AN EDUCATIONAL INTERVENTION ON GUIDELINES TO ATTENUATE SPINAL ANESTHESIA-INDUCED MATERNAL HYPOTENSION AND RELATED SIDE EFFECTS

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Dedication and Acknowledgments

I want to dedicate this section to express my gratitude to everyone who has supported me in disseminating my DNP project. The continual support and guidance provided by my faculty advisors, Dr. Korogoda and Dr. Wicks, ensured the success of this project. I am forever grateful for their patience, kind words, and encouragement throughout my academic career. I am thankful for my classmate, colleague, and friend Becky Bates – I would not have been able to finish anesthesia school or this project without her tremendous amount of support, advice, and friendship.

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Abstract

Background: Spinal anesthesia (subarachnoid block; SAB) is the preferred anesthetic technique used for elective cesarean sections (CS). While this technique is safe, hypotension and bradycardia are commonly occurring complications, putting both mother and baby at risk for adverse effects. Recent studies have examined the practice of administering prophylactic ondansetron, co-loading of crystalloids, and using sequential compressive devices as effective methods to reduce the incidence of spinal-induced maternal hypotension (SIH) and bradycardia. **Purpose:** This Doctor of Nursing Practice (DNP) project aimed to examine the impact of an educational intervention provided to Certified Registered Nurse Anesthetists (CRNAs) on evidence-based guidelines to attenuate spinal induced maternal hypotension and bradycardia. Outcomes included the effectiveness of an educational intervention, practice change, and barriers to change. **Methods:** The project utilized a post-intervention follow-up study design consisting of a pre-intervention survey, an online educational video, and a post-intervention survey. **Results:** Findings revealed a knowledge gap in the management of SIH. Although not statistically significant, there was an increase in knowledge and utilization of presented EBP to reduce SIH during elective CS. An educational intervention helped enhance CRNAs' knowledge regarding SIH management and encouraged practice change.**Recommendations and Conclusion:** Findings support the use of EBP guidelines for managing SIH for parturient patients. Larger-scale research on this topic is recommended to support practice implementation.

Keywords: ondansetron, spinal anesthesia, hypotension, cesarean section

Background and Significance

Spinal anesthesia is the preferred anesthetic of choice for mothers undergoing CS. Spinal anesthesia avoids risks associated with general anesthesia and provides quick pain relief without respiratory compromise. A common side effect of SAB is a sympathetic block that can occur in 55-90% of patients (Trabelsi et al., 2015). Sympathetic block leads to maternal hypotension and bradycardia, requiring close monitoring and quick intervention by anesthetists. Additionally, uteroplacental blood flow is not autoregulated and relies solely on maternal systolic blood pressure (Sklebar et al., 2019). Therefore, adequate maternal perfusion and oxygenation are needed to reduce adverse effects on the fetus.

Prevention of SAB-induced hypotension has been the focus of many studies in the last twenty years. Prophylactic administration of ondansetron, co-loading the patients with crystalloids, and sequential devices have shown to be the most effective methods. Ondansetron, a 5-hydroxytryptamine type 3 (5HT3) antagonist, reduces hypotension, nausea, and vomiting by blockading the Bezold-Jarisch reflex and serotonin receptors (Tubog et al., 2017). Co-loading of intravenous crystalloids increases vascular volume and reduces hypotension more effectively than preloading (Ni et al., 2019). Sequential compression devices have proven to effectively improve venous return and preload by decreasing venous pooling in the lower extremities and reducing hypotension (Hasanin et al., 2017). Vasopressors are still recommended to support hemodynamics when clinically appropriate. Nevertheless, there is clinical debate on which vasopressor is safest for parturient patients (Ferre et al., 2020; Lee et al., 2017; Sklebar et al., 2019).

Evidence-based practice (EBP) supports a combined modality to decrease hypotension and bradycardia, improving patient outcomes and satisfaction. The incidence or severity of SIH

in the parturient can be managed by prophylactically administering ondansetron, co-loading intravenous fluids, and applying sequential compression devices.

Purpose

The purpose of this project was to deliver an educational intervention to CRNAs addressing evidence-based methods to reduce the adverse effects of SAB-induced hypotension on healthy obstetric patients. Specific aims of this project were to 1) identify barriers to practice change regarding the use of pre-procedural ondansetron, 2) identify knowledge gaps amongst CRNAs of current evidence-based literature on reducing adverse effects of SAB-induced maternal hypotension, and 3) evaluate the efficacy of the educational intervention by assessing knowledge post-intervention.

Review of Current Evidence

A review of relevant research was conducted to appraise current literature on clinical methods to prevent or attenuate the adverse effects of spinal anesthesia on healthy patients undergoing CS. The databases used for this search included Cumulative Index to Nursing and Allied Health Lite (CINAHL), PubMed, and Google Scholar. The search encompassed the following keywords in combination and individually: spinal anesthesia, ondansetron, hypotension, cesarean section, neonatal outcomes, and Bezold-Jarisch reflex. A combination of Boolean operators (i.e., AND, OR) was utilized to populate the different typologies between terms and to narrow or expand the total articles found. This search resulted in approximately 110 articles. Each title was reviewed to determine which articles were relevant to the topic of study. The search was limited to peer-reviewed, meta-analysis, and randomized control trials (RCTs)

published in English. In addition to a web search, the article's bibliographies were examined to provide additional sources. A detailed summary of the literature review is outlined below.

