

The Efficacy of Neuraxial Ultrasound in the Obese Parturient

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Dedication

To our spouses, for their never-ending support, grammatical literacy, and understanding of bioinformatics. They are truly the unsung heroes of nurse anesthesiology education.

Acknowledgements

A special note of gratitude to Laura Rodgers and Howard Brown, for their assistance and expertise in fostering our inquisition and passion for learning.

Abstract

Introduction: Ultrasound technology may play a pivotal role in providing safe and effective neuraxial anesthesia for the obese parturient with difficult anatomical landmarks.

Literature: There is a significant association between elevated BMI and epidural failure, suggesting higher BMI increases the risk of multiple needle attempts. The use of ultrasound may decrease the number of needle passes in the obese parturient.

Purpose: The purpose of this project was to assess the efficacy of an ultrasound-assisted technique in minimizing needle passes, procedural complications, and procedural time for the obese parturient receiving neuraxial anesthesia.

Methods: A retrospective chart review was performed on eligible parturients who received neuraxial anesthesia at ProMedica Toledo Hospital between October and December of 2021. In addition, a prospective quasi-experimental design was implemented to assess the efficacy of pre-assessment neuraxial ultrasound. Eligible participants with a BMI 30 kg/m² or greater received ultrasound-assisted site identification prior to spinal or epidural administration.

Results: Ultrasound use yielded no statistically significant difference in the number of attempts for epidural ($p=0.521$), spinal anesthesia ($p=0.931$), or procedural complications ($p=0.358$). There was a statistically significant decrease in procedural time for ultrasound-assisted epidural placement ($p=0.034$), but no difference in subarachnoid blocks ($p=0.892$).

Conclusion: Implementation of an ultrasound-assisted technique for obese parturients receiving epidural anesthesia reduced procedural time. Ultrasound-assisted technique resulted in zero paresthesias and post-dural puncture headaches.

Keywords: Neuraxial Anesthesia, Epidural, Ultrasound, Obesity, Overweight, Pregnancy, Parturient

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The Efficacy of Neuraxial Ultrasound in the Obese Parturient

Background and Significance

Neuraxial anesthesia is commonly utilized in the perioperative care of the obstetric patient. The obese parturient presents with unique anatomical and physiological challenges in providing a safe and effective anesthetic. The patient with obesity often presents with decreased functional residual capacity, high risk of gastric aspiration, and an increase in oropharyngeal soft tissue, all of which may contribute to difficult airway management under general anesthetics (Parra & Loftus, 2013). Additionally, pregnancy causes edema, weight gain, and exaggerated lordosis that may make neuraxial needle insertion especially challenging.

The traditional neuraxial technique relies on palpation of anatomical landmarks for correct needle placement. Due to redundant tissue, identification of insertion landmarks can be difficult in an obese parturient making single needle pass less likely (Uyl et al., 2019). A systematic review conducted by Uyl and colleagues (2019) reported a two-fold increase in the rate of epidural failure amongst obese parturients compared to non-obese. Multiple attempts at performing neuraxial blockade increases the likelihood of post-dural puncture headache (PDPH), backache, spinal cord damage, bleeding, and infection. More devastating complications result in seizure, cauda equina syndrome, paraplegia, cardiac arrest, and death (Butterworth et al., 2013).

The use of an ultrasound-assisted technique has demonstrated potential in improving the first-attempt success of neuraxial blockade (Brodsky & Mariano, 2011). A high correlation between epidural difficulty and increased needle depth has been seen

(Sahin et al, 2014). Additionally, Malik and colleagues (2020) suggest that the true identification of the L4-L5 intervertebral space is significantly lower in obese full-term parturients and obese non-pregnant individuals when compared to the normal weight non-pregnant comparison (Malik, 2020).

Not only does ultrasound imaging encourage accurate needle placement at the desired vertebral interspace, but it also allows the provider to confidently determine the appropriate needle depth required to reach the epidural space (Sahin et al., 2014).

Despite claims supporting the efficacy of neuraxial ultrasound use, it is not commonly utilized in the clinical setting. Especially in high-risk populations, such as the obese parturient, the utilization of an ultrasound-assisted neuraxial technique may minimize associated risk and improve patient safety.

Problem Statement

Obese parturients, as defined by a Body Mass Index (BMI) of greater than 30 kg/m², are at increased risk for adverse outcomes after neuraxial anesthesia (Li et al., 2019). The purpose of this project was to assess the efficacy of an ultrasound-assisted technique and its use in minimizing procedural complications in the obese parturient receiving neuraxial anesthesia.

Literature Review

Search Methods

A literature search was conducted using the following medical databases: CINAHL, Google Scholar, PubMed, EMBase and Cochrane Central Register of Controlled Trials. Key search terms included: “neuraxial anesthesia OR spinal OR

epidural OR subarachnoid block” AND “ultrasound” AND “obesity OR overweight.”

Peer-reviewed articles pertaining to the use of ultrasound technology for neuraxial procedures in the adult patient with obesity were considered for inclusion. Additionally, the article must have been published within the last ten years (2010-2020) and written in the English language. Articles were excluded if they lacked relevance to the proposed question or if they presented a low level of evidence. Further exclusion criteria included: 1) the use of ultrasound technology outside of the obese population, 2) strictly pediatric or elderly patient populations, or 3) non-clinical outcomes of neuraxial ultrasound use.

A search of the medical databases yielded 362 results related to neuraxial ultrasound use in the obese population. Articles were excluded if they were duplicates or lacked relevance to the clinical question. 57 articles from the initial search were further evaluated across inclusion and exclusion criteria. 23 of the 57 articles were eliminated due to outcome variables not comparative to difficult landmark palpation. Seven articles were excluded for defining “difficult landmark palpation” across age groups (pediatric or elderly) as opposed to the status of obesity. Five studies were eliminated for reporting non-clinical outcomes of ultrasound usage, such as resident training or implementation of care. Three studies were eliminated for reporting the complications of neuraxial anesthesia in the obese population without citing the use of ultrasound. Lastly, one study was eliminated due to lack of publication in the English language.

18 studies were included in the synthesis: six from CINAHL, six from Google Scholar, six from PubMed. No relevant studies were identified in the Cochrane, EMBase or DARE medical databases. Of the 18 studies subjected to critical appraisal, there is one systematic review (Uyl et al., 2019), nine randomized control trials (Darrieutort-Laffitea

et al., 2017; Elsharkawy et al., 2017; Ghisi et al., 2019; Li et al., 2019; Mofidi et al., 2013; Sahin et al., 2014; Urfalıoğlu et al., 2016; Vernon et al., 2020; Wang et al., 2012), four retrospective comparison studies (Otten & Dunn, 2018), four cohort studies (Arnolds, Hofer & Scavone, 2020; Malik & Ismail, 2020; Selvakumar et al., 2017; Shaylor et al., 2016), and four case report studies (Morimoto et al., 2017; Ozcekic et al., 2017; Rana et al., 2020; Yim et al., 2019) (**Appendix A**).

Needle Passes (First-Attempt Success, Number of Needle Passes)

An increase in the rate of first attempt success when utilizing ultrasound technology for neuraxial anesthesia in the obese patient was observed (Ghisi et al., 2019; Li et al., 2019; Rana et al., 2020; Sahin et al., 2014; Shaylor et al., 2016; Wang et al., 2012; Yim et al., 2019). Likewise, a decrease in the number of needle passes required to achieve appropriate surgical conditions, if not achieved in one attempt, was reported with the use of ultrasound (Ghisi et al., 2019; Li et al., 2019; Mofidi et al., 2013; Rana et al., 2020; Sahin et al., 2014; Shaylor et al., 2016; Urfalıoğlu et al., 2016; Vernon et al., 2020; Wang et al., 2012).

