3 Overview of Regional Anesthesia

Stephen Davies, Emily Zoe Barney Hall, Jeffrey C. Gadsden, and W. Michael Bullock

Abstract

Spine surgery is complex. From surgical procedures to analgesia to patient factors, spine surgery warrants special consideration to improve the patient experience and outcomes. Patient-centered protocols offer a better path to success by improving surgical and anesthetic techniques, developing analgesic modalities, and hastening functional outcomes. Awake spine surgery touts many patient-centered benefits and is a novel approach to these procedures. Given the unique needs of both patient and surgeon in this setting, regional anesthesia is the cornerstone of intraoperative success and postoperative pain management. A wide array of regional anesthesia techniques addresses the need for intraoperative analgesia while concurrently forming a strong foundation for a multimodal approach to postoperative pain control.

Keywords: regional anesthesia, postoperative pain control, spinal anesthesia, epidural, paravertebral blocks, erector spinae plane blocks, quadratus lumborum blocks, classical transversus abdominis plane blocks

Key Points

- Spine surgery is reported to be among the most painful surgical procedures and poses significant challenges for pain management. Adverse outcomes associated with poorly controlled pain are well documented, as are the positive effects of multimodal pain control.[1,2]
- Awake approaches to spine surgery demonstrate a clear potential for improved patient outcomes and rely largely on regional anesthesia techniques.
- The most relevant regional anesthesia techniques for spine surgery include spinal anesthesia, epidural anesthesia, paravertebral blocks, erector spinae plane blocks, quadratus lumborum blocks, and anterior transversus abdominis plane blocks.
- Regional anesthesia techniques are imperative for both intraoperative analgesia and postoperative pain management, expanding the population who are eligible to undergo spine procedures and demonstrating a variety of improved outcomes.

3.1 Introduction

When examining the current literature, it becomes highly evident that spine surgery is painful. Severe and diffuse pain has been reported in the postoperative time frame, with median pain scores (using the 0–10 numerical rating scale [NRS]) on the first postoperative day ranging from 5 (spinal decompression) to 7 (spinal fusion).[3,4] Additionally, the negative consequences of poorly controlled postoperative pain are significant, ranging from delayed mobilization or pulmonary and thromboembolic events to prolonged hospital stays and the development of chronic pain syndromes.[5] Conversely, patients who experience effective postoperative pain management report increased satisfaction, as well as earlier mobilization and prevention of pulmonary and thromboembolic complications, leading to reduced postoperative mortality and morbidity.[6] Based on these findings, steps must be taken to ensure the best possible postoperative analgesia for spine surgery patients by utilizing a multimodal approach.

Expert Tip

Enhanced recovery after surgery (ERAS) protocols are multidisciplinary approaches that have been developed for almost every type of surgery to improve patient outcomes. They incorporate early function, diet and fluid balance, and analgesia. If protocols need to be developed, consult primary stakeholders (surgery, anesthesia, nursing, physical therapy, etc.).

Regional anesthesia (RA) proves particularly useful among the array of options for multimodal analgesia, specifically in the growing field of awake

spine surgery. These techniques offer a unique combination of intraoperative anesthesia and analgesia and prolonged postoperative pain control. Awake techniques for spine surgery have been used for various spine procedures, including, but not limited to, laminectomy, diskectomy, anterior cervical diskectomy and fusion, lumbar fusion, and dorsal column stimulator placement.[7] This chapter will introduce various RA techniques that are beneficial and relevant to both "asleep" and "awake" spine procedures.

Expert Tip

"Awake" spine surgery can be a misnomer, as the anesthesia given can range from no anesthesia to minimal sedation to deeper levels of sedation. Essentially, these procedures are performed without general anesthesia. The decision to perform an "awake" spine case is made jointly by the surgeon and anesthesiologist based on patient factors.

3.2 Blocks for Spine Surgery

This chapter provides an overview of many of the available and beneficial methods to implement RA in spine surgery.