Bezold Jarisch Reflex

Research studies supporting the existence and physiological effects of the cardiopulmonary Bezold-Jarisch reflex (BJR) date to the 1800s. The BJR is a cardiac inhibitory reflex resulting in a triad of symptoms when activated: bradycardia, hypotension, and peripheral vasodilation (Mark et al., 1953; Warltier et al., 2003). The original study by von Bezold and Hirt activated the reflex in animals by using veratrum alkaloids, causing an inhibition of the sympathetic nervous system (Warltier et al., 2003). Seventy years later, Jarisch and Richter conducted further studies supporting the presence of the BJR and validating its neuronal pathway (Mark et al., 1953; Warltier et al., 2003). The BJR afferent pathway consists of vagal nerve tracts in the heart modulating feedback to the medulla oblongata (Crystal & Salem, 2012; Kashihara, 2009; Warltier et al., 2003). These nerves are composed of C-type fibers distributed within the ventricular muscle that respond to mechanosensitive and chemo-sensitive stimuli (Crystal & Salem, 2012; Kashihara, 2009; Warltier et al., 2003). Physiological effects resulting from the BJR have been linked to cases of myocardial infarction, coronary angiography, aortic stenosis, heart failure, and neuraxial anesthesia (Crystal & Salem, 2012; Gao et al., 2015; Wang et al., 2014a; Wang et al., 2014b). There is limited evidence on whether the BJR is the sole contributor to the hemodynamic effects seen during neuraxial anesthesia, but it is one of the major contributors.

Spinal Anesthesia Induced Hypotension

Risks associated with general anesthesia, such as failed endotracheal intubation or aspiration of gastric contents, are decreased with spinal anesthesia (Fitzgerald et al., 2020; Klohr

et al., 2010; Lee et al., 2017; Sklebar et al., 2019). Therefore, spinal anesthesia is the preferred anesthetic for healthy patients undergoing CS. A sympathetic block occurs from local anesthetic administration into the subarachnoid space during spinal anesthesia, causing arterial and venous vasodilation (Ferre et al., 2020; Lee et al., 2017). As a result, hypotension commonly occurs post-SAB. If not treated promptly, it can lead to maternal and fetal compromise (Fitzgerald et al., 2019; Klohr et al., 2010; Lee et al., 2017; Sklebar et al., 2019). SAB-induced hypotension has an occurrence rate ranging from 7% to 75% in the parturient population during elective CS (Klohr et al., 2010; Sklebar et al., 2019). Maternal hypotension can cause vomiting, aspiration, loss of consciousness, cardiac collapse, and decreased uteroplacental blood flow (Mercier et al., 2013).

Management of SAB-induced hypotension has been heavily researched, yet there is no single most effective approach (Ferre et al., 2020; Fitzgerald et al., 2019; Gao et al., 2015; Lee et al., 2017). Even so, the goal of this project was to educate and provide anesthesia providers with current evidence-based methods to manage SIH. The literature supports a multimodal approach consisting of fluid therapy, mechanical lower extremity compression devices, vasopressors, and serotonin antagonists (Fitzgerald et al., 2019; Lee et al., 2017).

Neonatal Outcomes

There are limited human reports on the effects of maternal hypotension on fetal outcomes. Nevertheless, animal studies have shown that reduced uteroplacental blood flow can result in bradycardia and fetal acidosis, compromising fetal hemodynamics (Sklebar et al., 2019). Uterine blood flow is not autoregulated and depends on sufficient maternal blood pressure for placental perfusion and nutrient exchange. Ten percent of maternal cardiac output is used to perfuse the placenta at term (Nagelhout & Plaus, 2014). With an occurrence rate of nearly 80%, treating hypotension is of the utmost importance to the anesthesia provider.

Studies support the use of ondansetron to attenuate maternal hypotension caused by SAB. A study conducted on 603,385 parturients receiving ondansetron showed no increase in spontaneous abortions, stillbirths, or major birth defects when given in the third trimester (Pasternak et al., 2013). Trabelsi et al. (2015) further analyzed neonatal umbilical arterial blood and APGAR scores after birth, comparing ondansetron and normal saline given 5 minutes prior to SAB. The newborns from the ondansetron group had higher APGAR scores and lower lactate levels. The blood pH from the umbilical artery was closer to the physiologic range (Trabelsi et al., 2015). These findings suggest that ondansetron administered before SAB for healthy CS delivery is safe and beneficial for neonates.

Nausea & Vomiting

Intra-operative nausea and vomiting after spinal anesthesia is a common and unpleasant experience for pregnant patients (Mercier et al., 2013). Hormone changes alter the lower esophageal sphincter tone, a large gravid uterus compresses stomach contents, and hypotension from SAB all contribute to intra-operative nausea and vomiting in the parturient. Ashagrie et al. (2020) stated that maternal hypotension contributes to nausea and vomiting. These symptoms occur due to cerebral and gut hypo-perfusion, which stimulates the brain's vomiting center to release serotonin (Ashagrie et al., 2020). An observational study of 373 pregnant mothers delivering with a CS under SAB found that 40.8% of patients experienced nausea or vomiting, and 18.5% experienced both (Ashagrie et al., 2020). Limiting nausea and vomiting should not be overlooked and requires appropriate intervention by the anesthetist to maintain patient safety and satisfaction.

Ondansetron

Ondansetron is a 5-hydroxytryptamine subtype 3 (5-HT3) receptor antagonist commonly used intraoperatively to prevent nausea and vomiting (Gao et al., 2015; Tubog et al., 2017; Wang et al., 2014a). Zhour et al. (2018) analyzed 21 RCTs and found patients who received ondansetron during CS to have significantly lower incidences of nausea and vomiting. In addition to decreasing the incidence of nausea and vomiting, ondansetron has been studied as an alternative intervention for reducing SAB-induced hypotension. Spinal anesthesia decreases venous return to the heart, stimulating the 5-HT3 receptors. These receptors are located in the intracardiac vagal nerve endings and activate the BJR (Tatikonda et al., 2019; Trabelsi et al., 2015; Owczuk et al., 2008).

