EGYPTIAN JOURNAL OF ANAESTHESIA
2024, VOL. 40, NO. 1, 96–104
https://doi.org/10.1080/11101849.2024.2309108

Ultrasound guided bilateral erector spinae plane block vs caudal epidural block for peri-operative analgesia in lumbar canal stenosis surgeries: A randomized controlled study

Abdel Moneim Adel Abdel Moneim, Gomaa Zahry Hussein, Abdelrahman Ashraf Abdel Mohimen and Mohamed Fareed El Emady

Department of Anesthesiology, Surgical ICU and Pain Management, Faculty of Medicine – Cairo University, Cairo, Egypt

ABSTRACT

Background: Epidural analgesia is considered by many as cornerstone in postoperative analgesia during operations on the lumbar spine. A novel interfacial plane block that is gaining popularity recently which is erector spinae plane block

Aim: The goal of this research was to evaluate the analgesic effect of ultrasound guided ESP block versus single-shot ultrasound guided caudal epidural analgesia in lumbar canal stenosis surgeries perioperatively.

Patients & methods: This randomized controlled study was done on 56 patients presenting for lumbar canal stenosis surgery in Cairo university hospitals. Patients were randomly assigned equally to receive either ultrasound guided caudal epidural analgesia (Group A) or receive bilateral ultrasound guided lumbar ESP block (Group B) after induction of general anaesthesia. Time to first analgesia request postoperatively and cumulative 24 postoperative opioid consumption were recorded. VAS score was used to assess quality of postoperative analgesia.

Results: The mean time to 1st analgesia request in group A (caudal epidural group) was found to be 2.93 + 2.7 hrs while the mean time to 1st analgesia request in group B was found to be 14.73 + 8.24 hrs. Nevertheless, no variations among two groups were seen after twelve hours following surgery.

Conclusion: Bilateral lumbar ESPB looks to be beneficial block for providing excellent perioperative analgesia in lumbar canal stenosis surgery as it decreased opioid consumption significantly compared to US-CEB group. The simplicity and safety of the block make it getting popular.

ARTICLE HISTORY
Received 26 November 2023
Revised 29 December 2023
Accepted 18 January 2024

KEYWORDS
Ultra-sound; erector spinae block; caudal epidural block; lumbar canal stenosis surgeries

1. Introduction

Major lumbar spine operations are accompanied by excruciating postoperative discomfort that often lasts for at least three days. According to numerous research, postoperative pain peaks in first four hours and gradually subsides by 3rd day after lumbar spine surgery, effective and secure postoperative analgesic techniques are important for quick recovery [1].

Traditional opioid-based analgesic methods are linked to opioids' well-known side effects, such as nausea, vomiting, itching, and sleepiness [2].

Several researchers support epidural block as a gold standard for perioperative analgesia after lumbar spine procedures [3].

Intraoperative catheter placement has shown to be efficient measure to manage post-operative pain. This method can be useful although is not without problems. Spinal surgery can cause tear in the dura, resulting in risk of intrathecal installation of the local anesthetics which could also result in complete spinal anesthesia as well as hematoma and infection risk [4].

Caudal block can achieve effective pain control after lumbar canal stenosis surgeries by providing sensory block [5]. Single shot caudal injection of bupivacaine 0.25% 20 minutes before surgery has been proven to be safe and effective method for providing significant pain relief up to 24 hours after surgery [6]. But the drawback is some degree of motor block associated with the use of this concentration, which may interfere with the neurosurgical examination immediately after surgery to detect any possible motor deficit due to surgery. Bupivacaine 0.125% has been traditionally used in epidural analgesia during labor to provide analgesia without motor affection.

Erector spinae interfacial truncal plane block had been proposed in 2016 [7]. Several reports showed that the lumbar ESPB effectively controlled perioperative pain in studied cases with lumbar spine surgeries, decreasing use of analgesics [8], however only few

CONTACT Abdel Moneim Adel Abdel Moneim Abdelmoneim_Adel@Kasralainy.edu.eg Department of Anesthesiology, Surgical ICU and Pain Management, Faculty of Medicine – Cairo University, Cairo, Egypt

clinical research have focused on ESP block for lumbar surgeries [9].

The aim of this research was to evaluate the pre-emptive analgesic impact of ultrasound guided bilateral ESP block versus single shot Caudal epidural block in lumbar canal stenosis surgeries.

2. Patients & methods

This prospective randomized controlled research had been conducted at neurosurgery department in Kasr al Ainy teaching hospital belonging to Cairo University after getting approval from the Research Ethical Committee (MS-620-2021) and clinical trial registration (NCT05351203). Both surgeon and anesthetist fully explained research's objectives to each studied case, as well as specifics of anaesthesia method that would be applied. Informed written consents were signed by all participating patients.

Patients with known contraindications to regional anesthesia as coagulopathy e.g., INR > 1.5, prothrombin concentration (PC) < 60%, platelet number < 100,000, Infection at the site of needle insertion, low fixed cardiac output, increased intracranial tension, demyelinating lesions, spinal deformity, stenotic lesions of mitral and aortic valves, sepsis, known allergy to any of research drugs, ASA III-IV, aged < eighteen or > 65, with secondary surgery or declining to join in research had been excluded.

Both blocks were done by experienced anesthesiologist not involved in the study where both the patient and the outcome assessor, other than the block performer, were blinded to the study group.

