wojnakowski, Piotrowski, & Caraffa, 2009). Inadvertent perioperative hypothermia is associated with clinical complications such as myocardial ischemia, impairment of coagulation, increased risk of infection, poor wound healing, prolonged emergence increased incidence of postoperative shivering and prolonged recovery time (Feinstein & Miskiewicz, 2009). Early identification of IPH and its risk factors are vital components in preventing the incidence of IPH.

Many organizations recognize the importance of preventing IPH. The National Institute for Health and Care Excellence (NICE) developed guidelines to drive quality improvement for the prevention of perioperative hypothermia during each phase of the perioperative procedure (NICE, 2008). These guidelines are scheduled to be reviewed and updated in March of 2015 (NICE, 2011). Risk factors addressed in the guidelines include the American Society of Anesthesiologist (ASA) status, preoperative temperatures of below 36^0 C, combined general and regional anesthesia and patients at risk for cardiac complications. Their inadvertent perioperative guidelines will be reviewed and updated in March of 2015 (NICE, 2011).

In 1998, the American Society of Peri-Anesthesia Nurses (ASPAN) developed clinical practice guidelines aimed at improving patient outcomes through the prevention of hypothermia (Berry, Wick, & Magons, 2008). The ASA advocates for normothermia in their practice guidelines (Adriani, & Moriber, 2013). Normothermia is a Surgical Care Improvement Project (SCIP) measure initiated for prevention of surgical site infections. Additionally, SCIP is a coalition comprised of organizations interested in improving surgical care and reducing complications.

Perioperative hypothermia is defined as a core body temperature of less than 36˚ Celsius (C) or 96.8˚ Fahrenheit (F) occurring at any time during the perioperative period (Proveda, 2012). The primary cause of hypothermia during general or neuraxial anesthesia is the redistribution of body heat (Sessler, 2000). According to Kurz (2007), neuraxial anesthesia disrupts nerve conduction to more than half of the body. The regulatory system misinterprets the skin temperature in blocked areas as being abnormally elevated. Subsequently the system responds by tolerating lower than normal temperatures before triggering a defense response. This leads to the redistribution of heat because of the anesthetic block which impairs vasoconstriction, resulting in a progressive drop in temperature over time. Ultimately hypothermia results from heat loss exceeding heat production.

The operating room environment hinders the ability of the anesthetist to keep patients warm. Enviornmental risk factors that contribute to the incidence of IPH include skin exposures in cold operating room environments, general and neuraxial anesthesia, cold preparation solutions, cold intravenous (IV) solutions and, infusion of unwarmed blood products (Roberson, Dieckmann, Rodriguez, & Austin, 2013).

While all patients undergoing surgical procedures are at risk for IPH the very young and elderly are at a higher risk (Lynch, Dixon, & Leary, 2010). Physiological risk factors include comorbidities such as endocrine disorders, cardiac disorders, arthritis, paralysis, burns, trauma, hypoglycemia, intoxication, myocardial infarction and injuries involving the head and spinal cord (Hegarty, Walsh, Burton, Murphy, O'Gorman, & McPolin, 2009). The type of anesthetic is also a risk factor for IPH. Neuraxial anesthesia disrupts nerve conduction and inhibits thermoregulatory response (Kurz, 2007).

This scholarly project was implemented in a 196 bed adult health tertiary acute care facility. The facility provides the area's most advanced complex orthopedic surgeries as well as other specialty services. Combined neuraxial and sedation is and comfort warming are commonly used at this facility for surgical hip procedures (SHP). Surgical hip procedures often include elderly patients with multiple comorbidities. For these reasons this facility and patients undergoing SHP were chosen for this scholarly project.

Problem Statement

Inadvertent perioperative hypothermia is a serious problem that can lead to patient discomfort, increased cost and adverse patient outcomes. Although the incidence of IPH has improved with the advancement and utilization of technologies such as forced-air warming blankets and preoperative warming gowns, IPH continues to occur in up to 90% of surgical patients (Burns et al., 2009). The literature suggests that prewarming patients prior to surgery may help to reduce the incidence of IPH thereby decreasing the adverse and costly outcomes associated with it.

Purpose of the Project

This scholarly project focuses on the incidence of IPH in adult patients undergoing combined sedation and neuraxial anesthesia for SHP. This evidence-based practice project is designed to compare the effects of prewarming of adult patients undergoing SHP with combined sedation and neuraxial anesthesia, the incidence of IPH, length of stay in the post anesthesia care unit (PACU) and the occurance of postoperative shivering.

Significance of the Project

Inadvertent perioperative hypothermia is identified in the literature as an ongoing condition with significant consequences. Although the implementation of prewarming has been shown to decrease the incidence of IPH, few facilities practice it as a preventative care measure. Prewarming has shown progress in reducing the occurrence of IPH and improved patient outcomes (Lynch, Dion & Leary, 2010).

Clinical Question

Will prewarming patients for at least 30 minutes with forced air warming gowns set at medium heat (38 degrees C) reduce the incidence of IPH, length of stay in the PACU and shivering for adult patients undergoing SHP with combined sedation and neuraxial anesthesia?

Project Objectives

1. Evaluate the effect of preoperative warming on the incidence of perioperative hypothermia.
2. Evaluate the effect of preoperative warming on the length of stay in the PACU.

3. Evaluate the effect of preoperative warming on the incidence of postoperative shivering.

CHAPTER 2: LITERATURE REVIEW

A systematic review of the literature was performed using the keywords, hypothermia, surgery, prewarming and anesthesia. Databases were searched from January of 2001 through March of 2014. Databases searched were The Cumulative Index to Nursing and Allied Health (CINAHL), Science Direct, Medline, and PubMed.

