Local and Regional Anesthesia

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ORIGINAL RESEARCH

Lumbar Erector Spinae Plane Block as a Main Anesthetic Technique versus Spinal Anesthesia Combined with PENG Block for Urgent Intertrochanteric Fracture Surgery in Elderly Patients: Preliminary Results from a Multicenter Pilot Study

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Background and Aim: Neuraxial anesthesia is commonly used for intertrochanteric fracture surgery but may be contraindicated in frail elderly patients, particularly in the presence of anticoagulation or urgent surgical settings. The Lumbar Erector Spinae Plane Block (L-ESPB) has been proposed as a para-neuraxial technique potentially suitable as a main anesthetic strategy. This study aimed to evaluate whether L-ESPB could represent a viable alternative to Spinal Anesthesia (SA) combined with a Pericapsular Nerve Group (PENG) block in patients undergoing urgent intramedullary nailing for intertrochanteric fractures.

Methods: This multicenter comparative pilot study included ≥65 years undergoing surgery within 48 hours of hospital admission, between May and November 2025. Fifty patients were analyzed: 24 received L-ESPB as the sole anesthetic technique, and 26 received SA combined with a PENG block. The comparison focused on anesthesiologic plane adequacy, intraoperative hemodynamic stability, and postoperative recovery outcomes.

Results: An adequate anesthesiologic plane was achieved in all patients. Sensory and motor block onset was faster and more intense in the PENG + SA group. Intraoperatively, hemodynamic stability was more frequently preserved in the L-ESPB group (58.3% vs 19.2%, p = 0.02), despite similar surgical duration. Intraoperative ketamine rescue was required in a small proportion of patients in the L-ESPB group. Postoperatively, time to mobilization was shorter in the PENG + SA group, whereas pain scores remained low in both groups, with minimal need for rescue analgesia and no relevant anesthesia-related adverse events.

Conclusion: L-ESPB provided effective surgical anesthesia and was associated with greater intraoperative hemodynamic stability compared with SA combined with PENG block. These preliminary findings suggest that L-ESPB may represent a feasible alternative in elderly patients with contraindications to neuraxial anesthesia, warranting confirmation in larger prospective studies.

Keywords: lumbar erector spinae plane block, spinal anesthesia, pericapsular nerve group block, peng block, hip fractures, regional anesthesia, geriatric anesthesia

Introduction

Intertrochanteric fractures are common extracapsular fractures of the proximal femur, accounting for approximately 50% of all hip fractures.[1] They predominantly affect elderly patients, with a mean age of approximately 80 years, usually

https://doi.org/10.2147/LRA.S592174
Received: 27 December 2025
Accepted: 12 March 2026
Published: 27 April 2026

following low-energy falls in the presence of osteoporosis, and are more frequent in women.[2] This population is often characterized by frailty, multiple comorbidities, functional dependency, and conditions predisposing to recurrent falls, resulting in increased perioperative risk.[2,3]

Surgical treatment is generally indicated and most commonly involves intramedullary nail fixation or sliding hip screw placement, depending on fracture stability.[4] In this vulnerable population, early surgery—ideally within 48 hours—is a key determinant of outcome, whereas delays and inadequate perioperative management are associated with increased morbidity, prolonged hospitalization, and higher mortality.[5–7]

From an anesthetic perspective, neuraxial techniques are widely used for intertrochanteric fracture surgery but may be limited in the emergency setting by procedural urgency, acute medical contraindications, ongoing antithrombotic therapy, or difficulties in optimizing frail elderly patients within a narrow time window.[8] General anesthesia therefore remains a common alternative, although it may expose patients with limited cardiovascular reserve to hemodynamic instability and perioperative complications.[9,10]

Peripheral nerve blocks have long represented a cornerstone of multimodal analgesia for hip fracture surgery, demonstrating consistent benefits in postoperative pain control, reduced opioid consumption, and improved postoperative outcomes.[11,12] Building on this experience, several regional anesthetic strategies have been proposed, ranging from traditional peripheral nerve blocks to more recently introduced high-volume fascial plane.[13–15]

Deep regional techniques, such as combined lumbar plexus and sciatic nerve blocks, may theoretically provide complete surgical anesthesia but are limited by technical complexity and safety concerns, particularly in anticoagulated patients.[16] Alternative peripheral nerve–based approaches, such as the "Tetra-Block", have been described to achieve surgical anesthesia without relying on high-volume fascial plane injections.[17] Conversely, fascial plane blocks such as the Pericapsular Nerve Group (PENG) block have shown promising analgesic efficacy but are generally used as adjuncts rather than as standalone anesthetic techniques.[18]

More recently, the Lumbar Erector Spinae Plane Block (L-ESPB) has emerged as a versatile regional technique.[19] The effectiveness of fascial plane blocks is inherently volume-dependent, as their mechanism relies on the spread of local anesthetic within interfascial compartments rather than precise deposition around a single nerve.[18–20] Consequently, the extent of the block depends on how far the injectate travels along the fascial plane, a process governed by bulk flow, diffusion, anatomical constraints, and individual variability.[20–22] Larger volumes typically produce wider distribution and increase the likelihood of involving multiple neural targets, although the pattern of spread remains partly unpredictable.[20–23] High-volume L-ESPB injections have been shown to produce craniocaudal and anterior spread of local anesthetic, potentially involving the dorsal and ventral rami and extending toward the paravertebral and epidural spaces, suggesting its potential role as a standalone anesthetic technique.[20–24] Importantly, current ESAIC/ESRA guidelines classify the Erector Spinae Plane Block (ESPB) as a superficial and compressible block, allowing its use without interruption of antithrombotic therapy and avoiding the classical contraindications of neuraxial anesthesia.[25]

Despite these theoretical advantages, the role of L-ESPB as a standalone anesthetic technique for intertrochanteric fracture surgery has not yet been clearly defined. This study aimed to assess whether L-ESPB could represent a viable alternative to Spinal Anesthesia (SA) combined with a PENG block in patients undergoing fixation with intramedullary nailing within 48 hours of hospital admission for intertrochanteric fractures. The comparison focused on anesthesiologic plane adequacy, intraoperative hemodynamic stability and the overall postoperative recovery.

