A Quality Improvement Initiative to Reduce Postoperative Hypothermia after Cardiac Ablation

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Table of Contents

Abstract……4

Introduction……..6

Background……..6

Problem Statement……...8

Organizational "Gap" Analysis of Project Site……8

Review of the Literature……..9

Evidence-Based Practice: Verification of Chosen Option…….13

Evidence-Based Practice Model……14

Goals, Objectives, and Expected Outcomes……..……16

Setting Facilitators and Barriers…….17

Methods…….17

Project Design……19

Project Site and Population……19

Measurement Instrument(s)……...20

Data Collection Procedure…….22

Data Analysis…….23

Cost-Benefit Analysis/Budget……...24

Timeline…….24

Ethical Considerations/Protection of Human Subjects…….....25

Results……25

Interpretation/Discussion……...27

Limitations…….30

Conclusion…….32

References……..34

Appendix A……..…….....40

Appendix B……..…….....50

Appendix C……..……..51

Appendix D……..…….....52

Appendix E……53

Appendix F……..…54

Appendix G……55

Figures……..……..57

Tables…….58

Abstract

Introduction/Purpose

Hypothermia, a core temperature less than 36°C, occurs in approximately 70% of all surgical procedures and can lead to numerous complications, including increased healthcare costs, discomfort, bleeding, and surgical site infections. ASPAN's Second Edition of Evidence-Based Clinical Practice Guidelines for the Promotion of Perioperative Normothermia (ASPAN 2010 Normothermia Guidelines) are cost-effective, easy to implement, and have demonstrated success in reducing hypothermia. The purpose of this quality improvement project was to determine if the integration of ASPAN 2010 Normothermia Guidelines reduced postoperative hypothermia and recovery time in patients undergoing cardiac ablation with general anesthesia.

Methods

This retrospective cohort analysis was conducted for patients receiving cardiac ablation treatment over a twelve-week time frame. Subjects were divided into two groups: a pre-intervention group (n=26), which consisted of patients who received care over a six-week period before the implementation of ASPAN 2010 Normothermia Guidelines, and a post-intervention group (n=29) consisting of patients who received care for six weeks with guidelines in place. An electronic health record review of cardiac ablation patients was conducted to compare the difference in PACU discharge times, the occurrence of hypothermia, and how well body temperature was maintained between the groups following cardiac ablation procedures under general anesthesia.

Results

A total of 55 electronic medical records were reviewed of patients receiving cardiac ablation under general anesthesia over a twelve-week timeframe. The occurrence of hypothermia in the

pre-intervention group was 3.85%, while there was none in the post-intervention group. Compared with the pre-intervention group (*M*=53.6 minutes, *SD*=18), patients meeting inclusion criteria in the post-intervention group (*M*=44.73 minutes, *SD*=9.78) spent less time recovering from anesthesia in PACU; $t(42) = 2.03$, $p = 0.048$. Body temperatures in the pre-intervention group (*M* = -0.068°C, *SD* = 0.456) fell throughout the perioperative period while the post-intervention group's temperature (*M* = 0.154°C, *SD* = 0.275) was higher following cardiac ablation; $t\ (41) = -2.13$, $p = 0.04$.

Discussion/Conclusion

This analysis reveals that the application of ASPAN 2010 Normothermia Guidelines reduced recovery time and improved average patient temperatures throughout the perioperative period in patients undergoing cardiac ablation under general anesthesia in our medical center.

Keywords: Hypothermia, Anesthesia, Normothermia, ASPAN Guidelines

A Quality Improvement Initiative to Reduce Postoperative Hypothermia after Cardiac Ablation

For many years, the incidence of hypothermia has been a concern for health care providers in the perioperative setting. Inadvertent perioperative hypothermia (IPH) can lead to an abundance of complications that are detrimental to the health of the patient (Campbell et al., 2015; Pereira & De Mattia, 2019; Yi et al., 2017). Therefore, it is critically important to optimize normothermia in patients at risk for hypothermia. Clinical practice guidelines established by the American Society of PeriAnesthesia Nurses provides a research-based framework that clinicians can implement to reduce IPH in the clinical setting (American Society of PeriAnesthesia Nurses [ASPAN]; Hooper et al., 2010). This quality improvement project was conducted to determine the efficacy of these guidelines in a particularly susceptible cohort, cardiac ablation patients in the cardiac catheterization laboratory (cath lab).

Background

For over a century, providers have understood the correlation between reduced body temperature and the induction of anesthetic agents (Hare, 1888). IPH is very common in patients under general anesthesia and is defined by Bindu et al. (2017) as a core body temperature of less than 36 °C. Hypothermia can lead to a vast array of complications including shivering, patient discomfort, coagulopathy, cardiac arrhythmias, a delayed emergence from anesthesia, pain, nausea, surgical site infections, and a prolonged hospital stay (Campbell et al., 2015; Pereira & De Mattia, 2019; Yi et al., 2017). These complications can increase the overall cost of healthcare, reduce patient satisfaction, and pose a significant threat to the overall well-being of the surgical clientele (Cobb, Cho, Hilton, Ting, & Carvalho, 2016; Yi et al., 2017).

Under normal conditions, the body excels in managing core temperature, even down to the cellular level. However, the induction of anesthesia causes a precipitous decline in body temperature (Sessler, 2016). This decrease in core temperature is especially prevalent during the first hour of anesthesia and can last long into the postoperative period (Sun et al., 2015).

Patients undergoing cardiac ablation procedures in this regional medical center are at risk for complications related to IPH. This vulnerable population is often elderly, frail, and presents with a myriad of pre-existing comorbidities, which can be exacerbated by IPH (Kundi et al., 2020). Cardiac procedures increase the likelihood of IPH due to their prolonged duration, especially when prophylactic warming measures are not implemented (Li, Liang, & Feng, 2020). On average, cardiac ablation procedures in this cardiac cath lab are two to four hours in duration.

Preoperatively, while vascular access is secured, patients' extremities are exposed for prolonged periods. Intraoperatively, these cardiac ablation procedures require a motionless field for accurate diagnostic mapping of the cardiac structures. Due to the discomfort and duration of the procedure, general anesthesia is often needed. Procedural longevity, long periods of bodily exposure to cool ambient air, and the need for general anesthesia collectively contribute to the IPH experienced in this patient population (Li, Laing, & Feng, 2020). Unfortunately, healthcare providers often consider temperature conservation a low priority during the pre-procedure period. A structured, easy-to-implement set of clinical practice guidelines aimed at limiting these adverse outcomes would benefit patients.

ASPAN 2010 Normothermia Guidelines have demonstrated success in reducing the incidence of IPH and controlling healthcare costs (Kang & Park, 2020). Establishing these guidelines within the cardiac ablation program at this facility would provide a systematic, evidence-based approach to IPH prevention. Reduction in IPH could also reduce recovery time

in the PACU, decrease the incidence of shivering, and reduce the length of the overall hospital stay (Poveda & Nascimento, 2017; Yi et al., 2017). The purpose of this project was to implement ASPAN 2010 Normothermia Guidelines for patients undergoing cardiac ablation therapy in hopes that the occurrence of IPH would decrease.

While the initiation of a protocol such as the ASPAN 2010 Normothermia Guidelines could significantly benefit patient care in the cardiac cath lab, the use of this protocol could be expanded into all perioperative settings. These guidelines could also increase provider awareness of the occurrence of IPH in all areas of the hospital and provide a systematic approach to improving the quality of care in our facility.

Problem Statement

Despite standard intraoperative warming measures at this regional medical center, IPH continues to stymie the patients' recovery from anesthesia following cardiac ablation procedures. Unfortunately, this could lead to hypothermia-related complications. Prior to this project, there had been no data collection to determine if an evidence-based protocol for peri-anesthesia personnel could mitigate the occurrence of IPH.

Organizational "Gap" Analysis of Project Site

The incidence of IPH in patients recovering from cardiac ablation procedures had been verbally expressed, by nursing staff, as a growing cause for concern at our regional medical center. The goals of this project were to determine whether the implementation of ASPAN 2010 Normothermia Guidelines reduced the duration of recovery and the incidence of IPH in cardiac ablation patients. Ideally, all patients would be normothermic throughout the entire perioperative period. Also, IPH could be minimized through a standardized protocol grounded in evidence-based techniques. Should the findings from this project reveal that these guidelines effectively

reduce IPH for cardiac ablation patients, practice changes could be made in other perioperative environments to improve outcomes in all peri-anesthesia areas.

Observational analysis and interviews from the PACU staff revealed that IPH occurred in at least one cardiac ablation patient per week. Furthermore, shivering, a verbalized level of discomfort, and prolonged awakening were prevalent in this group. There was an apparent gap in care from both the anesthesia and perioperative nursing teams that could reduce IPH.

Review of the Literature

Using the CINAHL and PubMed databases, a search was conducted using MeSH terms hypothermia, ASPAN, and cardiac catheterization, yielding no results. However, when the term anesthesia was added to the search, 771 results were identified. Excluding articles published before 2016 and only including randomized controlled trials published in English, the terms were used in various combinations resulting in 39 items for review. The final 39 resulting publications were read for relevance and comparability. Secondary exclusions were made for duplications and topics not pertaining to warming measures found in the ASPAN 2010 Normothermia Guidelines. Following these secondary exclusions, 13 articles remained and can be found in the literature matrix (Appendix A).

Dating as far back as the late 1880s when Hare (1888) discovered temperature changes in patients receiving vaporized ether, experts in the medical community have been mindful of the effects of IPH from anesthetic medications on surgical patients. Morley (1903) described the loss of body heat under anesthesia due to "dilated skin vessels and to lessened heat production from diminished muscular movement" (p. 514). Morley's recommendations to prevent this phenomenon included warming the bed and wrapping the chest, arms, and legs with lint and bandages.

After the first half of the 20th century, scientists began studying not only the effects of hypothermia under general anesthesia but also its frequency. In a retrospective analysis of patients undergoing general anesthesia in China, Yi and colleagues (2017) found that nearly half of patients experience intraoperative hypothermia. Sagiroglu et al. (2020) evaluated patients undergoing abdominal surgery and found that over 63% of their subjects experienced inadvertent intraoperative hypothermia. Li et al. (2020) discovered that nearly 73% of patients undergoing thoracoscopic procedures became hypothermic during surgery. Jun et al. (2018) identified hypothermia in almost 90% of patients undergoing prostate surgery with passive warming methods. Despite more than a century of studies revealing the threat of hypothermia, healthcare providers have only reduced its occurrence modestly (Brodshaug et al., 2019; Jun et al., 2018; Sagiroglu et al., 2020; Yi et al., 2017).

While nearly everyone undergoing anesthesia will experience a decrease in body temperature, some risk factors predispose patients to IPH more than others. Li, Liang, and Feng (2020) found a correlation between hypothermia and procedures lasting longer than two hours, surgery in the morning, a BMI of less than 24 kg/m^2, and general anesthesia. Studies by Frisch et al. (2016) and Sagiroglu et al. (2020) agreed, associating hypothermia in patients with a lower BMI, advanced age (>52 years), and prolonged procedures under general anesthesia. Other risk factors of IPH include transfusion of blood products and excessive intravenous fluids, tobacco smoking, and male gender (Sagiroglu et al., 2020; Wetz et al., 2016).

Hypothermia can have detrimental effects on patient outcomes. According to Sessler (2016), the most common complication found in the literature that is associated with IPH is impaired coagulation. IPH leads to an increased need for blood transfusion and a lower hemoglobin and hematocrit level in surgery patients (Frisch et al., 2017; Sagiroglu et al., 2020).

Intraoperative hypothermia is associated with postoperative shivering, an increase in the number of intensive care unit (ICU) admissions, and a more extended postoperative stay in the hospital (Jun et al., 2020; Yi et al., 2017). According to Yi et al. (2017), hypothermia leads to overall poorer outcomes and increases the financial burden on the healthcare system.

