Spring 5-4-2025

Implementation of Guidelines for Preprocedural Ultrasound in Neuraxial Placement for Obstetric Patients with Scoliosis

Luther Nyirenda
nyirenda1@otterbein.edu

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Final Scholarly Project: Implementation of Guidelines for Preprocedural Ultrasound in Neuraxial Placement for Obstetric Patients with Scoliosis

Luther Nyirenda BSN, RN

Department of Nursing, Otterbein University

In Partial Fulfillment of the Requirements for the Degree

Doctor of Nursing Practice

2024

DNP Scholarly Project Team:

Dr. Brian Garrett, DNP, CRNA, Project Team Leader Approved by: Brian Garrett, CRNA

Dr. Joy Shoemaker, DNP, CNP, FNP-BC, Project Team Member

Dr. Amy Bishop, DNP, AGCNS, Project Team Member

Dr. Danielle Winch, DNP, CRNA, Project Team Member

Author Note

We have no conflicts of interest to disclose.

Correspondence concerning this article should be addressed to Otterbein Project Team Leader, 1 South Grove Street, Westerville, OH 43081. bgarrett@otterbein.edu

Abstract

Neuraxial anesthesia including epidural, spinal, and combined spinal-epidural, is used with 65% of parturients in the United States for the management of pain and discomfort. Conventional landmark palpation has been the mainstay technique for neuraxial anesthesia, but unfamiliar spinal anatomy can lead to incomplete blockade or an increased incidence of complications. Scoliosis causes lateral curvature and rotation of the spine leading to arthritis and soft tissue changes that can present obscure anatomical landmarks, cause difficulty in needle passage, and result in inadequacy of local anesthetic efficacy. The literature illustrates that preprocedural ultrasound is recommended for needle placement in parturients with difficult spinal anatomy and those with moderate to severe scoliosis. Despite the preprocedural ultrasound benefits of enhanced imaging of structures, and needle depth estimation and direction, in the United States, only 22% of obstetric units incorporated preprocedural ultrasound for neuraxial anesthesia. The model used for the DNP (Doctorate in Nursing Practice) project is the practice, evidence, and translation (PET) section of the John Hopkins Evidence-Based Practice Model (JHEBP) for healthcare professionals. This project's main objective is the implementation of evidence-based practice (EBP) guidelines for the facilitation of neuraxial anesthesia in parturients who present with scoliosis with preprocedural ultrasound or conventional landmark palpation. If implemented, the project can aid in first-pass success, allow for needle redirection accuracy, and decrease procedural time while also decreasing complications of incomplete blockade, vascular puncture, and post-dural puncture headache. Additional project objectives include an algorithmic approach to decision-making for neuraxial anesthesia based on patient characteristics, a comprehensive plan to implement the EBP guidelines, and a method to monitor, measure, and evaluate guidelines.

Keywords: Preprocedural, ultrasound, neuraxial, labor, anesthesia

Introduction

Unmanaged pain in the parturient can produce physiologic consequences for the fetus and mother. Neuraxial analgesia (e.g., spinal, epidural, and combined spinal/epidural techniques), provides pain management for parturients with reliable- and consistent analgesia while achieving optimal conditions for the labor process (Camann, 2015). Due to these physiologic changes, anesthesia techniques should be based upon Evidence-based Based Practice (EBP) guidelines that are routinely evaluated and improved upon to facilitate neuraxial anesthesia.

A spinal anesthetic requires accessing the subarachnoid or intrathecal space where cerebral spinal fluid (CSF) resides, and administering small volumes of local anesthetic that can cause sensory and motor blockade due to proximity of the spinal nerve root. Penetration of the subarachnoid space necessitates the prevention of needle migration into the spinal column, which is achieved by puncturing below the terminal end of the spinal cord or the conus medullaris which correlates in adults to the lumbar interspace one (L1) or lumbar interspace two (L2) (Brown & Fink, 2009). Spinal anesthesia allows for the rapid onset of local anesthetics in combination with pharmacological adjuncts that aid in facilitating surgical and procedural conditions.

An epidural anesthetic requires traversing the ligamentum flavum, subsequently accessing the potential space which includes blood vessels, and liquid fat, which is noted with a loss of resistance (LOR). With the necessary administration of larger volumes of local anesthetic and a more distal position from the nerve roots, the onset of action is slower, but the duration of pharmacologic effects is prolonged when compared to a spinal anesthetic. Additionally, an epidural anesthetic has the advantage of continuously delivering an infusion through a secured catheter. When the LOR is noted, the anesthesia provider can discern that they have not entered the subarachnoid space by assessing for cerebral spinal fluid (CSF). If placement is successful in the epidural space the anesthesia provider performs a test dose with 3 milliliters of 1.5% lidocaine and 1:200,000 epinephrine. The test dose aids in proper placement identification through assessment for vascular penetration, which would exhibit peripheral paresthesia, visual disturbances, and tinnitus, or subarachnoid penetration, which would exhibit changes in mentation, cardiovascular collapse, or motor blockade (Brown & Fink, 2009).

Neuraxial anesthesia is performed by positioning the patient in the lateral decubitus or sitting position, and the proceduralist proceeds to palpate a horizontal line, identified as ‘Tuffier’s line’, that correlates with the L4-L5 interspace. Tuffier’s line connects the superior aspects of the iliac crests and is used as an anatomical landmark for needle insertion during neuraxial anesthesia (Kim et al., 2014). Although suitable in many cases, conventional landmark palpation can be challenging due to physiologic changes in pregnancy that lead to inaccuracies during the procedure. In Roytman et al., (2021) in a non-pregnant sample, the L4-L5 interspace was only identified with a 35.7% accuracy. Conventional landmark palpation is referred to as a “blind” technique due to variability with patient spinal anatomy and needle trajectory as assumed by the performing provider. If predicted incorrectly complications of incomplete neuraxial blockade, dural puncture, vascular penetration, and post-dural puncture headache can be observed. Thus, conventional landmark palpation is more susceptible to errors when performed with unfamiliar or difficult spinal anatomy (Brown & Fink, 2009).

Preprocedural ultrasound is an alternative technique to facilitate the insertion, and placement of neuraxial anesthesia with successful sensory, and motor blockade. In comparison, the identification of L4-L5 interspace with preprocedural ultrasound was 94.9% in non-pregnant participants while in pregnant participants the accuracy was 82.7% (Malik & Ismail, 2020). Preprocedural ultrasound achieves visualization of superficial and deep structures with the utilization of a transducer that transmits sound waves that are reflected by anatomical structures which produces a real-time image. Preprocedural ultrasound can facilitate diagnostic, and procedural interventions that would otherwise be challenging in those with difficult spinal anatomy if using conventional landmark palpation (Arbona et al., 2011). Due to the lack of guidelines for preprocedural ultrasound and conventional landmark palpation during neuraxial anesthesia in parturients with scoliosis, the review of literature is warranted to plan, implement, and evaluate the EBP project.

Background

Neuraxial anesthesia is used frequently to facilitate optimal interventional or surgical conditions for the benefit of the healthcare professional and patient (Camann, 2015). In 2020, the United States had 3,613,647 births, and 2,787,858 involved the use of neuraxial anesthesia, or 77% of parturients (Centers for Disease Control and Prevention, 2022). Conventional landmark palpation has been the most widely adopted technique for neuraxial anesthesia since 1898, but in 1994 the use of ultrasound when performing peripheral or neuraxial nerve blockade was introduced (Leung, 2018). Comparatively, preprocedural ultrasound allows the ability to identify the optimal needle insertion site, needle trajectory, and estimated depth of the epidural space (Young et al., 2020). As reported by Young et al., (2020) conventional landmark palpation can become difficult in parturients due to a pronounced anteroposterior curvature of the spine (i.e., lumbar lordosis), soft tissue edema, and body habitus. Additionally, patients with difficult spinal anatomy as seen in scoliosis can benefit from preprocedural ultrasound compared to conventional landmark palpation.

Scoliosis is defined as a lateral curvature and rotation of the spine and is identified as thoracic, lumbar, or thoracolumbar depending on location. Introduced by John Cobb, a former orthopedic surgeon, the curvature, and degree of scoliosis can be determined by identifying the Cobb angle (Comerford, 2019). To measure the Cobb angle, vertebrae at the beginning and end of the spinal deformity have lines drawn until their intersection, which is then measured. The classification of Cobb angles as normal, mild, moderate, and severe has been categorized in Appendix A (Kusuma, 2017). The diagnosis of scoliosis warrants appropriate planning due to the systemic effects of scoliosis which can include nerve compression from bone misalignment, decreased range of motion, and chest wall deformities that can cause cardiopulmonary changes in severe disease progression (Kim et al., 2023). These characteristics can further complicate the facilitation of neuraxial anesthesia and lead to unreliable spread or incomplete blockade. Parturients who experience moderate to severe scoliosis can experience an increased risk of pain and discomfort due to sustained positioning, contractions, and pushing during the labor process which causes widespread physiologic stress (Young et al., 2020).

Relevance to Anesthesia

Although, neuraxial anesthesia has numerous associated complications, healthcare providers, professional organizations, and institutions should consider the implementation of EBP guidelines to facilitate successful neuraxial blockade for parturients with scoliosis or difficult spinal anatomy. As reported by Farshad (2022) 10 percent of women have scoliosis which includes an estimated 31 million individuals. Preprocedural ultrasound has been shown to facilitate neuraxial blockade while reducing associated complications when compared with conventional landmark palpation (Jiang et al., 2020; Young et al., 2020). When performing neuraxial anesthesia, special consideration for parturients with scoliosis is advised due to the risk and susceptibility to complications (Kim et al., 2019. As ultrasound technology has continued to evolve the imaging quality, clinical applications, portability, and affordability have improved thus anesthesia providers should consider its application in their practice. Despite existing literature describing the benefits of preprocedural ultrasound, there are no formal guidelines that solely address its use for scoliosis in a clinical setting, leading to a possible reduction in anesthesia providers incorporating an alternative technique into their practice (Peterman, 2022). The implementation plan for preprocedural ultrasound for neuraxial anesthesia requires the formation of EBP guidelines that will be monitored and evaluated based on quality improvement (QI).

Problem Statement

Comprehensive guidelines for preprocedural ultrasound with neuraxial anesthesia in parturients are lacking, but evidence-based research has demonstrated favorability in parturients with difficult spinal anatomy. The DNP project seeks to formulate a comprehensive plan to implement, monitor, and evaluate the efficacy of conventional landmark palpation or preprocedural ultrasound for parturients with normal or mild scoliosis and preprocedural ultrasound for moderate to severe scoliosis to enhance needle redirection, procedural time, and first pass success (FSP).

