Mitigating Surgical Site Infection Risks via Thermal Regulating Modalities

J. Shawn Robinson, BSN, RN and Vladimir Souverain BSN, RN

Nurse Anesthesia Program, Adventist University of Health Sciences

Project Mentor: Sarah Dycus, MSNA CRNA, BSN, RN, USAP-JLR Medical Group

Project Chair: Sarah Snell, MSNA CRNA, ADU-NAP Department Instructor

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Abstract

Forced-air warmers (FAW) are used routinely in the operating room to help manage hypothermia, which can lead to surgical site infections (SSI) if left untreated. However, recent evidence suggests an association between the use of forced-air warmers and surgical site infections, especially in patients undergoing general, orthopedic, and vascular procedures. To address this concern, a literature review was conducted by searching the Cochrane Databases, Access Anesthesiology, MEDLINE, CINAHL, and Academic Search Premier. Afterwards, an educational PowerPoint was conducted, with the objective of helping Adventist University of Health Sciences (ADU) Student Registered Nurse Anesthetists (SRNAs) understand the infection risk associated with FAW and offering recommendations to safely decrease the infection risks while preventing hypothermia perioperatively. A pre-test and a post-test were conducted before and after the presentation. Paired sample tests from the pre-test and the post-test showed that percentage scores significantly increased by 26.8. Additionally, a F test demonstrated that there was significantly less variance in the post-test percentage scores compared to the pre-test scores. These results suggest that the educational PowerPoint presentation successfully helped the ADU SRNAs expand their knowledge base regarding the relationship between FAWs and SSIs and best practices to reduce SSI hazards related to thermoregulation equipment.

Keywords: forced-air warmers, surgical site infections

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Introduction

Unintended perioperative hypothermia, defined as a core body temperature less than 36 degrees Celsius, is the most common thermal disturbance seen in surgical patients associated with significant mortality and morbidity (Kellam, Dieckmann, & Austin, 2013). According to (Reynolds et al., 2014), 70% of postoperative patients experience some level of hypothermia. Reynolds et al., 2014, also noted that 90% of surgical patients experience complications from hypothermia.

Nurse anesthetists, as professional anesthesia providers, have a responsibility to assure hypothermia is controlled in a safe and effective manner to prevent postoperative complications such as bleeding and infection. According to the American Association of Nurse Anesthetists, standard V thermoregulation, among other patient physiologic conditions, should be monitored closely during surgery (American Association, 2013). Hypothermic complications are responsible for between $2,500 to $7,000 per hospitalization (Administration on Aging, 2013). One tool at the disposal of anesthesia providers is forced-air warmers (Huang, Shah, Vinodkumar, Hegarty, & Greatorex, 2003). Developed in the 1980's, forced–air warmers have been recognized as the most clinically successful method to warm patients in the perioperative setting (Huang, 2003). Paradoxically, recent evidence has linked the use of forced-air warmers with an increased risk of surgical site infection (Albrecht, Gauthier, Belani, Litchy, & Leaper, 2011).

Perioperative hypothermia is a common problem seen around the world and the US. The World Health Organization (WHO) has recognized the significant impact this issue represents on a world-wide scale and has incorporated it into their "Safe Surgery Saves Lives" campaign (Albrecht et al., 2011).

The financial costs of an issue this prevalent significantly impacts the US health care system. In 2014 there were approximately 34 million surgical procedures in the US (Cullen, Hall, & Golosinkiy, 2009). With an estimated frequency of 70% of all surgical patients experiencing postoperative hypothermia, (Reynolds et al., 2014), the financial impact could be between 59.5 to 166.6 billion dollars annually.

The State of Florida has the largest population of older adults in the country, resulting in Medicare being a large payer for hospital services in the State of Florida (Administration on Aging, 2013). With denied reimbursements from CMS for hospital-acquired infections, resolution of post-operative infections related to forced-air warmers is needed to retain hospital financial stability and reduce patient complications (Peasah, McKay, Harman, Al-Amin, & Cook, 2013; MMRR, 2013). The impact of SRNAs is both local as well as national due to the CMS volume of services on health care costs and safety. Florida Hospital System (FH), is the largest Centers for Medicare and Medicaid Services (CMS) accepting system in Florida. Therefore, ADU SRNAs share the responsibility of creating a culture where care is provided in a cost-efficient manner while making patient's safety and comfort the priority.