Following approval from anesthesia department's ethics & research committee at Cairo University's Faculty of Medicine, 56 patients were divided into two groups at random using Excel random number table created by computer (Microsoft Corporation, Redmond, WA, USA) & kept secret by serially numbered, opaque, & sealed envelopes. Patients then had been haphazardly allocated into 1 of 2 groups: Group A: received caudal epidural block immediately after the induction of general anesthesia (GA). Group B: received ESPB after induction of GA.

After institutional Ethical Committee approval, studied cases scheduled for lumbar spine surgery for treatment of lumbar canal stenosis in the period from May 2022 to September 2022 had been recruited and informed consent was taken from patients.

All studied cases underwent clinical evaluations and investigations to rule out any of contraindications stated above. Complete blood picture, INR, liver function tests & serum creatinine had been among the necessary laboratory tests.

Intravenous midazolam (0.03–0.1 mg/Kg) premedicated the studied cases.

Basic monitoring in the form of non-invasive blood pressure, pulse oximeter, electrocardiogram had been used to keep eye on the studied cases throughout surgery (pre-operative and every 5 minutes intra-operative).

Studied cases had been positioned prone cautiously with enough personnel.

The ultrasound used was (Siemens® ACUSON X300), the scanning probe had been linear multi-frequency six-thirteen MHz transducer (L25 × six-thirteen MHz linear array).

Group (A): Caudal Epidural Block: after the patient was already positioned prone, sterilized the sacral area by betadine and was covered by sterile sheets. Sacral horns were palpated, sacral hiatus & epidural area were defined through ultrasound (Figure 1). Ultrasound (Siemens® ACUSON X300) portable scanner with a high-frequency linear transducer (10 MHz) had been used to identify caudal epidural space. A 22-gauge spinal needle was used for direct puncture of the sacrococcygeal membrane out of plane then the probe was rotated 90 degree to the longitudinal axis

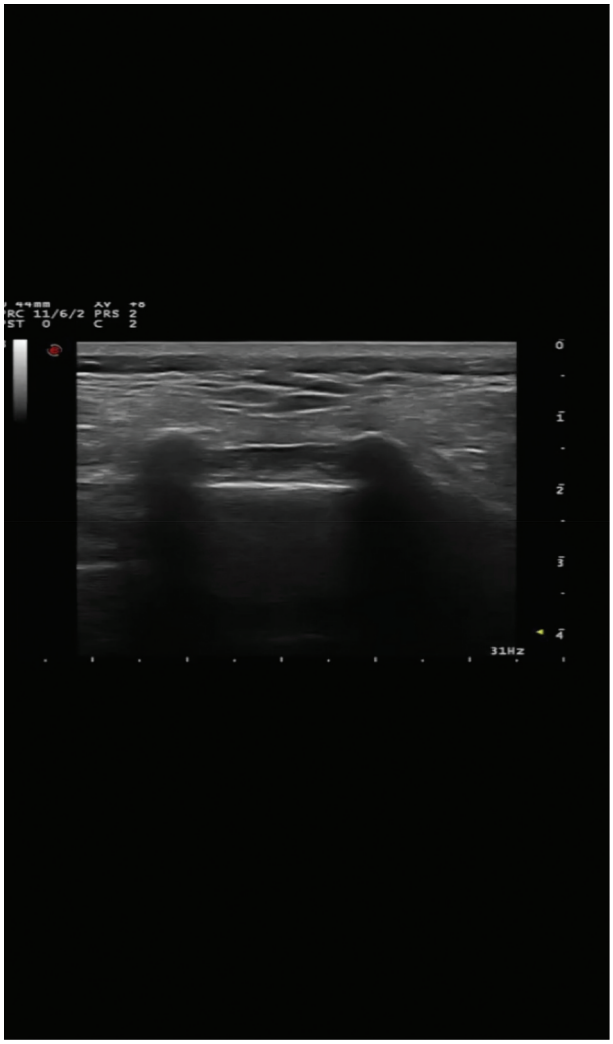

Figure 1. Ultrasound image showing the two sacral corn with the sacrococcygeal membrane and the sacral canal in between.

& needle was seen in plane in epidural space. Then injection of thirty ml 0.125% bupivacaine was done [10].

Group (B): bilateral US guided ESPB group: After skin sterilization, studied case was positioned prone, and an ESP block was administered at level of L3, the shadow of transverse process & erector spinae muscle were defined by placement of curvilinear ultrasound transducer three cm laterally to L3 spinous process. In order to reach TP while traversing all muscles, 22-gauge spinal needle was placed from cranial to caudal in direction of TP and in same plane as ultrasonic transducer (Figure 2) twenty mL of 0.25% bupivacaine were injected after making sure needle site was accurate [11]. Same processes were followed to repeat process on the other side.

Rescue analgesic protocol: Intra operative: i.v 0.5 µg/kg of fentanyl at any time if mean arterial blood pressure or heart rate raised by more than twenty percent from baseline reading.

Post-operative: paracetamol 1 gm every six hours, ketorolac 30 mg every twelve hours at regular basis.