Materials and Methods

This study was a Level III multicentric comparative pilot study conducted at the University of Naples Federico II (Naples, Italy) and at Isola Tiberina Hospital–Gemelli Isola (Rome, Italy). According to institutional policies, the Ethics Committees of both participating centers determined that formal ethical approval was not required for this type of study. All patients provided informed consent for anesthesia and agreed to the anonymous use of their data for scientific purposes. Data were retrospectively collected from patients with intertrochanteric fractures undergoing intramedullary nailing within 48 hours of hospital admission between May and November 2025, as part of routine clinical practice, and were archived by the departments. These records were anonymized and stored in a password-protected computerized database using MS Office Excel 2007 (Microsoft, Redmond, WA, USA). All procedures adhered to the 1964 Declaration

of Helsinki and subsequent amendments or comparable ethical standards and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement guidelines.[26]

Inclusion/Exclusion Criteria

The inclusion criteria were as follows:

- Adult patients (≥ 65 years old);
- American Society of Anesthesiologists Physical Status (ASA-PS) of I–IV;
- Patients undergoing urgent fixation with intramedullary nailing within 48 hours of hospital admission for intertrochanteric fractures;
- Patients whose medical records were fully accessible.

The exclusion criteria were:

- Inability to provide consent;
- Known local anesthetic allergy;
- Patients with neuropathic disease of the affected limb;
- Patients undergoing general anesthesia.

Study Population

After applying the above-mentioned criteria, 12 patients out of 62 were excluded (inability to provide informed consent, surgery performed under general anesthesia, allergy to local anesthetics, or incomplete medical records) leaving 50 patients eligible for the study. Of these, patients with contraindications to spinal anesthesia—such as non-optimized antithrombotic therapy, coagulation disorders, or other clinical conditions—underwent surgery under L-ESPB as the sole anesthetic technique (Figure 1).

Anesthesiologic Management

In the operating room, standard monitoring was established, including Electrocardiography (ECG), Heart Rate (HR), Peripheral Oxygen Saturation (SpO_2) measured by pulse oximetry, Body Temperature (°C), and Continuous Non-Invasive Blood Pressure (NIBP) measured every 5 minutes. Peripheral venous access was obtained using an 18–16 Gauge catheter. Pantoprazole 40 mg and prophylactic antibiotics (Cefazolin 1–2 g IV or Clindamycin 600 mg IV for allergic patients) were administered 30 minutes before skin incision. Pre-procedural premedication with Midazolam (0.01–0.03 mg/kg IV) was provided to improve patient compliance and comfort, titrated to achieve a target Richmond Agitation–Sedation Scale (RASS) score between 0 and −2.[27] Postoperative Nausea and Vomiting (PONV) prophylaxis consisted of 4 mg Ondansetron IV; in addition, 8 mg Dexamethasone IV was administered intraoperatively both as adjunctive therapy for PONV prevention and to prolong postoperative analgesia.

Intraoperatively, a continuous infusion of Dexmedetomidine IV was administered and titrated to maintain the same preoperative RASS score, with the infusion rate adjusted within a range of 0.6–0.9 mcg/kg/h; supplemental oxygen was provided via nasal cannula at a flow rate of 2 L/min. Episodes of hemodynamic instability – defined as Mean Arterial Pressure (MAP) < 60 mmHg; Systolic Blood Pressure (SBP) < 90 mmHg or > 20% decrease from baseline; HR < 60 bpm or a reduction ≥ 20% from baseline– as well as surgical duration were recorded. Hypotensive events were treated according to the protocol with intravenously crystalloids and/or Ephedrine. Intravenous crystalloids were administered at a rate of 4 mL/kg/hour, with careful titration based on hemodynamic status and comorbidities.[28]

After surgery, patients remained approximately 30 minutes in the Post-Anesthesia Care Unit (PACU) before being transferred to the ward. Side effects including, nausea and vomiting, pruritus, shivering, and delirium were assessed intraoperatively and postoperatively. When necessary, management was provided according to institutional standards.

