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HOT TOPICS IN PAIN AND HEADACHE (N ROSEN, SECTION EDITOR)

Expanding Role of the Erector Spinae Plane Block for Postoperative and Chronic Pain Management

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Abstract

Purpose of Review The erector spinae plane block (ESPB), first described in 2016, offers the promise of becoming a safe, less invasive, and technically less demanding alternative to conventional thoracic regional anesthetic techniques including thoracic epidurals and traditional paravertebral blocks. Clinical and cadaveric studies suggest that ESPB acts on the ventral rami of spinal nerves in the paravertebral space via penetration of the intertransverse connection tissues and moreover achieves visceral analgesia via the rami communicantes and sympathetic chain.

Recent Findings The block has garnered considerable appeal related to an inherently lower risk of neurovascular and pleural injury, low risk of local anesthetic systemic toxicity, and relative technical simplicity in comparison with epidural or paravertebral blockade. It has been utilized in the treatment of acute perioperative pain in a variety of clinical applications including breast, thoracic, and abdominal surgeries and trauma and may even offer some benefit in spine surgery.

Summary Given the combination of its efficacy and decreased associated risk when performed for perioperative pain, use of ESPB should be further explored for the management of chronic pain. Current literature at this time is limited to case studies and series performed by select groups. Though it is important to consider ESPB for chronic pain, further studies are needed to evaluate the efficacy and safety of the ESPB in the management of both acute and chronic pain.

Keywords Erector spinae plane block · Regional anesthesia · Chronic pain management · Perioperative analgesia

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Overview of the Erector Spinae Plane Block

Introduction

The erector spinae plane block (ESPB), first described in 2016, appears to be a safer, less invasive, and technically less demanding alternative to conventional thoracic regional anesthetic techniques [1, 2]. In comparison to commonly utilized regional anesthetic techniques such as thoracic epidural and paravertebral injections, the ESPB targets a plane remote from the pleura and neuraxial structures [3•]. It is used to perform ultrasound-guided regional anesthesia of the thoracic and abdominal walls [4]. When performing the ESPB, local anesthetic is injected into the fascial plane that is deep to the erector spinae muscle group. Similar to the transverse abdominis plane block as used for abdominal wall pain, craniocaudal local anesthetic spread of the ESPB may thus effectively provide anesthesia to the majority of the thoracic cavity [1]. In this review, therefore, the present investigation was

performed to provide a comprehensive update of the utility of the ESPB in the management of acute perioperative and chronic pain conditions.

Mechanism of Action

Since the emergence of the ESPB as a regional anesthetic technique, clinical studies have demonstrated that the block results in extensive cutaneous sensory analgesia resulting from involvement of both the ventral and dorsal spinal rami. Cadaveric injection studies and computerized tomographic scan imaging studies have been performed to determine the spread and area of action and to achieve a better understanding of the mechanism of action of ESPB [5•]. These studies in addition to clinical evidence suggest that ESPB acts on the ventral rami of spinal nerves in the paravertebral space via penetration of the intertransverse connection tissues and moreover achieves visceral analgesia via the rami communicantes and sympathetic chain [4].

In a cadaveric study of ten fresh human cadavers, the ESPB was performed with methylene blue dye bilaterally into the plane between the fifth thoracic transverse process and the erector spinae muscle. Subsequent dissection showed extensive cephalocaudal and lateral spread both superficial and deep to the erector spinae muscle group, attaining the anatomical limits of the serratus anterior attachments. Across all cases, the deep muscles (semispinalis, multifidus, rotatores, and interspinales) were not involved. There was no anterior spread into the paravertebral or intercostal spaces and the origins of the ventral and dorsal rami in the paravertebral space were not consistently involved. In this experiment, ventral rami were stained in only one of the 20 injections and the dorsal root ganglion was involved in two injections. Dorsal ramus involvement was more frequent, occurring posteriorly to the costotransverse foramen, thus suggesting that the dorsal rami are more likely to be blocked than ventral rami. Despite this finding, ventral ramus blockade has been observed in case reports and it is possible that this incongruity can be explained by the extensive lateral spread to the angle of the ribs that was similarly observed in cadavers [6•]. In clinical practice, it is important to consider the spread of local anesthetic solution in the desired plane because it may be affected by intrathoracic pressure changes, tissue tension, and gravitational effects on the patient [3•].