One common theme demonstrated throughout the literature: actively warming patients prior to arrival in the operating suite reduces the likelihood of postoperative hypothermia (Baradaranfard et al., 2019; Bayter-Marin et al., 2018; Bräuer et al., 2019; Conway et al., 2018; Grote, 2018; Jun et al., 2018; Kay et al., 2019; Lau et al., 2018; Sessler, 2016; Yi et al., 2017). Prewarming orthopedic patients before total joint arthroplasties of both the knee and hip reduce the incidence of perioperative hypothermia by 30% (Kay et al., 2019). A retrospective review of nearly 8,000 patients who received prewarming through guidelines established by the Association of the Scientific Medical Societies in Germany demonstrated a significant reduction in both intraoperative and postoperative hypothermia (Grote et al., 2018). A randomized controlled trial in South Korea by Jun and colleagues (2018) revealed that patients who received active warming before prostate surgery experienced less hypothermia upon arrival to PACU and less shivering.

Though the literature was consistent in describing the benefits of actively pre-warming patients, there are mixed results regarding the duration of warming needed during the preoperative phase. Lau et al. (2018) found that at least 30 minutes of preoperative warming reduced hypothermia periods following the induction of anesthesia. Bayter-Marin and fellow researchers (2018) recommend pre-warming for one hour. In addition to reducing IPH, Akhtar and colleagues (2016) discovered that prewarming patients before surgery increased patient comfort and overall satisfaction. Sessler (2016) indicated that, unlike pain or nausea, the

memories associated with IPH-induced thermal discomfort are intense and can last for years after surgery. According to Bayter-Marin et al. (2018), the economic costs of pre-warming are minimal and outweigh the risks associated with IPH, such as prolonged recovery times, nausea, and pain.

Ensuring that patients have intravenous (IV) fluids that are warmed in advance is also beneficial. A randomized control trial conducted on patients undergoing cesarean section revealed that the incidence of perioperative shivering and hypothermia was drastically lower in patients who received warmed IV fluids and forced-air warming throughout the procedure (Jun et al., 2019). Zaman et al. (2018) compared IV fluids at ambient room temperatures with warmed IV fluids and found that warmed fluids reduce the risk of IPH after abdominal surgery. Furthermore, patients receiving warmed fluids had less shivering and warmer core temperatures both on admission to PACU and 30 minutes after PACU arrival (Zaman et al., 2018).

ASPAN 2010 Normothermia Guidelines provide direction in advance of surgery by requiring the preoperative staff to assess both the patient's temperature and thermal comfort (Hooper, 2008). These guidelines address preoperative thermal discomfort and preoperative hypothermia preceding anesthesia to minimize the risk of IPH and its associated complications. Kang and Park (2020) recently demonstrated the effectiveness of these clinical practice guidelines in patients undergoing general anesthesia for upper extremity surgery. They found a significant reduction in the incidence of shivering, thermal discomfort, and body temperature.

While there is a wealth of information on hypothermia in the general operating room, there is a scarcity of data on hypothermia in patients in the cardiac cath lab setting. Conway et al. (2018) conducted a randomized controlled trial in cardiac cath lab patients receiving sedation for cardiac procedures in the cath lab. Their study compared the effects of passive thermal warming

with blankets with active forced-air warming. Results showed improved thermal comfort and a reduction in hypothermia in patients receiving forced-air warming. However, the patients in their study received only IV sedation rather than general anesthesia. There is a gap in the literature describing hypothermia in the cath lab setting in patients undergoing more lengthy procedures such as cardiac ablations. Hypothermia prophylaxis in more lengthy procedures is an area for future research. Also, there is a scarcity of studies in the cath lab setting in patients undergoing general anesthesia. A standardized, evidence-based protocol would fill this void. This project aimed to evaluate the effectiveness of ASPAN 2020 Normothermia Guidelines on IPH in the cath lab in one regional medical center.

Evidence-Based Practice: Verification of Chosen Option

The American Society of PeriAnesthesia Nurses' Normothermia Clinical Guidelines (ASPAN, 2020) were initially established in 2001 to guide healthcare workers to prevent and reduce perioperative hypothermia. These guidelines were developed based upon mounting evidence in the 1990s that IPH contributed to multiple complications. At the turn of the century, representatives from ASPAN developed the organization's first clinical practice guidelines designed to combat this issue. With the evolution of data on hypothermia that emerged in the years after that, ASPAN felt the need to update and modify its existing 2001 version due to the continued incidence of hypothermia during the perioperative period (Hooper et al., 2010).

The team responsible for updating ASPAN guidelines consisted of professionals from a variety of disciplines, including the American Association of Nurse Anesthesia (AANA), the American Society of Anesthesiologists (ASA), the Association of Perioperative Nurses (AORN), as well as ASPAN (ASPAN, 2020). Together, these organizations worked to develop a reliable and robust bedside tool for all perioperative team members. For this project, the second edition

of ASPAN Guidelines from 2010 was introduced to hospital employees and implemented due to their simplicity, cost-effectiveness, and remarkable success. The PICOT question for this project was: In adults under general anesthesia for cardiac ablation therapy (P), does the implementation of ASPAN 2010 Normothermia Guidelines (I) affect (C) the occurrence of IPH (O) following six weeks of implementation (T)?

Evidence-Based Practice Model

Integrating the ASPAN 2010 Normothermia Guidelines into practice at our facility required a systematic approach and framework. The process was guided through the use of an evidence-based practice model. Rosswurm and Larrabee (1999) developed a model that "guides nurses and other healthcare professionals through a systematic process for change to evidence-based practice." (p. 317). Their model serves as a guide to healthcare professionals who want to induce a change in the workplace through research appraisal and integration (see Appendix B). The six steps in Rosswurm and Larrabee's Model for Change to Evidence-Based Practice are:

1. Assess need for change in practice
2. Link problem with interventions and outcomes
3. Synthesize best evidence
4. Design a change in practice
5. Implementing and evaluating change in practice
6. Integrate and maintain change in practice.

Step one of the Rosswurm and Larrabee (1999) model began with an overall assessment of the need for change. In this regional medical center's PACU, seven out of ten nurses agreed that a difference in our warming protocol would benefit patients undergoing cardiac ablation. Also, all but one of the 10 PACU providers felt that we had not done enough as peri-anesthesia

nurses to keep patients warm after cardiac ablation procedures. Step two involved linking the problem with interventions and outcomes. According to Rosswurm and Larrabee (1999), an issue such as hypothermia must be connected with a standardized intervention or outcome, which we can determine from both the Nursing Outcomes Classifications (NOC) and Nursing Interventions Classifications (NIC). These resources provide a list of outcomes and interventions, respectively, that allow nursing leaders to determine the effectiveness of nursing interventions (Moorhead, Johnson, Maas, & Swanson, 2013). The NOC and NOC Likert scale spreadsheets are organized based on taxonomy. Specific outcomes and interventions for this project included identifying factors that cause IPH and monitoring the environment to prevent hypothermia.

The third step in the Rosswurm-Larrabee (1999) model involved synthesizing the best evidence by analyzing research findings. Researching the spectrum of evidence-based protocols through databases CINAHL and PubMed was conducted by the principal investigator. The ASPAN 2010 Normothermia Guidelines were appraised and felt satisfactory for this project, as they have been cost-effective and efficient in reducing hypothermia in previous research. Step four of the model involved designing a "change in practice" (Rosswurm & Larrabee, 1999, p. 320). An example of this step included readying the staff to begin the use of ASPAN protocols through a group conference in which the principal investigator introduced ASPAN Normothermia Guidelines to all peri-anesthesia team members. The team had to adjust and make changes in their daily routines to comply with the guidelines. Some of the necessary modifications included assessing oral temperatures upon arrival in the preoperative receiving room, ensuring the staff members were aware of the recommended operating room temperature, and using warmed intravenous fluids for procedures. This phase of team preparation was both mentally and physically challenging to the staff as they made necessary changes to comply with

ASPAN 2010 Normothermia Guidelines.

Step five encompassed the implementation of the ASPAN protocol and evaluation of its effectiveness with cardiac ablation patients. This critical phase in the retrospective assessment and appraisal ensured that all interventions were conducted per ASPAN 2010 Normothermia Guidelines. Through adherence to the guidelines, patients were more likely to remain warm throughout all phases of their perioperative experience. Following six weeks of carrying out ASPAN 2010 Normothermia Guidelines, the evaluation began. The evaluation process compared medical record data from six weeks of cardiac ablation procedures without guidelines in place with the six-week period in which care was provided following the implementation of ASPAN 2010 Normothermia Guidelines. Provider feedback was essential to ensure progress and stakeholder support. Collecting feedback and evaluation led to step six in the Rosswurm-Larrabee (1999) model, the phase where the protocol was integrated and maintained into the daily practice for cardiac ablation patients.

Goals, Objectives, and Expected Outcomes

The primary objective of this project was the determine if the implementation of ASPAN 2010 Normothermia Guidelines would reduce IPH in cardiac ablation patients under general anesthesia in a regional medical center. Guidelines established by ASPAN have been effective in lowering the rate of IPH in patients undergoing upper extremity surgery (Kang & Park, 2020) and in other settings. The primary outcome expected with this project was an oral temperature of 36°C or higher immediately upon arrival to the PACU following cardiac ablation procedures. Secondary data expectations included a reduction in the number of minutes spent in PACU and a reduced drop in body temperature throughout the perioperative course of treatment. This change in body temperature was determined by measuring the difference between the preoperative and

the postoperative temperature. Data were collected by the principal investigator by a retrospective medical record review and logged into the University of Alabama Box online data storage account.

Setting Facilitators and Barriers

The nursing staff in all areas of care pertinent to this project were registered nurses (RNs) with five to 30 years of experience in the perioperative setting. Project team members received instructions at the commencement of the ASPAN 2010 Normothermia Guidelines and supported the project. The cardiologist conducting the ablations was also supportive of the project. Anesthesia personnel received education on the guidelines before they were implemented and were responsible for ensuring they were followed. Administrators from all departments were excited about the potential benefits of this quality improvement project and were fully supportive. Resource allocation was minimal, as the equipment needed was already available for use.

Barriers to the successful implementation of this project included negligence or erroneous implementation of the guidelines by staff members. For this project to be successful, all team members had to follow ASPAN 2010 Normothermia Guidelines, accurately document data, and appropriately assess each patient's hypothermia risk factors. The ASPAN 2010 Normothermia Guidelines Data Collection Tool and Checklist (Appendix C) was an easy-to-follow tool for perioperative nurses.

Methods

Patients undergoing elective cardiac ablation procedures arrived in the preoperative holding room. Here, the pre-procedure nursing staff members performed an interview and conducted a preoperative baseline assessment that included temperature, the presence of

shivering, and the feeling of thermal discomfort. This information was documented on the ASPAN Normothermia Guidelines Data Collection Tool and Checklist (Appendix C) and was used to guide the warming measures.

The pre-procedure holding area was also where members of the anesthesia team obtained vascular access. Obtaining adequate vascular access was critical for the procedure and was identified as a vulnerable time for core temperature cooling as the patients' extremities were exposed for prolonged periods. During this phase, prewarming measures and passive warming through the placement of warmed blankets were initiated using ASPAN 2010 Normothermia Guideline recommendations.

Upon departure from the pre-procedure holding area, passive warming was again provided during transport to the cardiac cath lab. Protocol guidelines for ambient temperature and warming measures continued throughout the entirety of the procedure. Post-ablation, patients were returned to the PACU area, where post-procedure data collection occurred. Upon arrival to the PACU, the nursing staff obtained an oral temperature reading to evaluate body temperature. A standardized Welch Allyn SureTemp® Plus 692 thermometer designated for this project was used. The patient's oral temperature was documented in the medical record.

