EDUCATION ON THE ROLE OF PROPHYLACTIC ONDANSETRON IN PREVENTING SPINAL ANESTHSIA-INDUCED HYPOTENSION AMONG CESAREAN SECTION PATIENTS

Olivia Lanier

A Project Report Submitted to
the Faculty of The School of Nursing at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the
Doctorate in Nursing Practice

Greensboro, North Carolina
2024

Approved by:

Vadim Korogoda, DNP, CRNA	Project Team Leader
Wanda Williams, PhD, MSN, RN, WHNP-BC, CNE	DNP Program Director

Table of Contents

Dedication and Acknowledgements

Achieving my dream of becoming a Certified Registered Nurse Anesthetist would not have been possible without the unwavering love and support of my husband, Blake. Thank you for handling the "adult" parts of our life for the last three years, the countless dinners you made and lunches that you packed, your flexibility with my ever-changing schedule, and the constant pep-talks to keep me motivated. There are not enough words to convey my appreciation for the sacrifices you have made so I could follow my passions. *We* did it, babe!

Thank you to my parents for all of your love and support over the years. I know it was not easy to watch me move hundreds of miles from home first for undergrad, and then for my first job as a nurse, but I am so thankful that you encouraged me anyways. Without your love and encouragement, I would not have moved to North Carolina and ended up on the path that brought me to anesthesia school.

Special shoutout to my classmates Cynthia, Hanna, Megan, and Anna for keeping me sane for the last three years. There is no way I could have made it through without your support, commiseration, and laughs along the way. We celebrated the milestones together, shared stories, and spent countless hours together in carpool. I'm so thankful that our paths crossed and I get to call you my friends.

Thank you to the countless preceptors across the state of North Carolina who taught me how to be a confident and knowledgeable anesthesia provider. Their patience is unrivaled.

Abstract

Background: Hypotension resulting from the placement of a spinal anesthetic results in as much as 80% of obstetric patients experiencing low blood pressure over the course of a cesarean section. Hypotension can result in significant side effects for both mother and baby including nausea and vomiting, cardiac collapse, impaired uteroplacental perfusion, and fetal acidosis. Ondansetron is a 5-HT3 receptor antagonist that is effective in attenuating spinal-induced hypotension by blocking serotonin-activated 5-HT3 receptors and preventing the activation of the Bezold-Jarisch reflex, which results in hypotension, bradycardia, and vasodilation. **Purpose:** This project aimed to evaluate if an educational intervention would result in practice change, increased utilization of prophylactic ondansetron prior to cesarean sections done under spinal anesthesia, and improved patient outcomes. **Methods:** Participants attended an educational presentation on the role of ondansetron in preventing spinal-induced hypotension (SIH). Pre and post-intervention surveying was used to assess participant knowledge and perceptions on the incidence of clinical outcomes such as hypotension and use of vasopressors. A chart review collected data on elective cesarean sections under spinal anesthesia to evaluate the rate of prophylactic ondansetron use and vasopressor consumption. **Results:** 52 cases were reviewed, which showed an increase in prophylactic ondansetron administration after the intervention. There was a significant decrease in the average vasopressor consumption after the intervention. However, there was not a relationship between receiving prophylactic ondansetron and the incidence of hypotension. Survey results indicated increased participant knowledge regarding prophylactic ondansetron. **Conclusion:** The project was successful in resulting in CRNA practice change and increased use of prophylactic ondansetron. Educational presentations are an effective

way to inform CRNAs on evidence-based practice recommendations and can result in meaningful practice change and increased knowledge among participants.

Key Words: *ondansetron, hypotension, spinal anesthesia, spinal, spinal-induced, obstetrics, cesarean section.*

Background and Significance

Subarachnoid block, or spinal anesthesia, has been the preferred method of anesthesia for parturients undergoing elective Cesarean section for decades due to its effectiveness, ease of use, maternal awareness during fetal delivery, low maternal morbidity, and ability to limit medications that may transfer to the fetus (Noffsinger, 2022). However, hypotension and bradycardia persist as one of the leading side effects of spinal anesthesia, with incidence rates as high as 80% in the obstetric population (Gao et al., 2015). Prolonged, significant hypotension can have detrimental effects for both the mother and the fetus, including maternal bradycardia, nausea, vomiting, and dysrhythmias (Tubog & Bramble, 2022). Fetal effects can include acidosis, low Apgar scores, respiratory distress, and others, any of which could necessitate admission to a neonatal intensive care unit (Knigin et al., 2020).

The preferred strategy for managing maternal hypotension has changed over the last several decades as research and evidence have evolved. Evidence-based strategies discussed in the literature include IV fluid preloading vs co-loading, use of colloid vs crystalloid IV fluids, use of vasopressors (including ephedrine, phenylephrine, and norepinephrine), use of lower extremity sequential compression devices, low-dose spinal anesthesia, positioning, and use of 5-HT3 receptor antagonists such as ondansetron (Lee et al., 2017; Noffsinger, 2022). Despite the presence of multiple evidence-based interventions, Sklebar et al., (2019) stated that "selection of the most efficient treatment strategy to achieve hemodynamic stability during spinal anaesthesia for cesarean section continues to be one of the main challenges in obstetric anaesthesiology," (p. 90).

More recent literature discusses the use of 5-HT3 receptor antagonists such as ondansetron for managing spinal-induced hypotension. Researchers have hypothesized that

serotonin activation of 5-HT3 receptors can elicit the Bezold-Jarish Reflex, which may be responsible for the hypotension and bradycardia that are frequently seen after spinal anesthesia (Gao et al., 2015; Tubog et al., 2017). By administering ondansetron, these receptors are blocked from activation and less hypotension and bradycardia may be seen as a result. Multiple RCTs in the last decade have investigated the effectiveness of ondansetron in preventing hypotension and bradycardia, with many reporting statistically significant differences in the incidence of hypotension in patients who received ondansetron before spinal administration versus those who did not (El Khouly, N. I., & Meligy, A. M., 2016; Gao et al., 2015; Marashi et al., 2014; Sahoo et al., 2012; Tubog et al., 2017).

Purpose

The purpose of this project was to evaluate if an educational intervention would result in CRNA practice change and increase utilization of prophylactic ondansetron prior to cesarean sections done under spinal anesthesia leading to improved patient outcomes.

Literature Review

A literature review was completed using the following search terms: *ondansetron, hypotension, spinal anesthesia, spinal, spinal-induced, obstetrics,* and *cesarean section.* The databases searched included CINAHL, Scopus, and PubMed. Fifteen articles published between 2008 and 2022 were selected from these search terms. Inclusion criteria included publication in the last 15 years, randomized controlled trials, systematic reviews, retrospective analyses, meta-analyses, and articles published in the English language. Articles that were not published in English, were more than 15 years old, and were non-peer reviewed were excluded. After analysis, general themes included a discussion of multiple ways to prevent and treat maternal hypotension, maternal and fetal outcomes, changes in vital sign parameters including MAP

(mean arterial pressure), SBP (systolic blood pressure), DBP(diastolic blood pressure), and HR (heart rate), and decreased use of vasopressors necessary to treat hypotension.

Current State of Knowledge

Research into the mechanism of spinal-anesthesia-induced hypotension has identified the Bezold-Jarish reflex as the cause. Described as early as 1867 by Albert von Bezold and again by Adolf Jarisch in the late 1930s, the Bezold-Jarisch reflex is a cardio-inhibitory reflex that can result in bradycardia, hypotension, and vasodilation from mechanoreceptor activation in the left ventricle (Warltier et al., 2003). In the setting of spinal anesthesia, it has been hypothesized that serotonin-activation of 5-HT3 receptors plays a role in the potentiation of bradycardia, hypotension, and vasodilation (Gao et al., 2015). Ondansetron is a selective 5-HT3 receptor antagonist, prophylactic administration of this drug prevents the activation of receptors that would ultimately lead to the Bezold-Jarisch reflex and the resulting triad of symptoms (El Khouly et al., 2016; Lee et al., 2017). Research has determined this intervention may be considered the new "best practice" for preventing spinal anesthesia-induced hypotension.

Spinal Anesthesia

Spinal anesthesia has been the preferred method of anesthesia for cesarean sections for the last several decades due to its association with improved APGAR scores, improved patient satisfaction and maternal-newborn bonding, reduced hospital length of stay, and reduced fetal exposure to anesthetic drugs (Al-Husban et al., 2021; Havas et al., 2013; Knigin et al., 2020; Ring et al., 2021 Sung et al., 2021). Though general anesthesia (GA) remains necessary for emergent cesarean sections, situations of maternal or fetal distress, or for patients whom spinal or epidural anesthesia is contraindicated, it is also associated with risk of failed intubation, aspiration, intraoperative awareness, and respiratory complications for both mother and fetus (Al-Husban et al., 2021; Havas et al., 2013; Ring et al., 2021 Sung et al., 2021). Worldwide,

cesarean section is the most performed surgery, with nearly 30 million occurring each year (Kearns et al., 2021). With the failure rate of spinal anesthesia as low as 1%, it is an extremely reliable method of anesthesia for cesarean section (Al-Husban et al., 2021).