As SRNAs at FH, this issue is addressed as part of every case for patient safety. Presently, forced-air warmers are the gold standard modality to maintain normothermia in operating rooms at Florida Hospital. Standard of care for both the American Association of Nurse Anesthetist (AANA) and American Society of Anesthesiologist (ASA) establish temperature monitoring as an essential task for anesthesia providers (American Society, 2016). This project promoted quality patient care by helping nurse anesthesia students be familiar with what is best evidence-based practice for preventing hypothermia in the operating room. The project helped the student nurse anesthetists currently attending ADU understand the infection

risks associated with the use of forced-air warmers as well as the best practices found in current literature regarding prevention of perioperative hypothermia.

Problem Statement

The AANA, in standard V, declares temperature monitoring and the maintenance of normothermia to be the purview of the nurse anesthetist (American Association, 2013). With forced-air warmers being the most common hypothermia control modality at their disposal, and links between post-operative infections and forced-air warmers, clarification of best practices in thermoregulation is needed (Huang, 2003). The chief purpose of this project was to educate SRNAs currently enrolled at ADU on the correlation between the use of FAW and SSI and to inform about evidence-based practice recommendations to prevent hypothermia in the surgical setting.

Project Questions

Two research questions were developed to assist in the systematic review of the literature. The first question addressed the clinical problem, while the second addressed the educational intervention.

PICO: In patients undergoing surgical procedures (P), how does the use of forced-air warmers (I) compared to other body warming devices (C), influence postoperative infection rates (O) within the perioperative period (T)?

PICO: In Adventist University student registered nurse anesthetists (P), does a 30-minute (T) PowerPoint Presentation regarding body warming devices and their impact on adverse outcomes (I) result in an increase in knowledge base (O)?

Literature Review and Synthesis

Inadvertent perioperative hypothermia is a common problem seen in the surgical setting. Up to 70% of patients undergoing surgery in the US experience some level of hypothermia, while other estimates report that up to 90% of these surgical patients experience complications from hypothermia (Reynolds et al., 2014). Complications arising from inadvertent perioperative hypothermia include: Increased bleeding secondary to platelet dysfunction and coagulation abnormalities, delayed discharge from the intensive care units, increased hospital length of stay, and increased surgical site infections (Kellam et al., 2013; Moretti et al. 2009; Sessler, 1997). In addition, patients who experience a decrease in core temperature of 2 degrees Celsius intraoperatively require an additional 40 minutes in the Post-Anesthesia Care Unit, thus increasing the cost of hospital stay (Kellam et al., 2013; Lenhardt et al., 1997).

Approximately 34 million surgical procedures are performed annually in the US (Cullen, Hall, & Golosinkiy, 2009). Of these patients, as many as 70% may experience postoperative hypothermia (Reynolds et al., 2014), resulting in expenditures of more than 60 billion dollars annually. Clearly, perioperative hypothermia has a significant impact on overall US health Care expenditures.

Factors that lead to hypothermia in the operating theater include, naturally occurring radiation and conduction of heat away from the body, cold ambient operating room temperatures, heat loss from the surgical incision, and the use of cold intravenous fluids and irrigation solutions (Kellam et al., 2013). Other contributing factors are anesthetic-induced vasodilation which causes redistribution of core heat to the peripheries and the inhibitory effect of anesthetic agents with resulting thermoregulation problems (Kellam et al., 2013).

Despite the multifaceted etiology of perioperative hypothermia, anesthesia providers have a major role in helping reduce mortality and morbidity associated with perioperative hypothermia. Currently, the rewarming modalities used clinically with adults are forced-air warmers, heated water blankets, and conductive fiber blankets. However, forced-air warmers have been the gold standard for rewarming patients over the past 2 decades (Wood, Moss, Keenan, Reed, & Leaper, 2014).

Although effective at reducing the incidence of perioperative hypothermia, forced-air warmers have been hypothesized as a link to the increase of surgical site infections (Albrecht et al., 2011; Reed et al., 2013; Wood et al., 2014). To better appreciate the concern for infection associated with FAW, it is practical to understand the design and mechanics of this device. Most FAWs consist of a warming unit connected to a blower that helps circulate air (Wood et al., 2014). Ambient air enters the warming unit through a 0.2-micrometer intake filter and flows to a blanket through a connecting hose after being warmed in the thermal generator (Wood et al., 2014). The heated air exits the blanket through multiple ventilation cells located above the patient's skin. This warms the patient by convection (Wood et al., 2014).

