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Original Research Article

Erector Spinae Plane Block Supplementation to General Anaesthesia in Percutaneous Nephrolithotomy Surgery for Post-Operative Quality of Recovery

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Abstract

Background: Percutaneous nephrolithotomy (PCNL) is associated with substantial early postoperative pain and frequent opioid requirements that can delay recovery. Various analgesic techniques have been advocated as adjuncts to general anaesthesia in PCNL surgery. Regional anaesthesia plays a crucial role in enhancing patient care, improving the quality of treatment, and increasing patient satisfaction.

The erector spinae plane block (ESPB) may offer opioid-sparing analgesia and improve quality of recovery, but its impact on patient-centred outcomes after PCNL remains insufficiently defined.

Objective: To determine whether ESPB with 0.25% levobupivacaine, when added to general anaesthesia (GA), improves postoperative quality of recovery (QoR-15) compared with GA alone in adults undergoing elective PCNL.

Methods: The study was conducted after receiving Institutional Ethics Committee approval and CTRI trial registration. Single-centre, prospective, randomized, parallel-group study was conducted at People's College of Medical Science & Research Centre in India. Sixty adults (18–60 years, ASA I–II) scheduled for elective PCNL are randomized 1:1 to GA + ESPB (Group E) or GA only (Group C). ESPB is being performed after induction at the L1 level using 20 mL of 0.25% levobupivacaine. The primary outcome is QoR-15 on the day of discharge. Secondary outcomes include pain intensity at0 hr and every 4 hr to 24 hr, time to first rescue opioid, cumulative tramadol at 24 hr and 48 hr, postoperative nausea and vomiting, immediate postoperative haemodynamics, adverse events, and length of stay. Analyses were intention-to-treat (α=0.05).

Results: All randomized patients completed the primary outcome. QoR-15 at discharge was higher with ESPB (124.8±10.7) than control (115.7±12.3); mean difference 9.1 (95% CI, 3.7–14.4; p=0.001), exceeding the 8-point MCID. ESPB reduced pain at PACU/0 hr (mean difference −1.6, 95% CI −2.3 to −0.9; p<0.001), 4 hr (−1.6; p<0.001), 8 hr (−1.4; p<0.001), and 12 hr (−1.1; p=0.002), with no significant difference at 24 hr. Time to first rescue opioid was longer (7.8 [5.2–10.1] vs 2.6 [1.3–4.1] hr; p<0.001), and cumulative tramadol use was lower at 24 hr (50 [0–100] vs 150 [100–200] mg; p<0.001) and 48 hr (100 [50–150] vs 250 [150–300] mg; p<0.001). PONV (13.3% vs 36.7%; p=0.02) and antiemetic use (20.0% vs 46.7%; p=0.01) were reduced with ESPB. Immediate postoperative haemodynamics were similar; no block-related complications occurred. Length of stay was modestly shorter (2.0 [2.0–3.0] vs 2.5 [2.0–4.0] days; p=0.03).

Conclusion: ESPB added to GA improved patient-centred quality of recovery and provided opioid-sparing analgesia after PCNL, with a favourable safety profile. Adoption of ESPB within multimodal perioperative pathways for PCNL is supported; further multicentre work should refine results and evaluate comparative and economic outcomes.

Keywords: Erector spinae plane block; percutaneous nephrolithotomy; QoR-15; postoperative pain; opioid-sparing analgesia.

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Introduction

Percutaneous nephrolithotomy (PCNL) is the contemporary standard of care for large or complex renal calculi and yields high stone-free rates with smaller incisions than open surgery. Nevertheless, early postoperative pain after PCNL remains clinically significant because of dilation and manipulation of the renal capsule, tract, and overlying musculocutaneous tissues.

This pain often necessitates parenteral opioids in the first 24–72 hours, with attendant risks of nausea, vomiting, sedation, and delayed recovery—issues that have sustained interest in opioid-sparing strategies for PCNL. Evidence synthesizing peripheral nerve blocks (PNBs) as adjuncts to general anaesthesia (GA) suggests meaningful reductions in opioid consumption without compromising operative workflow, underscoring the value of regional techniques within multimodal analgesia pathways for endourologic surgery [1].