Mechanism of Action

When a spinal anesthetic is performed, a needle (typically 25-27G pencil-point) is introduced into the L3-L4 or L4-L5 space. It is advanced through the layers of skin and ligaments until the subarachnoid space. The introducer is removed, and a clinician will know they have successfully reached the subarachnoid space if clear cerebrospinal fluid (CSF) is seen. Local anesthetic (LA) is injected while the needle remains in place, with intermittent aspiration performed to ensure the needle remains in the subarachnoid space. Once all LA has been injected, the entire apparatus is removed from the patient's back and anesthesia onset begins within 3-5 minutes (Pardo & Miller, 2018).

In spinal anesthesia, the selected local anesthetic acts on the surrounding spinal cord nerve roots, blocking the resulting transmission of signals. Various nerve fibers are blocked depending on the density of local anesthetic injected and sensitivity of surrounding nerve fibers- spinal anesthesia usually results in significant sympathetic blockade, but less sensory blockade than epidural anesthesia. The blockade of sodium channels results in inhibition of spinal nerve impulse conduction, greatly reducing sensations of pain, and allows the spinal anesthetic to serve as the primary anesthetic in cesarean sections (Nagelhout & Elisha, 2018).

Side Effects

Spinal anesthesia is associated with the risk for significant side effects. Since it causes significant sympathetic blockade and results in vasodilation, a very common side effect is hypotension, occasionally accompanied by bradycardia. Hypotension also increases the risk of maternal nausea and/or vomiting. Severe and sustained spinal-induced hypotension (SIH) can

also result in cardiac collapse, impaired uteroplacental perfusion, and fetal acidosis (Al-Husban et al., 2021; Havas et al., 2013; Knigin et al., 2020; Ring et al., 2021). With the incidence of maternal hypotension reported as high as 80% (Gao et al., 2015), it is a side effect that anesthesia providers must be comfortable managing and anticipate treating in the majority of cesarean section patients.

Risks of Maternal Hypotension

Maternal Risks

Maternal hypotension is associated with a variety of negative outcomes, including nausea, vomiting, compromised uteroplacental perfusion, cardiovascular collapse, decreased level of consciousness, decreased cerebral perfusion, and even death if hypotension is severe and refractory to treatment (Lee et al., 2017; Noffsinger 2022; Sklebar et al., 2019; van Dyk et al., 2022). A study by Knigin et al. (2020) found that 43.4% of women undergoing elective cesarean sections experienced "sporadic hypotension," which was defined as one or more episodes of hypotension. Maternal hypotension is a persistent problem among the elective cesarean section population, and reducing its incidence will result in improved maternal outcomes.

Fetal Risks

Hypotension is also associated with negative fetal outcomes. As reported by Knigin et al. (2020), Neonates were 1.83 times more likely to experience acidosis when a mother had sporadic hypotension and three times more likely to experience acidosis when the mother experienced sustained hypotension. Acidosis increases the risk of fetal distress and the potential need for admission to a neonatal intensive care unit (Knigin et al., 2020). When maternal hypotension is severe enough to require vasopressors, this may exacerbate the problem and further worsen fetal acid-base balance (Cooper et al., 2002; Loughry et al., 2004). Knigin et al. (2020) described maternal hypotension as a "potentially modifiable risk factor" (p. 747) for fetal acidosis and

resulting fetal outcomes. By preventing maternal hypotension, clinicians are also improving fetal outcomes at the same time.

Prevention and treatment options for SIH

As the findings encouraging the use of ondansetron are recent, anesthesia providers have continued using other preventative and treatment methods. Current practice includes fluid pre or co-loading, crystalloid vs. colloid fluids, vasopressors, uterine displacement, lower limb compression, and low-dose spinal anesthesia. (Lee et al., 2017; Noffsinger, 2022; van Dyk et al., 2022). Significant research has been done in an attempt to identify the most effective interventions, with the Cochrane review by Chooi et al. (2020) reporting risk reduction between 8-39% across all interventions studied versus control groups (who were not given ondansetron). However, researchers reported the quality of evidence to be low or very low, which indicates a need for further research. Despite the research done thus far, evolving practice recommendations over the last several decades has led to a lack of consensus among anesthesia providers regarding the most effective option for managing SIH.

Evidence has changed in regard to the place of vasopressors in the management of hypotension. Ephedrine had been the vasopressor of choice to treat hypotension associated with spinal anesthesia for cesarean section in the 1970s. However, newer research determined that phenylephrine is more effective at maintaining uteroplacental perfusion and fetal acid-base balance (Noffsinger, 2022) and has become the recommended vasopressor by multiple anesthesia and obstetric societies worldwide (ASA, 2016; Kinsella et al., 2018). However, both vasopressors may cause fetal acidosis and result in suboptimal fetal outcomes (Cooper et al., 2002; Knigin et al., 2020), so avoidance of vasopressors is ultimately the preferred strategy.

With a multitude of options for preventing and treating spinal-induced hypotension, it can make it difficult for anesthesia providers to stay current on best practice recommendations.

However, as additional research into the role of ondansetron is conducted in the future, this may provide anesthesia providers with irrefutable evidence of its status as an emerging best practice.

Ondansetron

Mechanism of Action

Ondansetron is a 5-HT3 serotonin- receptor antagonist, primarily used for the prevention and treatment of nausea and vomiting. Nausea occurs when serotonin is released into the intestines, and through ondansetron's ability to block serotonin receptors, the sensation of nausea and vomiting is decreased (Griddine & Bush, 2022; Minami et al., 1996). Additionally, ondansetron works peripherally on the vagus nerve, which can sense nausea and vomiting triggers and relay them to the brain (Griddine & Bush, 2022). Hypotension only exacerbates nausea and vomiting, as hypotension triggers the chemoreceptor trigger zone to initiate vomiting (Singh et al., 2016). Ondansetron is an effective treatment for nausea and vomiting in addition to its role in attenuating spinal-induced hypotension.

Side Effects

Ondansetron is associated with side effects including headaches, fatigue, dry mouth, constipation, and malaise (Griddine & Bush, 2022). Additionally, clinicians may see QTc prolongation, increasing the risk for other arrythmias including Torsade de Pointes. Clinicians must consider this, especially if administering ondansetron to patient with a preexisting conduction abnormality.

Role in preventing SIH

The Bezold-Jarisch reflex is also activated by serotonin-mediated 5-HT3 receptors. By giving prophylactic ondansetron, these 5-HT3 receptors are blocked and the effects of the Bezold-Jarisch are attenuated (Gao et al., 2015). Since the Bezold-Jarisch reflex has been implicated as the mechanism behind spinal-induced hypotension, this explains why ondansetron has been effective as a prevention method for SIH.

Decreased incidence of hypotension

Since the mechanism of prophylactic ondansetron was identified and further research has been conducted, consensus has shown its efficacy in reducing the incidence of hypotension that patients experience after spinal anesthesia (Gao et al., 2015; Marashi et al., 2014; Owczuk et al., 2008; Sahoo et al., 2012; Tubog, 2017). With the incidence of maternal hypotension after spinal anesthesia reported between 50-80% (Lee et al., 2017; Marashi et al., 2014), providers must take note of the risk reduction associated with ondansetron use and how it may lead to better outcomes for both mother and baby.

Across all reviewed studies, multiple doses of ondansetron were selected, including 4, 6, 8, and 12mg (Chooi et al., 2020; Marashi et al., 2014; Owczuk et al., 2008; Sahoo et al., 2012). Chooi et al. (2020) found that the most significant reduction in hypotension was seen with 4mg and 6mg doses (54% and 52% respectively), indicating that 4-6mg may be the most effective dose for prevention of SIH.

Decreased use of vasopressors

Prophylactic use of ondansetron has been shown to decrease the magnitude of hypotension experienced after spinal anesthesia, but treating a low blood pressure with a vasopressor may still be necessary. Along with studying the effect of ondansetron on the incidence of hypotension, many studies also reported the average vasopressor use between the control and intervention groups. A statistically significant decrease in total vasopressor (phenylephrine or ephedrine) use was reported in five studies (El Khouly et al., 2016; Gao et al., 2015; Sahoo et al., 2012; Tatikonda et al., 2019; Tubog, 2017), with almost 25% more patients in the control groups requiring treatment of hypotension with a vasopressor. While some patients who receive prophylactic ondansetron may not require any vasopressors at all (El Khouly et al.,

2016; Tatikonda et al., 2019), many patients will still experience hypotension requiring intervention.

Gaps

Consistent research into the role of the Bezold-Jarisch reflex in SIH only began in the last decade, and those studies are still few in number. Given the relatively little amount of research available, the use of prophylactic ondansetron has not gained significant traction among most anesthesia providers. This topic could benefit from more research, as well as higher-quality studies such as meta-analyses. Additionally, there is a lack of research on the appropriate dose of ondansetron for preventing SIH since this is a newer topic with less published studies. This presents an opportunity for further investigation into a ceiling effect or maximum effective dose of ondansetron.