Ineffective filters used in forced-air warmers are hypothesized to be the culprit of the increase incidence of surgical site infections. Recent FAWs were found to harbor and promote bacterial growth (Albrecht et al., 2011; Reed et al.2013). This increased the potential spread of these contaminates within the operating theater. In fact, microbial swabs of internal pathway surfaces of FAW showed 90- 100% of the FAWs grew microbial agents that can potentially be harmful to patients (Albrecht et al., 2011; Reed et al.2013). Although current research demonstrates a need to question the safety and efficiency related to the design of FAW pertaining to infection prevention, there is not enough present-day evidence to prove that the

faulty design of FAW filtering systems lead directly to SSIs. Many of the studies reviewed used mannequins instead of human patients, which reduced the validity of the results. Moreover, other factors that heavily impact infection rates were not considered. These factors included, but are not limited to, maintenance records of the FAW used in the studies, the physical barrier created by surgical drapes, hospital infection rates, etc.

According to (McGovern et al., 2011; Dasari, Albrecht, & Harper, 2012), studies of FAWs utilized in conjunction with laminar airflow systems in operating rooms identified an elevated risk of surgical site infections due to air current disruption. However, the literature failed to establish a definitive association between FAWs and SSI because of factors such as, not considering the position of the surgical drapes in relation to the floor and the FAW unfiltered exhaust. Other limitations identified in the literature included the exclusive use of observational data that could be influenced by other factors such as antibiotic therapy, real OR traffic, and overall hospital infection rates (Albrecht et al., 2011; Dasari, Albrecht, & Harper, 2012; Huang, Shah, Vinodkumar, Hegarty, & Greatorex, 2003).

Forced-air warmers emit microscopic particles that circulate in the operating room. Scientists have measured the level of bacterial contamination in the air to establish a possible correlation between forced-air warmers and SSI. Statistical analysis revealed that in cases where FAWs were used, the level of bacterial contamination in the air was equal or lower than when FAWs were not used (Huang, Shah, Vinodkumar, Hegarty, & Greatorex, 2003; Moretti et al., 2009). Consequently, bacterial air contamination in the OR was attributed to medical staff behavior such as movements and general conversations (Dasari, Albrecht, & Harper, 2012; Moretti et al., 2009).

To a large degree, it appears this clearly defined link has not been demonstrated due to variables that have not been measured or considered. Huang et al. (2003) and Moretti et al. (2009) suggested that FAWs did not lead to SSI despite known bacterial growth identified within the FAWs. However, current literature supports the conclusion that forced air warmers foster bacterial growth, interferes with operating room airflow and emits particles into the sterile field (Albrecht, & Harper, 2012; Wood et al., 2014; Reed, 2013; Kellam et al., 2013; Liebhard, 2017). Current bellwether litigation between the manufacturer of FAWs and patients with SSI is moving through the legal system with the next hearing scheduled for February 2018 (Bair Hugger®, 2015).

Contribution and Dissemination/Justification

With hypothermia being one of the leading causes of mortality and morbidity in postoperative patients around the world, it is crucial to impress upon future anesthesia providers the importance of this safety issue (Albrecht et al., 2011). This project endeavored to synthesize key research in the field of SSI-related to FAWs to clarify the best and safest evidence-based practice for preventing hypothermia in the operating room. Fifty graduate level SRNAs currently enrolled at Adventist University of Health Sciences were presented an educational PowerPoint with the goal of helping ADU SRNAs understand the infection risk associated with FAW and recommendations to safely decrease the infection risk while preventing hypothermia perioperatively. This project PowerPoint was presented to the ADU SRNAs in a classroom setting via PowerPoint presentation on September 28, 2017 as assigned by ADU faculty. The efficacy of the presentation was demonstrated by the administration of a pre-and posttest on the subject to evaluate for comprehension.

Project Aims

The primary aim of this educational project was to increase participating ADU NAP student's knowledge base regarding SSIs related to FAW as demonstrated by statistically significant improvement in post-test scores as compared to baseline pretest scores.

Project Methods

Implementation of this project started with obtaining SRC and IRB approval. During the Fall MSNA 501 and 504 clinical conference hours, a PowerPoint Presentation was presented in to a convenience sample of 50 SRNAs from the 2018 and 2019 cohorts. As SRNAs arrived to class they were invited to participate in the PowerPoint. Participants were given an informed consent to review and sign. Inclusion criteria were SRNAs from the 2018 and 2019 who were present and who gave informed consent. SRNAs who met the following criteria were excluded from the PowerPoint Presentation: having a direct or competing interest in any products utilized for controlling patient hypothermia in the operating room setting, refusing to sign an informed consent, or being late to class. The participants took a pre-test on the topic to be presented. Next, the PowerPoint Presentation was presented by the two researchers followed by a question and answer session at the end of the educational PowerPoint. Afterwards, a post evaluation test was given to each participant and returned to the researchers prior to participants leaving the room. Both pre-and posttest only contained answers to the multiple-choice questions and did not have any personal identifiers. The tests were stored in a locked file at the home of a member of the Scholarly Project team. The test results and data were input to one of the researcher's personal computer with password protection for storage and evaluation. Individually distinguishable data were not collected. Upon completion of pre/posttest assessment, the data were compiled into an excel spreadsheet and submitted to Dr. Roy Lukeman for statistical analysis using SPSS. The

statistical analysis was performed using a paired sample t-test, with a predetermined significance level of $p < .05$. Once the project was completed the test results were deleted from all personal computer sources.