Among PNBs, the erector spinae plane block (ESPB) has gained rapid adoption since its first description by Forero and colleagues in 2016. ESPB entails deposition of local anaesthetic agent deep to the erector spinae muscle at the tip of the transverse process.

The proposed mechanism includes cranio-caudal spread within the fascial plane with indirect access to the paravertebral space, blocking dorsal and ventral rami across multiple thoracolumbar dermatomes—coverage that aligns well with the nociceptive inputs relevant to PCNL incisions and tract dilation [2,3]. While analgesic endpoints (e.g., pain scores and opioid use) are necessary, they are not sufficient to capture the patient-centred breadth of postoperative recovery. The 15-item Quality of Recovery (QoR-15) instrument is a validated, brief, and responsive measure spanning pain, physical comfort, physical independence, psychological support, and emotional state, with strong psychometric performance and feasibility in routine perioperative care [4].

Prior PCNL trials of ESPB have primarily emphasized analgesia and respiratory function; the effect of ESPB using 0.25% levobupivacaine on global, patient-reported recovery remains under-characterized.

Addressing this gap is clinically relevant in settings prioritizing early mobilization, reduced opioid exposure, and timely discharge. Accordingly, this study evaluates whether supplementing GA with an ESPB using 0.25% levobupivacaine improves postoperative QoR-15 scores in adults undergoing elective PCNL, and explores associated analgesic outcomes and adverse effects relative to GA alone.

Materials and Methods

Study Design and Setting: This study was designed as a prospective, randomized, parallel-group, controlled study and was conducted in the Department of Anaesthesiology, People's Hospital, associated with People's College of Medical Sciences & Research Centre, Bhopal, India.

Ethical Approval and Consent: The Institutional Ethics Committee approved the protocol (Ref:PCMS/OD/PS/IEC/2025/2571(5)). All participants were provided written informed consent in Hindi or English prior to enrolment.

Eligibility Criteria: Adults aged 18–60 years with American Society of Anaesthesiologists (ASA) physical status I–II who were scheduled for elective percutaneous nephrolithotomy (PCNL) under general anaesthesia were eligible. Patients were excluded if they declined consent, were <18 or >60 years, had ASA III–IV, had a known allergy to levobupivacaine, had spinal deformity, or were pregnant or lactating.

Sample Size, Randomization and Allocation Concealment: A total of 60 patients were recruited for feasibility within the defined study period and were allocated equally to two groups (n = 30 each).

Eligible patients were randomized in a 1:1 ratio to receive either general anaesthesia plus erector spinae plane block (Group E) or general anaesthesia alone (Group C) using a computer-generated random sequence. Allocation was concealed in sequentially numbered, opaque, sealed envelopes prepared by personnel not involved in recruitment or assessment.

Study Variables: Independent variables included age, sex, and weight. The primary dependent variable was postoperative Quality of Recovery measured using the QoR-15 on the day of discharge. Secondary variables included postoperative pain intensity (visual analogue scale [VAS] at four-hourly intervals and at 24 hours), time to first rescue opioid, cumulative opioid consumption at 24–48 hours, incidence of postoperative nausea and vomiting (PONV) and antiemetic use, immediate postoperative vital parameters, duration of surgery, block- or anaesthesia-related adverse events, and length of postoperative hospital stay.

Perioperative Management: All patients received a standardised general anaesthesia protocol in accordance with departmental practice. Routine monitoring (electrocardiography, non-invasive blood pressure, pulse oximetry, end-tidal carbon dioxide) was employed. Induction, maintenance, airway management, ventilation, fluid therapy, antiemetic prophylaxis, and extubation criteria were standardised and documented.

Intervention (Group E: GA + ESPB): Following induction of general anaesthesia and tracheal intubation, the erector spinae plane block (ESPB) was performed under aseptic precautions with the patient in the prone position. A 22-gauge, 8–10 cm short-bevel needle was inserted perpendicular to the skin at the level of the first lumbar spinous process, approximately 3 cm lateral to the midline. The needle was advanced until the transverse process was contacted at an approximate depth of 3.5 cm, then withdrawn by 1–2 mm. After negative aspiration, 20 mL of 0.25% isobaric levobupivacaine was injected incrementally into the erector spinae plane. Any block-related complications were recorded.