After six weeks of post-intervention data collection, the overall incidence of hypothermia was determined. The duration of time in PACU and the change in body temperature experienced by the patient throughout the procedure were also documented. All of these figures were compared to the six weeks of data preceding the implementation of guidelines. Data was entered into Minitab® statistical software, and independent *t*-tests were used to determine the effectiveness of the ASPAN 2010 Normothermia Guidelines. With the implementation of these safe, affordable interventions with cardiac ablation, the goal was to reduce the occurrence of

IPH, hasten recovery times, and promote the maintenance of core body temperature in elective cardiac ablation patients.

Project Design

A retrospective chart review of two groups of cardiac ablation patients was conducted to analyze the efficacy of ASPAN's guidelines in cardiac ablation patients. The control group consisted of patients who had received care based on traditional warming methods in the six weeks before initiating ASPAN's 2010 Normothermia Guidelines. The second group consisted of patients who had received care six weeks after the guidelines were implemented.

According to the authors of the ASPAN 2010 Normothermia Guidelines, assessment of near core temperatures is best carried out through an oral reading, which best approximates core temperature (Hooper et al., 2010). Therefore, oral temperature readings were collected from the medical records of both groups. Also, the duration of time spent in the PACU was obtained. This retrospective cohort design comparing both temperature and PACU duration were utilized for this project.

Project Site and Population

The initiative to reduce hypothermia in elective cardiac ablation patients took place in the cardiac cath lab of a regional medical center in southeast Alabama. The electrophysiologist was a board-certified cardiologist trained to perform radiofrequency and cryotherapy cardiac ablations in patients with irregular heart rhythms. This 400-plus bed hospital, the area's largest not-for-profit regional medical center, serving not only southeast Alabama but also southwest Georgia and northwest Florida.

Participants for this project included nursing staff from all three aspects of the perioperative setting. Also, the anesthesia care team, comprised of both certified registered nurse

anesthetists (CRNAs) and physician anesthesiologists (MDAs), had a role. The preoperative nursing staff assessed the patients' temperature and implemented the necessary warming measures to comply with the ASPAN 2010 Normothermia Guidelines. Forced-air warming and passive warming through warmed blankets were provided and used for warming during this period.

The perioperative cath lab nursing staff and anesthesia staff ensured the patient remained warm throughout transport and upon arrival to the cardiac cath lab. As designated by the ASPAN 2010 Normothermia Guidelines, interventions to ensure normothermia were continued until the end of the procedure. After the ablation, the patient was transferred to the PACU. Upon arrival to PACU, the patient's oral temperature was measured and documented. Interventions pertaining to the guidelines concluded after the patient is discharged from the PACU.

Inclusion criteria for patients receiving care following ASPAN 2010 Normothermia Guidelines in patients aged more than 18 years undergoing general anesthesia for cardiac ablation. Exclusion criteria included failure by perioperative staff to comply with ASPAN 2010 Normothermia Guidelines and procedures that were either canceled or had an unexpected complication.

Measurement Instruments

The ASPAN 2010 Normothermia Guidelines Data Collection Tool and Checklist (Appendix C) was provided for team members on every patient's chart in the ASPAN 2010 Normothermia Guidelines group. This guide mirrored ASPAN 2010 Normothermia Guidelines and included a checklist of items that ensured that the guidelines were followed correctly. First, registered nurses in the preoperative holding area assessed all pertinent topics of interest, such as oral temperature assessment, the presence of shivering, or verbalized thermal discomfort. Based

on this assessment, ASPAN 2010 Normothermia Guidelines required the initiation of forced-air warming or passive warming with heated blankets. The Data Collection Tool and Checklist (Appendix C) continued with the patient throughout treatment until reaching the PACU. Post-procedure data, such as temperature, was documented in each patient's medical record. After the project, data from these patients' medical records were uploaded to a password-protected UA Box account by the investigator. Any hard copies of these forms were shredded immediately upon transfer of data into the Box storage account. All data were de-identified of personal health information.

Throughout this project, the primary instrument used to measure the primary outcome of oral temperature upon arrival to the PACU was the Welch-Allyn SureTemp® Plus 692 thermometer manufactured by Welch Allyn. To ensure reliability and minimize measurement bias, a designated oral thermometer was used for this project in both the preoperative and postoperative areas. Validity was maximized by ensuring the thermometer was calibrated appropriately by the hospital's biomedical team before implementing the project. Also, using a standardized, easy-to-understand tool for data collection, validity and reliability are optimized.

The Pre-intervention Data Collection Tool (Appendix D) was utilized by the principal investigator during the data collection process to organize the information collected from individuals' electronic health records before the implementation of care guided by ASPAN's guidelines. Data collected after the implementation of ASPAN 2010 Normothermia Guidelines was documented on the Post-intervention Data Analysis Tool (Appendix E). These classified and de-identified records allowed for analysis and comparison of the two groups to determine the effectiveness of the ASPAN 2010 Normothermia Guideline intervention.

As part of the passive warming protocol, warmed blankets and fluids were used. The Steris Amsco® warming cabinet dual compartment warmer was located in areas of patient care. Warming cabinet temperature checks were conducted daily, per hospital policy, to ensure the temperature of both the fluids and the blankets remained at safe manufacturer recommendations. These measurements were visible via a digital screen on the front of the cabinet. A daily written temperature log was also attached to the door of the unit. According to our hospital's policy, the IV fluid compartment remained less than 104°F. The compartment on the bottom of the unit housed warmed blankets, which were safe up to 130°F.

Forced-air warming was a critical step taken in all phases of the ASPAN 2010 Normothermia Guidelines. Forced-air warming has been studied for years and found to be very effective at reducing the incidence of IPH (Cobb, Cho, Hilton, Ting, & Carvalho, 2016). Our facility used the Arizant Healthcare Bair-Hugger Model 750® accompanied by the manufacturer's warming blankets. These blankets came in various models, including an upper body, lower body, full-body, and underbody layouts. The two types of warming blankets used for cardiac ablations in our facility were primarily upper body or underbody because sterile groin access was mandatory for the procedure. The Bair-Hugger warming units had been inspected, calibrated, and maintained by the regional medical center's service department to comply with the manufacturer's recommendations for safe use.

Data Collection Procedures

Following IRB approval, retrospective chart reviews were performed via electronic Paragon software. This review of medical records was carried out for both the pre-intervention and post-intervention groups on all cardiac ablation procedures under general anesthesia. The pre-intervention group consisted of cardiac ablation recipients in the six weeks leading up to the

implementation of ASPAN 2010 Normothermia Guidelines. The post-intervention group consisted of a six-week period in which patients received care guided by ASPAN's protocol. Data collected from these electronic medical records included both the preoperative and postoperative oral temperature measurements, as well as the duration of time spent in the PACU.

No patient identifiers were used in this project. Patients in the pre-intervention group were listed in sequence and given a three-digit code, with the first subject receiving the code "001". Participants in the post-intervention group also were ordered chronologically, with the first person coded as "101". These data were entered and stored electronically on a university-provided Box storage account with password protection. All paper tools were immediately shredded upon electronic entry into the Box storage account.

Following the six-week post-implementation period, the data were analyzed using Minitab® statistical software. Since two independent groups were being compared, the independent sample *t*-test was used to analyze the groups and to determine if the guidelines reduced IPH (Kim, 2019). All findings were disseminated throughout the perioperative locations for further modifications and future planning.

Data Analysis

An independent, two-sample *t*-test was conducted comparing the data from both the Pre-intervention Data Collection Tool (Appendix D) and the Post-intervention Data Collection Tool (Appendix E). Group One (pre-intervention) consisted of patients who underwent cardiac ablation under general anesthesia in the six weeks before the implementation of ASPAN 2010 Normothermia Guidelines. Findings from this group were collected from the electronic medical records, de-identified, and documented on a Pre-intervention Data Collection Tool (Appendix D). Group Two (post-intervention) was made up of participants who received a cardiac ablation

post-implementation of the ASPAN 2010 Normothermia Guidelines. Data were collected from six weeks of implementation and documented on a Post-intervention Data Collection Tool (Appendix E). Since two independent groups were being compared, the independent sample *t*-test was used to analyze the groups' data (Kim, 2019).

Cost-Benefit Analysis/Budget

Implementing ASPAN 2010 Normothermia Guidelines had minimal to no impact on healthcare costs. The time to educate the staff on these guidelines during our monthly quality improvement meeting added no additional expense to our facility. At this meeting, a brief presentation was conducted by the primary investigator, and a handout of the guidelines was distributed to the anesthesia staff. Members of the perianesthesia team were also educated during a brief meeting and an informational handout distributed. The ASPAN 2010 Normothermia Guidelines require standard temperature monitoring, forced-air warming, warmed intravenous fluids, and passive warming methods. These activities were readily available to staff and did not increase costs because of their pre-existing availability. There was no cost to the patient, as these warming techniques are conducted routinely for most surgical patients. This project could minimize postoperative complications, which include cardiac irregularities in rhythm, shivering, thermal discomfort, and potential infection. Therefore, the benefits of this project far outweighed the cost of implementation.

Timeline

After receiving approval from the university and institutional review board (IRB), project implementation and data collection occurred over a twelve-week period. The data was then analyzed using an independent samples *t*-tests to determine whether statistically significant differences between the two groups. Following statistical analysis and comparison of data, the

two groups were compared to determine if the intervention (integration of ASPAN 2010 Normothermia Guidelines) improved the incidence of IPH. Once the outcomes of the project were identified, the findings were disseminated amongst the providers at the monthly staff meeting via a Microsoft PowerPoint presentation. The end goal for this project was to write a report detailing the conclusive results and the timeline of the project (Appendix F).

Ethical Considerations/Protection of Human Subjects

Approval was obtained from the University of Alabama's IRB (see Appendix G) before data collection for the DNP Project. Also, IRB approval was received through the local regional medical center's IRB panel to ensure the privacy and protection of all subjects reviewed for the project. The participants included in this study were protected by the Health Insurance Portability and Accountability Act of 1996, also known as HIPAA. Through HIPAA, personal information such as identification and health history are guaranteed to remain privatized (U.S. Department of Health and Human Services, 2013). Furthermore, the nursing staff and anesthesia personnel involved in this project followed the *Standards of Care* for the practice setting where the guidelines were implemented.

Data collected as a result of this project were de-identified and securely stored. The participants' coded numbers were kept in a password-protected UA Box storage account accessible only to the principal investigator. All physical documents, such as the data collection tools, were shredded immediately upon electronic entry into the UA Box storage account.

Results

Data from 55 electronic medical records were abstracted from cardiac ablation patients undergoing general anesthesia over a twelve-week timeframe. The pre-intervention data consisted of select information from 26 electronic medical records of patients who underwent

cardiac ablation before implementing ASPAN's 2010 Normothermia Guidelines. Pre-intervention cases occurred during a six-week period between July and August of 2020. Of these, one patient (3.85%) experienced IPH upon arrival to the PACU. All but four patients required Phase I recovery and were transferred to the PACU following their procedure. Therefore, PACU discharge times were available for 22 patients and ranged between 30 and 96 minutes. Temperatures taken upon arrival to the PACU in this group ranged between 35.5°C and 37.2°C.

The pre-intervention group's average temperature in the pre-procedure holding area was 36.72°C, with an average post-procedure temperature of 36.63°C. Therefore, before implementing the ASPAN 2010 Normothermia Guidelines protocol, there was an overall reduction in core body temperature of 0.07°C throughout the peri-procedure period. One patient in the pre-intervention group did not have a documented pre-procedure temperature. Therefore, the first temperature recorded upon arrival to the cath lab was used for the project.

Altogether, 29 patients received care with ASPAN 2010 Normothermia Guidelines for six weeks between August and October 2020. With these guidelines in place, there were no incidences of hypothermia upon arrival to the PACU. Three patients in the post-intervention group required prolonged recovery and were excluded due to complications unrelated to the project. As with the pre-intervention group, four patients in the post-intervention group met the criteria to bypass PACU and were transferred directly to the step-down unit for Phase II recovery. Of the remaining 22 patients, body temperatures in the post-intervention group ranged from 36.4°C to 37.2°C upon entry into the PACU. Also compared were temperature changes between this group's preoperative and postoperative readings and found to be an overall average (*SD*) increase of 0.15°C (*0.27*).

