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REVIEW

Paraspinal regional analgesic techniques in spine surgery—a narrative review

Venus Kit Sze Wu[1], Junyong In[2], Sakura Kinjo[1,*]

[1]Department of Anesthesia and Perioperative Care, University of California, San Francisco, CA 94143, USA
[2]Department of Anesthesiology and Pain Medicine, Dongguk University Ilsan Hospital, 10326 Goyang, Republic of Korea

***Correspondence**
sakura.kinjo@ucsf.edu
(Sakura Kinjo)

Abstract

Patients undergoing spine surgeries may experience intense postoperative pain and its related complications such as increased opioid use and delayed early ambulation. Therefore, adequate perioperative pain management is important to promote patient's recovery. In addition, many patients often present with pre-existing chronic pain and opioid use. Although regional analgesic techniques are widely used in other surgical fields, the use of this modality for spine surgery is still evolving. This review article discusses the use of regional analgesic techniques for pain management during spine surgeries. Specifically, we will review fascial plane blocks including erector spinae plane block, retrolaminar block, transversus abdominis plane block, thoracolumbar interfascial plane block, modified thoracolumbar interfascial plane block, multifidus cervicis plane block, and superficial cervical plexus block. In addition, the use of liposomal bupivacaine is discussed. Regional analgesic techniques are described as part of multimodal analgesia regimens and show promising analgesic effects and favorable outcomes in spine surgery. However, the results from the most recent articles revealed only a short-term and limited benefit. Further well-designed studies with greater sample sizes are needed to clarify the effects of regional analgesic techniques on perioperative pain management, including long-term benefits.

Keywords

Erector spinae plane block; Retrolaminar block; Spine surgery; Thoracolumbar interfascial plane block; Transversus abdominis plane block; Multifidus cervicis plane block; Superficial cervical plexus block; Inter-semispinal plane block

1. Introduction

Based on the Global Burden of Disease Study, lower back pain is the number one cause of musculoskeletal problems worldwide and the leading global cause of years lived with a disability [1]. Data from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample demonstrates a modest rise in the rate of lumbar spine surgeries performed from 1994 to 2000 [2]. Spinal surgery is associated with intense pain in the perioperative period, leading to decreased patient mobility and increased risk of perioperative complications such as deep vein thrombosis, pulmonary embolus, and pneumonia [3]. The number of levels involved in the procedure is directly related to postoperative pain and may involve multiple pathophysiologic pathways, including neuropathic, inflammatory, and nociceptive pain responses [4]. Median pain scores on a numeric rating scale (0–10) on the first postoperative day range from 5 to 7 [5]. Poorly controlled perioperative pain is associated with worse surgical outcomes, increased hospital length of stay, and increased risk of developing new chronic pain conditions [3].

Although opioids were previously relied on as the mainstay of postoperative pain management after spine surgery, pain management was still suboptimal, with significant opioid-related adverse effects including opioid-induced hyperalgesia, nausea, gastrointestinal, dysmotility, respiratory depression and risk of opioid habituation [6, 7]. To decrease these adverse effects, improve outcomes, and increase patient satisfaction, the Enhanced Recovery After Surgery (ERAS) Pathways have been widely adapted in different areas of surgery. As a part of ERAS pathway, the implementation of multimodal Analgesia (MMA) techniques has demonstrated improvement in the intensity of pain as well as patient outcomes while decreasing postoperative opioid requirements and opioid-related adverse effects [4]. Alongside opioids, MMA protocols may include nonopioid analgesics, nonsteroidal anti-inflammatory drugs, gabapentinoids, alpha-2-antagonists, ketamine, and regional pain management techniques [4]. Providing adequate postoperative pain control while minimizing opioid requirements promotes return of bowel function, earlier mobility and physical therapy, and earlier hospital discharge. As a part of MMA, regional analgesia has been used in different types of surgeries such as thoracic, abdominal, and orthopedic surgeries. Due to advancements in ultrasound-guided regional analgesia, indications of peripheral nerve blocks have expanded to spinal

surgeries.

This narrative review is focused on the use of regional analgesia for spine surgery. We describe various types of nerve blocks that have been used for pain management for spine surgery including Erector Spinae Plane (ESP) block, retrolaminar block, Transversus Abdominis Plane (TAP) block, Thoracolumbar Interfascial Plane (TLIP) block, modified TLIP block, multifidus cervicis plane block, superficial cervical plexus block. In addition, we discuss the use of liposomal bupivacaine in this review.