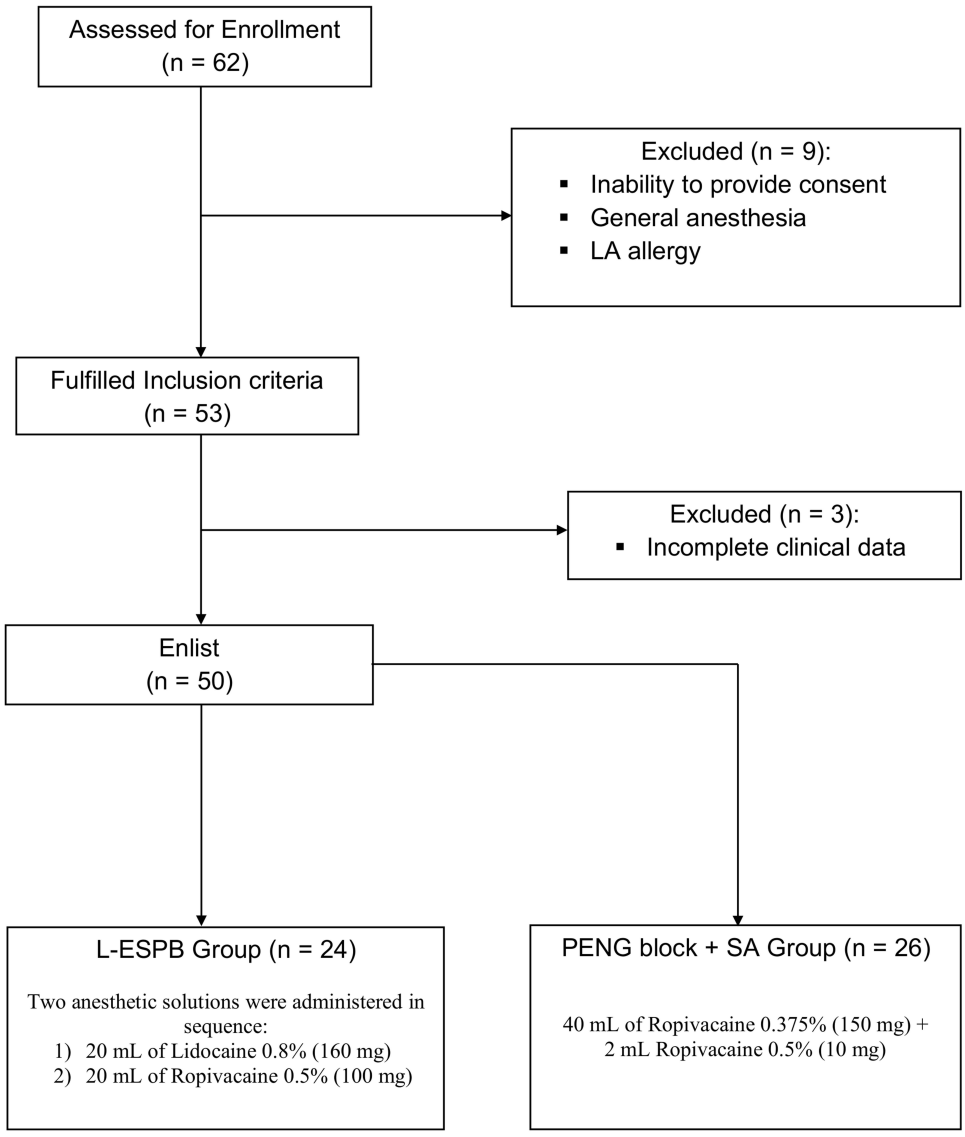

Figure 1 Flowchart of the study.
Abbreviations: mL, milliters; mg, milligrams; L-ESPB, Lumbar Erector Spinae Plane Block group; PENG + SA, Pericapsular Nerve block + Spinal Anesthesia group.

For postoperative pain management, Paracetamol 1 g IV was administered three times daily. Ketorolac 30 mg IV (not for glomerular filtration rate < 50 mL/min)[29] or Oxycodone, (up to 0.1 mg/kg), were available as rescue analgesia. Adequate pain control was defined as a Numerical Rating Scale (NRS) score below 4.

Interventions

All regional anesthesia procedures were performed by senior consultant anesthesiologists with advanced expertise in ultrasound-guided regional anesthesia, each having performed more than 100 L-ESPB and PENG blocks prior to the study period.

For each patient, the anesthetic strategy was defined preoperatively based on clinical status, fracture pattern, surgical urgency, and the presence of contraindications to neuraxial anesthesia.

L-ESPB Group

L-ESPB was performed with the patient in the lateral decubitus position, with the fractured limb positioned uppermost. A low-frequency curvilinear ultrasound probe (Samsung HS50) was placed longitudinally at the sacral level as an initial

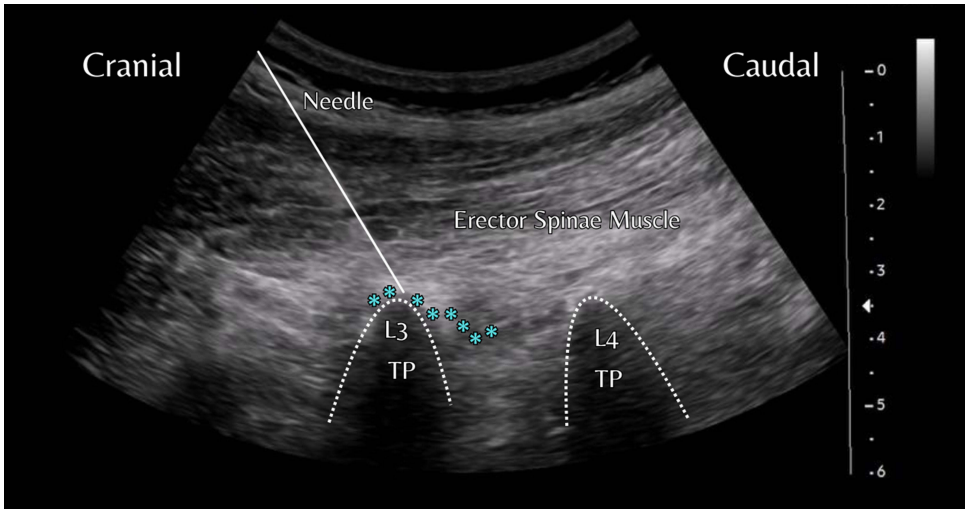

Figure 2 Ultrasound-guided L-ESPB. The block was performed using an in-plane cranio–caudal approach at the level of the L3 transverse process. The block needle is depicted as a continuous white line. White dotted curves outline the transverse processes of L3 and L4. Blue asterisks indicate the spread of local anesthetic within the target plane between the transverse process and the fascial plane of the erector spinae muscle. The depth scale on the right side of the image indicates the depth at which the block was performed.
Abbreviation: TP, transverse process.

landmark, and a counting-up technique was used to identify the lumbar transverse processes up to L3, characterized by the typical "trident sign" ultrasound appearance. At this level, the transverse process and the overlying erector spinae muscle were identified approximately 2–3 cm lateral to the spinous process. A 21-gauge, 100-mm echogenic needle (Pajunk) was advanced using an in plane cranio-caudal approach until contact with the transverse process was achieved deep to the erector spinae muscle. Correct needle placement was confirmed by hydrodissection with saline, demonstrating separation of the erector spinae muscle from the underlying transverse process. After careful negative aspiration, two anesthetic solutions were then administered sequentially under continuous ultrasound visualization: 20 mL of Lidocaine 0.8% (160 mg), followed immediately by 20 mL of Ropivacaine 0.5% (100 mg), for a total injectate volume of 40 mL (Figure 2).