Low sample size may also play a role in the limited research on this topic so far, with some studies having as few as 37 participants (Chooi et al., 2020). As awareness of this treatment modality increases, future studies will be able to recruit larger numbers of participants, increasing the validity and effect size and encouraging more anesthesia providers to incorporate new research into their daily practice.

Theoretical Framework

The theoretical framework used in this project is Lewin's Change Theory. It is a three-step process characterized by *unfreezing, change,* and *refreezing.* During the application of the *unfreezing* period, the PI identified the clinical problem and selected an educational presentation as the solution. In the *unfreezing* stage, one goal is to challenge the "status quo" and showing those involved that the current practices are not the best practice through interpretation and dissemination of current research. A key component of Lewin's theory is identifying the driving

and restraining forces that may be at play and creating solutions that enhance the driving forces, while also mitigating the restraining forces.

In the *change* step, the intervention is put into practice, with the goal of changing the mindset of participants so they are willing to accept the change as the "new normal." This is the step where the majority of the "work" takes place, as the intervention is implemented, and participants are presented with the facts highlighting that the current way of doing things is not the best way. In the context of this project, participants attended an educational presentation which highlighted current evidence-based practice and the mechanism of action behind the proposed intervention. This allowed participants to understand exactly *why* the new method promotes better patient outcomes.

The final step of Lewin's Change Theory, *refreezing*, occurs when the change becomes cemented as the "new normal." In this project, it was important to report the results to participating stakeholders so they could understand that the benefits to patient outcomes outweighed any restraining factors or discomfort from challenging the "status quo." It is also important to address any barriers to refreezing that may exist, as these may prevent the change from becoming the new standard practice. During surveying, participants were asked about potential barriers, and asked to identify any additional barriers they may foresee. The barriers and recommendations were presented to the facility for consideration after project completion.

Methods

Project Design

The project consisted of a mixed methods quality improvement approach, consisting of a pre-intervention survey, an educational PowerPoint Presentation delivered by the PI, and a post-intervention survey. Additionally, a chart review was conducted before and after the educational intervention to evaluate practice change. The survey also included open-ended questions for

participants to provide additional feedback that was not captured on the multiple-choice survey. The study used a convenience sample of anesthesia providers employed at the hospital site selected for implementation.

Evidence Based Model

The Johns Hopkins EBP model was selected to help guide the project, which focused on the use of ondansetron to prevent hypotension in patients undergoing spinal anesthesia for cesarean section. The first step in the Johns Hopkins EBP model is to develop the research question and identify stakeholders. Refining the exact wording of the EBP question continued while the project and intervention was being developed. Formal identification of the stakeholders and discussion of the project with the identified stakeholders helped to add a unique perspective to project planning and ensure their feedback was incorporated as appropriate.

The second step in the process was identifying evidence, as well as determining the quality of the evidence, synthesizing it, and using the research to develop recommendations for change. The literature review process showed that there were consistent results across multiple high-quality studies about the efficacy of ondansetron in preventing spinal-anesthesia based hypotension. Presenting high levels of evidence during the intervention period helped to encourage CRNAs to participate in the project because it showed to them that there is strong science and evidence behind the topic.

The final step in the Hopkins method was translation or taking the literature and best practice recommendations and turning them into an intervention. CRNAs were surveyed before and after an education intervention to evaluate for practice change as a result of participation in the educational session. Another key aspect of outcome evaluation was to assess patient outcomes and see if patients who were given ondansetron before their spinal anesthesia had lower rates of hypotension than those who did not.

Permissions

Approval from the IRB (Institutional Review Board) at UNCG and the hospital site were obtained before the project was implemented. The chief CRNA at the project site was also contacted and gave permission and support for the project to be conducted there. An additional staff CRNA was identified to serve as a resource to the PI.

Project Setting and Sample

The project was completed at a small satellite hospital of a large healthcare system in the Central North Carolina. The facility specializes in women's health and obstetrics, with over 1,500 births reported in 2021. Fifteen CRNAs are employed by the hospital to provide anesthesia services. A convenience sample of CRNAs at the facility was used. Inclusion criteria for participation included employment as a CRNA, primary site of employment at this facility, provides anesthesia for cesarean section patients. Exclusion criteria included non-CRNA healthcare providers, CRNAs whose primary practice site was elsewhere, and CRNAs who do not provide anesthesia for cesarean sections.

Implementation Plan

A chart review was completed for the 4-week period before the educational intervention was given. Non-identifiable data was collected by the PI in a private location. Inclusion criteria was patients undergoing elective cesarean sections under spinal anesthesia. Exclusion criteria was patients with private medical record and urgent or emergent cases. The following data was deidentified and entered into an Excel spreadsheet: baseline MAP, SBP, and DBP, if vasopressors were required, total dose of vasopressors received, utilization of a phenylephrine infusion, and incidence of hypotension (decrease in MAP >20% from baseline), and bradycardia (HR < 60BPM).

Two weeks before the presentation was scheduled to take place, a recruitment email was sent to the chief CRNA at the facility detailing the date and time of the presentation (Appendix

A). The chief CRNA forwarded this email to staff CRNAs so they were informed of the upcoming presentation. On the day of the presentation, a recruitment speech was given. (Appendix B). An information sheet was distributed and described the purpose of the project, time commitment, risks, and benefits to participation. Implied consent was obtained when completed the paper and pencil pre-intervention survey. The pre-intervention survey was collected via paper and pencil. After completion, paper survey responses were sealed in an envelope and stored securely in a locked cabinet. Responses were entered into Excel by the PI in a secure location, where they will be stored securely in a locked cabinet for three years before being shredded. Participants provided their email address on a separate sheet of paper so the post-intervention survey could be sent electronically 4 weeks after the educational presentation.

The educational intervention was a PowerPoint presentation lecture by the PI. The focus of the presentation was identifying alternative methods for management of hypotension following spinal anesthesia, cons to these alternative methods, the mechanism of action for ondansetron, the Bezold-Jarisch reflex, and the data supporting the use of prophylactic ondansetron. Time was allotted at the end of the presentation for questions.

The post intervention chart review was completed 4 weeks after the presentation, looking at the previous 4 weeks of cases, following the same process outlined in the pre-intervention chart review. This provided data that could be used to determine whether the educational presentation resulted in improved patient outcomes, as evidenced by reduced incidence of hypotension and decreased use of vasopressors.

Four weeks after the educational presentation, an electronic survey was sent to the email addresses provided by participants during the initial pre-intervention survey. The survey was completed in the online survey software, Qualtrics. The survey was open for responses for two

weeks. Data from the post-intervention survey was de-identified and downloaded to an Excel spreadsheet for analysis after the surveying period had closed. Data was stored on a password-protected laptop accessed only by the PI.

Budget, Time, and Resources

The PI contributed $100 to purchase refreshments for participants in the educational intervention. No other financial resources were required to implement this DNP project. 10 minutes was allotted for participants to read the information sheet and complete the pre-intervention survey. The educational intervention took about 20 minutes. Participants could complete the post-intervention survey at their leisure, but it was expected to take less than 10 minutes.

Instruments

A pre-intervention survey (Appendix C) created by the PI collected demographic data and included Likert-style questions on current clinical management of hypotension following spinal anesthesia, as well as their current knowledge of the mechanism of spinal-induced hypotension. Participants were asked to create a unique identifier (the last four digits of their cell phone number) in order to link pre and post-intervention surveys for data analysis. Additionally, seven Likert-style questions quantified how frequently cesarean section patients experienced side effects such as hypotension requiring treatment, bradycardia requiring treatment, and nausea or vomiting. The survey also assessed current use of prophylactic ondansetron in routine cesarean sections. The survey asked about potential barriers to implementing prophylactic ondansetron into their practice. An additional open-ended question allowed participants to identify other barriers not already mentioned.

A post-intervention survey (Appendix D) contained similar questions, as well Likert-type questions asking respondents to quantify how frequently their patients experienced

hypotension, bradycardia, and nausea or vomiting in the 4-week period since the educational intervention. The post-intervention survey additionally asked participants to identify any barriers they faced to incorporating the intervention into their daily practice. It also included a write-in section for any other feedback they wished to give regarding their clinical experiences, knowledge base, barriers to implementation, or feedback about the educational presentation.

Data Analysis

Survey

Data was collected from participants during the pre and post-intervention surveys and entered into a Microsoft Excel spreadsheet. Participants provided a unique identifier to link their pre and post-intervention survey responses but due to low participant numbers and participant misinterpretation of instructions, it was not possible to link pre and post intervention surveys, so analysis was done with descriptive statistics. During analysis, specific attention was paid to participant reported incidence of clinical outcomes, knowledge questions, and identification of barriers.

Open-ended questions were asked in each survey to allow for qualitative responses. Responses were reviewed and then grouped based on themes to allow for further analysis. However, opened ended responses were limited to comments such as “none,” or “great presentation” in regard to the educational presentation, so no distinct themes were able to be identified.

