

**Efficacy of Pre-procedural Ultrasound in Facilitating Neuraxial Anesthetics: An
Integrative Review**

Jonathan Brinser, BSN

Bryan College of Health Sciences

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JonBrinser@gmail.com

Abstract

The purpose of this integrative review is to investigate the efficacy of pre-procedural ultrasound examination to facilitate neuraxial anesthesia techniques and its impact on first attempt success rates, number of attempts required, and duration of procedure. A literature review was performed to obtain current research involving the use of ultrasound for neuraxial anesthesia. Fourteen randomized-control trials (RCT) met criteria and were included in this review. Six RCTs^{1,4,5,11,21,22} demonstrate significant increases in first attempt success rates and four RCTs¹⁷⁻²⁰ suggest no significant difference in the first attempt success rate when ultrasound is utilized for neuraxial anesthesia techniques. Ten of the RCTs^{1,4,5,11,21-26} suggest that the use of pre-procedural ultrasound examination significantly reduces the number of attempts required for neuraxial anesthesia techniques while three¹⁷⁻¹⁹ found no significant difference. Four out of five RCTs found a significant increase in total duration of the procedure when pre-procedural ultrasound examination was utilized.^{1,5,17,21} The most striking benefit of pre-procedural ultrasound examination is the reduction in number of attempts required for successful neuraxial anesthetics. Pre-procedural ultrasound is particularly beneficial in the obese patient population in whom landmarks are difficult to palpate.

Keywords – neuraxial, ultrasound, spinal, epidural.

Introduction

Neuraxial anesthesia techniques, such as spinal, epidural, and combined spinal-epidural (CSE) anesthesia, have been well established and are frequently used for various anesthesia applications. Traditional techniques require palpation of anatomical landmarks to identify the optimal puncture site.¹ However, research indicates that palpation of neuraxial landmarks for determination of puncture site is frequently inaccurate²⁻⁴ and increasingly difficult, especially in the obese population.^{4,5} A study by Furness et al.² demonstrated that the intercrystal line was correctly identified by palpation only 30% of the time.

The difficulty with which landmarks can be palpated is directly associated with the degree of technical difficulty of successfully performing neuraxial anesthetic techniques.⁶⁻¹⁰ It is not uncommon for multiple attempts to be required for success, especially in the obese population.⁵ Multiple attempts increase the risk of complications associated with neuraxial anesthesia such as unintended dural puncture, headache, backache, and epidural hematoma.^{5,6,11}

The use of ultrasound scanning to facilitate neuraxial techniques has been described in the literature as early as 1971.¹² With the use of pre-procedural ultrasound examination, users can identify intervertebral spaces, vertebral midline, depth to epidural or subarachnoid space, and optimal angle of needle insertion.^{2,13-16} This review focuses specifically on the use of pre-procedural ultrasound examination and not real-time ultrasound guidance.

The purpose of this integrative review is to investigate the efficacy of pre-procedural ultrasound examination to facilitate neuraxial anesthesia techniques and its impact on first attempt success rates, number of attempts required, and duration of procedure.

Methods

A literature review was performed searching CINAHL, Cochrane collection, MedlinePlus, PubMed, UpToDate, and all databases available to Bryan College of Health Sciences to obtain current research involving the use of ultrasound for neuraxial anesthesia. Search terms included: ultrasound, neuraxial, lumbar, epidural, spinal, subarachnoid block, SAB, intrathecal, combined spinal-epidural, CSE, anesthesia. Literature involving pediatrics, neonates, emergency room diagnostic procedures, and real-time ultrasound guidance was excluded from this review.

Review of Literature

Fourteen randomized-control trials (RCT) met the criteria and were included in this review. The RCTs include obstetric, orthopedic, and general adult surgery populations with a total of 1,858 participants. The 14 randomized-control trials were examined in order to deliver evidence pertaining to the impact of pre-procedural ultrasound examination on first attempt success, number of attempts required, and duration of neuraxial anesthesia techniques.