Control (Group C: GA only): Control patients received general anaesthesia alone without any regional block. Intraoperative management mirrored that of Group E.

Postoperative Analgesia and Assessments: After extubation, patients were transferred to the recovery area and subsequently to the ward. Pain was assessed using a 10-cm VAS at four-hourly intervals and at 24 hours. A standardised multimodal regimen was used; rescue opioid (institutional standard, e.g., intravenous tramadol) was administered when VAS ≥ 4 or upon patient request. The QoR-15 score was obtained on the day of discharge by a blinded assessor. Vital signs, PONV, antiemetic use, time to first rescue opioid, and adverse events were recorded prospectively.

Data Collection and Quality Assurance: Demographic, intraoperative, and postoperative data were captured on pre-piloted case-record forms by an independent observer and were subsequently entered into a secure master chart. Data completeness was checked daily and reconciled with anaesthesia records and nursing charts.

Statistical Analysis: Data were analysed using IBM SPSS Statistics version 22.0.Continuous variables were summarised as mean ± standard deviation or median (interquartile range) and were compared using independent-samples t-tests.

Repeated pain measures were analysed using linear mixed-effects models with fixed effects for group, time, and group×time interaction and random intercepts for subjects; Categorical variables were compared using Chi-square or Fisher's exact tests. Two-tailed $p < 0.05$ was considered statistically significant. Effect sizes (Cohen's d or risk difference) with 95% confidence intervals were reported.

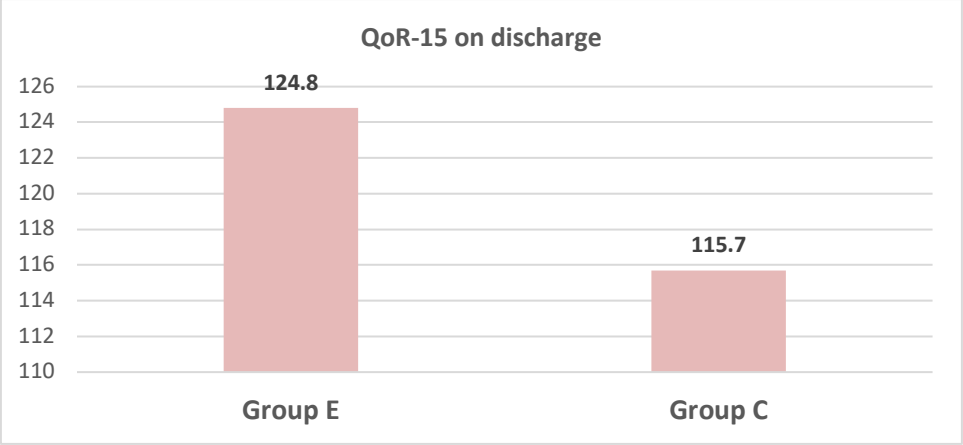
Results

Sixty adults undergoing elective PCNL were randomized 1:1 to ESPB+GA or GA only; all completed primary outcome assessment. Table 1 demonstrates that randomization achieved excellent baseline balance: age, sex, weight, ASA class, stone laterality, and operative duration were comparable between groups (all $p \geq 0.68$), minimizing confounding and supporting internal validity.

Table 1: Baseline characteristics

Characteristic	Group E (n=30)	Group C (n=30)	p value
Age, years, mean ±SD	43.8 ± 10.2	44.5 ± 9.6	0.76 (NS)
Male sex, n (%)	19 (63.3)	18 (60.0)	0.79 (NS)
Weight, kg, mean ± SD	68.3 ± 11.5	67.9 ± 10.8	0.91 (NS)
ASA I / II, n	12 / 18	11 / 19	0.79 (NS)
Stone side, left/right, n	14 / 16	13 / 17	0.81 (NS)
Duration of surgery, min, median (IQR)	86 (70–105)	88 (72–110)	0.68 (NS)

NS = Not Significant; n = number of patients



Graph 1: QoR-15 primary outcome

Table 2 shows the primary endpoint—QoR-15 at discharge—was higher with ESPB (124.8±10.7) than control (115.7±12.3), with a mean difference of 9.1 points (95% CI 3.7–14.4; p=0.001). This exceeds the established QoR-15 minimal clinically important difference (MCID 8 points) and corresponds to a moderate–large effect (Cohen's d=0.78), indicating a clinically meaningful improvement in global, patient-reported recovery.

