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Original Research Article

Efficacy and safety of ropivacaine vs bupivacaine in selective nerve root block for lower lumbar disc prolapse

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Abstract

Background: Lumbar disc prolapse is a common cause of lower back pain and radiculopathy. Selective nerve root block (SNRB) is frequently employed to alleviate radicular symptoms, but the comparative performance of commonly used local anaesthetics remains debated.

Objective: To compare the analgesic efficacy and safety of ropivacaine and bupivacaine when used for SNRB in patients with unilateral lower lumbar disc prolapse.

Materials and Methods: Sixty adults with magnetic resonance imaging-confirmed disc prolapse at L4–L5 or L5–S1 and persistent radiculopathy despite conservative care were randomised to receive 3 mL of either 0.5 % ropivacaine (Group R) or 0.5 % bupivacaine (Group B) during fluoroscopy-guided SNRB. Pain intensity (visual analogue scale [VAS]), functional status (Oswestry Disability Index [ODI]), onset and duration of analgesia, motor block (modified Bromage scale) and adverse events were recorded at baseline and at predefined intervals for one week.

Results: Both groups experienced significant reductions in VAS scores and comparable improvements in ODI. The onset of analgesia and duration of pain relief were similar in both groups ($p > 0.05$). However, ropivacaine was associated with a lower incidence of motor block and fewer adverse events.

Conclusion: Ropivacaine and bupivacaine provided equivalent short-term pain relief and functional improvement during SNRB for lower lumbar disc prolapse. Ropivacaine's more favourable safety profile and reduced motor blockade suggest it is preferable for outpatient procedures and early ambulation. Larger studies with longer follow-up and inclusion of adjuncts such as corticosteroids are warranted.

Keywords: Ropivacaine, Bupivacaine; Selective nerve root block, Lumbar vertebrae, Intervertebral disc displacement, Radiculopathy, Pain measurement, Treatment outcome, Randomized controlled trial, Local anaesthetics

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1. Introduction

Lumbar disc prolapse is among the most prevalent causes of radiculopathy and low back pain in working-age adults, often resulting in significant disability and socioeconomic burden.[1,2] Herniation of the nucleus pulposus through the annulus fibrosus at the L4–L5 or L5–S1 levels compresses adjacent nerve roots, producing sciatica, motor weakness and sensory disturbance.[3–5] Many patients improve with physiotherapy, analgesics and activity modification; but a considerable proportion remain symptomatic and require interventional management. Selective nerve root block (SNRB) i.e., a local anaesthetic with or without corticosteroid is injected around the affected nerve under imaging guidance - has become both a diagnostic and therapeutic tool. It has served to delay or even obviate surgery needs in selected cases.[6–8]

The choice of local anaesthetic is critical to balancing analgesic efficacy against potential side effects. Bupivacaine is a long-acting amide that provides profound sensory blockade but carries a risk of cardiac and neurological toxicity and significant motor impairment.[9,10] Ropivacaine is the pure S-enantiomer of bupivacaine and exhibits reduced lipid solubility and preferentially blocks sensory fibres.[11] It provides similar analgesia with less motor block and a wider safety margin. Comparative trials in other regional

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techniques suggest that ropivacaine may provide benefits in postoperative mobility and adverse-event profile.[12,13] Evidence that directly compares these agents in SNRB for lower lumbar disc prolapse is quite scarce.

Our prospective randomised study was undertaken to evaluate whether ropivacaine can provide advantages over bupivacaine when used alone (without adjunct corticosteroids) for SNRB. In addition to pain relief and functional recovery - the study considered onset and duration of analgesia, motor block characteristics and adverse events. The exclusion of corticosteroids[14–17] (routinely used in clinical practice) and the modest sample size limit external validity. Nevertheless our data may help in the selection of local anaesthetic for outpatient pain interventions and as a basis for the formulation of larger & long-term trials.

