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Research Article

Bilateral bi-level erector spinae plane blocks in scoliosis surgery: a retrospective comparative study

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ABSTRACT

Objective: This study aimed to compare the effect of the ultrasound (US) guided erector spinae plane block (ESPB) on pain scores, opioid requirement, patient satisfaction, and the length of hospital stay with standard analgesia methods following scoliosis surgery.

Methods: Twenty-seven patients (17 females, 10 males; mean age = 15.59 ± 3.24 years) who underwent scoliosis surgery with preoperative bilateral bilevel US-guided ESPB were the sample group, and the remaining 30 patients (20 females, 10 males; mean age = 15.57 ± 2.75 years) without ESPB were the control group. Bilateral bilevel injection ESPB was performed at two levels (T4 and T10). Postoperative pain scores, morphine consumption, patient satisfaction scores, and the number of patients requiring rescue analgesia were recorded. A visual analog scale (VAS) was used to score postoperative pain.

Results: VAS at rest and when mobile, as well as postoperative cumulative morphine consumption in the first postoperative 24 h, was significantly lower in the ESPB group. Thirteen patients in the control group but no in the ESPB group required rescue analgesics in the postoperative period. Both the time to the requirement of the initial dose of PCA and patient satisfaction scores were significantly higher in the ESPB group ($P < 0.001$ for both).

Conclusion: Given the need for improved recovery of the patients, ESPB seems to be an essential analgesic technique that may reduce both opioid consumption and the severity of the pain, thus increasing the satisfaction of the patients and decreasing the length of hospital stay.

Level of Evidence: Level IV, Therapeutic Study

Introduction

Posterior spinal fusion for scoliosis surgery may lead to severe postoperative pain which requires significant opioid use for adequate perioperative analgesia. This postoperative pain extends the time of recovery,[1,2] and thus, safe and efficient methods for perioperative analgesia are crucial and advantageous for early recovery and ambulation.

Traditional opioid-based analgesia techniques are characterized by well-known complications such as vomiting, nausea, sedation, and pruritus.[3] Although regional anesthesia is an essential part of multimodal analgesia, available options are limited.[4-7] Recently, an ultrasound (US)-guided erector spinae plane block (ESPB) method that anesthetizes ventral and dorsal rami of spinal nerves was introduced for the treatment of both postoperative and neuropathic pain.[8-10]

Due to the arousing interest of several physicians, ESPB application is reported to be effective in the breast,[11] weight loss,[12] and lumbosacral spine surgeries[8] as it reduces the need for analgesic drugs.

The main advantages of the ESPB are technical simplicity, minimal risk for the spinal cord, and fewer complications.[13] However, there are limited data for the use of the ESPB in scoliosis surgery.

This retrospective case–control study was set out to compare the effect of the US-guided ESPB on 24-hour postoperative cumulative morphine requirements with default opioid-based analgesia and to determine the difference in both postoperative pain control and patient satisfaction in scoliosis surgery.

Materials and Methods

Study design

This retrospective case–control study protocol was approved by the Institutional Ethical Committee board (2020-7/11). The electronic database of scoliosis surgery patients aged 14-20 years with the American Society of Anesthesiologists (ASA) physical status I-III who underwent scoliosis surgery for the treatment of idiopathic scoliosis between January 2017 and March 2020 was retrospectively reviewed.

The exclusion criteria included a known history of recent opioid use and obesity (body mass index (BMI) > 35 kg/m^2). Patients with congenital, neuromuscular, and posttraumatic deformity of the spine, those who underwent revision surgery, and ASA IV status, and patients who underwent procedures under epidural anesthesia were also excluded. Written informed consent was obtained from all participants who participated in this study.