An independent, two-sample t-test was performed to evaluate how effective the ASPAN 2010 Normothermia Guidelines were in improving postoperative body temperatures, thereby reducing the incidence of IPH. The change in body temperature during the perioperative period was measured by assessing the difference between the preoperative temperature and the postoperative temperature in both groups (see Figure 1). The group receiving ASPAN 2010 Normothermia Guidelines (M = 0.154°C, SD = 0.275) was warmer and maintained body temperature better than the control group, M = -0.068°C, SD = 0.456); t (41) = -2.13, p = 0.04 (see Table 1). Additionally, a two-sample t-test to compare the groups' duration of recovery. Patients in the pre-intervention group (M=53.6 minutes, SD=18) spent more time in the PACU than the post-intervention group (M=44.73 minutes, SD=9.78) following cardiac ablation, t(42) = 2.03, p = 0.048 (see Table 2).

Interpretation/Discussion

Based on the findings, the application of the ASPAN 2010 Normothermia Guidelines in the cardiac ablation patients at this facility was beneficial, both clinically and statistically, in hastening recovery and improving temperature throughout the perioperative period. Members of the post-implementation group were discharged from the PACU nearly nine minutes sooner. Furthermore, while the pre-intervention group's average temperature dropped throughout the cardiac ablation procedure, the post-intervention group experienced an overall increase in body temperature throughout their perioperative stay. Though these findings were the only measured outcomes, several other conclusions resulted from this project.

After the commencement of the ASPAN 2010 Normothermia Guidelines had begun, members of the postoperative nursing staff felt improvements were made in patient satisfaction and thermal comfort. Indeed, these guidelines were aggressive in their step-by-step, methodical

approach to patient warming; they also emphasized the importance of hypothermia prevention by ensuring a frequent evaluation of the patient's satisfaction and overall feeling of warmth. Akhtar and colleagues (2016) also found that satisfaction was significantly increased if the patients were warm throughout their entire perioperative experience. These periodic assessments presented caregivers with numerous opportunities to deliver warming measures while providing patients with a sense of control in their care. Through increased patient involvement and a more frequent assessment, our project has revealed several flaws in how we formerly practiced hypothermia prevention.

This practice's previous efforts to warm patients included warmed intravenous fluids, blankets, and intraoperative forced-air warming. However, the ASPAN 2010 Normothermia Guidelines recommend increasing procedure room temperatures to at least 68°F, a practice that had previously been often overlooked. In addition, prewarming in the preoperative holding area was initiated. A large body of evidence substantiates the benefits of warming patients long before their exposure to cold operating room environments (Ahktar et al., 2016; Bayter-Marin et al., 2018; Bräuer et al., 2019; Grote et al., 2018; Jun et al., 2018; Kay et al., 2019; Lau et al., 2019; Sessler, 2016).

While little research has been conducted regarding hypothermia in the cardiac cath lab, Conway and colleagues (2018) demonstrated improved patient outcomes with forced-air warming in the cath lab setting. Still, they failed to study patients under general anesthesia for lengthy procedures. Therefore, this project revealed how advantageous a standardized normothermia protocol could be for patients undergoing prolonged procedures under general anesthesia in the cath lab setting. Warming the procedure suite and ensuring that patients

received forced-air warming prior to anesthesia induction was an integral part of these guidelines.

Reducing healthcare costs is vital to the financial well-being of both the organization and the patient. The ASPAN 2010 Normothermia Guidelines were financially beneficial for the facility because of their ability to mitigate the complications associated with IPH without increasing overhead costs for the facility. Yi et al. (2017) demonstrated how maintaining normothermia throughout the perioperative period reduced overall healthcare expenses. This cost-savings was possible because ASPAN's protocol used the same equipment and personnel used in the standard daily operations. This project's improved outcomes might best be explained by focusing on hypothermia prevention strategies such as prewarming and frequent thermal assessment.

In addition to their efficacy and fiscal sustainability, it was essential to decide upon a set of evidence-based guidelines that were simple to learn for this facility's perioperative staff. The installation phase of the protocol proceeded without confusion or uncertainty. Handouts were provided that included a checklist for all stages of care, beginning with the preoperative holding unit and ending with the PACU. Other clinical practice guidelines were considered but seemed too convoluted for the organization's perianesthesia providers. The ASPAN 2010 Normothermia Guidelines were the best viable option for the organization's dilemma with IPH after cardiac ablations.

The use of the ASPAN 2010 Normothermia Guidelines was valuable in demonstrating a reduction in the occurrence of hypothermia and recovery time. They were simple, economical, and have been shown to improve care in various patient groups. The Rosswurm-Larrabee model for change to evidence-based practice guided this project.

Even amid the SARS-CoV-2 pandemic, evaluation of a sample size large enough to show a statistically significant difference between the two groups was obtained. All but three cardiac ablation patients were evaluated during the 12-week period. These three patients, all from the post-intervention group, were excluded from the project due to post-procedural complications unrelated to this project. These issues included a postoperative adverse drug reaction, a groin hematoma requiring surgical treatment, and heart rhythm disturbances that were successfully treated with antiarrhythmic medications. All three patients required prolonged observation in the PACU but were later discharged to a step-down unit. There was no documented hypothermia in the excluded patients either before or after the cardiac ablation procedure. Moving forward, our medical center will likely begin utilizing the ASPAN 2010 Normotheria Guidelines in the future for hypothermia prophylaxis.

Limitations

This retrospective review of body temperatures both before and after cardiac ablation procedures had several limitations. First, this review did not set limits on the type of cardiac ablation performed, with cryoablation and radio-frequency options both utilized to treat arrhythmias. Especially when compared to radio-frequency techniques, the use of cold cryotherapy to ablate dysrhythmic pathways could contribute in some way to the degree of postoperative hypothermia. Therefore, when compared to radio-frequency ablation, cryotherapy could impede efforts to maintain normothermia throughout the procedure. Due to the nature of this retrospective review, deciphering which variation of ablation was conducted on each patient was challenging. Some patients received both cryotherapy and radio-frequency ablation during their procedure, further convoluting any correlation between the type of ablation and the degree

of hypothermia. However, future studies to compare the differences in these two treatment modalities could influence approaches to hypothermia prophylaxis.

Second, the reduction of elective cardiac ablation cases due to the SARS-CoV-2 pandemic limited this project's potential sample size. Time constraints also played a significant role in the number of available cardiac ablation charts to review. Though the findings were statistically significant, a longer, more inclusive, prospective analysis with a larger sample would be an area for future research. Perhaps the limited timeframe and sampling size left a myopic view of the actual occurrence of hypothermia in this cohort before the launch of the protocol. After all, the average incidence of IPH as perceived by the perioperative nursing staff before the project's start was "weekly." Surprisingly, the six-week review only revealed one instance of hypothermia out of a 26-patient pre-intervention sample. A broader, more comprehensive assessment could be conducted to include a larger number of patients over a more extended period who received an ablation without clinical practice guidelines. A larger post-intervention group could also be used for comparison but would require time to allow for more ablations to be performed.

Finally, this project design failed to evaluate the patient's perception and satisfaction of warmth. In this particular retrospective analysis, there was no consideration for each patient's level of thermal comfort. Also, there was no means to measure this metric in a retrospective fashion since it is not documented in the patient's chart. Each phase in the ASPAN 2010 Normothermia Guidelines promotes thermal comfort for all patients throughout their perioperative experience. In summary, this project's design failed to consider the patient's subjective experience. A future qualitative prospective study to evaluate the impact of these clinical practice guidelines on patient subjective criteria should be considered.

Conclusion

The incidence of IPH in the cardiac ablation program at this regional medical center was a prevalent concern for the perianesthesia providers, particularly PACU nurses. Patients recovering from cardiac ablation procedures had longer recovery times compared to other groups. Also, some patients had voiced an overall feeling of thermal discomfort following their procedure. Before this project, the perianesthesia department at this medical center had yet to implement an evidence-based protocol to combat the issue of intraoperative hypothermia and its associated complications. This project investigated whether the implementation of clinical practice guidelines established by the ASPAN organization reduced the incidence of hypothermia in cardiac ablation patients and reduced recovery times in the PACU.

The ASPAN 2010 Normothermia Guidelines have been validated in numerous cohorts but have yet to be scrutinized in the cardiac ablation population. These particular guidelines were selected because of their historical efficacy and the relatively easy-to-understand concepts familiar to the perianesthesia team. This protocol augmented the providers' awareness of the patients' temperature throughout treatment and successfully reduced body temperature and IPH in the post-intervention group. Furthermore, these guidelines substantially reduced the overall recovery time, reducing healthcare costs to the patient and the hospital.

Hypothermia is a constant threat to the safety and well-being of all persons undergoing general anesthesia. Though there is an awareness of the absolute risk of IPH in nearly all general anesthetics, perianesthesia providers oftentimes neglect to act to minimize its occurrence. The consequences of hypothermia during and after surgery are well-known and have been described in numerous peer-reviewed publications.

This project exposed a gap in provider education and prioritization of hypothermia from the perianesthesia team members. Passive warming, through the application of blankets and warmed intravenous fluids, is a common theme in surgical suites. However, additional active warming measures like forced-air warming and ensuring appropriate ambient warmth in the operating room require a deliberate and intentional effort. It served as a reminder that more education is likely needed to further establish the need for patient warming throughout the perioperative process. This quality improvement initiative also demonstrated how easy, inexpensive, and beneficial clinical practice guidelines can be for high-risk groups in an organization.

As a result of this project, this facility concluded that the integration of ASPAN 2010 Normothermia Guidelines should be considered for all patients, especially for populations at risk for IPH. The availability of a standardized checklist provided perianesthesia providers with a recipe for success in deterring this unwanted outcome. Through the proper education of all team members and adherence to clinical practice guidelines established through evidence-based research, the perianesthesia team was able to advance an organization's entire practice through patient temperature management and minimization of IPH-related complications.

References

American Society of PeriAnesthesia Nurses. (2020). *Normothermia clinical guideline: ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia*. Retrieved from https://www.aspan.org/Clinical-Practice/Clinical-Guidelines/Normothermia

Akhtar, Z., Hesler, B. D., Fiffick, A. N., Mascha, E. J., Sessler, D. I., Kurz, A., Ayad, S., & Saager, L. (2016). A randomized trial of prewarming on patient satisfaction and thermal comfort in outpatient surgery. *Journal of Clinical Anesthesia, 33*, 376-385. https://doi.org/10.1016/j.jclinane.2016.04.041

Baradaranfard, F., Jabalameli, M., Ghadami, A., & Aarabi, A. (2019). Evaluation of warming effectiveness on physiological indices of patients undergoing laparoscopic cholecystectomy surgery: A randomized controlled clinical trial. *Journal of PeriAnesthesia Nursing, 34*(5), 1016-1024. https://doi.org/10.1016/j.jopan.2018.11.013

Berry, D., Wick, C., & Magons, P. (2008). A clinical evaluation of the cost and time effectiveness of the ASPAN hypothermia guideline. *Journal of PeriAnesthesia Nursing, 23*(1), 24-35. https://doi.org/10.1016/j.jopan.2007.09.010

Bindu, B., Bindra, A., & Rath, G. (2017). Temperature management under general anesthesia: Compulsion or option. *Journal of Anaesthesiology, Clinical Pharmacology, 33*(3), 306.