PENG Block + SA Group

PENG block was performed prior to SA to optimize perioperative analgesia, with the patient in the supine position. The block was carried out under ultrasound guidance using a low-frequency curvilinear probe (Samsung HS50); it was positioned to identify the femoral artery, the anterior inferior iliac spine, iliopubic eminence, psoas tendon, and superior pubic ramus. A 21-gauge, 100-mm echogenic needle (Pajunk) was advanced in-plane, with latero-medial approach, toward the musculofascial plane between the psoas tendon and the pubic ramus. After careful negative aspiration, a total volume of 40 mL of local anesthetic solution, consisting of ropivacaine 0.375% (150 mg) was injected (Figure 3).

Following completion of the PENG block, SA was performed with the patient carefully positioned in the lateral decubitus position, with the fractured side facing upward. After appropriate local skin disinfection and sterile draping, a midline approach was used at the L2–L3 or L3–L4 interspace. A 25-gauge Whitacre needle was advanced until free flow of cerebrospinal fluid was obtained, confirming correct intrathecal placement. Subsequently, 2 mL of isobaric Ropivacaine 0.5% (10 mg) were injected intrathecally.

In both groups, motor and sensory block were assessed in the operated limb using the Bromage and Hollmen scales, respectively.[30,31] Sensory testing was performed with pinprick and ice tests. An adequate anesthesiologic plane was defined by the presence of complete motor block (Bromage score 1, defined as inability to move feet or knees) and complete sensory block (Hollmen score 4), corresponding to loss of sensation in the affected limb. In cases of patient-reported discomfort, or the presence of facial grimace, the study protocol provided for the repeated intravenous boluses of ketamine at a dose of approximately 0.1–0.15 mg/kg, not exceeding 10 mg per bolus. Surgical incision was initiated only after achievement of these predefined criteria.

https://doi.org/10.2147/LRA.S592174

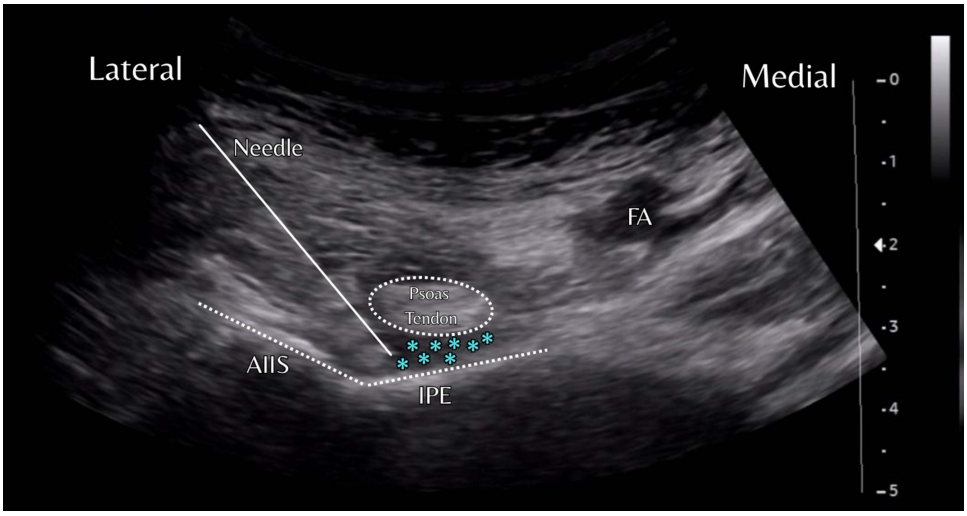

Figure 3 Ultrasound-guided PENG block. The block was performed using an in-plane lateral-to-medial approach. The block needle is shown as a continuous white line. A white dotted circle surrounds the psoas tendon. White dotted lines identify the anterior inferior iliac spine (AIIS) laterally and the iliopectineal eminence (IPE) medially. Blue asterisks indicate the spread of local anesthetic between the psoas tendon—visibly elevated following injection—and the IPE. The depth scale on the right side of the image indicates the depth at which the block was performed.
Abbreviations: AIIS, anterior inferior iliac spine; IPE, ileopectineal eminence; FA, femoral artery.

Data Extraction

All data in this study were extracted from medical records.

The demographic data obtained were: age, height, weight, Body Mass Index (BMI, kg/m^2), sex and ASA-PS;

Preoperative sensory and motor block assessment was performed using standardized clinical scales. Sensory block was evaluated using the Hollmen scale (Grade 1 = normal sensation; Grade 2 = reduced sensation; Grade 3 = perception of light touch; Grade 4 = complete loss of sensation), while motor block was assessed using the Bromage score (1, unable to move feet or knees; 2, able to move feet only; 3, just able to move knees; 4, full flexion of knees and feet). Both sensory and motor blocks were recorded at baseline (period before local anesthetic injection during block administration) and at 10, 15, and 20 minutes from baseline.

During the intraoperative period, the following data were extracted: HR, SBP, DBP and MAP recorded at predefined time points: baseline (period before local anesthetic injection during block administration), 20 minutes from baseline, 30 minutes from surgical incision, and at the end of surgery. The incidence of hemodynamic stability was recorded and compared between groups. The occurrence of anesthesia-related side effects (nausea and vomiting, pruritus, shivering, delirium) and the requirement for rescue ketamine, expressed as absolute numbers and percentages of patients, were documented. Duration of surgery, expressed in minutes, was recorded from skin incision to skin closure.

Postoperative pain intensity assessed with the NRS (0 meaning “no pain” and 10 meaning “worst pain imaginable”), was assessed at the end of surgery and at 6, 12, and 24 hours. Adequate pain control was defined as an NRS score ≤4.

The need for rescue analgesia was recorded at the same postoperative time points (end of surgery, 6, 12, and 24 hours), togheter with the incidence of PONV and the requirement for antiemetic therapy.

