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Research Article

Comparative Duration of Analgesia After Intercostal Nerve Block with Ropivacaine Versus Bupivacaine in Patients Undergoing Percutaneous Nephrolithotomy

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ABSTRACT

Background: Intercostal nerve block is used to provide postoperative analgesia following percutaneous nephrolithotomy (PCNL). The duration of analgesia may vary with the local anaesthetic regimen. **Aim:** To compare the duration of postoperative analgesia following intercostal nerve block with ropivacaine versus bupivacaine in patients undergoing PCNL. **Materials and Methods:** A prospective, randomised, double-blind comparative study was conducted at Dr. Jeyasekharan Hospital and Nursing Home, Nagercoil. Fifty patients aged 18–60 years with ASA physical status I or II were allocated to receive intercostal nerve block with either 10 mL of 0.75% ropivacaine or 10 mL of 0.5% bupivacaine, with 25 patients per group. Blocks were administered at completion of surgery under general anaesthesia. The primary outcome was time to first rescue analgesia. Secondary outcomes included 12-hour tramadol consumption and adverse events. Between-group estimates were recalculated from the reported aggregate data. **Results:** Mean duration of analgesia was 203.00 (30.86) minutes with ropivacaine and 260.00 (25.49) minutes with bupivacaine. Bupivacaine prolonged analgesia by 57.00 minutes (95% CI 40.89–73.11; $p<0.001$). Mean 12-hour tramadol consumption was 105.80 (22.25) mg and 98.80 (20.07) mg, respectively, without a significant difference ($p=0.249$). Postoperative nausea and vomiting occurred in five patients in each group (20.0%; $p=1.000$). No pneumothorax or local anaesthetic systemic toxicity was reported. **Conclusion:** The tested bupivacaine regimen provided longer initial analgesia than ropivacaine, without a demonstrated reduction in 12-hour tramadol consumption. Original statistical discrepancies require verification, and larger studies are needed to assess comparative safety.

Keywords: Percutaneous nephrolithotomy; Intercostal nerve block; Postoperative analgesia.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is an established surgical procedure for renal stone removal, but postoperative pain remains an important concern despite its minimally invasive approach. Pain following PCNL arises from injury to the skin and underlying tissues, dilatation of the renal capsule, creation of the nephrostomy tract and irritation associated with drainage tubes. Effective postoperative analgesia is therefore an essential component of perioperative care. Chou et al. (2016) [1] recommended individualised, multimodal pain management incorporating appropriate regional techniques, systemic analgesics and repeated assessment of treatment response. Such an approach is particularly relevant when adequate pain relief must be balanced against opioid-related adverse effects.

Intercostal nerve block offers a regional approach to postoperative analgesia following PCNL. By interrupting sensory transmission through the intercostal nerves supplying the operative region, it may delay the requirement for rescue medication. However, its effectiveness depends on the local anaesthetic regimen, injection site, surgical characteristics and contribution of visceral pain. Jonnavithula et al. (2017)[2] reported that intercostal blockade with ropivacaine provided longer analgesia and reduced rescue analgesic requirements compared with peritubal infiltration. Conversely, Choi et al. (2018)[3], studying tubeless

PCNL, found benefits from nephrostomy tract infiltration with ropivacaine, demonstrating that the relative effectiveness of regional techniques may vary between clinical settings.

Bupivacaine has also been investigated for postoperative regional analgesia in PCNL. Singh et al. (2019)[4] observed a longer interval before the first analgesic requirement and lower analgesic consumption with peritubal infiltration than with intercostal blockade using 0.25% bupivacaine. In contrast, Gyawali et al. (2024)[5] found no statistically significant differences between intercostal nerve block and peritract infiltration in postoperative pain scores, time to first rescue analgesia or total analgesic requirements. These contrasting findings emphasise that results obtained using different techniques and concentrations cannot be directly extrapolated to a comparison between local anaesthetic drugs.

A direct comparison of ropivacaine and bupivacaine administered through the same intercostal block technique can help clarify their relative duration of analgesia under a defined clinical protocol. Accordingly, the present study compared intercostal nerve block using 10 mL of 0.75% ropivacaine with 10 mL of 0.5% bupivacaine in patients undergoing PCNL, with particular emphasis on time to first rescue analgesia, postoperative tramadol consumption and adverse events.

AIM

To compare the duration of postoperative analgesia following intercostal nerve block with 0.75% ropivacaine versus 0.5% bupivacaine in patients undergoing PCNL.