In contrast, studies conducted by Darrieutort-Laffiteau and colleagues (2017) and Elsharkawy and colleagues (2017) found no difference in first attempt success with ultrasound use. The studies that did not note a decrease in the number of needle passes reported no difference between ultrasound and palpation groups in the obese individual (Darrieutort-Laffiteau et al., 2017; Elsharkawy et al., 2017) (**Appendix B**).

Procedural Time (Site Identification, Total Procedure)

Time is a perceived barrier to successful implementation of ultrasound technology in the clinical setting. The current literature evaluates time across two variables: 1) time

to identify insertion site, and 2) total procedural time. Both Vernon and colleagues (2020) and Wang and colleagues (2019) reported an increase in time required to identify the correct insertion site with ultrasound as opposed to traditional palpation techniques. Although Vernon and colleagues reported an increase in site-identification time, they reported overall shorter procedural time with ultrasound (Vernon et al., 2020).

This trend was not consistent across all studies. Due to the apparent lack of consensus, further research is needed to evaluate the time-effectiveness of using ultrasound techniques for neuraxial procedures in the patient with obesity (**Appendix B**).

Procedural Complications (Postdural Puncture Headache, Backache, Hemorrhage)

In minimizing needle insertion attempts, the use of ultrasound may decrease post-procedural complications (Vernon et al., 2020). Several studies report a decrease in neuraxial complications with the use of ultrasound technology (Molfidi et al., 2013; Rana et al., 2020; Urfalıoğlu et al., 2016; Uyl et al., 2019); however, others report no difference in patient-reported complications across ultrasound and palpation groups in the obese individual (Ghisi et al., 2019; Sahin et al., 2014; Wang et al., 2012). Specific complications such as post-dural puncture headache, backache, presence of heme or paresthesia were seldom identified in the current literature, and thus were difficult to interpret across various studies (**Appendix B**).

Framework

The American Association of Critical Care Nurses (AACN) Synergy Model of Patient Care strongly aligned with the underpinning and implementation of this project. This theory deduces that both patient characteristics and nurse competency contribute to patient outcomes. In evaluating this construct across the population of parturients with

obesity, it can be noted that these patients present with unique considerations that may impact the success of neuraxial anesthesia needle insertion. By improving nurse anesthetists' procedural competency through utilization of neuraxial technology, the safety, comfort, and satisfaction of the patient with obesity receiving neuraxial anesthesia may be improved (**Appendix C**).

Project Methodology

Project Design

To assess the efficacy of neuraxial ultrasonography, a prospective quasi-experimental design was implemented in January of 2022 (**N=50**). Eligible participants consented to ultrasound-assisted site identification prior to neuraxial anesthesia administration. To compare the proposed intervention against standard treatment, a retrospective chart review (**N=373**) was performed on all eligible parturients who received neuraxial anesthesia at ProMedica Toledo Hospital between October and December of 2021 (**Appendix D**).

Sample & Setting

The project took place at ProMedica Toledo Hospital, Ohio within the anesthesia department and the labor and delivery unit. At this facility, there is a high volume of laboring parturients, for which nurse anesthetists are the primary providers who perform neuraxial procedures. This facility is often at full capacity with ten labor and delivery rooms and five special care rooms for high-risk obstetric patients. Although ultrasound-assisted technique was not utilized at this facility, the ultrasound technology was readily available. The patient population of interest included obese parturients, as defined by a BMI greater than 30 kg/m², undergoing neuraxial anesthesia for labor.

Institutional Review Board (IRB) Approval

Prior to project implementation, expedited approval from the Institutional Review Board at ProMedica Toledo Hospital was acquired in October of 2021 on the basis of quality improvement (**Appendix E**). Additionally, the Institutional Review Board at Oakland University issued an IRB reliance agreement between Oakland University and ProMedica IRB in November of 2021. Through this process, the rights and the safety of the voluntary participant were ensured (**Appendix F**).

Eligibility Criteria

Parturients who desired an epidural anesthetic for laboring pain or a subarachnoid block for scheduled cesarean-section were examined across the outlined inclusion and exclusion criteria. Inclusion criteria included: age greater than 18 years, BMI > 30kg/m², English speaking, American Society of Anesthesiologist physical status classification I-III, and singleton pregnancy. Exclusion criteria for study participation included: emergent procedure, pre-term pregnancy (<37 weeks gestation), previous spinal surgery or anatomical abnormality, allergy to local anesthetic, patient refusal, infection, or coagulopathy. Standard departmental guidelines for performing neuraxial anesthesia were maintained regarding participant selection.

Patient Recruitment

Convenience sampling (**N=50**) was utilized for participant recruitment in the prospective arm of the study. Recruitment took place during the month of January 2022. Through the access of electronic health records, eligibility was assessed on-site for patients who were admitted to the labor and delivery unit. In addition, we recruited

eligible participants who were scheduled for cesarean section delivery. Those who were deemed eligible were consented for participation and underwent ultrasound-assisted insertion site identification.

All eligible parturients who had undergone neuraxial anesthesia for labor between October and December of 2021 were included in the retrospective chart review (**N=353**).

Analysis of Objectives

The number of needle insertion attempts was defined as the number of times that skin was penetrated during the neuraxial procedure. The number of needle insertion attempts was indicated in standardized Epic electronic medical record (EMR) procedural documentation and reported for both retrospective and prospective cohorts. Procedural complications were defined as the presence of heme, paresthesia, or the incidence of post dural puncture headache (also known as “wet tap”) within 24 hours of neuraxial procedure. The aforementioned variables were also indicated in standardized Epic EMR procedural documentation for both neuraxial anesthetic subtypes. Lastly, procedural time was determined by calculating the difference between EMR “Start Time” and “End Time” for both spinals and epidurals as recorded by the anesthesia provider. The time required for the pre-procedural ultrasound-assisted site identification was not assessed.

Procedures

Ultrasound-Assisted Needle Insertion Site Identification

Differing from an ultrasound-guided technique which uses real-time ultrasound imaging to guide needle placement during neuraxial administration, an ultrasound-

assisted technique strictly utilizes ultrasound technology to identify the appropriate site prior to actual needle insertion. Upon admission, eligible patients were consented for ultrasound-assisted needle insertion site identification (**Appendix G**).

Ultrasound imaging took place in the pre-operative setting for scheduled cesarean section surgery or on the labor and delivery unit for laboring parturients. Patients were placed in the seated position. Ultrasound imaging was performed using Sonase X6 Medison or GE Voluson Swift ultrasound machines to identify the underlying anatomical landmarks. A low-frequency curvilinear ultrasound probe was used for optimal imaging.

Step 1. The first step in the ultrasound imaging process was to determine the location and level of the desired intervertebral spaces. This was accomplished by first placing the ultrasound probe longitudinally in a parasagittal oblique orientation on the participants lower back. The sacrum, which was appreciated as a continuous hyperechoic line, was identified first.

Step 2. While moving the probe cephalad, the interspaces and laminae of each spinal bone were identified. The interspaces were appreciated by the absence of hyperechoic bone and the presence of the hyperechoic ligamentum flavum deep to the lamina. The laminae were appreciated by hyperechoic triangular “peaks”. The researcher marked and labeled the L4-L5, L3-L4, and L2-L3 interspaces on the participants skin with a surgical pen. This was accomplished by aligning the middle of the interspace with the middle of the ultrasound probe, marking the skin at the center of the probe to approximate the interspace.

Step 3. Next, the ultrasound probe was rotated to a transverse orientation to assess spinal midline. Spinous processes were identified as hyperechoic lines with a large steeple-like shadow. Aligning the hyperechoic line and shadow in the middle of the ultrasound image provided spinal midline. The skin was marked at the center of the probe and this process was performed at L3, L4 and L5. The intersection of the intervertebral and spinal midline markings provided insertion points for the neuraxial procedure.

