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Leighton School of Nursing

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Final Project Report for Students Graduating in May 2024

Spinal Induced Hypotension Prophylaxis: Indiana CRNA Techniques

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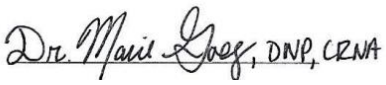

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Abstract

Anesthesia providers who give spinal anesthetics in obstetric anesthesia commonly witness spinal induced hypotension (SIH) in patients due to the sympathetic blockade after injection. This DNP project evaluated Indiana Certified Registered Nurse Anesthetists (CRNAs) and their utilization of preventative treatment for SIH after the administration of spinal anesthesia in healthy pregnant women undergoing elective cesarean sections. A needs assessment depicted a lack of research specifically concerning Indiana CRNAs and their prophylaxis practices when addressing SIH. This project design was a descriptive study and yielded a 13.27% response rate. By utilizing the Indiana Association of Nurse Anesthetists (INANA) email contact list of five hundred and sixty-five (565) members, an information sheet including implied consent, and an anonymous link to a 7-question *Qualtrics* self-assessment survey was administered. Survey questions included general demographics, prevention options, and treatment options utilized to prevent SIH in obstetrics. The select all that apply survey question regarding SIH prophylactic and rescue methods resulted in 296 responses from 75 Indiana CRNAs. After conducting data analysis, the most common practices of these 75 Indiana CRNAs were exposed. Data collection and analysis indicated the following results: 71 CRNAs reported administering an intravenous crystalloid infusion to reduce SIH (23.99%), 52 CRNAs reported administering intravenous ondansetron (17.58%), 48 CRNAs reported administering ephedrine boluses (16.22%), 47 CRNAs reported administering phenylephrine boluses (15.88%), and 37 CRNAs reported decreasing the height-based dosing of their spinal anesthetic (12.5%). This project assesses Indiana CRNA approaches to reduce SIH compared to current, published anesthesia practice guidelines.

Keywords: spinal anesthesia, hypotension, cesarean, prevention

Spinal Induced Hypotension Prophylaxis: Indiana CRNA Techniques

Spinal anesthesia is a standard anesthetic plan of choice utilized when caring for a healthy pregnant woman who is delivering via elective, scheduled cesarean section (Noffsinger, 2022). Spinal induced hypotension (SIH) arises due to a profound preganglionic sympathetic blockade after injection and direct vasodilation from the effects of local anesthetics (Noffsinger, 2022). The sympathetic blockade occurs due to the dense sensory neuraxial block required for cesarean sections, reaching up to the fourth thoracic dermatome level (T4) (Noffsinger, 2022). During this sympathetic response and peripheral vasodilation, there is a decrease in venous return and cardiac output leading to hypotension (Noffsinger, 2022). Pregnant women also have physiologic changes that leave them more susceptible to hypotension than non-pregnant women, including aortocaval compression from a gravid uterus and an increase in sympathetic tone (Noffsinger, 2022). Compared to non-pregnant women, pregnant women have a higher sympathetic tone and proliferation of vasodilatory prostaglandins make them less responsive to vasopressors (Noffsinger, 2022).

Hypotension in this patient population can lead to nausea, vomiting, and, more importantly, decreased uteroplacental perfusion, leading to fetal distress (Noffsinger, 2022). There are several prophylactic techniques used in anesthesia today to decrease the incidence of SIH in this patient population, including administration of crystalloids, administration of colloids, prophylactic phenylephrine infusions with additional bolus doses of phenylephrine or ephedrine, prophylactic IV ondansetron, a decrease in local anesthetic dosing, and lower limb compression stockings (Noffsinger, 2022). These techniques come with multiple variables, including patient demographics, the timing of administration, dosage, route, and drug choice, that play a factor in preventing SIH. Despite the multitude of prophylactic techniques listed, the

American Society of Anesthesiologists (ASA) does not have a set requirement for anesthesia providers to aid in the prevention of hypotension in this patient population (Apfelbaum et al., 2016).

Background

Maternal death from spinal anesthesia was prevalent as recently as 75 years ago, and early studies aimed to decrease aortocaval compression to enhance maternal hemodynamics and fetal status (Fichter & Nelson, 2019). Initial treatment for hemodynamic instability during spinal anesthesia included fluid pre-loading, maternal positioning, and utilization of compression stockings (Fichter & Nelson, 2019). Today, healthy parturients are still experiencing hypotension up to seventy to eighty percent (70-80%) of the time when undergoing spinal anesthesia when given without any prophylaxis (Noffsinger, 2022). As Fitcher & Nelson (2019) state, "…finding the solution to spinal anesthesia-induced hypotension has been likened to discovering the Holy Grail of obstetric anesthesia."

The ASA lists recommendations to assist the practitioner in decision-making when dealing with SIH from a cesarean section (Apfelbaum et al., 2016). These prophylactic techniques include intravenous (IV) fluid pre-loading or co-loading and the utilization of intravenous ephedrine or phenylephrine for treating hypotensive episodes (Apfelbaum et al., 2016). According to Nixon and Leffert (2022) from UpToDate, the current primary approach for inhibiting SIH includes implementing a low dose phenylephrine intravenous infusion, titrated to maintain systolic blood pressure $\geq$100 mmHg or $\geq$80% of baseline effect, starting at a dose of 25-50 mcg/minute. Recent studies from all over the world give insight into other prophylactic approaches. However, no single method of prevention implementation solves this frequent

predicament (Fichter & Nelson, 2019). Currently, no research regarding reported techniques utilized to prevent SIH exists in the Midwest, specifically Indiana.

Problem Statement

Spinal anesthesia is the most common procedure utilized for cesarean sections; however, it can lead to hypotension which can induce maternal nausea, vomiting, dizziness, and compromised uteroplacental perfusion (Xu, Mao, et al., 2019). Discovering a lack of research and reported techniques practiced in preventing SIH during a cesarean section by Certified Registered Nurse Anesthetists (CRNAs) in Indiana led to the following PICOT question to be developed: How do Indiana CRNAs utilize or disuse prophylactic hypotensive techniques before or after spinal administration for healthy parturients delivering via elective cesarean section? A quality improvement project was designed around this question to examine if Indiana CRNAs utilize techniques to reduce hypotension in this patient population prophylactically and if they are different from the current recommended practice.

Needs Assessment and Gap Analysis

Performing spinal anesthetics, especially in obstetrics, is a common practice for many CRNAs. In the year 2021 in Indiana, 30.4% of live births were delivered via cesarean section (March of Dimes, 2023). After a literature review, no research was found presenting the currently common practice of SIH prophylaxis utilized by Indiana CRNAs. Practitioners should be aware of the clinical recommendations regarding prophylaxis for SIH, as they can make their anesthetic plan based on the assessment of their patient. When discussing prophylactic SIH techniques with practicing Indiana CRNAs, many methods were mentioned based on provider preference, experience, and education. By performing a needs assessment on approaches to reducing SIH in cesarean section patients in Indiana, CRNA's can better understand current

practices, disseminate up-to-date information and recommendations, and provide patients with safe and effective care.

