Original Article

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Comparison of ultrasound-guided continuous erector spinae plane block versus continuous paravertebral block for postoperative analgesia in patients undergoing proximal femur surgeries

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Abstract

Background – Proximal femur fracture surgeries have become increasingly prevalent, presenting unique challenges for postoperative pain management due to patient demographics and comorbidities. Erector spinae plane block (ESPB) has emerged as a relatively safe alternative to paravertebral block (PVB). Our aim was to compare ultrasound-guided continuous ESPB with continuous PVB for postoperative analgesia in patients undergoing proximal femur surgeries under spinal anesthesia.

Methods – A prospective randomized interventional study was conducted on 60 patients between 18 and 60 years of age undergoing proximal femur surgeries under spinal anesthesia with American Society of Anesthesiologists physical status I and II between January 2019 and April 2020. Patients were randomly assigned to receive either ultrasound-guided continuous ESPB (Group E, n = 30) or ultrasound-guided continuous PVB (Group P, n = 30) using a computer-generated randomization table. The mean maximum visual analog scale (VAS) score, VAS score in the first 24 h, the time of rescue analgesia, and total requirement of rescue analgesia were assessed.

Results – The maximum VAS score within the first 24 h was numerically higher in Group P but statistically insignificant (p-value 0.279). VAS scores at 0, 1, 2, 6, and 18 h postoperatively were comparable in both groups. However, at the 24-h mark, the VAS score between Group E and Group P was statistically significant (p-value 0.018) but not clinically relevant. The mean paracetamol and tramadol requirements were comparable between the two groups.

Conclusion – Continuous ESPB is as effective as continuous PVB for postoperative analgesia in proximal femur surgeries. The enhanced safety profile of erector spinae block underscores its significance in postoperative pain management.

Keywords: erector spinae plane block, paravertebral block, proximal femur surgery, ultrasound, VAS score

1 Introduction

Surgical procedures often result in post-operative pain due to tissue damage and the release of inflammatory mediators. Effective pain management is crucial to minimize detrimental effects on patient outcomes. Hip and proximal femur surgeries, which are common for osteoporosis and trauma-related injuries, particularly affect elderly individuals with a high incidence rate of approximately 129 per 100,000 [1].

The complex nerve supply in the hip region contributes to both superficial and deep pain post-surgery. The hip joint is richly supplied by branches of femoral (L2–4), obturator (L2–4) sciatic nerves, and superior gluteal nerve (L4, L5, and S1) [2]. The skin incision of the posterolateral approach to the hip joint goes through the superior lateral gluteal region and the proximal part of the lateral thigh. This area is innervated by the lateral femoral cutaneous nerve from the lumbar plexus (L2–L3), the lateral cutaneous branch of ilio-hypogastric nerve (T12 and L1), and the subcostal nerve (T12 thoracic nerve) [3].

Given the limitations and complications associated with pharmacological pain relief methods, regional analgesia, including peripheral nerve blocks, is increasingly favored. Recent years have seen a rise in the use of regional analgesic techniques for proximal femur surgeries, with a particular

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focus on peripheral nerve blocks due to their safety profile [4–6]. Paravertebral block (PVB) and erector spinae plane blocks (ESPB) are emerging as promising options in postoperative pain management in proximal femur surgeries. However, there is a paucity of studies comparing the ultrasound-guided continuous PVB and ultrasound-guided continuous ESPB for postoperative analgesia in proximal femur surgeries. In this study, we aimed to address this gap in the literature.

2 Materials and methods

This prospective, randomized comparative study was conducted in a tertiary care hospital in India from January 2019 to April 2020, after receiving Institutional Ethical Committee clearance. The study was registered in the Clinical Trials Registry India (CTRI/2019/03/017975, date: 7/3/2019). The objective was to compare ultrasound-guided continuous ESPB and PVB for postoperative analgesia in patients undergoing proximal femur surgeries. All patients provided written informed consent.