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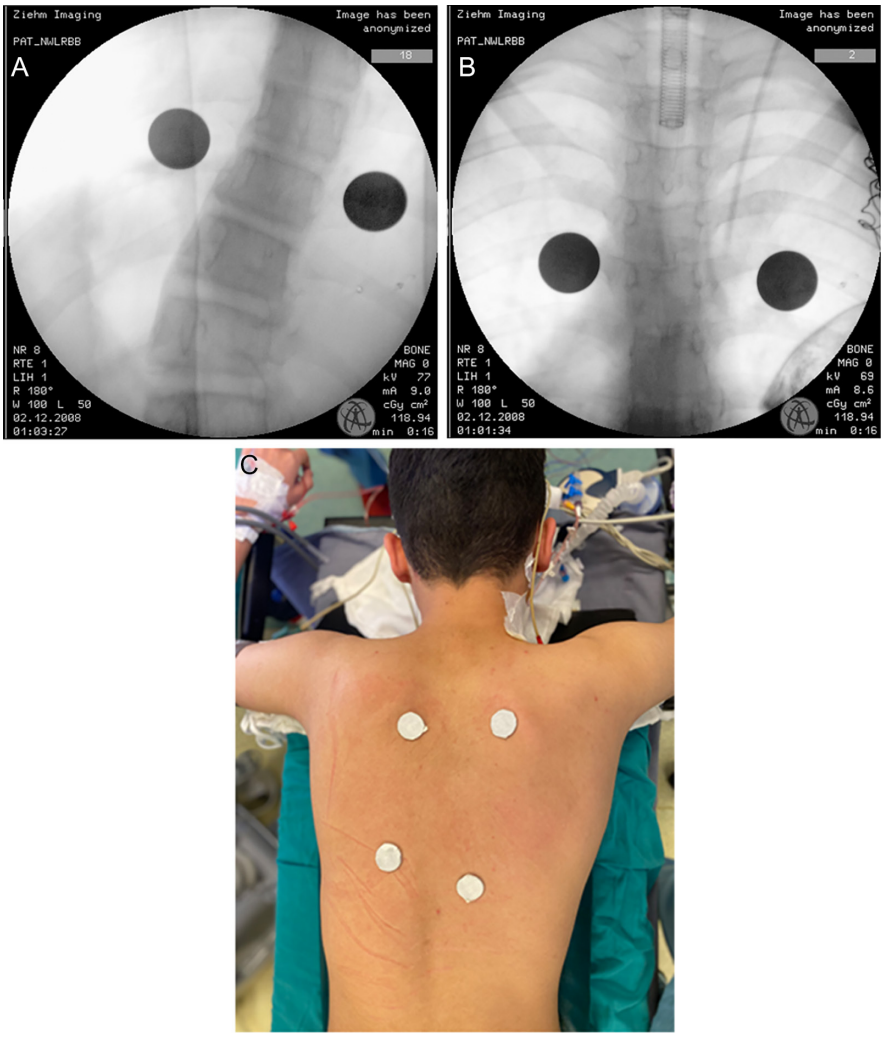

Figure 1. Scope images of injection points for ESPB at level T4-T10.

Perioperative anesthetic regimen

The technique for the erector spinae plane block

General anesthesia was provided with a combined anesthesia protocol of 2 μg/kg of fentanyl, 2-3 mg/kg propofol, and 0.4-0.6 mg/kg rocuronium for induction, followed by a continuous infusion of 0.5 μg/kg/min remifentanil and 6 mg/kg/h propofol. In the intraoperative period, remifentanil was titrated to maintain blood pressure and heart rate within 20% baseline values. An intravenous (iv) 0.03 mg/kg morphine as patient-controlled anesthesia (PCA) was started immediately before wound closure after the operation. A multimodal analgesia regimen including non-opioid analgesics acetaminophen and either a Non-Steroidal Anti-Inflammatory drug or a COX-2-specific inhibitor was given to all patients.

HIGHLIGHTS

- Scoliosis surgery may cause severe postoperative pain. This study aimed to compare the effect of erector spinae plane block(ESPB) on 24-hour postoperative cumulative morphine requirements and patient satisfaction regarding analgesia in scoliosis surgery.
- ESPB group had longer analgesic effect, and the time until the initial use of patient-controlled anesthesia device was longer, opioid consumption was lower as well.
- The results from this study indicate that the ESBP is an encouraging way for providing analgesia for spinal surgery and that it may minimize both opioid consumption and postoperative pain.