Nalbuphine Hydro-Chloride (0.1 mg/kg) was given if pain scores > 4/10

Primary outcome was defined by time to 1st analgesia request. While the secondary outcome included cumulative 24 hours opioid consumption, VAS score at 15 & 30 mins, then at 2, 6, 12, 24 hours post-operatively, Incidence of problems as (itching, vomiting, urinary retention and respiratory depression) among two groups, Block failure rate, Presence of any degree of motor block. Mean arterial blood pressure & heart rate readings recorded preoperatively as baseline readings, intraoperative after induction of general anesthesia then every fifteen minutes till end of surgery and postoperatively at 30 minutes then 2, 6, 12, 24 hours post-operatively.

3. Sample size

First rescue analgesia request was the primary outcome. A previous study concluded that the mean time to first rescue analgesia was 6.3 ± 1.15 hours [10] after bupivacaine caudal epidural. Sample size was calculated to detect a mean difference of 20% between both study groups. MedCalc Software version 14 was used for the calculation of the sample size. 44 patients (22 Patient in each group) at least were assigned to have a study power of 95% and

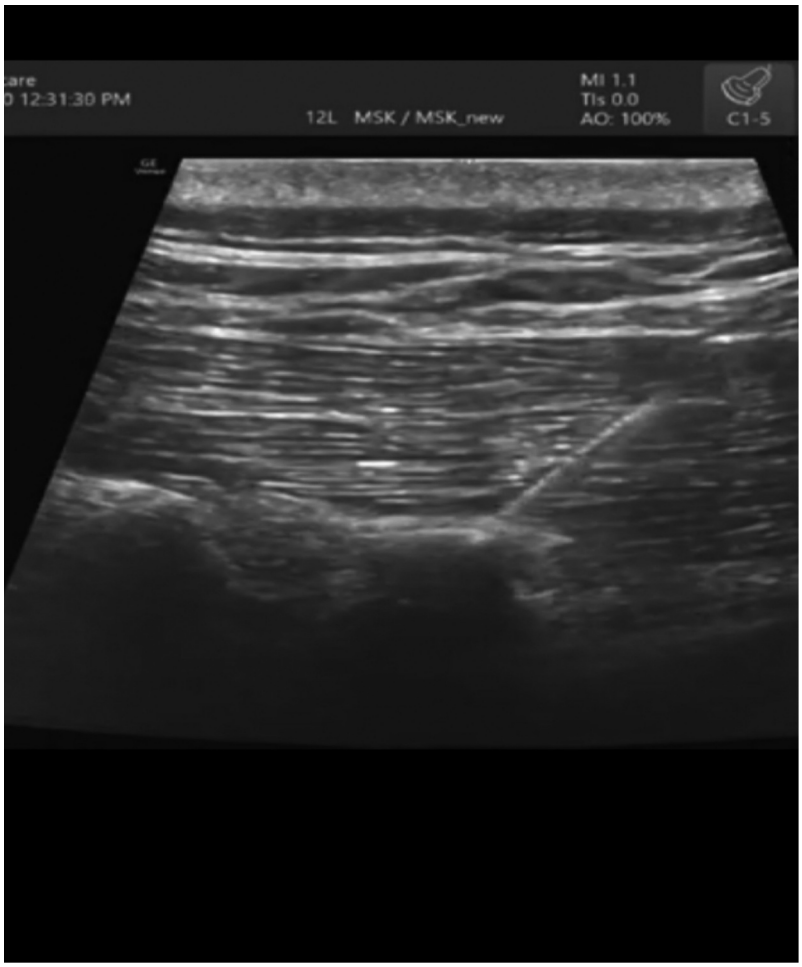

Figure 2. Ultasound image showing needle passing through erector spinae muscle to inject local anesthetic drugs between the muscle and the transverse process of L3 lumbar vertebrae.

an alpha error of 0.05. Patients were increased to 50 participants (25 in each group) to compensate for dropouts.

4. Statistical analysis

Data was analyzed using SPSS version 22. Data was checked for normality using Shapiro-Wilk test. Categorical data was reported as frequency and percentages and was analyzed by the Chi-square test. Normally distributed data was presented as means ± SD and were analyzed using Student T-Test, and abnormally distributed data was presented as median (IQR) and analyzed using the Mann-Whitney test. p values < 0.05 were considered significant.

5. Results

Fifty-six studied cases undergoing lumbar canal stenosis surgery had been randomly allocated in 2 equal groups. Studied cases had been randomly allocated into one of two groups: Group A (the CEB group $n = 29$) and Group B (the ESPB $n = 27$), of which six were excluded for block failure (Figure 3).

All patients received either of the two blocks after induction of GA. In CEB group, studied cases received 30 ml 0.125% Bupivacaine while in ESPB group, patients received 20 mL of 0.25% Bupivacaine bilaterally.

There was no difference among two groups concerning Age, gender or ASA as found in Table 1.