A review of two meta-analyses of RCTs supported the administration of ondansetron for reducing SAB-induced hypotension. The authors found that ondansetron can antagonize the BJR via the 5-HT3 receptors and thus decrease hypotension, leading to decreased nausea and vomiting (Gao et al., 2015; Tubog et al., 2017). Four RCTs demonstrated a significant reduction in hypotension when ondansetron was administered 5 minutes before spinal anesthesia compared to the control group (Marashi et al., 2014; Owczuk et al., 2008; Tatikonda et al., 2019; Trabelsi et al., 2015). Some of these studies were restricted to small sample sizes ranging from 80-150 obstetrical and non-obstetrical patients, potentially limiting the generalization of results. Trabelsi et al. (2015) observed that fewer patients experienced a decrease in systolic, diastolic, and mean arterial pressures in the interventional ondansetron group than in the saline group, $p < 0.001$. Wang et al. (2017) conducted two separate studies, investigating the effects of prophylactic ondansetron, and identifying the appropriate dose needed to attenuate SA-induced hypotension. Both RCTs showed a decreased incidence of maternal hypotension in the ondansetron group than in the saline group (Wang et al., 2014a; 2014b).

Furthermore, Wang et al. (2014a) concluded that 4 mg of ondansetron is the optimal dose required to reduce maternal hypotension when compared to 2 mg, 6 mg, and 8 mg. Another randomized study on pregnant women receiving SA found no significant decrease in hypotension between control and intervention groups but did find a significant decrease in cumulative episodes of hypotension and vasopressor consumption when prophylactic ondansetron was administered (Karacaer et al., 2017). Fewer incidences or severity of hypotension will decrease the necessity of vasoactive drugs to maintain maternal hemodynamics leading to increased safety and satisfaction.

Vasopressors

Vasopressors have conventionally been used to treat hypotension in all medical settings. The two most common vasoactive medications used during CS are phenylephrine and ephedrine (Ferre et al., 2020; Lee et al., 2017; Loughrey et a., 2004; Xu et al., 2018). The mechanisms of action differ between the two drugs. The superiority of one over the other in the obstetric population has been highly argued among providers (Ferre et al., 2020; Lee et al., 2017; Xu et al., 2018). Vasoactive drugs during CS may decrease uteroplacental perfusion and cause fetal acidosis (Lee et al., 2017; Loughrey et al., 2004; Xu et al., 2018). Ephedrine is a direct and indirect sympathomimetic medication that stimulates alpha- and beta-adrenergic receptors (Ferre et al., 2020; Lee et al., 2017). Phenylephrine is a direct-acting alpha agonist with a rapid onset and short half-life used as a continuous infusion or bolus (Lee et al., 2017). A meta-analysis comparing the safety of the two medications for SIH found phenylephrine was associated with lower incidences of fetal acidosis (Xu et al., 2018). Other studies found similar results; higher concentrations of CO_2, lactate, and glucose from newborn umbilical blood samples when ephedrine was used (Ngan et al., 2009; Veeser et al., 2012; Xu et al., 2018). Phenylephrine is

preferred as the primary rescue and maintenance vasoactive drug to treat SA hypotension (Lee et al., 2017; Xu et al., 2018). Research has focused on the optimal regimen of phenylephrine. Several studies comparing phenylephrine infusions to boluses found a significantly lower hypotension incidence when an intravenous infusion was used (Allen et al., 2010; Lee et al., 2017; Siddik-Sayyid et al., 2014). Though phenylephrine is preferred over ephedrine, a randomized double-blinded study by Steward et al. (2010) indicated a significant time and dose-dependent reduction in maternal heart rate and cardiac output with phenylephrine. Heart rate and cardiac output decreased with higher doses of phenylephrine and prolonged infusions, suggesting that further investigation of the effects on a fetus is needed (Stewart et al., 2014). Researchers have been prompted to find safer alternatives to treat SA-induced hypotension while minimizing maternal and fetal adverse effects. Consequently, previously discussed studies found significant reductions in vasopressor use when ondansetron was prophylactically used before spinal anesthesia (Marashi et al., 2014; Trabelsi et al., 2014; Wang et al., 2014a).

Intravenous Fluids

The type and timing of intravenous fluids for SAB-induced hypotension have also been highly debated in the literature. Multiple studies demonstrated reduced SIH when colloids were administered (Mercier et al., 2014; Mercier et al., 2013; Ni et al., 2017). Disadvantages such as cost, allergic reactions, and coagulation disturbances reduce colloid solutions' mainstream use (Ferre et al., 2020; Lee et al., 2017; Ni et al., 2017). Crystalloids are a less expensive alternative, and the timing of administration makes a difference in attenuating SAB-induced hypotension. Co-loading is defined as administering a solution at the initiation of SAB (Ni et al., 2017). Crystalloids are only retained in the intravascular space for approximately 30 minutes due to rapid redistribution, supporting the effectiveness of co-loading over preloading (Ni et al., 2017;

Tan et al., 2020). A meta-analysis of 824 parturient patients (10 RCTs) receiving SAB for CS supported co-loading of crystalloids reduced the incidence of SIH more effectively when compared to preloading (Ni et al., 2017). However, the administration of crystalloids alone does not conclusively attenuate SA-induced hypotension. A literature review suggested a combined treatment of fluids and vasopressors was commonly used in clinical practice (Lee et al., 2017; Ni et al., 2017; Sklebar et al., 2019).

Compression Devices/Leg Elevation

During pregnancy, hormonal changes and vena cava compression by the gravid uterus increase blood pooling in the lower extremities (Sujata et al., 2012). Sujata et al. (2012) evaluated the efficacy of lower extremity sequential compression devices in reducing maternal hypotension during elective CS (Sujata et al., 2012). These researchers found a decreased incidence of hypotension when compression devices were used. However, the authors report concomitantly using vasopressors and co-loading of fluids (Sujata et al., 2012). Another RCT with 75 patients compared leg elevation with pillows to regular supine positions and found a decreased incidence of hypotension and intraoperative vasopressor use by 40.9% (Hasanin et al., 2017). The authors concluded that leg elevation would help prevent and manage SA hypotension when combined with other measures; however, it may not be practical (Hasanin et al., 2017). The use of compression devices or leg elevation may work synergistically with other treatments to attenuate SA-induced hypotension by increasing venous return.