Time to mobilization and length of hospital stay were also recorded. Time to mobilization was defined as the interval (hours) between local anesthetic injection and the first mobilization of the lower limb, while length of hospital stay was defined as the number of days from hospital admission to discharge.

Statistical Analysis

Statistical analysis was performed using R software (version 4.3.3, R Foundation for Statistical Computing, Vienna, Austria) within the RStudio environment, employing the rstatix package for statistical testing.[32,33]

Given the exploratory nature of this pilot study and its retrospective design, no a priori sample size calculation was performed; all eligible patients meeting the inclusion criteria during the study period were included in the analysis.

Continuous variables were presented as mean ± standard deviation (SD) and analyzed using the Student's *t*-test, whereas non-normally distributed data were reported as median [interquartile range, IQR] and compared using the Mann–Whitney *U*-test.

Categorical variables were expressed as absolute and relative frequencies (number and percentage) and compared using the Chi-square (χ^2) test or Fisher's exact test, as appropriate.

All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant.

Results

The patients admitted to final analysis were 50, 24 in L-ESPB group and 26 in PENG + SA group (Figure 1).

Table 1 reports demographic and baseline clinical characteristics of the study population. No statistically significant differences were observed between groups. Age, weight, height, and BMI were comparable between the L-ESPB and PENG + SA groups. Sex distribution differed between groups, with a higher proportion of male patients in the L-ESPB group (70.8% vs 34.6%, p=0.023). The distribution of ASA-PS classes was similar between groups, with most patients classified as ASA II or III and no patients in ASA I or IV categories.

Table 2 summarizes the preoperative assessment of sensory and motor block evaluated using the Hollmen scale and Bromage score at baseline and at 10, 15, and 20 minutes after local anesthetic injection. At baseline, identical distributions were observed between groups for both sensory and motor assessments. After local anesthetic injection during block administration, the PENG+SA group showed a significantly faster and more intense sensory block, with higher Hollmen scores at 10 and 15 minutes compared with the L-ESPB group (p<0.001 for both time points). Conversely, motor block was more pronounced in the PENG+SA group, with significantly lower Bromage scores at 10 and 15 minutes (p<0.001). At 20 minutes, both groups reached comparable maximal sensory and motor block levels.

Table 1 Patients Characteristics

N=50	**L-ESPB (N=24)**		**PENG + SA (N=26)**		***t*-test**
	Mean	***SD***	***Mean***	***SD***	***p-value***
Age (years)	71.12	8.24	67.8	8.06	0.123
Weight (kg)	81.6	17.65	81.81	14.07	0.975
Height (cm)	172.62	8.45	166.96	9.94	0.124
BMI (kg/m^2)	27.04	5.68	29.63	6.41	0.344
	L-ESPB (N=24)		**PENG + SA (N=26)**		χ^2
	N	**%**	**N**	**%**	***p-value***
Sex*					
Male	17	70.83%	9	34.6%	0.023
Female	7	29.17%	17	65.4%	
ASA-PS°					
I	0	0%	0	0%	0.991°
II	13	54.2%	13	50%	
III	11	45.8%	13	50%	
IV	0	0%	0	0%	

Notes: *p-value refers to the overall comparison between groups. °The χ^2 test was performed for overall ASA-PS distribution.

Abbreviations: BMI, Body Mass Index; ASA-PS, American Society of Anesthesiologists-Physical Status; SD, standard deviation; L-ESPB, Lumbar Erector Spinae Plane Block group; PENG + SA, Pericapsular Nerve block + Spinal Anesthesia group.

Table 2 Preoperative Assessment of Sensory and Motor Block Evaluated at Baseline Time (Before Local Anesthetic Injection) and at 10, 15 and 20 minutes from Baseline Using the Hollmen Scale and Bromage Score

N=50	L-ESPB (N=24)		PENG + SA (N=26)		Mann–Whitney *U*-test
	Median	IQR	Median	IQR	p-value
Hollmen (grades)					
Baseline time	1	1-1	1	1-1	*
10 minutes from baseline	2	1-2	4	4-4	<0.001
15 minutes from baseline	3	3-3	4	4-4	<0.001
20 minutes from baseline	4	3-4	4	4-4	*
Bromage (scores)					
Baseline time†	4	4-4	4	4-4	*
10 minutes from baseline	3	2-3	1	1-2	<0.001
15 minutes from baseline	2	2-2	1	1-1	<0.001
20 minutes from baseline	1	1-1	1	1-1	*

Notes: *Statistical comparison was not performed because identical distributions (lack of variability) were observed between groups. †Baseline time refers to the period before local anesthetic injection during block administration.
Abbreviations: IQR, Interquartile range; L-ESPB, Lumbar Erector Spinae Plane Block group; PENG + SA, Pericapsular Nerve block + Spinal Anesthesia group.

Table 3 presents intraoperative data, including surgical duration, hemodynamic parameters, and side effects. Surgical duration did not differ between groups. Heart rate values were comparable at all recorded time points. Systolic and diastolic blood pressure values were significantly lower in the L-ESPB group at 20 minutes after local anesthetic

Table 3 Intraoperative Assessment: Surgical Duration, Hemodynamic Data, Side Effects and Number of Patients Receiving Rescue Ketamine

N=50	L-ESPB (N=24)		PENG + SA (N=26)		*t*-test
	Mean	SD	Mean	SD	p-value
Surgery duration (minutes)	49.04	7.74	47.23	6.94	0.389
HR (bpm)					
Baseline time†	76.83	15.27	72.58	13.23	0.299
20 minutes from baseline	82.95	25.01	74.07	10.94	0.119
30 minutes from surgery start	70.17	16.19	76.5	15.05	0.159
End of surgery	71.21	16.31	72.81	12.2	0.698
SBP (mmHg)					
Baseline time†	112.29	23.17	109.96	19.98	0.706
20 minutes from baseline	91.58	15.15	109.04	16.98	<0.001
30 minutes from surgery start	90.08	20.61	103.92	20.33	0.318
End of surgery	98.41	16.1	91.5	12.9	0.102
DBP (mmHg)					
Baseline time†	56.95	8.7	62.46	17.3	0.159
20 minutes from baseline	51.83	12.05	63.88	14.75	0.002
30 minutes from surgery start	52.96	14.57	60.88	13.6	0.053
End of surgery	53.79	17.14	55.5	11.72	0.685
MAP (mmHg)					
Baseline time†	78.83	20.37	71.61	15.45	0.167
20 minutes from baseline	69.34	10.78	73.46	13.7	0.242
30 minutes from surgery start	70.54	13.47	67.61	15.72	0.482
End of surgery	73.12	14.13	65.61	10.46	0.039

(*Continued*)

Table 3 (Continued).