Sixteen articles were selected that met the inclusion criteria of prewarming and, IPH. CINAHL yielded five results, EBSCOhost 23 results, Medline six results, and Science Direct 94 results. Of these 128 articles, 18 studies were initially selected. Two studies were excluded because study one only assessed thermal comfort (O'Brien, Greenfield, Anderson, Smith, & Morris, 2010) and study two only assessed nursing knowledge regarding IPH (Hegarty et al., 2009). Sixteen studies were appraised and leveled using the Melnyk and Fineout-Overholt Method (Melynk & Fineout-Overholt, 2011) which yielded the following results: five studies were Level I, systematic literature reviews (Burns, Wojnakowski, Piotrowski, & Caraffa., 2010; Kiekkas & Karga, 2005; Proveda, May 2012; Roberson, Dieckmann, Rodriguz, & Austin, 2013; Scott & Buckland, 2006). Nine studies were Level II, randomized control trials (RCT) (Adriani & Moriber, 2013; Andrzejowski, Hoyle, Eapen, & Turnubull., 2008; Fossum, Hays, & Henson, 2001; Horn, Bein, Bohm, Steinfath, Sahili, & Hocker, 2012; Leeth, Mamaril, Oman, Krumbach, 2010; Lynch, Dixon, Leary, & Holm, 2010; Nicholson, 2013; Vanni et

al., 2003; Wong et al., 2007) and 2 studies were Level VI descriptive studies (Berry, Wick, & Magons, 2008; Winslow et al., 2012).

A study conducted by Adriani & Moriber, (2013) compared preoperative warming of gynecological patients and the incidence of IPH and found no statistical significance in the temperature difference between patients who were prewarmed and those who were not ($p = 0.4$).

In contrast, a prior study performed by (Fossum et al., 2001) compared prewarming of patients undergoing general anestheisa for gynocological, orthopedic and urological surgery. This study reported statistical significance in patients that were prewarmed when compared to those who were not. This study reported that the prewarmed group was significantly warmer upon arrival to the PACU ($p = 0.000$).

Only one study was found that addressed cost. This Level VI study was conducted by (Berry, Wick, & Magons, 2008). The study focused on the cost of implementation of the American Society of PeriAnesthesia Nurses (ASPAN) Hypothermia Guideline, which was designed for the purpose of preventing unplanned perioperative hypothermia. This quasi-interventional study assessed the feasibility, cost, and time effectiveness of perioperative warming and found the guideline to be clinically feasible and able to be implemented without significant cost increases. This study found a $2,500.00 to $7,000.00 loss per surgical patient who developed hypothermia which averaged 1.5 degrees C below normal.

Two studies compared prewarming of laparoscopic cholecystectomy patients (Horn et al., 2012; Lynch et al., 2010). Horn et al. performed a RCT with a sample size of 200 ASA I and II patients undergoing laparoscopic cholecystectomies, hernia, breast and

minor orthopedic surgeries to assess the best prewarming time and found no statistically significant difference for the prewarming time. The intervals studied included ten, twenty and thirty minute periods ($p = 0.54$). Prewarming for as little as ten minutes was found to offer a stastically significant reduction in the incidence of IPH ($p = 0.0001$).

Lynch et al., (2010), conducted a quality improvement project and found that fewer prewarmed patients were hypothermic during the perioperative period. They also reported that postoperative length of stay was decreased by as much as 40% and wound infections were decreased by 64%. No inferential statistics were reported.

Melling, Scott, & Leapper, (2001) conducted a study comparing preoperative warming on the incidence of wound infection after clean surgery. This was a RCT with a sample size of 421 patients who were prewarmed for a minimum of 30 minutes prior to surgery. The study identified 19 wound infections in 139 patient who were not prewarmed (14%) and 13 out of 277 patients who were warmed preoperatively (5%), ($p = 0.001$).

A study by Mehta & Barclay (2014) found that the most significant factor determining intraoperative hypothermia was patient temperature at the start of the operation, ($p < 0.001$). This study found that a core temperature below 36.5 degrees C prior to surgery made a patient 20 times more likely to become hypothermic intraoperatively. The study also reported that epidural anesthesia was a statistically significant factor in the development of hypothermia at the beginning of the operation ($p = 0.09$). Patients that received an epidural had mean core temperatures of 0.3 degrees C lower than those who did not ($p = 0.02$). The study also reported that ASA scores of III or IV were not associated with increased IPH ($p > 0.05$).

Gahyun, Kim, Lee, Choi, Shin & Jeong (2014), conducted a RCT that compared the effect of pre-warmed intravenous fluids (IVF) on perioperative hypothermia and shivering after ambulatory surgery in patients who were administered monitor anesthesia care (MAC). Researchers found a statistically significant difference in the rate of IPH in patients who received prewarmed IV fluid ($p = 0.035$) and shivering ($p = 0.039$) in female patients undergoing urological procedures.

Billeter, Hohmann, Druen, Cannon, & Polk (2014) conducted a study to examine the relationship between IPH and severe complications and mortality in elective procedures. Their study identified risk factors for IPH that should be considered in the evaluation of patients prior to surgical procedures. This study found that severity of illness was the strongest predictor of for hypothermia in patients undergoing elective procedures. Patients at highest risk for IPH were elderly, diabetic men with anemia, chronic renal failure, weight loss and Alzheimer's disease. The most common complication in their study was sepsis. The study concluded that IPH was associated with a four-fold increase in mortality and doubled complication rates.

Ford & Harper (2014) evaluated the various new technologies that aid in the prevention of IPH. Devices evaluated included fluid warmers, forced-air warmers, water filled mattresses, circulating water garments, electric warming blankets, radiant warmers, carbon fiber warmers, resistive polymer blankets, heating pads, plastic garments, thermal exchange chamber and circulating sleeves. Resistive heating was compared to forced-air warming. Resistive heating showed promise but, required direct contact with the patient's skin and heat transfer occurs via conduction. A benefit of this type of warming is that the device can be placed underneath the body and turned on prior to patient

transfer to the operating room table and may offer a better and cheaper alternative to forced air-warming. Circulating water garments were also evaluated and show even greater promise in achieving higher core temperatures than forced-air warmers. The newest technology discussed was negative pressure warming devices that remove insulating air pockets and improve subcutaneous perfusion.