Single interventions to reduce maternal hypotension caused by SAB are not effective. Research supports combining several modalities to reduce SAB-induced hypotension. Educating anesthesia providers about these methods can lead to practice change, improving patient safety and satisfaction.

Conceptual Framework/Theoretical Model

Kurt Lewin's Change Theory was the framework used for this DNP project. This theoretical model emphasizes identifying the driving forces that facilitate and inhibit change. Driving forces push in a direction that causes change while restraining forces hinder and oppose change (Hayes, 2018). One objective of this DNP project was to encourage practice change by educating CRNAs about EBP methods to manage maternal hypotension caused by SAB. Lewin's (1951) three-stage model for change consists of *unfreezing, changing*, and *refreezing*. *Unfreezing* involves finding a method to eliminate old counterproductive patterns. The change stage occurs when there is a change in thought, feeling, and behavior. Refreezing establishes a new habit and becomes the standard operating procedure.

The *unfreezing* stage is essential to understand and accept a constant shift of ideas and new developments in medicine. Understanding that change is necessary and accepting change are crucial steps (Hayes, 2018). The pre-survey developed for this project allowed CRNAs to identify gaps in their knowledge regarding SAB-induced maternal hypotension, thereby weakening the restraining forces inhibiting change. The project aimed to strengthen the driving force and identify barriers to encourage CRNAs to be more receptive to change in practice.

The change stage is when the driving forces outweigh restraining forces, thus reducing barriers to change. This stage can take time as adjustments to new beliefs or attitudes develop (Hayes, 2018). The educational intervention provided CRNAs with the latest EBP research to support practice change. It was crucial to reinforce their willingness to improve the quality of care for obstetric patients by providing an EBP foundation for change.

The last stage, *refreezing*, establishes the change as the new equilibrium (Hayes, 2018). The post-survey developed for this project identified barriers to change and perceived improvement of patient outcomes. Change will be sustained by helping CRNAs identify barriers, learn new clinical standards, and recognize positive patient outcomes. Recommendations were presented to hospital administrators with changes to reduce barriers and encourage sustained practice change.

Methods

Design

This project was a post-intervention follow-up design consisting of a pre-intervention survey, an online educational video, and a post-intervention survey. Qualtrics web-based software was used to create and format the surveys for online access. Recruitment of participants occurred via email, which was distributed to all practicing CRNAs by the chief of the anesthesia department. The recruitment email explained the purpose and design of the project and contained the link to the pre-survey. Consent was voluntary and obtained when participants clicked on the pre-survey link.

The educational interventional video was embedded at the end of the pretest survey; the participants could not access it before completing the pretest survey. An answer to each question was required to continue with the pre-survey. Two faculty experts evaluated the video content for accuracy. Participants with the link had open access to the presentation to view or revisit in their leisure time. The online presentation addressed evidence-based methods to manage spinal-induced hypotension. Physiological effects and literature-based recommendations for pre-procedural ondansetron were described in detail. The content of the video focused on a

multimodal approach to managing spinal-induced hypotension following spinal anesthesia. The presentation detailed the use of prophylactic ondansetron, co-loading of crystalloid fluids, and mechanical compression devices to attenuate SAB-induced hypotension for parturient patients undergoing elective CS.

Posttest surveys were emailed one month after the interventional video. This DNP project's primary investigators (PIs) were Student Registered Nurse Anesthetists (SRNAs). The objectives for this project are outlined below.

1. Develop evidence-based guidelines to reduce spinal anesthesia-induced hypotension in patients undergoing elective CS.
2. Decrease the knowledge gap through an online educational intervention.
3. Identify barriers to practice change among participants.

Translational Framework

This project fundamentally adhered to the ACE Star Model of knowledge transformation, a framework for systematically incorporating evidence into clinical practice. Configured as a 5-point star, this model consists of five stages: knowledge discovery, evidence summary, translation into practice recommendations, integration into practice, and evaluation (STAR Model, 2020). The initial stage, the discovery of knowledge generated from empirical research, is omitted from this project.

Evidence summary is the task of synthesizing all the research findings. A literature review on the treatment of spinal-induced hypotension from online databases produced extensive results on the topic. Information was collected from systematic reviews, randomized control trials, and critically appraised articles to formulate practice guidelines. The next stage of the ACE Star

model involves translating the evidence into practice recommendations. During this stage, anesthesia providers were presented with clinically proven methods to manage spinal anesthesia's adverse side effects on parturient patients. Education encompassed the physiology and impact of using ondansetron, crystalloid co-loading, and sequential compression devices to reduce spinal-induced hypotension during cesarean delivery. Practice integration follows the development of practice guidelines. A post-survey was sent to providers and indirectly assessed this stage. The final stage is the evaluation phase. The goal was to evaluate the impact of new guidelines on patient outcomes, provider practice, and barriers to practice changes.

Setting and Sample

The main stakeholders in this study included anesthesia providers currently practicing obstetric anesthesia. No direct patient information or intervention was collected or conducted. However, patient outcomes were based on CRNAs' reports of healthy parturient patients undergoing elective CS. A convenience sample of members working at a private 660-bed urban hospital was gathered through recruitment emails. Inclusion criteria for participation included CRNAs actively practicing and administering spinal anesthesia. Exclusion criteria included SRNAs and providers with no obstetric anesthesia practice. A target of 30 participants was desired, with a maximum of 50 participants.