2. Search strategy

The authors performed a literature search in PubMed and Google scholar for articles published in English, using the search terms (spine surgery and analgesia with ESP block, retrolaminar block, TAP block and TLIP block, multifidus cervicis plane block, superficial cervical plexus block, and liposomal bupivacaine, respectively). The relevant references cited in retrieved articles were also reviewed. Neuraxial anesthesia/analgesia were excluded in this review.

3. Nerve blocks for spine surgery on thoracic and lumbar level

Table 1 summarizes the features of blocks described below. Fig. 1 shows the relevant anatomy related to the blocks.

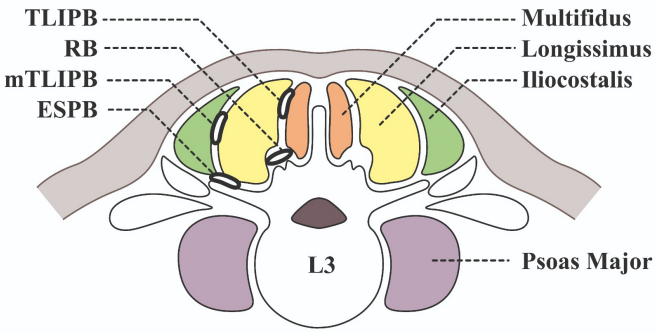

FIGURE 1. Schematic anatomy diagram in the lumbar spine for fascial plane blocks for spine surgery. ESPB, erector spinae plane block; RB, retrolaminar block; TLIPB, thoracolumbar interfascial plane block; mTLIPB, modified thoracolumbar interfascial plane block.

3.1 ESP block

The ESP block is a paraspinal myofascial plane block first described by Forero *et al.* [8] in 2016. It was used for thoracic analgesia in two patients with chronic thoracic neuropathic pain and two undergoing video-assisted thoracoscopic surgery. Ultrasound guidance is typically used for this technique, with local anesthetic deposited in the craniocaudal fascial plane between the erector spinae muscle and the transverse process of the vertebra. Local anesthetic diffusion anteriorly to the ventral and dorsal rami of the spinal nerves facilitates visceral and somatic analgesia [9]. ESP block is the most studied block for spine surgery among the nerve blocks reported in the literature. It has been used for different types of lumbar spine surgery such as microendoscopic surgery, discectomy, decompression surgery and posterior interbody fusion [10–13]. In addition, ESP block has shown to have opioid-sparing effect in thoracolumbar scoliosis surgery using a bilateral, bi-level technique [14]. Elias *et al.* [15] reported in their systematic review that ESP blocks reduced postoperative pain and opioid consumption for lumbar spine surgery, but this effect was sustained only for the short term. They concluded that current evidence is insufficient to support the widespread use of ESP blocks for spine surgery [15].

Rizkalla *et al.* [16] reviewed 15 studies (5 randomized controlled trials (RCTs), 5 case series, 4 case reports and 1 retrospective study), noting that ESP blocks were consistently found to be a safe and effective method of analgesia for lumbar surgery with limited adverse effects [16].

To date, other systematic reviews are available [17–20]. The most recent systematic review and meta-analysis by Oh *et al.* [19] included 12 RCTs (665 participants) who underwent lumbar spine surgery. ESP Block significantly reduced opioid consumption in the first 24 hours after surgery when compared with control. In addition, it lowered the pain scores for 48 hours after surgery, shorter length of hospital stay, and decreased the postoperative nausea and vomiting with increased patient satisfaction. Due to high heterogeneity, small sample size, variable block technique, and different local anesthetic concentration and volume, there is a still need for high quality of evidence to support these findings.

3.2 Retrolaminar block

The retrolaminar block with a catheter was first performed on the lamina of the thoracic vertebra in 2006 [21]. This approach was introduced to lower the risk of serious complications that thoracic epidural anesthesia and paravertebral blocks may cause, such as pneumothorax, hypotension, nerve damage, and dura puncture.

This is another superficial needle placement technique where the target is the plane between the erector spinae muscles and the lamina, but the target is more medial than the target of an ESP block. This block is performed from the cervical to lumbar levels and thus can be a useful anesthetic and analgesic technique for anterior lumbar interbody fusion (ALIF)/lateral lumbar interbody fusion (LLIF) [8, 22, 23].

A cadaver-based study of the retrolaminar block and ESP block spread found that the ESP block made the study dye spread more laterally. In contrast, the dye for the retrolaminar block spread vertically, suggesting a more efficient block of the dorsal rami with the retrolaminar block over the ESP. However, more thoracic spinal nerves were stained by the ESP block than by the retrolaminar block [24].