Continuous L2 PVB for postoperative analgesia after direct anterior total hip arthroplasty: a case series was studied by Ardon et al. [7]. The study observed mean maximum pain on postoperative day 0 in PVB was 5.4 ± 3.0. Taking these values as a reference, and assuming a mean difference of 2.5, the minimum required sample size with 80% power of study and 5% level of significance is 23 patients in each study group. To reduce the margin of error, a total sample size of 60 (30 patients per group) was taken. The 15 pilot studies were only done to ascertain the feasibility of the study and the timing and dosage of a block. The study was single blinded due to the resource limitation of the center. The patients remained unaware of the specific block they received. The same anesthesiologist performed the block in all the cases after having performed 20 blocks of each type.

A computer-generated random table system assigned patients to either of the following groups:

- Group E (n = 30): ultrasound-guided continuous ESPB.
- Group P (n = 30): ultrasound-guided continuous PVB.

Inclusion criteria encompassed patients aged 18–60 years, of any gender, undergoing proximal femur surgeries under spinal anesthesia with American Society of Anesthesiologists (ASA) grades I and II. Exclusion criteria included contraindications to regional anesthesia, known allergies to local anesthetics, bleeding disorders, anticoagulant use, severe kidney or liver disease, lack of proper comprehension due to dementia, and pregnant or lactating females.

All 60 patients underwent thorough pre-anesthetic evaluations and relevant investigations. Patients fasted in accordance with guidelines, and the study's purpose, advantages, and potential side effects of both techniques were explained to them before obtaining written informed consent. Linear visual analog scale (VAS) for determining the intensity of pain was explained to the patient. Premedication included Tab. Alprazolam 0.25 mg, Tab. Ranitidine 150 mg, and Tab. Metoclopramide 40 mg orally the night before surgery and 2 h prior to surgery.

Upon arrival at operation theatre, standard monitors were attached before giving regional anesthesia. Basal parameters like heart rate (HR), blood pressure (BP) – systolic, diastolic, and mean, oxygen saturation, and electrocardiography were recorded. An intravenous line was secured, and ringer lactate infusion was started. Emergency resuscitation equipment were kept ready.

In Group E (n = 30), patients were positioned in a sitting position with meticulous aseptic measures. The erector spinae muscles were identified, superficial to the tip of L2 transverse process, using a linear ultrasound transducer. Following administration of local anesthesia with 2% lignocaine, an 18-G, 10-cm Touhy's needle was carefully inserted using an in-plane approach, placing the tip within the fascial plane on the deep (anterior aspect) of erector spinae muscles. Once the needle's correct placement was confirmed by the visible spread of fluid, gently lifting the erector spinae muscle off the bony shadow of the L2 transverse process, a catheter was threaded through the Touhy's needle Figure 1.

For Group P (n = 30), a similar stringent aseptic protocol was followed. Patients were positioned in a sitting position, paravertebral space at L2 vertebrae was located under ultrasound guidance, and 18-G Tuohy's needle was inserted. After confirming the site using the hydro location technique, a catheter was threaded through the Tuohy's needle and precisely placed within the paravertebral space Figure 2.

Following the catheter placement, patients underwent surgery after receiving a subarachnoid block (SAB) with hyperbaric 0.5% bupivacaine (2.5 ml) and fentanyl (15 µg). The adequacy of SAB was verified by assessing the level of sensory blockade, typically through assessing analgesia to pinprick. Continuous monitoring included recording HR, SPO_2, non-invasive BP, blood loss, and urine output. Patients received inhalational oxygen via venturi mask and intravenous fluids tailored to their deficit and body weight, considering blood loss. Any bradycardia was treated with IV atropine sulfate (20 µg/kg), while hypotension was addressed with IV fluid boluses and IV mephentermine. Any other complications