Our primary result was time to 1st analgesia request, and we found that there was a variation among two groups. The mean time to 1st analgesia request in

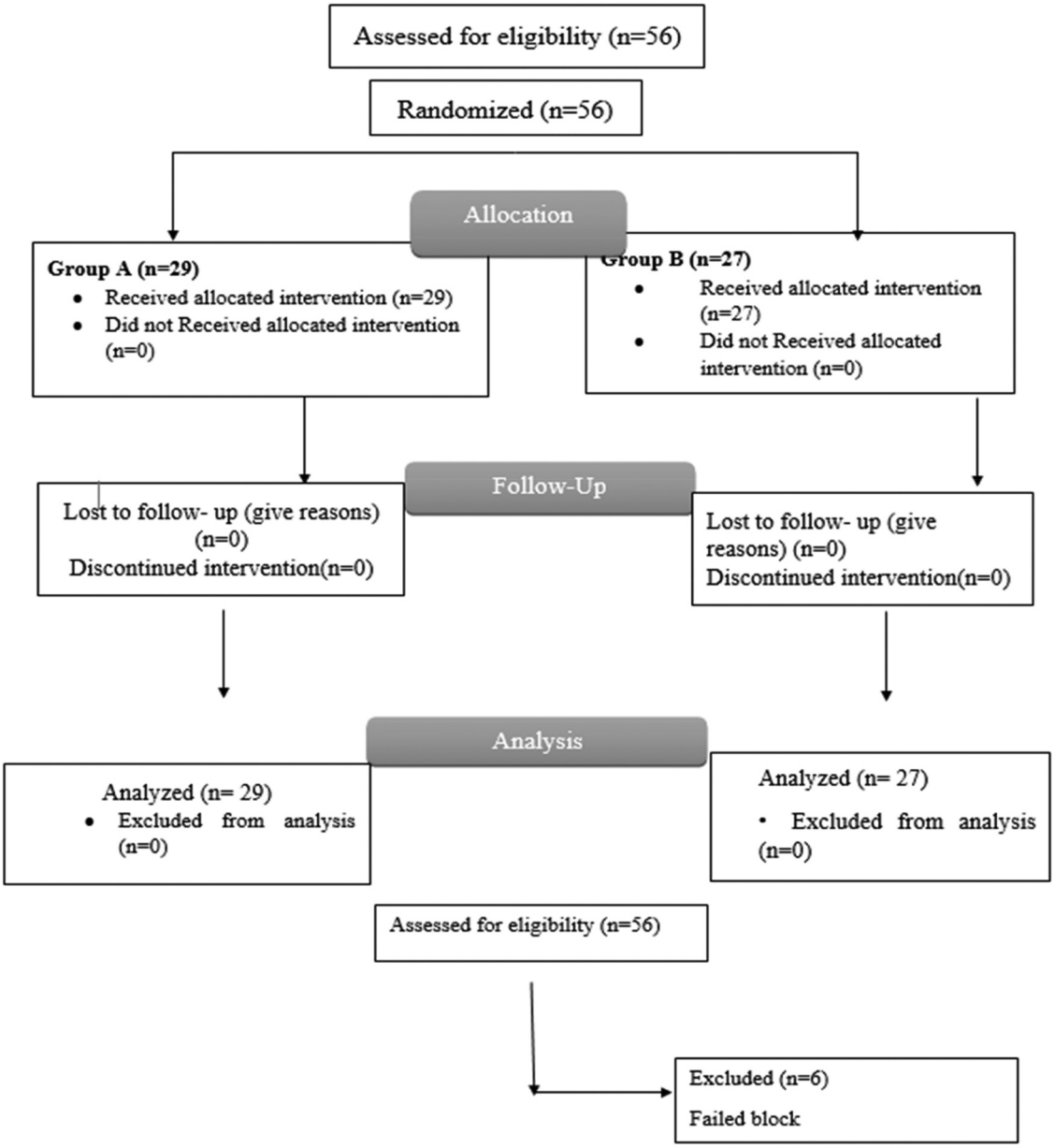

Figure 3. Consort of studied group.

Table 1. Demographic data.

		Group A CEB ($n = 25$)	Group B ESPB ($n = 25$)	P
Age		43.96 ± 11.66	47.20 ± 13.24	0.363
Sex	Female	14(56.0%)	10(40.0%)	0.258
	Male	11(44.0%)	15(60.0%)	
ASA	I	13(52.0%)	17(68.0%)	0.248
	II	12(48.0%)	8(32.0%)	

Data are presented as mean ± SD or frequency (%), *significant p value < 0.05, CEB: Caudal Epidural Block, ESPB: Erector Spinae Plane Block, ASA: American Society of Anesthesiology.

Table 2. Time to the first analgesic request.

	Group A CEB ($n = 25$)	Group B ESPB ($n = 25$)
Time to first analgesic. req. (hrs)	2.93 ± 2.70	14.73 ± 8.24

Data are presented as mean ±SD, CEB: Caudal Epidural Block, ESPB: Erector Spinae Plane Block.

group A (caudal epidural group) was found to be 2.93 ± 2.7 hrs while the mean time to 1st analgesia request in group B (erector spinae plane block) was found to be 14.73 ± 8.24 hrs as shown (Table 2).

In 1st twelve hours following procedure, VAS score in ESPB group was considerably lower than in CEB group, with P-value of < 0.001. Nevertheless, no statistically significant variations among two groups were seen after twelve hours following surgery (Figure 4)

Regarding Perioperative change in mean arterial blood pressure, there was only statistically significant difference between the two groups during 30 and 75 mins intra-operative and 24 hours post-operative where the MBP was significantly lower in group A at 30 and 75 mins intra-operative and significantly higher than group B at 24 hours post-operative. Otherwise there was no statistically significant difference in MBP between the two groups (Figure 5).