Step 4. Once the insertion points were determined, the ultrasound probe, still in the transverse orientation, was tilted cephalad or caudal until the posterior complex (ligamentum flavum/dura mater) was identified. The posterior complex was used as a surrogate for the epidural space. Electronic calipers were used to approximate the depth to the epidural space in centimeters. This step was provided for patients who were requesting epidural anesthesia and was subsequently written on the data collection sheet for the anesthesia provider's reference.

Neuraxial Anesthesia Administration

Anesthesia providers with varying degrees of experience participated in this study, inclusive of student registered nurse anesthetists (SRNA) and certified registered nurse anesthetists (CRNA). Standard spinal and epidural insertion techniques were maintained. Before performing the neuraxial procedure, appropriate intravenous access was verified and assessment of baseline vital signs were performed (fetal doppler heart monitor, non-invasive blood pressure, pulse oximeter and 3-lead electrocardiogram).

Subsequent blood pressure measurements were recorded at a minimum of every three minutes and more frequently as indicated.

Participating providers began the neuraxial procedure by performing a physical assessment of anatomical landmarks. If their assessment of midline and interspace did not align with the marked insertion points, the provider could use their determined insertion site. On the data collection sheet, anesthesia providers documented if they used the ultrasound-assisted insertion point. When there was a failed attempt using the ultrasound-assisted insertion point, the anesthesia provider would document why failure occurred (i.e., needle contact with bone).

Data Collection & Instrumentation

In addition to performing the ultrasound-assisted site identification, data collected on the prospective data collection sheet included: 1) class of obesity, 2) whether the patient had undergone previous neuraxial procedures, 3) patient positioning during ultrasound assessment, and 4) estimated depth to ligamentum flavum for each of the marked interspaces. This information was placed in the patient's chart for immediate access by the anesthesia provider performing the neuraxial procedure (**Appendix H**).

Immediately following successful neuraxial administration, the anesthesia provider performing the procedure documented 1) which neuraxial procedure they performed (i.e., spinal or epidural), 2) whether they used the ultrasound-assisted pre-marked site, and 3) years of anesthesia experience. This information was also

documented on the prospective data collection sheet located in the patient's chart.

(Appendix F).

Upon completion of the neuraxial procedure, the researcher reviewed the electronic medical record to assess 1) time required for the procedure, 2) presence of complications (i.e., presence of heme, paresthesias, post-dural puncture headache), and 3) number of attempts (**Appendix I**).

Retrospective Chart Review

To compare the proposed intervention against standard treatment, a retrospective chart review (**N=353**) was performed on all eligible parturients who received neuraxial anesthesia at ProMedica Toledo Hospital between October and December of 2021. All retrospective data collection was provided by the ProMedica Information Technology Services via formal request and approval through the ProMedica Institutional Review Board. The following data was provided: 1) patient demographics (age, gestational age, race, BMI), 2) surgical procedure (i.e., cesarean section), and 3) neuraxial variables including type of neuraxial anesthetic performed, needle depth (epidural placement), presence of complications, and neuraxial procedural times.

Project Implementation

Key Personnel

Those involved or affected by implementing an ultrasound-assisted technique for neuraxial procedures included hospital administration, anesthesia providers, labor and delivery nurses, and the obese parturient requesting neuraxial anesthesia for labor.

Hospital administration had a vested interest in both the financial and legal implications of neuraxial anesthesia administration. In support of the proposed

intervention, administration strives to minimize unfavorable outcomes that may reflect poorly on the institution. Conversely, ultrasound technology costs are covered by the hospital. Therefore, financial impact contrasting technology costs and treatment of adverse events should be evaluated.

Anesthesia personnel and labor and delivery nurses were predicted to be resistant to the proposed practice change. It was unclear if the perceived patient benefits of ultrasound use would outweigh the time and education required for the providers to become and remain confident and competent in the new skill. Additionally, obtaining the technology and performing site-identification prior to local anesthetic administration would add on to their existing workload. To mitigate these barriers, research staff performed the ultrasound imaging and ensured consistent availability of resources. After careful consideration and provider education prior to study implementation, both anesthesiologists and labor and delivery staff responded favorably to project implementation.

Potential Barriers to Implementation & Sustainability

The required resources for successful implementation included an ultrasound machine and the standard procedural equipment to administer neuraxial anesthesia for the laboring parturient. In addressing available resources, the project presented with adequate personnel to assist with coordination and facilitation of the project on site. Additionally, the proposed ultrasound technology was readily available in the clinical setting.

A potential barrier for the proposed intervention was the time required to obtain the ultrasound machine, perform the procedure, and record the data. Despite the availability of ultrasound machines at ProMedica Toledo Hospital, consideration was taken to ensure consistent presence on the labor and delivery unit.

Potential Benefits & Outcomes

Ultrasound assessment of depth of ligamentum flavum, midline, and correct identification of intervertebral space may improve the safety of neuraxial anesthesia. The utilization of an ultrasound-assisted technique was proposed to reduce the number of needle insertion attempts, thus decreasing the incidence of procedure-related complications such as paresthesias, heme with needle insertion, and post-dural puncture headache. Additionally, it was thought to reduce total procedural time required for successful local anesthetic administration. The expected outcomes included a reduction in the number of needle insertions, incidence of procedural complications, and total procedural time.

Ethical Considerations & Risk

There was no identifiable risk or anticipated harms associated with non-invasive ultrasound use. Participation in this study was completely voluntary. Participants were consented with the understanding that they could refuse to participate or discontinue participation at any time without penalty or a loss of benefits to which they were otherwise entitled. If patients decided not to participate or to discontinue participation, their decision did not affect future relations with ProMedica, its personnel, or associated facilities. All patient information was de-identified and maintained in a secure manner using the Research Electronic Data Capture (REDCap) database.

Timetable & Budget

Implementation of both the prospective and retrospective branches of the project was completed by February 1st, 2022 (**Appendix J**). Required technology was present at

Promedica Toledo Hospital, therefore no anticipated financial needs or prospective costs were noted in the implementation process. A potential increase in anesthesia labor time associated with ultrasound use was identified.

Dissemination Considerations

Study findings were presented to anesthesia personnel from ProMedica Toledo Hospital, including both SRNAs and CRNAs. The following topics were disseminated: 1) synthesis of the current literature, 2) study results, 3) demonstration on how ultrasound-assisted technique is performed and 4) barriers identified in the study that may impact future provider utilization. Additionally, findings were presented to the School of Nursing at Oakland University in June of 2022.

Evaluation Plan

Data Maintenance and Security

The EPIC electronic charting system was used to gather patient data in both the retrospective and prospective groups. REDCap software was used to compile de-identified patient data to ensure secure storage. Statistical software in Python was used for computation of the data in determining normality and performing analysis. Results of the data were then downloaded for use in the project report.

Categorizing Outcome Variables

Outcome variables from both the retrospective and prospective groups were differentiated by modality of neuraxial anesthesia received (i.e., epidural or spinal) and were further classified by degree of obesity as defined by the World Health Organization (WHO).