Review of the Literature

The literature search methodology examined articles regarding prophylactic techniques to reduce SIH in parturients undergoing elective cesarean sections. The review search used the keywords: *spinal anesthesia, hypotension, cesarean,* and *prevention*. This review was conducted in November 2022 using the databases: EBSCO Host: Medline Plus with full text and CINAHL Plus with full text. The database searches were performed using the BOOLEAN phrase spinal anesthesia hypotension cesarean AND prevention. The 290 database search results were reduced to exclude duplicate articles, articles not written or translated into English, article publications not within the past seven years, and articles not relating to the female gender resulting in 48 research articles shown in a PRISMA flow chart (Appendix A). The remaining research studies were examined to determine if the studies met the inclusion criteria. The search inclusion criteria included all articles written or translated into English, articles on spinal-induced hypotension preventative measures, and articles regarding spinal anesthesia and maternal hypotension.

Synthesis of Literature Review

Of the 32 articles, research studies that were not specific to spinal anesthesia, elective cesarean sections, or maternal hypotension were excluded. Research articles were further reduced to include 19 articles consisting of systematic literature reviews, literature reviews, randomized controlled trials, and meta-analyses analyzing different methods of SIH prophylaxis in parturients undergoing elective cesarean sections. In addition, three sources are included to represent current practice guidelines. The literature review matrix, which includes specific information and details of each study, is included in Appendix B.

Practice Guidelines

According to Nixon and Leffert (2022), current practice guidelines recommend keeping the maternal blood pressure within 10-20% of the patient's baseline blood pressure, or their systolic ≥100 mmHg, unless the patient has a history of severe hypertension. The primary strategy utilized is a phenylephrine drip titrated to effect between 25-100 mcg/kg/minute or rescue boluses of phenylephrine of 50-100 mcg as needed (Nixon & Leffert, 2022). In the presence of bradycardia, an ephedrine drip can substitute at a rate of 1-5 mg/minute or rescue boluses of 5-10 mg boluses (Nixon and Leffert, 2022). In addition, Nixon and Leffert (2022) include a rapid IV crystalloid bolus co-loading at the time of induction of the spinal anesthetic in their practice guidelines. The American Society of Anesthesiologist's practice guidelines supports IV fluid pre-loading or co-loading to prevent spinal-induced hypotension (Apfelbaum et al., 2016). In addition, the ASA recommends either IV phenylephrine or ephedrine depending on the maternal heart rate, although phenylephrine is the drug of choice (Apfelbaum et al., 2016). The Association of Anaesthetist practice guidelines states that prophylactic vasopressors are the preferred treatment of hypotension, alpha-agonists being the most appropriate choice, and phenylephrine being the most supported (Kinsella et al., 2017). In addition to IV colloids or crystalloid co-loading, vasopressors have support from the Association of Anaesthetists (Kinsella et al., 2017). Other practice recommendations to decrease SIH include maternal positioning to achieve left uterine displacement (Apfelbaum et al., 2016; Kinsella et al., 2017). Phenylephrine is the current gold standard for preventing maternal hypotension caused by spinal anesthesia partly due to a noticeable decrease in intraoperative nausea and vomiting and an improved fetal acid-base status compared to other drugs (Apfelbaum et al., 2016; Kinsella et al., 2017; Nixon & Leffert, 2022).

Crystalloid or Colloid Pre-loading or Co-loading

In a systematic review, crystalloid co-loading was recommended immediately post-spinal administration, in addition to a phenylephrine infusion (Fichter & Nelson, 2019). In a randomized controlled study, 10 mL/kg of a colloid co-load was found to be more effective in decreasing the norepinephrine infusion by approximately 30% compared to a crystalloid co-load (Jin et al., 2022). According to a systematic review and meta-analysis, colloid pre-loading was found to be superior to crystalloid pre-loading in decreasing SIH ($p<0.0001$) (Shang et al., 2021). Another meta-analysis showed crystalloid co-loading was superior in preventing hypotension than crystalloid pre-loading ($p=0.01$) (Ni et al., 2017).

Norepinephrine

Norepinephrine studies are compared to common vasopressors used to prevent maternal hypotension during spinal anesthesia. One study compared norepinephrine at 4 mcg/kg/minute and ephedrine at 4 mg/minute (Xu, Mao, et al., 2019). Findings suggest norepinephrine showed fewer cases of tachycardia ($p=0.002$), less heart rate fluctuation, lower heart rate ($p=0.04$), less fetal distress, and lower systolic blood pressure ($p=0.04$) when compared to the ephedrine infusion (Xu, Mao, et al., 2019).

Another study compared a fixed-rate infusion of norepinephrine and a variable-rate infusion of norepinephrine, but there were technical limitations of an inadequate dose design (Sheng et al., 2022). In a systematic review and meta-analysis comparing norepinephrine and phenylephrine, findings show no significant differences in the treatment of maternal hypotension ($p=0.11$) (Xu, Shen, et al., 2019). The norepinephrine group was less likely to experience bradycardia and intraoperative nausea and vomiting than the phenylephrine group ($p=0.005$)

(Xu, Shen, et al., 2019). This specific study showed no differences in Apgar scores and umbilical blood gases (Xu, Shen, et al., 2019).

When comparing norepinephrine, there is insufficient evidence to conclude that norepinephrine creates more efficient cardiac output and better blood pressure precision than phenylephrine (Xu, Shen, et al., 2019). More studies are needed before bringing norepinephrine into routine usage (Xu, Shen, et al., 2019).

A systematic review comparing norepinephrine to phenylephrine concluded that norepinephrine is similar to phenylephrine, with no apparent signs of maternal or neonatal adverse outcomes (Wang et al., 2018). This review showed a lower incidence of bradycardia and increased cardiac output, but more high-quality studies are needed before it can be appropriately implemented (Wang et al., 2018).

Intramuscular phenylephrine dosing was studied compared to a placebo in a randomized controlled trial and showed better neonatal acid-base status ($p=0.01$) and more stable maternal hemodynamics ($p<0.0001$) (Xu, Liu, et al., 2019). Fan et al. (2021) completed a double-blinded, randomized controlled trial comparing a norepinephrine infusion to an ephedrine infusion. It was found that norepinephrine resulted in less hypotension ($p=0.034$), less tachycardia ($p<0.001$), less nausea and vomiting ($p=0.004$), and potential neonatal benefits.

Ondansetron and Granisetron

Effects of prophylactic IV ondansetron given 5 minutes before the spinal anesthetic was performed were studied in a randomized, double-blinded controlled study, and no significant difference was found in the incidence of hypotension between the ondansetron groups and the control group ($p=0.767$) (Karacaer et al., 2017). The episodes of hypotension and norepinephrine consumption were considerably more significant in the control group compared to the

ondansetron group (p=0.009) (Karacaer et al., 2017). Ondansetron in this study did not prevent SIH, but it did decrease the norepinephrine requirement (Karacaer et al., 2017).

Another study compared the effects of prophylactic IV ondansetron, IV granisetron, a control, and the effect on ephedrine requirements (Aksoy et al., 2021). This randomized controlled trial showed that the ephedrine requirement in the control group was higher than both the ondansetron and granisetron group (p=0.033; p<0.001) (Aksoy et al., 2021). The ondansetron and granisetron groups also had lower nausea and vomiting than the control group (p<0.001) (Aksoy et al., 2021).