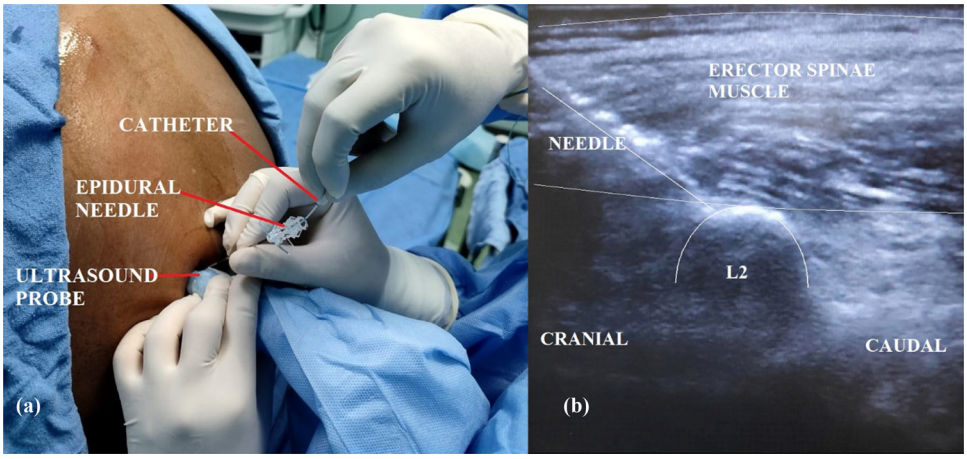

Figure 1: (a) Ultrasound-guided erector spinae block with catheter insertion in a sitting position. (b) Ultrasound image of erector spinae block showing needle, L2 vertebrae, and erector spinae muscle.

were managed following standard operating procedures and documented accordingly.

During surgery, the level of sensory block was continually monitored. When the sensory block receded to the T10 level, 25 ml of 0.5% ropivacaine was administered through the catheter. This was followed by the initiation of a continuous infusion of 0.25% ropivacaine at a rate of 5 ml per hour postoperatively for 24 h in both study groups.

Patients were closely monitored in the recovery room for 2 h before being transferred to the ward. Postoperatively, pain intensity was assessed using the VAS immediately after surgery, at 1, 2, 6, 18, and 24 h post-surgery. Patients received intravenous Paracetamol (1 g) when the VAS score at rest fell within the range of 4–7. If the pain persisted, inj. Tramadol (100 mg IV) was administered. Patient satisfaction was assessed 24 h after surgery.

The primary objective of the study was to compare the mean maximum VAS score. The secondary objective involved comparing VAS scores in both groups during the first 24 h, assessing the time of rescue analgesia, and evaluating the total requirement for rescue analgesics within 24 h.

Data obtained from the study was entered into a Microsoft Excel spreadsheet, and statistical analysis was conducted using appropriate software. Categorical variables were presented in terms of numbers and percentages (%), while continuous variables were expressed as mean ± SD and median. The normality of data was assessed using the Kolmogorov-Smirnov test. When the data sets were found to be non-normally distributed, quantitative variables were compared using an unpaired *t*-test/Mann–Whitney test. Qualitative variables were compared using the Chi-square test/Fisher's exact test. A *p*-value of <0.05 was considered statistically significant.

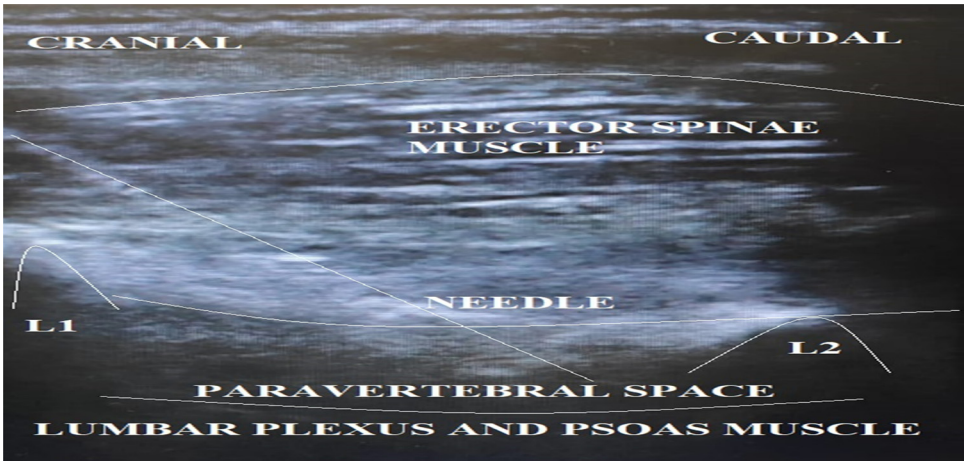

Figure 2: Ultrasound image of PVB showing needle, L1 and L2 vertebrae, and paravertebral space.