3.2.1 Spinal

- The goal of spinal anesthesia is the deposition of local anesthetic, with or without opioid in the intrathecal space, resulting in surgical anesthesia up to approximately the T6 level.
- This technique is the cornerstone of anesthesia and analgesia required for awake spine surgery, as it ensures that the patient is insensate and comfortable throughout the operation. Neuraxial placement technique and duration are primarily up to the provider's comfort and local anesthetic choice.[8]
- The choice of local anesthetic for spinal in awake spine surgery is multifactorial. It is mainly based on the spinal level(s) and duration of surgery.

Expert Tip

Spinals are best performed in the operating room. Immediately after spinal placement, patients can help position themselves on the operating room (OR) table. Any additional RA techniques for post-op analgesia can be done before the spinal is placed or after the patient is positioned on the OR table.

Expert Tip

If the spinal anesthesia is wearing off (i.e., the patient begins to feel the operative area during surgery), the surgeon can re-dose using a spinal needle as the dura is in their sterile field.

3.2.2 Epidural

- Epidural administration of local anesthetic and/or opiates provides profound and durable analgesia, the level of which is dictated by the site of placement and volume of injectate.
- While epidural analgesia has demonstrated clear benefit in multiple types of abdominal surgeries, there have been inconsistent data regarding its benefit in posterior spinal fusions.[9]
- Patients cannot be discharged with an epidural catheter, so other RA techniques have been developed to provide adequate analgesia while maintaining functionality (see below).

Expert Tip

Epidural analgesia is mainly performed for asleep spine surgery and more significant spine cases. If an epidural is warranted, it is generally best performed by the surgeon at the conclusion of surgery if an epidural space is present or at the next best location with an existing epidural space.

3.2.3 Paravertebral Blocks

- Currently widely employed in chest and abdominal surgery, paravertebral blocks (PVBs) provide reliable somatic and visceral coverage. They can anesthetize both the ventral and dorsal rami of the spinal nerve as it exits the intervertebral foramen and the sympathetic ganglia at that level of the spine (▶ Fig. 3.1).
- These can be performed as a single shot block, or a catheter can be placed.
- Data regarding PVB usage in spine surgery are sparse and inconclusive. Small prospective trials showed initial benefits, albeit brief, and more data are needed to establish their role in analgesia for spine surgery.[10]

3.2.4 Erector Spinae Plane Block

- Previously used for abdominal, thoracic, and breast procedures, the erector spinae plane (ESP) block aims to deliver local anesthetic between the transverse process and erector spinae muscles (see Chapter 4 for further discussion). This targets the dorsal rami of the corresponding spinal nerves as they exit at this level.
- These can be performed as a single shot block, or a catheter can be placed.
- The use of the ESP block in spine surgery is well demonstrated in the literature to decrease opioid consumption, increase patient satisfaction, decrease patient-reported pain, decrease length of stay, and decrease the rate of postoperative complications.[11]

3.2.5 Quadratus Lumborum Block

- Originally described as a variation of the transversus abdominis plane (TAP) block, the quadratus lumborum (QL) block, in every variation, aims to deposit local anesthesia in a manner that allows spread around the QL muscle and into the thoracolumbar fascia (see Chapter 9 for further discussion). At this point, both anterior divisions of spinal nerves and sympathetic ganglia within the thoracolumbar fascia are anesthetized, providing somatic and visceral analgesia.
- This block typically provides analgesia in the T7–L1 dermatomes, with additional spread into the thoracolumbar fascia and possibly paravertebral space. This spread allows for the blockade of sympathetic fibers as well as visceral analgesia, a notable and unique aspect of this truncal block.[12]
- These can be performed as a single shot block, or a catheter can be placed.

3.2.6 Classical Transversus Abdominis Plane Block

- Currently used in ERAS protocols for many different types of abdominal and gynecologic surgeries, the TAP block has proven safe and efficacious in reducing pain and opiate consumption postoperatively.
- Local anesthetic deposited in the TAP plane reliably anesthetizes anterior divisions of spinal nerves T6–L1, providing analgesia to the anterior abdominal wall inferior to the umbilicus.[13]
- These can be performed as a single shot block, or a catheter can be placed.