Data Collection

Following the university Institutional Review Board (IRB) and faculty approval, a recruitment email was sent by the PIs and described the purpose of the study. Recruitment began in September 2021 and lasted for a month. A link to a pretest survey was included at the end of the recruitment email. Data collected from the pretest survey included demographics, length of practice, type of anesthesia practice model, and experience level with obstetric anesthesia. All data was automatically collected and stored by Qualtrics web-based system as surveys were completed. Participation was voluntary, and informed consent was implied when participants completed the pretest survey. Inclusion and exclusion criteria were screened at the beginning of both surveys by asking participants if they currently practiced obstetric anesthesia and administered sub-arachnoid blocks to patients. The survey results were not included in the data analysis if the subject did not meet these criteria.

Instruments

Pretest and post-test surveys were developed by the PIs and reviewed by two content experts for accuracy and validity. The pretest survey included multiple-choice, Likert-scale, and open-ended questions. Multiple choice questions gathered demographic data, including age, gender, length of practice, and experience with OB anesthesia. One set of Likert-scaled questions was asked in both the pre-and post-surveys to identify knowledge gaps on SAB-induced hypotension management. Likert-scaled questions were also used to identify participants' perceived incidence of adverse effects after SAB-induced hypotension. Email addresses were requested in the pre-survey to email the follow-up post-test survey link. No other identifying information was obtained; email addresses were only accessible to the PIs of the project and were password protected on a secure network. Participants were asked to list their mother's

birthday; this information was used as an identifier to compare pre-and post-survey data.

The post-test survey was emailed to participants one month after completing the pre-survey. This survey included multiple-choice and Likert-scale questions. One multiple-choice question asked participants if they had practiced obstetric anesthesia within the last month to determine inclusion criteria. Likert-scale questions were asked in the pre-and post-surveys to identify gaps and retained knowledge. The last section of Likert-scale questions was used to identify barriers to practice.

Data Analysis

Data were analyzed with the assistance of a statistician from the University of North Carolina at Greensboro. All the data collected from the surveys was inspected for completion and quality control. Data from Qualtrics was then exported to Microsoft Excel to quantify and summarize participant responses from the pre and post-test. Descriptive statistics were used to analyze and summarize the data into patterns or reoccurring themes.

Results

There was a total of 40 survey responses. After analyzing for quality and completion, five participants were excluded from the pre-intervention and two from the post-intervention for incomplete surveys. Three did not meet the inclusion criteria of practicing spinal anesthesia. Thus, the final pre-intervention sample consisted of 30 participants, and the post-intervention consisted of 10 participants.

Demographic data collected included age, sex, degree level, years practicing anesthesia, and OB anesthesia. Descriptive statistics were used to describe the central tendencies of the data.

The sample consisted primarily of females (n=20), with 80% of the total sample equally distributed within the 26-35 (n=12) and 36-45 (n=12) age groups. Ninety percent of participants held a master's degree (n=16), 7% held a doctorate (n=2), and 3% held a certificate degree. Most participants (53%) reported practicing anesthesia for 6-10 years (n=16). Zero participants reported practicing OB anesthesia daily; comparatively, 83% practiced 2-3 times per month, and 17% practiced 2-3 times per week.

Identifying a clinical problem

Participants were asked six questions during the pre-intervention to identify a self-reported incidence of adverse effects following spinal anesthesia. Responses from the Likert scale questions were divided into two categories for comparison: scores 1-2 (never to rarely) and 3-5 (occasionally to very frequently). Occasionally to very frequently was used as a positive response to the incidence of complications. Ninety-three percent of participants reported hypotension occurring following SAB. Regarding the administration of vasopressors, 100% of CRNAs reported administering them after SAB. No participants reported severe bradycardia, but 53% reported bradycardia of 60 beats per minute (BPM) or less. Participants reported nausea 86% of the time, while vomiting was reported 56% of the time.

Knowledge

Likert-Scale questions were asked to rate participant knowledge regarding SIH management before and after the intervention. Baseline knowledge was evaluated pre-intervention, and the same questions were asked post-intervention to measure knowledge achieved. Descriptive statistics were utilized for meaningful comparison. Responses were rated on a five-point scale of "Strongly disagree" (1) to "Strongly disagree" (5). Multiple responses

demonstrated an average increase from pre- to post-intervention, suggesting an increase in knowledge. Seventy percent of participants reported being familiar with the BJR pre-intervention, increasing to 100% post-intervention. An increase from 60% to 75% was found in response to "ondansetron antagonizes cardiac serotonin receptors." There was not a significant increase in responses for preprocedural ondansetron reducing SIH (36-37%) and co-loading of crystalloids reducing SIH (93-100%). Seventy-five percent of participants responded being familiar with current EBP post-intervention, compared to 70% pre-intervention. Additionally, only 87% of participants agreed that nausea and vomiting result from hypotension caused by spinal anesthesia.

Barriers to Practice

Barriers to practice change regarding the use of pre-procedural ondansetron were assessed post-intervention using Likert-scale questions scored from "Strongly disagree" (1) to "Strongly agree" (5). All participants strongly disagreed that the administration of ondansetron caused adverse effects on the fetus at term. Time constraints to administering ondansetron before spinal anesthesia were not a barrier, as all participants responded: "Strongly disagree." Eighty percent of CRNAs disagreed that their colleagues do not support the use of pre-procedural ondansetron, and 20% were neutral. Half of the participants were not comfortable using unfamiliar interventions to manage SIH, while 10% stated they needed to see more EBP support to integrate presented interventions into practice. Fifty percent of participants scored "Strongly disagree" when asked if ondansetron was part of their facility's protocol for managing SIH. Despite the mentioned barriers, there was an increase (70-75%) of ondansetron utilization pre- and post-intervention. Eighty percent of CRNAs agreed to continue using pre-procedural ondansetron to reduce SIH.