When looking at the incidence of hypotension with prophylactic ondansetron in a randomized controlled superiority trial, it was found that hypotension did not decrease with ondansetron administration (p=0.23) (Oofuvong et al., 2018). In addition, heart rate, blood loss, and ephedrine requirements were similar in the ondansetron and the control groups (Oofuvong et al., 2018).

Lower Extremity Elevation or Compression

Sequential compression devices (SCDs) were studied in a randomized controlled trial to assess the effects on hemodynamic changes after spinal anesthesia (Javaherforooshzadeh et al., 2020). Ultimately, the diastolic blood pressure was found to be significantly higher in the SCD group (p<0.05), and the SCD group had a lower incidence of nausea (p=0.005), vomiting (p=0.001) and lower mean ephedrine requirement (p=0.001) (Javaherforooshzadeh et al., 2020).

Two randomized controlled trials reported the effects of leg elevation immediately after spinal administration (Assen et al., 2020; Hasanin et al., 2017). Both studies showed that patients who were part of the leg elevation group experienced a decreased incidence of hypotension (p=0.043) (p=0.005) (Assen et al., 2020; Hasanin et al., 2017).

Decreased Local Anesthetic Spinal Dosing

One systematic review evaluated ten clinical trials that compared the effectiveness of the mean effective dose of intrathecal hyperbaric bupivacaine in 50% of the population (ED50) to the mean effective dose in 95% of the population (ED95) (Tubog et al., 2018). Decreasing the dose of the local anesthetic to ED50 in the spinal was effective in decreasing the incidence of hypotension, but it created more patient discomfort (Tubog et al., 2018). The recommendation of this clinical trial states to utilize a dose that will increase patient satisfaction; however, if a dose of less than ED50 is to be utilized, a combined spinal epidural (CSE) technique would be most beneficial (Tubog et al., 2018).

Glycopyrrolate

The use of glycopyrrolate was assessed in a meta-analysis of 5 different randomized controlled trials (Patel et al., 2018). There was no difference in decreasing spinal-induced hypotension when using prophylactic glycopyrrolate ($p=0.59$) (Patel et al., 2018). When assessing the total phenylephrine requirements of the patient, those who received glycopyrrolate had significantly fewer phenylephrine requirements ($p=0.006$); however, the maximum heart rate ($p<0.0001$) and incidence of dry mouth ($p<0.0001$) was significantly increased in the glycopyrrolate group ($p<0.0001$) (Patel et al., 2018).

Discussion

There are no practice standards for SIH prophylaxis, but there are practice guidelines. Current practice guidelines list phenylephrine as the drug of choice to prevent SIH (Apfelbaum et al., 2016; Kinsella et al., 2017; Nixon & Leffort, 2022; & Noffsinger, 2022). Fluid blousing as a pre-load or co-load has produced several different results. Fluid blousing studies showed colloid pre-load or co-loading as more effective than crystalloid pre-loading or co-loading (Jin et

al., 2022 & Shang et al., 2021). Crystalloid pre-loading was also more effective than crystalloid co-loading (Ni et al., 2017). Ultimately, fluid boluses are most effective when used with a vasopressor (Apfelbaum et al., 2016). Norepinephrine has been studied in comparison to phenylephrine and ephedrine with positive outcomes; however, more favorable studies are needed to put this method into routine practice (Fan et al., 2021; Sheng et al., 2022; Wang et al., 2018; Xu, Mao, et al., 2019; & Xu, Shen, et al., 2019). While ondansetron and granisetron did not decrease spinal-related hypotension, they did decrease other vasopressor requirements while also decreasing nausea and vomiting (Aksoy et al., 2021 & Karacaer et al., 2017). More research is warranted regarding the use of ondansetron and its use in SIH prophylaxis. The articles found positive evidence of a reduction in blood pressure with both leg elevation and SCDs, although rescue medications were still needed (Javaherforooshzadeh et al., 2020; Assen et al., 2020; & Hasanin et al., 2017). When reducing the dosage of spinal anesthetics, evidence showed that redosing was likely to occur because of the mother's discomfort (Tubog et al., 2018). Glycopyrrolate was not found to have a positive effect in decreasing SIH, although it did decrease vasopressor requirements (Patel et al., 2018). Ultimately, there is no practice standard to reliably prevent SIH for women undergoing elective cesarean sections. More research is necessary to find the best practice.

Theoretical Framework

The Johns Hopkins Nursing Evidence-Based Practice for Nurses and Healthcare Professionals (JHNEBP) model is a framework utilized individually or for groups and guides the research project (John Hopkins Medicine, 2022). (See Appendix C). This model ensures that the best evidence-based practices will be appropriately implemented in patient care (Upstate Medical University Health Sciences Library, 2022). The PET process in the JHNEBP model identifies the

practice question, evidence to answer the question, and translation into practice (Upstate Medical University Health Sciences Library, 2022). In this study, a survey determines the utilization of SIH prophylactic techniques by Indiana CRNAs. An analysis is conducted, keeping in mind the most current recommendations centered around evidence-based practice, and the data has been disseminated to a professional organization.

Project Aims and Objectives

This project aims to assess currently practicing CRNAs in Indiana and their adherence to the recommended practice regarding SIH prophylaxis. Hypotension caused by spinal anesthesia in obstetric patients undergoing a cesarean section is common. This project assesses SIH prophylaxis techniques utilized by Indiana CRNAs compared to evidence-based practice recommendations through a survey. An anonymous survey has been distributed to Indiana CRNAs and asked qualitative questions regarding their techniques, if any, used for hypotension prevention during spinal anesthesia in patients undergoing a scheduled cesarean section. The expected outcome is that most Indiana CRNAs report using the recommended practice guidelines based on up-to-date and evidence-based practice. Dissemination with a professional organization has been established to assess the need for potential further education.

Project Design and Methods

An email with an anonymous link to a *Qualtrics* self-assessment survey was administered to the five hundred and sixty-five (565) Indiana Association of Nurse Anesthetists (INANA) group members. Mary Nguyen Reynolds, the 2022 president of the INANA and this project's Team Member, utilized her email contact list of INANA members to send out this survey. Actively practicing CRNAs in the State of Indiana were invited to participate in this survey composed by this DNP project's DNP student.

Project Site and Population

The DNP project takes place in the state of Indiana. Indiana is a midwestern state with various types of hospitals and practicing CRNAs. The population in this study includes any practicing CRNA in Indiana who works with laboring women and provides spinal anesthesia for cesarean sections. Exclusion criteria includes CRNAs who are not currently practicing or do not practice obstetric anesthesia.

Measurement Instruments

Measurement of the outcomes of this DNP project included an online self-assessment survey designed using *Qualtrics*. The survey that was distributed included seven quantitative questions evaluating methods these anesthesia providers utilize to prevent SIH in parturients undergoing elective cesarean sections (See Appendix D).

Data Collection Procedures

Data collection was completed with the online survey software program of *Qualtrics*. The email sent to the potential participants of the study granted access to an anonymous link for an online survey administered through *Qualtrics*. An information sheet with implied consent was presented in the email (See Appendix E). It stated the title of the project, an explanation of the survey, the risks associated with the project, and an invitation to participate. There was no risk to the participants; participation was entirely anonymous and voluntary. No identifying information was collected. The participants had access to the survey for two weeks, during which a reminder email was distributed after one week. Data collection was completed and stored through *Qualtrics,* and the survey closed after two weeks. The DNP student is the only person with access to the data and utilized a password-protected Marian University *Qualtrics* account. In addition, a password-protected laptop was utilized to access collected data. There are five

hundred and sixty-five (565) members in the INANA. The response rate goal was accomplished with 75 responses recorded. All data was collected, summarized, analyzed, and is presented under Results.