	L-ESPB (N=24)		PENG + SA (N=26)		χ^2
	N	**%**	**N**	**%**	**p-value**
Hemodynamic stability	14	58.3%	5	19.2%	0.02*
Side effects					
Nausea and vomiting	0	0%	0	0%	°
Pruritus	0	0%	0	0%	°
Shivering	0	0%	0	0%	°
Delirium	0	0%	0	0%	°
Patients receiving rescue ketamine	3	12.5%	0	0%	0.10*

Notes: *The χ^2 test was performed for the comparison of categorical variables. °Statistical comparison not applicable due to absence of events in both groups. †Baseline time refers to the period before local anesthetic injection during block administration.
Abbreviations: SD, standard deviation; L-ESPB, Lumbar Erector Spinae Plane Block group; PENG + SA, Pericapsular Nerve block + Spinal Anesthesia group; HR, heart rate; bpm, beats per minute; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure.

injection during block administration (SBP p<0.001; DBP p=0.002); however, these changes were transient and not associated with clinically significant symptoms or the need for therapeutic intervention. No differences were observed at baseline, 30 minutes from surgery start, or at the end of surgery. MAP was lower in the PENG+SA group at the end of surgery (p=0.039). Hemodynamic stability was more frequently observed in the L-ESPB group (58.3% vs 19.2%, p=0.02). No intraoperative side effects, including nausea, vomiting, pruritus, shivering, or delirium, were reported in either group. Intraoperative ketamine was required in 3 patients (12.5%) in the L-ESPB group and in none in the PENG + SA group, with no statistically significant difference between groups (p = 0.10).

Table 4 reports postoperative data. Time to mobilization was significantly shorter in the PENG+SA group compared with the L-ESPB group (p<0.001). Length of hospital stay was also slightly longer in the PENG+SA group (median 2.25 vs 2 days, p=0.045). Statistically higher NRS scores were observed in the PENG+SA group at 12 and 24 hours after surgery (p=0.006 and p=0.001, respectively); however, pain intensity remained low in both groups, with median NRS values not exceeding 1. The need for rescue analgesia was minimal and did not differ significantly between groups. No episodes of PONV or antiemetic requests were recorded during the postoperative period.

Table 4 Postoperative Assessment: Time to Mobilization, Length of Stay, Pain Intensity Assessed Using the NRS, Need for Rescue Analgesia, PONV, and Antiemetic Request

N=50	**L-ESPB (N=24)**		**PENG + SA (N=26)**		***t*-test**
	Mean	**SD**	**Mean**	**SD**	**p-value**
Time to mobilization (hours)	8.2	0.71	5.57	1.06	<0.001
N=50	**L-ESPB (N=24)**		**PENG + SA (N=26)**		**Mann–Whitney *U*-test**
	Median	**IQR**	**Median**	**IQR**	**p-value**
Length of stay (days)	2	1.81–2.5	2.25	2-2.75	0.045
NRS (point)					
At the end of the surgery	0	0-0	0	0-0	0.16
At 6 h after surgery	0	0-1.5	0	0-1.5	0.384
At 12 h after surgery	0	0-0	1	0-4	0.006
At 24 h after surgery	0	0-0	1	0-3.5	0.001

(*Continued*)

https://doi.org/10.2147/LRA.S592174

Table 4 (Continued).

	L-ESPB (N=24)		PENG + SA (N=26)		χ^2
	N	**%**	**N**	**%**	**p-value**
Need of analgesic rescue dose					
At the end of the surgery	0	0%	0	0%	§
At 6 h after surgery	0	0%	0	0%	§
At 12 h after surgery	1	4.16%	0	0%	0.29
At 24 h after surgery	0	0%	0	0%	§
PONV					
At the end of the surgery	0	0%	0	0%	§
At 6 h after surgery	0	0%	0	0%	§
At 12 h after surgery	0	0%	0	0%	§
At 24 h after surgery	0	0%	0	0%	§
Antiemetic request					
At the end of the surgery	0	0%	0	0%	§
At 6 h after surgery	0	0%	0	0%	§
At 12 h after surgery	0	0%	0	0%	§
At 24 h after surgery	0	0%	0	0%	§

Notes: [§]Statistical comparison not performed due to absence of events or identical distributions between groups.
Abbreviations: IQR, Interquartile range; L-ESPB, Lumbar Erector Spinae Plane Block group; PENG + SA, Pericapsular Nerve block + Spinal Anesthesia group; NRS, Numerical Rating Scale; h, hours; PONV, Postoperative Nausea and Vomiting.

Discussion

This multicenter pilot study provides the first comparative analysis between the L-ESPB used as a main anesthetic technique and the SA combined with PENG block for urgent intertrochanteric fracture surgery in elderly patients. Our findings suggested that both techniques provided effective regional anesthesia, although the PENG + SA group showed in a faster onset and greater intensity of sensory block, accompanied by a more pronounced early motor block compared with L-ESPB. Intraoperatively, L-ESPB was associated with greater hemodynamic stability, despite similar surgical duration and the absence of relevant side effects in both groups. The need for intraoperative ketamine rescue was limited to a small proportion of patients in the L-ESPB group and did not differ significantly between groups. In line with the case series by Ahiskalioglu et al, intraoperative ketamine was used only as low-dose rescue sedoanalgesia in selected patients, with a median requirement of zero and limited bolus administration, supporting its role as a protocolized rescue adjunct rather than a surrogate marker of block failure.[34]

Postoperatively, the PENG+SA group facilitated earlier mobilization, whereas length of hospital stay was slightly longer. Although statistically higher NRS scores were observed in the PENG+SA group at later postoperative time points, pain intensity remained low in both groups, with NRS median values not exceeding 1 and minimal need for rescue analgesia, suggesting limited clinical relevance of this difference.