First Attempt Success

A total of 10 RCTs examined the first attempt success rate of neuraxial anesthetics with utilization of pre-procedural ultrasound examination compared to use of the traditional palpation technique.^{1,4,5,11,17-22} Five of the trials defined an attempt as any forward advancement of the needle and 5 defined an attempt as any new skin puncture. Six RCTs^{1,4,5,11,21,22} demonstrate significant increases in first attempt success rates when pre-procedural ultrasound examination is utilized for neuraxial anesthesia techniques. Of the six RCTs, one excluded patients with obesity²¹ and three^{1,5,11} exclusively investigated patients with obesity, impalpable landmarks, scoliosis, or previous back surgery. In an RCT investigating patients with normal surface anatomic landmarks undergoing spinal anesthesia, Abdelhamid et al.²¹ found a first attempt success rate of 80% in the ultrasound group and 37.8% in the control group. In a trial examining 121 orthopedic patients with difficult surface anatomic landmarks, Chin et al.¹ found the first attempt success rate to be twice as high when pre-procedural ultrasound was utilized compared with conventional techniques. Among obese parturients, Sahin et al.¹¹ found first attempt success rates of 92% in the ultrasound group and 44% in the control group.

Data from four RCTs¹⁷⁻²⁰ suggest no significant difference in the first attempt success rate when ultrasound is utilized for neuraxial anesthesia techniques. Of the four randomized control trials, three¹⁷⁻¹⁹ either exclusively included patients with easily palpable landmarks or excluded patients with obesity or impalpable landmarks. The sole RCT²⁰ that did not exclude patients with obesity or impalpable landmarks studied 170 patients undergoing spinal anesthetic in the general adult population and revealed an average participant BMI of 25 kg/m². In this trial, the first attempt success rate was 64% with the use of ultrasound and 52% with manual palpation and this difference did not reach statistical significance.²⁰ An RCT conducted by Ansari et al.¹⁸

demonstrated no significant difference in first attempt success between the ultrasound and control groups when used by experts for spinal anesthesia in 150 non-obese parturients with easily palpable spines.

Number of Attempts

A total of 13 RCTs examined the number of attempts required for neuraxial anesthetics when utilizing ultrasound examination compared to the traditional palpation technique.^{1,4,5,11,17-19,21-26} Five articles defined an attempt as any forward advancement of the needle and five defined an attempt as any new skin puncture. Ten of the RCTs suggest that the use of pre-procedural ultrasound examination significantly reduces the number of attempts required for neuraxial anesthesia techniques.^{1,4,5,11,21-26} Four of the RCTs specifically investigated patients with obesity, a history of difficult epidural anesthesia, or conditions associated with difficult neuraxial anesthesia.^{1,5,11,24} In an RCT including 370 parturients, Vallejo et al.²⁶ demonstrated a significant reduction in number of attempts for epidural placement when pre-procedural ultrasound was performed. Chin et al.¹ investigated the use of neuraxial ultrasound for performing spinal anesthesia in 120 orthopedic patients with difficult surface anatomic landmarks and reported a two-fold decrease in number of attempts when ultrasound was utilized. A systematic review and meta-analysis by Perlas et al.²⁷ concluded that utilization of pre-procedural ultrasound decreases the number of needle punctures required in patients with normal surface landmarks as well as patients with anticipated difficulty due to obesity, scoliosis, or previous spinal surgery.

Three of the thirteen RCTs evaluating the impact of pre-procedural ultrasound on the number of attempts required for neuraxial anesthesia do not demonstrate a significant difference when compared with traditional techniques.¹⁷⁻¹⁹ These three trials excluded patients with obesity or difficult to palpate landmarks. In a study examining CSE performance in 108 parturients with a BMI less than 35 kg/m² and palpable landmarks, Tawfik et al.¹⁹ found no significant difference in number of needle passes or skin punctures between ultrasound and control groups.

Duration of Procedure

Seven RCTs evaluated the time required to identify the puncture site when using ultrasound examination compared to the traditional palpation technique.^{1,4,5,21-23,25} Six of the seven RCTs found a significant increase in the time required to identify the puncture site when the ultrasound technique was utilized.^{1,4,5,21-23} Kallidaikurichi Srinivasan et al.²² reported an average increase of 81.5 seconds in time required to identify the puncture site when using the ultrasound method. Nassar et al.⁴ examined pre-procedural ultrasound facilitated CSE insertion in 110 parturients and revealed mean times to identify puncture site of 3.0 (+/- 0.8) minutes and 0.4 (+/- 0.2) minutes in the ultrasound and control groups, respectively.