The PICOT format provides a structural framework for examining and answering a specific question. The five components of the PICOT format include (P) population, (I) intervention, (C) comparison, (O) outcome, and (T) timeline (Melnyk & Fineout-Overholt, 2019). The practice question is:

“In laboring (T) obstetric patients with scoliosis undergoing neuraxial anesthesia (P), how would the implementation of preprocedural ultrasound (I) in comparison to the conventional landmark palpation (C) affect first-time pass rates, needle redirection, and procedure time (O)?”.

Objectives

The objective of the DNP project is to develop and implement evidence-based practice guidelines for preprocedural ultrasound and conventional landmark palpation for parturients with scoliosis who present for neuraxial anesthesia. The project will translate evidence into practice with the following objectives:

1. Develop EBP guidelines for identification and categorization of spinal curvature to disseminate the difficulty of neuraxial placement for parturients with scoliosis.
2. Develop a comprehensive plan to implement conventional landmark palpation or pre-procedural ultrasound to facilitate neuraxial placement based on the severity of scoliosis.
3. Develop a comprehensive plan on how to monitor the clinical outcomes of first-pass success rate, needle redirection, and procedure time.
4. Develop a comprehensive plan on how to adjust the guidelines if the use of conventional landmark palpation or pre-procedural neuraxial placement if outcomes are not met.

Literature Review

Existing evidence was evaluated that included randomized control trials, meta-analyses, systemic reviews, and cohort studies for the recommendation of preprocedural ultrasound and conventional landmark palpation for parturients who require neuraxial anesthesia. Evaluation for risk and translation is warranted if implemented by a healthcare professional or organization.

Literature Search Strategy

The DNP scholar reviewed the literature to synthesize current and relevant studies on the implementation of guidelines for preprocedural ultrasound neuraxial placement compared to the conventional landmark palpation in parturients with scoliosis to assess first-time pass rates, needle redirection, and procedure time. Otterbein University’s Courtright Memorial Library tool “One Search” is an online tool that stores published literature through multiple databases but can be employed as one search engine. The “One Search” tool database search includes PUBMED, CINAHL, Cochrane Library, ProQuest, and EBSCO. Additional literature was searched through Elsevier Science Direct and MEDLINE databases. Literature was delivered as full-text HTML and full-text PDF, which allowed for entire publications to be analyzed, and synthesized. Search terms *ultrasound and neuraxial placement* were input using the Boolean Operator AND, the following terms included *ultrasound and neuraxial placement in scoliosis patients,* and *guidelines for preprocedural ultrasound neuraxial placement with difficult anatomy*.

The result list yielded approximately 247 articles; search terms were revised to narrow the broad selection of literature. The publication date was adjusted to the past ten years and “full text” was chosen as text availability. Acceptance criteria for the publication year was extended from five to ten years due to the limitation of literature and the lack of changes to the use of neuraxial anesthesia in obstetrics concerning the proposed PICOT question. Exclusion criteria for the selected papers comprised preliminary studies, articles older than ten years from publication, reports that did not provide full-text links, articles not in English, and articles on irrelevant topics. The literature search of seven databases yielded the review and synthesis of 10 studies. The appraisal of the literature using the John Hopkins Evidence-Based Practice (JHNEBP) tools resulted in four articles with level one, four with level two, and one with level four evidence. The DNP scholar acknowledges that the literature did not delineate “difficult spinal anatomy” and that there was limited research on participants with only scoliosis. The DNP scholar summarized and synthesized the content, strength, and quality of evidence in a literature table found in Appendix B. The outcomes for the project seek to monitor and evaluate first pass success (FPS) rate, needle redirection, and procedure time between these approaches for neuraxial anesthesia.

First Pass Success (FPS)

Jiang et al., (2020) identify FPS as a single puncture through the skin with successful delivery of neuraxial anesthesia whether a single dose or continuous catheter. A systemic review and meta-analysis that included 13 studies with 1,235 participants primarily examined FPS and resulted in a higher rate of

FPS in the ultrasound group compared to conventional landmark palpation. Statistical analysis showed that the FPS with random effects of 1.49 and confidence interval (CI) of 95% (1.21, 1.84), a subgroup analysis was performed with the participants who were perceived to experience difficult puncture and demonstrated that ultrasound could improve FPS in participants with difficult anatomy [fixed effects 1.40, CI 95% (1.12, 1.75)] whereas participants who were easily palpable did not demonstrate improvement with the use of ultrasound [fixed effects 1.09, CI 95% (0.93, 1.28)] (Jiang et al., 2020).

Sidiropoulou et al., (2020) performed a systemic review and meta-analysis that compared preprocedural ultrasound and conventional landmark palpation. FPS was shown to have a combined risk ratio (RR) of 1.5 and a CI of 99% (1.22 to 1.86) among 1,897 participants, and in a subgroup analysis of 374 participants with difficult spines and obesity showed a RR of 1.84 and a 99% CI (1.44 to 2.34) (Sidiropoulou et al., 2020). The statistical analysis resulted in the generalized recommendation of preprocedural ultrasound for neuraxial anesthesia but did not analyze a subgroup of those with easily palpable anatomy as seen in (Jiang et al., 2020). In the studies performed by Sidiropoulou et al., (2020) and Jiang et al., (2020) a correlation between the use of preprocedural ultrasound and increased FPS when performing neuraxial anesthesia was statistically relevant. The sub-group of easily identified landmarks in participants was not statistically beneficial when compared with conventional landmark palpation.

Conversely, a double-blind, randomized control trial (RCT) conducted by Tawfik et al., (2017) did not exhibit a statistically significant change in FPS between preprocedural ultrasound and conventional landmark palpation. The statistical analysis resulted in FPS with epidural catheterization at 60% in the palpation group and 58.5% in the preprocedural ultrasound group, a 95% CI of the difference in proportions between the groups was −18.5% to 21.6%; $P > 0.99$ (Tawfik et al., 2017). In comparison, an RCT performed by Arzola et al., (2015) studied a group of 17 second-year anesthesia residents and five anesthesia fellows who performed 128 epidural catheter insertions which resulted in FPS at 50% in the conventional palpation group compared to 60% preprocedural ultrasound group (respectively; $P = 0.26$) demonstrating a clinically insignificant correlation. The residents and fellows who performed these procedures were equally educated and trained, but the participants of the study had easily palpable lumbar spines which could have skewed the results (Tawfik et al., 2017). FPS can be affected by the physical examination of the patient, the proceduralist's experience and technique, anatomical deviations, and the type of neuraxial anesthesia (Jiang et al., 2020). The literature demonstrated that preprocedural ultrasound may increase the FPS rate compared to the conventional landmark method when difficult spinal anatomy is present. Comparatively, the use of preprocedural ultrasound in participants who have easily palpable spinal anatomy has been shown to exhibit comparable results to conventional landmark palpation but further research in a larger and diverse sample is needed for a conclusion to be discerned (Arzola et al., 2015; Jiang et al., 2020; Tawfik et al., 2017).

Needle Redirection

Kim et al., (2020) identified needle redirection as the number of forward advancements in needle direction without the withdrawal of the entire needle out of the skin. Multiple needle redirections have demonstrated increased pain and discomfort for patients undergoing neuraxial anesthesia (Darrieutort-Laffite et al., 2015). 44 participants with difficult spinal anatomy receiving spinal anesthesia were included in an RCT to assess the primary outcome of attempted needle redirection between preprocedural ultrasound versus conventional landmark palpation. The median number of passes between the preprocedural ultrasound and conventional landmark palpation was (1.5 to 6) with $P < 0.001$ and a 95% CI with RR or difference in medians 4.5 (1–8) (Kim et al., 2020). In a randomized prospective study conducted by Grau et al., (2003), preprocedural ultrasound for neuraxial anesthesia demonstrated a decrease in the number of needle placement attempts between 2.2 ± 1.1 compared to conventional landmark palpation that demonstrated 1.3 ± 0.6. The maximum VAS (visual analog score) in the conventional landmark palpation group was 1.3 ± 2.1 compared to 0.8 ± 1.5 in the preprocedural ultrasound group ($P < 0.006$). As a primary outcome, patient-reported pain during the epidural injection with the use of VAS was studied in an RCT performed by Darrieutort-Laffite et al., (2015). Statistical analysis of VAS demonstrated 2.01 ± 1.6 in the preprocedural ultrasound group compared to 2.95 ± 2.5 in the conventional landmark palpation group ($P < 0.054$). while needle redirection demonstrated 1.6 ± 2.71 in the preprocedural ultrasound group compared to 2 ± 2.7 in the conventional landmark palpation group

(P < 0.53). VAS between the conventional landmark palpation and preprocedural ultrasound group showed a trend reduction but was not statistically relevant while needle redirections performed in a single attempt were similar (Darrieutort-Laffite et al., 2015; Grau et al., 2003).

Procedure Time

Neuraxial anesthesia can be performed in about four minutes whether conventional landmark palpation or preprocedural ultrasound is used, but the literature has shown that the chosen technique can influence the number of number needle insertions, FPS, and procedure satisfaction (Elsharkawy et al., (2017). Due to the varying definitions in the literature and for the DNP project, procedure time will be identified as the time taken for needle insertion identification and for the performance of the neuraxial procedure (Young et al., 2020). A systemic review and meta-analysis including 22 studies with 2,462 participants assessed procedure time as a co-primary outcome. The literature resulted in the overall time taken to identify the insertion point of the needle demonstrated a CI of 95% 52.90 (14.10–91.70) with P < 0.008 and time taken to perform the neuraxial procedure was CI 95% - 13.79 (29.03–1.45) with P < 0.080, the overall time taken to identify the insertion point of the needle and perform the neuraxial procedure was unchanged between the use of ultrasound or conventional landmark palpation 20 parturients with impalpable lumbar spinous processes undergoing elective cesarean delivery were selected to participate in an RCT to compare preprocedural ultrasound and landmark palpation in locating the needle insertion point. Despite more time being required in the ultrasound group (91.8 ± 30.8 s compared to landmark palpation 32.6 ± 11.4s, P <0.001) there was no significant difference in the total procedural time between groups (ultrasound 191.8 ± 49.4s compared to palpation 192 ± 110.9s, P=0.99) (Young et al., 2020). These results correlate with findings seen by Jiang et al., (2020) who concluded that participants who were deemed to have difficult spinal anatomy, had increased first-time success rates with no significant change to procedure time with the use of preprocedural ultrasound compared to conventional landmark palpation.