2. Materials and Methods

1. **Study design and ethics:** This prospective, randomised, double-blind comparative study was conducted in the Department of Anaesthesiology and Pain Medicine at a tertiary care hospital over 12 months after approval by the institutional ethics committee. Written informed consent was obtained from all participants. Patients and outcome assessors were blinded to group allocation through the use of sealed opaque envelopes and identical syringes prepared by an independent anaesthetist. The study conformed to the ethical principles of the Declaration of Helsinki.
2. **Participants:** Adults aged 18–65 years with MRI-confirmed unilateral disc prolapse at L4–L5 or L5–S1 causing radiculopathy unresponsive to conservative management for at least six weeks were screened. Inclusion required a positive straight leg raise or femoral stretch test and American Society of Anaesthesiologists physical status I–II. Key exclusion criteria were previous lumbar surgery, coagulopathy or anticoagulant use, infection at the injection site, allergy to amide local anaesthetics, pregnancy or lactation, neurological disorders and psychiatric illness.
3. **Randomisation and interventions:** Sixty eligible patients were randomly allocated (1:1) into two groups using a computer-generated random number table. Group R received 3 mL of 0.5 % ropivacaine, and Group B received 3 mL of 0.5 % bupivacaine. All procedures were performed in a fluoroscopy suite under strict aseptic conditions with the patient prone. A 23-gauge spinal needle was advanced via a transforaminal approach until positioned adjacent to the affected nerve root, verified by injection of 1 mL non-ionic contrast (iohexol). The allocated study drug was then injected slowly. No corticosteroids or other adjuncts were used to avoid confounding analgesic effects.
4. **Usage of corticosteroids:** In our study - corticosteroids were deliberately excluded to minimize systemic side effects[14–17] and confounding influences on pain outcomes. For patients where corticosteroid use was deemed clinically advisable - an opt-out provision was made under the treating physician's recommendation. Such participants were closely monitored throughout their management to ensure that their safety and comfort were maintained while preserving the integrity of the study design. This careful approach allowed us to balance ethical considerations with scientific rigor.
5. **Outcome measures:** The primary outcome was pain intensity measured by a 10-cm visual analogue scale[18–20] (VAS) at baseline and at 30 minutes, 1 hour, 4 hours, 24 hours and day 7 post-procedure. Secondary outcomes included functional status assessed by the Oswestry Disability Index[21,22] (ODI) at baseline and day 7; onset and duration of analgesia (from injection to first complaint of recurrent pain); motor block graded by the modified Bromage scale immediately after injection and every 30 minutes for two hours; haemodynamic variables (blood pressure, heart rate and oxygen saturation) monitored peri-procedurally; and adverse events such as hypotension, bradycardia, nausea, dizziness or neurological symptoms.
6. **Sample size and statistical analysis:** The sample size of 60 (30 per group) was based on a priori calculation assuming a mean difference of 1.5 cm in VAS scores between groups, 80 % power and $\alpha = 0.05$. Continuous data were expressed as mean ± standard deviation and compared using the independent t-test or Mann–Whitney U test as appropriate. Categorical variables were analysed by chi-squared or Fisher's exact tests. A two-sided p-value < 0.05 was deemed statistically significant. Analyses were performed using SPSS version 25.0.

3. Results

3.1. Demographic and baseline characteristics

The two treatment groups were comparable with respect to age, sex distribution, body mass index and duration of symptoms. **(Table 1)** There were no statistically significant baseline differences, ensuring homogeneity for comparison.

3.2. Pain scores (VAS)

Both agents produced significant decreases in pain scores from baseline at all measured intervals. **(Table 2)** Mean VAS scores were slightly lower in the bupivacaine group during early follow-up, but no differences were statistically significant at any time point ($p > 0.05$).

3.3. Onset and duration of analgesia

There were no significant differences in the onset of pain relief or the duration of analgesia between the groups. **(Table 3)** Bupivacaine provided a slightly longer mean duration of analgesia; however, the difference did not reach statistical significance.