Figure 1. *World Health Organization (WHO) Classification of Obesity*

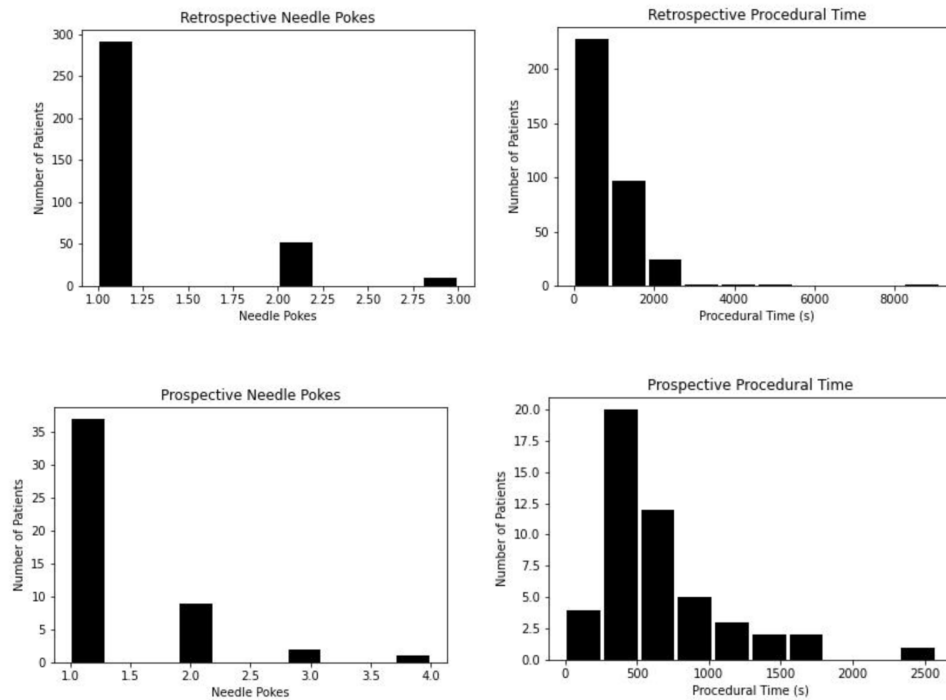
Obesity Classification	BMI (kg/m ²)
Underweight	<18.5
Normal	18.5-24.9
Overweight	>25
Pre-Obese	25.0-29.9
Obese Class I	30-34.9
Obese Class II	34-39.9
Obese Class III	>40

Results

Statistical Consideration

Statistical analysis was performed in Python using *SciPhy1.0: Fundamental Algorithms for Scientific Computing*. Descriptive statistics were applied to demographic data to evaluate average age (years) and BMI (kg/m²) across both the prospective and retrospective groups. Continuous data, including number of needle pokes (#) and procedural time (seconds), was tested for normality using histograms and the Shapiro-Wilks test (**Figure 2**). As all p-values obtained from the Shapiro-Wilk test were significant ($p < 0.05$), the data was not deemed as normally distributed; therefore, the Mann-Whitney U test was used to analyze the two samples. Lastly, the presence or absence of complications was categorically analyzed using Fisher's Exact test with a 2-tailed p value of < 0.05 being considered as statistically significant.

Figure 2. *Testing Normality*



Demographic Data

Descriptive statistics were calculated to describe the characteristics of the sample population. Demographic data and descriptive information were collected to determine average age, BMI, and racial profile of both the prospective and retrospective cohorts.

Demographic data revealed that the majority of patients in both the retrospective and prospective groups were Caucasian, 68.8% and 82.0% respectively. The average age of the patients in the retrospective group was 28.69 years (**Table 1**), whereas the prospective group had a mean age of 28.52 years old (**Table 2**). Lastly, the average BMI in the retrospective and prospective groups was 37.57 kg/m² and 38.95 kg/m² respectively.

Table 1. *Retrospective Demographic Variables*

Demographics	<i>n</i> (%)	Age (years)	BMI (kg/m²)
African American	57 (16.2%)	27.88	38.77
Caucasian	243 (68.8%)	28.99	37.27
Hispanic	22 (6.2%)	27.32	37.44
Other	31(8.8%)	28.79	37.70
Grand Total	353	28.69	37.57

Table 2. *Prospective Demographics Variables*

Demographics	<i>n</i> (%)	Age (years)	BMI (kg/m²)
African American	5 (10%)	26.2	34.32
Caucasian	41(82%)	29	39.71
Hispanic	2 (4%)	18.5	38.85
Other	2 (4%)	34.5	34.85
Grand Total	50	28.52	38.95

Number of Attempts

The Mann-Whitney U test was conducted to examine whether the mean number of attempts was significantly different after ultrasound-assisted site identification in the obese parturient. The result of the two-tailed Mann-Whitney U test was not significant in examining the number of attempts based on an alpha value of 0.05.

Number of attempts, defined as the number of times that skin was penetrated during the neuraxial procedure, was recorded in both the retrospective and prospective cohorts. Results were further organized by obesity classification as defined by the World Health Organization, and by modality of neuraxial anesthesia (i.e., Epidural vs. SAB).

The average number of attempts for parturients who underwent ultrasound-assisted site identification for epidural anesthesia was 1.23 (**Table 3**). Likewise, the average number of attempts required for spinal anesthesia was 1.53 in the prospective group. The difference in the number of attempts between the retrospective and prospective groups was not found to be statistically significant for epidural ($p=0.521$) or spinal (0.931) anesthesia. Likewise, classification of obesity did not result in a statistically significant difference in the number of attempts required to achieve successful neuraxial anesthesia.

Table 3. *Number of Attempts*

<i>Retrospective (N = 353)</i>			<i>Prospective (N = 50)</i>		p-value
BMI (kg/m²)	<i>n</i>	Attempts	<i>n</i>	Attempts	
Epidurals	274	1.19	31	1.23	0.521
30-34.9	124	1.18	11	1.18	0.360
35-39.9	89	1.20	8	1.13	0.324
40+	61	1.20	12	1.33	0.743
Spinals	79	1.25	19	1.53	0.931
30-34.9	25	1.16	4	2.00	0.960
35-39.9	19	1.16	7	1.29	0.855
40+	35	1.37	8	1.40	0.669
Grand Total	353	1.20	50	1.34	–

**p-values <0.05 considered statistically significant*

Procedural Time

Procedural time was determined by calculating the difference between EMR “Start Time” and “End Time” for both spinals and epidurals. On average, the procedural time after performing ultrasound assessment for epidural anesthesia was four minutes faster than the control retrospective group. The Mann-Whitney U test yielded a statistically significant decrease in epidural procedural time in parturients who underwent ultrasound assessment ($p=0.034$) (**Table 4**). Conversely, there was no statistically significant difference in procedural time for those who underwent spinal anesthesia when comparing the prospective and retrospective groups ($p=0.892$).

Table 4. *Procedural Time*

<i>Retrospective (N=353)</i>			<i>Prospective (N=50)</i>		
BMI (kg/m²)	<i>n</i>	Time (min)	<i>n</i>	Time (min)	p-value
Epidurals	274	0:17	31	0:13	0.034*
30-34.9	124	0:17	11	0:15	0.366
35-39.9	89	0:18	8	0:12	0.089
40+	61	0:15	12	0:13	0.083
Spinals	79	0:06	19	0:06	0.892
30-34.9	25	0:05	4	0:06	0.796
35-39.9	19	0:06	7	0:05	0.660
40+	35	0:06	8	0:07	0.822
Grand Total	353	0:15	50	0:11	–

**p-values <0.05 considered statistically significant*

Procedural Complications

The presence of heme, paresthesia, or the incidence of wet tap within 24 hours of neuraxial procedure was indicated in standardized Epic EMR procedural documentation for both neuraxial anesthetic subtypes. A Chi-square Test of Independence requires all cells to have expected values greater than zero and 80% of cells to have expected values of at least five, thus Fisher's exact test with a 2-tailed p value of <0.05 was considered as statistically significant.

Of note, no patients in the prospective cohort reported paresthesia or wet taps following neuraxial anesthesia (**Table 6**). Due to the low incidence of reported complications in the prospective group, the three procedural complication subtypes were grouped and compared against the retrospective cohort. A Fisher's exact test was conducted to examine if there was an association between ultrasound use and the incidence of complications. No statistically significant association was noted ($p=0.358$) (**Table 7**).

