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Original Research Article

A COMPARATIVE STUDY USING ULTRASONOGRAPHY GUIDED ERECTOR SPINAE PLANE BLOCK BETWEEN 0.25% LEVOBUPIVACAINE VERSUS 0.25% LEVOBUPIVACAINE WITH DEXMEDITOMIDINE FOR POST OPERATIVE PAIN RELIEF IN PATIENTS UNDERGOING PERCUTANEOUS NEPHROLITHOTOMY SURGERY UNDER GENERAL ANAESTHESIA

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the standard surgical procedure for large renal calculi but is frequently associated with significant postoperative pain. Ultrasound-guided erector spinae plane block (ESPB) has emerged as an effective regional analgesic technique. This study evaluated the efficacy of adding dexmedetomidine to levobupivacaine for ESPB in patients undergoing PCNL.

Materials and Methods: This prospective, randomized comparative study included 60 patients (ASA I–II, 18–70 years) undergoing PCNL under general anaesthesia. Participants were randomized into two equal groups. Group A received ultrasound-guided ESPB with 19 mL of 0.25% levobupivacaine plus 1 mL normal saline, while Group B received 19 mL of 0.25% levobupivacaine with dexmedetomidine 20 µg. Postoperative pain was assessed using the Visual Analogue Scale (VAS) for 24 hours.

Results: Baseline demographic and perioperative characteristics were comparable between the groups ($p>0.05$). The duration of postoperative analgesia was significantly longer in Group B than in Group A (1048.57 ± 255.09 vs. 397.77 ± 90.20 minutes; $p<0.001$). Total 24-hour tramadol consumption was significantly lower in Group B (113.33 ± 45.36 mg) compared with Group A (250.00 ± 49.13 mg; $p<0.001$). VAS scores were significantly lower in Group B at 6, 8, and 12 hours postoperatively ($p<0.001$), while scores were comparable during the early postoperative period and at 24 hours.

Conclusion: The addition of dexmedetomidine (20 µg) to 0.25% levobupivacaine in ultrasound-guided ESPB significantly prolongs postoperative analgesia, reduces postoperative opioid requirement, and improves pain control following PCNL without compromising haemodynamic stability or increasing adverse effects.

Keywords: Percutaneous nephrolithotomy, Erector spinae plane block, Dexmedetomidine Levobupivacaine, Postoperative analgesia, Regional anaesthesia.

INTRODUCTION

Renal calculi are among the most common urological disorders worldwide, with an increasing incidence in both developed and developing countries. Percutaneous nephrolithotomy (PCNL) is the preferred minimally invasive procedure for managing large or complex renal stones (>2 cm). Although PCNL offers high stone clearance rates with reduced morbidity compared to open surgery, postoperative pain remains a significant concern, contributing to delayed mobilization, prolonged hospital stay, and reduced patient satisfaction.[1]

Postoperative pain after PCNL has both visceral and somatic components. Visceral pain results from renal capsule distension, parenchymal tract formation, and irritation of the kidney and ureter, while somatic pain arises from the skin incision, muscle dissection, and the presence of the nephrostomy tube. Pain transmission primarily involves the T10–L2 spinal segments, making effective regional analgesia an important component of perioperative pain management.[2]

Conventional analgesic strategies include systemic opioids, non-steroidal anti-inflammatory drugs (NSAIDs), and regional techniques such as local anaesthetic infiltration, intercostal nerve block, paravertebral block, and epidural analgesia. Although opioids provide effective pain relief, their use is limited by adverse effects including respiratory depression, nausea, vomiting, sedation, and opioid dependence. NSAIDs may increase the risk of nephrotoxicity and gastrointestinal complications, while epidural and paravertebral blocks require technical expertise and are associated with complications such as hypotension, pneumothorax, and epidural hematoma. These limitations have prompted the search for safer and more effective regional analgesic techniques.[3]

The ultrasound-guided erector spinae plane block (ESPB), first described by Forero et al. in 2016, has emerged as a promising regional anaesthesia technique owing to its simplicity, safety, and ability to provide both somatic and visceral analgesia. The block is performed by injecting local anaesthetic between the erector spinae muscle and the transverse process, allowing spread into the paravertebral space and blockade of the dorsal and ventral rami of the spinal nerves. This broad sensory coverage makes ESPB particularly suitable for postoperative analgesia following PCNL.[4,5]