Bräuer, A., Müller, M. M., Wetz, A. J., Quintel, M., & Brandes, I. F. (2019). Influence of oral premedication and prewarming on core temperature of cardiac surgical patients: A prospective, randomized, controlled trial. *BMC Anesthesiology, 19*(55). https://doi.org/10.1186/s12871-019-0725-7

Brodshaug, I., Tettum, B., & Raeder, J. (2019). Thermal suit or forced air warming in prevention of perioperative hypothermia: A randomized controlled trial. *Journal of PeriAnesthesia Nursing, 34*(5), 1006-1015. https://doi.org/10.1016/j.jopan.2019.03.002

Cobb, B., Cho, Y., Hilton, G., Ting, V., & Carvalho, B. (2016). Active warming utilizing combined IV fluid and forced-air warming decreases hypothermia and improves maternal comfort during cesarean delivery: A randomized control trial. *Anesthesia & Analgesia*, *122*(5), 1490-1497.

Conway, A., Ersotelos, S., Sutherland, J., & Duff, J. (2018). Forced air warming during sedation in the cardiac catheterisation laboratory: A randomized controller trial. *Heart, 104*(8), 685.

Frisch, N. B., Pepper, A. M., Rooney, E., & Silverton, C. (2017). Intraoperative hypothermia in total hip and knee arthroplasty. *Orthopedics*, *40*(1), 56-63. https://doi.org/10.3928/01477447-20161017-04

Grote, R., Wetz, A. J., Bräuer, A., & Menzel, M. (2018). Prewarming according to the AWMF S3 guidelines on preventing inadvertent perioperative hypothermia 2014: Retrospective analysis of 7786 patients. *Der Anaesthesist, 67*(1), 27-33. https://doi.org/10.1007/s00101-017-0384-3

Hare, H.A. (1888). Experiments to determine the influence on the normal bodily temperature with the reference to the use of external heat. *Therapeutic Gazette, 12*, 317.

Hegarty, J., Walsh, E., Burton, A., Murphy, S., O'gorman, F., & McPolin, G. (2009). Nurses' knowledge of inadvertent hypothermia. *AORN Journal*, *89*(4), 701-713.

Hooper, V. D., Chard, R., Clifford, T., Fetzer, S., Fossum, S., Godden, B., Martinez, E.A., Noble, K.A., O'Brien, D., Odom-Forren, J., Peterson, C., Ross, J., & Wilson, L. (2010).

ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia. *Journal of PeriAnesthesia Nursing*, *25*(6), 346-365.

Jun, J., Chung, M. H., Kim, E. M., Jun, I., Kim, J. H., Hyeon, J., Lee, M.H., Lee, S.L., & Choi, E. M. (2018). Effect of pre-warming on perioperative hypothermia during holmium laser enucleation of the prostate under spinal anesthesia: A prospective randomized controlled trial. *BMC Anesthesiology*, *18*(1), N.PAG. https://doi.org/10.1186/s12871-018-0668-4

Jun, J. H., Chung, M. H., Jun, I. J., Kim, Y., Kim, H., Kim, J. H., Choi, Y.R., & Choi, E. M. (2019). Efficacy of forced-air warming and warmed intravenous fluid for prevention of hypothermia and shivering during caesarean delivery under spinal anaesthesia: A randomised controlled trial. *European Journal of Anaesthesiology (EJA)*, *36*(6), 442-448. https://doi.org/10.1097/EJA.0000000000000990

Kang, S., & Park, S. (2020). Effect of the ASPAN guideline on perioperative hypothermia among patients with upper extremity surgery under general anesthesia: A randomized controlled trial. *Journal of PeriAnesthesia Nursing*. https://doi.org/1016/j.jopan.2019.11.004

Kay, A. B., Klavas, D. M., Hirase, T., Cotton, M. O., Lambert, B. S., & Incavo, S. J. (2019). Preoperative warming reduces intraoperative hypothermia in total joint arthroplasty patients. *Journal of the American Academy of Orthopaedic Surgeons*. https://doi.org/10.5435/JAAOS-D-19-00041

Kaufner, L., Niggemann, P., Baum, T., Casu, S., Sehouli, J., Bietenbeck, A., Boschmann, M., Spies, C.D., Henkelmann, A. & von Heymann, C. (2019). Impact of brief prewarming on anesthesia-related core-temperature drop, hemodynamics, microperfusion and

postoperative ventilation in cytoreductive surgery of ovarian cancer: a randomized trial. *BMC Anesthesiology*, *19*(1), 161.

Kim, H. Y. (2019). Statistical notes for clinical researchers: the independent samples t-test. *Restorative Dentistry & Endodontics*, *44*(3).

Kundi, H., Noseworthy, P. A., Valsdottir, L. R., Shen, C., Yao, X., Yeh, R. W., & Kramer, D. B. (2020). Relation of frailty to outcomes after catheter ablation of atrial fibrillation. *The American Journal of Cardiology*. https://doi.org/10.1016/j.amjcard.2020.01.049

Lau, A., Lowlaavar, N., Cooke, E. M., West, N., German, A., Morse, D. J., Görges, M. & Merchant, R. N. (2018). Effect of preoperative warming on intraoperative hypothermia: A randomized-controlled trial. *Canadian Journal of Anesthesia*, *65*(9), 1029-1040. https://doi.org/10.1007/s12630-018-1161-8

Li, Y., Liang, H., & Feng, Y. (2020). Prevalence and multivariable factors associated with inadvertent intraoperative hypothermia in video-assisted thoracoscopic surgery: A single-center retrospective study. *BMC Anesthesiology*, *20*(1), 25. https://doi.org/10.1186/s12871-020-0953-x

Moran, K., Burson, R., & Conrad, D. (2017). *The Doctor of Nursing Practice scholarly project: A framework for success* (2nd ed.). Jones & Bartlett Learning: Burlington, MA.

Morley, W.H. (1903). The effect of anesthesia upon the body temperature. *The Journal of the Michigan State Medical Society*, *2*, 510-514.

Pereira, N. H. C., & De Mattia, A. L. (2019). Postoperative complications related to intraoperative hypothermia. *Enfermería Global*, *18*(3), 300-313.

Poveda, V. D. B., & Nascimento, A. D. S. (2017). The effect of intraoperative hypothermia upon blood transfusion needs and length of stay among gastrointestinal system cancer

surgery. *European Journal of Cancer Care*, *26*(6), e12688. https://doi.org/10.1111/ecc.12688

Rosswurm, M. A., & Larrabee, J. H. (1999). A model for change to evidence-based practice. *The Journal of Nursing Scholarship, 31*(4), 317-322.

Sagiroglu, G., Ozturk, G. A., Baysal, A., & Turan, F. N. (2020). Inadvertent perioperative hypothermia and important risk factors during major abdominal surgeries. *Journal of the College of Physicians and Surgeons Pakistan 2020, 30*(2), 123-128. https://jcpsp.pk/archive/2020/Feb2020/03.pdf

Sessler, D.I. (2016). Perioperative thermoregulation and heat balance. *Lancet 2016, 387,* 2655-2664. https://doi.org/10.1016/S0140-6736(15)00981-2

Steelman, V.M. (2017). Conductive skin warming and hypothermia: An observational study. *AANA Journal (85)*6, 461-468.

Slotman, G. J., Jed, E. H., & Burchard, K. W. (1985). Adverse effects of hypothermia in postoperative patients. *The American Journal of Surgery, 149*(4), 495-501. https://doi.org/10.1016/S0002-9610(85)80046-5

Sun, Z., Honar, H., Sessler, D. I., Dalton, J. E., Yang, D., Panjasawatwong, K., Doroee, A.F., Salmasi, V., Saager, L. & Kurz, A. (2015). Intraoperative core temperature patterns, transfusion requirement, and hospital duration in patients warmed with forced air. *Anesthesiology: The Journal of the American Society of Anesthesiologists*, *122*(2), 276-285. https://doi.org/10.1097/ALN.0000000000000551

US Department of Health and Human Services. (2013). Modifications to the HIPAA privacy, security, enforcement, and breach notification rules under the health information technology for economic and clinical health act and the genetic information

nondiscrimination act; Other modifications to the HIPAA rules. *Federal Register*, *78*(17), 5566-5702.

Wetz, A. J., Perl, T., Brandes, I. F., Harden, M., Bauer, M., & Bräuer, A. (2016). Unexpectedly high incidence of hypothermia before induction of anesthesia in elective surgical patients. *Journal of Clinical Anesthesia*, *34*, 282-289.

Williams, A. K. (2018). Benefits of passive warming on surgical patients undergoing regional anesthetic procedures. *Journal of PeriAnesthesia Nursing*, *33*(6), 928-934. https://doi.org/10.1016/j.jopan.2017.09.010

Yi, J., Lei, Y., Xu, S., Si, Y., Li, S., Xia, Z., Shi, Y., Gu, X., Yu, J., Xu, G., Gu, E., Yu, Y., Chen, Y., Jia, H., Wang, Y., Wang, X., Chai, X., Jin, X., Chen, J., … Gu, E. (2017). Intraoperative hypothermia and its clinical outcomes in patients undergoing general anesthesia: National study in China. *PloS One*, *12*(6), e0177221. https://doi.org/10.1371/journal.pone.0177221

Appendix A

Literature Matrix (Melnyk & Fineout-Overholt, 2015)

Source/Year	Purpose	Sample/ Setting	Design/Level of Evidence	Results	Implications
Akhtar, Z., Hesler, B. D., Fiffick, A. N., Mascha, E. J., Sessler, D. I., Kurz, A., Ayad, S., & Saager, L. (2016). A randomized trial of prewarming on patient satisfaction and thermal comfort in outpatient surgery. *Journal of Clinical Anesthesia*, *33*, 376-385. https://doi.org/10.1016/j.jclinane.2016.04.041	To determine if forced-air prewarming improves patient satisfaction after outpatient surgery and to evaluate the effect on core temperature and thermal comfort	Setting: Preoperative area, operating room, and PACU Sample: n=115, aged 18-75 years, ASA Class <4, BMI 15-36 kg/m^2	Prospective randomized controlled trial (Level II)	Total 102 patients Prewarming did not reduce redistribution hypothermia, but prewarmed patients had an increased level of thermal comfort	Increased patient satisfaction and increased thermal comfort with prewarming
Baradaranfard, F., Jabalameli, M., Ghadami, A., & Aarabi, A. (2019). Evaluation of warming effectiveness on physiological indices of patients undergoing laparoscopic cholecystectomy surgery: A randomized controlled clinical trial. *Journal of PeriAnesthesia Nursing*, *34*(5), 1016-1024. https://doi.org/10.1016/j.jopan.2018.11.013	To evaluate warming on physiological indices of patients undergoing laparoscopic cholecystectomies	Settting: Iran Sample: n=96 assigned to three groups (forced-air warming [n=32], warmed IV fluids [n=32], and control [n=32])	Three-group randomized controlled trial (Level II)	Mean heart rate and mean systolic blood pressure were different in warmed patients	Warmed fluids and forced-air warming are recommended; both of these recommendations are present in ASPAN's 2010 Normothermia Guidelines
Bayter-Marin, J., Cárdenas-Camarena, L., Durán, H., Valedon, A., Rubio, J., & Macias, A. A. (2018). Effects of thermal protection in patients undergoing body contouring procedures: A controlled clinical trial. *Aesthetic Surgery Journal*, *38*(4), 448-456. https://doi.org/10.1093/asj/sjx155	To evaluate the effects of hypothermia in patients undergoing plastic surgery procedures lasting longer than 3.5 hours; evaluate how using cost-effective measures can prevent hypothermia during surgery	Setting: Clinica El Pinar in Bucaramanga, Colombia (February – November 2015) Sample: n=122 assigned to three groups (Group 1: [n=43] no protective measures, Group 2: [n=39] intraoperative warming measures, Group 3: [n=40] warming measures both preoperatively and intraoperatively	Three-group randomized controlled trial (Level II)	Group 1 (control group) had a higher degree of hypothermia, longer recovery time from anesthesia, longer recovery time, increased pain, increased thermal discomfort, required more opioids, and more nausea More than 85% (n=104) of all patients developed hypothermia Hypothermia common in longer procedures even with intervention; authors recommend protective measures both before and during anesthesia Authors recommend pre-	Inexpensive warming measures both before and during the operative period in long procedures can prevent hypothermia, shorten anesthesia recovery, and reduce the side effects of hypothermia. Also, these measures may have significant economic savings. Pre-warming recommended prior to anesthesia