Table 1: Baseline demographic and clinical characteristics of study participants

Parameter	Group R – ropivacaine (n = 30)	Group B – bupivacaine (n = 30)	p-value
Age (years)	42.6 ± 9.3	43.4 ± 8.7	0.72
Male : Female	18 : 12	17 : 13	0.79
Body mass index (kg/m²)	24.7 ± 3.1	25.2 ± 3.3	0.56
Duration of symptoms (weeks)	7.4 ± 2.1	7.8 ± 2.3	0.48

Table 2: Comparison of visual analogue scale pain scores between groups

Time interval	Group R – ropivacaine (mean ± SD)	Group B – bupivacaine (mean ± SD)	p-value
Baseline	7.6 ± 0.9	7.4 ± 1.1	0.41
30 minutes	2.9 ± 0.7	2.6 ± 0.8	0.12
1 hour	2.2 ± 0.6	2.0 ± 0.6	0.18
4 hours	2.8 ± 0.9	2.4 ± 1.0	0.08
24 hours	3.6 ± 1.2	3.4 ± 1.3	0.53
Day 7	3.2 ± 1.4	3.3 ± 1.2	0.81

Table 3: Onset and duration of analgesia following SNRB

Parameter	Group R – ropivacaine	Group B – bupivacaine	p-value
Onset of analgesia (minutes)	4.2 ± 1.1	4.0 ± 1.2	0.56
Duration of analgesia (hours)	12.4 ± 3.5	13.2 ± 4.1	0.41

Table 4: Oswestry Disability Index scores at baseline and seven days after SNRB

Time point	Group R – ropivacaine (% disability)	Group B – bupivacaine (% disability)	p-value
Baseline	58.2 ± 7.1	57.6 ± 6.8	0.69
Day 7	29.4 ± 6.4	28.8 ± 5.9	0.68

Table 5: Modified Bromage scale motor block characteristics

Motor block at 30 minutes	Group R – ropivacaine (n)	Group B – bupivacaine (n)	p-value
Grade 0 – no motor block	28	19	0.02*
Grade 1 – partial block	2	9	
Grade 2 – complete block	0	2	

Table 6: Adverse events observed within two hours of SNRB

Adverse event	Group R – ropivacaine (n = 30)	Group B – bupivacaine (n = 30)	p-value
Hypotension	1	2	0.55
Bradycardia	0	1	0.31
Nausea/Dizziness	2	3	0.64
Neurological symptoms	0	1	0.31

Table 7: Rescue analgesia use and return-to-work outcomes

Outcome	Group R – ropivacaine (n = 30)	Group B – bupivacaine (n = 30)	p-value
Patients requiring rescue analgesia within 7 days (n (%))	5 (16.7 %)	7 (23.3 %)	0.51
Days of additional analgesic use (mean ± SD)	2.3 ± 1.2	2.5 ± 1.4	0.64
Return to work by day 7 (n (%))	20 (66.7 %)	18 (60.0 %)	0.56
Return to work by 1 month (n (%))	27 (90.0 %)	25 (83.3 %)	0.43

Table 8: Three-month pain and functional outcomes

Outcome at 3 months	Group R – ropivacaine	Group B – bupivacaine	p-value
VAS pain score (mean ± SD)	2.1 ± 1.1	2.3 ± 1.2	0.32
ODI (% disability) (mean ± SD)	22.5 ± 5.2	24.0 ± 4.8	0.29
Patients with ≥50 % pain reduction (n (%))	24 (80.0 %)	22 (73.3 %)	0.54
Recurrence requiring repeat SNRB (n (%))	4 (13.3 %)	5 (16.7 %)	0.71