Chart Review

De-identified data was collected and entered to a Microsoft Excel spreadsheet. A two-sample t-test was used to compare pre and post intervention data regarding average vasopressor requirement. Using a t-test allowed for comparison of the means of the pre and post-intervention data and ability to determine if a statistically significant difference between the two groups was present. An alpha value of 0.05 was used. After analysis, the p-value was 0.005, indicating that

there was a statistically significant difference in vasopressor requirements before and after the educational intervention.

A Chi-square test was used to determine the relationship between use of prophylactic ondansetron and incidence of hypotension. With a Chi-square test, a null hypothesis is identified- in this case, the null hypothesis was “Prophylactic Ondansetron and Hypotension are NOT associated.” An alpha value of 0.05 was used. After analysis, a p-value of 0.7222 was calculated, allowing us to accept the null hypothesis. In other words, we did NOT have sufficient evidence that there is an association between prophylactic ondansetron and the incidence of hypotension among this chart review data set.

Additional analysis was completed for chart review data using descriptive statistics to evaluate rate of prophylactic ondansetron usage, overall ondansetron usage, and patient demographic data.

Results

Survey

Seven CRNAs completed the pre-intervention survey, while five CRNAs completed the post-intervention survey, yielding a completion rate of 71.4% The first five questions of pre-intervention the survey collected demographic data. There were 3 males and 4 females that participated, with 3 in the 36-45 age range, 2 in the 46-55 range, and 2 in the 56-65 age range. 6 participants reported holding a master’s degree in anesthesia and 1 reported having a doctoral degree in anesthesia. This group was experienced CRNAs, with 3 reporting 11-15 years of anesthesia experience, 2 reporting 16-20 years of experience, and 2 reporting more than 20 years of experience in anesthesia. 4 participants stated that they practiced OB anesthesia 2-3x monthly, 2 reported providing OB anesthesia 2-3x weekly, and 1 person reported performing OB anesthesia daily.

Six questions asked participants to reflect on their clinical experience and rank how strongly they agreed or disagreed with a statement on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree." 5/7 (71.4%) participants stated that they believe prophylactic ondansetron reduces the incidence of hypotension after a spinal anesthetic. 5/7 (71.4%) participants reported routinely giving prophylactic ondansetron before cesarean sections done under spinal anesthesia. 7/7 (100%) of participants reported that they often had to treat hypotension among cesarean section patients. 7/7 (100%) participants reported routinely using a vasopressor infusion during cesarean sections under spinal anesthesia.

Seven questions asked participants to report how frequently their cesarean section patients experienced things such as hypotension, bradycardia, and nausea and/or vomiting. (Appendix E). These questions used a 5-point Likert scale ranging from "never" to "very frequently." In the pre-intervention survey, 7/7 (100%) reported that their patients "frequently" or "occasionally" experienced hypotension, defined as a decrease in baseline MAP more than 20%. In the post-intervention survey, 5/5 (100%) reported "frequently" or "occasionally" seeing hypotension among their cesarean section patients. 7/7 (100%) reported "frequently" or "occasionally" treating hypotension with a vasopressor infusion or boluses, while 100% of post-survey participants also reported using vasopressor infusions or boluses to treat hypotension.

6/7 pre-intervention survey participants (85.7%) reported that patients "occasionally" experienced bradycardia (HR <60 BPM), while 6/7 (85.7%) reported that patients "rarely" or "never" experienced severe bradycardia (HR <40 BPM). In the post-intervention survey, 4/5 (80%) reported that patients "occasionally" experienced bradycardia (HR < 60 BPM), and 4/5 (80%) reported that patients "rarely" experience severe bradycardia (HR < 40 BPM). However, 6/7 pre-survey participants (85.7%) also reported "rarely" needing to treat bradycardia with

atropine or glycopyrrolate. In the post-intervention survey, 4/5 (80%) reported “rarely” needing to treat bradycardia or severe bradycardia with atropine or glycopyrrolate. Among pre-survey participants, 5/7 (71.4%) reported that their patients “occasionally” experienced nausea and/or vomiting, with 1/7 (14.2%) reporting it “very frequently” occurred and 1/7 (14.2%) reported it “rarely” occurred. In the post-survey, 5/5 (100%) reported that patients “occasionally” experienced nausea and/or vomiting.

In the next seven questions, participants were asked to report how strongly they agreed or disagreed with statements regarding knowledge of SIH and treatment methods (Appendix F). 5/7 (71.4%) reported that they understood the mechanism of action of ondansetron’s role in preventing SIH, while 4/7 (51.7%) reported feeling comfortable explaining how ondansetron attenuates the Bezold-Jarisch reflex to a colleague. In the post-intervention survey, 100% stated they understood the mechanism of how prophylactic ondansetron prevents SIH and 100% stated that they would be comfortable explaining the role of ondansetron in attenuating the Bezold-Jarisch reflex to a colleague. 6/7 (85.5%) agreed that fetal acidosis risk increases with multiple doses of vasopressors, and 7/7 (100%) agreed that fetal outcomes are affected by maternal hypotension.

The final ten questions asked participants to identify potential barriers to implementing prophylactic ondansetron into their practice (Appendix G). Before the intervention, 3/7 (42.8%) participants stated they needed to see more evidence before incorporating prophylactic ondansetron, while 4/7 (51.7%) reported that their facility policy utilizes other methods to prevent SIH. After the intervention 4/5 (80%) stated they “disagree” or “strongly disagree” when asked if they needed to see more evidence supporting the use of prophylactic ondansetron before incorporating it into their practice. 3/5 (60%) participants in the post-survey reported that they

had never heard of prophylactic ondansetron to prevent SIH, while 2/7 (28.5%) reported this on the pre-intervention survey. On the post-intervention survey, 3/5 (60%) reported that they do not have time to administer ondansetron before a spinal anesthetic, while 1/7 (14.2%) agreed with this statement on the pre-intervention survey. 100% of participants before and after the intervention reported they could easily access ondansetron, and 5/7 (71.4%) pre-survey participants reported that they had no barriers to adding prophylactic ondansetron into their practice. When given a write-in section to identify potential barriers, no participants chose to provide additional answers. In the post-survey, 5/5 (100%) reported having no barriers to incorporating prophylactic ondansetron into their clinical practice, and no additional write-in barriers were provided by participants.

The post-intervention survey also included unique questions regarding the educational presentation. 5/5 (100%) stated that the presentation was effective in increasing their knowledge of prophylactic ondansetron. 3/5 (60%) reported that they had begun implementing prophylactic ondansetron into their practice, and 100% reported that they would encourage colleagues to implement prophylactic ondansetron into their practice. 100% stated that they believe prophylactic ondansetron is an effective method to prevent SIH.

Chart Review

A total of 52 cases were reviewed during a period of five weeks before and five weeks after the educational intervention. There were 27 cases included before the intervention and 25 after the intervention. All patients were females undergoing elective cesarean sections under spinal anesthesia. Cases performed under GA or with epidurals were excluded from review. The average age of patients was 32.75 years old. Patients with private or confidential charts were also excluded.

A key outcome that was evaluated was the incidence of hypotension. Overall, 40/52 patients (76.9%) experienced at least one episode of hypotension throughout their cesarean section, with 21/27 (77.8%) before intervention and 19/25 (76%) after intervention. A Chi-square test was performed to evaluate the relationship between prophylactic ondansetron utilization and incidence of hypotension. This resulted in a p-value of 0.7222, indicating that there was *not* evidence to support an association between prophylactic ondansetron and the incidence of hypotension.

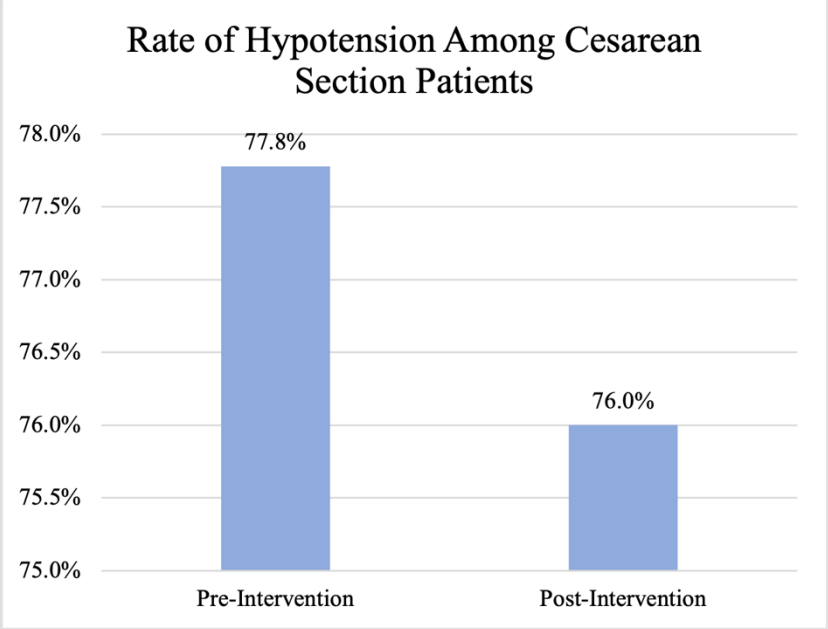


Figure 1: Rate of Hypotension Among Cesarean Section Patients

At this facility, the culture among most anesthetists was to start a routine phenylephrine infusion, so 44/52 (84.6%) of patients received a phenylephrine infusion during the course of their cesarean section. Before intervention, 26/27 (96.3%) patients required a phenylephrine infusion, and after intervention 18/25 (72%) required a phenylephrine infusion. Based on the high utilization rate of phenylephrine infusions, the decision was made to evaluate average vasopressor use before and after intervention to evaluate if implementing prophylactic

ondansetron resulted in a statistically significant difference in vasopressor use. This was accomplished using a 2 sample t-test, where a p-value of 0.005 was calculated, indicating that there was a statistically significant difference in vasopressor use before and after intervention. Total vasopressor use was calculated by adding the total micrograms of phenylephrine received via infusion with the total dose of IV boluses (also in micrograms). Additionally, Gao et al. (2015) converted every 10mg of ephedrine used into 50mcg of phenylephrine for calculating total vasopressor use, so the same conversion was applied to this chart review data set as well. Before intervention, the average vasopressor use was 2819mcg of phenylephrine or equivalent ephedrine. After intervention, the average vasopressor use was 1748mcg.