The induction of general anesthesia was followed by bilateral bi-level ESPB positioning at both T4 and T10 vertebral levels under standardized monitorization protocols (Figure 1). Standard intraoperative monitoring included electrocardiogram, SpO_2 monitoring, end-tidal carbon dioxide, invasive blood pressure, and nasopharyngeal body temperature.

With the patient in the prone position, a 22-gauge needle (Stimuplex, ultra 360®, 50 mm Braun) was inserted through erector spinae muscle under US (GE Medical Sytems, Phoenix, Ariz, USA) guidance in longitudinal axis over the tip of the transverse process (Figure 2).

Until the tip of the needle reached the tip of the transverse process, the needle was diverted and advanced through the caudad-to-cephalad direction at T4 level and a cephalad-to-caudad direction at T10 level.

The confirmation of the correct position of the needle tip was provided by administration of 1-2 mL of 5% dextrose. Subsequently, 0.25% bupivacaine to a total volume of 40 mL was injected (2.5 mg/kg bupivacain+ 2 mL dexamethasone +saline). The local anesthetic solution was injected in increments, ensuring the adequate and equal distribution of the anesthetic agent. The distribution of the injected fluids in both directions was observed under US guidance. Extra care

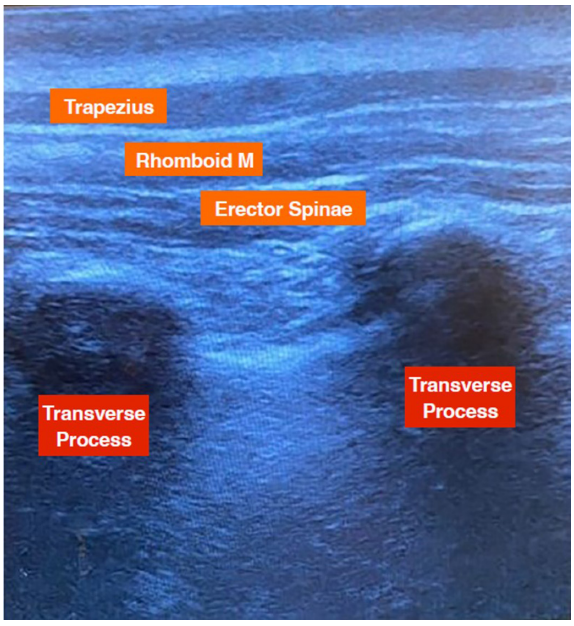

Figure 2. Sonographic anatomy for ESPB.

was taken to ensure that the total bupivacaine dose did not exceed 3 mg/kg. The same protocol was applied to the opposite side. The anesthesia procedures were performed by the same physician (SA) in all operations.

Study variables

After surgery, post-operative analgesia included oral acetaminophen (15 mg/kg/6 h) and iv PCA devices with 1 mg/mL morphine(lock-out interval 15 minutes, maximum dose 24 mg/day, no background infusion).

A visual analog scale (VAS) ranging from 0 to 10 (0=no pain, 10=worst imaginable pain) was used to score the postoperative pain. The VAS scores were recorded immediately in the recovery room, at 4, 8, 12, and 24 hours postoperatively during bed rest and at 8, 12, and 24 hours during mobilization.

Additional postoperative measures included time to first need of PCA, total consumption of morphine, rescue analgesia, in-hospital stay, and incidences of opioid-related complications including nausea and vomiting.

Patient satisfaction was assessed on the 24th hour following the surgery using a 5-point satisfaction score (5=most satisfied, 0=unsatisfied).

Rescue analgesia was prepared with intramuscular meperidine (1 mg/kg) on-demand or whenever the VAS score was ≥4.

All evaluations were done by the surgical ward nurse experienced in the field and supervised by a 3-year anesthesiology resident on each follow-up visit.

Statistical analysis

Deriving the mean and standard deviation (SD) from a previous study at a significance level of .05 and power of 0.8, the sample size was determined as 24 for each group by the power analysis.[6] As per the evaluation of exclusion and inclusion criteria of our study, we included 27 patients who are eligible for the data analysis. The control group consisted of 30 patients with similar demographic data to provide a more secure statistical evaluation.