When difficult spinal anatomy is identified the use of ultrasound can benefit FPS, and reduce needle redirections, while not prolonging procedure time. Additionally, the integration of preprocedural ultrasound has reduced the incidence of complications including post-dural headache, vascular puncture, and failed blockade (Young et al., 2020). Grading the degree of curvature with scoliosis, proper patient positioning and the implementation of ultrasound can improve outcomes for laboring patients with difficult spinal anatomy who require neuraxial anesthesia. A structured approach when a parturient presents with scoliosis requiring neuraxial anesthesia with a reported Cobb Angle of less than 10 degrees (normal) or more than 10 degrees but less than 25 degrees (mild), the use of preprocedural ultrasound or conventional landmark palpation is recommended. Comparatively, when the Cobb Angle is more than 25 degrees, but less than 45 degrees (moderate) or more than 45 degrees (severe) the use of preprocedural ultrasound is recommended instead of conventional landmark palpation. Complicated spinal deformity (e.g., level of curvature, spinal hardware, suspected soft tissue changes) could also benefit from the use of preprocedural ultrasound compared to conventional landmark palpation (Jiang et al., 2020; Kim et al., 2020; Young et al., 2020).

The proposed EBP guidelines seek to facilitate successful puncture, insertion, and blockade of neuraxial anesthesia with the reduction of complications related to the procedure (e.g., post-dural headache, vascular puncture, and failed blockade). The implementation of guidelines for the use of preprocedural ultrasound when performing neuraxial anesthesia for those with moderate to severe scoliosis will require appropriate training and competency. With the integration of preprocedural ultrasound, an anesthesia provider may enhance the efficacy, reliability, and safety of neuraxial anesthesia for parturients with difficult spinal anatomy including scoliosis.

Design & Method Plan

The selection of an appropriate framework to collect and analyze outcomes for a specified research problem is instrumental in EBP. The certified registered nurse anesthetist (CRNA), anesthesia assistant (AA), and physician anesthesiologist seek to improve patient care throughout the perioperative setting with literature review, and clinical expertise. The selected practice model for the DNP project was the practice, evidence, and translation (PET) section of the JHEBP Model (Appendix C). This model incorporates the use of current research and non-research evidence to determine that clinical practice is effective and safe (Dang et al., 2022). The PET section of the JHEBP model has three main components which include:

1. Develop a practice question.
2. Find, evaluate, and appraise the best evidence.
3. Translate the best evidence into practice.

The PET section of the JHEBP model provides a systematic approach to the development of best practices. Development of a practice question involves six steps (steps 1-6), finding the best evidence involves five steps (steps 7-11), and translation of the best evidence into practice as seven steps (steps 12 – 19) (Dang et al., 2022). In the future, if a healthcare professional or organization were to implement the project, the DNP scholar has completed phases 1 through 2, with a provided draft to accomplish phase 3, including implementation and quality improvement (QI).

Implementation

Step 1: Recruit an Interprofessional Team

The DNP scholar recruited the obstetrics, anesthesia, finance, patient safety, quality improvement, and information technology departments to develop and implement the project. The involvement of each selected department is briefly described below;

- Anesthesia: Trained professionals in providing neuraxial anesthesia and integral to the implementation of the project.
- Obstetrics: Participation by nurses, physicians, and ancillary staff in the unit to assist anesthesia providers in the implementation of guidelines.
- Financial: Oversight of the utilization of personnel, equipment, and technology to reduce cost and improve patient care.

- Patient Safety: Evaluation of guidelines to prevent and reduce risks, errors, and harm that may occur to patients.
- Quality Improvement: Assess, evaluate, and recommend standardized processes to achieve intended results and improve patient and healthcare outcomes.
- Information Technology: Development of an EMR (electronic medical record) infrastructure to input, record, and evaluate information about the DNP project for further data analysis.

Step 2: Define the Problem

The problem statement is provided in a previous portion of the DNP project.

Step 3. Develop and Refine Your EBP Question

The PICOT question is provided in a previous portion of the DNP project.

Step 4. Identify Your Stakeholders

The DNP scholar identified stakeholders including the finance department, vendors (e.g., Sonosite, General Energy Ultrasound, and Phillps Ultrasound), patient safety, obstetrical personnel, institutional management, QI, and professional organizations (American Medical Association, and American Association of Nurse Anesthesiologists).

Step 5. Determine Responsibility for Project Leadership

The DNP scholar determined the assignment of project leadership as the chief CRNA or physician anesthesiologist. The selection was based on the education level of a DNP degree, Doctor of Osteopathic Medicine (DO) or Doctor of Medicine (MD), and interest in the DNP project thus providing the resources to be an effective leader and member of an interprofessional team.

Step 6. Schedule Team Meetings

Schedule meetings every two weeks to establish, implement, and evaluate initiatives related to the EBP question.

Step 7, 8, 9 & 10: Conduct, Appraise, Summarize, and Synthesize the Level and Quality of Evidence

The literature review, analysis, and synthesis are provided in the previous portion of the DNP project.

Step 11: Develop Guidelines for Change Based on Evidence Synthesis

EBP guidelines are provided in a previous portion of the DNP project.

Step 12: Determine the Fit and Feasibility of Guidelines for the Translation Plan

Utilization of an algorithmic approach, when a parturient presents with scoliosis requiring neuraxial anesthesia, may be beneficial for anesthesia and obstetric personnel. The ability to improve pain and discomfort for parturients while enhancing FPS, and decreasing needle redirections and complications may provide departmental advantages through decreased complication-related cost, reduced procedural time, and improved patient management for obstetrical nursing staff.

Step 13: Create an Action Plan

Anesthesia personnel will require training on the use of preprocedural ultrasound and conventional landmark palpation for neuraxial anesthesia. The selected team leader with the advisement of team members will assist in creating a framework to implement the guidelines, provide training, and acquire resources for evaluation and improvement. The process of implementation is described below:

Education and Training

The implementation of a training program for anesthesia providers would allow the enhancement of anesthesia provider skillsets regardless of experience.

Learning objectives will include the following:

1. Identification of spinal anatomy including vertebral bodies, intervertebral ligaments, and related structures.
2. Distinguish indications, contraindications, various approaches, and complications associated with neuraxial anesthesia.
3. Describe the principles of ultrasound and their application.

4. Demonstrate proper patient positioning and anatomical landmarks for needle direction.
5. Decide the insertion point and estimate the distance to the epidural space.
6. Explain FPS, needle redirection and insertion, and procedural time.

Depending on the size of the anesthesia department selected member(s) would be the expert delegate(s) who possess a total of 200 actual neuraxial injections or placements with 100 attempts being on the obstetric population. The selected expert delegate(s) would be a resource to other members of the anesthesia department and participate in neuraxial anesthesia when dealing with complex anatomy, problem-solving, and oversight of the implementation of the project. Anesthesia providers would receive didactic teaching in the forms of reading material and graphic instruction on preprocedural ultrasound and conventional landmark palpation for neuraxial anesthesia. The selected reading material and graphic instruction are resources that incorporate relevant and current evidence-based practices for neuraxial anesthesia. These resources are open-access, available for download, and were intended to be used in academic and clinical settings (Boccio & Schiliro, 2021; Kalagara et al., 2021). The review material intends to provide anesthesia providers with instruction on anatomical structures, techniques, and implications of neuraxial anesthesia.

Following completion of the review material, the anesthesia staff will need to successfully achieve neuraxial anesthesia with five conventional landmark palpation approaches and five preprocedural ultrasound approaches with the supervision of the selected delegate expert(s) until competency has been reached. One-on-one feedback from a selected expert delegate will help to ensure a standardized approach among anesthesia providers (Tawfik et al., 2017). Those who accomplish competency and perform five preprocedural ultrasounds and five conventional landmark palpation approaches can supervise and train additional staff. A reference sheet for the performance of conventional landmark palpation and preprocedural ultrasound is available in Appendix D.

Biomedical Engineering and Finance

A portable ultrasound machine is required for preprocedural imaging in the obstetric unit, if not currently present the purchase of an ultrasound machine is warranted. In collaboration, the finance department, biomedical engineering, and anesthesia team leader consider image quality, warranty resources, portability, and maintenance costs when selecting the desired ultrasound machine. Additional costs for equipment maintenance and software updates should be discussed as long-term implementation could be adopted.

Information Technology

The EMR provides an interface to input pertinent patient information and operates as a database that can provide analysis and evaluation of information. An IT professional will collaborate with team members to develop applications within the EMR to properly record, monitor, and evaluate the measured outcomes of parturients with varying degrees of scoliosis who receive neuraxial anesthesia. The EMR will have the ability to evaluate data and initiate protocols when certain triggers are met such as parturients with normal to mild scoliosis being recommended to conventional landmark palpation or preprocedural ultrasound per the discretion of the performing provider while parturients with moderate to severe scoliosis would be recommended for preprocedural ultrasound.

Obstetrical Nursing

Obstetric nurses will be required to complete assigned learning modules on how to assist the anesthesia provider during the neuraxial blockade and the identification of post-procedure complications that would warrant further anesthesia consultation. Throughout the procedure, the assigned obstetric nurse will assist the anesthesia provider with gathering requested equipment, monitoring vital signs, and other tasks that are within the nursing scope of practice. Additionally, a secondary anesthesia provider will be present to monitor the performance of the anesthesia provider to assess for successful neuraxial blockade, first pass success, procedure time, needle redirection, and complications. Following the procedure, the performing anesthesia provider and the monitoring anesthesia provider will individually complete the procedure checklist documentation, which can be found in Appendix E.

Timeline & Budget

Timeline

The implementation of the guidelines is estimated to take a total of 12 months. Development of guidelines, departmental infrastructure, training, purchase, retrieval of equipment, and EMR adaptations should take a total of four months. Once the review of educational material, and an ultrasound machine are obtained, competency with conventional landmark palpation and preprocedural ultrasound should be achieved. An objective of 50% of anesthesia providers should be trained by the fourth month, with the consideration that it could take up to six months to achieve close to 100% competency in the anesthesia department. Implementation of guidelines would begin in month five with obstetrical nursing staff educated on assigned learning modules, necessary equipment for neuraxial anesthesia (e.g., ultrasound machine), EMR infrastructure integration, and at least 50% of the anesthesia staff trained and competent with preprocedural ultrasound and conventional landmark palpation. QI including compliance, monitoring, and evaluation should be endorsed beginning month six when full implementation of guidelines has been present for one month. See Appendix F, for a proposed project timeline placed in a Gantt Chart, which is a bar chart depicting the start and finish dates of project elements for planning and managing implementation.