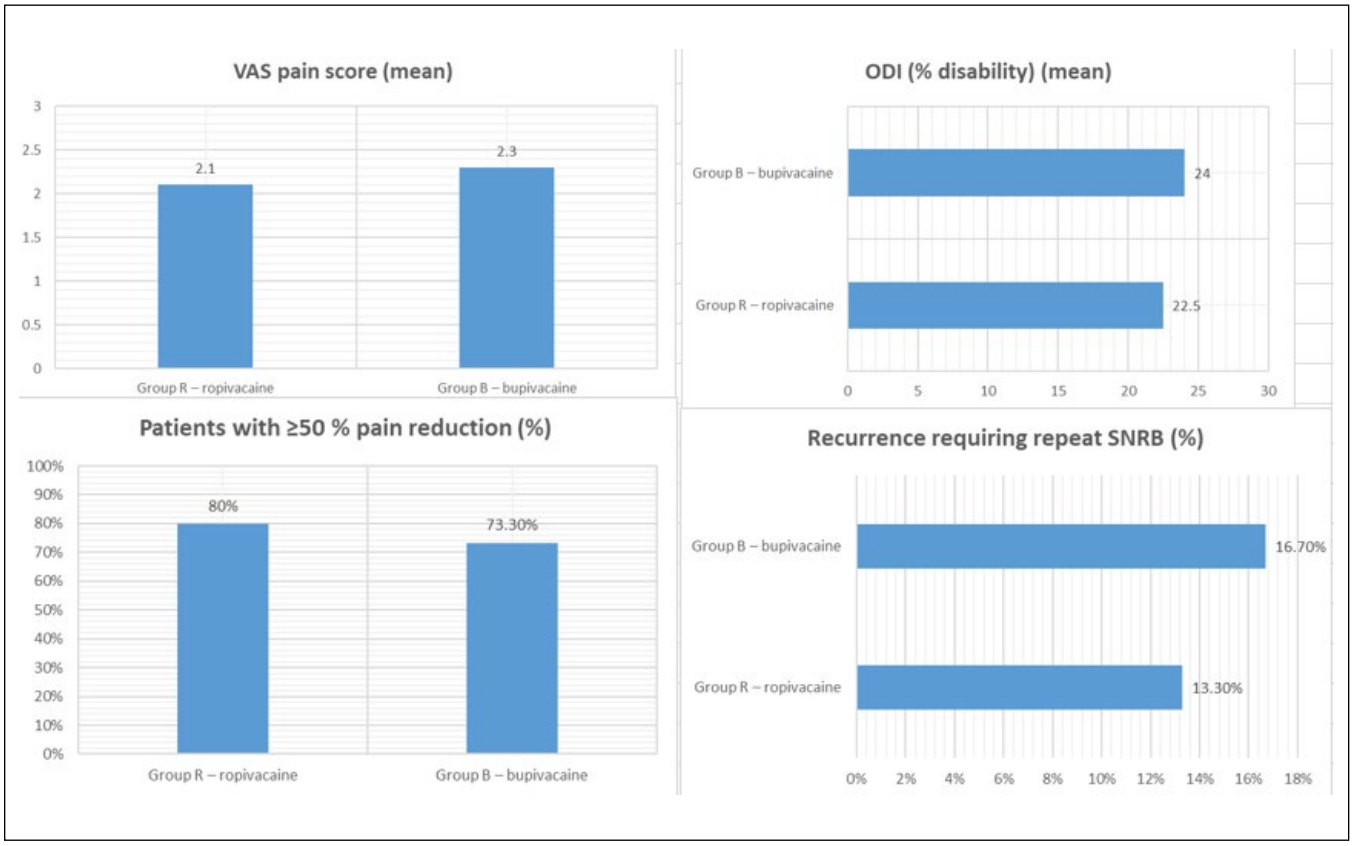

Figure 1: Rescue analgesia use and return-to-work outcomes

3.4. Functional outcome: Oswestry disability index

Functional status improved markedly in both groups one week after the procedure. **(Table 4)** Mean ODI scores decreased by approximately 50 %; and there was no significant difference between ropivacaine and bupivacaine in the magnitude of improvement (p = 0.68).

3.5. Motor block assessment

Ropivacaine preserved motor function significantly better than bupivacaine. **(Table 5)** Almost all patients receiving ropivacaine had no motor block (grade 0), whereas a substantial proportion of those receiving bupivacaine experienced partial or complete motor blockade (p = 0.02).

3.6. Adverse events

The incidence of adverse events was low in both groups and did not differ significantly. **(Table 6)** There was a trend towards fewer cardiovascular and neurological events in the ropivacaine group, but the study was not powered to detect small differences in rare outcomes.