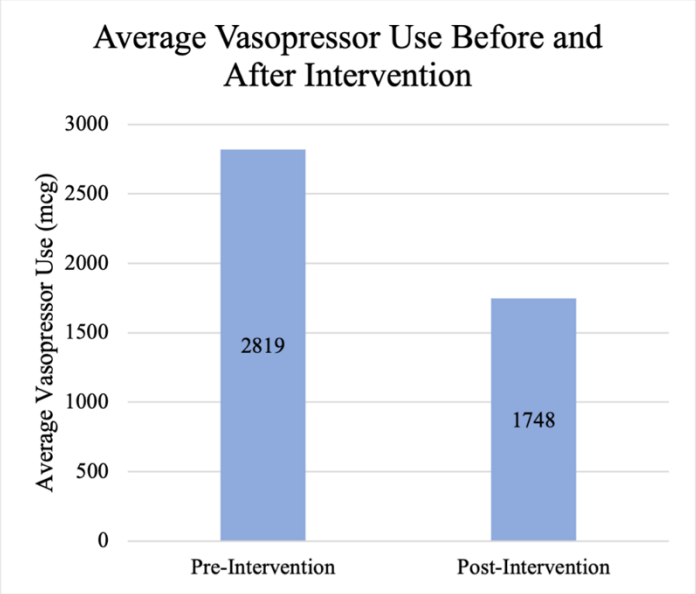


Figure 2: Comparison of pre and post intervention vasopressor consumption

51/52 (98%) of patients received ondansetron at any point during their cesarean section. However, 11/27 (40.7%) received prophylactic ondansetron before intervention, and 13/25 (52%) received prophylactic ondansetron after the educational intervention. Though there was an increase in overall usage of prophylactic ondansetron, a large gap to the overall utilization rate remained that could have been improved upon.

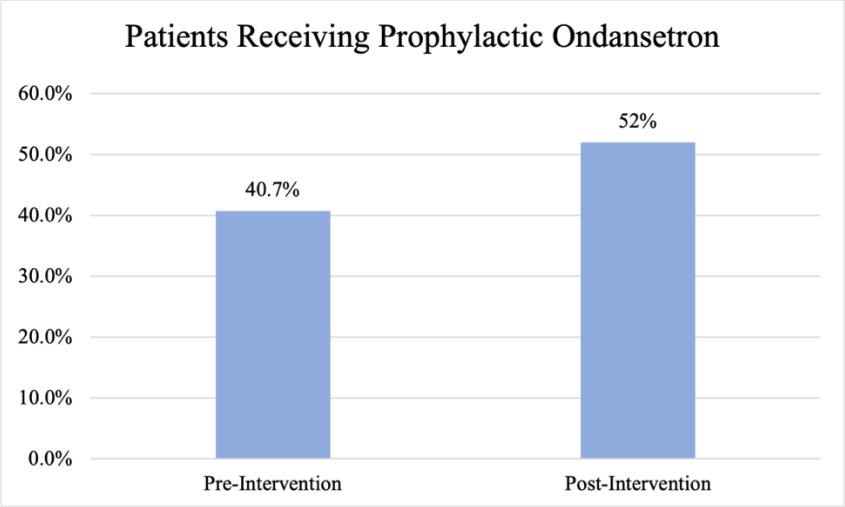


Figure 3: Pre and post intervention rate of prophylactic ondansetron administration

Discussion

The participants in this intervention were overwhelmingly very experienced CRNAs, with none having less than 11 years of experience. This may have both aided and impeded the project aim of increasing the rate of prophylactic ondansetron utilization. Due to their extensive experience, some of these clinicians may have their own preferred strategy for managing hypotension that they are most comfortable with. Additionally, the use of ondansetron to prevent SIH is a relatively newer research topic that likely would not have been taught when most of the participants would have received their anesthesia education. Newer CRNAs may have been educated on the mechanism of action behind prophylactic ondansetron during their anesthesia education and may already be comfortable with this intervention.

Based on CRNA-reported incidence of clinical outcomes, hypotension, hypotension requiring vasopressor boluses, and nausea and/or vomiting decreased after the educational intervention. However, the chart review data showed very similar rates of hypotension among pre and post-intervention groups (77.8% vs 76%). The overall rate of hypotension in this chart review data set was 76.9%, in line with the findings of Gao et al. (2015), who reported that

hypotension occurs in up to 50% of the obstetric population. The chart review data did show a significant decrease in the use of vasopressors with 96.3% of patients requiring a vasopressor infusion before the intervention and 72% requiring an infusion after the intervention. This is supported by participants' survey responses. In the pre-survey, 100% of participants reported regularly using a vasopressor infusion, while 80% of post-survey participants reported "frequently" or "very frequently" using a vasopressor infusion. Additionally, before the intervention, patients required an average of 2819mcg of phenylephrine. After the intervention the average phenylephrine requirement was 1748mcg, indicating a 38% decrease in vasopressor requirement. Decreased vasopressor use results in improved uteroplacental perfusion, reducing the risk of neonatal acidosis and improving outcomes for patients.

One area with a significant variance between the pre and post-survey data was the barrier of sufficient time to administer prophylactic ondansetron. On the pre-survey, 14.7% of participants did NOT feel they had sufficient time, compared to 60% of post-survey participants. This significant increase may be due to a perception of adequate time before attempting to put it into practice and discovering they did not have the expected time. Depending on the workflow of some OB anesthesia departments, the patients may meet the anesthetist in the operating room instead of in a pre-op area, making it challenging to administer prophylactic ondansetron without impeding the workflow for a spinal anesthetic.

This is in contrast with the surveys, where 71.4% of pre-survey participants and 100% of post-survey participants stated that they did not have any barriers to implementing prophylactic ondansetron. When given the opportunity in both the pre and post-intervention surveys, no participants chose to write in other barriers that they might anticipate.

One confounding factor among this chart review group was their high utilization rate of phenylephrine infusions. Nearly 85% of the patients included in the chart review received a phenylephrine infusion during their cesarean section. This may help prevent a precipitous drop in blood pressure immediately after injection of spinal anesthesia and promote a more stable blood pressure over the surgery. Due to the high utilization rate of infusions, one crucial metric evaluated in the chart review was overall vasopressor consumption. Before the educational intervention, the average vasopressor use was 2819mcg of phenylephrine, compared to an average of 1748mcg after the intervention. This was a statistically significant difference among our chart review data set. While this may be attributed to a higher rate of prophylactic ondansetron after the intervention, less circulating vasopressors can result in improved fetal outcomes by reducing the risk of fetal acidosis associated with maternal hypotension and uteroplacental perfusion alterations caused by vasopressors (Al-Husban et al., 2021; Havas et al., 2013; Knigin et al., 2020; Ring et al., 2021).

Though there was an increase in the utilization rate of prophylactic ondansetron after the educational intervention (40.7% vs 52%), there was still room for improvement as 98% of all patients received ondansetron throughout their cesarean section. Adjusting the timing of ondansetron administration to give it before the spinal is placed could result in a decrease use of vasopressors as was seen in the chart review, benefitting both mother and baby. The educational intervention acknowledged that most CRNAs give ondansetron during a cesarean section and included an emphasis on adjusting the timing of an already routine medication. The difference between CRNA-reported integration of prophylactic ondansetron (80%) and the utilization rate in the data (52%) shows that not all restraining forces were effectively mitigated during the unfreezing phase of Lewin's Change Theory. This may have been due to under-appreciation of

the fast-paced environment in an OB operating room, the variance in workflows across facilities, or unidentified factors. Knowing this, future versions of this project should focus on ways to seamlessly integrate prophylactic ondansetron into practice even under time constraints, and be sure to discuss them with participants during the educational presentation.