Budget

Expenses associated with implementing guidelines include costs for EMR infrastructure, training, equipment, and QI. Appendix G summarizes the expected costs for project implementation. Anesthesia providers will be allotted four in-service hours to review the reading and graphic instruction and to complete the 20-question assessment. These requirements are encouraged to be completed outside of the workplace to not interfere with workflow while in clinical settings and will not strain co-workers who would otherwise have to cover for absences for training. To avoid overtime compensation, anesthesia providers would either take operating room assignments that start late or end early to allow in-service requirements to be completed while achieving less than 40 hours of work for the week. The average range of compensation for anesthesia providers is between $63.00 to $194.00 with anesthesia assistants averaging the lower end, CRNAs within the middle range, and physician anesthesiologists at upper compensation (Talent, 2023). The four hours of in-service for anesthesia providers would be an expense range between $378.00 - $1,164.00. Obstetric nursing staff will be trained through online learning modules that can be completed outside of the workplace to not interfere with staffing needs. The average compensation range for an obstetric nurse is $37.01 per hour with four hours of online requirements, equating to an expense of $148.04 (Talent, 2023). To avoid overtime compensation, the obstetric nurse will work a shortened shift by four hours to accumulate a total of no more than 40 hours for the week.

Building the necessary infrastructure within the EMR for input, storage, and evaluation of data would take an estimated 10 hours. The average income of an IT specialist is $31.54 per hour (Talent, 2023), equating to a cost of $315.40. The guidelines and outcomes will need to be monitored for compliance and require four hours per month by a QI specialist. The average income of a QI specialist is $29.14 per hour, with a total cost for six months being $407.96. It is determined that acquiring the reading and graphic instructional material would not be an expense due to the open access to the material. The cost of an ultrasound machine can vary widely with brand-new machines ranging between $20,000 to $200,000, used can range between $5,000 and $40,000, and refurbished can cost between $28,000 to $70,000 (Wannall, 2022). Maintenance fees and software updates should be considered before purchase thus $2,000 will be included for these expenses. The purchase of a used or refurbished ultrasound machine can be advantageous for the finance department due to acquiring a quality and functional machine while reducing cost, but ultimately collaboration with the anesthesia and biomedical engineering departments will aid in the decision for device purchase. The total budget for the project is estimated to be between $8,249.40 to $74,034.40.

Steps 14 & 15: Secure Support and Resources to implement an action plan

A comprehensive plan to implement the project is provided in the implementation section.

Step 16: Evaluate Outcomes

The following section of the project provides a blueprint for QI if the implementation plan is used.

Monitoring the Guidelines

Incorporating staff adherence throughout the implementation and quality improvement of the DNP project allows for decreased negative attitudes and perceptions towards adopted practices which can have negative implications for patient safety (Vaismoradi, 2020). The development of an interprofessional infrastructure that includes the obstetric nurses, anesthesia providers, the QI, and the IT department will allow for outcomes of FPS rates, needle redirection, and procedure time to be properly monitored, evaluated, and improved. Beginning in the 6^{th} month, the QI department will audit patient charts that match the criteria of obstetric patients with scoliosis requiring neuraxial anesthesia. With the information documented by the obstetric nursing staff regarding patient characteristics (e.g., height, weight, Cobb Angle degree, implication of spinal or epidural blockade, and perceived difficult spinal anatomy), the EMR infrastructure will organize the inputted data for audits. Additional features in the EMR will initiate a protocol for the use of conventional landmark palpation or preprocedural ultrasound dependent on admission data. Following the procedure, the post-procedure checklist is completed and includes an evaluation section that includes blockade success, procedural time, first pass success, needle redirection or reinsertion, and associated complications. The QI department will provide an audit monthly to the team leader and interprofessional team.

Staff Adherence

The QI department will provide audits of obstetrical nursing staff adherence on completing their project-related admission and post-procedure checklist documentation. The objective is for 100% of patients in the obstetrical unit to be evaluated for participation in the implementation. Additionally, obstetric nurses will assist the anesthesia provider with their neuraxial anesthesia procedure with patients who initiated the indicators and will complete a post-procedure checklist. To initiate and retain adherence to the process by obstetric nursing staff, the use of posters, handouts, and reminder emails will be used to provide transparency and enhance the care of obstetric patients. The QI department will report compliance rates to the team leader and interprofessional team monthly.

Outcome Monitoring

As mentioned, the primary outcomes of FPS, number of attempts, and procedural time will be included in the evaluation section of the post-procedure documentation that is completed by the primary obstetric nurse for the patient and the performing anesthesia provider. Thus, allowing discrepancies to be identified, evaluated, and improved. The QI department should perform a retrospective chart review of the previous year to assess for benchmarks for the primary outcomes. Suggested benchmarks for primary outcomes are provided below;

- Greater than 60% first-pass success rates.
- Less than two needle redirections.
- Procedural time of less than 240 seconds or four minutes.

Total procedure time was defined by Wu et al. (2020) as the time to identify landmarks and needling time despite the use of conventional or landmark palpation. Needle redirection was defined by Darrieutort-Laffite et al., (2015) as each time the needle direction needed to be changed without the need to remove it from the skin whereas removal from skin and reinsertion was defined as a needle reinsertion. FPS was identified by Sidiropoulou et al., (2021) as a single needle puncture with or without redirection of the needle to obtain the desired outcome (e.g., presence of cerebrospinal fluid, injection of local anesthetic, or threading of the epidural catheter). The QI department will report primarily on these three outcomes to the team leader and interprofessional team monthly.

Complication Monitoring

In the post-procedure documentation, a location for complication-related events such as post-dural headache, vascular puncture, LAST (local anesthetic systemic toxicity), and the ability to add a note for further event-related documentation will be present. The objective would be to compare the previous year’s neuraxial anesthesia-related complications in the obstetric unit and achieve a goal of zero incidence following the implementation of the guidelines. The QI department will report incidence rates of complications to the team leader and interprofessional team monthly. The patient safety representative and team leader will evaluate complication incidents to determine areas of improvement.

Limitations, Barriers, and Future Direction

The plan for implementation of these guidelines was designed to be easily adaptable for varying practice settings, but barriers and limitations should be addressed before implementation. A barrier to implementation could be hesitation by anesthesia providers to learn preprocedural ultrasound. Proper training with experienced team members could be beneficial in alleviating this hesitation. In an RCT conducted by Tawfik et al., (2017) there was no difference in success rates between novice and expert anesthesia providers when performing neuraxial anesthesia. If select anesthesia providers need additional training the proposed timeline allows for an additional two months. Additionally, the consideration of increased workload among obstetrical nursing staff and anesthesia providers is warranted but, as discussed by Jiang et al., (2020) there were no significant increases in procedural time between conventional landmark palpation and preprocedural ultrasound. If numerous patients need preprocedural ultrasound for neuraxial anesthesia an additional machine should be purchased to decrease patient wait times and reduce the incidence of complications.

Throughout the literature, preprocedural ultrasound and real-time ultrasound were not exclusively researched and could yield results on which technique would be optimal when performing ultrasound for neuraxial anesthesia. The criterion used to define “difficult spinal anatomy” was not always specifically defined in the literature. Advanced age, pregnancy, obesity, spinal conditions, or deformities (kyphosis, lordosis, or scoliosis) can be contributors to difficult spinal anatomy thus guidelines for scoliosis were generalized from these findings. Extraneous variables that can perpetuate difficulty in performing neuraxial anesthesia should also be addressed. Two possible variables are improper instruction from the anesthesia provider related to patient positioning, and the patient’s spinal mobility which can manipulate intervertebral spaces.

Lastly, a consistent stepwise approach to conventional landmark palpation or preprocedural ultrasound was not disclosed in the literature, thus extraneous variables may influence the success of neuraxial anesthesia placement. Future direction on this topic warrants further investigation into the discussed barriers, limitations, and considerations to better provide evidence-based guidelines.

Step 17: Report Outcomes to Stakeholders

The implementation plan would be disseminated to the anesthesia, obstetric, and nursing staff utilizing the facility's current communication practices.

Step 18: Identify Next Steps

The DNP scholar has prepared a plan for the implementation, monitoring, and evaluation of outcomes with guidelines for adjustments in the future.

Step 19: Disseminate Findings

The DNP scholar will disseminate the project to level one trauma centers which are level III maternity centers that provide obstetric patients with labor and delivery anesthesia services. A resource poster of the EBP project will be developed, evaluated, and then displayed for anesthesia personnel to interpret, evaluate, and incorporate the guidelines. If the project were to be implemented and beneficial changes were incorporated based upon EBP, those findings should be shared with other providers and institutions of anesthesia.

Conclusion and Guidelines

Neuraxial anesthesia is the preferred technique for parturients in the facilitation of labor, due to the ability to modulate autonomic, sensory, and motor responses. Anesthesia providers experience challenges in the placement and maintenance of neuraxial anesthesia in parturients with unfamiliar or difficult spinal anatomy, especially in moderate to severe scoliosis. The literature provides evidence that the use of preprocedural ultrasound has increased first-pass success, decreased needle redirection, and unchanged procedure time for neuraxial anesthesia in patients with difficult spinal anatomy (Jiang et al., 2020*;* Kim et al., 2020; Young et al., 2020). In conclusion, implementation of the guidelines and evaluation should increase the clinical occurrence and effectiveness of neuraxial anesthesia for parturients with scoliosis or difficult spinal anatomy. In the future, preprocedural ultrasound as a recommended guideline to provide neuraxial anesthesia to parturients with predicted difficulty in spinal anatomy should be considered by healthcare providers, professional organizations, and institutions.

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Appendix A

Scoring of Cobb Angle in Scoliosis

Classification	Degree of Cobb Angle
Normal	Cobb angle < 10 degrees
Mild	Cobb angle > 10 degrees but < 25 degrees
Moderate	Cobb angle >25 degrees but < 45 degrees
Severe	Cobb angle > 45 degrees

Note: Kusuma, B.A. (2017). Determination of spinal curvature from scoliosis x-ray images using K-means and curve fitting for early detection of scoliosis disease. *2017 2nd International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE).* https://doi.org/10.1109/ICITISEE.2017.8285486

Appendix B

Literature Summary Table

Citation	Conceptual Framework	Design/ Method	Sample/Setting	Variables Studied and Definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence:
Author Year Title County Funding	**Theoretical basis for study**		**Number Characteristics Exclusion criteria Attrition**	**Independent variables IV1 =, IV2 = Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths Limitations Risk or harm Feasibility of use in your practice**
Young et al., (2020) Conventional landmark palpation versus preprocedural ultrasound for neuraxial analgesia and anaesthesia in obstetrics – a systematic review and meta-analysis with trial sequential analyses. County: NR Funding: NR	None	SR and MA Purpose: compare the efficacy, time, and safety of neuraxial blockade in obstetric patients with preprocedural ultrasound in comparison to the landmark palpation. • Timeframe: NR • Location: NR	Searched: 6 databases from inception to February 2020 N = 22 RCTs (included 2462 participants) accepted out of 4978 RCTs. Landmark palpation was conducted in 1,232 participants compared to 1,230 preprocedural ultrasound. • Inclusion criteria ○ RCTs that included pregnant women having neuraxial procedures. ○ Use of epidural, spinal or combined anesthetic. ○ Non-automated preprocedural ultrasound as the intervention and conventional landmark palpation as the comparator.	**IV1 =** landmark palpation. **IV2 =** preprocedural. ultrasound. **DVI=** successful placement of neuraxial anesthesia (spinal, epidural, or combined).	○ Primary outcomes: first-pass success rate, procedure time, and performance of the neuraxial procedure.	○ Inverse-variance method ○ Risk ratio with the Mantel–Haenszel (MH) method ○ CI	CI: ○ First- pass success rate = 1.41 ○ Procedure time = 13.79 ○ Procedural pain = 0.96 ○ Patient satisfaction = 0.37 First-pass success rate Risk ratio MH, 95% CI ○ 1.46	Level I	Conclusion: use of ultrasound compared to landmark palpation was more successful in first-time pass success, and reduced related complications but had no change in procedural time. Strengths: evaluated an extensive sample pool and used statistical programs to reduce the incidence of type-2 statistical error. Limitations: nomenclature describing needle technique was not consistent in the included RCTs. Feasibility: recommendations are reasonable to implement, considering most facilities have ultrasound devices. Risk/Benefit (harm): benefits outweigh the risks.