Statistical analysis was done using GraphPad version 8.0.2. The distribution of the variables was analyzed by the Kolmogorov–Smirnov test. Both the mean and standard deviation were employed to represent quantitative variables. The Student's *t*-test for the variables with normal distribution and the Mann–Whitney *U* test for variables with non-normal distribution were applied. The one-way analysis of variance test was employed when necessary. A *P*-value of <.05 was considered statistically significant.

Results

The study group consisted of 27 patients (17 females, 10 males), while 30 patients (20 females, 10 males) comprised the control group. The mean age of the subjects in the EPSB group was 15.59 ± 3.24 years, while the mean age in the control group was 15.57 ± 2.75 years. The ESPB and control groups were comparable regarding age, BMI (21.55 ± 2.314 vs. 19.61 ± 3.192 kg/m^2, respectively), female to male ratio, ASA physical status, intraoperative blood loss (306.5 ± 56.16 vs. 318.3 ± 62.26 mL, respectively), duration of surgery (3.444 ± 0.5064 vs. 3.02 ± 0.04, respectively), and time of extubation (6.926 ± 2.037 vs. 10.00 ± 4.177 minutes, respectively) (Table 1).

Postoperative cumulative morphine consumption in the first 24 hours postoperative was significantly lower in the ESPB group compared to the control group (4.92 ± 0.53 vs. 2.21 ± 0.47 iv morphine mg equivalents; $P < .0001$) (Table 2).

Thirteen patients in the control group required meperidine for rescue analgesia, whereas none of the patients in the ESPB group required opioids in the postoperative period ($P < .001$).

The time to the requirement of the initial dose of PCA was significantly higher in the ESPB group (6.81 ± 0.96 vs. 1.36 ± 0.55 hours; $P < .001$).

Visual Analog Scale scores at the postoperative 1, 4, 8, 12, and 24 hours at rest and at the 8 and 24 hours when mobile were significantly lower in the ESPB group ($P < .001$ for all variables). The clinical significance of the VAS scores was confirmed with verbal statements of the patients' rating of their pain as "mild pain," "moderate pain," "severe pain," "a lot better," "a little better," "much the same," "a little worse," or "much worse."

Table 1. Comparison of the demographic clinical variables between the study groups

	EPSB (n=27)	Control (n=30)	*P*
Age (years)	15.59 ± 3.24	15.57 ± 2.750	0.97
BMI (kg/m^2)	21.55 ± 2.314	19.61 ± 3.192	0.12
F/M	17/10	20/10	
ASA			
I	15	19	0.28
II	12	6	
III	0	3	
Hospital stay (days)	3.22 ± 0.577	4.93 ± 0.583	**<0.001**
Intraoperative blood loss (mL)	306.50 ± 56.16	318.30 ± 62.26	0.45
Intraoperative analgesics (μg/kg/dk)	9.55 ± 1.28	14.10 ± 1.26	**<0.001**
Time of extubation (minutes)	6.92 ± 2.03	10.00 ± 4.17	**<0.05**
Operation time (minutes)	3.44 ± 0.50	3.02 ± 0.04	**<0.001**

ESPB, erector spinae plane block; BMI, body mass index; ASA, American Society of Anesthesiologists.
P values that are written bold represent statistical significance.

Table 2. Comparison of the study variables between the groups

	EPSB (n=27)	Control (n=30)	*P*
Initial use of PCA (hours)	6.81 ± 0.96	1.36 ± 0.55	**<0.001**
VAS 1 hour (resting)	1.33 ± 0.48	4.26 ± 0.90	**<0.001**
VAS 4 hours (resting)	1.51 ± 0.50	3.63 ± 0.66	**<0.001**
VAS 8 hours (resting)	1.63 ± 0.49	3.56 ± 0.81	**<0.001**
VAS 12 hours (resting)	1.51 ± 0.57	3.86 ± 0.62	**<0.001**
VAS 24 hours (resting)	1.25 ± 0.71	2.86 ± 0.77	**<0.001**
VAS 8 hours (mobile)	2.63 ± 0.49	4.50 ± 0.82	**<0.001**
VAS 24 hours (mobile)	2.03 ± 0.9799	3.66 ± 0.75	**<0.001**
Patient satisfaction	4.66 ± 0.48	2.56 ± 0.56	**<0.001**
Opioid consumption (iv morphine milligram equivalents)	4.92 ± 0.53	2.21 ± 0.47	**<0.0001**
Complications of opioid use			
Yes	0	6	**<0.05**
No	27	24	
Need for rescue analgesics			
Yes	0	13	**<0.01**
No	27	17	