OBJECTIVES

1. To compare the time from intercostal nerve block administration to the first requirement for rescue analgesia between the two groups.
2. To compare total tramadol consumption during the first 12 postoperative hours between the two groups.
3. To compare postoperative nausea and vomiting and recorded block-related complications between the two groups.

MATERIAL AND METHODOLOGY

Source of data

Data were obtained from patients admitted for PCNL at Dr. Jeyasekharan Hospital and Nursing Home, Nagercoil, Tamil Nadu. Preoperative clinical findings, anaesthetic records and postoperative observations recorded in the study proforma constituted the source data.

Study design

The study was conducted as a prospective, randomised, double-blind, parallel-group comparative interventional study. Fifty eligible patients were allocated equally to the ropivacaine and bupivacaine groups.

Study location

The study was conducted in the Department of Anaesthesia at Dr. Jeyasekharan Hospital and Nursing Home, Nagercoil, Tamil Nadu, among patients undergoing PCNL.

Sample size

The study included 50 patients, with 25 patients in each group.

Inclusion criteria

Patients were included if they:

1. Were aged 18–60 years.
2. Belonged to American Society of Anesthesiologists physical status classes I or II.
3. Underwent PCNL.
4. Provided written informed consent.

Exclusion criteria

Patients were excluded if they:

1. Declined participation.
2. Had an ASA physical status other than I or II.
3. Had a history of allergy to amide local anaesthetics.
4. Were pregnant.
5. Required two or more renal punctures.
6. Had staghorn calculi.

Ethical considerations

Approval was obtained from the institutional ethical and scientific committee. Written informed consent was obtained before enrolment. The anaesthetic procedure, study drugs and postoperative pain assessment were explained to the participants. The supplied thesis did not provide an ethics approval number or trial registration identifier.

Randomisation and blinding

Computer-generated randomisation using QuickCalcs software was employed to allocate participants to two groups:

Group	Intervention	Number

Group R	Intercostal nerve block with 10 mL of 0.75% ropivacaine, equivalent to 75 mg	25
Group B	Intercostal nerve block with 10 mL of 0.5% bupivacaine, equivalent to 50 mg	25

An anaesthesiologist who knew the allocation supervised preparation of the study drug by a trained anaesthesia technician. A second anaesthesiologist, blinded to allocation, administered the block and recorded postoperative outcomes. The thesis described the study as double-blind, although the allocation-concealment procedure and implementation of participant blinding were not fully detailed.

Procedure and methodology

Preoperative assessment included a detailed history, physical examination and evaluation of anaesthetic fitness. Investigations included complete blood count, blood glucose, renal function tests, urine examination, blood grouping, electrocardiography and chest radiography, as documented in the thesis. Participants were instructed in the use of the 0–10 visual numerical pain scale.

On the day of surgery, fasting status, consent and anaesthetic fitness were confirmed. Intravenous access was established, and standard monitoring included electrocardiography, non-invasive blood pressure and pulse oximetry. General anaesthesia was administered using the institutional protocol described in the thesis, which included fentanyl, thiopentone and succinylcholine for induction and intubation, followed by maintenance with isoflurane, nitrous oxide–oxygen and atracurium.

At completion of surgery, while the patient remained prone and under general anaesthesia, a landmark-guided intercostal nerve block was administered under aseptic precautions. Two intercostal spaces above the PCNL port site were identified. Following needle positioning and negative aspiration for blood and air, 5 mL of the allocated local anaesthetic was injected at each of the two levels, giving a total volume of 10 mL. Neuromuscular blockade was subsequently reversed, and the patient was extubated after adequate recovery.

Postoperative assessments were performed at 30 minutes and at 1, 2, 3, 4, 6, 9 and 12 hours. Pain scores, pulse rate, blood pressure and oxygen saturation were recorded.

The primary outcome was duration of analgesia, defined as the interval between intercostal block administration and the first rescue analgesic dose when the pain score exceeded 3.

Intravenous tramadol was administered as rescue analgesia, and cumulative consumption during the first 12 postoperative hours was recorded. The thesis described both weight-based dosing and incremental boluses; the exact dosing schedule requires reconciliation with the original protocol before publication.

Postoperative nausea and vomiting were recorded. Patients were also monitored for pneumothorax and clinical features suggestive of local anaesthetic systemic toxicity. The thesis defined hypotension as a reduction in mean blood pressure of at least 20% from baseline, bradycardia as a heart rate of 50 beats/minute or less, and respiratory depression as a respiratory rate of 10/minute or less and/or oxygen saturation of 92% or less.

Sample processing

No research-specific biological sample processing formed part of the analgesia comparison. Blood and urine samples were collected for routine preoperative investigations. No local anaesthetic plasma concentrations were reported.