3 Results

Out of 72 patients approached, 60 were eligible for the final analysis (of 70, 2 declined, 6 were ASA III, 2 patients received general anesthesia and 2 had catheter-related issues) Figure 3.

The mean age of participants in Group E was 39.63 years, and in Group P was 40.4 years, with both groups consisting of 80% male and 20% female participants. Both groups were comparable with respect to patient demographics and anthropometric parameters (Table 1).

We included intertrochanteric fracture femur, subtrochanteric fracture femur, and fracture neck of femur in our study (Table 2).

The different proximal femur surgeries that were performed in both the groups are given in Table 3. In Group P, 15 patients underwent proximal femur nailing (PFN), 11 had cannulated cancellous screw (CCS) fixation, 3 had dynamic hip screw (DHS) fixation, and 1 patient had dynamic condylar screw fixation. In Group E, 19 patients received PFN, 8 had CCS fixation, 1 underwent DHS fixation, 1 had a valgus osteotomy, and 1 had plating.

We did not observe any difference in the efficacy between the two block groups with the different types of surgery performed.

In the majority of patients in both groups, the time between spinal and block (in hours) fell within the 1- to 3-h range, accounting for 76.67% in E and 83.33% in P. For those exceeding 3 h, 23.33% were in Group E, and 16.67% in Group P, showing no significant distinction. The time distribution was normal, allowing for parametric testing. Additionally, there was no significant variation in the mean time between spinal and block for Group E (2.51 ± 0.63) and Group P (2.75 ± 0.77) [p value 0.18, t test]. We did not observe any difference in the time taken to perform the block as it was not our objective.

Mean maximum VAS refers to the mean of the maximum VAS recorded in the 24 h in the particular study