Ethical Considerations

Ethical considerations for the DNP project included keeping all responses anonymous without any identifiable information and obtaining implied consent from participants. The implied consent information sheet explained the reason behind the study and what was to be done with the information collected. All information collected from participants was to be disclosed with permission from each participant. There were no ethical concerns or risks for this project. The DNP student will delete the raw data collected for this project after three years.

Results

A total of 565 Indiana CRNAs were contacted to participate in this DNP project. The population sample size consisted of 75 Indiana CRNAs (n=75) who answered all survey questions, demonstrating a 13.27% response rate. 75 CRNAs completed the survey within a two-week period. Years of experience varied from 0-9 years of practice (48%) to 10+ years of practice (52%). Most respondents also consisted of CRNAs practicing in Northern Indiana (47.5%) versus Central Indiana (30%) or Southern Indiana (22.5%). Many of these Indiana CRNAs reportedly worked in a local community hospital (46.67%). Please see Table 1 to view the demographics of all survey respondents.

Table 1
Participant Demographics

Survey Questions	Characteristics	Frequency	Percentage
CRNA experience (years)	< 5 years	19	25.33
	5-9 years	17	22.67

	10-14 years	13	17.33
	15-20 years	5	6.67
	> 20 years	21	28
Location in Indiana	Northern Indiana	38	47.5
	Central Indiana	24	30
	Southern Indiana	18	22.5
Healthcare facility	Large hospital network	25	33.33
	Local community hospital	35	46.67
	Critical access hospital	13	17.33
	Obstetric clinic	0	0
	Other: Please specify	2	2.67

Note: The two open-ended responses for the healthcare facility included “All” and “ASC”.

Participant SIH Background and Prophylaxis

The survey administered to Indiana CRNAs aided in determining the participants background with SIH. A majority of responses indicated the healthcare facility in which the CRNA worked, did not have a protocol for treating SIH (78.67%). Additionally, 84% of Indiana CRNAs reported the use of prophylactic techniques. The most reported uses of prophylactic techniques by Indiana CRNAs included intravenous crystalloid infusion (23.99%), intravenous zofran (17.58%), ephedrine bolus (16.22%), phenylephrine bolus (15.88%), and decreased height-based dosing of spinal anesthetic (12.50%). Please see Table 2 to view all survey results.

Table 2

Participant Background with Spinal Induced Hypotension (SIH) Prophylaxis

Survey Questions	Characteristics	Frequency	Percentage

Healthcare facility SIH protocol	Yes	6	8
	No	59	78.67
	Unknown	10	13.33
CRNA use of prophylactic techniques	Yes	49	65.33
	No	4	5.33
	Sometimes	8	10.67
	Always	14	18.67
Prophylactic or rescue techniques utilized by CRNAs for SIH	Intravenous crystalloid infusion	71	23.99
	Intravenous colloid infusion	2	0.68
	Combined intravenous crystalloid and colloid infusion	1	0.34
	Phenylephrine bolus	47	15.88
	Phenylephrine infusion	11	3.72
	Ephedrine bolus	48	16.22
	Ephedrine infusion	2	0.68
	Norepinephrine infusion	0	0.00
	Intravenous ondansetron	52	17.58
	Intravenous granisetron	2	0.68
	Sequential Compression Devices (SCD’s)	16	5.41
	Patient leg elevation	0	0.00
	Decreased height-based dosing of spinal anesthetic	37	12.50
	Intravenous glycopyrrolate	2	0.68
	None of the above	0	0.00

Other: Please specify	5	1.69

Note: The select all that apply question regarding prophylactic and rescue methods to treat SIH warranted 296 total responses. Percentages are calculated by using a total of 296 responses.

Qualitative Results

Question six and question seven consisted of open-ended questions regarding other prophylactic methods not mentioned in the previous question. Many responses included Zofran and Ephedrine. Please see Table 3 for a full list of added responses from participants.

Table 3
Participant Qualitative Results

Survey Questions	Participant Response
Other methods utilized to decrease SIH not listed (Question 6)	1. IV Zofran 2. Ephedrine skin wheel on SAB 3. IM Ephedrine 4. Occasionally will give Ephedrine 10mg IVP and then give the rest of that vial (40mg) IM in the thigh right after spinal/before drape to help prevent a drop. 5. Zofran
Other techniques utilized (Question 7)	1. IM Ephedrine 2. Intravenous Zofran 3. No 4. No 5. IM Ephedrine 6. 25 mg Ephedrine IM after spinal is placed and patient is placed supine. 7. IM ephedrine if I've not given sq 8. No 9. No 10. No 11. Zofran approximately 5 minutes before spinal 12. No 13. I treat SIH based on HR and patient symptoms, which can occur before the BP reads. I will bolus phenylephrine if the heart rate increases above 100 bpm or, if the patient reports nausea, I'll bolus phenylephrine or ephedrine based on the HR. 14. Uterine wedge 15. See other 16. N/A

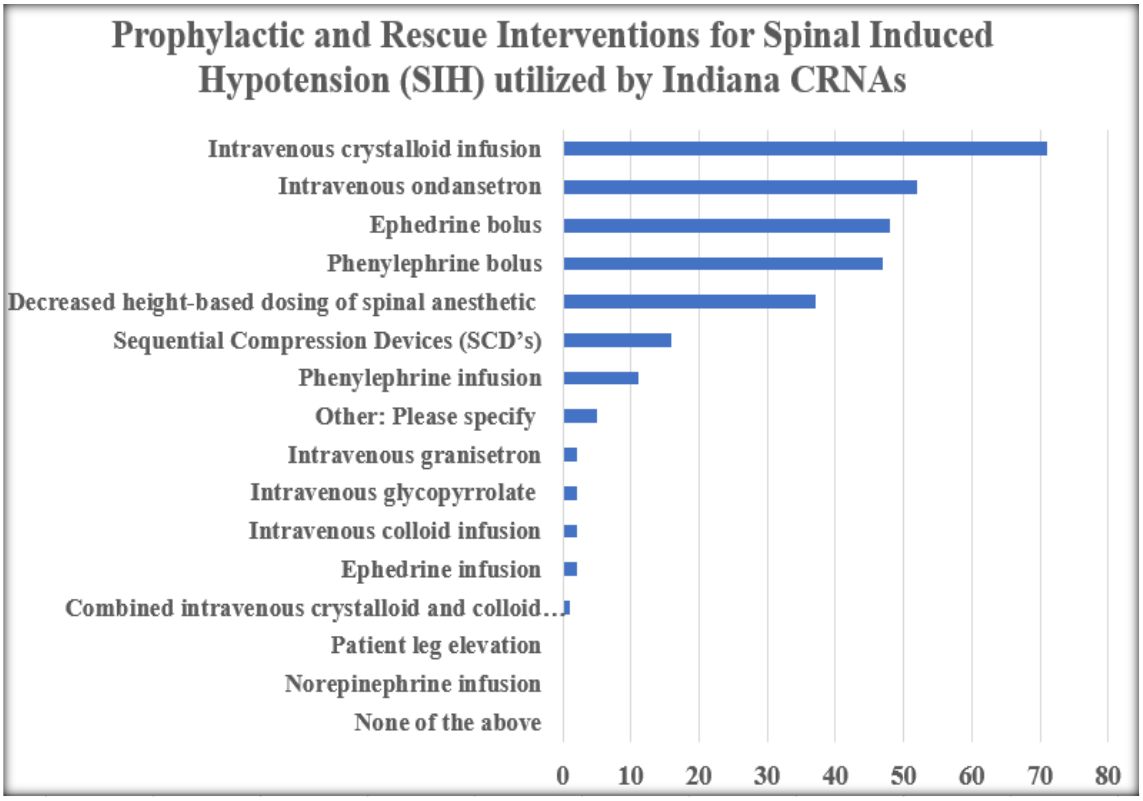
Note: Answers are displayed as they were submitted.