There was no statistically significant difference between the two study groups as regarding intra-operative and postoperative heart rate changes till 2 hours post-operative ($p < 0.05$) as shown in Figure 6.

However, there was a statistically significant difference between the two groups from 2 hours post-operative till 24 hours post-operative ($p > 0.05$) as shown in Figure 6).

There was a statistically significant difference between two groups in total opioid consumption both intra-operative and postoperative where the mean total intra-operative consumption of fentanyl in Group A (CEB) was 118.60 ± 33.90mic while the mean total intra-operative fentanyl consumption in Group B (ESPB) was 100 ± 0.00mic ($p < 0.011$).

The total post-operative Nalbuphine consumption in Group A (CEB) was 15.21 ± 4.57 mg while the total post-operative Nalbuphine consumption in Group B (ESPB) was 9.50 ± 1.08 mg ($p < 0.001$) as found in Table 3.

The frequency of complications (Nausea, vomiting, Itching) was greater in CEB group ($p = 0.003$) as shown in (Table 4)

No other complications were identified in form of urine retention or respiratory problems.

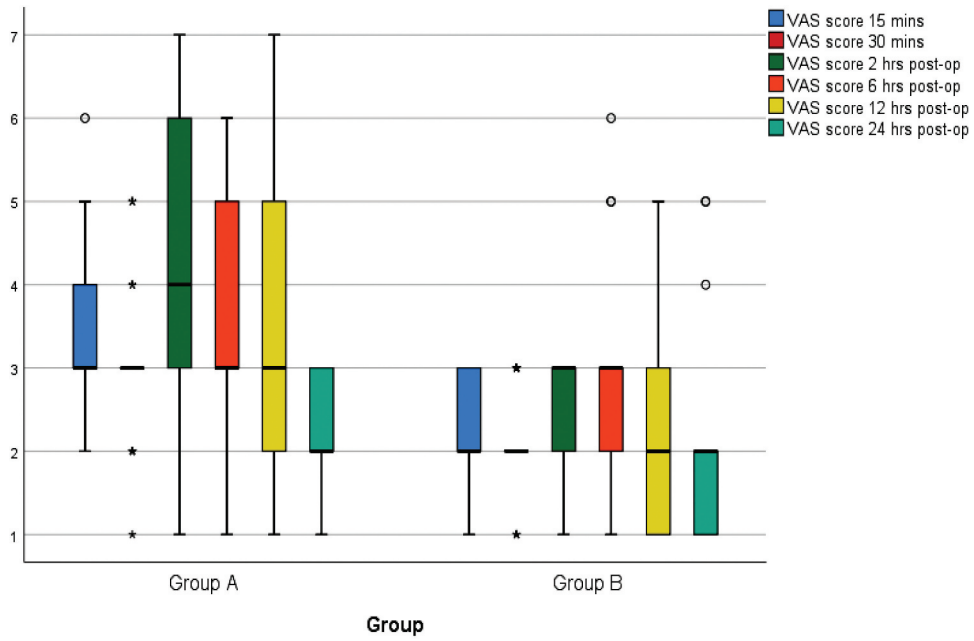

Figure 4. Postoperative visual analogue score over time in the two studied groups.

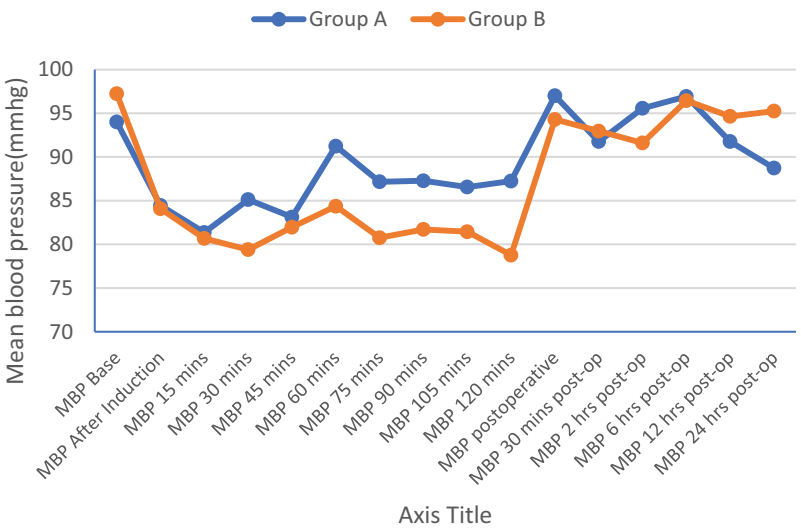

Figure 5. Changes of the mean arterial pressure over time in the two studied groups.