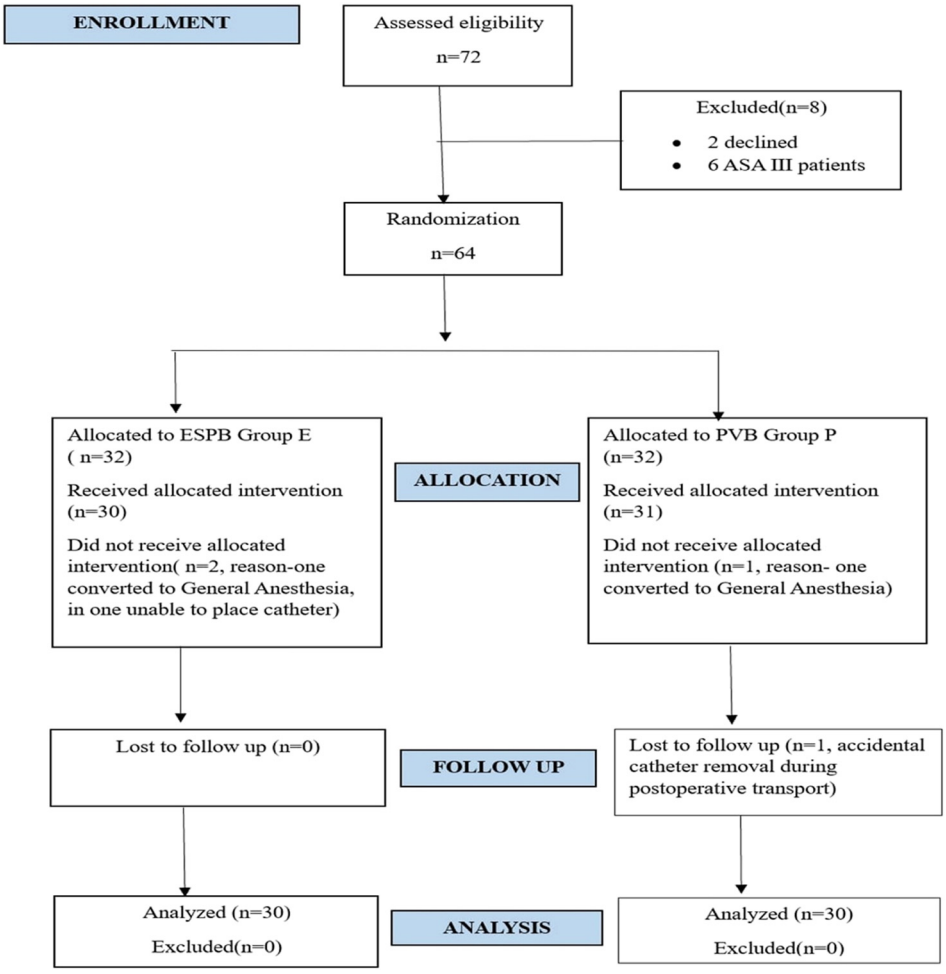

Figure 3: Consort diagram of the study.

Table 1: Demographic and anthropometric comparison between Group E and Group P

Variables	Group E (n = 30)	Group P (n = 30)	p value
Age (years) – mean ± SD	39.63 ± 12.23	40.4 ± 12.14	0.716
Gender – male – n%	80%	80%	1
Gender – female – n%	20%	20%	1
Weight (kg) – mean ± SD	63.7 ± 8.69	67.17 ± 6.43	0.11
Height (cm) – mean ± SD	166.63 ± 5.49	169.07 ± 5.53	0.092
BMI (kg/m^2) – mean ± SD	23.08 ± 3.38	23.49 ± 1.79	0.568
ASA grade I – n%	66.67%	63.33%	0.787
ASA grade II – n%	33.33%	36.67%	0.787

BMI – body mass index; ASA grade – American Society of Anesthesiologists physical status grading.

Table 2: Types of proximal femur surgeries performed in both groups

	Group P	Group E
Intertrochanteric fracture femur	7	14
Subtrochanteric fracture femur	11	7
Fracture neck of femur	12	9

Table 3: Different surgeries performed in both groups

	Group P	Group E
PFN	15	19
CCS fixation	11	8
DHS fixation	3	1
Valgus osteotomy		1
Plating		1
DCS fixation	1	

PFN – proximal femur nailing; CCS – cannulated cancellous screw; DHS – dynamic hip screw; DCS – dynamic condylar screw.

group. Apart from this, VAS was also recorded at 0, 1, 2, 6, 18, and 24 h and compared. VAS scores recorded at 0, 1, 2, 6, and 18 h post-surgery exhibited no significant differences between Groups E and P. However, at 24 h, a statistically significant difference in VAS scores emerged (p value 0.018, Mann–Whitney test) (Table 4). Group E exhibited a VAS score of 2.33, while Group P scored 1.77 at the 24-h mark. While statistically significant, we feel that it will not change our treatment practically. The difference may be due to PVB being anatomically closer to the nerve roots. Due to the resource limitation of our center, only static VAS scoring was performed. We recognize the limitation of our study for not being able to compare dynamic VAS scoring.

The mean maximum VAS score in the first 24 h for Group E was 4.77 ± 1.33, while for Group P, it was 5.1 ± 0.76, with a total mean of 4.93 ± 1.09. The median VAS scores were identical in both groups, at 5, with interquartile ranges indicating slight variations (4–5 for Group E and 5–5 for Group P). The range of scores spanned from 0 to 7 in Group E and 3 to 7 in Group P, with the overall range being 0 to 7. The Mann–Whitney test yielded a p-value of 0.279, suggesting no statistically significant difference in the mean maximum VAS scores between the two groups.

The time to first analgesia showed no significant difference between Groups E (3.71 h) and P (3.72 h), with a p-value of 0.98 (Mann–Whitney Test). Most patients in both groups required rescue analgesia within 24 h (Group E: 93.33%, Group P: 96.67%). There was no statistical difference in the distribution of rescue analgesia requirements between the groups (p value 1, Fisher exact test).