Discussion

Project findings shed light on CRNA practice trends, knowledge, and challenges related to the management of spinal-induced adverse effects for elective CS. Incidence of hypotension, nausea, vomiting, bradycardia and use of vasopressors after SAB were all reported by CRNAs. The results of this project are consistent with the literature that spinal anesthesia-induced bradycardia, hypotension, nausea, and vomiting are common in practice. Sklebar et al. (2019) and Klohr et al. (2010) found up to 75% incidence of hypotension in parturient patients following spinal anesthesia. Comparably, 93% of participants of this project agreed that hypotension occurs following spinal anesthesia. Likewise, Ashagrie et al. (2020) found that 40% of parturient patients experienced nausea or vomiting. This project found that 53% of participants agreed that vomiting occurs following spinal anesthesia. All participants reported using vasopressors following SAB, mirroring Ferre et al. (2020), Xu et al. (2018), and Loughrey et al. (2004) report on the conventional use of vasopressors for the management of SIH. The prevalence of symptoms and survey responses demonstrated that practice is focused on treatment and not on the prevention of SAB complications.

Creating change can be difficult, as described by Lewin's Change Theory (Hayes, 2018). Challenging the status quo and reducing barriers to change are crucial first steps—this project aimed to challenge how anesthesia providers manage SIH with an educational intervention. By introducing up-to-date literature to support the EBP of SIH management, the goal was to create practice change by integrating newly obtained knowledge into practice. Comparison of pre-and post-survey results supported an increase in knowledge after the educational video was presented. The most significant increase occurred with the familiarity of BJR (70-100%) and ondansetron antagonizing serotonin receptors (60-75%).

Additionally, 75% of participants agreed they were familiar with current EBP, compared to 70% pre-intervention. However, there was only a slight increase for preprocedural ondansetron (36-37%) and administration of co-loading crystalloids (93-100%) for reducing SIH. These small shifts suggest a learning opportunity, and reinforcement of interventional education is needed.

The change will occur with education, communication, and support for the participants as they become familiar with the new (Hayes, 2018). The absence of ondansetron from standardized protocols (50%) and unfamiliarity with ondansetron for SIH management (50%) were the most reported barriers to practice change. In comparison, 10% of participants reported needing more evidence-based support to integrate the presented interventions into practice. Interestingly, 80% of participants agreed to continue using pre-procedural ondansetron to reduce SIH. Through communication and education amongst their peers, change in practice can be feasible.

Limitations

A significant limitation was that due to the COVID-19 pandemic, this project was conducted online to minimize staff and PIs exposure to the virus. It was unknown if the CRNAs fully or partially viewed the educational intervention. Since some CRNAs reported needing more EBP literature, presenting the intervention as an in-service at the facility would have ensured the CRNAs received the full educational intervention. The data was limited to a small convenience sample from only one facility, further limiting the generalization of results. Most participants did not provide their mother's date of birth to link pre-and post-surveys, leading to limited statistical analysis of the data. A larger sample and completed results would have yielded more meaningful data.

Another limitation was the pre-and post-surveys created by the PIs of the project. The content was reviewed by anesthesia experts, but no reliability or validity scores were established for the surveys. Thus, it was difficult to determine if the surveys measured the intended outcomes.

Recommendations for Future Study

Most of the studies reviewed for this project were RCTs or meta-analyses that supported a multimodal approach for SIH management. However, there are studies that conflict with the findings of this project. The small sample sizes and convenience samples from most studies limited the generalization of the results. Additionally, some CRNAs reported the need for more quality EBP literature as a barrier to practice implementation. Further research with larger-scale RCTs would be beneficial to identify the efficacy of current guidelines for the management of SIH. Evaluating the effect of these interventions on complications from spinal anesthesia in other types of cases may improve outcomes for other patient populations.

Additionally, this project only evaluated participants' subjective responses to incidences of hypotension, nausea, vomiting, and vasopressor use after spinal anesthesia during elective CS. No objective data from patient charts were collected to measure outcomes after implementing EBP-supported guidelines. A retrospective chart review will more accurately evaluate the efficacy and the results of practice change.

Relevance and Recommendations for Clinical Practice

This DNP project supported the use of EBP education to reinforce knowledge and best current practices for anesthesia providers. Practice guidelines and protocols should be implemented to promote quality and safe patient care using the newest EBP. Practice change can be supported by regular EBP education utilizing conferences or staff meetings to introduce new guidelines to anesthesia providers.

Conclusion

This DNP project sought to increase provider knowledge by introducing an educational intervention to CRNAs about EBP guidelines for managing SIH in patients undergoing elective CS. Awareness and utilization of the current EBP increased after the educational intervention, mostly with preprocedural ondansetron. Barriers were identified and reported to the facility to increase the use of the best EBP to decrease complications after spinal anesthesia for CS. Despite the lack of statistical significance found in the data, the specific aims of this project were met.

Current research supports pre-procedural ondansetron, co-loading of intravenous fluids, and sequential compression devices for attenuating SIH during CS. Educating anesthesia providers and adopting EBP guidelines in clinical practice leads to better perioperative outcomes and improved quality of care. Removing barriers will allow providers to practice using the newest EBP and improve patient outcomes.

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Appendix A

Pre -Intervention Survey

Please enter the month and year (xx/xx) of your mother's birthday. (This is used to link pre & post surveys)					
Please submit your email address (This will be used to send the post-intervention survey)					
Sex	Male☐ Female☐ Other☐				
Age	<25☐ 26-35☐ 36-45☐ 46-55☐ 55-65☐ >65☐				
Degree	Certificate☐ Masters☐ Doctorate☐				
Number of years practicing anesthesia	< 1☐ 1-5☐ 6-10☐ 11-15☐ 16-20☐ >20☐				
How often do you practice obstetric anesthesia?	Daily☐ 2-3x Weekly☐ 2-3x Monthly☐ Never☐				
Please select what is most applicable to your experience/practice following spinal anesthesia in obstetrics.	**Never**	**Rarely**	**Occasionally**	**Frequently**	**Very Frequently**
Hypotension (a 20% or greater decrease in MAP) occurs following spinal anesthesia.					
Bradycardia (60BPM or less) occurs following spinal anesthesia.					
Severe bradycardia (less than 40BPM) occurs following spinal anesthesia.					
In your practice, how often do you see parturient patients become nauseous after receiving spinal anesthesia?					
In your practice, how often do your parturient patients vomit after receiving spinal anesthesia?					
In your practice, how often do you have to administer vasopressors following spinal anesthesia?					
I administer ondansetron before spinal anesthesia.					