Table 5. *Retrospective Procedural Complications*

BMI (kg/m ²)	<i>n</i>	Heme	Paresthesia	Wet Tap
30-34.9	149	0	1	0
35-39.9	108	2	2	0
40+	96	0	2	1
Grand Total	353	2	5	1

Table 6. *Prospective Procedural Complications*

BMI (kg/m2)	<i>n</i>	Heme	Paresthesia	Wet Tap
30-34.9	15	1	0	0
35-39.9	15	1	0	0
40+	20	0	0	0
Grand Total	50	2	0	0

Table 7. *Grouped Procedural Complications*

Complications	Prospective	Retrospective	p-value	Odds Ratio
Yes	2	8	—	—
No	48	345	—	—
Grand Total	50	353	0.358	1.797

Discussion

Analysis of Findings

The number of needle passes, procedural time, and the incidence of neuraxial complications post-procedure have major implications for the care provided to the obese parturient. It is known that every additional insertion attempt increases the risk of infection, hematoma, and neurological damage (Sahin et. al, 2014). Additionally, injecting local anesthetic at the wrong intervertebral level may place the patient at increased risk for procedural complications such as spinal cord damage or high neuraxial blockade (Malik & Ismail, 2020). The literature suggests that ultrasound technology may be useful in improving first-attempt success while encouraging accurate needle placement

at the desired vertebral interspace of patients with difficult anatomical landmarks (Brotsky & Mariano, 2011; Sahin et al., 2014).

Needle Passes. In contrast to the current study, which reports no statistically significant difference in needle passes with an ultrasound-assisted technique, the literature reports that ultrasound imaging has been shown to be superior to the landmark palpation technique in achieving first-pass needle success with neuraxial anesthesia (Ghisi et al., 2019; Li et al., 2019; Sahin et al., 2014; Shaylor et al., 2016; Wang et al., 2012; Yim et al., 2019). More specifically, the use of ultrasound may decrease the number of needle passes required to achieve successful neuraxial anesthesia in the obese parturient (Ghisi et al., 2019; Li et al., 2019; Sahin et al., Tubinis et al., 2019; 2014; Shaylor et al., 2016; Urfalıoğlu et al., 2016; Vernon et al., 2020; Wang et al., 2012). Contrasting findings may be due to altered positioning between scanning and the neuraxial procedure, or resultant from a small sample size.

Procedural Time. The evidence on whether an ultrasound-assisted technique increases (Ghisi et al., 2019; Urfalıoğlu et al., 2016) or decreases (Li et al., 2019; Sahin et al., 2014) total neuraxial procedural time is inconclusive; however, the current study reports a statistically significant decrease in time required to perform epidural anesthesia with the use of an ultrasound-assisted technique. A significant decrease in epidural procedure time may be due to less re-directions during actual placement of local anesthetic. Of note, the current study did not report the time required to perform ultrasound-assisted site identification, thus, the decrease in total procedural time does not account for the time or allocated resources prior to the actual neuraxial procedure.

Procedural Complications. In minimizing needle insertion attempts, the use of ultrasound may decrease post-procedural complications (Vernon et al., 2020). The use of ultrasound has been associated with a lower incidence of backache (Urfalıoğlu et al., 2016) that often results from difficult needle insertion. The current study assessed paresthesia, heme and PDPH as likely complications following neuraxial anesthesia. The incidence of complications was negligible in both the ultrasound-assisted and traditional landmark technique groups. Although the presence of complications was not statistically significant, it should be noted that the ultrasound-assisted group yielded zero paresthesias or PDPHs. A decrease in paresthesias may be attributed to the improved accuracy of midline. A decrease in PDPHs may be attributed to the depth to the posterior complex provided to anesthesia providers prior to epidural placement.

Facilitators & Barriers

Potential barriers for the implementation of neuraxial ultrasound include perceived difficulty, lack of available equipment, inadequate provider training, and time required to perform the task (Wong et. al, 2020). At ProMedica Toledo Hospital on the Labor and Delivery Unity, the ultrasound machine is shared with the obstetric team, thus, availability of ultrasound may be delayed at times. Additionally, there are two machines that differ greatly in image quality. Neuraxial ultrasound was perceived positively from both the anesthesia and obstetric teams, with the goal of optimizing patient outcomes.

Limitations

The researchers acknowledge limitations to this study. With regards to the study design, the lack of participant and anesthesia provider blinding increased the risk of selection and observation bias. Accurate provider reporting of number of attempts was

limited due to the inability of the researchers to be present during the neuraxial procedures. Of note, when providers required greater than 3 attempts for neuraxial placement, the charting option on the EPIC EMR was “3 or more” for attempts. The exact number greater than 3 attempts relied on the anesthesia provider to specify the actual number of attempts in the comment section, this is not routinely performed. This may have skewed the results for both the prospective and retrospective data.

The small study sample size limited the ability to assess for both clinical and statistical significance with regards to procedural complications (heme, paresthesia, PDPH). This is due to the low frequency of neuraxial complications observed.

Although the researchers meticulously positioned patients correctly in the seated position for pre-assessment scanning, it is likely there were position deviations during actual neuraxial anesthesia due to provider preferences or patient factors such as increased labor pain or anxiety. Patients scheduled for c-section were scanned on a stretcher with their legs hanging off the side in a dependent position, while during spinal administration the procedure was done on an operating table where the patient’s legs may or may not have been hanging in a dependent manner based on provider preference.

Lastly, the researchers utilized two ultrasound machines, Sonase X6 Medison and GE Voluson Swift, that were shared with the obstetric team. The GE Voluson Swift ultrasound machine was the newer model which provided higher quality imaging. This machine was not always available to the researcher, which limited the ability to achieve the optimal image for pre-assessment scanning. Additionally, the researchers were novice providers with limited ultrasound experience.

Recommendations

Utilization of an ultrasound-assisted technique could improve the efficacy and safety of neuraxial anesthesia. Positioning is critical for accurate placement of an epidural or spinal, thus limiting factors that may influence position changes may improve the success of ultrasound use. The researchers encourage future studies to address the previously discussed limitations. A study where the provider performs both the pre-assessment scanning and neuraxial procedure in the same setting would improve the efficacy of ultrasound use and patient outcomes, primarily due to a reduction in positional changes. We recommend ultrasound assistance for patients with difficult palpation of anatomical landmarks, or for patients with a history of difficult placement. Ultrasound assistance could also be beneficial and utilized outside of the obstetric setting for any patient with risk factors for difficult needle placement.

Implications for Nursing Practice

Ultrasound technology can provide invaluable information while performing neuraxial anesthesia. For patients with obesity, difficult to palpate anatomical landmarks, or patients with a history of difficult spinal or epidural placement, an ultrasound-assisted technique may prove to be beneficial. Point of care ultrasound (POCUS) is gaining traction in the anesthesia community as ultrasound technology becomes more available, affordable, and reliable. Compared to other point of care scans, neuraxial ultrasound imaging is quick to learn and perform. Neuraxial structures under ultrasound are easily definable and recognizable. We recommend neuraxial ultrasound become a standard in POCUS education.

Contribution of Project in Achieving DNP Essentials

The underpinning and implementation of this project was guided by The

American Association of Critical Care Nurses (AACN) Synergy Model of Patient Care Model which met Essential I, *Scientific Underpinnings for Practice*. By encouraging best practice change that aligns with current and appraised scientific research findings, our project met both Essential II, *Organizational and Systems Leadership for Quality Improvement and Systems Thinking*, and Essential III, *Clinical Scholarship and Analytical Methods for Evidence-Based Practice*. Essential IV, *Informational Systems/Technology and Patient Care Technology for the Improvement and Transformation of Health Care*, was met by integrating ultrasound technology into patient care as well as thorough analysis of data provided by the ultrasound technology.