Expert Tip

Ultrasound guidance is instrumental in ensuring RA success and enhancing safety when performing PVB, ESP, QL, and TAP blocks. It can also assist the provider in identifying important landmarks when performing spinal and epidural techniques. It is difficult to perform neuraxial techniques under real-time guidance and should only be attempted by providers adept at both neuraxial and ultrasound techniques.

3.3 Benefits of Regional Anesthesia for Awake Spine Surgery

- The aforementioned truncal blocks have already been implemented in spine surgeries performed under general anesthesia (GA). For example, studies examining the outcomes of the addition of ESP blocks in “asleep” spine surgeries tout decreased opioid use, prolonged time to the first rescue analgesic, reduced number of patients who required rescue analgesia, lowered incidence of postoperative nausea and vomiting (PONV), and increased patient satisfaction.[14,15,16]

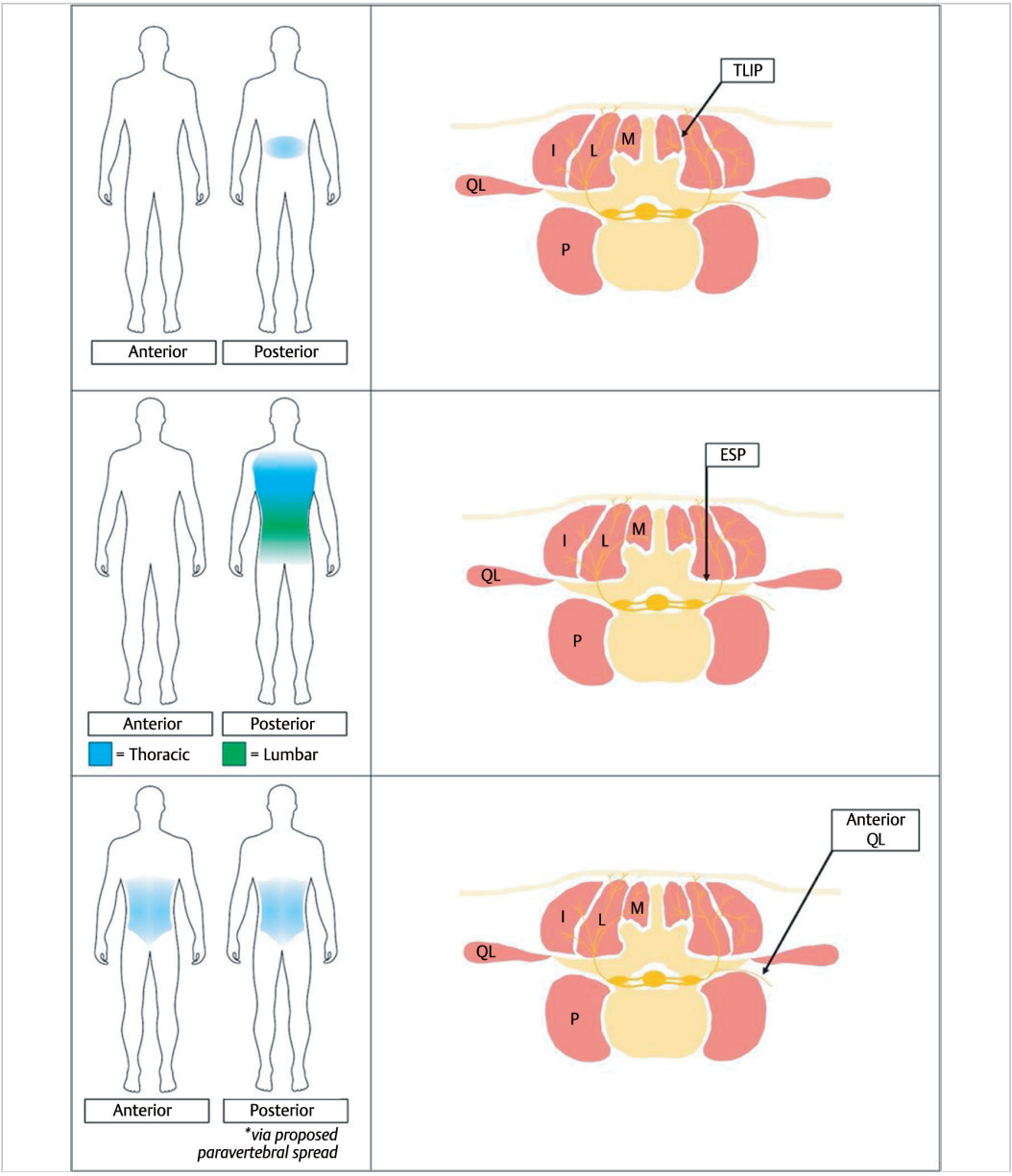

Fig. 3.1 Schematic showing the anatomy of the injection site and area of coverage associated with TLIP, erector spinae plane (ESP), and quadratus lumborum (QL) blocks. A TLIP block placed between the multifidus and longissimus will anesthetize the area two to three levels above and below the injection site. In ESP blocks, injected local anesthetic spreads between the transverse process and erector spinae. Both thoracic and lumbar ESP blocks are used, producing anesthesia of the dorsal rami. Local anesthetic is deposited along the QL in QL blocks, anesthetizing the ventral rami for anterior coverage, while proposed paravertebral anesthetic spread allows for posterior coverage. ESP, erector spinae plane; QL, quaratus lumborum; TLIP, thoracolumbar interfascial plane. (Reproduced from Salven DS, Sykes DAW, Erickson MM, et al. Regional anesthesia in spine surgery: a narrative review. J Spine Pract 2023;2:40–50. Open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0).)

- There are significantly fewer studies examining the use and outcomes of RA for awake spine surgery, but early findings suggest similar benefits and improvement in patient outcomes. That said, current evidence provides a promising outlook on these techniques:
  - By meta-analysis, spine surgeries utilizing a spinal anesthetic have been associated with a reduced incidence of PONV, shorter length of hospital stay, and lower intraoperative blood loss.[8,17] The addition of the ESP to a spinal anesthetic revealed a further reduction in opioid use.[18]
  - Compared to a general anesthetic approach, cases that utilized a spinal anesthetic demonstrated decreased rates of PONV, decreased total operative time, improved positioning, increased efficiency, decreased OR cost, decreased blood loss, and decreased length of time in postanesthesia care unit.[19]
  - RA has been associated with less need for intravenous vasoactive agents given a decrease in intraoperative cardiopulmonary lability.[20]
- Additionally, RA provides an alternative anesthetic option for those patients who would be considered at high risk of an adverse event secondary to their comorbidities should they undergo a general anesthetic.[21]
  - One of the ultimate achievements of employing a RA technique for awake spine surgery is sparing the patient exposure to GA.
  - As a blossoming field of research, current data indicate that there are fewer adverse effects to a regional anesthetic compared to a general anesthetic, especially as it relates to the aged brain; in these patients, GA can be a risk of long-lasting cognitive functional impairments.[22]
  - Investigations into the role of GA as a causal mechanism involved in perioperative cognitive disorders implicate alterations to tau protein, inflammation, calcium dysregulation, and mitochondrial dysfunction.[23]
  - Further research continues to examine whether reduced *depth* of anesthesia using spinal anesthesia reduces the incidence of delirium.[24]

3.4 Conclusion

- Many RA techniques are relevant and beneficial for intraoperative and postoperative analgesia in patients undergoing awake spine surgery.
- Each technique has nuanced differences that require thoughtful preparation and discussion between anesthesia and surgical colleagues to develop an appropriate and patient-specific plan.
- While data regarding the improved outcomes for awake spine surgery when utilizing RA techniques are still limited, early signals indicate an array of benefits, including an increased cohort of surgical candidates, reduced length of hospital stay, reduced opioid use, earlier ambulation, reduced PONV, and decreased intraoperative blood loss.