PCA, patient-controlled anesthesia; ESPB, erector spinae plane block; VAS, visual analog scale; iv, intravenous. *P* values that are written bold represent statistical significance.

Compared to the control group, the patients in the ESPB group were more satisfied; the mean satisfaction scores were 4.66 (SD: ±0.48) in the ESPB and 2.56 (SD: ±0.56) in the control group ($P < .001$). Similarly, the length of hospital stay was significantly lower in the ESPB group (3.22 ± 0.57 vs. 4.93 ± 0.58 days; $P < .001$).

Six patients in the control group developed opioid-related complications and required iv metoclopramide, whereas none of the patients in the ESPB group experienced a complication during the postoperative follow-up.

We did not experience any block-related complications or block failures. None of the patients required postoperative intensive care admission and prolonged intubation.

Discussion

In the current study, preoperative application of bilateral bi-level US-guided ESPB provided efficient postoperative analgesia and patient satisfaction after scoliosis surgery. We found that ESPB was related to a more prolonged analgesic effect, and the time until the initial use of PCA device was longer in the block group, as well as a lower postoperative opioid consumption. As far as we know, this report is the first comparative study on anesthesia techniques for scoliosis surgery.

In their randomized controlled study of adult major lumbar spine surgery patients, Singh et al[13] concluded that pain scores in the ESPB group were lower immediately after surgery and at 6 hours after surgery compared to the control subjects. In our study group, pain scores in the ESPB group were significantly lower at all-time points both during resting and mobilization for 24 hours. However, the main difference between their study and ours was the use of PCA devices in the postoperative period. Instead, they preferred iv morphine 3 mg boluses for rescue analgesia, and patients were given iv diclofenac 1.5 mg/kg every 8 hours. Therefore, the pain management practices of each anesthesiology team might be the cause of these different results. Also, dexamethasone added to bupivacaine as an adjuvant drug in single-dose ESPB might have contributed to the achievement of low VAS scores with prolonged analgesic effect up to 24 hours after surgery.

We performed 2 levels of block bilaterally. Chin et al[14] reported that physical spread over at least 3-6 vertebral levels in the erector spinae plane from a single injection of 20 mL makes coverage of the entire surgical incision in scoliosis surgery feasible with 2 injections per side. Also, Tulgar et al[15] reported their results of comparing the single or bi-level application of ESP block in 12 patients undergoing thoracotomy. They observed that the Numeric Rating Scale scores in the first 12 hours were higher in the single-level group than in the bi-level group.

Most lumbar spine surgeries lead to severe postoperative pain, which generally lasts a minimum of 3 days.[16] Thus, the prolonged analgesic effect can increase the comfort of lumbar spine surgery patients. Erector spinae plane block is reported to provide this effect in different studies with no side effects for a wide range of time intervals.[8,17-20] There is a risk of dura mater damage for epidural anesthesia while implemented in the course of spine surgery, and thus the risk of intrathecal penetration of local anesthetics increases.[21] On the other hand, the needle remains distant from the nerves, major vessels, neuraxis, and pleura in ESPB technique which makes it a safe and simple procedure with fewer complications and advantageous over Epidural Analgesia.[22] Our finding is in agreement with this finding which showed that the initial use of PCA can be extended to 6 hours with no observed side effects or complications if ESPB is preferred. Although some research has been carried out on ESPB, no single study exists that compares the anesthesia techniques in scoliosis surgery. Considering that scoliosis surgery is a complex type of surgery, we have observed that ESPB has an advantage over traditional anesthesia techniques even in this complexity.