Graphed Results

An organized graph of the survey results of prophylactic and rescue interventions for SIH utilized by Indiana CRNAs are included in Figure 1, please see below.

Figure 1

How do Indiana CRNAs utilize or disuse prophylactic hypotensive techniques before or after spinal administration for healthy parturients delivering via elective cesarean section?



Discussion

This descriptive study surveyed current practices of Indiana CRNAs and their approach to preventing and treating hypotension in healthy parturients undergoing a cesarean section. Overall, CRNA responses were gathered from individuals working in Northern Indiana (47.5%) and local community hospitals (47.5%). The number of CRNAs who reported their facility does not have a SIH protocol was evident with a 78.67% response rate. In addition, 84% of Indiana CRNAs reported their use of prophylactic techniques for SIH. Current practice guidelines

recommend fluid loading and phenylephrine as the drug of choice to prevent SIH (Apfelbaum et al., 2016; Kinsella et al., 2017; Nixon & Leffort, 2022; & Noffsinger, 2022). When compared to current practice guidelines, Indiana CRNAs are utilizing the current practice recommendations of intravenous crystalloid fluid loading (23.99%), ephedrine boluses (16.22%), and phenylephrine boluses (15.88%). While current practice guidelines suggest phenylephrine drips are useful in preventing SIH, only 3.72% of Indiana CRNAs reported utilizing this prophylactic measure. Significant methods utilized by Indiana CRNAs that are not listed as current practice guidelines included administration of Zofran (17.58%) and decreased height-based dosing of spinal anesthetic (12.5%).

Limitations

The limitations in this study include utilizing only generic names for the medications listed in the survey. Several responses in the open-ended answers from the survey listed Zofran as a medication utilized in their preventative measures in addressing SIH. Listing both the generic and trade names in the survey would have cleared up any confusion for the sample population.

Conclusion

Pregnant women undergoing elective cesarean sections experience hypotension up to 70-80% when undergoing spinal anesthesia without any prophylactic measures in place (Noffsinger, 2022). This descriptive study was able to analyze prophylactic techniques for SIH utilized by Indiana CRNAs through an online survey and compare the results to the current recommended practice guidelines. A majority of responses from Indiana CRNAs included the current recommended practice guidelines with the exception of phenylephrine infusions. Practice guidelines should continue to be evaluated and distributed to anesthesia providers to ensure best

practice for patient populations. Future studies implementing phenylephrine drips as prophylaxis to SIH can give further insight to all Indiana CRNAs practicing in obstetrics.

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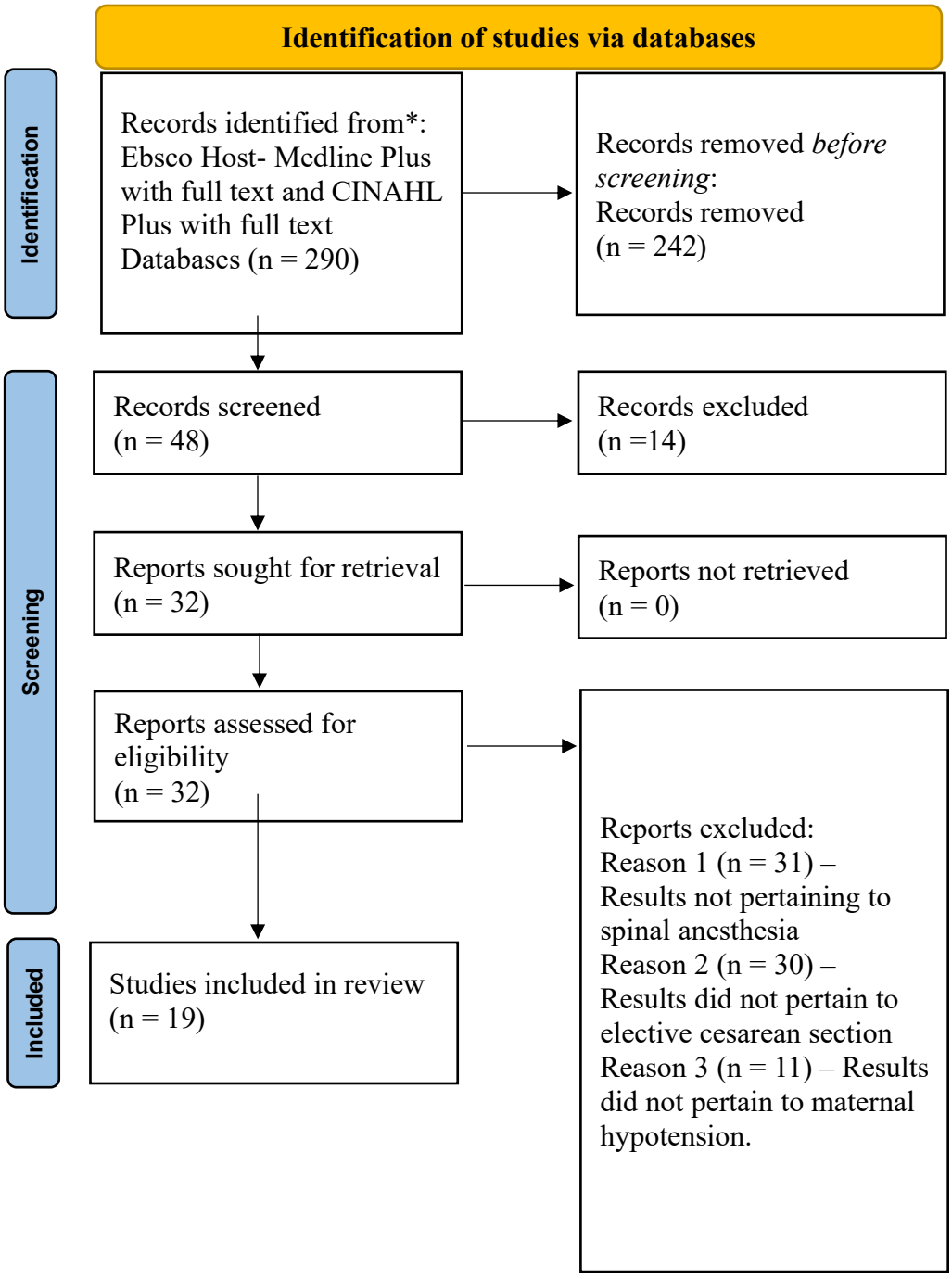
Appendix A