Table 2: QoR-15 primary outcome

Outcome	Group E (n=30)	Group C (n=30)	Between-group difference (95% CI)	p value	Effect size
QoR-15 on discharge, mean ± SD (0–150)	124.8 ± 10.7	115.7 ± 12.3	9.1 (3.7 to 14.4)	0.001*	Cohen's d = 0.78

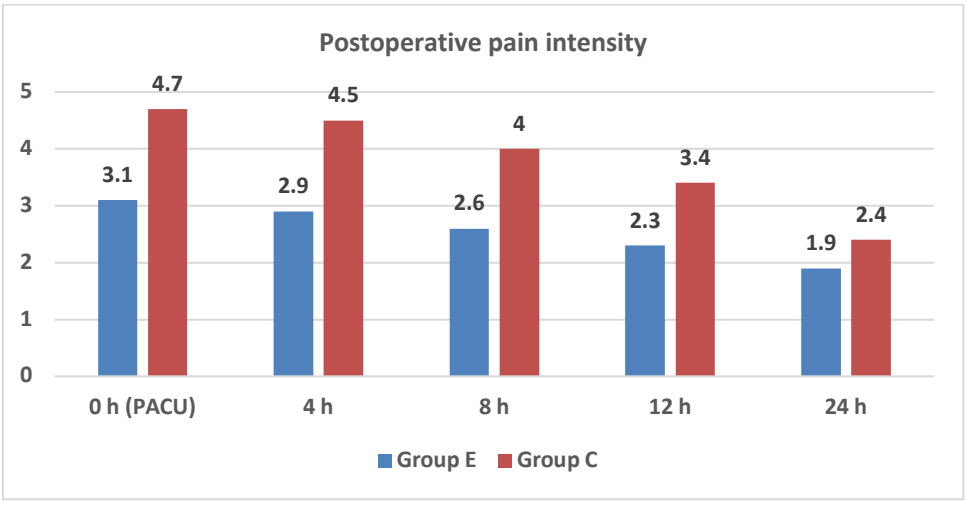
***=Significant**

For secondary outcomes, Table 3 shows ESPB reduced pain at PACU/0 h, 4 h, 8 h, and 12 h (mean differences −1.1 to −1.6; all p≤0.002), with no significant difference at 24 h (p=0.08); mixed-effects modeling confirmed significant main effects for group and time and a group×time interaction (all p<0.001), consistent with an early analgesic advantage that attenuates by 24 h.

Table 3: Postoperative pain intensity

Time point	Group E mean ± SD	Group C mean ± SD	Mean diff (95% CI)	p value
0 h (PACU)	3.1 ± 1.2	4.7 ± 1.4	−1.6 (−2.3 to −0.9)	<0.001*
4 h	2.9 ± 1.3	4.5 ± 1.5	−1.6 (−2.3 to −0.9)	<0.001*
8 h	2.6 ± 1.2	4.0 ± 1.4	−1.4 (−2.1 to −0.7)	<0.0018
12 h	2.3 ± 1.1	3.4 ± 1.3	−1.1 (−1.8 to −0.4)	0.002*
24 h	1.9 ± 1.0	2.4 ± 1.2	−0.5 (−1.1 to 0.1)	0.08(NS)

Linear mixed-effects model: group p<0.001; time p<0.001; group×time p<0.001



Graph 2: Postoperative pain intensity

Table 4 indicates a longer time to first rescue opioid with ESPB (median 7.8 vs 2.6 h; log-rank p<0.001), reflecting about a 62% lower hazard of requiring rescue (HR≈0.38), and markedly lower cumulative tramadol at 24 h (Δ −100 mg) and 48 h (Δ −150 mg) (both p<0.001).