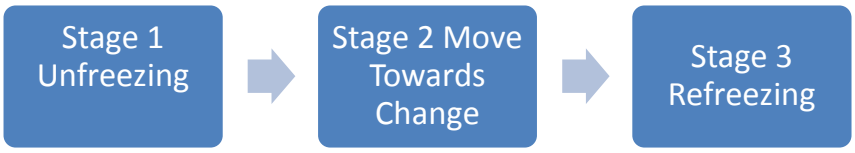
In conclusion the majority of the studies included in this review support this scholarly project, however, 2 studies failed to show statistical significance regarding the effect of prewarming upon the incidence of IPH (Adriani & Moriber, 2013; Hooven, 2011). One of these studies was a quasi-experimental designed study with convenience sampling (Adriani et al.). In this study, a different method of measuring the patient's temperature was used during the intraoperative period. This study did not account for initiation time for intraoperative warming or the ambient temperature of the operative suite. The other study was a cohort study that compared temperature trends between the prewarmed group and a comparison group but the only measure evaluated was the first tympanic temperature taken during the postoperative phase (Hooven et. al.). This study did not compare the incidence of hypothermia intraoperatively between the two groups.

Conceptual/Theoretical Framework

Lewin's Three Stages of Change Theory was applied to the strategic plan for this project. Lewin's Change Theory describes a three-stage process for initiating change after a needed change is identified. The three stages described by Lewin's theory are; unfreezing, changing and refreezing (Sare & Ogilvie, 2010). This theory fits well with implementation of this project as the implementation of prewarming in all network

facilities will require a practice change. Assessment of barriers that prevent change will also be necessary to change practice.

Lewin's Change Theory also fits well into today's healthcare economic climate. According to Sare and Ogivile (2010), Lewin's theory accounts for the driving forces that push towards a direction that creates change. The theory also accounts for the restraining forces that inhibit change. A state of equilibrium is obtained when driving forces are equal to the restraining forces. Lewin's theory consists of 3 stages:



Stage One. Unfreezing

During stage one, a force field analysis is needed to evaluate the positive forces that drive the project towards the desired change and the negative forces that oppose or restrict the project from advancing towards desired change (Sare & Ogilvie, 2010). A force field analysis was done and positive and negative forces were reviewed. Positive forces included decreased incidence of IPH, increased patient comfort and satisfaction scores, decreased need for perioperative blood products, and decreased infection rates. Negative forces included the cost of the warming gowns and equipment, complaints from physicians about the heat given off by the product, difficulty in proving a cost savings and resistance of staff to change in procedure related to attitude or prior experience.

Stage Two. Changing

Stage two of Lewin's Change Theory emphasizes change as a process. During this stage, understanding the need for a change depends on training and coaching. During stage two of this project, communication was emphasized. Meetings were designed to

share information on a regular basis with the team in an effort to discuss and resolve issues and concerns that arose as the project progressed. The focus of this stage was to facilitate the project plan and minimize misunderstandings and errors.

Stage Three. Refreezing

During stage three of Lewin's Change Theory, the change is established and becomes the new norm. Stage three has not occurred. During this phase the implementation of prewarming should become policy and replace the previous method of sending patients to the operating suites without the benefits obtained by prewarming. The results found during this study will be disseminated to the care teams of this facility so that policies can be developed to prevent the return of prior practices and beliefs (Sare and Ogilvie, 2010).

CHAPTER 3: METHODOLOGY

Project Design

This project was designed to improve the current standard of comfort warming prior to SHP by comparing the effects of prewarming on the incidence of IPH between the intervention group and the comparison group. A pre-test and post-test design was used to measure interventional prewarming as a method to improve patient outcomes and implement best practice to decrease the incidence of IPH.

The current method of prewarming is patient-controlled (comfort warming). The patient is given a warming gown that is then attached to a forced air warming device in the preoperative area. The thermostat control is regulated by the patient for comfort, and is adjustable for cooling or warming. Warming time for the patient may last from zero minutes to several hours. For this study patients in the intervention group were prewarmed for a minimum of 30 minutes prior to their SHP. Patients in the comparison group were not prewarmed.

Currently, patients are prewarmed, however, there are no measures in place for how long a patient is prewarmed or at what temperature. The intervention for this project was the implementation of prewarming for a minimum of 30 minutes prior to surgery with a forced air warming device. The warming device has three temperature settings (low, medium and high) and will be set at the medium setting which forces warm air into a warming gown at 38 degrees C.

The intervention group consisted of patients who had SHP during the months of January and February of 2015. The comparison group consisted of patients who had undergone SHP at the same facility during February of 2010, December of 2010, January of 2011 and February of 2011 which was a period prior to the current practice of comfort warming.

This project was granted approval by the Institutional Review Board (IRB) of the study site. The IRB did not require consent since the project simply modified current practice and posed minimal risk to the patient. Prior to the implementation of this project, staff meetings were held with the preoperative, intraoperative and postoperative care teams. Three sessions were held to familiarize the care team members in each area with the plan, data sheets, skin sensor placement and the process. A single preoperative care nurse reviewed charts on the day prior to surgery and flagged the charts of patients who met inclusion criteria. On the day of surgery, data sheets were completed by each care nurse in each department. A data collection tool was developed for the study and was used to collect data during the preoperative, intraoperative and postoperative phases. Data sheets were secured by the PACU RNs in a locked drawer at the nurse's station and picked up daily by the principle investigator (PI). Any missing data was collected by the PI via retrospective chart review.