IV = independent variable; DV = dependent variable; NR = not reported; SR = systematic review; MA = meta-analysis; RCT = randomized controlled trial; CI = confidence interval; MH = Mantel Haenszel

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Citation	**Conceptual Framework**	**Design/ Method**	**Sample/Setting**	**Variables Studied and Definitions**	**Outcome Measurement**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence:**
Author **Year** **Title** **County** **Funding**	**Theoretical basis for study**		**Number** **Characteristics** **Exclusion criteria** **Attrition**	**Independent variables** **IV1 =, IV2 =** **Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths** **Limitations** **Risk or harm if implemented** **Feasibility of use in your practice**
Darrieutort-Laffite et al., (2015) Usefulness of a pre-procedure ultrasound scanning of the lumbar spine before epidural injection in patients with a presumed difficult puncture. County: NR Funding: NR	None	RCT Purpose: Determine if the selection of the optimum puncture level by ultrasound may facilitate epidural injection in case of presumed difficult puncture. • Timeframe: April 2013 and January 2014. • Location: Department of Rheumatology of the Nantes University Hospital.	171 participants were eligible, 89 were excluded and 2 declined. N = 80 participants who were hospitalized for steroid epidural injection for the treatment of sciatica due to disc herniation or lumbar stenosis. Inclusion criteria: BMI (Body Mass Index) > 30 kg/m^2. age > 60 years or lumbar scoliosis (Cobb angle > 10◦). Exclusion criteria: patients with a history of spinal surgery or spinal malformation like spina bifida, pregnant women, patients taking anti-platelet drugs, and those participating in another study were excluded.	**IV1 =** Landmark palpation **IV2 =** Preprocedural ultrasound **DVI=** Successful epidural injection	○ Primary outcome: reported pain assessed by a VAS. ○ Secondary outcomes: needle redirections, and procedural time.	○ Student t-test ○ Chi Squared test	○ Pain: 2.01 ± 1.6 in the US group versus 2.95 ± 2.5 in the control group ○ Needle redirection: 1.6 ± 2.7 in the US compared to 2 ± 2.7 in the control group ○ Procedural time: 65.9 ± 31.8 in the US compared to 77.3 ± 39.2 in the control group	Level II	Conclusion: reduction in VAS scores in the US compared to the control group but was not statistically significant. Needle redirection was not different between either study group. Strengths: the first study to directly evaluate pain during the procedure as a primary outcome and participants were blinded to the study. Limitations: broad selection criteria for this study which included sex, age, body mass index (BMI), type of radicular pain (L4, L5, S1 or radicular claudication), and presence and angle of lumbar scoliosis. Feasibility: despite the sample differing from the population in the proposed DNP project, several recommendations can be adapted. Risk/Benefit (harm): benefits outweigh the risks.

IV = independent variable; DV = dependent variable; NR = not reported; RCT = randomized controlled trial; CI = confidence interval; ; N = sample size

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Citation	Conceptual Framework	Design/ Method	Sample/Setting	Variables Studied and Definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence:
Author Year Title County Funding	**Theoretical basis for study**		**Number Characteristics Exclusion criteria Attrition**	**Independent variables IV1 =, IV2 = Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths Limitations Risk or harm if implemented Feasibility of use in your practice**
Kim et al., (2020) Ultrasound-Assisted Versus Landmark-Guided Spinal Anesthesia in Patients with Abnormal Spinal Anatomy: A Randomized Controlled Trial County: NR Funding: None	None	RCT Purpose: could US technique reduce the number of needle passes required for block success compared with the landmark-guided technique in patients with abnormal spinal anatomy. ○ Timeframe: March 2018 and July 2018 ○ Location: Seoul National University Hospital	83 participants were assessed for eligibility and 39 were excluded related to inclusion criteria or refusal. N = 44 who were adult ASA I/II/III scheduled for orthopedic surgery under spinal anesthesia with lumbar spine abnormalities with one of the following: ○ Mild to severe lumbar scoliosis noted in spinal X-Ray defined as a cobb angle equal to or greater than 10 degrees. ○ History of lumbar spinal surgery involving L2–L5 Exclusion criteria: contraindications to spinal anesthesia, coagulopathy, or local infection at the puncture site	**IV1 =** landmark palpation (control group) **IV2 =** preprocedural ultrasound **DVI=** number of needle passes	○ Primary outcome: number of needle passes ○ Secondary outcomes: first pass success rate, procedure time, pain scores, and the incidences of radicular pain, paresthesia, and bloody tap during the neuraxial procedure	○ Mann-Whitney U test for continuous variables ○ Fisher exact test for incidence variables ○ CI	P value (disseminated from Mann-Whitney U test and Fisher exact test) ○ Number of needle passes = <.001 ○ Procedure time = 0.888 ○ Procedural pain = 0.12 CI: ○ Number of needle passes = 4.5 ○ Procedure time = 5 ○ Procedural pain = 2	Level II	Conclusion: US was found to have reduced the number of needle passes with an increased first pass success rate without significantly prolonging total *competence in using preprocedural ultrasound, an anesthesia provider has the potential to improve the efficacy of neuraxial anesthesia procedures in obstetrics.* when compared with landmark palpation Strengths: unlike other similar RCTs that lacked those with abnormal spinal anatomy this study focused on this population to derive their research. Weaknesses: participants were not blinded, and the results could be imbalanced due to more participants with prior spinal surgery being in the landmark palpation group. Feasibility: findings from this study could be implemented, considering most facilities have ultrasound devices. Risk/Benefit (harm): benefits outweigh the risks

IV = independent variable; DV = dependent variable; NR = not reported; RCT = randomized controlled trial; CI = confidence interval; N = sample size; US = ultrasound

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Citation	Conceptual Framework	Design/ Method	Sample/Setting	Variables Studied and Definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence:
Author **Year** **Title** **County** **Funding**	**Theoretical basis for study**		**Number** **Characteristics** **Exclusion criteria** **Attrition**	**Independent variables IV1 =, IV2 = Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths** **Limitations** **Risk or harm if implemented** **Feasibility of use in your practice**
Elsharkawy et al., (2017) Real-time ultrasound-guided spinal anesthesia in patients with predicted difficult anatomy. County: NR Funding: internally by department of general anesthesia and outcomes research, Cleveland clinic	None	RCT ○ Purpose: if real-time US guidance facilitates spinal anesthesia in patients with risk factors for difficult insertion. ○ Timeframe: NR ○ Location: Department of general anesthesiology, Department of outcomes research, Case Western reserve University	40 assessed for eligibility and 2 declined to participate. N = 38 Inclusion criteria: elective candidates for total hip or knee arthroplasty who were. ○ 55 years or older. ○ body mass index (BMI) greater than 30 kilograms/meters per second squared. ○ scoliosis with greater than 30-degree curvature, or inability to palpate the spinous processes as determined by an attending anesthesiologist.	**IV1 =** landmark palpation **IV2 =** preprocedural ultrasound **DVI=** success placement of spinal anesthesia	Primary outcomes: number of attempts required for spinal anesthesia. Secondary outcomes: insertion time, block success, procedural difficulty scores, and patient satisfaction.	Means and standard deviations where applicable. For primary outcome(s) Kruskal-Wallis non-parametric test of the difference between the US and control conditions.	Authors hypothesized that real-time Us guidance would result in a 20% lower number of attempts compared to the control group. P value ○ number of needle attempts = 0.83 ○ insertion time = 0.06 ○ procedural satisfaction = 0.09 ○ procedural difficulty = 0.001	Level II	Conclusion: first pass success, procedural time and procedure difficulty was increased in the US group while successful blockade was achieved in both groups. An adverse outcome of post-dural puncture headache was noted in the control group. Strengths: provided basis for future studies to assess effectiveness, safety, cost-effectiveness, and feasibility of real-time US guidance. Weaknesses: difficult spinal insertion was not well defined in this study. The authors and anesthesiologists were not blinded to the study. Feasibility: Although both approaches provided successful blockade, US shows the ability to decrease adverse outcomes thus improving patient safety in the clinical setting. Risk/Benefit (harm): benefits outweigh the risks

IV = independent variable; DV = dependent variable; NR = not reported; RCT = randomized controlled trial; CI = confidence interval; US =ultrasound; N = sample size