Barriers and Limitations

A limitation of the project was the small sample size. The facility where the project was implemented is a community hospital with a small anesthesia department. All of the CRNAs working the day of the presentation attended. A slightly larger sample size may have been achieved if the presentation had been given multiple times, though there would have been overlap among the participants. A second presentation also may have allowed for barriers to be addressed that participants thought of after reflecting on their workflow during cesarean sections that may not have been included in their survey responses. To reach a larger sample size, the presentation could have been given at the health system's larger hospitals or recorded and sent as an electronic learning module to a broader audience of CRNAs.

Time was an additional limitation in this project. The presentation was given before the cases for the day began, so there was only a certain amount of time available before the CRNAs needed to prepare for their patients. Given more time, additional types of teaching methods such as videos could have been incorporated. There also could have been time allocated for an open discussion and questions after the presentation finished.

Recommendations for Future

Anesthesia for cesarean sections is a cornerstone of practice as a CRNA. The anesthesia community must work to provide the highest standard of care so that mothers and their babies can have the best possible outcomes for a life-changing moment in time. This project could easily be replicated across most hospitals as it does not require specialized equipment or

medication that is not currently available. This type of project involving surveys and an educational intervention is an easy and effective way to educate providers and keep them up to date with emerging evidence-based practice recommendations. This project could be adapted in the future for a wide range of anesthesia topics, or updated as new evidence about SIH emerges.

A focus on altering the timing of an already routine intervention has the potential to be very impactful on patient outcomes. If a facility or group were to implement a similar project, better success could be seen by giving the presentation multiple times or incorporating visual aids/reminders into the operating room. While the incidence of hypotension seen among our data set was comparable to the average among cesarean section patients, our project did see a statistically significant difference in the total vasopressor use before and after the educational presentation despite only a modest increase in the overall utilization of prophylactic ondansetron. Incorporating additional reinforcement methods would help increase the rate of prophylactic ondansetron and could help reduce the total vasopressor requirement and incidence of hypotension further.

Time was identified by participants as the largest barrier to implementing prophylactic ondansetron. Strategies were discussed in the presentation to overcome potential time barriers, but additional reinforcement could have improved the prophylactic ondansetron utilization rate. Other ways this could have been improved include providing additional education sessions, posters in the breakroom, follow-up emails, physical reminders in the OB ORs asking “Did you give prophylactic ondansetron?” or an electronic medical record pop-up notice.

The barrier of lack of time could also be alleviated by evaluating the workflow of labor and delivery nurses. Before a cesarean section, they will give the patient multiple medications as ordered by the obstetrician. It may be possible for them to administer the ondansetron when they

are giving the other ordered medications, which would reduce the time burden on CRNAs and also provide more time for the ondansetron to reach its peak effects before the spinal is administered, resulting in more effective attenuation of SIH.

Conclusion

This project aimed to provide an educational intervention with the goal of changing CRNA practice to increase the use of prophylactic ondansetron in cesarean sections done under spinal anesthesia. The project also investigated the incidence of hypotension and total vasopressor use before and after the intervention to assess patient outcomes.

The educational presentation successfully increased CRNA's knowledge of prophylactic ondansetron and its mechanism of action. It also increased CRNA's likelihood of using prophylactic ondansetron, with 80% of post-survey participants reporting that they had begun incorporating it into their practice. While the data did not support a relationship between receiving prophylactic ondansetron and the incidence of hypotension, there was a significant decrease in the average vasopressor dose required and the utilization rate of phenylephrine infusions.

Additional reinforcement of the importance of prophylactic ondansetron administration via additional education sessions, physical reminders in the operating room, or electronic medical record pop-ups could improve the rate of prophylactic ondansetron use. Evaluation of the workflow of labor and delivery nurses could provide an opportunity for administration of the ondansetron with the other medication they give the patient before a cesarean section. The use of an educational intervention to discuss evidence-based practice recommendations was successful in meeting the project aim of causing CRNA practice change. It also resulted in an increase in the rate of prophylactic ondansetron use and a significantly decreased vasopressor requirement among patients undergoing elective cesarean sections under spinal anesthesia. This intervention

should continue to be encouraged among obstetric anesthesia providers, as the administration of prophylactic ondansetron was an effective method to improve patient outcomes through decreased rates of hypotension and vasopressor consumption.

References

Al-Husban, N., Elmuhtaseb, M. S., Al-Husban, H., Nabhan, M., Abuhalaweh, H., Alkhatib, Y. M., Yousef, M., Aloran, B., Elyyan, Y., & Alghazo, A. (2021). Anesthesia for Cesarean Section: Retrospective Comparative Study. *International Journal of Women's Health*, *13*, 141–152. https://doi.org/10.2147/IJWH.S292434

American Society of Anesthesiologists (2016). Practice Guidelines for Obstetric Anesthesia: An Updated Report by the American Society of Anesthesiologists Task Force on Obstetric Anesthesia and the Society for Obstetric Anesthesia and Perinatology. *Anesthesiology*, *124*(2), 270–300. https://doi.org/10.1097/ALN.0000000000000935

Cooper, D. W., Carpenter, M., Mowbray, P., Desira, W. R., Ryall, D. M., & Kokri, M. S. (2002). Fetal and Maternal Effects of Phenylephrine and Ephedrine during Spinal Anesthesia for Cesarean Delivery. *Anesthesiology*, *97*(6), 1582–1590. https://doi.org/10.1097/00000542-200212000-00034

Chooi, C., Cox, J. J., Lumb, R. S., Middleton, P., Chemali, M., Emmett, R. S., Simmons, S. W., & Cyna, A. M. (2020). Techniques for preventing hypotension during spinal anaesthesia for caesarean section. *The Cochrane Database of Systematic Reviews*, *2020*(7), CD002251. https://doi.org/10.1002/14651858.CD002251.pub4

El Khouly, N. I., & Meligy, A. M. (2016). Randomized controlled trial comparing ondansetron and placebo for the reduction of spinal anesthesia-induced hypotension during elective cesarean delivery in Egypt. *International Journal of Gynecology & Obstetrics*, *135*(2), 205–209. https://doi.org/10.1016/j.ijgo.2016.06.012

Gao, L., Zheng, G., Han, J., Wang, Y., & Zheng, J. (2015). Effects of prophylactic ondansetron on spinal anesthesia-induced hypotension: A meta-analysis. *International Journal of Obstetric Anesthesia*, *24*(4), 335–343. https://doi.org/10.1016/j.ijoa.2015.08.012

Griddine, A., & Bush, J. S. (2022). Ondansetron. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK499839/

Havas, F., Orhan-sungur, M., Yenigun, Y., Karadeniz, M., Kilic, M., & Ozkan Seyhan, T. (2013). Spinal anesthesia for elective cesarean section is associated with shorter hospital stay compared to general anesthesia. *Ağrı - The Journal of The Turkish Society of Algology*, *25*(2), 55–63. https://doi.org/10.5505/agri.2013.42204

Kearns, R. J., , Shaw, M., Gromski, P. S., Iliodromiti, S., Pell, J. P., Lawlor, D. A., , & Nelson, S. M. (2021). Neonatal and early childhood outcomes following maternal anesthesia for cesarean section: A population-based cohort study. *Regional Anesthesia and Pain Medicine*, *46*(6), 482–489. https://doi.org/10.1136/rapm-2020-102441

Kinsella, S. M., Carvalho, B., Dyer, R. A., Fernando, R., McDonnell, N., Mercier, F. J., Palanisamy, A., Sia, A. T. H., Van de Velde, M., & Vercueil, A. (2018). International consensus statement on the management of hypotension with vasopressors during caesarean section under spinal anaesthesia. *Anaesthesia*, *73*(1), 71–92. https://doi.org/10.1111/anae.14080

Knigin, D., Avidan, A., & Weiniger, C. F. (2020). The effect of spinal hypotension and anesthesia-to-delivery time interval on neonatal outcomes in planned cesarean delivery. *American Journal of Obstetrics and Gynecology*, *223*(5), 747.e1-747.e13. https://doi.org/10.1016/j.ajog.2020.08.005

Lee, J. E., George, R. B., & Habib, A. S. (2017). Spinal-induced hypotension: Incidence, mechanisms, prophylaxis, and management: Summarizing 20 years of research. *Best Practice & Research Clinical Anaesthesiology*, *31*(1), 57–68. https://doi.org/10.1016/j.bpa.2017.01.001

Marashi, S. M., Soltani-Omid, S., Soltani Mohammadi, S., Aghajani, Y., & Movafegh, A. (2014). Comparing Two Different Doses of Intravenous Ondansetron With Placebo on Attenuation of Spinal-induced Hypotension and Shivering. *Anesthesiology and Pain Medicine*, *4*(2), e12055. https://doi.org/10.5812/aapm.12055

Minami, M., Endo, T., & Hirafuji, M. (1996). [Role of serotonin in emesis]. *Nihon Yakurigaku Zasshi. Folia Pharmacologica Japonica*, *108*(5), 233–242. https://doi.org/10.1254/fpj.108.233

Nagelhout, J.J. & Elisha, S. (2018). *Nurse Anesthesia* (6th edition). Elsevier.

Noffsinger, S. R. (2022). Evidence-Based Prevention Strategies for the Management of Spinal Anesthesia-Induced Hypotension in Healthy Parturients Undergoing Elective Cesarean Delivery. *AANA Journal*, *90*(4), 311–316.