Data collection

The study proforma captured age, sex, weight, ASA physical status, treatment allocation, block timing, postoperative pain assessments, time to first rescue analgesia, cumulative tramadol consumption and adverse events. For the present manuscript draft, anonymised aggregate results were extracted from the thesis; patient-level records were not available for reanalysis.

Statistical methods

The original study used SPSS version 20.0. The thesis described assessment of normality with the Kolmogorov–Smirnov test, comparison of continuous variables using independent-samples t-tests or Mann–Whitney U tests, and comparison of categorical variables using chi-square tests.

For the present summary-data reanalysis, continuous variables were expressed as mean (SD). Welch’s independent-samples t-test was used to calculate approximate between-group comparisons and 95% confidence intervals from the reported summary statistics. Categorical variables were expressed as within-group frequencies and percentages. Pearson’s chi-square test was used for sex and ASA distribution; Fisher’s exact test was used for postoperative nausea and vomiting. Newcombe–Wilson confidence intervals were

calculated for differences in proportions. Two-sided \(p<0.05\) was considered statistically significant.

These recalculations did not permit verification of distributions, outliers, missing observations or the original rank-based analyses.

OBSERVATION AND RESULTS

Table 1. Comparison of demographic characteristics and ASA physical status

Characteristic	Group R	Group B	Difference (95% CI)	Test statistic	p value
Age, years	46.32 (10.06)	46.28 (8.87)	0.04 (-5.36 to 5.44)	Welch's t=0.015	0.988
Weight, kg	64.36 (7.79)	62.20 (7.94)	2.16 (-2.31 to 6.63)	Welch's t=0.971	0.336
Male, n (%)	13 (52.0)	14 (56.0)	-4.0 (-29.35 to 22.10)	χ^2=0.081	0.777
Female, n (%)	12 (48.0)	11 (44.0)			
ASA I, n (%)	12 (48.0)	12 (48.0)	0.0 (-25.79 to 25.79)	χ^2=0.000	1.000
ASA II, n (%)	13 (52.0)	13 (52.0)			

Mean age was 46.32 (10.06) years in Group R and 46.28 (8.87) years in Group B, with no statistically significant difference (p=0.988). Mean weight was 64.36 (7.79) kg and 62.20 (7.94) kg, respectively (p=0.336). Men constituted 52.0% of Group R and 56.0% of Group B (p=0.777). Both groups had identical ASA distributions, with 48.0% classified as ASA I and 52.0% as ASA II. These findings showed no statistically detectable baseline differences in the reported characteristics; they did not establish equivalence or exclude imbalance in unreported variables.

Table 2. Comparison of duration of analgesia

Outcome	Group R	Group B	Mean difference (95% CI)	Test statistic	p value
Time to first rescue analgesia, minutes	203.00 (30.86)	260.00 (25.49)	-57.00 (-73.11 to -40.89)	Welch's t=-7.121	<0.001
Median duration, minutes	195	255			
Interquartile range width, minutes	45	25			

Mean duration of analgesia was significantly longer in Group B, at 260.00 (25.49) minutes, compared with 203.00 (30.86) minutes in Group R. Bupivacaine prolonged the mean interval to first rescue analgesia by 57.00 minutes, with a 95% CI of 40.89–73.11 minutes (p<0.001). Median durations were 255 and 195 minutes, respectively, supporting the same direction of difference.

Table 3. Comparison of rescue tramadol consumption during the first 12 postoperative hours

Outcome	Group R	Group B	Mean difference (95% CI)	Test statistic	p value
Cumulative tramadol consumption, mg	105.80 (22.25)	98.80 (20.07)	7.00 (-5.05 to 19.05)	Welch's t=1.168	0.249
Median consumption, mg	90	100			
Interquartile range width, mg	40	40			

Mean tramadol consumption during the first 12 postoperative hours was 105.80 (22.25) mg in Group R and 98.80 (20.07) mg in Group B. Although mean consumption was 7.00 mg lower with bupivacaine, the confidence interval included zero and the difference was not statistically significant (95% CI for R-B: -5.05 to 19.05 mg; p=0.249). Thus, the longer initial analgesia observed with bupivacaine did not demonstrate a corresponding reduction in cumulative tramadol use over 12 hours.