In a technical report performed to assess local anesthetic spread, an ESPB was performed at the T10 level. MRI imaging was performed 45 and 90 min after injection. ESPB decreased pinprick and cold sensation from T6 to T12 over the anterolateral aspect of the left thoracoabdominal wall. Imaging demonstrated the spread of contrast both deep to the erector spinae muscles and along the paravertebral region, with circumferential epidural spread observed from T5 to T12 through the left T5 to T12 intervertebral foramina. Intercostal spread was observed from T6 to T12 on the left side. These observations suggest that the mechanism of action of ESPB is through both transforaminal and epidural spread, which may give the technique an advantage over thoracic interfascial plane blocks that act through the blockade of intercostal nerves [5•].

Anatomy of the Erector Spinae Plane Block

It was initially believed that the ESPB was anatomically identical to the retrolaminar block. While ESPB targets the tips of the transverse processes, the retrolaminar block targets the laminae and involves injection into the musculofascial plane between the paraspinal muscles and underlying vertebrae. Compared with the erector spinae muscle group, the muscles overlying the lamina (spinalis and transversospinalis muscle group) are thicker and have the potential to result in varying patterns of local anesthetic spread in the retrolaminar block compared with the ESPB [4].

Anatomical dissection and MRI were used to compare injectate spread following ESPB and retrolaminar block in three fresh cadavers. Each block was administered on opposite sides of each cadaver at the level of T5 along with 20 mL of radiocontrast dye. Through anatomical dissection, it was observed that more extensive spread of dye occurred in the three hemithoraces that received ESPB compared with those that received retrolaminar block. With ESPB, cephalocaudal spread (9, 14, and 14 vertebral levels) was greater than with retrolaminar block (6, 7, and 9 levels). In all but one cadaver, in which dye is spread 6 cm laterally to the midline in the sixth intercostal space, medial-lateral spread with retrolaminar block was limited to the region between the spinous processes and the edge of the bony lamina. Medial-lateral spread of dye with ESPB was less extensive in the transversospinalis muscle group adjacent to the midline but was consistently seen laterally in the intercostal space. Most significantly, lateral spread with the ESPB was seen in the fifth intercostal space, extending 9 to 10 cm laterally in all three hemithoraces. Intercostal spread with ESPB may explain the action of ESPB on ventral rami [4].

Injectate distribution to the neural foramina and epidural space was seen using both techniques across two to five vertebral levels centered around the level of injection. This provides a mechanism of action for the clinically reported somatic and visceral analgesia and confirms the existence of anatomical pathways for anterior spread of local anesthetic. The incidence of epidural spread with ESPB suggests an association with possible consequent hypotension; however, it is difficult to ascertain this association without further clinical evaluation in live subjects [4].

Safety and Complications

The ESPB has garnered considerable appeal related to relative technical simplicity in comparison to epidural or paravertebral blockade and furthermore, an inherently lower risk of neurovascular injury and local anesthetic toxicity. The technique is regarded as a peripheral nerve block, so it is thought to likely be safe in anticoagulated patients [7]. There have been few complications and unintended consequences reported with ESPB despite its use in numerous clinical applications, including upper limb amputation, retropubic prostatectomy, and a range of other thoracic and abdominal procedures [5•, 7]. A single study has reported the occurrence of iatrogenic pneumothorax following ESPB. While this adverse event is highly undesirable and likely to be associated with patient morbidity, the study in question does not state the specifics of the needle used, the orientation of the ultrasound probe, nor the anatomical approach of the ESPB. The study also does not report causation beyond a temporal relationship, leaving the possibility for other mechanisms such as bullous lung disease to explain the pneumothorax. Thus, more thorough and continued evaluation of the risk of pneumothorax and other associated adverse events associated with ESPB is necessary [7].