Several randomized controlled trials have demonstrated the effectiveness of ESPB in reducing postoperative pain and opioid consumption after PCNL. Studies have reported prolonged time to first rescue analgesia, reduced opioid requirements, and lower pain scores compared with conventional analgesic techniques. A recent systematic review and meta-analysis further confirmed that ESPB significantly improves postoperative analgesia with moderate-quality evidence supporting its use in PCNL.[6-8] However, the duration of analgesia following a single-shot ESPB is limited, encouraging the use of adjuvants to prolong its effect.

Although the individual benefits of ESPB, dexmedetomidine, and levobupivacaine have been well documented, evidence regarding the combined use of dexmedetomidine with levobupivacaine in ESPB for patients undergoing PCNL remains limited. Therefore, the present study was undertaken to compare the postoperative analgesic efficacy of ultrasound-guided ESPB using 0.25% levobupivacaine alone versus 0.25% levobupivacaine with dexmedetomidine in patients undergoing PCNL under general anaesthesia, with respect to duration of analgesia, postoperative analgesic consumption, haemodynamic changes, and adverse effects.

MATERIALS AND METHODS

This prospective, randomized comparative clinical study was conducted in the Department of Anaesthesiology and Critical Care, Kempegowda Institute of Medical Sciences and Research Centre Hospital, Bengaluru, India, over 18 months after approval from the Institutional Ethics Committee. Sixty adult patients (18–70 years) with American Society of Anesthesiologists (ASA) physical status I–II undergoing percutaneous nephrolithotomy (PCNL) with a single subcostal nephrostomy tract were enrolled after obtaining written informed consent.

Patients with ASA grade ≥III, body mass index (BMI) >30 kg/m², known allergy to local anaesthetics, excessive intraoperative bleeding, or those requiring postoperative mechanical ventilation were excluded.

Patients were randomized using a computer-generated randomization sequence into two equal groups (n=30 each):

- **Group A:** Ultrasound-guided erector spinae plane block (ESPB) with 19 mL of 0.25% levobupivacaine plus 1 mL normal saline.
- **Group B:** Ultrasound-guided ESPB with 19 mL of 0.25% levobupivacaine plus dexmedetomidine 20 µg (1 mL).

All patients underwent standardized general anaesthesia. After routine monitoring and baseline haemodynamic recording, anaesthesia was induced with intravenous glycopyrrolate (0.2 mg), fentanyl (2 µg/kg), propofol (2 mg/kg), and atracurium (0.5 mg/kg), followed by endotracheal intubation. Anaesthesia was maintained with sevoflurane in an air–oxygen mixture (MAC 1.0). At the completion of surgery, an ultrasound-guided ESPB was performed at the T10 vertebral level by an experienced anaesthesiologist before extubation.

Postoperative pain was assessed using the Visual Analogue Scale (VAS; 0–10) at 0, 15, 30, and 45 minutes, and at 1, 2, 4, 6, 8, 12, and 24 hours

postoperatively. Rescue analgesia (intravenous tramadol 100 mg) was administered when VAS ≥5. The primary outcome was the duration of analgesia, defined as the time to first rescue analgesia. Secondary outcomes included total 24-hour tramadol consumption, VAS pain scores, haemodynamic parameters (heart rate and mean arterial pressure), and incidence of adverse effects.

The sample size was calculated using data from a previous study by Kalabhavi et al,[7] assuming a 5% significance level and 90% power. A minimum of 30 patients per group was required, yielding a total sample size of 60 participants.

Statistical Analysis: Data were analysed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Between-group comparisons were performed using the independent Student's *t*-test or Mann–Whitney *U* test, as appropriate. Categorical variables were analysed using the Chi-square test. A *p* value <0.05 was considered statistically significant.

RESULTS

A total of 60 patients were enrolled and equally randomized into Group A (levobupivacaine) and Group B (levobupivacaine with dexmedetomidine). No participant was excluded from the final analysis.