PRISMA 2020 Flow Diagram



Appendix B

Citation	Research Design	Population / Sample size n=x	Major Variables	Instruments / Data collection	Results
Aksoy et al. 2021	Randomized Controlled trial	n=125 parturients undergoing elective cesarean sections and spinal anesthesia	Age, height, weight, ASA status, operation time, mean blood pressure, baseline heart rate, baseline SpO2 values, time to T6 level, time of regression to T10 level, ephedrine requirement, atropine requirement, intraoperative nausea and vomiting, shivering	Intraoperative hemodynamic changes recorded every 2 minutes for 20 minutes, then every 5 minutes until the end of the operation; visual analogue scale (VAS)	Ondansetron and granisetron resulted in lower ephedrine requirements p=0.001; ephedrine requirement in group III was higher than in group I p=0.033 and group II p<0.001; ephedrine requirement in group II lower than group I, but not statistically significant p=0.055; patients with nausea and vomiting were lower in groups I and II compared to group III p<0.001
Apfelbaum, et al. 2016	Practice Guidelines	N/A	N/A	N/A	Recommendations: IV fluid pre-loading or co-loading; IV ephedrine or phenylephrine
Assen et al. 2020	Open randomized controlled trial	n=52 parturients scheduled for elective cesarean sections with spinal anesthesia	Age, height, weight, BMI, baseline SBP and DBP, baseline HR, number of previous cesarean sections, time of spinal to delivery, duration of	Comparison of SBP and DBP, bradycardia, and phenylephrine consumption between the two groups.	Hypotension was decreased in the leg elevation group (p=0.043); Risk of developing post spinal hypotension in the leg elevation group

			surgery, intraoperative fluid, weight of baby, nausea and vomiting, bradycardia, and blood loss		compared to control group was (p=0.47); Severe hypotension was significantly decreased in leg elevation group (p=0.02)
Fan et al. 2021	Double-blinded randomized controlled trial	n=177 parturients scheduled for elective cesarean section with spinal anesthesia	Age, BMI, height, weight, gravidity, type of parturient, gestation, upper blockade, duration from SA to umbilical cord clamp, uterine tonic, duration of surgery, volume of LR, EBL	Baseline HR and SBP measured; assessment of dermatomal level of spinal; SBP and HR recorded every 2 minutes after spinal for 30 minutes; umbilical arterial blood gas; comparison of intervention and control group	Decreased hypotension with norepinephrine than ephedrine (p=0.034); Tachycardia was lower in norepinephrine group than the ephedrine group (p<0.001); Fewer patients experienced nausea and vomiting in the norepinephrine group than in the ephedrine group (p=0.004); norepinephrine group had neonatal cerebral regional saturations (p=0.008)
Fichter & Nelson 2019	Systematic Review	n=25 Review comparing different techniques in reducing hypotension during spinal anesthesia in	Definitions of hypotension, differing techniques, differing dosages	Incidence of hypotension regarding prevention technique	Recommendations: Prespinal – LE compression, 5-HT3 Antagonist; Immediately post-spinal: Crystalloid co-load, phenylephrine infusion, left lateral tilt;

		pregnant women undergoing elective cesarean section			Intraoperatively: Crystalloid maintenance, continue phenylephrine infusion, return to supine position.
Hasanin et al. 2017	Randomized controlled trial	n=150 parturients scheduled for cesarean section with spinal anesthesia	Age, weight, time from spinal to delivery, total infused volume, urine output, blood loss, incidence of hypotension, ephedrine consumption, nausea and vomiting, bradycardia, and hypotensive episodes	Arterial blood pressure, heart rate, intraoperative ephedrine consumption, incidence of post spinal hypotension, and incidence of nausea and vomiting	Groupe LE showed lower incidence of post spinal hypotension ($p=0.005$); LE group showed less ephedrine consumption ($p=0.001$)
Javaherforoshzadeh et al. 2020	Randomized controlled trial	n=76 parturients undergoing elective cesarean section with spinal anesthesia	Age, height, weight, gestational age, maximum sensory block, skin incision to delivery time, spinal anesthesia to delivery time, duration of surgery	Comparison of maternal hemodynamic changes within 75 minutes after spinal anesthesia, nausea, vomiting and neonatal Apgar score at 1 and 5 minutes between the groups.	Diastolic blood pressure was significantly higher in the SCD group than in the control group ($p<0.05$); SCD group had lower incidences of nausea ($p=0.005$) and vomiting ($p=0.001$); SCD group had lower mean ephedrine dosages per patient ($p=0.001$)
Jin et al. 2022	Randomized controlled study	n=200 parturients undergoing	Age, height, weight, gestational age, baseline SBP, baseline	Baseline systolic blood pressure, NIBP measurement every	ED50 and ED90 norepinephrine infusion

		elective cesarean section and spinal anesthesia	HR, upper sensory level, spinal anesthesia to delivery interval, total norepinephrine consumption before delivery, intravenous fluid volume given	minute after intrathecal injection to delivery, then every 3 minutes until surgery complete, and dermatome level of spinal	combined with crystalloid co-load 10mL/kg colloid co-load decreased the dose of prophylactic norepinephrine infusion by ~30% compared to crystalloid co-load
Karacaer et al. 2017	Prospective, randomized, double-blinded, controlled study	n=108 parturients undergoing elective cesarean sections and spinal anesthesia	Age, weight, height, BMI, parity, indications for cesarean, previous cesarean history, acute fetal distress, duration of surgery, Apgar score, umbilical blood gas	Incidence of hypotension, cumulative episodes of hypotension, total norepinephrine consumption, adverse effects	No significant difference found in the incidence of hypotension between the groups (p=0.767); Cumulative episodes of hypotension and norepinephrine consumption were significantly greater in Group S than Group O (p=0.009)
Kinsella et al. 2017	Practice Guidelines	N/A	N/A	N/A	Recommendations: vasopressors for hypotension; alpha-agonists most appropriate– phenylephrine being most supported; left lateral uterine displacement and IV colloid or crystalloid co-loading used in addition to vasopressors