				warming for 1 hour with forced-air warming with blankets before OR arrival	
Bräuer, A., Müller, M. M., Wetz, A. J., Quintel, M., & Brandes, I. F. (2019). Influence of oral premedication and prewarming on core temperature of cardiac surgical patients: A prospective, randomized, controlled trial. *BMC Anesthesiology, 19*(1). https://doi.org/10.1186/s12871-019-0725-7	To evaluate how oral premedication with benzodiazepines (BZD) effects core temperature and to evaluate the effectiveness of prewarming in attenuating the effect of oral premedication on core temperature	Setting: Single-center in Germany Sample: n=48 participants (24 in control group, 24 in experimental group)	Prospective, single-center randomized controlled trial (Level II)	Oral premedications with BZD lower core temperatures significantly Prewarming did not completely offset drop in core temp from oral premedications Prewarmed patients had a significantly higher core temperature at the beginning of surgery compared to control group	Prewarming is beneficial to reduce post-induction drop in core temperature and is recommended, especially if premedicated with oral BZD Oral BZD should be avoided if possible
Brodshaug, I., Tettum, B., & Raeder, J. (2019). Thermal suit or forced air warming in prevention of perioperative hypothermia: A randomized controlled trial. *Journal of PeriAnesthesia Nursing, 34*(5), 1006-1015. https://doi.org/10.1016/j.jopan.2019.03.002	To compare the effectiveness of forced-air warming with a passive insulation suit for preventing perioperative hypothermia	Setting: Oslo University Hospital, Ullevaal Sample: n=30 undergoing spine surgery Thermal suit (n=15) and forced-air warming (n=15)	Prospective, open, randomized controlled trial (Level II)	Forced-air warming was significantly more efficient and reversed perioperative hypothermia when compared to passive thermal suits. Passive thermal blankets are no more effective than warmed cotton blankets More than half of patients undergoing orthopedic spinal surgery in study developed unintended perioperative hypothermia	Unintended perioperative hypothermia common in all patients, but forced-air warming effective and efficient in returning normothermia
Conway, A., Ersotelos, S., Sutherland, J., & Duff, J. (2018). Forced air warming during sedation in the cardiac catheterisation laboratory: A randomised controlled trial. *Heart, 104*(8), 685.	To determine if forced-air warming reduces hypothermia for procedures with sedation in the cardiac catheterization laboratory	Setting: Australia Sample: n=140 All participants received passive warming with warmed cotton blankets	Parallel-group randomized controlled trial (Level II)	Forced-air warming reduced hypothermia and improved thermal comfort Forced-air warming reduced shivering and increased thermal comfort	Authors recommend forced-air warming to improve thermal comfort and reduce post-procedural hypothermia

		Control group (n=69) allocated to passive warming only Experimental group (n=71) received forced-air warmer with "upper" or "lower" body forced-air warming blankets			
Frisch, N. B., Pepper, A. M., Rooney, E., & Silverton, C. (2017). Intraoperative hypothermia in total hip and knee arthroplasty. *Orthopedics*, *40*(1), 56-63. https://doi.org/10.3928/01477447-20161017-04	To determine the incidence of perioperative hypothermia in the total knee arthroplasty and total hip arthroplasty To evaluate perioperative hypothermia's impact on complications and outsomes	Setting: 2 academic hospitals, Detroit, Michigan Sample: n=2,397 TKA (n=1,456) THA (n=941)	Retrospective cohort study (Level IV)	Overall incidence of hypothermia 37% Strong association between general anesthesia, prolonged procedures and hypothermia Hypothermia associated with increased blood loss Hypothermia was not associated with increased blood transfusion or postoperative complications	General anesthesia is significantly associated with hypothermia Prolonged procedures lead to hypothermia risk
Grote, R., Wetz, A. J., Bräuer, A., & Menzel, M. (2018). Prewarming according to the AWMF S3 guidelines on preventing inadvertent perioperative hypothermia 2014: Retrospective analysis of 7786 patients. *Der Anaesthesist*, *67*(1), 27-33. https://doi.org/ 10.1007/s00101-017-0384-3	To evaluate the hypothermia rates that can be achieved when prewarming in the anesthesia induction room is introduced into the clinical practice and performed in addition to intraoperative warming	Setting: Martin Luther University Halle Wittenberg (Germany) Sample: n=3,899 prewarmed patients between Jan 2015-Dec 2016 Control group (n=3,887) between July 2012-August 2014	Retrospective, Single-center cohort study (Level IV)	Prewarmed patients showed a hypothermia rate of 15.8% and 5.1% intraoperatively and postoperatively, respectively. Control group showed 30.4% and 12.4% intraoperative/ postoperative rate 52% reduction in intraoperative hypothermia 41% reduction in postoperative hypothermia	Prewarming is recommended by AWMF guidelines and produced a clinically relevant reduction in intraoperative and postoperative hypothermia
John, M., Crook, D., Dasari, K., Eljelani, F., El-Haboby, A., & Harper, C. M. (2016). Comparison of resistive heating and forced-air warming to	To determine if resistive heating offers a cheaper alternative to the	Setting: Perioperative setting, United Kingdom	Prospective, randomized single-blinded study	A significantly higher rate of hypothermia was present at the end	Forced-air warming found within ASPAN's 2010 Normothermia

prevent inadvertent perioperative hypothermia. *BJA: The British Journal of Anaesthesia*, *116*(2), 249-254. https://doi.org/10.1093/bja/aev412	prevention of perioperative hypothermia compared to forced-air warming	Sample: n = 160 total Groups consisted of forced-air warming (n=78) or resistive heating (n=82)	(Level II)	of surgery in patients receiving resistive heating. Final intraoperative temperatures were also lower in resistive heating group Both groups demonstrated some degree of hypothermia following surgery	Guidelines is a beneficial means of reducing the risk of hypothermia after surgery when compared to resistive heating.
Jun, J., Chung, M. H., Kim, E. M., Jun, I., Kim, J. H., Hyeon, J., . . . Choi, E. M. (2018). Effect of pre-warming on perioperative hypothermia during holmium laser enucleation of the prostate under spinal anesthesia: A prospective randomized controlled trial. *BMC Anesthesiology*, *18*(1), N.PAG. https://doi.org/10.1186/s12871-018-0668-4	To assess whether forced-air warming at 43C upon admission to PACU will prevent hypothermia or shivering during enucleation of the prostate under spinal anesthesia	Setting: South Korea Sample: n=50 Control group (n=25) received usual care with warmed blankets Forced-air warming group (n=25) received usual care +20 minutes of prewarming	Prospective, single-blind, randomized controlled trial (Level II)	Prewarmed group had higher temperature upon admission to PACU compared with control group The incidence of hypothermia on PACU admission was lower in the prewarming group The incidence of shivering was lower in the prewarming group 56% of prewarmed patients became hypothermic, compared to 88% of patients without prewarming	Prewarming is beneficial for patients under spinal anesthesia, produces less hypothermia upon admission to PACU and reduces shivering Prewarming reduces the incidence of postoperative hypothermia
Jun, J. H., Chung, M. H., Jun, I. J., Kim, Y., Kim, H., Kim, J. H., Choi, Y.R., & Choi, E. M. (2019). Efficacy of forced-air warming and warmed intravenous fluid for prevention of hypothermia and shivering during caesarean delivery under spinal anaesthesia: A randomised controlled trial. *European Journal of Anaesthesiology (EJA)*, *36*(6), 442-448. https://doi.org/10.1097/EJA.0000000000000990	To assess the efficacy of combined pre-anesthetic forced-air warming in combination with warmed intravenous fluid infusion for preventing hypothermia and shivering during cesarean section under spinal anesthesia	Setting: Tertiary care facility Sample: n=50 parturients aged 20-45 undergoing cesarean under spinal anesthesia Active warming group with forced air warming and warmed IV fluids (n-25) Control group with no active warming or	Randomized controlled trial (Level II)	Hypothermia and shivering were reduced more so in the actively warmed group than the control group Maternal thermal comfort scores were higher in the active warming group	Forced air warming and warmed IV fluids are beneficial to patients when trying to prevent intraoperative hypothermia

		warmed IV fluids (n=25)			
Kang, S., & Park, S. (2020). Effect of the ASPAN guideline on perioperative hypothermia among patients with upper extremity surgery under general anesthesia: A randomized controlled trial. *Journal of PeriAnesthesia Nursing*. https://doi.org/10.1016/j.jopan.2019.11.004	To evaluate the effect of ASPAN Guidelines on body temperature, shivering, thermal discomfort, and hypothermia in patients undergoing upper extremity surgery	Setting: Republic of Korea Sample: n = 54 with 3 exclusions; experimental group (n=26) and control group (n=25)	Randomized controlled trial (Level II)	Improvements in body temperature, the incidence of shivering, thermal discomfort, and thermal comfort in the experimental group receiving ASPAN Guidelines	ASPAN Guidelines are appropriate for patients undergoing general anesthesia and reduce hypothermia in patients having upper extremity surgery
Kay, A. B., Klavas, D. M., Hirase, T., Cotton, M. O., Lambert, B. S., & Incavo, S. J. (2019). Preoperative warming reduces intraoperative hypothermia in total joint arthroplasty patients. *Journal of the American Academy of Orthopaedic Surgeons*. https://doi.org/10.5435/JAAOS-D-19-00041	To evaluate the effectiveness of preoperative warming measures to prevent perioperative hypothermia in patients undergoing total joint arthroplasty	Setting: Houston Methodist Hospital, Houston, Texas Sample: n=672	Retrospective review (cohort) (Level IV)	Forced air warming reduced hypothermia rate by 30% Time from entry into the operating room until the start of surgery should be minimized BMI had protective effect in total knee arthroplasty patients	Prewarming reduced perioperative hypothermia
Lau, A., Lowlaavar, N., Cooke, E. M., West, N., German, A., Morse, D. J., Görges, M. & Merchant, R. N. (2018). Effect of preoperative warming on intraoperative hypothermia: A randomized-controlled trial. *Canadian Journal of Anesthesia*, *65*(9), 1029-1040. https://doi.org/10.1007/s12630-018-1161-8	To evaluate the effects of preoperative forced-air warming on intraoperative hypothermia	Setting: Royal Columbian Hospital, New Westminster, British Columbia, Canada Sample: n=200 Control Group (n=101) Pre-warmed Group (n=99)	Randomized controlled trial (Level II)	A minimum of 30 minutes of preoperative warming reduced intraoperative hypothermic exposure Compared with only intraoperative forced-air warming, pre- and intraoperative warming preserved intraoperative normothermia better	Prewarming reduced the degree of hypothermia intraoperatively
Li, Y., Liang, H., & Feng, Y. (2020). Prevalence and multivariable factors associated with inadvertent intraoperative hypothermia in video-assisted thoracoscopic surgery: A single-center retrospective study. *BMC Anesthesiology*, *20*(1), 25. https://doi.org/10.1186/s12871-020-0953-x	To analyze the prevalence of intraoperative hypothermia and factors related to inadvertent hypothermia in adults undergoing video-assisted thoracoscopic surgery (VATS) under general anesthesia	Setting: Peking University People's Hospital, China Sample: n=1,467	Single-center retrospective cohort study (Level IV)	72.7% of adults who underwent VATS suffered intraoperative hypothermia Associated factors with inadvertent hypothermia include age, BMI > 24, duration of surgery > 2 hours, surgery in the morning, and general anesthesia with	Intraoperative hypothermia common Hypothermia prolongs length of stay Higher ambient OR temperatures reduce hypothermia Prolonged procedures increase risk of hypothermia