Table 4. Comparison of postoperative adverse events

Adverse event	Group R, n (%)	Group B, n (%)	Risk difference, percentage points (95% CI)	Test	p value
Postoperative nausea and vomiting	5 (20.0)	5 (20.0)	0.0 (-22.14 to 22.14)	Fisher's exact	1.000
Pneumothorax	0 (0.0)	0 (0.0)	0.0 (-13.32 to 13.32)	Not informative: no events	
Local anaesthetic systemic	0 (0.0)	0 (0.0)	0.0 (-13.32 to 13.32)	Not informative: no	

toxicity				events	

Postoperative nausea and vomiting occurred in five patients in each group, representing 20.0% of each treatment group (p=1.000). No pneumothorax or local anaesthetic systemic toxicity was reported. However, the small sample and wide confidence intervals precluded conclusions regarding comparative safety or exclusion of uncommon complications.

DISCUSSION

The principal finding of this study was that intercostal nerve block with 10 mL of 0.5% bupivacaine produced longer postoperative analgesia than 10 mL of 0.75% ropivacaine in patients undergoing PCNL. The mean difference favoured bupivacaine by 57 minutes. However, cumulative tramadol consumption during the first 12 postoperative hours and the observed frequency of postoperative nausea and vomiting did not differ significantly.

Baseline characteristics and their implications

Age, weight, sex and ASA physical status showed no statistically detectable differences between the groups. These findings supported descriptive comparability for the reported variables but did not prove that all determinants of postoperative pain were balanced. Wu et al. (2022)[6] identified associations between postoperative pain and stone characteristics and operative factors in a retrospective PCNL cohort. Stone burden, operative duration, nephrostomy characteristics and access details were not sufficiently presented in the current comparative results to assess their balance. Consequently, residual clinical differences could not be excluded solely on the basis of the demographic comparisons.

Duration of analgesia and comparison with intercostal-block studies

The longer analgesia observed with bupivacaine applied specifically to the two regimens tested. Ropivacaine was administered at 75 mg and bupivacaine at 50 mg; the study therefore compared different drugs at different concentrations and doses. It did not establish an equipotent dose comparison or a general ranking applicable to all block techniques.

Jonnavithula et al. (2017)[2] found that ropivacaine intercostal blockade provided better analgesic outcomes than peritubal infiltration. This supported the usefulness of ropivacaine in an intercostal technique, but did not contradict the present finding because their comparison concerned injection techniques rather than ropivacaine versus bupivacaine. Choi et al. (2018)[3] demonstrated early pain benefits with ropivacaine nephrostomy tract infiltration in tubeless PCNL, further indicating that the surgical setting and anatomical site of drug delivery influence the result.

Singh et al. (2019)[4] reported a time to first analgesic demand of approximately 8.06 hours after intercostal blockade and 12.97 hours after peritubal infiltration with bupivacaine. These durations exceeded those in the present study, where mean duration was approximately 3.38 hours with ropivacaine and 4.33 hours with bupivacaine. Such differences should not be interpreted as direct evidence of inferior block performance because concentrations, injection protocols, operative characteristics and rescue criteria differed. Gyawali et al. (2024)[5] reported no significant difference between bupivacaine intercostal blockade and peritract infiltration, illustrating variability across trials.

Chen et al. (2021)[7], in a systematic review and meta-analysis, found evidence supporting intercostal blockade compared with control for selected postoperative pain outcomes, while its advantage over peritubal infiltration remained uncertain. More recently, Long et al. (2025)[8] analysed 27 trials and found stronger evidence for erector spinae plane, paravertebral and quadratus lumborum blocks than for intercostal block or local infiltration relative to placebo. These findings place the present drug comparison within a broader and evolving evidence base; they do not directly test the two regimens used here.

Rescue analgesic consumption and alternative regional approaches

Despite the approximately one-hour extension of initial analgesia with bupivacaine, the mean difference in 12-hour tramadol consumption was only 7 mg and was not statistically significant. This illustrates why time to first rescue medication and total analgesic consumption should be evaluated separately. Delaying the first dose may improve early comfort without substantially changing subsequent analgesic requirements.

Paneque et al. (2023)[9] described PCNL pain management as a combination of surgical and anaesthetic strategies, including regional techniques, systemic analgesia and modifications to nephrostomy drainage. Their review supports interpreting the present findings within a multimodal approach rather than treating either local anaesthetic as a complete postoperative analgesic regimen.

Ramachandran et al. (2021)[10] found that erector spinae plane block prolonged time to first analgesia and reduced tramadol consumption compared with incision-site infiltration. Ibrahim and Elnabtity (2019)[11] similarly found lower postoperative morphine use and delayed patient-controlled analgesia requirements following bupivacaine erector spinae plane block compared with placebo. These studies demonstrated opioid-sparing effects when different anatomical techniques or active treatment versus placebo were compared. Their results cannot establish that switching from ropivacaine to bupivacaine within an intercostal technique would produce an equivalent reduction.