Table 4: Opioid timing and consumption (tramadol protocol)

Outcome	Group E (n=30)	Group C (n=30)	Between-group comparison	p value
Time to first rescue opioid, h, median (IQR)	7.8 (5.2–10.1)	2.6 (1.3–4.1)	HR 0.38 (log-rank)	<0.001*
Cumulative tramadol 24 h, mg, median (IQR)	50 (0–100)	150 (100–200)	Δ = −100 (−130 to −70)	<0.001*
Cumulative tramadol 48 h, mg, median (IQR)	100 (50–150)	250 (150–300)	Δ = −150 (−200 to −100)	<0.001*

***=Significant**

Table 5 shows clinically relevant antiemetic benefits aligned with opioid sparing: PONV (13.3% vs 36.7%; RR 0.36; p=0.02) and antiemetic use (20.0% vs 46.7%; RR 0.43; p=0.01) were both reduced, with no block-related complications and similar rates of hemodynamic events.

Table 5: PONV and safety

Event within 24 h	Group E (n=30)	Group C (n=30)	Effect estimate (95% CI)	p value
PONV, n (%)	4 (13.3%)	11 (36.7%)	RR 0.36 (0.15–0.86)	0.02*
Antiemetic use, n (%)	6 (20.0%)	14 (46.7%)	RR 0.43 (0.21–0.90)	0.01*
Hypotension requiring treatment, n (%)	1 (3.3%)	1 (3.3%)	RD 0.0 (−0.10–0.10)	1.00 (NS)
Sedation (over sedation episodes), n	0	1	—	0.31 (NS)
Block-related complications	0	—	—	—

***=Significant; NS = Not Significant**

Finally, Table 6 confirms no meaningful differences in immediate postoperative MAP or HR (p≥0.49), alongside a modest but significant reduction in length of stay with ESPB (median −0.5 day; p=0.03), strengthening the overall signal that ESPB improves recovery quality and efficiency without compromising safety.

Table 6: Haemodynamics and Length of Stay

Outcome	Group E (n=30)	Group C (n=30)	Difference (95% CI)	p value
MAP at PACU, mmHg, mean ± SD	86 ± 11	84 ± 12	2 (−4 to 8)	0.52 (NS)
HR at PACU, bpm, mean ± SD	79 ± 12	81 ± 13	−2 (−8 to 4)	0.49 (NS)
Postop hospital stay, days, median (IQR)	2.0 (2.0–3.0)	2.5 (2.0–4.0)	Δ = −0.5 (−0.9 to −0.1)	0.03*

Overall, Erector spinae plane block added to general anaesthesia significantly improved patient-centred recovery after PCNL: QoR-15 at discharge was ~9 points higher than control, exceeding the MCID. ESPB provided superior early analgesia, delayed first rescue, and reduced 24–48 h opioid use, with corresponding reductions in PONV. Haemodynamics and adverse events were similar, and length of stay was modestly shorter. Overall, ESPB is an effective, safe, and practical adjunct for opioid-sparing recovery in PCNL.

Discussion

In this randomized study, supplementation of general anaesthesia with a single-shot lumbar erector spinae plane block (ESPB) using 0.25% levobupivacaine was associated with a clinically and statistically meaningful improvement in postoperative recovery after PCNL. The between-group difference in QoR-15 exceeded the updated minimal clinically important difference (MCID) of 8 points, indicating that the benefit was perceptible and relevant to patients. Our findings align with contemporary clinical data in PCNL showing higher QoR-15 scores and better early recovery when ESPB is added to standard anaesthetic care. [5,6]. Analgesic outcomes in our cohort--lower early postoperative pain scores, reduced 24-hour opioid consumption, and prolonged time to first rescue analgesia—are concordant with multiple randomized trials in PCNL. Gultekin et al. reported significantly lower pain scores and analgesic needs with ESPB versus control; Ramachandran et al. demonstrated opioid-sparing effects compared with incision-site infiltration; Sarkar et al. showed decreased tramadol use and delayed rescue requests versus saline placebo; and Prasad et al. confirmed benefit even with fluoroscopy-guided ESPB. Taken together, these trials support the robustness of ESPB's analgesic effect across variations in block

level, imaging modality, and local anaesthetic regimens, which mirrors our experience using 0.25% levobupivacaine at L1. [7-10].