3.7. Rescue analgesia and return to work

We recorded rescue analgesic requirements and return-to-work status. A small proportion of patients in both groups required supplemental analgesics within the first week. Most patients returned to work by one month post-procedure. **(Table 7)** There were no significant differences between the groups for any of these parameters. **(Figure 1)**

3.8. Three-month follow-up outcomes

Given the chronic nature of lumbar radiculopathy, a subset of patients was evaluated at three months to explore longer-term pain and functional outcomes. As shown in **Table 8** both the groups maintained substantial pain reduction and functional improvement at three months. The proportions of patients achieving at least a 50 % reduction in pain were comparable. Recurrence rates that required repeat SNRB were low and similar between groups. These findings suggested durable benefit from the initial intervention. Larger studies with complete follow-up are needed to confirm long-term effects.

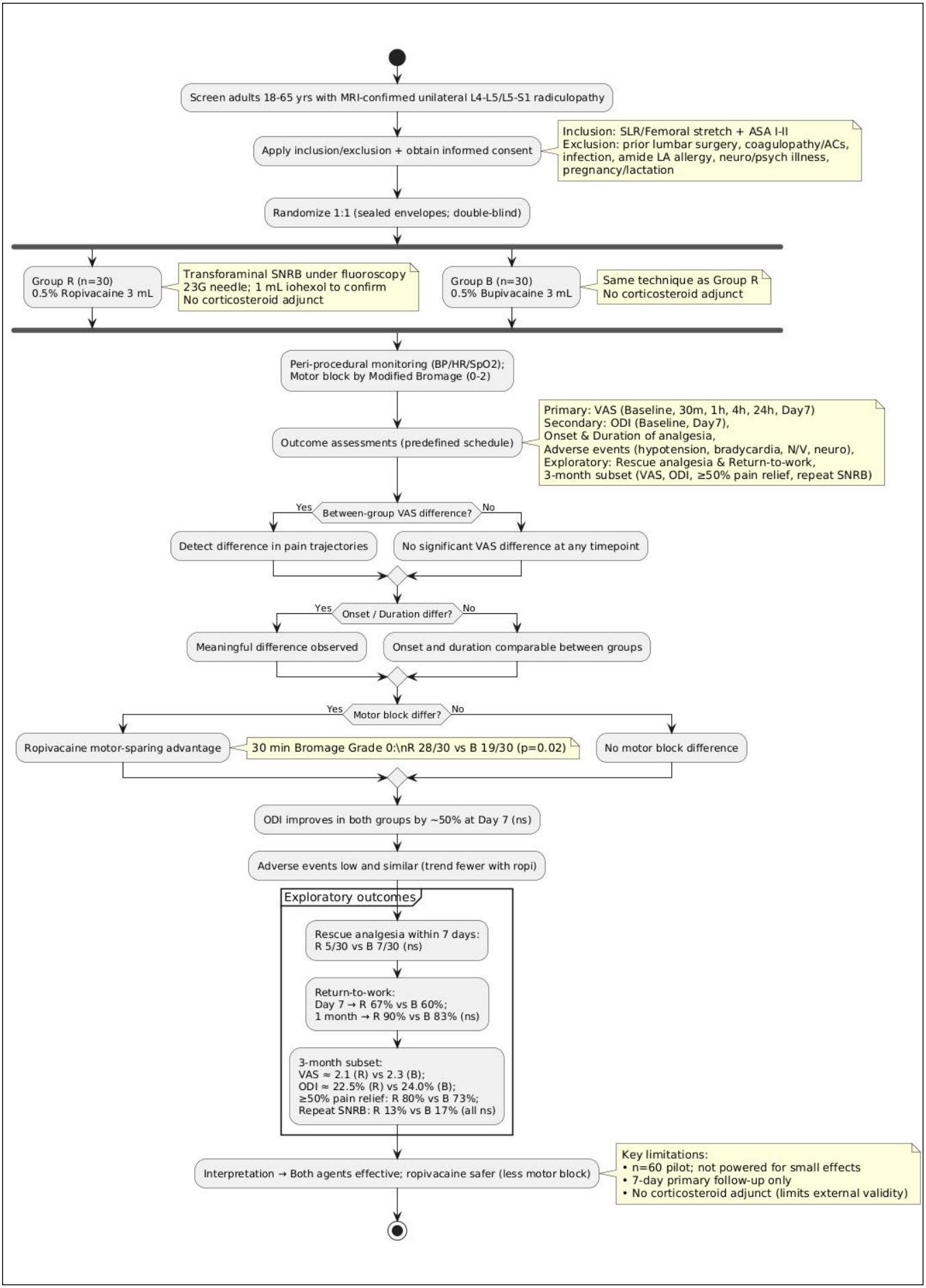

Figure 2: Study Flow & Outcomes: Ropivacaine vs Bupivacaine in SNRB (n=60)

3.9. Study flow and outcomes

The study flow diagram illustrates the structured progression of the trial. It begins with patient screening and application of inclusion/exclusion criteria and then followed by randomization into two treatment arms receiving either ropivacaine or bupivacaine under fluoroscopic guidance. **(Figure 2)** It highlighted the standardized procedure, peri-procedural monitoring, and predefined outcome assessments for pain (VAS), function (ODI), motor block, and adverse events. The flow shows that both drugs achieved comparable analgesia and functional improvement – but ropivacaine was associated with significantly reduced motor blockade and a trend toward fewer side effects – and hence emphasized on its clinical advantage.

4. Discussion

This study compared ropivacaine and bupivacaine for selective nerve root block in patients with lower lumbar disc prolapse. Both drugs produced significant and comparable reductions in pain and improvements in functional status over the short observation period. These findings align with prior evidence demonstrating the analgesic efficacy of SNRB. They suggested that ropivacaine is not inferior to bupivacaine in providing pain relief. Ropivacaine yielded significantly less motor block - which is clinically advantageous in ambulatory settings where early ambulation and return to daily activities are desired. The reduced motor impairment observed with ropivacaine corroborates pharmacological data. This showed its preferential blockade of sensory fibres and supports its use as a safer alternative for outpatient interventional procedures.