				PVB block after intubation	
Sagiroglu, G., Ozturk, G. A., Baysal, A., & Turan, F. N. (2020). Inadvertent perioperative hypothermia and important risk factors during major abdominal surgeries. *Journal of the College of Physicians and Surgeons Pakistan 2020*, *30*(2), 123-128. https://jcpsp.pk/archive/2020/Feb2020/03.pdf	To investigate the relationship between inadvertent perioperative hypothermia and possible important risk factors during major abdominal surgery	Setting: Trakya University Hospital, Edirne, Turkey (2016-2018) Sample: n=529 Hypothermia Group (<36C) (n=335) Normothermia Group (36 - 37.5C) (n=194)	Cross-sectional descriptive study (Level VI)	Factors associated with hypothermia include: male gender, advanced age, high ASA, smoking, prolonged duration of operation, transfusion of fluids and PRBCs 63.3% of patients experienced hypothermia Increased shivering in hypothermia group	Long procedures correlate with an increased risk of hypothermia shivering, increased blood loss possible with hypothermia
Sessler, D. I. (2016). Perioperative thermoregulation and heat balance. *The Lancet*, *387*(10038), 2655-2664. https://doi.org/10.1016/S0140-6736(15)00981-2	This review discusses the effect of anesthesia on thermoregulation, the effect of hypothermia on the body, and complications associated with perioperative hypothermia. Also, this review describes the body's thermoregulation and heat balance.	N/A	Expert Review (Level VII)	1L of ambient IV fluid infused in a 70kg patient reduces mean body temperature by 0.25C Most heat is lost from the skin, so actively warming the skin surface is beneficial A single layer of passive insulation reduces cutaneous heat loss by 30%; this is countered by the 30% reduction in metabolic heat production produced by anesthesia Redistribution hypothermia is partly ameliorated by pre-warming patients General and neuraxial anesthesia impair thermoregulation of temperature It is unknown how anesthetics impair thermoregulatory control	All fluids should be warmed Active warming beneficial Pre-warming beneficial Passive warming of little benefit because of metabolic loss of heat production related to anesthesia Even mild hypothermia prolongs the actions of many drugs, prolonging anesthesia recovery Though non-life threatening, thermal discomfort memories are strong and may persist for years

				In a typical OR environment, peripheral tissues are 2-4C cooler than core temperatures Cause of hypothermia in most patients under anesthesia is a combination of anesthesia-induced thermoregulatory impairment, cool OR temperatures, and operative exposure (thermoregulatory impairment being the most important) Heat lost within first hour caused by vasodilation from anesthesia agents allowing redistribution of blood from peripheral tissues to core and vise versa. Redistribution followed by slow linear reduction in core temperature (based upon heat loss vs heat production) Primary mechanisms of perioperative heat loss are radiation and convection Eventually, plateau phase is reached in core (either because heat loss = production or because vasoconstrictive thermoregulation begins), but will continue to drop in periphery Best-documented complication of hypothermia = coagulopathy	

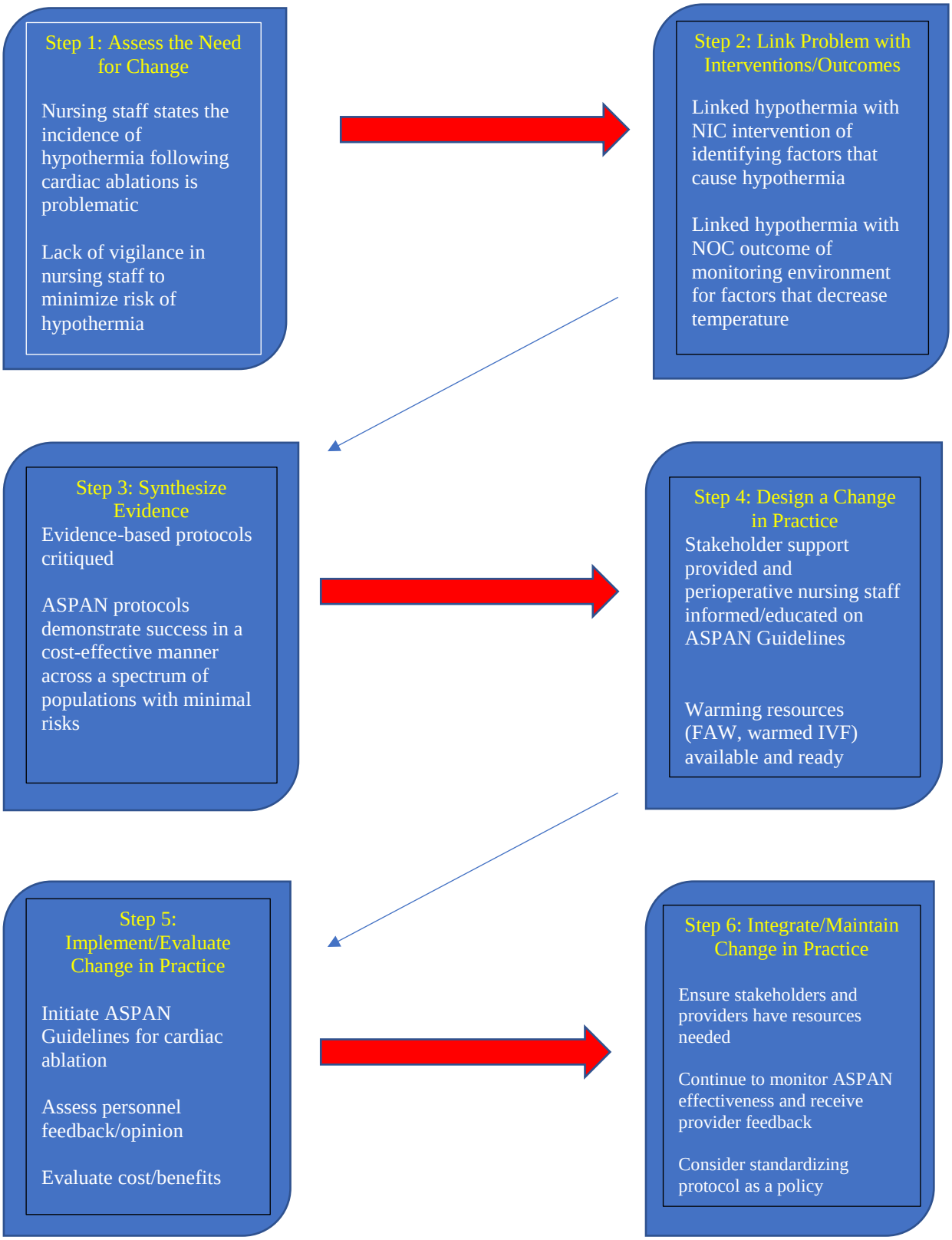
				Hypothermia reduces systemic immune activation and decreases macrophage mobility Hypothermia reduces tissue healing through vasoconstriction Even mild hypothermia prolongs duration of drugs through thermal sensitivity of enzymes Patients who are 2C hypothermic at the end of surgery take 2 hours to return to normothermia and thermal comfort Unlike pain and nausea, postoperative thermal discomfort memories are intense and can last years after surgery	
Su, S., & Nieh, H. (2018). Efficacy of forced-air warming for preventing perioperative hypothermia and related complications in patients undergoing laparoscopic surgery: A randomized controlled trial. *International Journal of Nursing Practice (John Wiley & Sons, Inc.), 24*(5), 1. https://doi.org/10.1111/ijn.12660	To determine the efficacy of forced-air warming for preventing perioperative hypothermia and complications in patients undergoing laparoscopic surgery	Setting: 1,500 bed teaching hospital in Taiwan Sample: n=127 undergoing laparoscopic thoracic or abdominal surgery Forced-air warming (n=64) Passive warming (n=63)	Randomized, double-blind design (Level II)	Group with forced-air warming had fewer complications (intraoperative bleeding, time to rewarming above 36C, pain level, and shivering) than control group who received passive warming	Forced-air warming is shown to reduce complications from perioperative hypothermia
Wetz, A. J., Perl, T., Brandes, I. F., Harden, M., Bauer, M., & Bräuer, A. (2016). Unexpectedly high incidence of hypothermia before induction of anesthesia in elective surgical patients. *Journal of Clinical Anesthesia*, *34*, 282-289.	To estimate the incidence of hypothermia before anesthesia and to determine if certain factors predict its incidence	Setting: Goettingen, Germany Sample: n=493	Review of 7 prospective trials (Level III)	Associated risk factors for pre-induction hypothermia include male gender and older patients (age > 52 years)	Pre-induction hypothermia is common and should be addressed Increased age associated with preoperative hypothermia

					ASPAN Guidelines include preoperative temperature assessment and management
Yi, J., Lei, Y., Xu, S., Si, Y., Li, S., Xia, Z., Shi, Y., Gu, X., Yu, J., Xu, G., Gu, E., Yu, Y., Chen, Y., Jia, H., Wang, Y., Wang, X., Chai, X., Jin, X., Chen, J., … Gu, E. (2017). Intraoperative hypothermia and its clinical outcomes in patients undergoing general anesthesia: National study in China. *PloS One*, *12*(6), e0177221. https://doi.org/10.1371/journal.pone.0177221	To determine the overall incidence of inadvertent intraoperative hypothermia and its risk factors associated with clinical outcomes in China	Setting: China; sample selected from 28 hospitals Sample: n=3,132	Cross-sectional study with randomized sampling (Level IV)	Overall incidence of hypothermia was 44.3% When compared to normothermic patients, patients with hypothermia had more ICU admissions, longer PACU stays, longer postoperative stays 30-day mortality and surgical site infection rates were similar Decreased risk of hypothermia seen with increased BMI (>25), higher baseline body temperatures, higher ambient temperatures, and active warming Risk for hypothermia increased with major surgery and long anesthesia	Intraoperative hypothermia is common Hypothermia associated with shivering, increased ICU admissions, and longer postoperative hospital stays Increased financial burden with hypothermia Poorer outcomes with hypothermia
Yi, J., Liang, H., Song, R., Xia, H., & Huang, Y. (2018). Maintaining intraoperative normothermia reduces blood loss in patients undergoing major operations: A pilot randomized controlled clinical trial. *BMC Anesthesiology*, *18*(1), N.PAG. https://doi.org/10.1186/s12871-018-0582-9	To determine whether active intraoperative warming reduced bleeding in patients undergoing open thoracic surgery and total hip replacement surgeries	Setting: China Sample: n=62 Passive Warming (n=32) Active Warming (n=30)	Prospective, parallel two-arm randomized controlled trial (Level II)	Intraoperative blood loss higher with passive warming compared to active warming Perioperative hemoglobin value decline more in passive warming group Forced-air warming maintained intraoperative normothermia in all subjects, but 21 of 32 (71.8%) of patients with passive warming experience intraoperative hypothermia	Perioperative active warming leads to less blood loss, significantly reduces hypothermia

				Platelet counts, prothrombin time, INR, and fibrinogen values did not differ significantly from preoperative to postoperative in either group	
Zaman, S. S., Rahmani, F., Majedi, M. A., Roshani, D., & Valiee, S. (2018). A clinical trial of the effect of warm intravenous fluids on core temperature and shivering in patients undergoing abdominal surgery. *Journal of PeriAnesthesia Nursing, 33*(5), 616-625. https://doi.org/10.1016/j.jopan.2016.12.010	to investigate the effect of warm intravenous fluids on shivering and core temperature of patients undergoing abdominal surgery	Sample: Intervention Group (n=35) Control Group (n=31) Setting: Kurdistan, Iran	Two-group randomized clinical control trial (Level II)	There was a significant difference between the two groups in terms of shivering, core temperature, and pulse rate at the time of admission to the PACU and 30 minutes after	Warmed IV fluids reduce the risk of postanesthetic hypothermia after abdominal surgery when compared to fluids at room temperature

