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Comparative Evaluation of Spinal Anaesthesia Characteristics of Hyperbaric Levobupivacaine versus Hyperbaric Ropivacaine in Adult Patients Undergoing Inguinal Hernia Surgery: A Prospective Observational Study

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Abstract: ***Background: Spinal anaesthesia is widely preferred for lower abdominal surgeries including inguinal hernia repair, offering multiple clinical advantages over general anaesthesia. Levobupivacaine and ropivacaine, both relatively newer local anaesthetic agents, possess favourable safety profiles with reduced cardiotoxic and neurotoxic effects compared to conventional bupivacaine. This study was designed to systematically compare the spinal anaesthesia characteristics of hyperbaric levobupivacaine (0.5%) with hyperbaric ropivacaine (0.75%) in adult patients scheduled for inguinal hernia repair. Methods: A prospective observational study was conducted at a tertiary care centre in South Gujarat, India, following institutional ethical committee approval. Seventy adult male patients of ASA physical status I, II, and III, aged 18-60 years, undergoing inguinal hernia surgery under spinal anaesthesia were enrolled and divided into two groups: Group L (n=35) receiving hyperbaric levobupivacaine (0.5%, 3.5 mL) and Group R (n=35) receiving hyperbaric ropivacaine (0.75%, 3.5 mL). Sensory block was assessed using the pin-prick method, and motor block was evaluated with the Modified Bromage Scale. Hemodynamic parameters were monitored throughout the perioperative period. Results: Both agents produced comparable onset of sensory block at T10 (Group L: 4.6±1 min; Group R: 4.3±1.7 min; p=0.354) and similar highest sensory levels. However, levobupivacaine provided significantly longer duration of sensory block (266.3±24.1 min vs. 170.6±19.7 min; p<0.001), motor block (238.8±19.6 min vs. 151.4±14.3 min; p<0.001), and analgesia (202.47±19.35 min vs. 164.14±32.25 min; p<0.001). Time to unassisted mobilisation and micturition were also significantly prolonged in Group L. Hemodynamic parameters were comparable between groups with no significant intergroup differences. Conclusion: Hyperbaric levobupivacaine provides longer duration of sensory, motor block, and analgesia, making it suitable for prolonged surgical procedures. Hyperbaric ropivacaine, with its shorter block duration and early motor recovery, is a more appropriate choice for ambulatory and day-care surgeries.***

Keywords: Spinal anaesthesia, Levobupivacaine, Ropivacaine, Inguinal hernia, Modified Bromage Scale, Sensory block, Motor block

1. Introduction

Spinal anaesthesia has long been established as the preferred anaesthetic technique for lower abdominal surgical procedures, particularly inguinal hernia repair, owing to its safety, efficacy, favourable hemodynamic profile, reduced intraoperative blood loss, and cost-effectiveness when compared with general anaesthesia. The evolution of local anaesthetic agents for intrathecal use has been driven by the need to balance adequate surgical anaesthesia with minimising adverse effects.

Bupivacaine, a racemic amide local anaesthetic, has historically been the most widely used agent for spinal anaesthesia. While it provides excellent surgical conditions, its association with serious cardiovascular and central nervous system toxicity has prompted extensive research into safer alternatives. Levobupivacaine, the pure S (-)-enantiomer of bupivacaine, and ropivacaine, a propyl homologue of mepivacaine, have emerged as clinically relevant alternatives with improved safety margins.

Levobupivacaine exerts its pharmacological action through reversible blockade of neuronal sodium channels. It shares comparable potency with bupivacaine but demonstrates a superior safety profile, attributed largely to its higher protein-binding affinity (97%) and reduced cardiovascular and central nervous system toxicity. Its use in subarachnoid block, epidural anaesthesia, peripheral nerve blocks, and local infiltration has grown considerably in recent years.

Ropivacaine is a newer amino-amide local anaesthetic with a chemical structure similar to bupivacaine but with lower lipid solubility. This pharmacological distinction results in shorter duration of motor blockade, faster motor recovery, and reduced systemic toxicity, rendering it particularly attractive for ambulatory surgical settings and day-care procedures.