Sex differences may also influence pain perception and responses to regional anesthesia, with women generally exhibiting greater pain sensitivity and lower pain thresholds than men, likely due to a combination of biological and psychosocial factors.[35,36] Although regional techniques typically provide comparable overall analgesic efficacy between sexes, differences in analgesic requirements and side-effect profiles have been reported.[37] Therefore, the marked imbalance in sex distribution between groups could have influenced pain reporting and perceived block intensity, and should be considered when interpreting these postoperative outcomes.

The L-ESPB provided adequate surgical anesthesia in all patients, supporting the hypothesis that specific volume-dependent mechanisms allow for extensive neural block.[20] The mechanism is likely attributed to the anterior diffusion of local anesthetic into the paravertebral and epidural spaces, affecting both the ventral and dorsal rami of the spinal nerves.[21] This spread is critical for surgeries involving the hip and femur, which require block of the lumbar plexus branches.[21–24] Our results align with Tulgar et al, who reported that L-ESPB could serve as a sole anesthetic method in

high-risk elderly patients, confirmed by Magnetic Resonance Imaging (MRI) showing spread from T12 to L5 and cadaveric study.[20–24] The use of 40 mL of local anesthetic in our protocol likely facilitated this longitudinal and anterior spread, consistent with previous studies correlating injectate volume with block extent.[20–24]

Patient positioning may have further influenced this distribution. The block was performed in the lateral decubitus position, which may facilitate gravity-assisted migration of the injectate along the erector spinae plane. Shan et al, in a randomized imaging study, demonstrated posture-dependent spread after ESPB, with non-supine positions associated with greater anterior and paravertebral extension.[38] This mechanism could have contributed to the effective neural block observed in our cohort, although it remains speculative in the absence of direct imaging confirmation.

Within this mechanistic framework, it is also important to clarify the rationale for the use of a high-volume PENG block (40 mL) in the PENG+SA group. Although multicenter data have confirmed the strong analgesic value of the PENG block in hip fracture patients—primarily as part of a multimodal analgesic strategy rather than as a sole anesthetic technique—emerging anatomical and clinical evidence suggests that larger injectate volumes may enhance cranio-caudal and medial spread within the iliopsoas and iliopectineal plane.[39–42] Cadaveric and imaging studies have shown that higher volumes can increase the likelihood of capturing not only the anterior hip capsular articular branches, but also contributions from femoral and obturator-related pathways.[41,43,44] Clinical investigations comparing different PENG volumes (20–40 mL) further support a volume–effect relationship, with higher volumes associated with improved analgesic coverage at the cost of increased motor involvement.[40,44] Accordingly, the use of a high-volume PENG block (40 mL) was justified in this study given the extracapsular nature of intertrochanteric fractures, as lower volumes commonly reported in the literature would likely have provided analgesic coverage limited to intracapsular articular branches, resulting in inadequate control of pain from periarticular and extracapsular structures.

From a clinical perspective, the comparison between L-ESPB and SA combined with PENG block should be interpreted within a framework of tailored regional anesthesia strategies for frail elderly patients. Although selective or low-dose SA may reduce hemodynamic instability, it remains contraindicated in anticoagulated patients and still involves sympathetic block.[25,45] Current evidence suggests that selective SA and peripheral nerve blocks should be viewed as complementary, rather than competing, techniques, selected according to patient comorbidities, surgical urgency, and anticoagulation status.[14,46] In this context, randomized data have shown that both peripheral nerve blocks and selective SA can be safely and effectively employed when appropriately selected, with patient-centered outcomes guiding technique choice.[14] Our findings place the L-ESPB within this spectrum as a distinct option: not a benign peripheral block, but a "Para-Neuraxial" technique capable of producing neuraxial-like effects. When SA is contra-indicated, high-volume L-ESPB may therefore represent a valuable alternative, provided that delayed onset is anticipated and hemodynamics are managed with neuraxial-level vigilance.

An important finding of our study is the observation that, although SBP and DBP values were significantly lower in the L-ESPB group at 20 minutes after local anesthetic injection compared with the PENG+SA group, overall intraoperative hemodynamic stability was more frequently preserved with L-ESPB. This finding emphasizes the distinction between transient blood pressure reductions and clinically relevant hemodynamic instability. In contrast, Coviello et al reported significant hemodynamic instability following ESPB performed with 20 mL of ropivacaine 0.5%, suggesting that block level, and perioperative context may account for these divergent observations.[47] Based on these considerations, the use of high-volume L-ESPB as a sole anesthetic technique supports a proactive and carefully hemodynamic management strategy, particularly in elderly patients. Although a longer time to mobilization was observed with this technique, mobilization still occurred well within the timeframe recommended by current guidelines for hip fracture surgery, which advocate ambulation within 24 hours to reduce complications such as thromboembolism, pneumonia, delirium, pressure injuries, and mortality.[48] Therefore, the observed delay is unlikely to have had a meaningful impact on postoperative outcomes and may represent a clinically acceptable trade-off for the improved hemodynamic stability provided by L-ESPB, particularly in patients in whom cardiovascular safety may take precedence over rapid ambulation.