Use of the Erector Spinae Plane Block for Acute Regional Anesthesia

ESPB has been utilized in the treatment of acute perioperative pain in a variety of clinical applications; outcomes from studies and individual reports suggest that the ESPB may be a safe and affective regional anesthetic option for thoracic, breast, thoracolumbar spine, and abdominal surgeries.

Breast Surgery

ESPB has been cited as an alternative to paravertebral block for use as perioperative analgesia in several procedures, including thoracic and abdominal surgery. In a report of right subcutaneous mastectomy due to breast cancer with patient refusal of epidural placement, bilateral ESPB was performed at the T5 transverse process. Injectate was delivered as a mixture of ropivacaine (75 mg) and mepivacaine (16 mg) bilaterally. Postoperatively, the patient remained consistently below a pain numerical rating score (NRS) of 1/10 on three separate occasions, with no breakthrough analgesia required [8]. Still, there are reports suggesting that ESPB may fail to deliver adequate analgesia for patients undergoing breast resection. In a report of ESPB, using 25 mL 0.25% levobupivacaine, for segmental resection of the right supero-lateral breast, only the right lateral branches of the T2–T6 intercostal nerves were blocked. Similarly, in a report of ESPB, using 15 mL 0.25% levobupivacaine, for segmental resection of the infero-lateral breast, the anterior T2–T6 intercostal nerves were incompletely anesthetized [9]. These results, in addition to those obtained in the cadaveric study by Ivanusic et al., highlight the need for further assessment of the extent of ESPB spread [3•, 9]. Given the ease of administration and tolerability, the ESPB may be a viable option for patients undergoing breast surgery, who frequently report postoperative pain following mastectomy and reconstruction [8]. Prior to adoption of the ESPB as a new "gold standard" for multimodal analgesia in breast surgery; however, the technique requires additional clinical evaluation of its efficacy.

Rib Fracture

Traumatic rib fractures are associated with severe pain which may lead to poor respiratory patient outcomes. Epidural anesthesia is commonly used for the management of rib fracture pain. In a report of a 50-year-old male with multiple unilateral right-sided rib fractures (T6–T9), an ESPB with insertion of a catheter technique offered effective extended analgesia. ESPB was initially delivered at the T5 level with 20 mL 0.25% levobupivacaine to achieve immediate pain relief. Subsequently, a continuous infusion of 10 ml per hour of 0.125% plain bupivacaine provided analgesia spanning the duration of 4 days. The patient, whose initial NRS pain score was 6/10 at rest and 10/10 with movement, rated his pain as a 0/10 at rest and 1/10 with activity and coughing following his ESPB. Further sensory evaluation confirmed loss of cold sensation over the right hemithorax from T1 to T9 with partial blockade of the C7 and C8 dermatomes [10].

Lumbosacral Spinal Surgery

There is some speculation that ESPB may even be useful in multimodal analgesia for lumbosacral spine surgery, where severe postoperative pain is a significant cause of postoperative morbidity, extended length of hospital stays, and marked opioid use. While conclusive evidence is lacking, there are case studies which suggest a low thoracic ESPB can anesthetize the dorsal rami of spinal nerves that innervate the paraspinal muscles and bony vertebra. Melvin et al. performed a case series whereby ESPB was performed at the level of T10 or T12 in six patient undergoing lumbosacral spine surgery; three lumbar decompressions, two sacral laminoplasties, and one coccygectomy [18]. Following induction of general anesthesia, single-injection ESPBs were performed in three patients while bilateral continuous ESP block catheters were placed in the remaining three. All six patients had minimal postoperative pain and very low postoperative opioid requirements, with no discernible motor or sensory block in any of the cases and no interference with intraoperative somatosensory evoked potential monitoring used in two of the cases. Further research and data is required prior to this block becoming a standard of care, but the potential benefits do seem to warrant further exploration [11].