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4 Erector Spinae Plane Blocks

Emily Zoe Barney Hall and W. Michael Bullock

Abstract
The erector spinae plane (ESP) block is a fascial plane block that targets the dorsal spinal nerve roots (rami) prior to traveling through the paraspinal muscles toward more superficial structures. Given that these nerves innervate the posterior spinal structures that are violated in spine surgeries, they are safe, easy, and efficient targets for depositing local anesthetics to achieve intraoperative and postoperative analgesia for posterior spine procedures. While current literature is blossoming with examples of improved patient outcomes when the ESP block is added to traditional anesthetics for lumbar spine surgery, significantly less data exist regarding the same regional anesthetic technique as it applies to awake spine surgery.

Keywords: erector spinae, ESP, regional anesthesia, awake spine surgery, postoperative pain control, truncal blocks

Key Points

- ESP blocks intend to anesthetize the dorsal rami of the spinal nerves by depositing local anesthetic between the deep fascia of the erector spinae muscles and the vertebral transverse process.
- This paraspinal fascial plane block has a bony landmark as an endpoint, making it safe and easy to teach.
- This technique should be performed bilaterally to achieve optimal analgesia.
- Multiple lumbar levels are anesthetized with higher volumes of dilute local anesthetics with one injection.
- A growing body of data demonstrates that the addition of the ESP block to a general anesthetic will decrease postoperative opioid use, lower rates of postoperative nausea and vomiting, increase patient satisfaction, reduce patient-reported pain scores, and decrease length of stay.[1]

4.1 Introduction

The erector spinae plane (ESP) block was first described by Forero et al in 2016 as a means of treating thoracic neuropathic pain.[2] Since then, this paraspinal interfacial plane block has become popular among regional anesthesiologists for various indications. The increase in utilization of the ESP block is likely multifactorial, but, in the era of ultrasonographical guided procedures, it is tied closely to the ease of application, low complication rates, effective postoperative analgesia, and reduction of opioid consumption seen with other fascial plane blocks.[3] Similar findings have been echoed in the literature surrounding the addition of the ESP block to traditional general anesthetics for lumbar spine surgery.[1] This chapter will discuss the relevant anatomy, block performance, function, and current data supporting the use of the ESP block for awake spine surgery.

4.2 Erector Spinae Plane Block

4.2.1 Relevant Anatomy

- The erector spinae muscles are a group of paraspinal muscles that run vertically in the groove lateral to the vertebral column from the base of the skull to the pelvis. This group consists of iliocostalis, longissimus, and spinalis from lateral to medial and lies deep to the thoracolumbar fascia.
- The erector spinae muscles are innervated by the dorsal rami of corresponding spinal nerves and aid with back and head extension.
- The dorsal rami of the spinal nerves, which are also responsible for innervating the posterior spinal structures and their associated tissues, can be found close to where they exit the vertebral foramina. They will then travel posteriorly through the intertransverse connective tissues and paraspinal muscles to reach more superficial layers[4] (▶ Fig. 4.1).

4.2.2 Block Function

- Pain after spine surgery can arise from any violated layer, ranging from skin, muscle, and

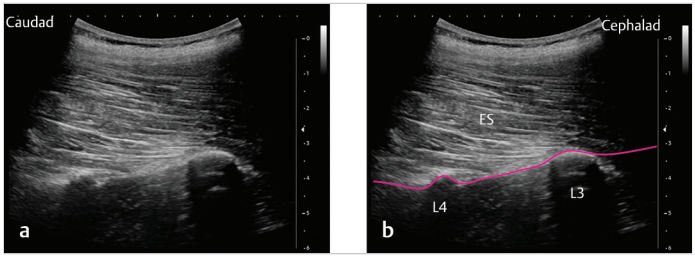

Fig. 4.1 **(a)** Ultrasound image of lumbar spine area using a curvilinear transducer. **(b)** Outline of the anterior border of the erector spinae muscles over the L3 and L4 transverse processes. ES, erector spinae muscle. Depth is in centimeters.

fascia to vertebra, ligaments, and facet joints. The dorsal rami of the spinal nerves innervate all of the aforementioned posterior tissues and bony structures.[5]

- The ESP blocks anesthetize the dorsal rami of the spinal nerves by depositing local anesthetic in the interfascial plane between the erector spinae muscles and the vertebral transverse process.
- While there remains controversy surrounding the definite mechanism of the ESP block in both cadaveric and radiologic studies, block efficacy is thought to be related to the spread of local anesthetic to the paravertebral or epidural space at the corresponding vertebral levels.[2,6]
- This block is safe and ideal for practitioners who do not frequently utilize regional anesthesia. Ultrasound image acquisition is simple, and the endpoint of the transverse process provides a "bony backstop."