Initially data was collected from a convenience sample of 56 patients. From that sample, subjects were randomized into either an odd or even numbered groups, based upon assignment via a random numb generator (http://www-.randomizer.org/form.htm). All patients assigned an even number were then matched to a patient who underwent a SHP prior to the implementation of prewarming.

Temperatures were recorded before and after prewarming, in the preoperative holding area, upon arrival to the operative suite and then every fifteen minutes for the duration of the intraoperative phase and again upon arrival to the PACU. Preoperative temperatures were measured via a skin temperature probe placed in the axillary area of the arm contralateral to the operative hip prior to prewarming and again approximately ten minutes after the initiation of prewarming. All patients were prewarmed on the medium setting (38 degrees C) and covered with a single sheet. Each patient was prewarmed for a minimum of 30 minutes. Prewarming began in the preoperative holding area and was continued in the operative suite. Ambient temperatures for the operative suites were collected for two weeks prior to the study and the average temperatures were found to be similar between the all operating room with a mean temperature of 64.8 degrees F.

Participants

Twenty-eight patients were selected by convenience sample and matched to a historical group for comparison. Patients were matched according to ASA physical status, age, gender, BMI and procedure. For control purposes, patients were limited to only those undergoing SHP with combined sedation and neuraxial anesthesia. The ASA Physical Status Classification System classifies patients based on physical status prior to surgery. Patients classified as ASA I are normal healthy patients, ASA II classification includes patient with mild systemic disease without substantive functional limitations, ASA III classification includes patients with one or more moderate to severe systemic diseases and substantive functional limitations (Titus, 2013).

The intervention and comparison groups were matched by age (+/- 3 years), gender, procedure and the BMI using a classification system published by the Centers for Disease Control (http://www.cdc.gov/obesity/adult/defining.html). Patient data for the comparison group was obtained through query of the facility's patient record system and included patients who had SHP during Febuary of 2010, December of 2010, January of 2011 and Febuary of 2011.

Inclusion and exclusion criteria were as follows:

Inclusion Criteria:

1. Patients aged 40 to 80.
2. Patients classified as ASA I, II and III.
3. Patients who are undergoing SHPs with combined sedation and neuraxial anesthesia.

Exclusion Criteria:

1. Patients undergoing SHP that lasted < than 1 hour or exceeded 3 hours in the intraoperative suite.
2. Patients with starting temperatures of 100.9 degrees F or greater.
3. Patients with central nervous system impairment that could cause vasomotor instability or inability to detect temperature.
4. Patients with insulin dependent diabetes.
5. Patients with thyroid disorders.

Setting

The setting for this study was a 196 bed not-for-profit adult health, tertiary acute care facility. This facility provides the area's most advanced complex orthopedic surgeries as well as specialty services that include bariatric and pelvic surgical procedures. This full-service tertiary adult care hospital was chosen for this project because of its current method of prewarming patients prior to surgical procedures. All patients at this facility are currently given a warming gown to wear in the preoperative area if they choose.

Tools and Measures

In the intervention group, body temperatures were obtained by a skin temperature sensor. A skin temperature sensor was placed in the axillary area opposite to the surgical hip procedure. This position allowed for the most accurate temperature based on patient's position and fit of the warming gown.

A data collection form was designed to record demographic data that included age, gender, height and, weight. Data collected included admission temperatures that were taken in the preoperative holding area by the preoperative nursing personnel before prewarming was initiated and after prewarming was completed. Intraoperative temperatures were taken in the operative suite by the certified registered nurse anesthetists (CRNA) and recorded during the intraoperative phase on the data sheet. Postoperative temperatures were taken in the PACU by the registered nurses (RN) and recorded during the postoperative phase of the data sheet. Shivering was noted if demerol 12.5 mg was administered during the postoperative period which is a standard protocol for shivering or if shivering was recorded by the PACU nurses. All data

collected on the data collection form was reviewed and rechecked by the PI via the electronic medical record (EMR). Data collection for this evidenced based project is described for each phase of the perioperative period (see Appendix B & C).

Intervention and Data Collection

The intervention for this project was the implementation of prewarming prior to surgery. Subjects were prewarmed for a minimum of 30 minutes on medium heat (38 degrees C) prior to the surgical procedure. Data was collected during three phases of the perioperative period and included Phase I, which was during the preoperative period and counted from arrival time to discharge to Phase II. Phase II occurred during the intraoperative period and was counted starting from the admission time to the operative suite (in-room time) until discharge time to the PACU. Phase III occurred in the PACU and started upon arrival time to the PACU and ended upon discharge time to the assigned hospital unit.

Temperatures were measured during all phases of the perioperative period for the intervention group using the same skin temperature sensor. If skin temperatures were not recorded, axillary or oral temperatures were used for the analysis. A skin temperature sensor was placed in the axillary area of each subject on the opposite side of the surgical site. Placement of the temperature sensor in this location secures the sensor in the most adducted arm during the procedure and distal to the source of forced air warming. This temperature monitor was placed in the patient's axillary area while in the preoperative holding area and remained at the same site during all phases of the perioperative period. For the comparison group oral temperatures were recorded during Phase I; skin

temperatures were recorded during Phase II and oral temperatures were recorded during Phase III.

Methods

Prior to the implementation of this project, several meetings and inservices were held with the preoperative, intraoperative and postoperative personnel (see Appendix A, B & C). It was suggested during one of the meetings that we color code the data collection sheets for easy recognition regarding this project. Data collection tools were printed on blue paper and placed on the front of the chart the day prior to surgery by the preoperative champion. Data sheets were collected daily by the PI and examined for accuracy and legibility. Steps needed to retrieve missing data included retrieval of data from the hospital database and patient's electronic medical record (EMR). The PI performed this.