Abdominal Surgery

ESPB is performed at the level of T4–T5 for breast and thoracic surgery but can also be performed at the level of T7–T8 to block the thoracoabdominal nerves for abdominal surgery [12]. As the number of abdominal surgeries involving multiple procedures and/or incisions increases and pain management becomes more complex, ESPB may play a role in simplifying analgesia protocols. To date, preliminary evidence from three cases has been put forth to support the success of ESPB at the level of T7 in providing analgesia following laparoscopic bariatric surgery, which is becoming increasingly popular in North America. This implementation of ESPB is notable since up to 42% of patients who undergo laparoscopic bariatric surgery experience severe pain and are subsequently treated with an average of 73 mg morphine IV in the first 48 h following surgery [12].

One application of ESPB in the treatment of laparoscopic bariatric surgery was in a 35-year-old woman scheduled for Roux-en-Y gastric bypass. This patient received general anesthesia and underwent uneventful surgery though experienced severe postoperative deep epigastric pain, recalcitrant to opioids, and a quadratus lumborum block. ESPB was subsequently performed at the T7 transverse process, consisting of 10 mL normal saline, 5 mL 2% lidocaine, and 5 mL 1% ropivacaine. Five minutes following ESPB, the patient reported that her pain decreased to 1/10 and remained well controlled at a pain NRS of 3–4/10 throughout the remainder of her hospital stay [12]. Another successful application of ESPB was reported in a patient who had undergone Roux-en-Y gastric surgery. Bilateral ESPB was performed at the T7 transverse using 20 mL 0.5% ropivacaine and resulted in a decrease of pain NRS from 8/10 to 2/10 [12]. In a similar case, a 65-year-old male received an ESPB with peripheral nerve catheter prior to undergoing a laparoscopic sleeve gastrectomy. In a similarly reported fashion, the ESPB was performed at the T7 transverse process with 20 mL 0.5% ropivacaine bilaterally. Following the surgery, pinprick testing confirmed sensory loss over the T7–T11 dermatomes. Using the peripheral nerve catheter, his pain was well controlled with intermittent boluses of 20 mL 0.5% ropivacaine [12].

In a case of percutaneous nephrolithotomy, continuous administration of local anesthetic via ESPB provided adequate analgesia eliminated the need for breakthrough opioids. ESPB with catheter was performed postoperatively at the T8 transverse process. Subsequent pinprick testing confirmed that dermatomal blockade extended through T4–L1 along the midaxillary line [13]. This finding is notable as PCNL is generally accompanied by severe pain and discomfort originating from the kidneys (T10–L1 spinal nerves), ureters (T10–L2 spinal nerves), and surgical incision site.

Novel Use in the Management of Chronic Pain

Given the combination of its efficacy and decreased associated risk when performed for perioperative pain, use of ESPB has further been explored for the management of chronic pain.

Refractory Thoracic Neuropathic Pain

Refractory thoracic neuropathic pain is a complication that results from factors such as surgery or trauma and results in constant debilitating pain that can be refractory to conventional analgesia, in as many as one-quarter to one-half of patients [14]. The initial publication of Forero et al. in October 2016 introduced ESPB as a potential alternative for managing chronic refractory thoracic neuropathic pain. The team presented two separate case studies to showcase initial findings from the implementation of ESPB in patients at their chronic pain clinic in Canada [2].