Appendix B

Rosswurm – Larrabee Model of Change



Appendix C

ASPAN 2010 Normothermia Guidelines Data Collection Tool and Checklist

Risks – Age > 70, preoperative SBP > 140 mmHg, female gender, BMI at/below normal (< 25 kg/m^2), diabetes mellitus with autonomic dysfunction

Preoperative/Preadmission

Assessment

- ☐ Measure temperature (institute forced-air warming if < 36°C/96.8°F)
- ☐ Presence of shivering/piloerection
- ☐ Thermal comfort

Intervention

- ☐ Institute passive warming (warm blankets)
- ☐ Keep ambient temperature > 24°C/75°F
- ☐ Consider forced-air warming (minimum 30 minutes)

Goal

- ☐ Acknowledges thermal comfort
- ☐ Avoid proceeding to OR unless > 36°C

Intraoperative

Assessment

- ☐ Review risk factors
- ☐ Frequent temperature monitoring (at a minimum, q15 minutes)
- ☐ Thermal comfort
- ☐ Discuss findings/risks with anesthesia

Intervention

- ☐ Minimize skin exposure to ambient air
- ☐ Initiate passive warming (warm blankets, drapes, warm irrigation/fluids)
- ☐ Maintain ambient temperature of 20-25°C/68-77°F (AORN Standard)
- ☐ Forced-air warming (prewarming preferred)

Goal

- ☐ Normothermia upon departure to PACU

PACU Phase I & II

Assessment

- ☐ Assess risk factors
- ☐ PACU arrival temperature
  - Greater than 36°C? Continue monitoring
  - Less than 36°C? Implement forced-air warming immediately
- ☐ Thermal discomfort?
- ☐ Signs of hypothermia (shivering, piloerection, cold extremities)

Intervention

- ☐ Passive warming measures (blankets, avoid exposure)
- ☐ Ambient room temperature > 24°C (75°F)
- ☐ Implement warming measures if needed
- ☐ Measure temperature upon discharge

Temperature:

Preoperative _____ PACU Arrival _____ Discharge_____

Shivering/Thermal Discomfort

Preoperative _____ PACU Arrival _____ Discharge_____

Appendix D

Pre-intervention Data Collection Tool

Patient (De-identified)	Pre-Procedure Temperature (°C)	PACU Arrival Temperature (°C)	PACU Duration (minutes)

Appendix E

Post-intervention Data Collection Tool

Patient (De-identified)	Pre-Procedure Temperature (°C)	PACU Arrival Temperature (°C)	PACU Duration (minutes)

Appendix F

Timeline of Events

August 2020	Approval from Institutional Review Board for data collection received from both university and regional medical center Begin an electronic collection of data from Summer 2020 to evaluate IPH in patients prior to the implementation of ASPAN 2010 Normothermia Guidelines; document data on Pre-intervention Data Collection Tool (Appendix D); log data onto secure Box account and shred paper tool
Late August 2020 – Early September 2020	Begin a retrospective review of data from the six-week period in which all patients received care via the ASPAN 2010 Normothermia Guidelines; document on Post-Intervention Data Collection Tool (Appendix E); transfer all data to UA Box storage account
Late September – Early October 2020	Conclusion of data collection; data entered UA Box storage account; all paper tools shredded; compile data and analyze using Minitab® statistical software via independent t-tests
October 2020	Dissemination of data via written report/presentation to department
Early – Late November 2020	Manuscript submission to the *Journal of PeriAnesthesia Nursing.*

Appendix G

THE UNIVERSITY OF ALABAMA® | *Office of the Vice President for* Research & Economic Development
Office for Research Compliance

August 19, 2020

Kerry Varner
Department of Nursing
College of Nursing
The University of Alabama
Box 870358

Re: IRB #20-06-3678 "A Quality Improvement Initiative to Reduce Postoperative Hypothermia after Cardiac Ablation"

Dear Mr. Varner:

The University of Alabama Institutional Review Board has granted approval for your proposed research. Your protocol has been given exempt approval according to 45 CFR part 46.104(d)(4) as outlined below:

(4) Secondary research for which consent is not required: Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met:

(iii) The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under 45 CFR parts 160 and 164, subparts A and E, for the purposes of ''health care operations'' or ''research'' as those terms are defined at 45 CFR 164.501 or for ''public health activities and purposes'' as described under 45 CFR 164.512(b)

The approval for your application will lapse on August 18, 2021. If your research will continue beyond this date, please submit the annual report to the IRB as required by University policy before the lapse. Please note, any modifications made in research design, methodology, or procedures must be submitted to and approved by the IRB before implementation. Please submit a final report form when the study is complete.

Good luck with your research.

Sincerely,

Carpantato T. Myles, MSM, CIM, CIP
Director & Research Compliance Officer

Jessup Building Box 870127 Tuscaloosa, AL 35487-0127
205-348-8461 Fax 205-348-7189 Toll Free 1-877-820-3066

Southeast HEALTH
MEDICAL CENTER

June 9, 2020

Kerry Varner
Southeast Alabama Medical Center
1108 Ross Clark Circle
Dothan, Alabama 36301

Re: A Quality Improvement Initiative to Reduce Postoperative Hypothermia after Cardiac Ablation

Dear Mr. Varner:

I reviewed the submitted study proposal, "A Quality Improvement Initiative to Reduce Postoperative Hypothermia after Cardiac Ablation" in which you will be the Principal Investigator. Upon expedited review, this study is granted exempt status from the Southeast Health Institutional Review Board. In order for your study to meet the criteria for exempt status, you must ensure the patient information is recorded in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects, such as Medical Record Numbers or Patient Encounter Numbers.

*****If your study requires mining or reviewing patients' Protected Health Information ("PHI"), please follow the Data Management Procedure attached hereto. *****

The IRB requests a written report of the findings at the conclusion of the study. Any publication of the data from this study should have IRB approval.

If you have any questions please contact Jennifer Brannon in the Medical Staff Services office at 793-8759.

Sincerely,

Charles Harkness, DO, MBA
CMO / VP Medical Affairs
IRB Chair
CH/jb

Figure 1.
Success Rate Maintaining Body Temperature

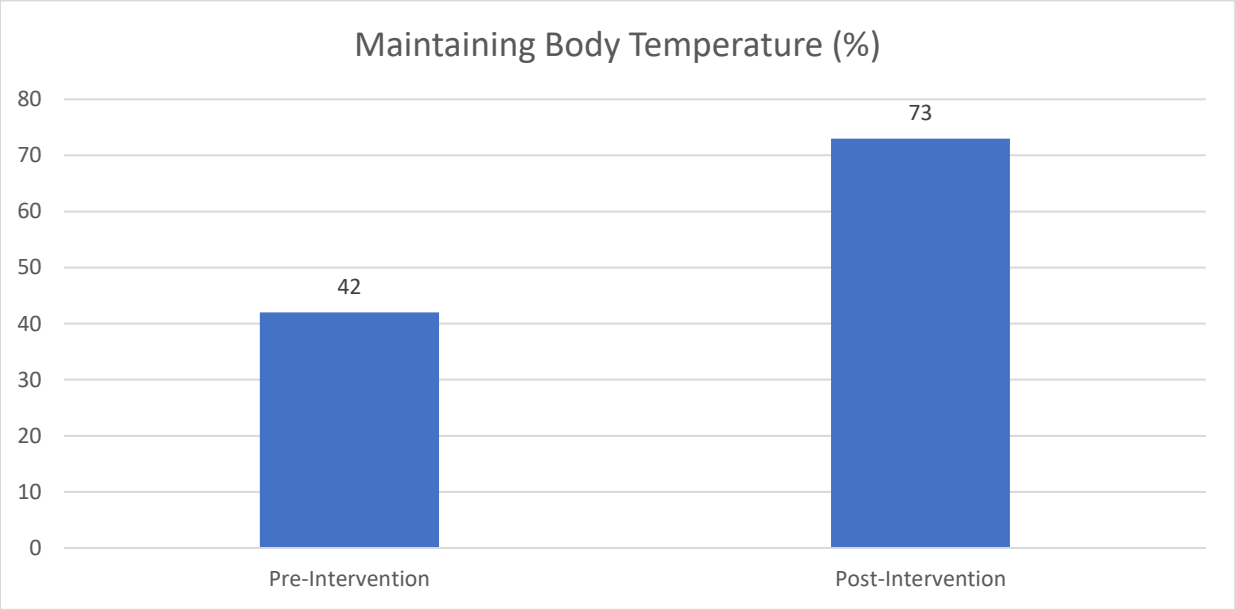


Figure 2. *Preoperative vs. Postoperative Temperature Assessments*

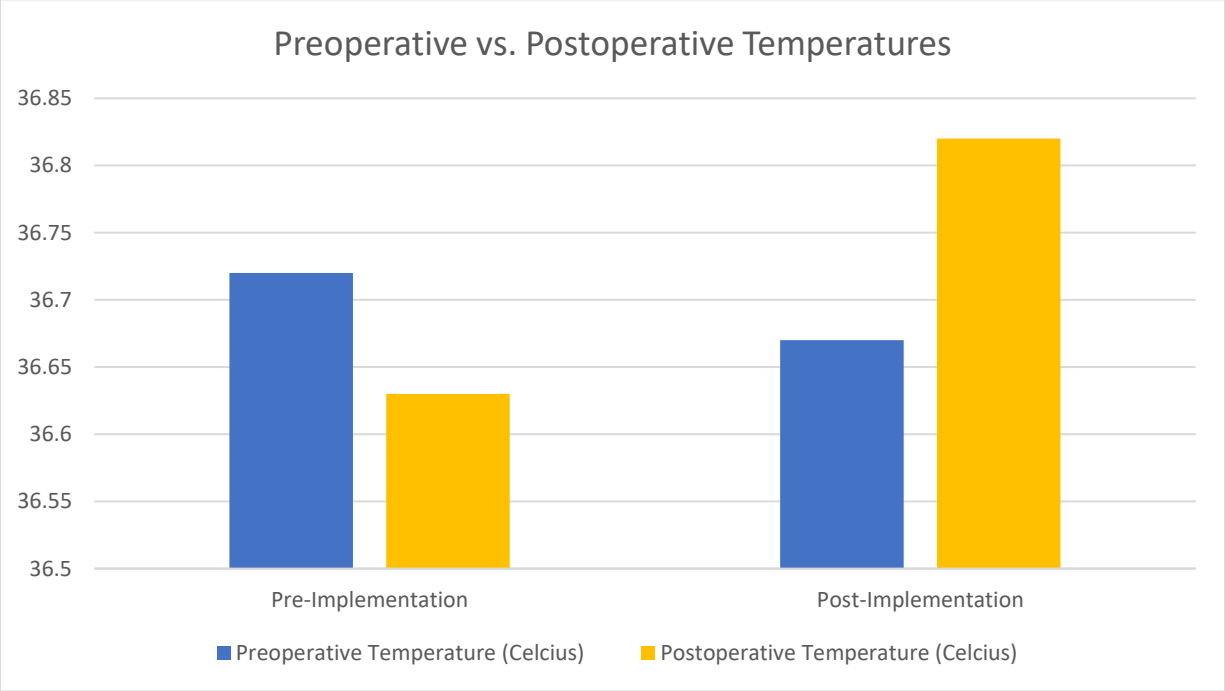


Table 1.

t-test Results – Comparing Perioperative Change in Temperature (°C)

Group	*N*	Mean	StDev	SE Mean	*t*	df	*p*
Pre-Intervention	26	-0.068	0.456	0.089	-2.13	41	0.04
Post-Intervention	26	0.154	0.275	0.054			

Table 2.

t-test Results – Comparing Recovery Time in Minutes

Group	*N*	Mean	StDev	SE Mean	*t*	df	*p*
Pre-Intervention	26	53.6	18	3.8	2.03	42	0.048
Post-Intervention	22	44.73	9.78	2.1			