After review and verification of the data forms the data was recorded in a master codebook kept on a secure, password-protected server within the hospital system. The data collection tools were de-identified and numbered by the identification (ID) number on the master codebook list. Subjects in the intervention group were labeled from 1-56. Subjects in the comparison group were labeled 101-156. Data entry was checked twice for congruency and errors were corrected prior to data analysis. The matched comparison group data was also placed into the codebook and paired with the intervention group. Data collected during each phase of the perioperative period is described as follows:

Data collected during Phase I occurred in the preoperative holding area where preoperative warming began. Documentation included; thermal initiation start times and end times, height and weight, admission temperature and the post prewarming

temperatures which were recorded after the implementation of prewarming immediately prior to discharge to the operative suite. If the post-warming temperature was not recorded, the first intraoperative temperature was recorded.

Data collected during Phase II, where standard intraoperative warming occurred, began in the operative suite and data collection included initiation time of intraoperative warming and, completion time of intraoperative warming. The type and amount of IVF was recorded and also noted was if the IVF was warmed. The amount of blood loss was also recorded for each procedure.

Data collected during Phase III occurred in the PACU where the postoperative temperature was recorded on the anesthesia record within 5 minutes of arrival. Admission times and transfer to and from PACU were recorded to determine the length of stay in the PACU.

Daily meetings assured fidelity. Meetings were held as needed with data collectors to assess understanding of the data collection process. Data was entered twice and then analyzed for congruency.

Patients were prewarmed in the preoperative holding area utilizing a warming gown and a forced-air warming unit set on medium heat with a single cotton sheet placed over it for a minimum of 30 minutes. The patient was included in the study if they met the minimum prewarming time of 30 minutes. Forced air-warming was discontinued if perspiring was observed, the patient became uncomfortable, or the patient's temperature climbed above 37.1˚ C. The incidence of perspiration was noted on the data collection sheet. One patient perspired but met inclusion criteria and minimum warming criteria and therefore was included per protocol.

Project Analysis

Descriptive statistics including means and standard deviations or counts and percents were reported. Continuous data were compared using the paired *t*-test. For categorical data, McNemar's test was utilized. Both of these tests take into account the matching between the intervention group patients and the comparison group patients. SAS© version 9.2 was used for all analyzes. A *p*-value of less than 0.05 was considered statistically significant.

Translation and Impact on Practice

Prewarming of patients prior to surgical procedures decreases the incidence of IPH (Andrzejowski, Hoyle & Turnbull, 2008). The implementation of prewarming during this project is supported by the literature as a best practice for all patients as an effective measure for the prevention of IPH. Inadvertent perioperative hypothermia is associated with increased length of stay, increased incidence of postoperative wound infections, coagulopathy, morbid cardiac events, shivering and decreased patient comfort (Kurz, 2007).

Fiscal Impact

The prevention of IPH could result in an estimated cost reduction of $2, 500.00 to $7000.00 per patient (Roberson et al., 2013). Upfront cost was found to be the major barrier for implementation of prewarming. There are also problems with the types of prewarming devices currently available. The lower body and upper body forced air warming blankets are the most economical but, there isn't an effective way to utilize one warming blanket during the different phases of the perioperative period. Warming gowns are the most convenient method for prewarming because the forced air warming device is

very small and is attached to the wall in the preoperative area. Warming gowns cost approximately $15.00 each compared to lower or upper body forced air warming blanket costing approximately $4.95 each. It would be difficult for the budgets of individual units to absorb the additional supply cost and the cost cannot be passed to the patient because of the manner in which they are billed; patients are charged a flat rate. Bundling of prices makes sharing cost for supplies difficult between departments.

CHAPTER 4: RESULTS

There were no statistically significant differences in age, BMI and procedure between the groups. Mean age for the intervention group was 59.28 and for the comparison group 59.50 ($p = 0.923$). The mean BMI for the intervention group was 28.34 and 28.23 for the comparison group ($p = 0.942$). The intervention group was comprised of 27.5% females and 27.5% males as was the comparison group. The ASA status was not a matching parameter for the two groups but there was no statistically significant difference between the two groups ($p = 0.942$) (see Table 2).

Project Findings

In the comparison group: 24 of 28 patients (86%) became hypothermic during the intraoperative phase whereas in the intervention group: 11 out of 28 patients (29%) became hypothermic during the intraoperative phase.

Twenty-eight pairs consisting of one subject in the intervention group and one subject in the comparison group were divided into four groups to test significance.

- Group 1: Hypothermia occurred in both intervention and comparison groups, ten pairs, 10/28 = 35.7%.
- Group 2: Hypothermia occurred in neither intervention nor comparison group, three pairs, 3/28 =10.7%.

- Group 3: Hypothermia occurred in the intervention group only, one pair, 1/28 = 3.6%. (The intervention subject became hypothermic but the matched comparison subject did not).
- Group 4: Hypothermia occurred in the comparison group only, 14 pairs, 14/ 28 = (50%) $p<0.001$ (McNemar's test).

A paired *t*-test was also conducted to evaluate the impact of prewarming during the three phases of the perioperative period for the groups. The Sig (2-tailed) value is significant during all 3 phases. Findings were as follow:

- Preoperative Period: There was a statistically significant difference ($t = 2.22$, $p = 0.030$) in the admission temperature between the Implementation ($M = 98.07$) and Comparison ($M = 97.71$) group. The temperature difference was not clinically significant with a value of 0.35 degrees F. (see Table 3).
- Intraoperative Period: There was a statistically significant difference ($t = 2.84$, $p = 0.006$) in the intraoperative temperature between the Intervention ($M = 96.80$) and Comparison ($M = 95.04$) group. The result was both clinically and statistically significant (see Table 4).
- Postoperative Period: There was a statistically significant difference ($t = -2.09$, $p = 0.042$) in the Intervention ($M = 97.84$) and Comparison ($M = 97.59$) group. The temperature difference was not clinically significant with a value of 0.25 degrees F (see Table 5).