Through interprofessional collaboration with the anesthesia and obstetric team, Essential VI, *Interprofessional Collaboration for Improving Patient and Population Health Outcomes*, was met. The study also met Essential VII, *Clinical Prevention and Population Health for Improving the Nation's Health*, by addressing clinical prevention, through means of risk reduction, and population health through specific examination of the obese population who required neuraxial anesthesia. Lastly, the design, implementation, and evaluation of our study along with the dissemination of our findings to the ProMedica Anesthesia Group met Essential VIII, *Advanced Nursing Practice*.

Conclusion

The literature supports the effectiveness of neuraxial ultrasound in improving first-attempt success, decreasing total needle passes, and improving patient satisfaction when compared to traditional palpation techniques in the obese population. Insufficient evidence suggests that ultrasound technology may decrease complications, procedural

time, and improve true identification of the L3-L4 interspace for needle insertion, but additional research is needed to support these claims.

The current study reported a decrease in procedural time in the administration of epidural anesthesia with no statistically significant difference in needle attempts or procedural complications. Performing neuraxial anesthesia on those with difficult anatomical landmarks comes with increased risk for undesirable outcomes and procedural complications. Improving accuracy and avoiding complications such as post-dural puncture headache, backache and hemorrhage is not only desirable but essential in providing a competent anesthetic regardless of body mass index.

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Appendix A

Level of Evidence Synthesis Table

	Level I Systematic Review or Meta- Analysis	Level II Randomized Control Trial	Level III Comparison Study Quasi-experimental	Level IV Case Control Cohort Study
Arnolds, Hofer & Scavone (2020)			X	
Darrieutort-Laffite et al. (2017)		X		
Ghisi et al. (2019)		X		
Li et al. (2019)		X		
Malik & Ismail (2020)			X	
Morimoto et al. (2017)				X
Ozcekic et al. (2017)				X
Rana et al. (2020)				X
Sahin et al. (2014)		X		
Selvakumar et al. (2017)			X	
Shaylor, et al. (2016)			X	
Urfahoglu et al. (2016)		X		

Uyl et al. (2019)	X			
Vernon et al. (2020)		X		
Wang et al. (2012)		X		
Yim et al. (2019)				X

Appendix B

Procedural Outcomes Synthesis Table

	Procedural Variables: Ultrasound Use vs. Anatomical Palpation Technique				
	First Attempt Success	Number of Needle Passes	True Site Identification	Insertion Site Identification Time	Procedural Time (Total)
Arnolds, Hofer & Scavone (2020)			No Change		
Darrieutort-Laffite et al. (2017)	No Change	No Change			No Change
Ghisi et al. (2019)	Increased	Decreased			Increased
Li et al. (2019)	Increased	Decreased		No Change	Decreased
Malik & Ismail (2020)			Increased		
Morimoto et al. (2017)					
Ozcekic, et al. (2017)					
Sahin et al. (2014)	Increased	Decreased			Decreased
Selvakumar et al. (2017)					
Shaylor et al. (2016)	Increased	Decreased			
Tubinis et al. (2019)		Decreased			Decreased
Urfahoglu et al. (2016)		Decreased			Increased
Uyl et al. (2019)					No Change
Vernon et al. (2020)		Decreased		Increased	Decreased

Wang et al. (2012)	Increased	Decreased		Increased	Increased
Yim et al. (2019)	Increased				

Provider and Patient Outcomes Synthesis Table

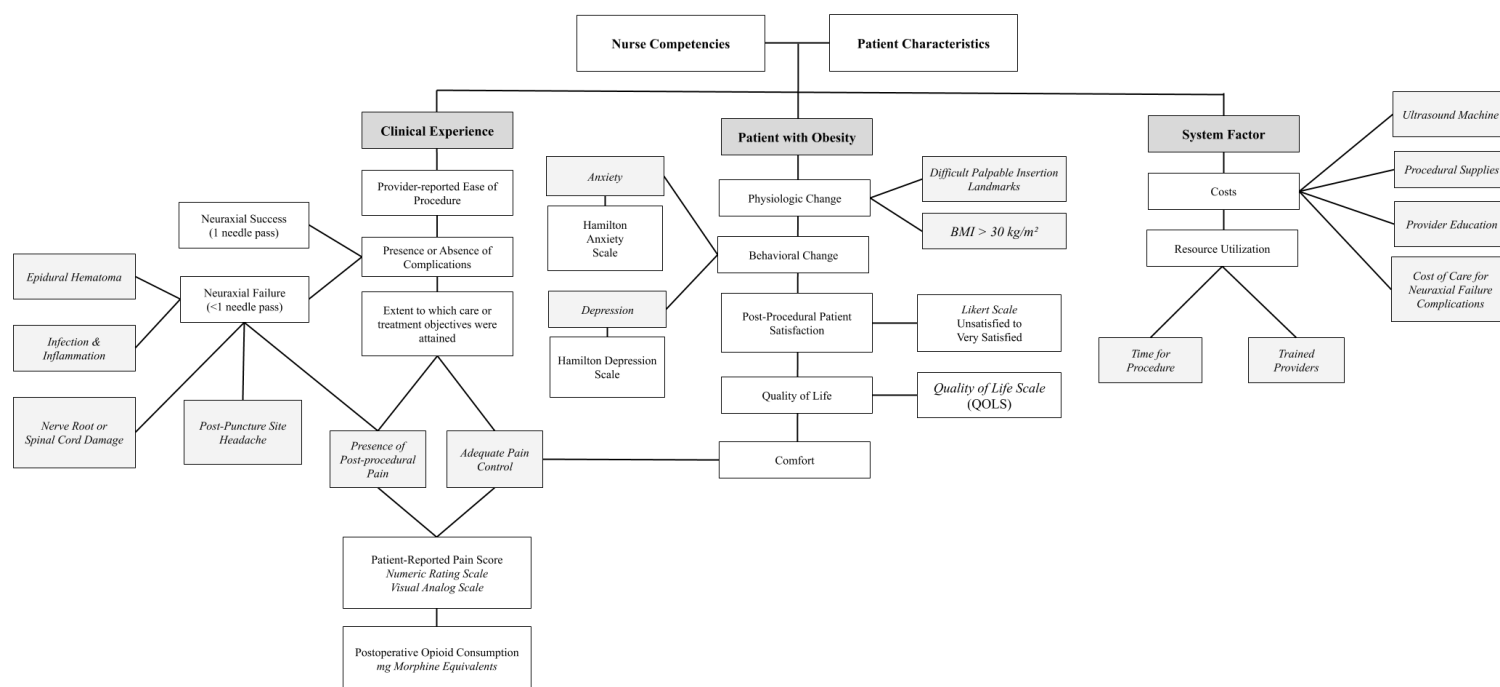
	Provider-Reported	Patient-Reported		
	Procedural Difficulty	Pain Score	Patient Satisfaction	Neuraxial Complications
Arnolds, Hofer & Scavone (2020)				
Darrieutort-Laffite et al. (2017)		No Change		No Change
Ghisi et al. (2019)				No Change
Li et al. (2019)		No Change	Increased	
Malik & Ismail (2020)				
Morimoto et al. (2017)				
Ozcekic, et al. (2017)				
Sahin et al. (2014)				No Change
Selvakumar et al. (2017)				
Shaylor et al. (2016)	Decreased	No Change		
Urfahoglu et al. (2016)				Decreased
Uyl et al. (2019)				Decreased
Vernon et al. (2020)			No Change	
Wang et al. (2012)				No Change
Yim et al. (2019)				