Ni et al. 2017	Meta-analysis	n=10 studies determining whether crystalloid infusion co-load or crystalloid pre-load would be better for hypotension prophylaxis in spinal anesthesia for women undergoing cesarean sections	Difference in parturients and medical history	Intraoperative incidence of hypotension, need for vasopressors, hemodynamic variables, neonatal outcomes, and incidence of maternal nausea and vomiting	Hypotension was significantly higher in the pre-load group compared to the co-load group ($p=0.01$); Intraoperative vasopressors were higher in pre-load group ($p=0.02$); Nausea and vomiting were higher in the pre-load group ($p<0.0001$)
Nixon & Leffert 2022	Practice Guidelines	N/A	N/A	N/A	Recommendations: Aim to keep blood pressure within 10-20% of baseline; phenylephrine drip or rescue boluses; ephedrine drip or rescue boluses; rapid IV crystalloid bolus
Noffsinger 2022	Systematic Review	n=25 25 articles comparing prophylactic spinal-induced hypotension techniques in pregnant women undergoing	Definition of hypotension, healthy parturients, differing techniques, dosage, current evidence, current common practice	Incidence of hypotension regarding prevention technique; electronic literature search using multiple databases	15 mL/kg rapid crystalloid pre-load or co-load; a colloid pre-load of 250-300 mL; prophylactic IV phenylephrine infusion; rescue boluses of ephedrine or phenylephrine PRN; IV ondansetron; small

		elective cesarean sections			doses of local anesthetic; Lower limb compression devices
Oofuvong et al. 2018	Randomized controlled superiority trial	n=215 parturients undergoing elective cesarean sections and spinal anesthesia	Age, weight, height, BMI, type of operation, site of spinal, number of blocks, anesthesia level, analgesia level, premedication with metoclopramide, and premedication with ranitidine	Comparison of hypotension mean arterial pressure, heart rate, vasopressor requirements, blood loss, and maternal and fetal complications between groups. Changes in BP and HR were compared using the generalized estimating equations method.	Incidence of hypotension (p=0.23); Hypotension before delivery (p=0.02); Heart rate, ephedrine requirements, and blood loss were similar among all groups; Metoclopramide requirement was lower in group O2 compared to group NS (p=0.01)
Patel et al. 2018	Meta-analysis	n=5 trials that assessed the effects of glycopyrrolate on spinal induced hypotension during cesarean section	Differences in parturients and medical history	Intraoperative hypotension, vasopressor requirement, heart rate, nausea and vomiting, dry mouth, and Apgar scores, risk ratios, and mean differences.	No difference between prophylactic group and glycopyrrolate group in decreasing spinal-induced hypotension (p=0.59); Total phenylephrine dose required was significantly decreased with glycopyrrolate (p=0.006); Max heart rate was significantly increased in glycopyrrolate group (p<0.0001); Glycopyrrolate group had a significant

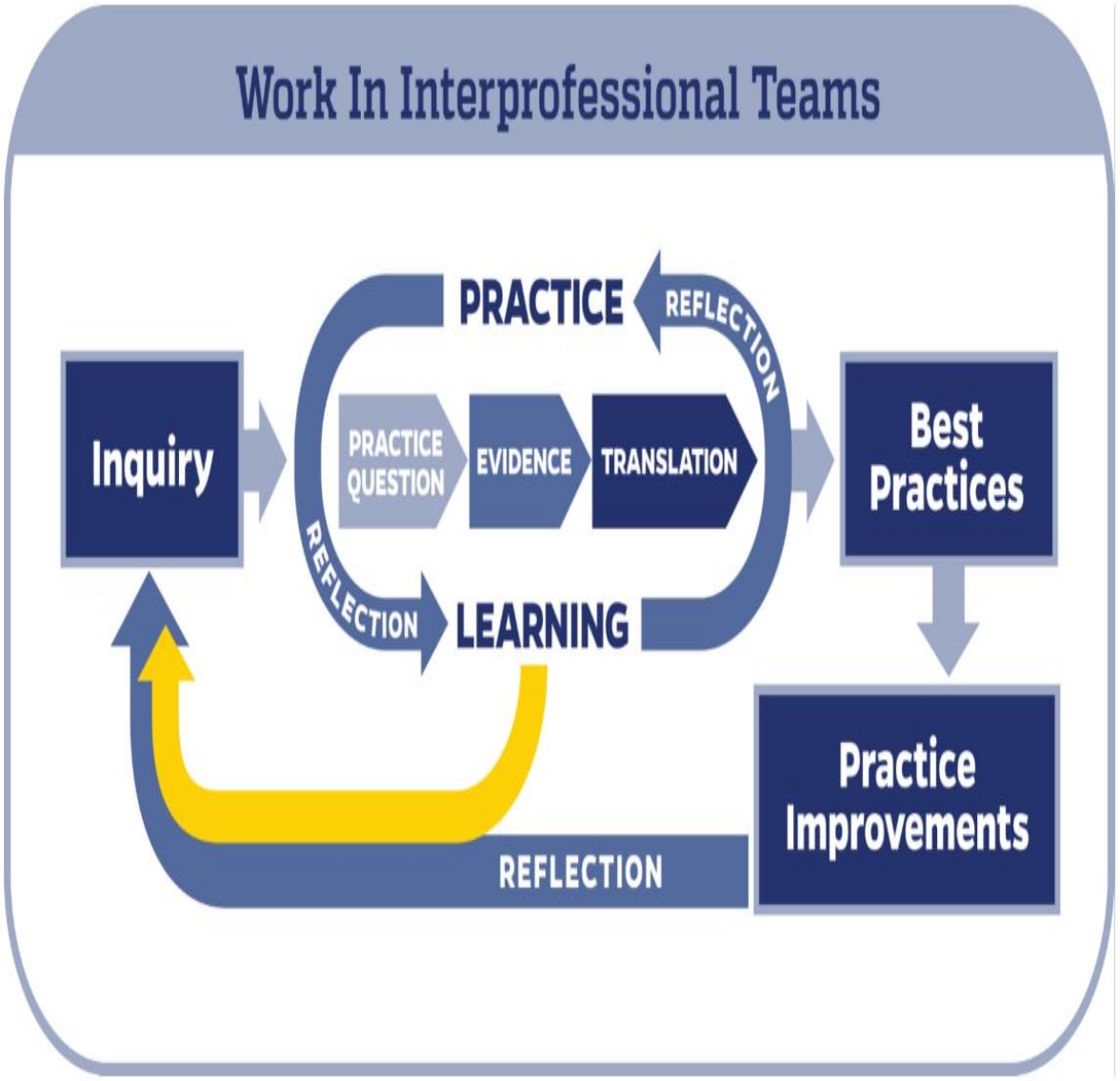
					increase in dry mouth ($p<0.0001$)
Shang et al. 2021	Systemic review and meta-analysis	n=33 trials comparing colloid pre-loading with crystalloid pre-loading in pregnant women undergoing cesarean delivery and spinal anesthesia	Difference in parturients and medical history	Hypotension, total ephedrine dose, phenylephrine requirement, incidence of nausea and vomiting, Apgar score, and umbilical pH	Less hypotension in the colloid group compared to the crystalloid group ($p<0.0001$); ephedrine requirement was lower in colloid group ($p=0.009$); Total phenylephrine requirement was lower in colloid group ($p=0.0002$); nausea and vomiting were decreased in colloid group ($p=0.02$)
Sheng et al. 2022	Prospective randomized, controlled study	n=161 parturients scheduled for an elective cesarean section with spinal anesthesia	Difference in parturients and medical history	Incidence of maternal hypotension, hemodynamic performance, physician interventions, reactive hypertension, bradycardia, nausea, vomiting, norepinephrine accumulative dose before delivery, neonatal outcomes	Incident of maternal hypotension significantly lower in Group V than in Group F ($p<0.001$); Group V needed more physician intervention compared with group F ($p<0.001$). Overall, technical limitations of inadequate dose design, so neither group was optimal.
Tubog et al.	Systematic Review	n=10 clinical trials evaluating	Source/country, ASA class, dose-finding method, dosing	Spinal induced hypotension, intraoperative pain	Decreasing the dose of local anesthetic and decreases the incidence