The mean paracetamol requirement was comparable between both groups (Group E: 1.13 g, Group P: 1.17 g) with no statistical difference (p value 0.814, Mann–Whitney Test). The mean tramadol requirement was also similar (Group E: 86.67 mg, Group P: 96.67 mg) with no significant difference (p value 0.391, Mann–Whitney test). Patient satisfaction was 100% in both groups, and no complications were observed.

4 Discussion

This study marks the first-ever prospective, randomized comparison of ultrasound-guided continuous ESPB with

Table 4: Comparison of visual analog scale between Groups E and P

Visual analog scale (h)	Group E (n = 30) mean (SD)	Group P (n = 30) mean (SD)	p value
At 0	1.47 (0.68)	1.33 (0.55)	0.369
At 1	2.4 (0.72)	2.2 (0.89)	0.299
At 2	2.67 (1.06)	2.57 (0.94)	0.797
At 6	2.93 (1.41)	3.03 (1.07)	0.488
At 18	2.77 (0.86)	2.6 (0.86)	0.382
At 24	2.33 (0.99)	1.77 (0.68)	0.018

continuous PVB for postoperative analgesia in proximal femur surgeries. The key findings confirm that both techniques are equally effective, which has significant implications for clinical practice and future research in this field.

The introduction of ESPB by Forero et al. [8] in 2016 has introduced a promising technique for postoperative analgesia. Its use for post-operative analgesia for hip surgeries was first demonstrated by Tulgar et al. [9] in 2017. The advantages of ESPB lie in its superficial anatomy, reducing the risk of complications and allowing for straightforward landmark visualization. The non-inferiority of ultrasound-guided continuous ESPB compared to PVB in our study suggests that it can be a safe and effective alternative for patients undergoing proximal femur fracture surgery.

Comparative studies between the ESPB and the PVB have provided valuable insights into their efficacy, safety, and applicability in various surgical contexts. One study by Moorthy et al. [10] concluded that the ESPB provided better overall Quality of Recovery-15 (QoR-15) scores at 24 and 48 h postoperatively compared to the PVB in patients undergoing video-assisted thoracoscopic surgery. However, there were no significant differences between the two techniques in terms of pain levels, opioid consumption, or chronic post-surgical pain at 3 months. Another study by Yang et al. [11] found that bilateral ultrasound-guided ESPB and PVB provided comparable quality of postoperative recovery (QoR-15 scores) in obese patients undergoing laparoscopic sleeve gastrectomy. Additionally, there were no significant differences between the two groups in terms of pain scores, opioid consumption, or other recovery-related outcomes. One meta-analysis by Weng et al. [12] concluded that the ESPB provides superior analgesia compared to systemic analgesics within 24 h after breast surgery. Additionally, ESPB offers similar analgesic effectiveness to the PVB, making it a viable alternative for postoperative pain management in breast surgery. Forero et al. [8] reported that the ESP block could be a suitable alternative to the PVB for abdominal surgeries, providing effective analgesia with a simpler technique and lower risk. These studies suggest that while both blocks are effective, the ESP block might be preferred in certain surgical contexts due to its simplicity and lower risk of complications.

Several studies have compared the ESPB with other blocks in hip surgeries. For instance, Tulgar et al. [13] conducted a prospective feasibility study comparing lumbar erector spinae block and transmuscular quadratus lumborum block for postoperative analgesia in patients undergoing hip and femur operations. They found improved analgesic effects compared to standard intravenous analgesia, though it is important to note that their cases were performed under general anesthesia, unlike our study which utilized spinal anesthesia. Furthermore, they employed single-shot blocks, while our study employed continuous blocks, which may explain the differing requirements for rescue analgesia.

Chen et al. [14] conducted a study comparing continuous lumbar erector spinae block with continuous lumbar plexus block in revision hip arthroplasty and found no significant differences in opioid consumption and pain scores similar to our study. However, our study's prospective nature and exclusive use of spinal anesthesia distinguish it from Chen et al., s retrospective analysis, which involved varied modes of intraoperative anesthesia and postoperative analgesia plans.