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Citation	Conceptual Framework	Design/ Method	Sample/Setting	Variables Studied and Definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence:
Author Year Title County Funding	**Theoretical basis for study**		**Number Characteristics Exclusion criteria Attrition**	**Independent variables IV1 =, IV2 = Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths Limitations Risk or harm if implemented Feasibility of use in your practice**
Jiang et al., (2020) Could preprocedural ultrasound increase the first-pass success rate of neuraxial anesthesia in obstetrics? A systematic review and meta-analysis of randomized controlled trials. County: NR Funding: The Research Foundation of Technology Bureau of Anhui Province, China	None	SR and MA ○ Purpose: determine first-pass success rates of preprocedural ultrasound compared to landmark palpation for neuraxial anesthesia in obstetrics ○ Timeframe: NR ○ Location: NR	Included RCTs that compared landmark palpation and ultrasound in neuraxial anesthesia in obstetrics. Exclusion criteria: ○ Patient who were pregnant with twins ○ Patients contraindicated for neuraxial anesthesia. ○ Patients scheduled for urgent caesarean section. ○ Unobtainable or repeated publication of data. 45 studies had full text reviewed and 27 studies were excluded. N = 18 RCTs (included 1,844 participants) ○ Searched: 6 databases from inception to February 2020	**IV1 =** preprocedural ultrasound **IV2 =** landmark palpation **DVI=** successful placement of neuraxial anesthesia	Primary outcomes: first pass success rate. Secondary outcomes: incidence of failed puncture, number of redirections, number of punctures, procedural time, and adverse events.	For continuous variables, the pooled effects were analyzed by mean difference (MD) or standard mean difference and 95% CI whereas dichotomous intervals were expressed through 95% CI and relative rate. The levels of statistical heterogenicity or allowable randomness were quantified with adapted X2, P values, and I2, as appropriate.	Risk ratio MH, 95% CI FSP ○ FSP: 1.49 [1.21, 1.84] Number of redirections ○ -1.07 [-1.44, -0.69] Number of punctures ○ -0.86 [-1.22, -0.55] Procedural time ○ -0.18 [-0.86, -0.49] Failed puncture ○ 0.44 [0.19, 1.07]	Level I	Conclusion: preprocedural ultrasound was beneficial in first-time pass success with those with difficulty anatomy but not in patients who had easily palpable spinal anatomy. Strengths: assessed a wide range of neuraxial anesthesia techniques, and approaches when comparing landmark and ultrasound-guided placement. Weaknesses: no disclosure of years of experience between operationalist and the approach of ultrasound-guided neuraxial placement varied between studies. Feasibility: the result of this study favors the use of preprocedural ultrasound in those with difficult spinal anatomy, but further evidence is needed to assess Usefulness in easily palpable participants. Risk/Benefit (harm): benefits outweigh the risks

IV = independent variable; DV = dependent variable; NR = not reported; SR = systematic review; MA = meta-analysis; RCT = randomized control trials; CI = confidence interval; MH = Mantel–Haenszel; N = sample size; FSP = first pass success

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Citation	**Conceptual Framework**	**Design/ Method**	**Sample/Setting**	**Variables Studied and Definitions**	**Outcome Measurement**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence:**
Author **Year** **Title** **County** **Funding**	**Theoretical basis for study**		**Number** **Characteristics** **Exclusion criteria** **Attrition**	**Independent variables IV1 =, IV2 = Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths** **Limitations** **Risk or harm if implemented** **Feasibility of use in your practice**
Sidiropoulou et al., (2021) Pre-Procedural Lumbar Neuraxial Ultrasound—A Systematic Review of Randomized Controlled Trials and Meta-Analysis County: NR Funding: NR	None	RCT and MA Purpose: examine current evidence on the utilization of a preprocedural neuraxial ultrasound and investigate specific predetermined outcomes in patients. Requiring neuraxial procedures, as well as in a subgroup of these with non-palpable landmarks due to obesity or difficult spinal anatomy. ○ Timeframe: NR ○ Location: NR	Inclusion criteria: ○ Full-text reports of RCTs with a parallel-group design (pre-procedural ultrasound vs non-ultrasound-assisted control groups). Exclusion criteria: ○ Not explicitly disclosed. Searched: 4 databases with 4,203 initially obtained, 4,171 excluded related to criteria regarding screening and eligibility N = 32 RCTs (3439 patients included)	**IV1 =** pre-procedural ultrasound **IV2 =** landmark palpation **DVI=** successful placement of lumbar neuraxial anesthesia	Outcomes: technical failure rate, number of needle redirections, procedural time, and needling time	RMS was used to perform meta-analyses. Random effects The model was utilized and is presented as the SMD or RR with 99% CI.	Standard mean difference IV, Random, 99% CI Failure of neuraxial procedures ○ 0.69 [0.43, 1.10] Technical failure in difficult spines and obese patients ○ 0.53 [0.22, 1.27] First time success rate ○ 1.50 [1.22, 1.84] First time success rate in difficult spines and obese patients ○ 1.84 [1.44, 2.34] Number of needle redirections ○ -0.34 [-0.79, 0.09] Number of needle redirections in difficult spines and obese patients ○ -0.23 [-0.85, 0.39	Level I	Conclusion: pre-procedural ultrasound reduces the failure rate and number of needles redirections, while it increases the first attempt success rate but further research is necessitated for its effects on needling and procedural time. Strengths: compares the use of ultrasound guidance in easy versus difficult populations to further demonstrate the utility of ultrasound. Weakness: the authors were not detailed in their description of "difficult spines". Most RCTs used in this literature were not blinded to either the proceduralist or patients. Feasibility: the incorporation of ultrasound in those with and without difficult spinal anatomy is favorable and can provide clinicians with improved success rates. Risk/Benefit (harm): benefits outweigh the risks

IV = independent variable; DV = dependent variable; NR = not reported; RCT = randomized controlled trial; MA = meta-analysis; RCT = randomized control trial; RR = relative risk; CI = confidence interval; RMS = *Review Manager software*

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Citation	Conceptual Framework	Design/ Method	Sample/Setting	Variables Studied and Definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence:
Author **Year** **Title** **County** **Funding**	**Theoretical basis for study**		**Number** **Characteristics** **Exclusion criteria** **Attrition**	**Independent variables IV1 =, IV2 = Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths** **Limitations** **Risk or harm if implemented** **Feasibility of use in your practice**
Tawfik et al., (2017) Does Preprocedural Ultrasound Increase the First-Pass Success Rate of Epidural Catheterization Before Cesarean Delivery? A Randomized Controlled Trial County: NR Funding: Department of Anesthesia and Surgical Intensive Care, Mansoura University Hospitals, Mansoura, Egypt.	None	RCT Purpose: compare preprocedural ultrasound with conventional palpation for epidural catheterization performed by a single experienced anesthesiologist as a component of double-interspace combined spinal–epidural (CSE) anesthesia for cesarean delivery. ○ Timeframe: NR ○ Location: University Hospitals, Mansoura, Egypt	Inclusion criteria: ○ ASA physical status II parturients with full-term singleton pregnancy undergoing elective cesarean delivery using double-interspace CSE anesthesia. Exclusion criteria: ○ age <19 or >40 years ○ body mass index ≥35 kg/m2. ○ women presenting in labor or having any contraindication to neuraxial anesthesia. ○ marked spinal deformity. ○ previous spinal surgery. ○ impalpable anatomical landmarks. 134 assessed for eligibility, 30 excluded due to criteria. N = 108	**IV1 =** pre-procedural ultrasound **IV2 =** landmark palpation **DVI=** first pass success of epidural catheterization	Primary outcomes: rate of successful epidural catheterization at the first needle pass Secondary outcome: FSP, number of needle passes, procedural time, patient satisfaction, complications of procedure (incidence of unintentional dural and vascular punctures, failed block, unilateral or patchy block, and backache).	Normally distributed data are presented as mean ± SD and were compared using the Student t test. Nonnormally distributed data are presented as median (range). Data for the duration of the epidural procedure (nonnormally distributed, positively skewed) are presented as mean ± SD and were compared using the Student t test with unequal variances. The 95% CI of the difference between the 2 groups in proportions of the first-pass success rate.	*P value* Success at the first needle pass ○ >0.99 Number of needle passes ○ 0.99 Duration of the epidural procedure ○ 0.083 Patient satisfaction ○ 0.55	Level II	Conclusion: This RCT found that pre-procedural ultrasound did not increase FSP and secondary outcomes were similar among the preprocedural US and landmark palpation group. Strengths: Utilized a single anesthesiologist throughout the study thus limiting extraneous factors from multiple operationalist. The technique was performed in a 7-step approach among all participants. Weakness: Inclusion criteria were assessed by one operationalist which can increase bias. Excluded those with difficult anatomy (spinal deformity, previous spinal surgery, and impalpable landmarks. Feasibility: The intended primary outcome of first-pass success was indifferent between groups, the usefulness of US in a clinical setting should be considered in those with complex spinal anatomy. Risk/Benefit (harm): Benefits outweigh risks

IV = independent variable; DV = dependent variable; NR = not reported; RCT = randomized controlled trial; MA = meta-analysis; RR = relative risk; CI = confidence interval; SD = standard deviation; FSP = *first pass success*

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Citation	Conceptual Framework	Design/ Method	Sample/Setting	Variables Studied and Definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence:
Author Year Title County Funding	**Theoretical basis for study**		**Number Characteristics Exclusion criteria Attrition**	**Independent variables IV1 =, IV2 = Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths Limitations Risk or harm if implemented Feasibility of use in your practice**
Arzola et al., (2015) Spinal ultrasound versus palpation for epidural catheter insertion in labour County: NR Funding: Departmental resources of the Department of Anesthesia and Pain Management, Mount Sinai Hospital, and Department Sunnybrook Health Sciences Centre, University of Toronto.	None	RCT Purpose: determine if preprocedural ultrasound improves the ease of insertion of labor epidural catheters compared to palpation technique following a training program in ultrasound ○ Timeframe: NR ○ Location: Mount Sinai Hospital	Inclusion criteria: ○ Proceduralist: anesthesia residents and fellows. ○ Participants full-term parturients with easily palpable lumbar spines. Exclusion criteria: ○ Patients with contraindications to epidural anesthesia. ○ Patients with previous spinal surgery, trauma, or spinal deformity. 164 parturients evaluated for inclusion and 128 parturients were randomized for the study (84 epidurals performed by 17 residents and 44 epidurals performed by 5 fellows)	**IV1 =** pre-procedural ultrasound **IV2 =** landmark palpation **DVI** procedure time, insertion attempts number of needle passes, and total procedure	Primary outcomes: rate of successful epidural catheterization at the first needle pass Secondary outcome: FSP, number of needle passes, procedural time, patient satisfaction, complications of procedure (incidence of unintentional dural and vascular punctures, failed block, unilateral or patchy block, and backache).	Student's t test Or Wilcoxon Rank Sum test and Pearson's Chi-square or Fisher's exact test were used to analyze continuous and categorical variables. Multivariable analysis was used to analyze duration of procedures	Epidural insertion time between U/S and palpation group P = 0.14. FPS (50% vs 60%, P=0.26), Number of interspace levels attempted (4/68 vs 2/60, P =0.68) Number of needles passes (P =0.43), Number of Threading attempts and patient satisfaction. (P = 0.93)	Level I	Conclusion: This RCT found despite unformed training among anesthesia providers there was no benefit in improved ease of insertion, procedural time, needle passes, and attempted interspaces. Strengths: One of few studies that compare the experience of anesthesia providers providing neuraxial anesthesia with varying techniques. Educated providers in a uniform fashion. Weakness: Limited via the sample size and varying degrees of experience among providers. Participants were "easily" palpable thus not allowing for a wide range of variety of samples. Feasibility: The use of providing a uniform training experience for anesthesia providers could be promising for future implementations Risk/Benefit (harm): Benefits outweigh risks