Yayik et al. (2020)[12] reported lower postoperative fentanyl consumption after paravertebral block than after peritubal infiltration. Khot et al. (2023)[13] found similar analgesic duration and postoperative analgesic use between paravertebral and erector spinae plane blocks. Hatipoglu et al. (2018)[14] also investigated paravertebral blockade against intravenous tramadol-based analgesia. Together, these studies demonstrate the relevance of evaluating regional coverage and systemic rescue protocols alongside the choice of local anaesthetic.

Raman and Prabha (2021)[15] reported substantially longer analgesia with posterior quadratus lumborum block than with saline in patients undergoing PCNL under spinal anaesthesia. This represented a different background anaesthetic and block technique from the present study. Singh et al. (2025)[16] found reduced opioid consumption with erector spinae plane block in a meta-analysis of randomised trials, while Zheng et al. (2022)[17] reported opioid-sparing benefits with quadratus lumborum block. Zhao et al. (2022)[18] evaluated paravertebral blockade across renal surgery trials. These sources provide context for future comparative studies but cannot substitute for direct evidence comparing the present intercostal drug regimens.

Adverse events and clinical interpretation

Postoperative nausea and vomiting occurred in 20.0% of patients in each group. No pneumothorax or local anaesthetic systemic toxicity was reported. Nevertheless, 25 participants per group were insufficient to assess uncommon complications reliably. El-Boghdadly et al. (2018)[19] discussed the recognition and management of local anaesthetic systemic toxicity, while Neal et al. (2021)[20] provided the updated ASRA management checklist. These publications reinforce that an absence of toxicity in a small trial should not be interpreted as proof of equal or negligible toxicity risk.

Gan et al. (2020)[21] emphasised risk assessment and preventive strategies for postoperative nausea and vomiting. The identical observed rates in this study should therefore be interpreted within the common general anaesthetic, antiemetic and rescue analgesic protocols. Individual PONV risk factors were not adequately reported to support adjusted comparisons.

Finally, statistical significance does not establish the patient-perceived importance of a treatment effect. Myles et al. (2017)[22] demonstrated the importance of clinically meaningful changes in postoperative pain measurement. Although the 57-minute difference in this study was statistically clear, its practical value would be better assessed alongside validated pain trajectories, patient satisfaction, mobilisation and recovery outcomes. Those outcomes were not available in sufficient numerical detail. The most defensible interpretation is that bupivacaine delayed the first rescue analgesic requirement under this protocol, without demonstrated superiority in overall 12-hour opioid use or safety.

CONCLUSION

In this study of 50 patients undergoing PCNL, intercostal nerve block with 10 mL of 0.5% bupivacaine provided significantly longer analgesia than 10 mL of 0.75% ropivacaine. Bupivacaine prolonged the mean time to first rescue analgesia by 57 minutes (95% CI 40.89–73.11). However, cumulative tramadol consumption during the first 12 postoperative hours and postoperative nausea and vomiting did not differ significantly. No pneumothorax or local anaesthetic systemic toxicity was reported, although the sample was insufficient to establish comparative safety. These findings support longer initial analgesia with the tested bupivacaine regimen, subject to verification of the original dataset.

LIMITATIONS OF THE STUDY

1. **Small, single-centre sample:** Only 50 patients were included, limiting precision and generalisability.
2. **Unverifiable original sample-size calculation:** The calculation presented in the thesis did not reproduce its stated sample requirement.
3. **Statistical inconsistencies:** Some reported test statistics and p values were inconsistent with the group summaries;

recalculations require confirmation using patient-level data.

4. **Short follow-up:** Outcomes were assessed over 12 postoperative hours, without longer-term analgesic or recovery assessment.
5. **Different concentrations and doses:** The comparison involved 75 mg ropivacaine and 50 mg bupivacaine, without establishing equipotency.
6. **Incomplete procedural information:** Operative duration, stone burden, nephrostomy characteristics and other potential pain determinants were insufficiently reported for comparison.
7. **Limited numerical pain data:** A usable longitudinal pain-score table was unavailable, preventing assessment of pain trajectories.
8. **Incomplete reporting of trial conduct:** Allocation concealment, participant flow, block failures and the exact rescue dosing schedule require clarification.
9. **Limited safety assessment:** Zero serious adverse events in 25 patients per group did not exclude uncommon complications.
10. **Restricted population and historical practice:** Findings were limited to selected ASA I–II adults aged 18–60 years treated in 2013–2014 and may not directly generalise to contemporary PCNL pathways.

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