In the first case, a 67-year-old male presented with a four-month history of burning and stabbing neuropathic pain radiating from the spine into the anterior chest wall. The pain was rated as 10/10 on NRS, described as disruptive to sleep and overall quality of life, and recalcitrant to NSAIDs, steroids, opioids, and marijuana. ESPB was performed with an initial injection of 20 mL 0.25% bupivacaine reducing his pain to 0/10 within 2 h. Over the next week, an indwelling epidural catheter was inserted to facilitate multiple injections of the same dosage. Each provided complete analgesia averaging 12 h per injection. Further, the bupivacaine dosage was increased and combined with gabapentin and amitriptyline. The combination provided complete analgesia at rest and, upon return of discomfort, diminished neuropathic pain rated 3/10. Unfortunately, the patient continued to report pain between 8/10 and 10/10 with arm movement. When computed tomography imaging was used to assess injectate spread, lytic vertebral lesions were found and eventually diagnosed as metastatic complication of primary bladder carcinoma [2]. In the following case, a 48-year-old man presented to the pain clinic with a three-year history of chronic neuropathic pain secondary to rib fractures from an MVA. The patient had used acetaminophen, codeine, and oxycodone to no analgesic effect and agreed to an ESPB that was initially performed in the same anatomic location as that of the previous patient, but instead using 20 mL 0.5% ropivacaine. Three hours later, a subsequent injection of the same dosage of ropivacaine was this time performed deep to the erector spinae muscle. During a 30-day follow-up visit, the patient reported that pain had been reduced to 25% of its original severity. Notably, the patient also reported complete cessation of allodynia. His pain did not require any medication for management and the patient was reportedly very pleased with his improved quality of life [2].

Forero et al. continued exploring ESPB by treating a cohort of seven patients with refractory thoracic neuropathic pain secondary to thoracotomy. Of the seven patients, all presented with severe pain of varying qualities and all seven initially received ropivacaine ESPB and immediately responded to treatment with complete or nearly-complete pain resolution. The dosages ranged from potencies of 0.25 to 0.50% as well as 20–30 mL absolute volume depending on patient size and administration of previous injection. The subsequent injections were tapered and were reduced in total volume of the drug. Four of the seven patients experienced extended relief from their pain. A 58-year-old male received injections at four- and six-week intervals that controlled his pain for at least 4 weeks. An 81-year-old female reported satisfactory control of her pain and did not receive further injections but remained at a pain level of 3/10. A 64-year-old male received biweekly injections, reporting that the pain returned every 2 weeks. A 55-year-old male received three injections, stating that with subsequent injections, the effect lasted longer. Starting at two and a half weeks and building up to 4 weeks, the significant pain relief allowed him to return to work and reduce his opioid load [14].

Unfortunately, the results achieved by the other three patients were not as favorable. A 77-year-old man received an injection that only lasted 2 h before his pain returned to its previous intensity. A subsequent injection, 2 weeks later only lasted 24 h. A third injection again provided only 24 h of relief. He stated that his episodic sharp pain had ceased but still reported hyperalgesia and allodynia. The patient passed 4 weeks after the third injection. A 66-year-old woman received an initial injection that only provided analgesia for 2 days before returning to its original intensity; she declined further injections. Similarly, a 67-year-old woman received an injection that lasted 4 h before returning to its original intensity; she also declined further interventions [14].

Fusco et al., a team of Italian physicians, also corroborated some of Forero's findings in October 2017 by presenting the findings of the case of a 44-year-old male with severe unilateral chest pain rated 8/10 that had afflicted him for 5 years. Using the ESPB approach, levobupivacaine and dexamethasone were injected and provided complete pain relief for 45 days. When the pain returned, it peaked at a severity of 5/10. The patient returned to the pain clinic and, for comparison, a paravertebral block was administered and provided pain relief for only 10 days [6•].