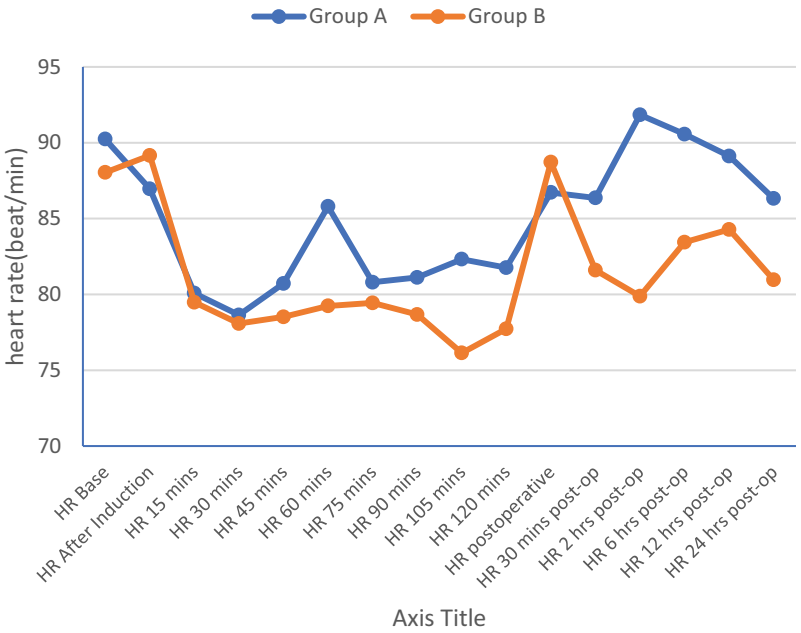

Figure 6. Mean heart rate changes over time in the two studied groups.

None of the cases complained of any degree of motor blockade in either of the two groups.

There was no statistically significant variation in block failure rate (where block would be considered failure if studied case needed more than two doses of rescue analgesia in 1st hour postoperatively) between both groups ($p > 0.05$) as shown in Table 5.

6. Discussion

This research found clear decrease in requirement to first analgesic use following bilateral US guided ESPB as preemptive analgesic method in studied cases undergoing lumbar canal stenosis surgeries compared to ultrasound guided caudal epidural block. Moreover,

Table 3. Total perioperative opioid consumption.

	Group A CEB ($n = 25$)	Group B ESPB ($n = 25$)	P
Nalbuphine (mg)	15.21 ± 4.57	9.50 ± 1.08	**<0.001***
Fentanyl (mic)	118.60 ± 33.90	100.00 ± 0.00	**0.011***

Data are presented as mean ± SD, CEB: Caudal Epidural Block, ESPB: Erector Spinae Plane Block.

Table 4. Postoperative complications in both groups.

	Group A CEB ($n = 25$)	Group B ESPB ($n = 25$)	P
Itching	3(12.0%)	1(4.0%)	**0.003***
Nausea	9(36.0%)	2(8.0%)	
Vomiting	4(16.0%)	2(8.0%)	
Nausea and vomiting	4(16.0%)	2(8.0%)	

Data are presented as frequency (%), *significant p value < 0.05, CEB: Caudal Epidural Block, ESPB: Erector Spinae Plane Block.

Table 5. Block failure rate.

		Group A CEB	Group B ESPB	P value
Block failure rate	Total number	29 (100%)	27 (100%)	0.671
	Failed	4 (14.29%)	2 (7.41%)	
	successful	25 (89.29%)	25 (92.59%)	

Data are presented as frequency (%), CEB: caudal epidural block. ESPB: Erector spinae plane block.

US-ESPB also significantly reduced both intra-operative and post-operative total opioid consumption in addition to reducing postoperative VAS scores in 1st 12 h after surgery, with decrease in incidence of postoperative complications compared to the US-CEB.

Opioid consumption reduced in ESP block group compared to caudal epidural group in our research, however there was no significant variation in Bromage scale or block failure rate among 2 groups. There was also variation in MBP (during 30,75 mins) and HR (from 2 hours till 24 hours post-op) but mean HR measurements were nearly comparable with no significant variation among two groups intra- operatively.

Years old in CEB group was 43.96 + 11.66 while in ESPB it was 47.20 + 13.24 ($p = 0.363$) in the CEB group there were 11 males (44.0%) and 14 females (56.0% %) while in the ESPB group there were 15 males (60.0%) and 10 females (40.0%) ($p = 0.258$).

Most likely primary mechanism of action of ESP block is direct action of local anesthetic drugs through the physical spread and diffusion to the neural structures in the fascial plane deep to erector spinae muscle.

In our research, the duration of analgesia was more prolonged in ESPB group in comparison with the caudal epidural group as showed by time to 1st analgesia request & lower VAS scores in first 12 hours postoperative. This difference could be partially explained as lower concentration was used in the US- CEB to avoid motor blockade to allow immediate post-operative neurosurgical examination to detect any nerve root injury for better patient and surgeon satisfaction.

Blockade of rami communicants in ESPB which can cause sympathetic fibers to become blocked leading to systemic hypotension, but much less than that with the epidural block [12]. There is greater incidence of hypotension with epidural anesthesia & Paravertebral blocks have previously been described when compared to ESPB [13].

This supports safety of ESPB in special group of patients with limited cardiovascular reserve when sympathetic blockage can lead to extensive hypotension and hypo perfusion [14].

studied cases undergoing spinal surgery have been investigated when using epidural analgesia [15]. Nevertheless, problems like epidural hematoma & dural puncture are possible with epidural analgesia [16]. In addition, the motor blockage following surgery that may come with epidural analgesia obstructs postoperative neurological evaluation. This may cause postoperative surgical issues to take longer to diagnose & manage. As a result, other alternatives that avoid these issues are necessary [17].

According to a study by Singh et al. [3] which reported that pre-operative bilateral US ESPBs had been more efficient than conventional post-operative analgesics in postoperative pain control after lumbar spine surgeries. Studied cases in ESPB group had lower pain levels than studied cases in control group both immediately & six hours following surgery.