Our observation of lower PONV is biologically plausible given the opioid-sparing seen with ESPB and is consistent with consensus recommendations that emphasize multimodal, opioid-reducing strategies to prevent PONV. Although individual PCNL trials have varied in whether PONV reductions reach statistical significance, the overall direction of effect favors ESPB-based regimens, which matches the pattern we detected. [11].

A credible mechanistic explanation for these clinical effects is provided by imaging data showing that injectate from ESPB can extend cranio-caudally beneath the erector spinae muscle with spread toward the neural foramina and intercostal spaces. Such dispersion plausibly accounts for blockade of dorsal and ventral rami across multiple thoracolumbar dermatomes relevant to PCNL nociception (T10–L2), offering both somatic and partial visceral analgesia. Variability in paravertebral or epidural spread has been observed, which may contribute to between-patient heterogeneity in block intensity and duration—an observation consistent with the range of effect sizes reported in the literature and in our trial. [12].

Safety and feasibility also warrant comment. We did not encounter block-related complications, and our findings are in line with a meta-analysis of RCTs in PCNL showing ESPB reduces pain and opioid use without increasing adverse events relative to control. While ultrasound guidance predominates in published RCTs, fluoroscopy-guided and landmark-assisted techniques have also been described successfully; regardless of approach, meticulous technique and appropriate monitoring remain essential. [9,13].

Strengths of this work include randomized allocation, standardized perioperative care, and the use of a validated patient-centred endpoint (QoR-15) alongside conventional analgesic outcomes. The study also adds pragmatic evidence from an Indian tertiary-care context, where optimizing recovery and reducing opioid exposure are high-priority goals in day-to-day practice.

Several limitations should be acknowledged. First, the single-centre design and modest sample size limit precision and generalizability; larger multicentre trials could refine estimates and detect rarer adverse events. Second, our single-shot technique and fixed 20 mL volume may not represent the optimal dose–volume strategy for levobupivacaine; dose-finding or catheter-based studies could clarify whether extended analgesia translates into additional recovery gains. Third, we assessed pain primarily at rest; dynamic pain and functional milestones (e.g., ambulation, incentive spirometry) might better capture the full recovery profile after PCNL. Finally, although allocation was randomized, blinding of the proceduralist was not feasible and could introduce performance bias, a recurrent challenge in regional anaesthesia trials.

Clinically, these data support incorporating ESPB into multimodal pathways for PCNL in resource-diverse Indian settings. Given the consistent opioid-sparing and improvements in QoR-15 observed here and across the literature, ESPB represents a practical, low-risk adjunct to general anaesthesia. Future research should compare ESPB against other established regional techniques (paravertebral, epidural, peritubal infiltration), evaluate ultrasound versus non-ultrasound approaches head-to-head, and explore whether continuous ESPB or adjuvants can further enhance recovery while maintaining safety.

Conclusion

Adding a single-shot lumbar erector spinae plane block (ESPB) with 0.25% levobupivacaine to general anaesthesia for PCNL was associated with clinically meaningful improvement in patient-reported recovery and superior analgesia without additional safety concerns. The between-group difference in QoR-15 at discharge (~9 points) exceeded the minimal clinically important difference, while early postoperative pain scores, time to first rescue, cumulative opioid use through 48 hours, and PONV all favoured ESPB. Hemodynamic stability was comparable, and no block-related complications occurred; postoperative length of stay was modestly shorter with ESPB. These findings support incorporating ESPB into multimodal pathways for PCNL in resource-diverse settings. Future multicentre trials should compare ESPB with alternative regional techniques, evaluate dose–volume optimisation or catheter strategies, and assess cost-effectiveness and longer-term functional recovery.

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