Opioids, which may are the cornerstones of perioperative analgesia in spine surgeries, give rise to opioid-induced hyperalgesia and adverse effects including the risk of opioid habituation, respiratory depression and nausea, and gastrointestinal dysmotility.[23,24] In their comprehensive investigation into ESPB, Singh et al[13] concluded that ESPB reduces the postoperative need for opioids, and 2 recent studies, Yayik et al[25] and Cesur et al.[26] in the same way, were able to show reduced opioids consumption in the first 24 hours postoperative. In the current study, our data further confirm the idea that the use of ESPB may minimize postoperative opioid consumption.

In this study, a 22-gauge needle (Stimuplex, ultra 360®, 50 mm Braun) was inserted through erector spinae muscle under US (GE Medical Sytems) guidance in longitudinal axis over the tip of the transverse process. Although cases of blind puncture or under fluoroscopy have been described, the technique is usually guided by US (Kot et al).[27] Jadon et al[27] used fluoroscopy, and on the other hand, Kot et al[28] used US in their studies.

In scoliosis surgery, there are several postoperative analgesia techniques to minimize the pain intensity and opioids consumption including iv PCA with morphine, EA, intrathecal opioids (ITOs), and iv ketamine as a unit of multimodal analgesia, and ESPB.[29,30] Intravenous patient-controlled anesthesia with morphine may lead to pruritus, vomiting, and nausea and should be evaluated to be combined with other techniques to reduce the use of morphine. Despite being the most preferred technique in spine surgery, the need to retain the urinary catheter and the inadequate assessment of motor function should not be ignored in the EA technique. Respiratory depression may emerge as the potential risk if a higher ITO dose is administered. Although iv ketamine administration is encouraged by

the recent guidelines,[31] the lack of optimal timing, mode of administration, and dose results in controversial outputs within different studies. In the ESPB technique, instead, only 2 rare complications such as muscle weakness and pneumothorax are reported to date.[32] In our comparative study, neither these 2 complications nor any other complications were observed in ESPB group.

A substantial amount of literature has been reported on postoperative analgesia management.[13,19,20,25,26,33] Over half of these surveys highlighted that successful pain management not only decreases postoperative complications but also the length of hospital stay and the cost of hospitalization, by accelerating the recovery of patients. Likewise, we assert that ESPB usage reduces both length of hospital stay and cost of hospitalization.

Even though the accumulating evidence by a majority of case reports about ESPB makes us think this block is a good option to provide effective analgesia in thoracic surgery, its effect in spine surgery is still uncertain. So far, the generalizability of till-published research on ESPB is controversial. Research on the effect of ESPB has been usually restricted to limited comparisons of case reports. The sample size of some articles is small, many of them are retrospectively studied, most of them are case presentations, and some need their research to be improved. Although the results are promising, the current study has some limitations. Firstly, the study includes a small sample size with retrospective database evaluation. Second, the data are limited only to a single-center experience of same physicians. Also, the patients, surgeon, and anesthesiologist were not blinded to the intervention, and due to the young age of the patients, the block application was required to be performed under anesthesia, and thus, the success of the block could not be tested. The study also includes confounders of number of operated spinal levels that might affect the study outcomes. Further future prospective and multi-centered patient-surgeon blinded studies research might confirm our findings, and a comparative study of ESPB with other analgesic interventions should also be conducted.

Given the complications and their risk for prolonged postoperative opioid use and postoperative pain, there is an increasing interest to control perioperative pain with anesthesia. Thanks to its simplicity to be performed under US guidance and fewer complications, the ESBP is an encouraging way of spine surgery anesthesia that may minimize both opioid consumption and postoperative pain.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Bursa Uludağ University (Approval No: 2020-7/11).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Author Contributions: Concept - B.A., S.A.; Design - B.A., S.A.; Supervision - S.A., S.B.G.; Materials - S.B.G., S.A.; Data Collection and/or Processing - S.A., S.B.G.; Analysis and/or Interpretation - B.A., S.B.G; Literature Review - S.B.G., B.A., S.A; Writing - S.A., S.B.G.; Critical Review - S.A., B.A.