Please select what is most applicable to your knowledge and experience.	**Strongly Disagree**	**Disagree**	**Neither Disagree nor Agree**	**Agree**	**Strongly Agree**
I am familiar with the Bezold-Jarisch Reflex.					
Ondansetron antagonizes cardiac serotonin receptors.					
Pre-procedural Ondansetron reduces the incidence of spinal-induced hypotension.					
Co-loading with crystalloids reduces the incidence of spinal-induced hypotension.					
Sequential Compression Devices reduce the incidence of spinal-induced hypotension.					
Administration of multiple doses of vasopressors adversely affects fetal pH.					
Nausea is a result of post-spinal hypotension.					
Vomiting is a result of post-spinal hypotension.					
I am familiar with the current evidence-based practices for managing spinal-induced hypotension.					

Appendix D

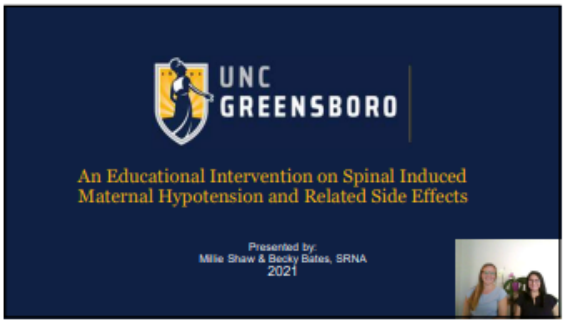
Post-Intervention Survey

Please enter the month and year (xx/xx) of your mother's birthday. (This is used to link pre-and post-surveys)					
In the **LAST MONTH**, how often did you practice obstetric anesthesia?	Daily☐ 2-3x Weekly☐ 2-3x Monthly☐ Never☐				
In the last month, please indicate your perception of the effectiveness of preprocedural ondansetron, co-loading of crystalloids, and sequential compression devices on the following:	**No effect**	**Minor Effect**	**Moderate Effect**	**Strong Effect**	**Very strong**
Spinal-induced hypotension					
Bradycardia					
Nausea					
Vomiting					
Intraoperative vasopressor requirement					
Please select what is most applicable to your knowledge and experience	**Strongly Disagree**	**Disagree**	**Neither Disagree**	**Agree**	**Strongly Agree**
I am familiar with the Bezold-Jarisch Reflex.					
Ondansetron antagonizes cardiac serotonin receptors.					
Pre-procedural Ondansetron reduces the incidence of spinal-induced hypotension.					
Co-loading with crystalloids reduces the incidence of spinal-induced hypotension.					
Sequential Compression Devices reduce the incidence of spinal-induced hypotension.					
Administration of multiple doses of vasopressors adversely affects fetal pH.					
Nausea is a result of post-spinal hypotension.					

Please select what is most applicable to your experience/practice following spinal anesthesia in obstetrics.	**Never**	**Rarely**	**Occasionally**	**Frequently**	**Very Frequently**
I administer ondansetron before spinal anesthesia					
Please select the answer most applicable to your practice	**Strongly Disagree**	**Disagree**	**Neither Disagree**	**Agree**	**Strongly Agree**
I believe ondansetron ***has adverse*** effects on the fetus at term.					
My colleagues ***do not*** support the use of pre-procedural ondansetron.					
I need to see more evidence-based support in the literature to integrate the presented interventions into my practice.					
I have time constraints that prevent me from administering ondansetron before spinal anesthesia.					
Ondansetron is currently not part of my facility's protocol on managing spinal-induced hypotension.					
I am ***not*** comfortable using unfamiliar interventions to manage spinal-induced hypotension.					
I will continue to utilize pre-procedural ondansetron for reducing spinal-induced hypotension.					
Please indicate any barrier(s) you have encountered when implementing the presented interventions to manage spinal-induced hypotension in your clinical practice.					
Vomiting is a result of post-spinal hypotension.					
I am familiar with the current evidence-based practices for managing spinal-induced hypotension.					

Appendix C

Interventional PowerPoint



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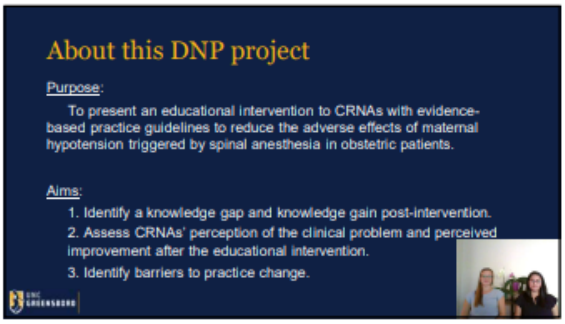

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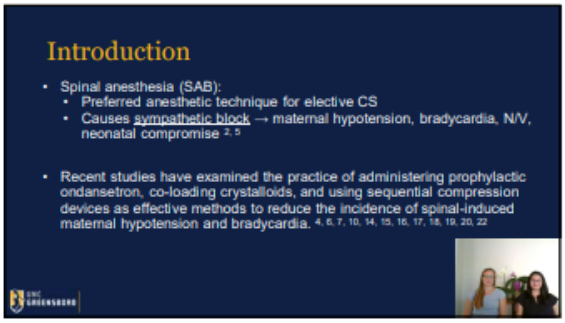