Four out of five RCTs found a significant increase in total duration of the procedure when pre-procedural ultrasound examination was utilized.^{1,5,17,21} Wang et al.⁵ discovered the mean duration for the total CSE procedure in obese parturients to be 9.37 (+/- 1.35) minutes in the ultrasound group and 7.67 (+/- 1.52) minutes in the palpation group. Chin et al.¹ found the mean total procedure time to be increased by 4.2 minutes (12.2 +/- 6.0 versus 7.9 +/- 7.7) when pre-

procedural ultrasound was utilized for spinal anesthesia in orthopedic patients with difficult surface anatomic landmarks.

Nine RCTs evaluated the time required to perform the anesthetic technique, not including the time required to identify the puncture site.^{1,4,11,17-22} Four^{1,11,20,21} found a significant decrease, three^{17,18,22} found a decrease that failed to reach statistical significance, and one⁴ found a significant increase in the time required to complete the anesthetic technique after ultrasound was utilized to identify the puncture site. In orthopedic patients with difficult surface anatomic landmarks, Chin et al.¹ revealed a decrease in mean time required to perform the spinal anesthetic when pre-procedural ultrasound was utilized. The mean time required to perform the spinal anesthetic was 5.0 (+/- 4.9) minutes in the ultrasound group and 7.3 (+/- 7.6) minutes in the palpation group. Sahin et al.¹¹ demonstrated decreased median spinal procedure times of 22 seconds in the ultrasound group and 52 seconds in the control group.

Discussion

Although the evidence indicates improved first attempt success rate, the most striking benefit of pre-procedural ultrasound examination is the reduction in number of attempts required for success. The only evidence denying a significant improvement in first attempt success rate or number of attempts comes from three RCTs that either excluded patients without easily palpable landmarks, excluded patients with obesity, or utilized a sample with an average BMI of 25 kg/m². However, several other RCTs did find significant improvement even when examining this same patient population.^{5,11,21} Thus, the evidence examined in this review regarding efficacy of

pre-procedural ultrasound examination is least consistent in the non-obese and/or easily palpable landmark population. Even so, a current systematic review and meta-analysis concludes that “neuraxial ultrasound increases the efficacy of lumbar epidural or spinal anesthesia by decreasing the risk of technical failure and the number of needle punctures required, both in patients with normal surface landmarks and those at risk of difficult insertion due to obesity, scoliosis, or previous spine surgery”.²⁷ Pre-procedural ultrasound seems to be particularly beneficial in the obese patient population in whom landmarks are difficult to palpate.

The increase in time required to identify the puncture site using ultrasound may be partially offset by the trend towards a reduction in time required to perform the actual procedure. Furthermore, it is during this time that the patient is most likely to experience discomfort and be exposed to risks associated with the procedure.⁶ More research is required to determine the impact of pre-procedural ultrasound on the duration of the procedure as well as the magnitude and importance of this impact.

It is evident that the use of pre-procedural ultrasound reduces the number of attempts and thus reduces one of the factors associated with risk of complications. However, a primary barrier to its acceptance into routine practice may be the fact that many practitioners are not familiar with neuraxial sonoanatomy or the technical performance of the procedure. This is compounded by the additional time required to identify the puncture site when using pre-procedural ultrasound examination. Therefore, it is unlikely that the routine use of pre-procedural ultrasound will become standard practice for all patients in the near future.

Due to the fact that the total procedure time is increased by pre-procedural ultrasound examination, it is feasible it will most often be utilized specifically for patients with expected difficulty and in situations where time constraints are of little concern. Pre-procedural ultrasound may not replace the traditional palpation technique; rather, it may be utilized as an adjunct to facilitate neuraxial anesthetic procedures for patients in which difficulty is anticipated. More research is necessary to determine the feasibility of pre-procedural ultrasound examination and in which populations and settings it is most practical for routine application.

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