Further, Ahiskalioglu et al., a team of Turkish physicians, also showed the potential efficacy of ESPB through another case study of a 29-year-old male with chronic pain in the left thoracic and axillary regions due to complications from Ewing's sarcoma. A catheter was put in place via an ultrasound-guided ESPB approach and an initial bolus of 20 mL 0.25% bupivacaine almost instantly reduced his pain. The catheter was left in place providing a 5 mL/h infusion for 48 h before the patient was discharged. Once home, he received 15 mL 0.125% boluses every 12 h for 15 days before the injections were discontinued and he began management with a low-dose opioid and pregabalin. His pain remained less than 20% of original severity for 3 months before the procedure in full was repeated, again showing analgesic effect [15].

Chronic Shoulder Pain

Following success with the treatment of refractory thoracic neuropathic pain, Forero et al. continued experimental injections to try and treat chronic shoulder pain in September 2017. The reasoning of the team for implementation of ESPB relies of the fact that the erector spinae muscle travels all the way to the cervical spine, so a block administered at the T2/T3 level should propagate to the shoulder girdle. The subject was a 73-year-old male with bilateral rotator cuff tears, subacromial bursitis, bicipital tendinopathy, and degenerative changes to the AC joints that were treated conservatively with NSAIDs and subdeltoid bursa injections as needed as opposed to a more aggressive surgical route. After this treatment, the patient reported his pain as an 8/10 that interfered with his sleep; he could not abduct his shoulder past 90°. The patient was injected with 20 mL 0.5% bupivacaine along with 40 mg of methylprednisolone and reported complete resolution of pain within10 min. Further, he regained full range of motion of his shoulders. Upon follow-up 3 months later the patient reported that mild pain (2/10) in his left shoulder could be elicited upon movement and was absent at rest, but his right shoulder had severe pain (9/10) at rest. The patient requested another ESPB, and it was performed this time with 20 mL 0.375% bupivacaine, 5 mg/mL epinephrine, and 40 mg of methylprednisolone. This injection formulation was repeated 1 week later at the request of the patient even though he only had mild pain during movement. Unfortunately, 6 weeks later he reported that after experiencing complete analgesia the first 2 weeks, the pain returned and peaked at 8/10 severity. Another block was preformed, this time with 20 mL 0.25% ropivacaine. Six weeks later the patient reported the same findings: excellent analgesia for the first few weeks followed by recurrence. One final ESPB was performed and at the time of publication, 2 weeks following the final injection, the patient was pain-free [16].

Alternative Implementations

Ueshima et al. reported the successful treatment of a 70-year-old woman with post-herpetic neuralgia using 10 mL 0.25%

levobupivacaine administered at T6. The patient reported a decrease in her visual analog scale score from 72/100 to 7/100; the block was repeated biweekly for 2 weeks and completely resolved the woman's pain [17]. Takahashi et al. presented the case of a 72-year-old woman with failed back surgery syndrome. Following administration of a bilateral ESPB performed with 20 mL of 0.1875% ropivacaine, the patient reported complete resolution of her pain to less than 10% of its original severity for 10 h. The procedure was repeated twice within a month providing an overall reduction of baseline pain to less than 40% of its original severity [11].

Conclusion

The EPSB is a novel technique developed in 2016 and pioneered by Dr. Mauricio Forero at McMaster University in Ontario [2]. Recent literature has shown that ESPB is efficacious in both acute and chronic settings. Perioperatively, ESPB has shown promise as a viable option for patients undergoing breast, thoracic, and abdominal surgery. It has also demonstrated efficacy in the management of unremitting chronic pain. Unfortunately, as this new block has only been utilized for the last 2 years, the literature is currently limited to individual cases performed by few groups. Given the presented evidence, it is important for pain physicians to consider utilization of the ESPB as part of their armamentarium in treating acute surgical and chronic unremitting pain, though further studies are needed to evaluate the safety and efficacy in these applications.

Compliance with Ethical Standards

Conflict of Interest Ivan Urits, Kyle Gress, Karina Charipova, Patrick Laughlin, Vwaire Orhurhu, and Omar Viswanath declare no conflict of interest. Alan D. Kaye discloses that he is on the Speakers Bureau for Depomed, Inc. and Merck.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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