Owczuk, R., Wenski, W., Polak-Krzeminska, A., Twardowski, P., Arszulowicz, R., Dylczy-Sommer, A., Wujtewicz, M., Sawicka, W., Morzuch, E., & Smietanski, M. (2008). Ondansetron Given Intravenously Attenuates Arterial Blood Pressure Drop Due to Spinal Anesthesia: A Double-Blind, Placebo-Controlled Study. *Regional Anesthesia and Pain Medicine*, *33*(4), 332–339. https://doi.org/10.1016/j.rapm.2008.01.010

Pardo, M.C., & Miller, R.D. (2018). *Basics of Anesthesia* (7th edition). Elsevier.

Ring, L., Landau, R., & Delgado, C. (2021). The Current Role of General Anesthesia for Cesarean Delivery. *Current Anesthesiology Reports*, *11*(1), 18–27. https://doi.org/10.1007/s40140-021-00437-6

Sahoo, T., SenDasgupta, C., Goswami, A., & Hazra, A. (2012). Reduction in spinal-induced hypotension with ondansetron in parturients undergoing caesarean section: A double-

blind randomised, placebo-controlled study. *International Journal of Obstetric Anesthesia*, *21*(1), 24–28. https://doi.org/10.1016/j.ijoa.2011.08.002

Singh, P., Yoon, S. S., & Kuo, B. (2016). Nausea: A review of pathophysiology and therapeutics. *Therapeutic Advances in Gastroenterology*, *9*(1), 98–112. https://doi.org/10.1177/1756283X15618131

Sung, T.-Y., Jee, Y. S., You, H.-J., & Cho, C.-K. (2021). Comparison of the effect of general and spinal anesthesia for elective cesarean section on maternal and fetal outcomes: A retrospective cohort study. *Anesthesia and Pain Medicine*, *16*(1), 49–55. https://doi.org/10.17085/apm.20072

Tatikonda, C. M., Rajappa, G. C., Rath, P., Abbas, M., Madhapura, V. S., & Gopal, N. V. (2019). Effect of Intravenous Ondansetron on Spinal Anesthesia-Induced Hypotension and Bradycardia: A Randomized Controlled Double-Blinded Study. *Anesthesia: Essays & Researches*, *13*(2), 340–346. https://doi.org/10.4103/aer.AER_22_19

Tubog, T. D. (2017). Effects of Ondansetron on Attenuating Spinal Anesthesia-Induced Hypotension and Bradycardia in Obstetric and Nonobstetric Subjects: A Systematic Review and Meta-Analysis. *AANA Journal*, *85*(2), 113–122.

van Dyk, D., Dyer, R. A., & Bishop, D. G. (2022). Spinal hypotension in obstetrics: Context-sensitive prevention and management. *Best Practice & Research Clinical Anaesthesiology*, *36*(1), 69–82. https://doi.org/10.1016/j.bpa.2022.04.001

WakeMed By the Numbers, WakeMed Health & Hospitals, Raleigh & Wake County, NC. (n.d.). Retrieved March 19, 2023, from *https://www.wakemed.org/about-us/wakemed-by-the-numbers*

Warltier, D. C., Campagna, J. A., & Carter, C. (2003). Clinical Relevance of the Bezold–Jarisch Reflex. *Anesthesiology*, *98*(5), 1250–1260. https://doi.org/10.1097/00000542-200305000-00030

Appendix A
Recruitment Email Sent to Project Site Chief CRNA

Hello, my name is Olivia Lanier and I am a third year SRNA at UNCG. I will be presenting my DNP project to your team on Friday, September 8th, 2023. My project discusses the role of prophylactic ondansetron in preventing spinal anesthesia-induced hypotension among cesarean section patients. As you know, this patient population can often experience hypotension after a spinal anesthetic, resulting in nausea or vomiting and decreasing placental perfusion. Newer research in obstetric anesthesia has shown that prophylactic ondansetron can be effective in reducing the frequency and magnitude of hypotension caused by spinal anesthesia sympathectomy.

The purpose of this project is to evaluate if education on the role of prophylactic ondansetron will result in anesthesia provider practice change and adoption of this intervention into their routine practice.

The total time commitment for participation in my project is under one hour. On September 8th, you will complete a pre-intervention survey and I will give a brief presentation. Four weeks after the presentation you will complete a post-intervention survey. All responses will be de-identified and will not be linked to you. Participation in my project is completely voluntary and you may withdraw at any time without penalty.

I would really appreciate your participation in my project! Please feel free to contact me with any questions before the presentation.

Thank you,
Olivia Lanier, BSN, RN, SRNA

Appendix B
Recruitment Speech Given to Participants

Hello, my name is Olivia Lanier and I am a third year SRNA at UNCG. Thank you for allowing me to be here today. I am going to talk to you about the role of prophylactic ondansetron for preventing spinal-anesthesia induced hypotension among cesarean section patients as part of my DNP project. The purpose of this project is to evaluate if education on the role of prophylactic ondansetron will result in anesthesia provider practice change and adoption of this intervention into their routine practice. Today, I will ask you to fill out a short survey asking demographic data, current knowledge about the role of prophylactic ondansetron and barriers to implementing prophylactic ondansetron. I will give a brief presentation. I will also collect your email address today so that in four weeks, you will receive an electronic post-intervention survey that should take 5-10 minutes to complete. All survey responses will be de-identified and will not be linked to you. Participation in my project is completely voluntary and you may withdraw at any time without penalty. I really appreciate your participation in my project! Does anyone have questions I can answer?

Appendix C

Pre-Intervention Survey

Please provide the month you were born and the high school that you graduated from. This will be used to link your pre-intervention survey and post-intervention survey for data analysis. This information will be de-identified and will not be linked to you in any way.

Gender	☐ Male ☐ Female ☐ Prefer to describe:
Age	☐ <26 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-65 ☐ >65
Level of Education	☐ Certificate ☐ Master's Degree ☐ Doctoral Degree
Years Practicing as a CRNA	☐ <1 ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ >20
How Frequently do you practice OB Anesthesia?	☐ Daily ☐ 2-3x Weekly ☐ 2-3x Monthly ☐ Never

Based on your clinical experience, please read the following statements and indicate how strongly you agree or disagree with the statements:	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Not applicable
I believe that prophylactic ondansetron reduces hypotension from spinal anesthesia						
I routinely give prophylactic ondansetron before elective cesarean sections under spinal anesthesia						
My cesarean section patients regularly experience nausea and/or vomiting						
I often must treat hypotension following a spinal anesthetic (using phenylephrine, ephedrine, or other methods)						
I often must treat bradycardia (HR <60 bpm) following a spinal anesthetic (using glycopyrrolate, atropine, or other methods)						
I routinely use a vasopressor infusion (such as phenylephrine) during cesarean sections under spinal anesthesia						

Please consider your experience as an anesthesia provider for cesarean section under spinal anesthesia and report how frequently your patients experience the following:	Very Frequently	Frequently	Occasionally	Rarely	Never	Not applicable
Hypotension (20% decrease or more in MAP from baseline)						
Hypotension requiring a vasopressor infusion (ie phenylephrine)						
Hypotension requiring vasopressor boluses (ie, phenylephrine or ephedrine)						
Bradycardia (HR < 60 BPM)						
Severe bradycardia (HR <40 BPM)						
Bradycardia or severe bradycardia requiring treatment (glycopyrrolate or atropine)						
Nausea and/or vomiting						

Please read the following statements and indicate how strongly you agree or disagree with the statement. In these questions SIH stands for “spinal-induced hypotension”	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
I understand the mechanism of how prophylactic ondansetron prevents spinal-induced hypotension					
I would be comfortable explaining ondansetron’s role in attenuating the Bezold-Jarisch reflex to a colleague					
I stay up-to-date with current best practices in obstetric anesthesia					
Co-loading with crystalloids effectively reduces the incidence of SIH					
Vasopressors are the most effective way to manage SIH					
Risk for fetal acidosis increases with multiple doses of vasopressors					
Fetal outcomes are affected by maternal hypotension					

The following questions are asking you assess potential barriers to implementing prophylactic ondansetron before cesarean sections into your practice. Please read each statement and indicate how strongly you agree or disagree. *SIH refers to spinal-induced hypotension	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Not applicable
I have never heard of using prophylactic ondansetron to prevent SIH						
I am uncomfortable using prophylactic ondansetron to prevent SIH						
I need to see more evidence supporting the use of prophylactic ondansetron before I am comfortable incorporating it into my practice						
I have previously tried using prophylactic ondansetron, but did not think it was effective in reducing SIH						
I am more comfortable using other methods to manage hypotension during cesarean sections						
My supervising anesthesiologists do NOT want prophylactic ondansetron administered						
I cannot access ondansetron easily						
My facility's policy utilizes other methods to manage SIH						
I do not have time to administer ondansetron before a spinal anesthetic is performed						
I do not have any barriers to incorporating prophylactic ondansetron into my practice						

Have you experienced any other barriers to implementing prophylactic ondansetron into your practice? Please describe below:

Appendix D

Post-Intervention Survey

Please provide the month you were born and the high school that you graduated from. This will be used to link your pre-intervention survey and post-intervention survey for data analysis. This information will be de-identified and will not be linked to you in any way.