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References

1. Saleh A, Thirukumaran C, Mesfin A, Molinari RW. Complications and readmission after lumbar spine surgery in elderly patients: an analysis of 2,320 patients. *Spine J*. 2017;17(8):1106-1112. [CrossRef]
2. Lin I, Wiles L, Waller R, et al. What does best practice care for musculoskeletal pain look like? Eleven consistent recommendations from high-quality clinical practice guidelines: systematic review. *Br J Sports Med*. 2020;54(2):79-86. [CrossRef]
3. Cohen BE, Hartman MB, Wade JT, Miller JS, Gilbert R, Chapman TM. Postoperative pain control after lumbar spine fusion. Patient-controlled analgesia versus continuous epidural analgesia. *Spine*. 1997;22(16):1892-1897. [CrossRef]
4. Klatt JW, Mickelson J, Hung M, Durcan S, Miller C, Smith JT. A randomized prospective evaluation of 3 techniques of postoperative pain management after posterior spinal instrumentation and fusion. *Spine*. 2013;38(19):1626-1631. [CrossRef]
5. Taenzer AH, Clark C. Efficacy of postoperative epidural analgesia in adolescent scoliosis surgery: a meta-analysis. *Paediatr Anaesth*. 2010;20(2):135-143. [CrossRef]
6. Hong RA, Gibbons KM, Li GY, Holman A, Voepel-Lewis T. A retrospective comparison of intrathecal morphine and epidural hydromorphone for analgesia following posterior spinal fusion in adolescents with idiopathic scoliosis. *Paediatr Anaesth*. 2017;27(1):91-97. [CrossRef]
7. Tripi PA, Poe-Kochert C, Potzman J, Son-Hing JP, Thompson GH. Intrathecal morphine for postoperative analgesia in patients with idiopathic scoliosis undergoing posterior spinal fusion. *Spine*. 2008;33(20):2248-2251. [CrossRef]
8. Melvin JP, Schrot RJ, Chu GM, Chin KJ. Low thoracic erector spinae plane block for perioperative analgesia in lumbosacral spine surgery: a case series. *Can J Anaesth*. 2018;65(9):1057-1065. *English*. [CrossRef]
9. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. *Reg Anesth Pain Med*. 2016;41(5):621-627. [CrossRef]
10. Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. *Anaesthesia*. 2017;72(4):452-460. [CrossRef]
11. Finneran JJ 4th, Gabriel RA, Khatibi B. Erector spinae plane blocks provide analgesia for breast and axillary surgery: a series of 3 cases. *Reg Anesth Pain Med*. 2018;43(1):101-102. [CrossRef]
12. Chin KJ, Malhas L, Perlas A. The erector spinae plane block provides visceral abdominal analgesia in bariatric surgery: a report of 3 cases. *Reg Anesth Pain Med*. 2017;42(3):372-376. [CrossRef]
13. Singh S, Choudhary NK, Lalin D, Verma VK. Bilateral ultrasound-guided erector spinae plane block for postoperative analgesia in lumbar spine surgery: a randomized control trial. *J Neurosurg Anesthesiol*. 2020;32(4):330-334. [CrossRef]
14. Chin KJ, Lewis S. Opioid-free analgesia for posterior spinal fusion surgery using erector spinae plane (ESP) blocks in a multimodal anesthetic regimen. *Spine (Phila Pa 1976)*. 2019;44(6):E379-E383. [CrossRef]
15. Tulgar S, Selvi O, Ozer Z. Clinical experience of ultrasound-guided single and bi-level erector spinae plane block for postoperative analgesia in patients undergoing thoracotomy. *J Clin Anesth*. 2018;50:22-23. [CrossRef]
16. Bianconi M, Ferraro L, Ricci R, et al. The pharmacokinetics and efficacy of ropivacaine continuous wound instillation after spine fusion surgery. *Anesth Analg*. 2004;98(1):166-172. [CrossRef]
17. Singh S, Chaudhary NK. Bilateral Ultasound guided erector spinae plane block for postoperative pain management in lumbar spine surgery: a case series. *J Neurosurg Anesthesiol*. 2019;31(3):354. [CrossRef]