2018		hyperbaric bupivacaine and the mean effective dose in 50% (ED50) and 95% (ED95) of patients	intervals, intrathecal solution, lumbar level, position, assessment for sensory level, minimum effective dose, other outcomes, definition of spinal induced hypotension, prophylaxis, treatment,	supplementation, hyperbaric bupivacaine dose, intrathecal opioid dose	of spinal induced hypotension and maternal and fetal consequence; Dose at ED50 decreased spinal induced hypotension, but it created more patient discomfort due to inadequate anesthesia; Doses at ED95 provided adequate anesthesia but increased risk of maternal hypotension; CSE recommended if planning to underdose local in spinal anesthesia
Wang et al. 2018	Systematic literature review	n=9 review of reports reviewing hypotension with norepinephrine and phenylephrine in spinal anesthesia for elective cesarean sections	Frequency of post-spinal hypotension, bradycardia, hypertension, rescue boluses, success of NE to maintain BP, dose response curve, cardiac output	Comparison of variables between groups in studies presented	Norepinephrine is similar to phenylephrine; Norepinephrine had lower incidence of bradycardia and greater cardiac output; Norepinephrine seems to be a good alternative, but more favorable, high-quality studies needed
Xu, Liu et al.	Randomized Controlled trial	n=99 parturients undergoing elective cesarean	Age, gestational week, height, weight, BMI, ASA grade, number of	Noninvasive blood pressure monitoring, heart rate; baseline	Significant differences in umbilical artery pH: $p<0.05$;

2019		section and spinal anesthesia	previous deliveries, baseline SBP, baseline DBP, baseline HR, neonatal weight, anesthesia time, time from end of anesthesia to delivery, intraoperative fluid volume, intraoperative blood loss, intraoperative urine volume	blood pressure defined as SBP, DBP, and HR average of three continuous measurement with variations within 10%; hypotension defined as decrease in SBP >20% of baseline SBP; POC arterial and venous blood gas analyzer; APGAR score; admission to NICU	Fetal acidosis: p=0.01; maternal intraoperative hypotension: p<0.0001; preventative intramuscular phenylephrine provides a better neonatal acid-base status and more stable maternal hemodynamics
Xu, Mao et al. 2019	Double Blinded, Randomized Controlled trial	n=97 women undergoing an elective cesarean section and spinal anesthesia	Age, height, weight, gestational age in weeks, repeated cesarean delivery, block dermatome at 5 mins and 15 minutes, fasting time, volume of co-hydration, estimated blood loss, time of induction to delivery, time of uterine incision to delivery, drug consumption: norepinephrine and ephedrine; volume of vasopressor, birth weight	Tachycardia, bradycardia, hypertension, hypotension, severe hypotension, hypotensive episodes, number or rescue top-ups, hemodynamic performance error including median performance error (MDPE), median absolute performance error (MDAPE), neonatal APGAR scores, and umbilical arterial blood gas	Group N had fewer cases of tachycardia (p=0.002); Group N had lower standardized HR (p=0.04); Group N had a lower MDPE for HR (p=0.003); Group N highest HR than group E (both p<0.05); standardized SBP in group N was lower than in group E (p=0.04). 4mcg/kg/min of norepinephrine had fewer cases of tachycardia, less fluctuation and lower HR than ephedrine drip.

Xu, Shen et al. 2019	Systemic review and meta-analysis	n=294 Systemic literature search leading to review of 4 reports and 294 parturients	Maternal outcomes: hypotension, hypertension, IONV, maternal CO, BP control precision; Neonatal outcomes: Apgar scoring, umbilical cord blood gas; heterogeneity analysis and publication bias	Comparison of variables between groups in studies presented	No difference in norepinephrine and phenylephrine for treatment of maternal hypotension (p=0.11); No difference in the occurrence of hypertension (p=0.45); Norepinephrine group less likely to experience bradycardia and IONV than phenylephrine group (p=0.005)

Appendix C



Adapted from Dang, D., Dearholt, S., Bissett, K., Ascenzi, J., & Whalen, M. (2022). *Johns Hopkins evidence-based practice for nurses and healthcare professionals: model and guidelines.* 4th ed.

Appendix D

1. How long have you been a practicing CRNA?
    a. <5 years
    b. 5-9 years
    c. 10-14 years
    d. 15-20 years
    e. >20 years

2. Where do you practice as a CRNA in Indiana? Select all that apply.

**Northern Indiana is everything North of Noblesville, IN.
**Central Indiana is everything between Noblesville, IN and Columbus, IN.
**Southern Indiana is everything South of Columbus, IN.

    a. Northern Indiana
    b. Central Indiana
    c. Southern Indiana

3. How would you describe the Indiana healthcare facility in which you work?
    a. Large hospital network
    b. Local community hospital
    c. Critical access hospital
    d. Obstetric clinic
    e. Other: Please specify _____

4. Does your healthcare facility have a protocol for spinal induced hypotension (SIH) prophylaxis in obstetric anesthesia?
    a. Yes
    b. No
    c. Unknown

5. Do you use prophylactic technique(s) to decrease the incidence of SIH in obstetric anesthesia?
    a. Yes
    b. No
    c. Sometimes
    d. Always

6. Do you use any of the prophylactic or rescue techniques to reduce SIH in obstetric anesthesia listed below? Select all that apply.
    a. Intravenous crystalloid infusion
    b. Intravenous colloid infusion
    c. Combined intravenous crystalloid and colloid infusion
    d. Phenylephrine bolus
    e. Phenylephrine infusion
    f. Ephedrine bolus
    g. Ephedrine infusion

h. Norepinephrine infusion
i. Intravenous ondansetron
j. Intravenous granisetron
k. Sequential Compression Devices (SCD's)
l. Patient leg elevation
m. Decreased height-based dosing of spinal anesthetic
n. Intravenous glycopyrrolate
o. None of the above
p. Other: Please specify _____

7. Do you use another prophylactic technique to reduce SIH in obstetric anesthesia not listed above? If yes, please briefly explain here.

_____

Appendix E

Spinal Induced Hypotension Prophylaxis: Indiana CRNA Techniques

This descriptive study is presented by a Marian University Doctor of Nursing Practice student in the Nurse Anesthesia track. This research project aims to evaluate Indiana CRNAs and the use of prophylactic treatment spinal induced hypotension (SIH) for healthy pregnant woman undergoing elective cesarean sections. You are invited to participate in this research project because you currently practice anesthesia as a CRNA in Indiana. If you do not practice obstetric anesthesia, you should not sign up for this study. Participation in this research survey is voluntary, and you may withdraw participation at any time without penalty.

This 7-question survey will take approximately 5 minutes to complete. Questions will include general demographics, prevention, and treatment options utilized to prevent hypotension after spinal administration in obstetrics. This survey is anonymous, and no identifying information will be collected. All information will be kept confidential, and data will be stored securely in a password-protected electronic format. The results of this study will only be used for scholarly purposes and may be shared with Indiana Association of Nurse Anesthetists (INANA) members.

This research project has been reviewed and approved by the Marian University Institutional Review Board (IRB). If you have any questions about this survey, please contact the Marian IRB at IRB@marian.edu or Kristen Thomas at kthomas759@marian.edu.

By clicking on the survey link, you agree you are a currently practicing, licensed CRNA in Indiana and agree to participate in this survey.