A continuous retrolaminar block has been reported as an effective pain management technique for breast cancer surgery [25, 26], rib fracture [27], video-assisted thoracoscopic surgery [28], and lumbar trauma [22], but thus far, there is no report available for spine surgery.

Although the retrolaminar block has been reported to be effective, clinical data are still insufficient. For example, thus far, no reports have investigated the optimal dose and

TABLE 1. The features of ESP, RL, TAP, TLIP, and mTLIP blocks.

Block	Target injection point	Possible spreading area	Patient's Position	Potential Complications	Clinical indications	Contraindications	Comments
ESP	Between the erector spinae muscles and the transverse process	Paravertebral space, epidural space, intercostal space, and intervertebral foramina (Spread more laterally) [24, 58, 59]	Sitting, Lateral or prone	Pneumothorax	From the cervical to lumbar	Bleeding Infection	Simpler and safer than traditional PVB
RL	Between the erector spinae muscles and the lamina	Paravertebral space, epidural space, intercostal space, and intervertebral foramina (Spread more vertically) [24, 60]	Sitting lateral, prone	Vascular puncture, local anesthetic systemic toxicity	From the cervical to lumbar	Bleeding Infection	Clinical data is limited in spine surgery
TAP	Between internal oblique and transverse abdominis muscles	Thoracoabdominal, subcostal, and iliohypogastric/ilioinguinal nerves	Supine	Liver injury	Anterolateral abdominal wall-related surgery, ALIF, LLIF	Posterior approach spinal surgery. Bleeding Infection	Does not cover the back area
TLIP	Between the multifidus and longissimus muscles	Dorsal rami of spinal nerves	Lateral or Prone	Neuraxial nerve injury	Lumbar	Bleeding Infection	
mTLIP	Between the longissimus and iliocostal muscles	Dorsal rami of spinal nerves	Lateral or prone	Vascular puncture, local anesthetic systemic toxicity	Lumbar	Bleeding Infection	Lower risk of neuraxial nerve injury compared to TLIP [61]

ESP: Erector spinae plane; PVB: Paravertebral block; RL: Retrolaminar; TAP: Transversus abdominal plane; TLIP: Thoracolumbar interfascial plane; mTLIP: Modified thoracolumbar interfascial plane; ALIF: Anterior lumbar interbody fusion; LLIF: Lateral lumbar interbody fusion.

concentration of local anesthetics for this block. Randomized clinical studies are needed to assess efficacy for spine surgery.

3.3 TAP block

Since the TAP block was first described in 2001 as an abdominal field block [29], it has been regarded as a safe pain management technique for the anterior abdominal wall, as part of a multimodal approach [30, 31]. The TAP block is commonly performed under ultrasound guidance [32]. TAP blocks are now used for pain control in patients undergoing large bowel resection, appendectomy, cesarean section, hysterectomy, renal transplantation, abdominoplasty, and iliac bone grafting [33].

TAP is an interfascial space between the transversus abdominis and internal oblique muscles, visualized with an ultrasound transducer [34–36].

The anterolateral abdominal wall is mainly supplied by the anterior rami of the spinal nerves originating from T6 to L1 [37]. Considering that the TAP block is a field block, they do not always coincide with the innervation area. Støving *et al.* [35] reported that its cutaneous sensory block area is nondermatomal and does not cross the midline.

Tsai *et al.* [36] standardized various expressions of TAP blocks used in previous studies into four categories based on the involved spinal nerves and the transducer positions: subcostal, oblique subcostal, lateral, and posterior TAP blocks. Among these categories, the appropriate approach for analgesia and anesthesia in ALIF and LLIF surgery would be to apply the lateral and posterior approaches together. Reisener *et al.* [38] conducted a large-sample, retrospective study in

patients undergoing a single-injection TAP block under general anesthesia as part of their ALIF compared to those that did not. They reported that a single-injection TAP block was associated with a significantly shorter length of stay, less postoperative nausea/vomiting, and lower opioid consumption in the post-anesthesia care unit. Soffin *et al.* [30] also reported that a single-injection TAP block as a part of MMA for lumbar spine fusion was a feasible approach with high patient acceptance and no block related adverse events were observed [30].

A continuous TAP block may provide effective analgesia in abdominal surgery such as cesarean section and renal recipients [39–42]. However, it has not been reported whether a continuous TAP block provides an additional analgesic effect compared to a single-injection TAP block in spine surgery. Therefore, studies comparing single injection and continuous infusion technique for pain management are needed.