In this research, the mean time for first dose of rescue analgesia was 14.73 ± 8.24 hours in the ESPB group, indicating that postoperative analgesia was more prolonged in this group. Studied cases in the study done by Singh et al. needed their 1st dose of rescue analgesia after 5.8 ± 0.75 hours in the ESPB, compared to 2.42 ± 0.59 hours in control group. This could be explained as the injectate in our study was closer to the level of surgical intervention as ESP block was performed at level of (T10), but in our research, injection was performed at level of (L3).

ESP block was studied in different type of surgeries, In a research done by Oksuz et al. [18], Comparing postoperative analgesia consumption, pain scores, & studied case satisfaction in studied cases undergoing breast reduction surgery under general anaesthesia using tumescent anaesthesia technique (involves subcutaneous infiltration of large volumes of tumescent fluid containing lidocaine, saline, & adrenaline to generate anesthesia of targeted areas) & erector spinae block. He found that the ESP block is more effective than tumescent anaesthesia.

According to a study by Abdelhamid et al. [19], where 2 groups made up total of 67 studied cases were assigned. ESP block group received US guided bilateral ESP block with twenty mL of 0.25% Bupivacaine on each side, whereas epidural group received one-shot lumbar epidural block with twenty mL of 0.25% Bupivacaine. They found that the duration of postoperative analgesia was more prolonged in the group who received ESPB in comparison to the single shot lumbar Epidural group 11.5 [9,14] and 7 [5,8]hours respectively.

According to a study by Eskin et al. [20], where 120 adult studied cases in total undergoing lumbar spine surgery were involved in trial & randomly assigned to ESP group (n = forty), MTP group (n = forty), &control group (n = forty). Prior to GA, studied cases in ESP group underwent bilateral ESP block by receiving twenty mL injection of 0.25% bupivacaine at level of vertebrae in middle of incision. In midpoint transverse to pleura plane block (MTP) group, identical LA was given bilaterally at T12/L1 level. Following surgery. VAS score was used to measure postoperative pain throughout 1st forty-eight hours after surgery. When VAS value

was greater than three, pethidine was administered as emergency analgesic. The primary result was mean pain score. Secondary result was use of rescue analgesics &amount of tramadol released from PCA. the study found that both ESP block and midpoint transverse to Pleura Plane block were efficient in controlling postoperative pain after lumbar spine surgeries with more superior results in the ESP group, these findings are consistent with our study in that US- ESPB is superior in reducing postoperative pain scores, time to 1st analgesia request& total opioid consumption post-operative in lumbar spine surgeries with lesser incidence of post-operative complications.

Based on research by Sekar et al. [21], the research comprised forty-two studied cases undergoing discectomy in lumbosacral spine using posterior route, in control group the patients received single caudal epidural injection of twenty ml of normal saline after induction of general anesthesia. studied cases in trial group ($n = 42$) got single twenty ml caudal epidural injection that contained active medications 1 ml tramadol(50 mg) &15 ml bupivacaine (0.5%) and 4 ml of distilled water. The mean time for first analgesia request was 10.6 (SD6.9) hours.

In our study, we used more volume but lower concentration of bupivacaine (30 ml bupivacaine 0.125%) without adjuvant, this could explain the more prolonged time to 1st analgesia request in this research compared to ours. Also, the degree of motor blockade post- operative was not assessed in this research and almost all patients in the trial group developed transient urine retention.

On the other side, ESP block may be not effective with the visceral pain of some abdominal surgeries, according to research by Sakae et al. [22], thirty-one studied cases who underwent open cholecystectomy were included, of whom fifteen were in intervention group (ESP block) & sixteen were in positive control group (epidural). ESP blockade was not shown to be effective method for pain control after open cholecystectomy at doses used in that research as the use of opioids was seven-fold higher in the ESP group.

This study finding was against our study. However, the control group in this study received morphine with thoracic epidural contrary to our study, and the type of local anesthetic used (20 ml of 0.5% Ropivacaine), which is less potent than Bupivacaine used in our study.

7. Conclusion

As a result of significantly lower opioid usage compared to US-CEB group, bilateral US-ESPB appears to be effective technique for delivering appropriate intraoperative & postoperative analgesia in lumbar canal stenosis surgeries.

8. Limitations

This study was done on one type of lumbar spine surgeries (laminectomy+/_ discectomy).

9. Recommendations

When compared to other blocks, ESP block is special because of how straightforward & secure it is. Volume, concentration, & kind of local anaesthetic must now be subject of clinical investigations.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

[1] Bianconi M, Ferraro L, Ricci R, et al. The pharmacokinetics and efficacy of ropivacaine continuous wound instillation after spine fusion surgery. Anesth Analg. 2004 Jan;98(1):166–172.

[2] Cohen BE, Hartman MB, Wade JT, et al. Postoperative pain control after lumbar spine fusion. Patient-controlled analgesia versus continuous epidural analgesia. Spine (Phila Pa 1976). 1997 Aug;22 (16):1892–1897. doi: 10.1097/00007632-199708150-00016

[3] Singh S, Choudhary NK, Lalin D, et al. Bilateral ultrasound-guided erector spinae plane block for postoperative analgesia in lumbar spine surgery: a randomized control trial. J Neurosurg Anesthesiol. 2020 Oct;32(4):330–334. doi: 10.1097/ANA.0000000000000603

[4] 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 Jul;101(1):175–180.