Please leave any additional feedback you may have about the educational presentation.

Please consider the educational presentation on prophylactic ondansetron that you attended. Please read each statement and indicate how strongly you agree or disagree. *SIH refers to spinal-induced hypotension	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
The educational presentation was effective in increasing my knowledge about prophylactic ondansetron					
The educational presentation was clear and the presenter was thorough					
I understand the mechanism of how prophylactic ondansetron prevents spinal-induced hypotension					
I would be comfortable explaining ondansetron's role in attenuating the Bezold-Jarisch reflex to a colleague					
I have begun implementing prophylactic ondansetron into my practice					
I need to see more evidence supporting the use of prophylactic ondansetron before I am comfortable incorporating it into my practice					
I will encourage my colleagues to implement prophylactic ondansetron into their practice					
I believe that prophylactic ondansetron is an effective way to reduce SIH					

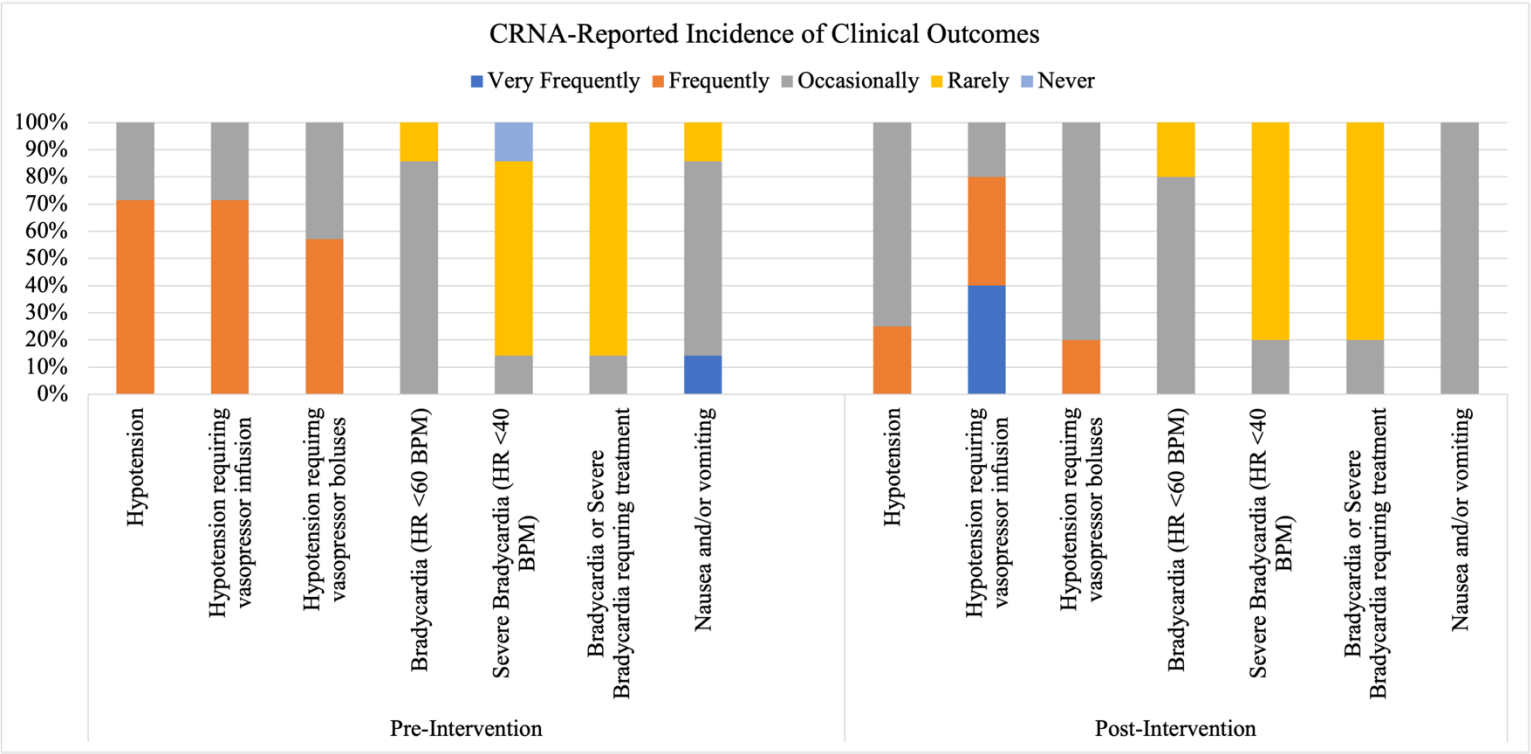
The following questions are asking you assess potential barriers to implementing prophylactic ondansetron before cesarean sections into your practice. Please read each statement and indicate how strongly you agree or disagree. *SIH refers to spinal-induced hypotension	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Not applicable
I have never heard of using prophylactic ondansetron to prevent SIH						
I am uncomfortable using prophylactic ondansetron to prevent SIH						
I need to see more evidence supporting the use of prophylactic ondansetron before I am comfortable incorporating it into my practice						
I have previously tried using prophylactic ondansetron, but did not think it was effective in reducing SIH						
I am more comfortable using other methods to manage hypotension during cesarean sections						
My supervising anesthesiologists do NOT want prophylactic ondansetron administered						
I cannot access ondansetron easily						
My facility's policy utilizes other methods to manage SIH						
I do not have time to administer ondansetron before a spinal anesthetic is performed						
I do not have any barriers to incorporating prophylactic ondansetron into my practice						

Please consider your experiences in the last **FOUR WEEKS** as an anesthesia provider for cesarean section under spinal anesthesia and report how frequently your patients experience the following:	Very Frequently	Frequently	Occasionally	Rarely	Never
Hypotension (20% decrease or more in MAP from baseline)					
Hypotension requiring a vasopressor infusion (ie phenylephrine)					
Hypotension requiring vasopressor boluses (ie, phenylephrine or ephedrine)					
Bradycardia (HR < 60 BPM)					
Severe bradycardia (HR <40 BPM)					

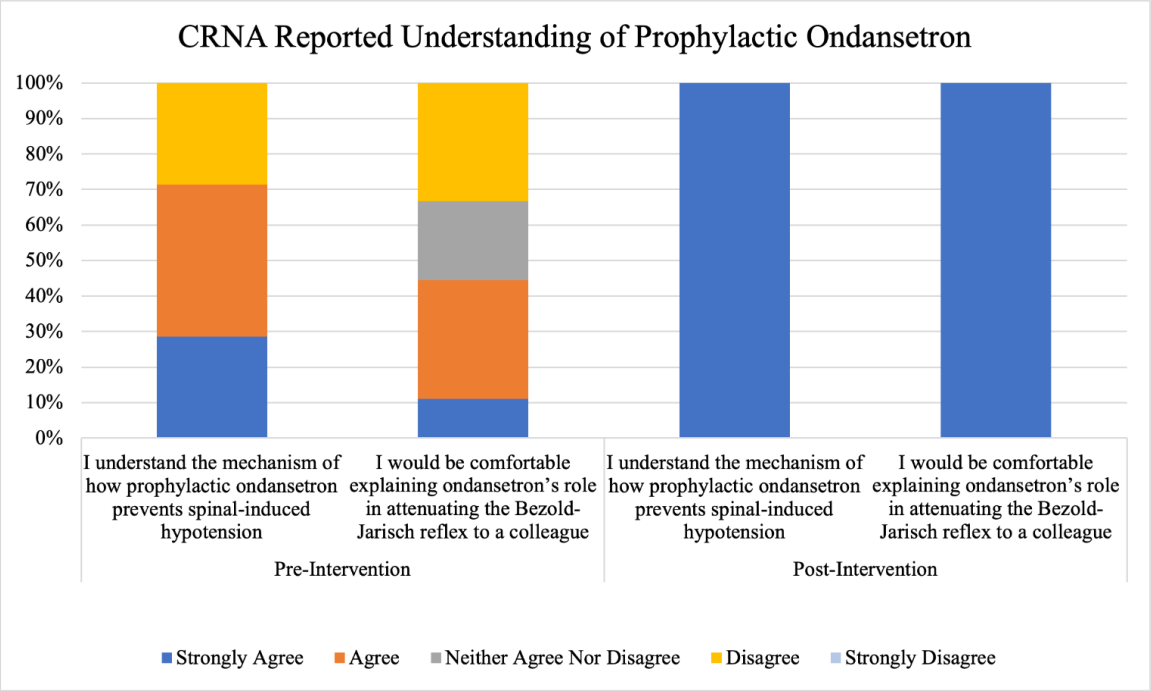
Bradycardia or severe bradycardia requiring treatment (glycopyrrolate or atropine)					
Nausea and/or vomiting					

Have you experienced any other barriers to implementing prophylactic ondansetron into your practice? Please describe below:

Appendix E



Appendix F



Appendix G