3.4 TLIP block and modified TLIP block

The TLIP block is one block within the paraspinal interfacial plane (PIP) blocks family [43]. In this block, the needle is advanced in a lateromedial orientation between the multifidus and longissimus muscles of the thoracolumbar spine. The TLIP block was first described by Hand *et al.* [44], for postoperative pain control following lumbar surgeries. This block is less likely to cause a ventral rami blockade than an ESP block since local anesthetic is administered farther away from the nerve roots.

The modified TLIP block, proposed as the lumbar longissimus plane block [43], was described as an alternate method that would reduce the risk of neuraxial nerve injury by advancing the needle in a mediolateral orientation with a local anesthetic administered between the longissimus and iliocostal muscles [45]. A modified TLIP block is performed lateral to the standard TLIP block and may be technically easier. Chen *et al.* [46] performed a randomized controlled trial (RCT) comparing TLIP block and control (0.9% saline) in 60 patients who were scheduled for lumbar spinal fusion surgery. They found that patients who received a preoperative bilateral single shot TLIP block had significantly decreased opioid and anesthetic consumption, short postoperative hospital stay, and no significant differences in postoperative complications compared to the control group [46]. Ozmen *et al.* [47] performed a RCT where 90 patients scheduled for lumbar disk surgery were divided into a control group and a modified TLIP block group, and pain scores and opioid use were evaluated during the first postoperative 24 hours [47]. They concluded that pain scores and opioid consumption were superior in the modified TLIP group.

There are few studies comparing different types of blocks in spine surgery. Wang *et al.* [48] compared ESP block, TLIP, and control group (no block) in lumbar spine fusion [48]. Both ESP block and TLIP block provided better analgesia and reduced opioid consumption up to 48 hours after surgery when compared with control.

Ciftci *et al.* [11] studied patients who underwent lumbar decompression surgery. They divided the patients in 3 groups: ESP block; mTLIP block; control group. ESP block and mTLIP block provided better analgesia and less opioid consumption than control in the first 24 hours. However, there was no superiority between ESP block group and mTLIP group.

4. Nerve blocks for spine surgery on cervical level

Fig. 2 shows the relevant anatomy related to the cervical blocks described below.

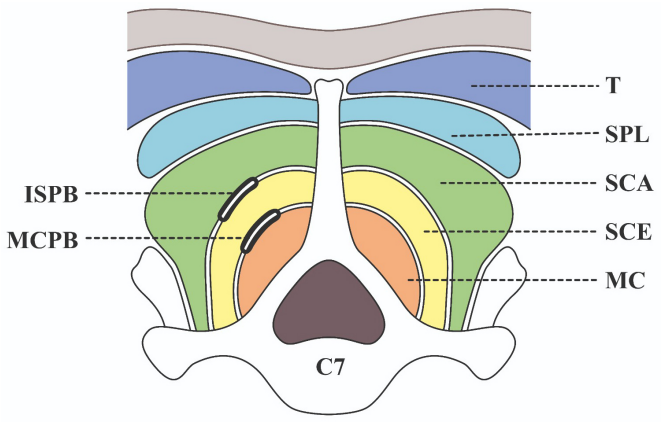

FIGURE 2. Schematic anatomy diagram in the cervical spine for fascial plane blocks for spine surgery. ISPB, inter-semispinal plane block; MCPB, multifidus cervicis plane block; T, trapezius muscle; SPL, splenius capitis muscle, SCA, semispinalis capitis muscle; SCE, semispinalis cervicis muscle; MC, multifidus cervicis muscle.

4.1 Multifidus cervicis plane block and inter-semispinal plane block

The multifidus cervicis plane block primarily intends to block the dorsal rami of cervical spinal nerves and has been utilized successfully in cervical laminoplasty [49]. However, in elderly patients it is sometimes difficult to identify the correct injection plane, leading to the development of the inter-semispinal plane block where local anesthetic is deposited between the semispinalis cervicis and semispinalis capitis muscles [50]. The authors identified the inter-semispinal block as a more superficial block compared to the multifidus cervicis plane block and noted equivalent effects in a comparative pilot study involving healthy volunteers. Its superficial location also improves the safety of the block as there is less likelihood of puncture of the dorsal artery or injection into intrathecal space. A prospective RCT was performed for use of inter-semispinal plane block for postoperative analgesia following cervical spine surgery and demonstrated decreased 24-hour postoperative analgesic consumption and lower pain scores in the first 12 postoperative hours [51].