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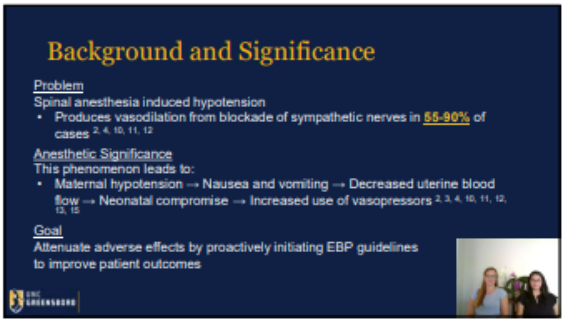

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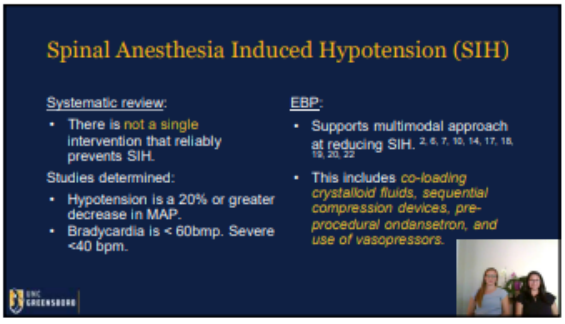


6

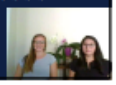
Ondansetron

Literature review

- A 5-HT3 antagonist.
- SIH stimulates the 5-HT3 receptors located in the intracardiac vagal nerve endings and chemoreceptor trigger zone. [11, 12, 16, 21]
- SIH activates the Bezold-Jarisch reflex via the 5-HT3 receptors. As a result, the *Bezold-Jarisch reflex causes bradycardia*. [1, 9, 11, 12, 21]

EBP

- Groups that received ondansetron prior to spinal anesthesia had: [13, 14, 15, 16]
  - fewer episodes of hypotension
  - fewer episodes of bradycardia
  - fewer episodes of nausea and vomiting
  - decreased use of vasopressor use
  - better neonatal outcomes
- Ondansetron antagonizes cardiac serotonin receptors, therefore reducing the incidence of SIH. [4, 6, 7, 16, 18, 19, 20, 22]



7

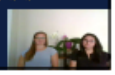
Neonatal Outcomes

Literature review

- Neonates born to mothers with prolonged SIH were significantly more acidotic, hypoxic, and had an increased risk of neurological deficits. [3, 10, 11, 12, 13]
- Exposure to ondansetron during pregnancy does not cause any major birth defects, spontaneous abortion, or preterm delivery. [7, 15, 18, 22]

EBP:

- With administration of pre-procedural ondansetron, neonates experienced higher Apgar scores and less acidosis. [3, 4, 15, 18, 19, 22]
- *Evidence supports the use of ondansetron 5 minutes prior to spinal anesthesia to improve the metabolic and vital parameters in the newborn.* [4, 6, 7, 16, 18, 19, 20, 22]



8

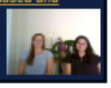
Nausea & Vomiting

Literature review

- Parturient patients are always considered a full stomach with a high risk of aspiration. [11, 12]
- SIH leads to nausea/vomiting from decreased cerebral blood flow. [2, 10,11, 12, 16, 19, 20, 22]

EBP

- Found significantly lower incidences of nausea & vomiting caused by SIH during CS in ondansetron groups when compared to control groups. [4, 6, 7, 16, 18, 20, 22]
- *Administering ondansetron five minutes prior to spinal anesthesia prevents nausea and vomiting at its origin.*



9

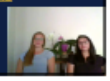
Co-loading Crystalloids

Literature review

- Crystalloids are less expensive and have little to no risk of allergic reactions or coagulation disturbances. [14]
- Crystalloids are retained in the intravascular space for a *maximum of 30 mins.* [11, 12]

EBP

- Coloading crystalloids is defined as administering solution at the initiation of spinal anesthesia. This practice reduces SIH when compared to preloading. [11, 12, 14]
- *Coloading 15-20 ml/kg of crystalloids increases intravascular volume and reduces maternal SIH.*



10

Sequential Compression Devices

Literature review

- Blood pooling in the lower extremities occurs due to hormonal changes and vena caval compression from pregnancy. [11, 12]
- Due to the sympathetic block, SIH will further increase blood pooling. Resulting in decreased preload leading to maternal hypotension. [2, 3, 10, 11, 12, 13]

EBP

- Sequential compression devices reduce SIH by increasing venous return.
- *The use of compression devices can reduce SIH when used in combination with coloading of fluids.* [17]

11

Vasopressor requirements

Literature review

- Vasoactive medications decrease uteroplacental perfusion, which can contribute to fetal acidosis. [3, 6, 10, 11]
- Ephedrine was associated with higher incidence of fetal acidosis when compared to neosynephrine. [8]

EBP

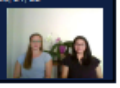
- Further studies are needed to find safer alternatives to treat SIH while minimizing fetal adverse effects.
- Pre-procedural ondansetron is effective at decreasing vasopressor requirements, therefore minimizing fetal acid-base disturbances. [4, 6, 16, 20, 22]

12

Conclusion

Studies have shown that a multimodal approach is safe and effective at reducing the incidence of SIH by:

- Sequential compression devices
  - Increases venous return [17]
- Coloading crystalloids
  - Increases vascular volume [11, 12, 14]
- Administering ondansetron five minutes before spinal anesthesia
  - Reduces the Bezold-Jarisch reflex [18, 19, 20]
  - Antagonizes cardiac serotonin receptors [7, 11, 12, 16, 18, 19, 20, 21, 22]
  - Decreases nausea and vomiting [4, 6, 7, 16, 18, 19, 20, 21, 22]
  - Decreases vasopressor requirements [4, 6, 7, 18, 19, 20, 22]



13

UNC GREENSBORO

Thank You

In 1 month, you will receive a link (via email) to complete a follow-up survey to assess for your utilization of pre-procedural IV ondansetron, perceived barriers to its utilization, and to evaluate self-reported efficacy in patient outcomes.

14

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