Discussion of Results

The findings of this study concluded that patients in the intervention group were less likely to become hypothermic during the intraoperative phase than the matched

comparison. There was no statistically significant difference between the groups in the PACU length of stay. There was no statistical difference in shivering between the groups, only one patient shivered. Our findings agree with the literature regarding the occurrence of IPH in the perioperative period. Our findings do not agree with the literature regarding the length of stay and this may be related to our measure which only included the PACU length of stay. The incidence of shivering also failed to agree with the literature and this may be due to failure to document the incidence on the data sheets or that the shivering did not require the administration of demerol in the PACU.

One limitation of this study was the difference in methods used for monitoring intraoperative temperatures compared to the preoperative and postoperative temperatures. Changing the implementation of preoperative patient controlled comfort warming would have changed the current practice at the facility. It was decided before implementation of this project to obtain the comparison group of patients who had undergone similar procedures prior to the current practice of comfort warming. Traditionally oral temperatures were obtained in the preoperative and postoperative periods, and skin temperatures were monitored during the intraoperative period. In the comparison group, only oral temperatures were recorded for the preoperative and postoperative periods and skin temperatures were monitored intraoperatively. To control for the difference between oral temperatures taken during the preoperative and postoperative phases and the skin temperatures taken in the intraoperative phase, 1 degree Fahrenheit was added to the lowest intraoperative temperature for each patient and used for the analyses (Sinh et al., 2000).

Differences in heat redistribution were controlled by, matching patients in the intervention group with the historical group for age, BMI, procedure and those who received combined sedation and neuraxial anesthesia during the surgical procedure. While we could not control for ambient room temperatures, operative suite temperatures were collected for a two week period prior to the initiation of this scholarly project. Ambient room temperatures in the intraoperative suites were obtained from the electronic database and averaged for each operating room (OR) where surgical hip procedures were performed. The mean temperature for the operative suites was similar in all of the SHP rooms. The mean operating room ambient temperature was 64.8 degrees F (18.2 degrees C).

Results showed outliers that consisted of patients with dramatic drops in temperature during the intraoperative period. The outliers were left in the dataset for analysis because the occurrence of extreme hypothermia is seen clinically, and these patients are likely to be at the greatest risk for the adverse effects of IPH. This affected the standard deviation for the intraoperative group.

Challenges during the implementation of this project included the inability to conclude readiness for discharge from the PACU. Multiple variables that affected length of stay included new staff, limitations in obtaining beds outside of PACU and lack of documentation reflecting when patients were ready for discharge.

This project originally was designed to use the same form for temperature monitoring during all phases of the perioperative period. In order to provide this, skin temperature sensors were obtained from the operating room for monitoring patients. Cables were unavailable in the preoperative and postoperative areas. Three cables were

obtained and placed in the preoperative area and the postoperative area for monitoring skin temperatures.

Another challenge to implementation of this project was the extra work for staff in documentation of vital signs during all phases of the perioperative period. The number and pace of admissions, surgeries and discharges in each of the perioperative phases affected data sheet documentation. Missing data was retrieved via retrospective chart review by the PI. All patients with incomplete data sheets were included in the findings after the data sheets were completed.

CHAPTER 5: PROJECT SIGNIFICANCE

Implications

The results of this project showed statistical significance in the reduction of IPH between the intervention group and the comparison group and therefore we recommend prewarming as an effective means of decreasing the incidence of IPH. This project did not find statistical significance in the PACU length of stay or the incidence of shivering, however there was a dramatic clinical difference in the occurrence of IPH, therefore it is important that this information is disseminated to the clinical area in order to encourage a change in policy to require prewarming.

We found that prewarming demonstrated effectiveness in decreasing the incidence of IPH. Prewarming had the greatest impact during the intraoperative phase where even mild hypothermia has been associated with prolonged drug action, reduced resistance to wound infections and impaired clotting and platelet function (Fossum, Hays & Henson, 2001). Through the implementation of prewarming poor patient outcomes such as these may be minimized which is especially important in the delivery of quality anesthesia care.

Summary

This was a small pretest, posttest evidenced based scholarly project implemented to evaluate the effect of prewarming on the incidence of IPH, shivering and PACU length of stay in one facility. Data analysis demonstrated a statistically significant decrease in

the incidence of IPH during the intraoperative period in the intervention (prewarmed group). There was only one incidence of postoperative shivering noted during the analysis and, therefore, the incidence of shivering revealed no statistical difference between the groups. Length of stay in the PACU was found to be statistically significant but clinically insignificant with a mean difference of three minutes noted. This project supports current literature that prewarming prior to surgical procedures decreases the incidence of IPH. Although the literature indicates length of stay in the PACU is decreased and the incidence of postoperative shivering is decreased, this project indicated no clinical significance differences related to PACU length of stay or in the incidence of shivering in the postoperative area.

Limitations included the inability to monitor temperature for both groups with the same monitoring mode. Intraoperative temperatures were monitored with a skin temperature sensor whereas preoperative, and postoperative temperatures were measured with oral thermometers. In as effort to control for the difference in temperature monitoring, a calculation was performed that added one degree Fahrenheit to the intraoperative skin temperature as a conversion factor to an oral temperature (Singh, Sharma, Khandelwal, & Kothari, 2000).

Recommendations

The potential benefits of prewarming far out way the cost of its implementation. The principals behind the benefits of prewarming are important for positive patient outcomes and are supported by current literature. Nursing procedures and protocols can have a major influence on the quality of care and implementation of best practice techniques that are foundationally supported in the literature.

Evaluation tools need to be developed to aid in early identification of patients most at risk for IPH. Researched based protocols regarding the implementation of prewarming can be found in the literature however; simplified versions or checklists would fit better in today's transitional healthcare setting. Education of staff aimed at early recognition and interventions for IPH will raise consciousness of the adverse outcomes that are associated with it.