Townsend et al. [15] conducted a randomized controlled study comparing 24-h opioid requirements between lumbar erector spinae block and spinal anesthesia alone for total hip arthroplasty. They found that the erector spinae block reduced opioid utilization in the first 8 h but not beyond. In contrast, our study addressed this limitation by using continuous local anesthetic infusion.

A recent study by Flaviano et al. [16] compared the ESPB and fascia iliaca block after total hip arthroplasty. While the fascia iliaca block exhibited more reliable sensory effects, there was no statistical difference in postoperative opioid requirements. The advantage of the ESPB was evident in preserved quadriceps motor strength postoperatively, particularly beneficial for early patient mobilization.

Surange and Mohan [17] compared continuous PVB with continuous epidural block for postoperative hip surgeries. Both blocks effectively controlled postoperative pain, similar to our findings. Their use of the loss of resistance technique contrasted with our use of ultrasound-guided catheter insertion. Notably, they did not assess postoperative opioid requirements, as our study did.

Wardhan et al. [18] compared continuous L2 PVB with continuous lumbar plexus block for postoperative analgesia in patients undergoing minimal access hip arthroplasty. Their results demonstrated that postoperative pain scores were similar between the two groups, mirroring our findings.

In our study, we performed the blocks under real-time ultrasound guidance. There was no incidence of any block-related complication in our study. However, we cannot comment on the rare complications that may happen as the number of cases performed is less. For this, a large no of cases needs to be performed to uncover the rare complications. We refer to the theoretical benefit that is thought to be the advantage of the ESPB as it has a bony endpoint, preventing deeper structures from any accidental injury and the spread of drug limiting the autonomic response [19].

The primary strength of our study lies in its non-inferiority design, which establishes that continuous lumbar erector spinae block is comparable to continuous PVB in managing postoperative pain in proximal femur surgeries. Our study stands out as the first-ever comparison between these two continuous block techniques using a structured approach to evaluate maximum VAS score, 24-h mean VAS score, and the need for rescue analgesia in both groups.

However, our study has limitations, including the subjective nature of pain perception and the potential variation among patients. The occurrence of postoperative fever in three out of the 60 recruited patients confounded total paracetamol requirements and pain scores. Our study was single-blinded, and the relatively small sample size due to a short recruitment duration may introduce bias. Another limitation of our study is that we did not account for multiplicity, which may explain why the VAS at 24 h showed statistical significance. Variability in the surgical procedures performed could also affect pain requirements

5 Conclusion

Our study demonstrates that continuous ESP block is equally effective in managing postoperative pain in patients undergoing proximal femur fracture surgery compared to PVB. This technique proves to be a safe, easy, and effective addition to our arsenal for postoperative pain management following proximal femur fracture surgery. Further studies are needed to compare the two blocks using standardized surgical techniques and to evaluate the optimal volume and concentration of local anesthetics.

Research ethics: Research involving human subjects complied with all relevant national regulations, institutional policies and is in accordance with the tenets of the Helsinki Declaration (as amended in 2013), and has been approved by the authors' Institutional Review Board IEC/VMMC/SJH/Thesis/October/2018-146.

Informed consent: Informed consent was obtained from all individuals included in this study, or their legal guardians or wards.

Author contributions: The authors have accepted responsibility for the entire content of this manuscript and approved its submission. The individual author contributions are: Aditya Mehrotra – concept, design, definition of intellectual content, literature search, clinical studies, data acquisition and analysis, statistical analysis, manuscript preparation; Madhu Dayal – concept, design, definition of intellectual content, clinical studies, manuscript review; Sushmita Bairagi – guarantor, concept, design, definition of intellectual content, literature search, clinical studies, manuscript preparation, editing and manuscript review.

Competing interests: The authors state no conflict of interest.

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Data availability: The raw data can be obtained on request from the corresponding author.

Artificial intelligence/machine learning tools: Not applicable.

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