18. De Lara González S, Basora Macaya M, Tió M, Martínez-Camacho A, Fuster S, Sala-Blanch X. L4 erector spinal plane block after lumbar spine arthrodesi: a case-series. *Rev Esp Anestesiol Reanim (Engl Ed)*. 2019;66(10):537-542. [CrossRef]
19. Ueshima H, Inagaki M, Toyone T, Otake H. Efficacy of the erector spinae plane block for lumbar spinal surgery: a retrospective study. *Asian Spine J*. 2019;13(2):254-257. [CrossRef]
20. Calandese F, Adduci A. Erector spinae plane block for acute postoperative pain management after anterior thoracolumbar spine surgery. *J Clin Anesth*. 2019;52:55-56. [CrossRef]
21. Gottschalk A, Freitag M, Tank S, et al. Quality of postoperative pain using an intraoperatively placed epidural catheter after major lumbar spinal surgery. *Anesthesiology*. 2004;101(1):175-180. [CrossRef]
22. Gauger VT, Voepel-Lewis TD, Burke CN, et al. Epidural analgesia compared with intravenous analgesia after pediatric posterior spinal fusion. *J Pediatr Orthop*. 2009;29(6):588-593. [CrossRef]
23. Shah A, Hayes CJ, Martin BC. Characteristics of initial prescription episodes and likelihood of long-term opioid use - United States, 2006-2015. *MMWR Morb Mortal Wkly Rep*. 2017;66(10):265-269. [CrossRef]
24. Lavand'homme P, Steyaert A. Opioid-free anesthesia opioid side effects: tolerance and hyperalgesia. *Best Pract Res Clin Anaesthesiol*. 2017;31(4):487-498. [CrossRef]
25. Yayik AM, Cesur S, Ozturk F, et al. Postoperative analgesic efficacy of the ultrasound-guided erector spinae plane block in patients undergoing lumbar spinal decompression surgery: a randomized controlled study. *World Neurosurg*. 2019;126:e779-e785. [CrossRef]
26. Cesur S, Yayik AM, Ozturk F, Ahiskalioglu A. Ultrasound-guided low thoracic erector spinae plane block for effective postoperative analgesia after lumbar surgery: report of five cases. *Cureus*. 2018;10(11):e3603. [CrossRef]
27. Kot P, Rodriguez P, Granell M, et al. The erector spinae plane block: a narrative review. *Korean J Anesthesiol*. 2019;72(3):209-220. [CrossRef]
28. Jadon A, Swarupa CP, Amir M. Fluoroscopic-guided erector spinae plane block: a feasible option. *Indian J Anaesth*. 2018;62(10):806-808. [CrossRef]
29. Seki H, Ideno S, Ishihara T, Watanabe K, Matsumoto M, Morisaki H. Postoperative pain management in patients undergoing posterior spinal fusion for adolescent idiopathic scoliosis: a narrative review. *Scoliosis Spinal Disord*. 2018;13:17. [CrossRef]

30. Chin KJ, Dinsmore MJ, Lewis S, Chan V. Opioid-sparing multimodal analgesia with bilateral bi-level erector spinae plane blocks in scoliosis surgery: a case report of two patients. *Eur Spine J*. 2020;29(Suppl 2):138-144. [CrossRef]
31. Schwenk ES, Viscusi ER, Buvanendran A, et al. Consensus guidelines on the use of intravenous ketamine infusions for acute pain management from the American Society of Regional Anesthesia and Pain Medicine, the American Academy of Pain Medicine, and the American Society of Anesthesiologists. *Reg Anesth Pain Med*. 2018;43(5):456-466. [CrossRef]
32. Selvi O, Tulgar S. Ultrasound guided erector spinae plane block as a cause of unintended motor block. *Rev Esp Anestesiol Reanim (Engl Ed)*. 2018;65(10):589-592. [CrossRef]
33. Canturk M. Ultrasound-guided bilateral lumbar erector spinae plane block for postoperative analgesia after spondylolisthesis correction surgery. *J Clin Anesth*. 2019;57:77-78. [CrossRef]