[5] Samagh N, Pai RK, Mathews TK, et al. Pre- emptive caudal epidural analgesia with ropivacaine for lumbosacral spine surgery: A randomized case control study. J Anaesthesiol Clin Pharmacol. 2018;34(2):237–241. doi: 10.4103/joacp.JOACP_72_17

[6] Saoud A, Elkabarity R, Abdellatif A. Efficacy of preemptive caudal analgesia in single level lumbar spine decompression and fusion surgery. world spinal column J. 2012;3:71–9.

[7] Qiu Y, Zhang T-J, Hua Z. Erector Spinae Plane Block for Lumbar Spinal Surgery: A Systematic Review. J Pain Res. 2020;13:1611–1619. 10.2147/JPR.S256205.

[8] Melvin JP, Schrot RJ, Chu GM, et al. Low thoracic erector spinae plane block for perioperative analgesia in lumbosacral spine surgery: a case series. Can J Anesth Can d'anesthésie. 2018;65(9):1057–1065. doi: 10.1007/s12630-018-1145-8

[9] Celik M, Tulgar S, Ahiskalioglu A, et al. Is high volume lumbar erector spinae plane block an alternative to transforaminal epidural injection? Evaluation with MRI. Reg Anesth & Pain Med. 2019 Sep 1;44(9):906 LP–907. doi: 10.1136/rapm-2019-100514

[10] Hussien E, Mohammed G, El Shaer A, et al. Efficacy of sacral epidural blockade with bupivacaine versus morphine as pre-emptive analgesia for lumbar laminectomy surgeries. J Anaesth. 2016 Apr.-June;9(2):260.

[11] 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 Jun 1;126:e779–85. doi: 10.1016/j.wneu.2019.02.149

[12] He W, Wu Z, Zu L, et al. Application of erector spinae plane block guided by ultrasound for postoperative analgesia in breast cancer surgery: a randomized controlled trial. Cancer Commun. 2020 Mar 1;40(2–3):122–125. doi: 10.1002/cac2.12013

[13] Shokri H, Kasem A. Analgesic efficacy of erector spinae block in comparison to thoracic epidural anesthesia in patients undergoing transthoracic esophageal surgical procedure. Res Opin Anesth Intensive Care. 2020 Jan 1;7(1):124–130. doi: 10.4103/roaic.roaic_35_19

[14] Ahiskalioglu A, Tulgar S, Celik M, et al. Lumbar erector spinae plane block as a main anesthetic method for hip surgery in high risk elderly patients: initial experience with a magnetic resonance imaging. Eurasian J Med. 2020 Feb;52(1):16–20. doi: 10.5152/eurasianjmed.2020.19224

[15] Meng Y, Jiang H, Zhang C, et al. A comparison of the postoperative analgesic efficacy between epidural and intravenous analgesia in major spine surgery: a meta-analysis. J Pain Res. 2017;10:405–415. doi: 10.2147/JPR.S128523

[16] Ehrenfeld JM, Agarwal AK, Henneman JP, et al. Estimating the incidence of suspected epidural hematoma and the hidden imaging cost of epidural catheterization: A retrospective review of 43,200 cases. Reg Anesth & Pain Med. 38(5):409 LP–414.2013 Sep 1. http://rapm.bmj.com/content/38/5/409.abstract

[17] Blumenthal S, Borgeat A, Nadig M, et al. Postoperative analgesia after anterior correction of thoracic scoliosis: a prospective randomized study comparing continuous double epidural catheter technique with intravenous morphine. Spine (Phila Pa 1976). 2006;31(15):1646–1651. doi: 10.1097/01.brs.0000224174.54622.1b

[18] Oksuz G, Bilgen F, Arslan M, et al. Ultrasound-guided bilateral erector spinae block versus tumescent anesthesia for postoperative analgesia in patients undergoing reduction mammoplasty: a randomized controlled study. Aesth Plast Surg. 2019 Apr;43(2):291–296. doi: 10.1007/s00266-018-1286-8

[19] Abdelhamid HS, ElSabbagh HA, Amin SM, et al. Erector spinae plane block vs. single shot epidural block for postoperative analgesia in lumbar spine surgery: a randomized controlled trial. Anaesth Pain Intensive Care. 2022 Jun 13;26(3):310–317. doi: 10.35975/apic.v26i3.1897

[20] Eskin MB, Ceylan A, MÖ Ö, et al. Ultrasound-guided erector spinae block versus mid-transverse process to pleura block for postoperative analgesia in lumbar spinal surgery. Anaesthesist. 2020;69(10):742–750. doi: 10.1007/s00101-020-00848-w

[21] Sekar C, Rajasekaran S, Kannan R, et al. Preemptive analgesia for postoperative pain relief in lumbosacral spine surgeries: a randomized controlled trial. Spine J. 2004;4(3):261–264. doi: 10.1016/j.spinee.2003.11.009

[22] Sakae TM, Yamauchi LHI, Takaschima AKK, et al. Comparison between erector spinal plane block and epidural block techniques for postoperative analgesia in open cholecystectomies: a randomized clinical trial. Brazilian J Anesthesiol. 2020;70(1):22–27. doi: 10.1016/j.bjan.2019.12.009