Timeline

The Scholarly Project was initiated in May 2017 and extended to June 15, 2017. Data collection and implementation were accomplished in the Fall MSNA 501 and 504 Clinical Conference course. Post-implementation data were collected at the end of the presentation of the educational PowerPoint and ended within 3 weeks of post-implementation data collection and evaluation. Dissemination will be completed on April 9, 2018 with a poster presentation.

Data Collection Plan

All participants were educated regarding informed consent and required to sign the consent prior to participation. An identical pre- and post-test containing 10 multiple-choice questions was administered. The pretest had to be completed prior to the PowerPoint presentation and the post test was administered immediately upon completion of the presentation. These tests were handed directly to one of the two researchers by each participant. Both the pre-and post-tests were counted to assure that all students participating completed and returned both a pre, as well as a post test. Both pre-and post-tests were fully de-identified. There was a total of 6 exchanges of information to and from researchers and participants individually. The exchanges were handing of consent to the participant, participant returning consent to the researcher, handing of the pre-test to the participant, participant returning pre-test to the researcher, and finally handing of the post-test to the participant, participant returning post-test to the researcher.

Evaluation Plan

The intent of this scholarly project was for ADU SRNAs to increase their knowledge base regarding the infection risks associated with FAWs and how these risks can be mitigated. The pre-test and post- test consisted of 10 multiple choice questions that assess knowledge base regarding SSIs related to FAWs and modalities available to mitigate the dangers of SSI-related to perioperative hypothermia. Data were collected and compiled into an Excel spreadsheet and submitted to Dr. Roy Lukman for analysis using SPSS.

Data were then analyzed using a paired sample t-Test with a predetermined significance level of $p<.05$.

Results

The pre-test revealed a mean score of 68.6% with a standard deviation of 21.85 and a standard error mean of 3.09. The results of the post-test demonstrated a mean score of 95.4% with a standard deviation of 9.08 and a standard error mean of 1.28. The paired sample tests revealed a mean of -26.80, a standard deviation of 18.78, a standard error mean of 2.65, and a t value of -10.089, which is associated with a $p<0.0001$. Mean percentage scores significantly increased by 26.8 overall.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	68.6000	50	21.85387	3.09060
	Post-Test	95.4000	50	9.08239	1.28444

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Test - Post-Test	-26.80000	18.78341	2.65637	-32.13818	-21.46182	-10.089	49	.000

In addition to the significant increase in the mean percentage values, there was also a noticeable difference in the two standards of deviation. Consequently, a F test was conducted to assess the significant difference between the two standard deviations. The obtained F value of 5.78 is associated with a $p<0.001$, which is statistically significant. Please note table below:

	Variable 1	*Variable 2*
Mean	68.6	95.4
Variance	477.5918367	82.48979592
Observations	50	50
df	49	49
F	5.789708065	
P(F<=f) one-tail	3.73052E-09	
F Critical one-tail	1.607289463	

Limitations

This project had limitations due to several areas of concern. As the time to perform this project was limited in the scope of a Master's degree program of study, there was a need for rapid dissemination and evaluation of the PowerPoint. Since the PowerPoint presentation was limited to a class period, pre-test and post-test were administered on the same day, which made it

difficult to truly assess retention. Having 30 days & 60 days post-presentation evaluation for retention of key teaching points would have been beneficial. Additionally, the PowerPoint was presented to a small homogeneous sample of 50 participants. Actual change to practice behaviors was not being tested in this scholarly project. Lastly, there was a limitation that the questionnaire was an invalid instrument.

Conclusion

The average score between the pre-test and post-test increased significantly, which indicates that the SRNAs' knowledge base regarding SSIs related to the use of forced-air warmers significantly improved. There was also significantly less fluctuation in the post-test percentage scores compared to the pre-test results, which further verifies the change in knowledge base regarding SSIs related to the use of forced-air warmers. Optimistically, the observed increase in knowledge will lead to implementation in the SRNAs' clinical practice.

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