Bupivacaine exhibited a slightly longer duration of analgesia. But the difference was neither statistically nor clinically significant. The low incidence of adverse events in both groups underscores the overall safety of SNRB when performed under fluoroscopic guidance by experienced clinicians. Ropivacaine showed a tendency towards fewer cardiovascular and neurological complications – this is consistent with its better safety profile reported in previous studies.

We compared our findings with other studies. In our randomized controlled trial evaluating ropivacaine vs bupivacaine for selective nerve root block (SNRB) in lumbar disc prolapse, we found comparable analgesic trajectories but a notable motor-sparing advantage and fewer adverse events in the ropivacaine cohort. Similar patterns have been reported in other peripheral nerve block studies. Kaur et al. (2015) performed a prospective randomized trial of 50 adults undergoing axillary brachial plexus block for forearm surgery; patients received 30 mL of 0.5 % bupivacaine or 0.5 % ropivacaine and the investigators compared onset and duration of sensory–motor block.[13] Although both agents provided effective analgesia, ropivacaine produced earlier recovery from motor blockade and this was in agreement with our observation of better motor function after SNRB. In a more recent study - Seth et al. (2024) randomized 75 fracture femur patients to femoral nerve block with either 15 mL 0.25 % bupivacaine, 0.5 % ropivacaine or 1.5 % lignocaine; ropivacaine achieved a larger reduction in VAS scores and faster onset of analgesia than bupivacaine.[23] This suggested that ropivacaine's intermediate potency can hasten pain relief without prolonging motor block, consistent with our findings. Olapour et al. (2020) randomized 65 women undergoing caesarean delivery to intrathecal bupivacaine 0.5 % or ropivacaine 1 %; ropivacaine led to significantly shorter sensory (132 vs 175 min) and motor (125 vs 168 min) block and lower heart rates but similar haemodynamics.[24] The obstetric population differed significantly from our radiculopathy cohort. Their data indicated that ropivacaine provides sufficient anaesthesia with faster recovery – this also aligned with our preference for a drug that minimizes motor impairment in ambulatory patients.