Table 1: Baseline demographic and perioperative characteristics

Variable	Group A (n=30)	Group B (n=30)	p-value
Age (years), Mean ± SD	42.97 ± 14.32	46.03 ± 13.23	0.392
Male/Female, n	19/11	13/17	0.196
Weight (kg), Mean ± SD	72.07 ± 9.37	69.40 ± 9.07	0.267
ASA I/II, n	18/12	16/14	0.795
Duration of surgery (hours), Mean ± SD	2.07 ± 0.34	2.23 ± 0.43	0.102

Baseline demographic characteristics, ASA physical status, and duration of surgery were comparable between the two groups (all p>0.05), indicating successful randomization.

Table 2: Comparison of postoperative VAS scores

Time	Group A	Group B	p-value
0 min	0.00 ± 0.00	0.00 ± 0.00	1.000
2 hours	1.87 ± 1.20	1.53 ± 0.78	0.392
4 hours	2.43 ± 1.55	2.03 ± 0.81	0.700
6 hours	4.40 ± 1.43	2.77 ± 0.63	<0.001
8 hours	5.53 ± 0.90	3.47 ± 0.57	<0.001
12 hours	6.13 ± 1.36	4.20 ± 0.96	<0.001
24 hours	5.57 ± 0.73	5.33 ± 0.76	0.240

Pain scores remained similar during the first 4 postoperative hours. Group B demonstrated significantly lower VAS scores at 6, 8 and 12 hours (p<0.001), indicating prolonged postoperative analgesia with dexmedetomidine.

Table 3: Postoperative analgesic outcomes

Variable	Group A	Group B	p-value
Duration of analgesia (minutes)	397.77 ± 90.20	1048.57 ± 255.09	<0.001
Total tramadol consumption (mg/24 h)	250.00 ± 49.13	113.33 ± 45.36	<0.001

Addition of dexmedetomidine significantly prolonged postoperative analgesia (approximately 17.5 vs 6.6 hours) and reduced 24-hour tramadol requirement by nearly 55% compared with levobupivacaine alone.

Table 4: Comparison of postoperative haemodynamic parameters

Parameter	Findings
Heart rate	Comparable between groups throughout 24 hours (all *p*>0.05)
Systolic blood pressure	No significant intergroup difference (all *p*>0.05)
Diastolic blood pressure	No significant intergroup difference (all *p*>0.05)
Mean arterial pressure	Stable and comparable in both groups (all *p*>0.05)

Addition of dexmedetomidine to levobupivacaine did not produce clinically significant changes in heart rate or blood pressure, demonstrating excellent haemodynamic stability.

Table 5: Postoperative adverse effects

Adverse effect	Group A n (%)	Group B n (%)
Nausea	2 (6.7)	1 (3.3)
Vomiting	1 (3.3)	0

Adverse effect	Group A n (%)	Group B n (%)
Hypotension	1 (3.3)	1 (3.3)
Tachycardia	1 (3.3)	0
Bradycardia	0	2 (6.7)
Patients with any adverse effect	5 (16.7)	4 (13.3)

Fisher's exact test: p=1.000

The incidence of adverse effects was low and comparable between groups. Nausea and vomiting were more frequent in Group A, whereas transient bradycardia occurred only in Group B. No serious complications attributable to the erector spinae plane block were observed.

DISCUSSION

The present prospective randomized comparative study evaluated the effect of adding dexmedetomidine to 0.25% levobupivacaine in ultrasound-guided erector spinae plane block (ESPB) for postoperative analgesia following percutaneous nephrolithotomy (PCNL). The findings demonstrated that dexmedetomidine significantly prolonged postoperative analgesia, reduced postoperative opioid requirement, improved pain scores during the intermediate postoperative period, and maintained haemodynamic stability without increasing adverse effects.