IV = independent variable; DV = dependent variable; NR = not reported; RCT = randomized controlled trial; FSP = *first pass success*

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

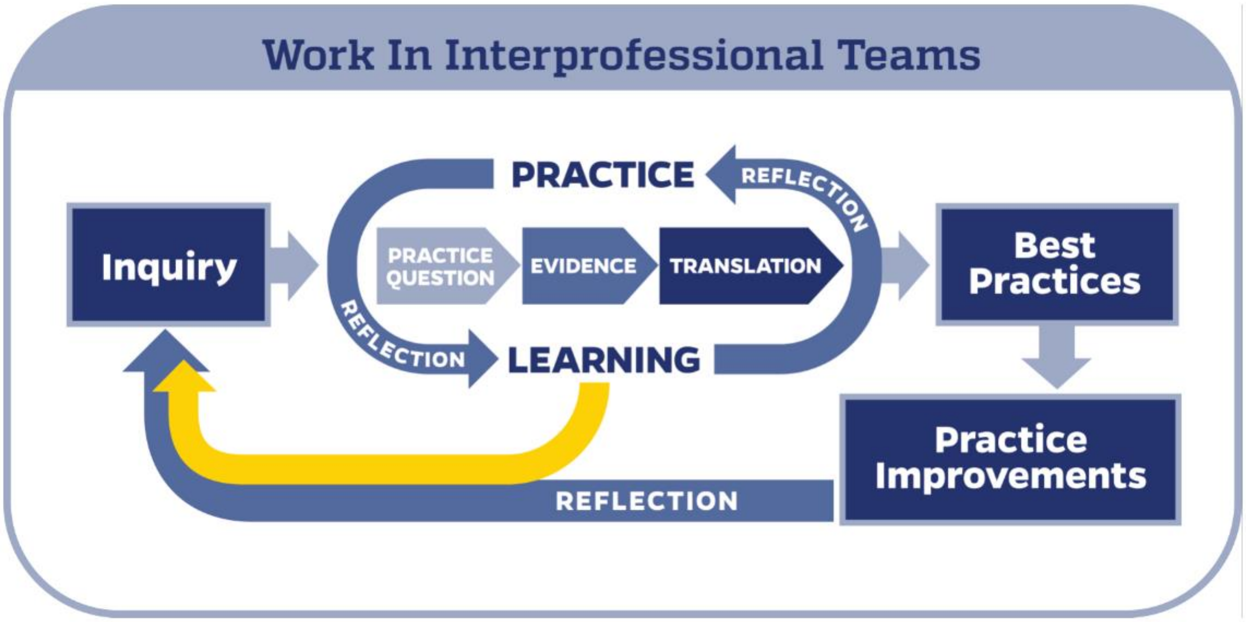
Citation	Conceptual Framework	Design/ Method	Sample/Setting	Variables Studied and Definitions	Outcome Measurement	Data Analysis	Findings	Level of Evidence	Quality of Evidence:
Author **Year** **Title** **County** **Funding**	**Theoretical basis for study**		**Number** **Characteristics** **Exclusion criteria** **Attrition**	**Independent variables** **IV1 =, IV2 =** **Dependent variables**	**What scales used - reliability info (alphas)**	**What stats used**	**Statistical findings**	**Level**	**Strengths** **Limitations** **Risk or harm if implemented** **Feasibility of use in your practice**
Farshad et al., (2022) Long-term outcome of patients with adolescent idiopathic scoliosis seeking nonoperative treatment after a mean follow-up of 42 years County: NR Funding: NR	None	Therapeutic study Purpose: This study aimed to investigate the long-term outcome of nonoperative-treated AIS patients. Comparison between a bracing and an observation approach were performed. ○ Timeframe: NR ○ Location: Department of Orthopedics, Balgrist University Hospital, University of Zurich, Forchstrasse	Inclusion criteria: ○ Patients with AIS with a minimum Cobb angle of 10° in the major curve, age of 10–20 years at the time of diagnosis as well as nonoperative treatment, availability of a full standing anteroposterior X-ray of the spine at diagnosis, and a minimum follow-up of 20 years. 332 participants evaluated for inclusion and 20 participants were selected for the study.	**IV1 =** Observed AIS candidates **IV2 =** AIS candidates with structural brace **DVI** long term outcomes	Primary outcomes: long term outcomes Secondary outcome: Physical functioning, body pain, general health, social functioning, emotional health, and mental health.	Outcome associations were assessed using Spearman rank correlation tests. Differences between the groups with/ without brace were compared using the Mann–Whitney U test.	Primary curve progressed from 32° ± 15° to 52° ± 25° with P = 0.371. Final follow-up, a mean ODI score of 7 ± 7.9 points, P = 0.668.	Level IV	Conclusion: After a mean of 42 years, patients with nonoperative treatment of moderate AIS demonstrated a good clinical outcome despite the progression of the deformity. Strengths: Assessed varying ages and degrees of curvature of AIS Weakness: Limited due to age differences at first diagnosis within the selected groups. Feasibility: This study provides background for AIS and the systemic changes that can accrue treated to the degree of curvature. Risk/Benefit (harm): Benefits outweigh risks

IV = independent variable; DV = dependent variable; NR = not reported; RCT = randomized controlled trial; MA = meta-analysis; RR = relative risk; CI = confidence interval; SD = standard deviation; FSP = first pass success; AIS = Adolescent idiopathic scoliosis

Note: Adapted from Melnyk, B. M., & Fineout-Overholt, E. (2019). Evidence-based practice in nursing & healthcare a guide to best practice. *Wolters Kluwer.*

Appendix C

Johns Hopkins Evidence-Based Practice Model



Note: 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. *Sigma Theta Tau International.* https://www.hopkinsmedicine.org/evidence-based-practice/model-tools.html

Appendix D

Guidelines for Neuraxial (Spinal or Epidural) with Conventional Landmark Palpation or Preprocedural Ultrasound

TITLE: Neuraxial (Spinal or Epidural) with Conventional Landmark Palpation or Preprocedural Ultrasound	**NUMBER:**
ISSUE DATE:	**EFFECTIVE DATE:**
DEVELOPED / REVISED BY: Luther Nyirenda & Brian Garrett	
REVIEWED BY: Brian Garrett	**DATE REVIEWED:**
APPROVED BY:	

SCOPE - This guideline is in effect for anesthesia providers who perform neuraxial anesthesia in the obstetric setting.

PURPOSE STATEMENT:

The purpose of this guideline is to provide evidence-based practice guidelines regarding the use of conventional landmark palpation or procedural ultrasound for neuraxial anesthesia. Neuraxial anesthesia can provide sensory and motor blockade for optimal surgical or procedural conditions. Parturients with difficult spinal anatomy or scoliosis can affect the efficacy of local anesthetics and additives. The selection of preprocedural ultrasound or conventional landmark palpation should include an assessment of indications and contraindications, risks and benefits, block duration, and angle of spinal curvature (Cobb Angle) to achieve appropriate blockade.

Consideration generally includes:

a) Obtaining appropriate preoperative assessment.
b) Addressing consent and surgical preferences.
c) Utilizing technical aspects during administration, whether conventional landmark palpation or preprocedural ultrasound.

d) Availability of anesthesia providers to address complications and appropriate interventions to address any potential complications.

e) Providing appropriate post-anesthesia care following neuraxial anesthesia.

DEFINITIONS:

- Neuraxial anesthesia: local anesthesia placed around the nerves of the central nervous system, into the subarachnoid or epidural space.
- Motor block: block that paralyzes the motor function of a muscle.
- Sensory block: block that selectively inhibits pain transmission.

GUIDELINE:

Neuraxial (Spinal or Epidural) with Conventional Landmark Palpation

Conventional landmark palpation can be performed with a midline or paramedian approach, and the choice of approach is based on patient condition and clinician preference.

Epidural Midline Approach

1. Placement of patient in the lateral decubitus or sitting position (based on proceduralist's preference, and patient cooperation).
2. Proper aseptic technique, sterilization of field, and preparation of necessary equipment.
3. Skin and underlying tissue infiltration is commonly performed with lidocaine 1% for pain and discomfort.
4. An epidural needle with a stylet (to decrease needle congestion with tissue) is advanced through subcutaneous fat, the supraspinous ligament, and the interspinous ligament.
5. When the interspinous ligament has been penetrated, the proceduralist removes the stylet and places a loss of resistance (LOR) syringe onto the epidural needle.
6. The epidural needle with the LOR syringe (filled up with saline, or air) is directed into the ligamentum flavum while applying pressure to the plunger assessing until LOR is noted.

7. Once LOR has been achieved the proceduralist can assume that placement in the epidural space has been obtained.

Epidural Paramedian Approach

1. Placement of patient in the lateral decubitus or sitting position (based on proceduralist's preference, and patient cooperation).
2. Proper aseptic technique, sterilization of field, and preparation of necessary equipment.
3. The insertion site of the needle is moved 1 centimeter (cm) caudal and 1 cm lateral with an angle of 10 – 25 degrees from the midline (this will bypass the supraspinous and interspinous ligaments).
4. The needle is advanced into the skin and the proceduralist removes the stylet and places a LOR syringe onto the epidural needle.
5. The epidural needle with the LOR syringe (filled up with saline, or air) is directed into the ligamentum flavum while applying pressure to the plunger until LOR is noted.
6. Once LOR has been achieved the proceduralist can assume that placement in the epidural space has been obtained.

It should be noted that if there is free-flowing clear liquid the suspicion of subarachnoid penetration is warranted and either a continuous spinal anesthetic or reattempt of the epidural should be performed. Upon completion of the midline or paramedian approach for neuraxial anesthesia, an epidural catheter must be threaded through the LOR syringe or epidural needle until the 20-centimeter mark, then the epidural needle is removed over the catheter being cautious not to remove the catheter during the process. The epidural catheter is then withdrawn to achieve 3 – 5 cm within the epidural space. Following a test dose must be performed, which commonly includes the injection of 3 milliliters of 1.5% lidocaine with 1:200,000 epinephrine. Intravascular injection should be suspected if an increase in heart rate by 20 to 30 beats per minute or 15 to 20 mmHg in systolic blood pressure is noted whereas if cardiovascular collapse, motor blockade or changes in mentation are noted subarachnoid injection should be suspected. If intravascular or subarachnoid injections are excluded, then the infusion of medication through the epidural catheter is suitable (Sage & Holladay, 2022).