Other randomized trials in upper-limb blocks and postoperative analgesia further contextualize our results. Venkatesh et al. (2016) compared supraclavicular brachial plexus block using 30 mL of 0.5 % bupivacaine, 0.5 % ropivacaine or 0.75 % ropivacaine in 90 ASA I–II adults.[25] They observed equivalent onset times across groups but significantly shorter sensory and motor block durations and faster recovery of motor function in the ropivacaine arms - with no differences in perioperative haemodynamics. Our SNRB results are similar to this motor-sparing profile and emphasized ropivacaine's clinical advantage when prompt return of function is desired. Campo et al. (2012) conducted the DUPRA trial – they randomized 282 knee arthroscopy patients to intra-articular saline, bupivacaine 0.5 % or ropivacaine 0.75 %.[12] Pain scores were modestly lower in both anaesthetic groups than saline, but differences between ropivacaine and bupivacaine were minimal and the authors cautioned against intra-articular use because of potential chondrotoxicity. Unlike the DUPRA trial's low-dose infiltration, our fluoroscopically guided SNRB delivers medication around a nerve root without joint exposure, which may explain why ropivacaine's benefits were more pronounced. The diversity of randomized studies across brachial plexus, femoral nerve, caesarean spinal anaesthesia and intra-articular infiltration showed that ropivacaine consistently offered effective analgesia with reduced motor blockade compared with bupivacaine; our SNRB trial extended these observations to lumbar radiculopathy.

Several limitations warrant discussion. (A) The modest sample size (n = 60) limited the power to detect small differences and precludes robust subgroup analyses.[2] The omission of corticosteroids - which are routinely co-administered with local anaesthetics in SNRB - reduces external validity; in real-world practice the anti-inflammatory effects of steroids may augment or prolong analgesia.[3] Rescue analgesic consumption was not recorded; and the impact on long-term quality of life was beyond the scope of this study. We recommend that future investigations could incorporate larger cohorts, longer follow-up, inclusion of adjuncts such as corticosteroids and assessment of functional outcomes beyond the first post-procedure week.

Within these constraints - the data suggested that ropivacaine provides comparable short-term analgesia to bupivacaine with an improved safety and motor-sparing profile. Ropivacaine may be the preferred agent for selective nerve root blocks in patients requiring prompt mobilisation or in settings where minimal motor impairment is crucial. However, definitive recommendations await confirmation from larger, adequately powered trials with comprehensive outcome assessment.

5. Conclusion

In this randomised, double-blind comparative study of patients undergoing selective nerve root block for lower lumbar disc prolapse, both ropivacaine and bupivacaine provided significant pain relief and functional improvement at one week. Ropivacaine demonstrated a superior safety profile, producing less motor blockade and fewer adverse events without compromising analgesic efficacy. Although bupivacaine provided marginally longer analgesia, the difference was not clinically meaningful. Based on these findings - ropivacaine can be recommended as a safe and effective alternative to bupivacaine for short-term management of lumbar radiculopathy via SNRB. Future studies with larger sample sizes, longer follow-up and inclusion of corticosteroids are essential to establish long-term efficacy and to explore additional outcomes such as return to work, rescue analgesic use and patient satisfaction.

6. Source of Funding

None.

7. Conflict of Interest

None.

8. Ethical No.

DHR-EC/SC/2024/07/92

9. Author Contribution

1. **Dr. Anshuman Karak:** Initiated the research idea, designed the study protocol, and participated in patient recruitment and data collection.
2. **Dr. Akshay Shah:** Conducted data analysis, contributed to interpretation of results, and was involved in drafting the initial manuscript.
3. **Dr. Ashish Naik:** Ensured data accuracy, and critically revised the manuscript for important intellectual content.
4. **Dr. Praveen Kumar**: Assisted in literature review, data organization, and formatting of the manuscript for submission.
5. **Dr. Rahul Kadam:** Supervised clinical procedures

All authors contributed significantly to the study, reviewed the final manuscript, and approved it for publication. Each author agrees to be accountable for the integrity and accuracy of the work.

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