Appendix C

Theoretical Substruction Modified from

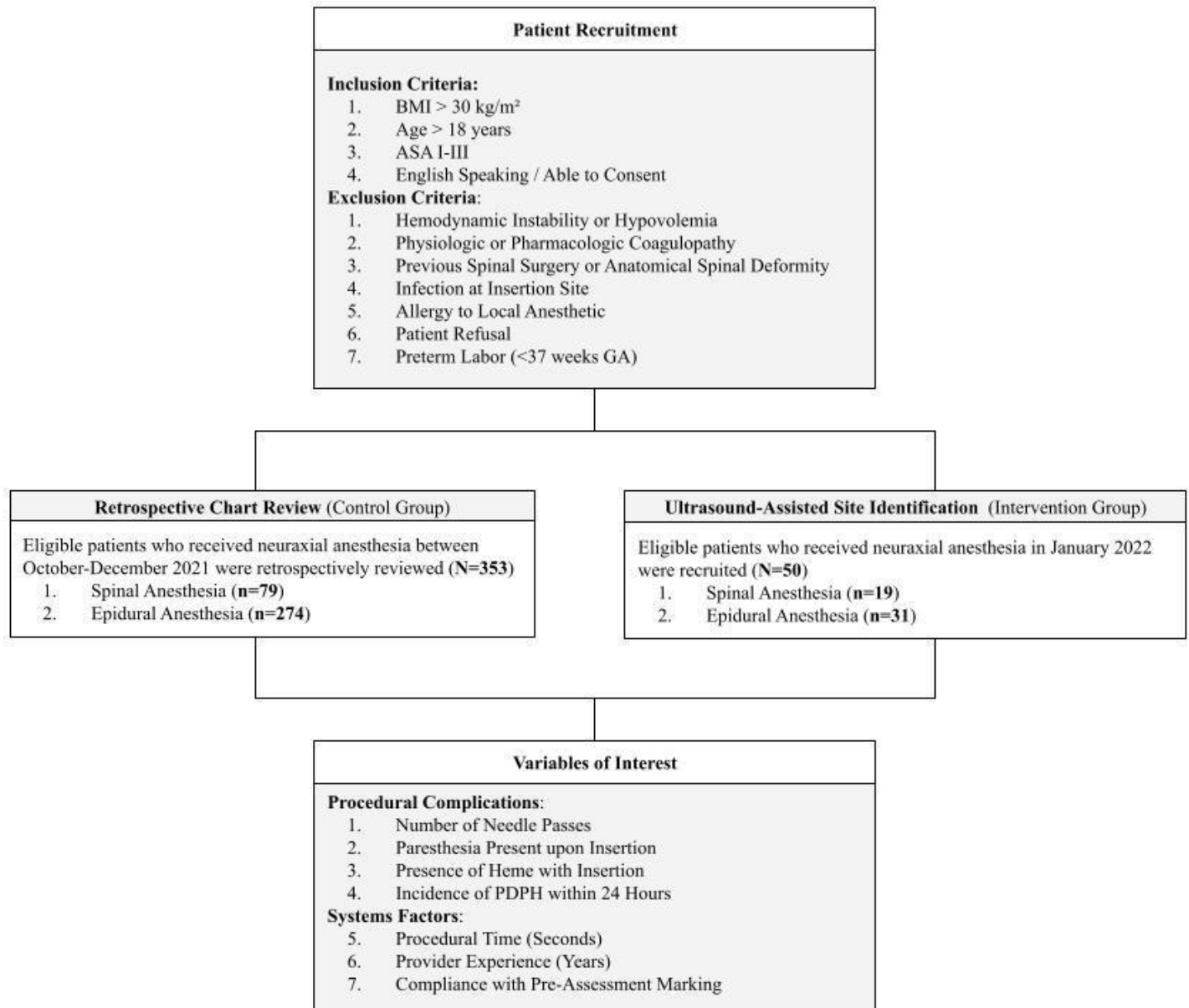
The American Association of Critical-Care Nurses (AACN)

Synergy Model of Patient Care



Appendix D

Study Protocol & Methodology



Appendix E

ProMedica IRB Approval



October 04, 2021

Howard Brown, CRNA

RE: **IRB #21-160**: The Efficacy of Neuraxial Ultrasound in the Obese Parturient

Dear Mr. Brown:

I have reviewed and approved your application for expedited review of the new study listed above on . Your study is eligible for expedited review Category #4) Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.) Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual. Category #5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes (such as medical treatment or diagnosis). (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(4). This listing refers only to research that is not exempt.)

Approval includes the following documents:

- Protocol Version 9/14/2021 (Protocol)
- EMR Data Collection Tool (Retrospective) (Misc/Other)
- ICF Form (Consent/Assent Form)
- Methods/Protocol (Protocol)
- Procedural Data Collection Tool (Prospective) (Misc/Other)

If applicable, the following apply to your study:

Waiver: No Waiver
Consent Procedure: Written Informed Consent Document
Vulnerable Subjects: None
Drug/Device Agent: N/A
IND/IDE/HDE #: N/A

The listings of currently approved study personnel and approved sites are available at the end of this document.

You are granted permission to conduct your study as described in your application effective immediately. This study will expire on: 10/03/2022 No approval period defined.

Although the ProMedica IRB has granted you permission to conduct your study as described in your application, you may be subject to further appropriate review and approval or disapproval by officials of the institution (45 CFR 46.112 & 50 CFR 56.112). Please note that any changes to the study must be promptly reported and approved by the PHS IRB before being implemented. Some changes may be approved by expedited review (45 CFR 46.110 & 50 CFR 56.110); others require full board review.

If you have any questions or require further information, please contact the ProMedica IRB Office, at (419) 291-5362 or e-mail: phsirb@promedica.org.

Sincerely,

Electronically signed by Howard Stein, MD on 10/04/2021 2:42 PM ET

Chair, ProMedica Institutional Review Board

October 04, 2021

Currently approved study personnel (individuals authorizing this research included):

- Howard Brown, CRNA - Principal Investigator
- Anthony Rote, BSN, SRNA - Sub-Investigator
- Howard Brown, CRNA - Coordinator
- Robert DeRosa, MD - Dept Chair/Medical Director
- Rylie Pierce, BSN, SRNA - Sub-Investigator

Currently approved study sites:

ProMedica
ProMedica Toledo Hospital

Appendix F

Oakland University Research Agreement



Date: November 3, 2021

Study #: IRB-FY2021-279

Study Title: The Efficacy of Neuraxial Ultrasound in the Obese Parturient

Submission Type: Initial

IRB Decision: Rely on External IRB

Research Team:

Anthony Rote

Anthony Rote, Rylie Pierce, Laura Rodgers

In accordance with 45 CFR 46.114, an IRB Reliance Agreement has been approved for the above referenced study.

FINDINGS:

- This project has been approved by ProMedica IRB under an expedited review Category #4 - Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves; and Category #5 - Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes (such as medical treatment or diagnosis).
- ProMedica IRB approval letter IRB #21-160, entitled "The Efficacy of Neuraxial Ultrasound in the Obese Parturient" was issued 10/4/2021.
- Approval expires 10/03/2022.
- Oakland University PI, Anthony Rote, BSN, SRNA, is listed as a Sub-Investigator on the ProMedica approved study.

NOTE TO RESEARCHER:

- The IRB Reliance Agreement is between Oakland University and ProMedica IRB. The OU IRB is relying on ProMedica IRB, which is acting as the IRB of record for this collaborative research project.
- A copy of the fully executed IRB Reliance Agreement dated 11/03/2021 can be found in Cayuse in the [Submission Details](#) page under [Attachments](#). Please download and save for your record.

The IRB of record decision expires on October 3, 2022.

Please remember to update the Oakland University IRB with copies of all of the IRB of Record future decision letters or memos including, but not limited to IRB continuing approval, approval of modifications/amendments, study closure or termination, unanticipated problems involving risk to subjects or others, etc., by updating your submission in Cayuse.

This letter can be found in Cayuse in the [Submission Details](#) page under [Letters](#).

If you have any question, contact the IRB staff.