Healthcare dollars, reimbursement and productivity are focused more in today's healthcare climate than ever before however, quality of care and patient outcomes are the primary focus. Future study recommendations include evaluation of new and quality technology to determine the best value and the best results are needed.

In today's healthcare climate, working lean is important and there are real problems with the cost involved in prewarming patients, it takes more time, the cost of the warming equipment is expensive which taxes departmental supply budgets and patient billing is often bundled. When it is not feasible to prewarm a patient, alternative measures are necessary. Alternative solutions for the prevention of IPH should be protocol and outcome driven, such as increasing operating room temperatures to maintain normothermia.

It is vital for the perioperative care teams to assume responsibility for the occurrence of IPH. Nursing personnel play a major role in the provision of effective interventions to prevent and treat IPH. Inadvertent perioperative hypothermia can be easily and affordably managed through standardized measures based on current guidelines and recommendations noted in the literature

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APPENDIX A: INFORMATION PACKET

Information Packet for Preoperative, Intraoperative and Postoperative care teams.
CMC-Mercy Pre-warming Study 1/15/15

Problem: Inadvertent perioperative hypothermia is associated with increased healthcare cost and poor patient outcomes. Adverse outcomes associated with perioperative hypothermia include: decreased metabolic rate, decreased cardiac output, metabolic acidosis, decreased clotting function, increased postoperative infections and poor wound healing. Postoperative shivering increases oxygen consumption, norepinephrine release and can contribute to myocardial ischemia. The CDC advocates the prevention of hypothermia during the perioperative period to reduce the incidence of surgical site infections. The ASA advocates normothermia in their practice guidelines.

Protocol: This evidenced based practice implementation focuses on inadvertent perioperative hypothermia in adult patients undergoing combined sedation and neuraxial anesthesia (sedation with spinal or combined spinal, epidural anesthesia) for surgical hip procedures.

Purpose: The purpose of this project is to determine the effectiveness of preoperative warming of patients with a forced air warming device and gown during the preoperative period verses methods, and its effect on the incidence of inadvertent perioperative hypothermia, cost related to length of stay in the PACU and the incidence of post-operative shivering.

Sample Size: Fifty-seven patients undergoing surgical hip procedures are needed to complete this study. This sample will be matched to the comparison group by patient ASA status, age, gender, surgical procedure and BMI to a comparison group consisting of patients who have undergone the same procedure without prewarming.

Inclusion Criteria:

1. Patients with ASA classification of I, II, or III will be included in the study.
2. Patients between the ages of 40 and 80 undergoing surgical hip procedures with combined sedation and neuraxial anesthesia will be included.

Exclusion Criteria:

1. Patients under the age of 40 and over the age of 80 will be excluded.

Information Packet for Preoperative, Intraoperative and Postoperative care teams.

2. Patients undergoing surgical hip procedures that last less than 1 hour or exceed 3 hours are excluded.
3. Patients who are febrile are excluded (temperature greater than 100.9 degrees F.
4. Patients with central nervous system impairment that may cause vasomotor instability or inability to feel temperature.
5. Patients with insulin-dependent diabetes will be excluded.
6. Patients with hypothyroidism or hyperthyroidism will be excluded.

Consent: No consent is required. Waiving of consent was approved by the CMC IRB.

Process: Preoperative Phase:

1. Temperature on admission will be measured with a skin temperature disc placed in the axillary area of the arm opposite the surgical site.
2. Patient will be placed into a warming gown and prewarming will be started on medium heat. Prewarming should begin within 5 minutes of temperature documentation.
3. Patients will be pre-warmed in the pre-operative setting with a Bair Paws Warming Device and gown for 30 minutes prior to surgical hip procedure.
4. Post pre-warming temperature will be recorded on data sheet within 1 minute of completion of prewarming.

Intra-operative Phase:

1. There is an intraoperative recording area on the data collection tool.
2. Temperature recording will continue via the same skin temperature skin disc intra-operatively.
3. Patient will be warmed with a Bair Hugger blanket after prepping, and draping is completed and stopped within 5 minutes of transfer to PACU.
4. Please document when warming begins and ends with the anesthesia record so that total warming times can be compared in the analysis.
5. Temperature will be recorded every 15 minutes on the anesthesia record.
6. Crystalloid should be obtained from the warmer.
7. Blood loss should be recorded in ccs.

Information Packet for Preoperative, Intraoperative and Postoperative care teams.
CMC-Mercy Pre-warming Study 1/15/15

Post-operative Phase:

1. Data collection via data sheet includes:
    a. Arrival time and skin temperature utilizing the same skin temperature method.
    b. Incidence of post-operative shivering and medication administration for shivering.
    c. Documentation of the time that the patient is ready for discharge.
    d. Actual discharge time.
    e. Data sheets will be collected and placed in a locked drawer designated by Diane Purcell and picked up by the PI (Dianne Earnhardt: 704-560-1473).

Analysis: Descriptive statistics, including means, standard deviations, counts, and percentages will be calculated. Baseline and demographic variables will be compared between the 2 groups using Student's T-test for interval data, the Wilcoxon rank sum test for ordinal data, and the chi-square test or Fisher's exact test for categorical data. A two-tailed p-value of less than 0.05 will be considered statistically significant.

After the analysis, the results will be shared with at CMC-Mercy Hospital. Thank you, everyone for your support during implementation of this project.

Sincerely,

Dianne Earnhardt CRNA, MSN

APPENDIX B: DATA COLLECTION SHEETS

Data Collection Sheets Page 1

CMC-Mercy Pre-Warming Study Data Collection Tool

For Questions: Please call Dianne Earnhardt (704) 560-1473

Patient is scheduled for a Surgical Hip Procedure with Spinal, Epidural or Combined Spinal Epidural Anesthesia and sedation.