4.2.3 Block Performance

- The anesthesia team typically performs the ESP block in the preoperative area with the patient under light sedation, allowing time for the block to onset while the patient is transferred to the operating room (OR) and appropriately positioned for the procedure.[7] However, these blocks can also be performed in the OR.
- After having the patient either in a sitting position (preop) or prone (after induction of anesthesia in the OR), the low-frequency curvilinear ultrasound probe is placed in a parasagittal orientation 1 to 3 cm off midline. The sacrum is identified, and laminar levels are counted in a cephalad direction to the approximate midpoint of the surgical spinal area. After determining the desired location, lateral translation of the probe is necessary to visualize the transverse processes. The optimal image for block performance clearly demonstrates multiple levels of transverse processes with overlying erector spinae muscles.

Expert Tip

The ESP block can be performed with the patient in a sitting position, lateral, or prone based on the operator's preference, patient comfort, or timing of the block.

Expert Tip

While the ideal level for the ESP block is the surgical area's midpoint level, the block performance level is dictated mainly by the clarity of the image and patient anatomy. Suppose conditions do not allow for transverse process contact directly at the midpoint level. In that case, a dilute local anesthetic of approximately 30 mL will spread approximately four lumbar levels, providing some flexibility for block location.

- A chlorhexidine-based prep is used to clean the skin over the area of the needle insertion site; however, other appropriate antiseptics may be used.
- The block needle is then advanced under ultrasound guidance from cranial to caudal via an in-plane approach, passing through the erector spinae muscles until reaching the transverse process.
- The endpoint is needle-to-bone contact on the dorsal surface of the transverse process such that, after negative aspiration, a test injection of saline demonstrates spread along the submuscular plane between the erector spinae and the transverse process in both a cephalad and a caudad direction.

Expert Tip

Intramuscular spread is more common when the needle contacts the top of the transverse process. Aiming for the upper corners of the transverse process increases the chances for successful interfascial plane injection. This will facilitate lifting the muscle and the fascia from the bone when injecting the local anesthetic.

Expert Tip

If the operator is in the correct plane, the local anesthetic injection should expand the interfascial plane area. Once the injection is stopped, the muscle slowly sinks back toward the transverse process, pushing the injectate throughout the interfascial plane. This is called the "breathing sign" and indicates a successful block.

- After location confirmation, the anesthesiologist's local anesthetic of choice will be delivered incrementally in the same plane.
- The same procedure is then performed on the contralateral side.
- These can be performed as single-shot blocks or fascial plane catheters. If implemented as single-shot blocks, they can be prolonged with additive medications such as epinephrine, dexamethasone, dexmedetomidine, or liposomal bupivacaine.
- The addition of liposomal bupivacaine (Exparel, Pacira Biosciences, Tampa, FL) to extend the benefits of the ESP block have been studied for a variety of surgical indications, and may decrease length of hospital stay, time to ambulation, postoperative pain, and narcotic use (▶ Fig. 4.2).[8,9,10]

Expert Tip

In our practice, 20 mL of liposomal bupivacaine (Exparel, Pacira Biosciences) admixed with 30 mL of 0.5% bupivacaine HCl (for a total of 50–25 mL per side) is the local anesthetic of choice for both intraoperative and postoperative analgesia.[11]