4.2 Superficial cervical plexus block

There is one RCT that has studied the use of superficial cervical plexus blocks in patients undergoing anterior cervical discectomy and fusion [52]. Forty-six patients were randomized to either receive a superficial cervical plexus block or no block. Authors noted that although the early quality of recov-

ery improved when measured by a 40-item quality of recovery questionnaire, both groups had similar opioid consumption and discharge times.

4.3 Cervical ESP block

Elsharkawy *et al.* [53] performed a cadaveric study of ultrasound guided cervical ESP blocks performed posterior to the transverse process of C6 or C7 consisting of a 20 mL injectate that contained India ink [53]. Dissection was performed demonstrating craniocaudal and medial-lateral dye spread. The authors noted that the C5, C6, C7 roots of the brachial plexus and dorsal rami were consistently stained and suggested that this type of block could be utilized for patients undergoing cervical spine surgeries. However, they also noted that the phrenic nerve was stained in 3 of the 10 injections performed. The concern for potential bilateral phrenic nerve block may preclude the use of bilateral cervical ESP blocks for cervical spine surgery. A recently published prospective, randomized controlled, double blinded study randomized 86 patients receiving posterior cervical spine surgery to regional anesthesia with ESP block versus a control group [54]. The ESP block demonstrated less intraoperative opioid consumption, muscle relaxant use, surgical duration, intraoperative blood loss, postoperative pain, and earlier mobilization.

5. Liposomal bupivacaine

Liposomal bupivacaine (LB) is an extended-release bupivacaine which has been used for various types of surgery. The analgesic effect of LB is supposed to be significantly longer than plan bupivacaine and may last up to 72 hours [55]. There is one systematic review that investigated LB efficacy in spine surgeries [56]. In this systematic review, 10 articles (total of 1112 patients) were included for analysis. Authors concluded that LB was associated with lower postoperative opioid consumption, pain scores, and hospital length of stay. Odds of adverse effects was comparable or lower compared to controls. However, due to the multiple limitations (*e.g.*, small number of studies, more retrospective studies than prospective studies, variability in injection sites and technique, different dose and volume of LB), the evidence is still limited. Therefore, more prospective RCTs with larger sample size are needed to validate the results.

6. Possible side effects of regional analgesia in spine surgery

Although regional analgesia for spine surgery is considered to be safe in general [57], one must keep in mind that any regional blocks carry some risks such as local anesthetic systemic toxicity, infection, and hematoma formation. Other potential undesirable effects of regional analgesia include blockade of the ventral rami which may result in motor or sensory block of the lower extremities, interference with neuromonitoring, phrenic nerve block, and pneumothorax (Table 1).

7. Conclusions

Increasingly, regional blocks are being described as part of MMA regimens in spine surgeries. By blocking the dorsal rami of the spinal nerves, regional techniques target the innervation of overlying skin, paraspinal muscles, and vertebrae. Depending on the location and type of surgery, different types of blocks may be used. For example, retrolaminar blocks and ESP blocks can be used in cervical, thoracic, and lumbar surgery. A TAP block is most effective in spine surgeries that involve an anterior lateral abdominal incision. The TLIP block and modified TLIP block are used in lumbar lesions.

The efficacy of regional anesthetic techniques in spine surgery and their use in perioperative MMA is likely to further expand with continued advancements in surgical techniques such as minimally invasive spine surgery.

Thus far, regional blocks show promising analgesic effects and favorable outcomes in spine surgery. However, there is still a deficiency in the current literature to help determine the optimal perioperative pain management strategy for spine surgery, especially as it pertains to regional analgesia and techniques. Small sample numbers in many studies, heterogeneity in study design, inconsistency in terminology and language, and the large amount of retrospective data weaken the ability to validate and generalize many conclusions. Further well-designed studies with greater sample sizes are needed to clarify the associations with possible neurological complications.

ABBREVIATIONS

MMA: multimodal analgesia; ESP: erector spinal plane; TAP: transversus abdominis plane; TLIP: thoracolumbar interfascial plane; ALIF: anterior lumbar interbody fusion; LLIF: lateral lumbar interbody fusion; mTLIP: modified thoracolumbar interfascial plane.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

SK—designed the review article. VKSW, JI and SK—conducted literature search and review. VKSW and JI—wrote and revised the manuscript. SK—provided critical feedback on the manuscript and contributed to the revision process. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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