Despite the intraoperative challenges, the ESPB demonstrated a clear advantage in the postoperative phase, with lower NRS scores at 12 and 18 hours. This prolonged effect may be due to the slow clearance of local anesthetic from the paravertebral space acting as a depot, or the broad coverage of the posterior rami (often missed by PENG or femoral nerve blocks), which innervate the posterior hip capsule and gluteal muscles.[49]

In the context of high-volume fascial plane blocks, particular attention should also be paid to the risk of Local Anesthetic Systemic Toxicity (LAST).[50] Fascial plane blocks are inherently volume-dependent techniques, often requiring large injectate volumes to achieve adequate spread, which may increase systemic exposure to local anesthetics.[15] Recent evidence has emphasized that diligent care should be taken to minimize the risk of LAST in these settings, especially through careful dose adjustment, vigilant monitoring, and adherence to "start low, go slow".[49,50] This consideration is particularly relevant in elderly patients with multiple comorbidities, who may exhibit increased susceptibility to systemic toxicity due to altered pharmacokinetics and reduced physiological reserve.[51,52]

Within this safety framework, the use of adjuvants represents a potential strategy to enhance block efficacy while allowing for a reduction in local anesthetic dose, thereby mitigating the risk of LAST.[50,53] This concept is especially attractive for fascial plane blocks, where block success relies on injectate volume rather than precise nerve targeting. Recent narrative data have provided new insights into the perineural combination of dexmedetomidine and dexamethasone, suggesting promising effects in prolonging analgesia with a favorable safety profile.[54] Nevertheless, despite the widespread off-label use of perineural adjuvants, high-quality evidence indicates important distinctions between administration routes.[55–57]

A recent systematic review and meta-analysis demonstrated that both intravenous and perineural dexamethasone significantly prolong analgesia compared with control, with a clear dose–response relationship. Importantly, intravenous dexamethasone (approximately 8–10 mg) was associated with additional benefits, including a greater reduction in postoperative nausea and vomiting, while higher doses did not confer further analgesic advantage. Although perineural dexamethasone (approximately 4 mg) was also effective, this route remains off-label.[58] On this basis, and considering routine clinical safety, the intravenous route appears preferable for standard practice. Accordingly, in the present study, dexamethasone was administered intravenously in both groups. This approach allowed us to optimize analgesic efficacy while maintaining a favorable safety profile and avoiding off-label perineural administration.

This study has several limitations that should be acknowledged. First, the retrospective and non-randomized design inherently limits causal inference and increases susceptibility to unmeasured confounding. Group allocation was based on clinical indications—most notably the presence of contraindications to SA in the L-ESPB cohort—which may have introduced selection bias and reflected differences in baseline risk not fully captured by ASA-PS or routine clinical variables. Consequently, patients in the L-ESPB group likely represented a higher-risk population, including individuals with anticoagulation, frailty, or comorbidities precluding neuraxial anesthesia. This context should be considered when interpreting the findings, as the successful use of L-ESPB as a standalone anesthetic technique in such patients may further support its potential role in scenarios where neuraxial approaches are not feasible.

Second, the relatively small sample size may have limited statistical power and increased the risk of type II error, potentially obscuring clinically relevant differences between groups. Moreover, although multicenter, the study involved only two institutions, which may restrict the generalizability of the findings to other clinical settings and perioperative pathways.

Third, although epidural spread was inferred from hemodynamic changes and block extent, no imaging studies were performed to confirm injectate distribution. Sensory block assessment was limited to dermatomal mapping and did not include specific articular branch testing. In addition, the retrospective design precluded control over anesthetic selection and intraoperative management, and the absence of a standardized vasopressor protocol may have influenced the incidence of intraoperative hypotension. Accordingly, the present investigation should be interpreted as a pilot study with preliminary results, intended primarily to generate hypotheses and inform the design of future adequately powered prospective studies.

Conclusion

L-ESPB, when used as a sole anesthetic technique for urgent intertrochanteric fracture surgery, appears to be a feasible and clinically meaningful alternative to SA combined with PENG block in elderly patients. Although associated with a slower onset and delayed mobilization, L-ESPB provided adequate surgical anesthesia in all cases and was associated with a higher rate of preserved intraoperative hemodynamic stability, suggesting a clinically acceptable trade-off in frail elderly patients where cardiovascular stability may take precedence over rapid postoperative ambulation.

From a postoperative perspective, both techniques achieved effective analgesia with minimal need for rescue opioids, and although earlier mobilization was observed in the PENG+SA group, pain intensity remained low and clinically comparable between strategies. These preliminary findings support the concept that L-ESPB should not be regarded as a simple peripheral block, but rather as a para-neuraxial technique capable of producing neuraxial-like effects, particularly when high volumes are employed.

In patients with contraindications to neuraxial anesthesia, high-volume L-ESPB may therefore represent a valuable alternative, provided that anesthesiologists anticipate delayed onset and adopt vigilant, proactive perioperative monitoring and hemodynamic management. Future prospective randomized studies are warranted to better define optimal dosing strategies, confirm safety profiles, and clarify patient-centered outcomes in frail geriatric populations.

Abbreviations

ASA-PS, American Society of Anesthesiologists Physical Status; BMI, Body Mass Index; DBP, Diastolic Blood Pressure; ECG, Electrocardiography; ESPB, Erector Spinae Plane Block; FiO_2, Fraction of Inspired Oxygen; HR, Heart Rate; IQR, Interquartile Range; IV, Intravenous; L-ESPB, Lumbar Erector Spinae Plane Block; LA, Local Anesthetic; LAST, Local Anesthetic Systemic Toxicity; MAP, Mean Arterial Pressure; MRI, Magnetic Resonance Imaging; NIBP, Non-Invasive Blood Pressure; NRS, Numerical Rating Scale; PACU, Post-Anesthesia Care Unit; PENG, Pericapsular Nerve Group; PONV, Postoperative Nausea and Vomiting; RASS, Richmond Agitation–Sedation Scale; SA, Spinal Anesthesia; SBP, Systolic Blood Pressure; SD, Standard Deviation.

Acknowledgments

The authors would like to thank the reviewer, Anna Onza, for the effort and the time spent in the linguistic revision of the manuscript.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

The authors have no sources of funding to declare for this manuscript.

Disclosure

The author reports no conflicts of interest in this work.

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