The baseline demographic characteristics, ASA physical status, body weight, and duration of surgery were comparable between the two groups, indicating successful randomization and minimizing potential confounding factors. Similar baseline characteristics have been reported in previous randomized trials evaluating ESPB for PCNL, allowing reliable comparison of analgesic outcomes.[6,7,8]

The most important finding of this study was the significant prolongation of postoperative analgesia in patients receiving dexmedetomidine as an adjuvant. The duration of analgesia increased from approximately 6.6 hours with levobupivacaine alone to 17.5 hours with levobupivacaine plus dexmedetomidine, representing nearly a threefold increase. This observation is consistent with previous studies demonstrating that perineural dexmedetomidine prolongs the duration of sensory blockade by enhancing local anaesthetic action through peripheral α_2-adrenoceptor activation and inhibition of nociceptive transmission.[9,10] Similar prolongation of analgesia has been reported in ESPB for various surgical procedures, including PCNL, breast surgery, and shoulder arthroscopy, as well as in recent meta-analyses evaluating dexmedetomidine as an adjuvant in regional anaesthesia.[11]

The prolonged analgesic effect translated into a marked opioid-sparing benefit. Patients receiving dexmedetomidine required approximately 55% less tramadol during the first 24 postoperative hours than those receiving levobupivacaine alone. Reduced opioid consumption is clinically important because it minimizes opioid-related adverse effects and facilitates enhanced postoperative recovery. Comparable reductions in postoperative opioid requirement have been consistently reported in previous randomized trials and systematic reviews evaluating ESPB for PCNL and other surgical procedures.

Postoperative pain scores were similar during the first four hours after surgery, reflecting the comparable initial analgesic effect of levobupivacaine in both groups. However, pain scores became significantly lower in the dexmedetomidine group between 6 and 12 hours postoperatively, corresponding to the period when the effect of levobupivacaine alone begins to diminish. By 24 hours, pain scores were comparable between the groups, indicating that the analgesic benefit of dexmedetomidine primarily extends the duration rather than the overall duration of postoperative pain control. These findings closely parallel those reported in previous ESPB studies.[12,13]

An important observation of the present study was the preservation of haemodynamic stability. Heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure remained comparable between the groups throughout the 24-hour postoperative period. Despite the sympatholytic properties of dexmedetomidine, no clinically significant hypotension or persistent bradycardia occurred, suggesting that low-dose perineural dexmedetomidine produces predominantly local analgesic effects with minimal systemic haemodynamic consequences. This finding agrees with published meta-analyses demonstrating the haemodynamic safety of dexmedetomidine as an ESPB adjuvant.

The incidence of adverse effects was low and comparable between both groups. Although transient bradycardia occurred in a small proportion of patients receiving dexmedetomidine, it required no intervention. Conversely, nausea and vomiting were observed more frequently in the levobupivacaine-only group, likely reflecting the higher postoperative tramadol consumption. These findings support the favourable safety profile of dexmedetomidine when used as a perineural adjuvant in ESPB.[14,15]

Our study has few limitations- The study has certain limitations. It was conducted at a single centre with a relatively small sample size, and only one dose of dexmedetomidine (20 µg) was evaluated. Long-term outcomes, patient satisfaction, and quality-of-recovery measures were not assessed. Larger multicentre randomized trials evaluating different

dexmedetomidine doses and long-term postoperative outcomes are warranted.

Overall, the present study demonstrates that the addition of 20 µg dexmedetomidine to 0.25% levobupivacaine for ultrasound-guided ESPB significantly prolongs postoperative analgesia, reduces opioid consumption, and improves postoperative pain control after PCNL without compromising haemodynamic stability or increasing adverse effects, supporting its use as an effective component of multimodal analgesia.

CONCLUSION

The present study concludes that the addition of dexmedetomidine (20 µg) to 0.25% levobupivacaine in ultrasound-guided erector spinae plane block significantly prolongs the duration of postoperative analgesia, reduces total rescue analgesic consumption, and lowers pain scores during the intermediate postoperative period (6–12 hours) in patients undergoing percutaneous nephrolithotomy under general anaesthesia, without causing clinically significant haemodynamic alterations or adverse effects. The combination of levobupivacaine with dexmedetomidine in ESPB offers a safe, effective, and opioid-sparing regional analgesic strategy that may be incorporated into multimodal postoperative pain management protocols for PCNL.

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