Thank you

The Oakland University IRB



Institutional Review Board for the Protection of Human Subjects

Institutional Review Board (IRB) Reliance Agreement

Institution or Organization Providing IRB Review (Designated IRB)

Name of Designated IRB (Institution/Organization): ProMedica IRB

IRB Registration #: _____ Federalwide Assurance (FWA), if any # _____

Institution Relying on the Designated IRB:

Oakland University

FWA# FWA00003480

IRB Registration # 00000087

The Officials signing below agree that Oakland University may rely on the Designated IRB for review and continuing oversight of its human subjects research described below:

This agreement is limited to the following specific protocol(s):

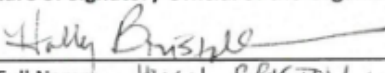
Research Project: IRB #21-160: The Efficacy of Neuraxial Ultrasound in the Obese Parturient

Principal Investigator: Howard Brown, CRNA, MSN (ProMedica PI) and Anthony Rote, BSN, SRNA (Oakland University PI)

Sponsor or Funding Agency: N/A Award Number, if any: _____

The review performed by the Designated IRB will meet the human subject protection requirements of Oakland University's OHRP-approved FWA. The Designated IRB will follow written procedures for reporting its findings and actions to appropriate officials at Oakland University. Relevant minutes of the Designated IRB's meetings will be made available to Oakland University upon request. Oakland University remains responsible for ensuring compliance with the Designated IRB's determinations and with the terms of its OHRP-approved FWA. This document must be kept on file by both parties and provided to OHRP upon request.

Signature of Signatory Official of the Organization Providing IRB Review (Designated IRB):

 Date: 11-2-2021
 Print Full Name: Holly BRISTOL
 Institutional Title: Institution Official

Signature of Signatory Official of Oakland University:

David Stone  Date: 10/19/21
 Print Full Name: David Stone, PhD
 Institutional Title: Vice President for Research and Institutional Official

OLA-May 1, 2018

Appendix G

ID# _____

Patient Consent Form

Purpose of Study: The purpose of this study is to *maximize your comfort* when we place your spinal or epidural catheter. We plan to do this by using an ultrasound machine. The ultrasound machine allows your anesthesia provider to visualize your spine and the correct space to put the pain medication. To ensure your safety and comfort, your anesthesia provide will be able to use the information provided by the ultrasound machine in addition to traditional methods in which they feel your spine to identify the correct injection site.

Am I eligible to participate in this study?

You **ARE** able to participate in this study if you plan to receive an epidural catheter or spinal anesthesia to assist in the birthing process. You should **NOT** participate in this study if you do **NOT** wish to receive a spinal or epidural.

What should I expect if I agree to participate in this study?

1. We will ask you to sit on the side of the bed and hang your feet off the edge.
2. After we have you positioned correctly, we will use the ultrasound probe and place cold gel on your back. This helps us to identify the correct place in your back to administer the medication.
3. When we find the right spot, we will use a pen to make a small dot to mark the correct spot for your anesthesia provider to put the medication.

What are the risks and benefits of participating in this study?

Using ultrasound is non-invasive; this means that it does not hurt or cause discomfort. Ultrasound may decrease the number of needle pokes needed for your spinal or epidural to work correctly, and may lessen the chance of headache after an epidural. It may also decrease the time it takes your provider to get you comfortable before your procedure. There are no identifiable risks associated with the current study.

_____ **(Initial Here)** *I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost.*

Participant Name **(Printed)**: _____

Participant Signature: _____ Date: _____

Witness: _____ Date: _____

Any Questions? Questions regarding the current study can be directed to Rylie Pierce (RylieAPierce@gmail.com) or Anthony Rote (roteaj14@gmail.com)

Appendix H

ID#: _____

Procedural Data Collection Tool (Prospective)

For Researcher: Pre-Operative Assessment

- I. BMI (kg/m²): _____
☐ **Class I Obesity:** 30-34.9 kg/m²
☐ **Class II Obesity:** 35-39.9 kg/m²
☐ **Class III Obesity:** >40 kg/m²
- II. Has patient received neuraxial anesthesia in past: **Check All that Apply**
☐ Spinal
☐ Epidural
☐ No Previous Neuraxial
- III. Patient Positioning: **Check All that Apply**
☐ Patient was in sitting position for ultrasound identification
☐ Legs were in dependent position hanging from bed
☐ Spinal Deformities Noted: _____
☐ Position Deviation Required: _____
- IV. **Estimated Depth to Ligamentum Flavum (cm):** _____
-

For Anesthesia Provider: Procedural Data

- I. Which neuraxial procedure did you perform:
☐ Intrathecal Injection (**Spinal**)
☐ Epidural Catheter (**Epidural**)
- II. Did you insert needle at pre-marked needle insertion site:
☐ **YES** I used pre-marked insertion site
☐ **NO** I did not use pre-marked insertion site
 If “**NO**”, Why Not: _____
- III. How many years, *including your education*, have you been practicing anesthesia?
☐ 0-3 years (i.e. SRNA or Anesthesia Resident)
☐ 3-5 years
☐ 5-10 years
☐ >10 years

Note: *procedural time, number of needle passes, and presence of complications (i.e. paresthesia, heme, PDPH) will be recorded via EMR documentation*

Appendix I

ID#: _____

EMR Data Collection Tool (Retrospective)

Date of Chart Review & Researcher Initials: _____

Patient Eligibility and Inclusion:

- ☐ BMI > 30 kg/m²
- ☐ Age > 18 years
- ☐ ASA I-III
- ☐ English Speaking
- ☐ Procedure between April-July of 2021
- ☐ Neuraxial Administered for Elective Procedure or Standard Induction

Patient Demographic Information

Age: _____

Race: _____

BMI (kg/m²): _____

- ☐ **Class I Obesity:** 30-34.9 kg/m²
- ☐ **Class II Obesity:** 35-39.9 kg/m²
- ☐ **Class III Obesity:** >40 kg/m²

Surgical Procedure: _____

Date of Procedure: _____

Previous Neuraxial (**Circle One**) Yes / No*Neuraxial Information*Which *neuraxial procedure* was performed:

- ☐ Intrathecal Injection (**Spinal**)
- ☐ Epidural Catheter (**Epidural**)

Reported Depth of Needle Insertion (cm): _____

Potential Complications

Number of Needle Punctures: _____

Heme on Insertion (**Circle One**): Yes / No

Paresthesia on Insertion (**Circle One**): Yes / No

Post-Dural Puncture Headache (**Circle One**): Yes / No

Procedural Time

If patient received **Epidural**:

- Time of Consent: _____
- Time of Epidural Medication Administration: _____
- **Medication Time - Consent Time** (in Seconds): _____

If Patient received **Spinal**:

- “Start Data Collection” Time: _____
- Time of Intrathecal Medication Administration: _____
- **Medication Time - Data Collection Time** (in Seconds): _____

ID# _____

Prospective EMR Data Collection Tool (Prospective)

Patient Demographic and Procedural Information

Surgical Procedure: _____

Date of Procedure: _____

Age: _____

Race: _____

Estimated Depth to Ligamentum Flavum (cm): _____**Reported Depth of Needle Insertion (cm):** _____*Potential Complications*

Number of Needle Pokes: _____

Heme on Insertion (**Circle One**): Yes / NoParesthesia on Insertion (**Circle One**): Yes / NoPost-Dural Puncture Headache (**Circle One**): Yes / No*Procedural Time*If patient received **Epidural**:

- Time of Consent: _____
- Time of Epidural Medication Administration: _____
- **Medication Time - Consent Time** (in Seconds): _____

If Patient received **Spinal**:

- “Start Data Collection” Time: _____
- Time of Intrathecal Medication Administration: _____
- **Medication Time - Data Collection Time** (in Seconds): _____

Project Timeline

[illegible]