Preoperative Phase:

Date:_____

Procedure:_____

Height:_____

Weight_____

ASA:_____

Age:_____ *(Protocol is 40-80 yrs of age)*

Patient ID Label

Prewarming Start Time	Prewarming End Time
Hour: Minute:	Hour: Minute:

Admission Skin Temperature	Post-Warming Skin Temperature
Celcius	Celcius

Prewarming Incomplete Reason *(less than 30 minutes)* **(Please Circle One)**

Patient Refusal	
Sweating	
Other:	If Other, Please Describe:

Over for Intraop and Postop Phases

APPENDIX C: DATA COLLECTION SHEETS (page 2)

CMC-Mercy Pre-Warming Study Data Collection Tool

Intra-Operative Phase

In-Room Time	
Hour:	Minute:

Surgical Incision Time	
Hour:	Minute:

Surgical Completion Time	
Hour:	Minute:

Blood Loss	
Blood Loss Amount	cc's

Was Patient warmed Intraoperative ?	Yes	No
Warming On:	Hour:	Minute:
Warming Off	Hour:	Minute:

Was 1 Cover Blanket over Bair-Hugger Used?	Yes	No

Intraoperative Temperature	
Introperative Temperature Highest:	Celcius
Intraoperative Temperature Lowest:	Celcius

Fluids: Please Use IVF from Warmer Intra-Operatively per Protocol

Warmed IVF per protocol Type and Amount (Please Circle Type & Record Amount

LR	NS	Albumin	Colloid	Blood	
					cc's

Unwarmed IV Fluid type and amount (OFF PROTOCOL) (Please Circle Type & Record Amount)					
LR	NS	Albumin	Colloid	Blood	
					cc's

Post-operative Phase

Admission Time	Admission Skin Temperature
Hour: Minute:	Celcius

Time Patient is Ready for Transfer to Floor or Unit	Actual Time Patient Transferred to Floor or Unit
Hour: Minute:	Hour: Minute:
	Temperature? (Please Circle 1) Yes No

Patient Medicated for Shivering (Please Circle One) Yes No

APPENDIX D: PREOPERATIVE INSERVICE

Preoperative Inservice

Handout: for Patient Qualifiers for CMC-Mercy Prewarming Study

IF ALL ANSWERS ARE YES PATIENT QUALIFIES FOR STUDY (No consent required)

1. Patient is scheduled for a surgical hip procedure with Spinal, Epidural or Combination Spinal Epidural

   Anesthesia…….…….....Yes No
2. Patient is over the age of 39 but less than 81 years of age…….....Yes No
3. Patient is ASA classification of I, II, or III…….…….…Yes No
4. Patient is not an insulin dependent diabetic. ……....Yes No
5. Patient does not have hypothyroidism or hyperthyroidism. ……Yes No
6. Patient has no central nervous system impairment that may cause vasomotor Instability or inability to feel temperature……...…Yes...No
7. Patient is afebrile…….....Yes...No
8. Temperature on admission will be measured with a skin temperature disc placed in the axillary area of the arm opposite the surgical site.
9. If the patient is scheduled for a supine surgical procedure, the temperature disk should be placed under the arm in the axillary area towards patients back. (Arms will be extended during surgery if the patient is supine…this will keep the temperature monitor from being exposed to the environment).

PREOPERATIVE INSERVICE (continued)

10. Patient will be placed into a warming gown and prewarming will be started on medium heat. Prewarming should begin within 5 minutes of temperature documentation.
11. Patients will be pre-warmed on medium setting for 30 minutes.
12. Post pre-warming temperature will be recorded on data sheet within 1 minute of completion of prewarming (immediately prior to transfer to OR).
13. If patient begins to perspire stop prewarming procedure and include patient in Study but note on the chart how long patient was prewarmed and note perspiring.

TABLE 1: DATA COLLECTION

Table 1: Data Collection

Preoperative Data Collection	Intraoperative Data Collection	Postoperative Data Collection
Date	Admission to Operating Room Time	Admission time
Procedure	Surgical Incision Time	Admission Temperature
Age	Intraoperative Warming Start and End Times	Incidence of Shivering
Height and Weight	Patient Intraoperative Temperature (high and low)	Time of Discharge from PACU
Prewarming Start and End Time	Discharge to PACU time	
Postwarming Temperature		

TABLE 2: DEMOGRAPHICS

Table 2: Demographics

	All Subjects	**Intervention Group**	**Comparison Group**	***p***
Age (Mean)	59.39	59.286	59.500	0.923
Gender (Counts & %)	M 28/50% F 28/50%	F 14/27.5% M 14/27.5%	F 14/27.5% M 14/27.5%	NS
ASA (Mean)	2.089	2.143	2.036	0.314
BMI (Mean)	28.290	28.345	28.236	0.942

TABLE 3: PREOPERATIVE TEMPERATURES

Table 3: Preoperative Temperatures

Preoperative Temperature					
Group	**n**	**Mean**	**SD**	**Difference**	**95%CI for Difference**
Intervention	28	98.07	0.61	0.35	-0.67 to -0.03
Comparison	28	97.71	0.58		

TABLE 4: INTRAOPERATIVE TEMPERATURES

Table 4: Intraoperative Temperatures

Intraoperative Temperature					
Group	**n**	**Mean**	**SD**	**Difference**	**95%CI for Difference**
Intervention	28	96.80	2.03	1.76	-3.00 to -0.52
Comparison	28	95.04	2.58		

TABLE 5: POSTOPERATIVE TEMPERATURES

Table 5: Postoperative Temperatures

Postoperative Temperature					
Group	**n**	**Mean**	**SD**	**Difference**	**95% CI for Difference**
Intervention	28	97.84	0.35	0.25	-0.50 to -0.01
Comparison	28	97.59	0.54		