4.3 Erector Spinae Plane Data

4.3.1 Data for General Anesthesia in Spine Surgeries

- A growing body of literature surrounds the benefits of adding ESP blocks for postoperative pain control for spine surgeries performed under a general aesthetic.[12]
- Current evidence demonstrates the ESP's ability to reduce opioid utilization significantly, decrease postoperative pain scores, prolong time to first rescue analgesic, lessen the number of patients requiring rescue analgesia, and lower the incidence of postop nausea and vomiting. One notable study of 700 patients revealed a significant decrease in morphine utilization in patients who underwent ESP in the first 24 hours following surgery compared to a control group.[13,14] Additional studies revealed better patient satisfaction and earlier time to ambulation in patients who underwent lumbar spine surgery under general anesthesia supplemented with ESP.[15]
- Randomized controlled trials in patients requiring lumbar spine surgeries exhibit reduced pain scores and decreased opioid consumption compared to control groups.[16] This difference was limited in studies incorporating Enhanced Recovery After Surgery (ERAS) protocols.[17]

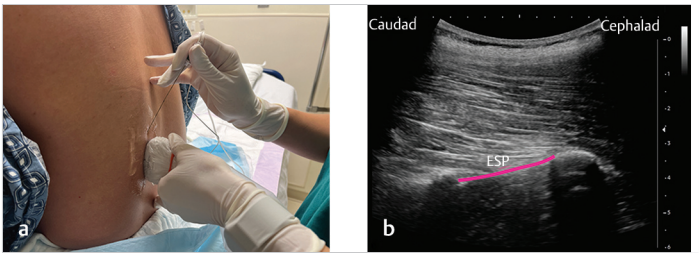

Fig. 4.2 **(a)** The patient is shown positioned sitting for ESP block. **(b)** Block area for ESP block. ESP, erector spinae plane (*pink*). Depth is in centimeters.

4.3.2 Data for Awake Spine Surgery

- Very little research has been published on the niche topic of ESP blocks for awake spine surgery, and current literature searches are limited mainly to case reports.
- One case report demonstrated the successful utility of the ESP block's analgesic properties for minimally invasive endoscopic diskectomy in the awake state.[18]
- Another case report employed ESP block catheters to allow for continuous infusion of local anesthetic to improve the management of acute postoperative pain following minimally invasive transforaminal lumbar interbody fusion.[19]
- The only current prospective randomized controlled trial tested the hypothesis that ESP block plus sedation was as effective as local infiltration anesthesia with fentanyl and propofol plus sedation. In this study, the primary endpoint was the volume of fentanyl and propofol administered during surgery. The authors found that patients who underwent ESP block plus sedation required lower doses of fentanyl and propofol during surgery than those who had local infiltration. The group that received local infiltration anesthesia resulted in the need for deeper sedation and had a higher complication rate, but pain management and patient satisfaction were the same between groups.[20]
- Based on the limited data available on this topic, further research regarding the role of ESP blocks is required to carve out the benefits and ideal population for this anesthetic technique.

4.4 Clinical Example

An 84-year-old woman with right leg radiculopathy presents for L3 laminectomy. Her medical comorbidities include severe chronic obstructive pulmonary disease (on 2 L of O_2 at baseline), coronary artery disease with left ventricular ejection fraction of 35%, hypertension, and type 2 diabetes mellitus. She was offered an awake spine surgery to minimize complications from surgery and anesthesia secondary to her medical issues (possible prolonged intubation and opioid-related side effects). She was given a 10-mg isobaric bupivacaine spinal in the OR, aids in positioning herself on the OR table, and then given bilateral ESP blocks at L3. She was given headphones to listen to a podcast. Surgery proceeds without incident, and she is taken to the postanesthesia recovery area (PACU). She does not ask for or receive any opioid medications in recovery and is monitored overnight, given her comorbidities. She was discharged the following morning.

4.5 Conclusion

The ESP block is a fascial plane block that anesthetizes the dorsal rami of the spinal nerves. Depending on the patient's needs, this regional anesthesia technique can be performed as a single-shot block or with catheter placement. As it has proven beneficial in spine surgery under general anesthesia, integrating ESP blocks for awake spine surgery holds significant promise for patient-centered outcomes. Because of the ease and efficiency of this block, it can be easily integrated into the workflow of the anesthetic and operative teams.

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