Spinal Midline Approach

1. Placement of patient in the lateral decubitus or sitting position (based on proceduralist's preference, and patient cooperation).
2. Proper aseptic technique, sterilization of field, and preparation of necessary equipment
3. Skin and underlying tissue infiltration is performed with lidocaine 1% for pain and discomfort.
4. A spinal needle introducer needle is inserted through the subcutaneous fat, supraspinous ligament, and into the interspinous ligament.
5. A spinal needle is inserted through the introducer and passes through the ligamentum flavum, identified with a loss of resistance.
6. The spinal needle is then advanced into the dura-subarachnoid membranes where a secondary change in resistance is noted.
7. During needle advancements, the stylet can be removed to assess the outflow of CSF, which indicates penetration into the subarachnoid space.
8. Attach the syringe with the intended spinal anesthetic. Gently aspirate some CSF into the syringe. If a hyperbaric technique is being used, a "swirling" in the solution will be noted due to the dextrose content.
9. Needle aspiration should be performed to assess for intravascular puncture.
10. Once slow administration of spinal anesthetic is performed, the needle and introducer are withdrawn as a unit.
11. The patient is then placed in the appropriate position to achieve proper anesthetic conditions.

Spinal Paramedian Approach

1. Placement of patient in the lateral decubitus or sitting position (based on proceduralist's preference, and patient cooperation).
2. Proper aseptic technique, sterilization of field, and preparation of necessary equipment.
3. Skin and underlying tissue infiltration is performed with Lidocaine 1% for pain and discomfort.
4. The insertion site of the needle is moved 1 centimeter (cm) caudal and 1 cm lateral with an angle of 10 – 25 degrees from the midline (this will transverse the supraspinous or interspinous ligaments).
5. A spinal needle is inserted through the introducer and passes through the ligamentum flavum, identified with a loss of resistance.
6. During needle advancements, the stylet can be removed to assess the outflow of CSF, which indicates penetration into the subarachnoid space.
7. Attach the syringe with the intended spinal anesthetic. Gently aspirate some CSF into the syringe. If a hyperbaric technique is being used, a "swirling" in the solution will be noted due to the dextrose content.
8. Needle aspiration should be performed to assess for intravascular puncture.
9. Once slow administration of spinal anesthetic is performed, the needle and introducer are withdrawn as a unit.
10. The patient is then placed in the appropriate position to achieve proper anesthetic conditions.

Neuraxial (spinal or epidural) with preprocedural ultrasound

The use of preprocedural ultrasound benefits anesthesia providers in situations where spinal anatomy can be difficult through ease of use, enhanced spinal visualization, and effective planning (Kim et al., 2020). The common probe approaches are the longitudinal paramedian or transverse approach, the efficacy between the two approaches has not been highly researched, but the chosen approach relies on the clinician's experience and patient condition.

Longitudinal Paramedian Approach

1. The probe is positioned vertically over the sacral area (three centimeters left of the midline and angled medially).
   - The sacrum can be used as an identification landmark as it appears as a hyperechoic white line.
2. The probe is then moved cephalad until the vertebral laminae and the interspaces are identified.
   - As the probe is moved cephalad a hyperechoic saw-like image is seen and can be identified as the vertebral laminae and interspaces.
3. The level of the interspaces, starting with L5 to S1, can then be counted above the sacrum and marked for needle insertion.

Transverse Approach

1. The probe is positioned horizontally perpendicular to the sacral area and can be identified as midline with the presence of the spinal process.
   - The spinous process will be seen as a small hyperechoic structure following the skin and progresses deep as a long triangular hypoechoic acoustic shadow.
2. The probe is moved caudal or cephalad until an interspace is noted.
   - A flying bat can be used as a visual cue for the transverse approach with the articular processes as ears and transverse processes as wings. The position of the probe when the "flying bat" is identified is the angle at which the needle should be inserted.
3. The middle of the probe along the horizontal and vertical edges can now be marked on the skin, corresponding to the midline and interspace level,

- The ultrasound image can be frozen with the built-in caliper, and the distance from the skin to the epidural space can be measured.

4. The intersection of these two marks on the skin determines the needle puncture site.

Note: Adapted from Lamichhane-Wagle, S., & McGuire, A. (2022). Evidenced-based practice guideline development: Selection of local Anesthetics and additive dexamethasone in brachial plexus blocks. *Otterbein University Digital Commons*. https://digitalcommons.otterbein.edu/cgi/viewcontent.cgi?article=1059&context=stu_doc

Appendix E

Placement of Spinal Neuraxial Anesthesia with Preprocedural Ultrasound or Conventional Landmark Palpation Checklist		
Task	**Met**	**Not Met**
Performing anesthesia provider has reviewed the patient's history and assessed for indications, and contraindications for the procedure.	-	-
Performs a "time-out" and places monitors on the patient (cardiac leads, pulse oximetry, and NIBP).	-	-
Verifies that spinal or epidural kit tray, nonsterile and sterile gloves, and cleansing solution are present.	-	-
Palpates the superior aspects of the iliac crests and identifies the intersection at the L4 spinous process with nonsterile gloves on. Marks position at the L3/4 or L4/L5 interspace with finger indentation or marker.	-	-
Opens the spinal or epidural tray before placing sterile gloves on.	-	-
Puts on sterile gloves with proper technique.	-	-
Cleans the skin with an aseptic solution.	-	-
Applies sterile drapes.	-	-
Draws up medications in the appropriate syringes and checks dose, concentration, and volume.	-	-
Administers local anesthesia in a wheal at the previously marked site.	-	-
If preprocedural ultrasound is used, verification of appropriate transducer with sterile technique is used, and imaging characteristics are appropriate for the provider. Clearly announces the identification of spinal landmarks pertinent to the procedure. **(bypass step if preprocedural ultrasound is not indicated).**	-	-

Inserts the introducer needle until subarachnoid space is reached and cerebral spinal fluid (CSF) is noted.	-	-
Withdraws the stylet when CSF is obtained.	-	-
Confirms CSF flow by aspiration before and after injecting anesthetic.	-	-
Removes the spinal and introducer needle together once completed.	-	-
Outcome Evaluation		
Task	**Met**	**Not Met**
Blockade success.	-	-
First pass success.	-	-
Procedure completed under 240 seconds or 4 minutes.	-	-
Less than two needle redirections.	-	-
Needle reinsertion (needle taken out of skin and inserted again, indicate number of times in the comment section)		
No complications noted (e.g., post-dural headache, vascular puncture, LAST)	-	-
Additional Comments (please provide any pertinent notes regarding procedure):		

Note: Adapted from Udani, A.D., Macario, A., Nandagopal, K., Tanaka, M.A., & Tanaka, P. (2014). Simulation-based mastery learning with deliberate practice improves clinical performance in spinal anesthesia. *Anesthesiology Research and Practice.*

Placement of Epidural Neuraxial Neuraxial Anesthesia with Preprocedural Ultrasound or Conventional Landmark Palpation Checklist		
Task	**Met**	**Not Met**
Performing anesthesia provider has reviewed the patient's history and assessed for indications, and contraindications for the procedure.	-	-
Performs a "time-out" and places monitors on the patient (cardiac monitor, pulse oximetry, and NIBP).	-	-
Verifies that spinal or epidural kit tray, nonsterile and sterile gloves (appropriate size), and cleansing solution are present.	-	-
Palpates the superior aspects of the iliac crests and identifies the intersection at the L4 spinous process with nonsterile gloves on. Marks position at the L3/4 or L4/L5 interspace with finger indentation or sterile disposable marker.	-	-
Opens the spinal or epidural tray before placing sterile gloves on.	-	-
Puts on sterile gloves with proper technique.	-	-
Cleans the skin with an aseptic solution.	-	-
Applies sterile drapes.	-	-
Draws up medications in the appropriate syringes and checks dose, concentration, and volume.	-	-
Administers local anesthesia in a wheal at the previously marked site.	-	-
If preprocedural ultrasound is used, verification of appropriate transducer with sterile technique is used, and imaging characteristics are appropriate for provider. Clearly announces identification of spinal landmarks pertinent to procedure. **(bypass step if preprocedural ultrasound is not indicated).**	-	-
Inserts Tuohy needle into skin, advancing through subcutaneous	-	-

supraspinous ligament into interspinous ligament.		
Removal of inner stylet and attachment loss of resistance (LOR) syringe filled with air or saline.	-	-
Advances the Tuohy needle a few millimeters at a time, while tapping on the syringe plunger until LOR is achieved.	-	-
Appropriate measurement and insertion of epidural catheter.	-	-
Appropriate removal of epidural needle over the catheter with desired marking at the skin.	-	-
Attachment of connector and filter, aspirate to ensure there is no CSF.	-	-
Administration of test dose with 3 millimeters of 1.5% lidocaine with epinephrine.	-	-
Appropriate response from test dose is noted.	-	-
Securement of the catheter to the patient.	-	-
Outcome Evaluation		
Task	**Met**	**Not Met**
Blockade success.	-	-
First pass success.	-	-
Procedure completed under 240 seconds or 4 minutes.	-	-
Less than two needle redirections.	-	-
Needle reinsertion (needle taken out of skin and inserted again, indicate number of times in the comment section).		
No complications noted (e.g., post-dural headache, vascular puncture, LAST).	-	-

Additional Comments (please provide any pertinent notes regarding procedure):

Note: Adapted from Udani, A.D., Macario, A., Nandagopal, K., Tanaka, M.A., & Tanaka, P. (2014). Simulation-based mastery learning with deliberate practice improves clinical performance in spinal anesthesia. *Anesthesiology Research and Practice.*

Appendix F

Table 1

Estimated Timeline of Implementation of Guidelines for Preprocedural Ultrasound in Neuraxial Placement for Obstetric Patients with Scoliosis

<table>
<tr><th>Task</th><th colspan="12">Month</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>Development of Guidelines</td><td></td><td colspan="11"></td></tr>
<tr><td>Training, Purchasing, and Technology</td><td colspan="4"></td><td colspan="8"></td></tr>
<tr><td>Implementation of Guidelines</td><td colspan="4"></td><td colspan="8"></td></tr>
<tr><td>Compliance and Outcomes</td><td colspan="5"></td><td colspan="7"></td></tr>
<tr><td>Evaluation and Adjustment</td><td colspan="5"></td><td colspan="7"></td></tr>
</table>

Appendix G

Table 2

Estimated Budget for Implementation of Guidelines for Preprocedural Ultrasound in Neuraxial Placement for Obstetric Patients with Scoliosis

Expense	Hours	Pay Rate	Cost
Labor Costs			
Information Technology Specialist	10	$31.54	$315.40
Quality Improvement Specialist	24	$29.14	$407.96
Capital Costs			
Obstetric Nurse Training	4	$37.01	$148.04
Anesthesia Provider Training	6	$63.00 to $194.00	$378.00 - $1,164.00
Ultrasound Machine	-	-	$7,000 – 72,000
Other			
Acquiring Educational Resources	-	-	$0.00 (open access resources)
Total			$8,249.40 - $74,034.40