Comparative data on hyperbaric formulations of these two agents in the context of inguinal hernia surgery remain limited. Both agents have been independently investigated in various surgical contexts, but direct comparisons focusing on their intrathecal characteristics- onset, peak, duration of sensory and motor blockade, hemodynamic stability, and postoperative analgesic requirements- are sparse. This study

was therefore designed to systematically compare the spinal anaesthesia characteristics of hyperbaric levobupivacaine 0.5% and hyperbaric ropivacaine 0.75% in adult male patients posted for inguinal hernia repair under spinal anaesthesia.

2. Aims and Objectives

Primary Objective: To compare the characteristics of spinal anaesthesia including onset of sensory and motor block, highest level of sensory and motor blockade, duration of sensory and motor blockade, and duration of post-operative analgesia between hyperbaric levobupivacaine and hyperbaric ropivacaine.

Secondary Objectives: To compare hemodynamic parameters (pulse rate, systolic and diastolic blood pressure, SpO2) between the two groups, and to document and compare complications and adverse effects associated with each agent.

3. Materials and Methods

3.1 Study Design and Setting

A prospective observational study was conducted at a tertiary care hospital in South Gujarat, India, following approval from the Institutional Research and Ethics Committee. The study was carried out over a defined period in the Department of Anaesthesiology and included adult patients scheduled for elective inguinal hernia surgery under spinal anaesthesia.

3.2 Study Population

Seventy adult male patients aged 18 to 60 years belonging to American Society of Anesthesiologists (ASA) physical status I, II, and III, who were scheduled for inguinal hernia repair under spinal anaesthesia, were included after obtaining valid written informed consent. Patients were excluded if they had contraindications to spinal anaesthesia (including coagulopathy, localised infection at the injection site, or neurological diseases), major cardiorespiratory or hepatorenal disorders, or were presenting with strangulated, obstructive, or irreducible hernias.

3.3 Grouping and Drug Administration

Following eligibility verification, patients were divided into two groups of 35 each: Group L: Received hyperbaric levobupivacaine 0.5% (3.5 mL intrathecally)

Group R: Received hyperbaric ropivacaine 0.75% (3.5 mL intrathecally)

Spinal anaesthesia was administered at the L3-L4 intervertebral space using a 25-gauge Quincke spinal needle under strict aseptic precautions with the patient in the sitting position. All patients were preloaded with Ringer's lactate 10 mL/kg intravenously prior to the block. Premedication consisted of intravenous midazolam 1 mg to allay anxiety.

3.4 Monitoring and Assessment

Pulse rate, non-invasive blood pressure, and SpO2 were recorded at baseline and at 2-minute intervals for the first 20 minutes, every 10 minutes up to 30 minutes, and subsequently every 30 minutes for the remainder of the study period. Sensory block was assessed by the pin-prick method, and motor block was graded using the Modified Bromage Scale (Table 1). Sensory and motor parameters were checked every 2 minutes for the first 15 minutes, then every 15 minutes thereafter.

A sensory level of T10 and Modified Bromage grade 2 or higher was considered adequate for surgical readiness. Failure to achieve T10 within 15 minutes was classified as a failed block. Intraoperative discomfort was managed with intravenous fentanyl 1-2 mcg/kg; cases requiring general anaesthesia were excluded from the final analysis. Duration of analgesia was defined as the time from administration of spinal anaesthesia to the first patient complaint of pain (VAS score ≥3).

Table 1: Modified Bromage Scale

Grade	Description
0	No motor block — full movement
1	Can flex knee and move foot, but cannot raise extended leg
2	Can move foot only; unable to flex knee
3	Unable to move foot or knee

3.5 Statistical Analysis

Data were expressed as mean ± standard deviation (SD) for continuous variables and as frequency with percentage for categorical variables. Intragroup comparisons were performed using the paired t-test, and intergroup comparisons were made using the unpaired Student's t-test. Categorical data were compared using the chi-square test. A p-value of less than 0.05 was considered statistically significant, and $p<0.001$ was considered highly significant. All statistical analyses were performed using standard software.

4. Observations and Results

4.1 Demographic Profile

A total of 70 adult male patients were enrolled. Two patients from Group R did not achieve adequate spinal anaesthesia and were excluded; their data were replaced to maintain 35 patients in each group. The demographic profiles were comparable between groups, with a mean age of 43.2±13.6 years in Group L and 42.7±11.2 years in Group R (p=0.8, Table 2).

Table 2: Demographic Profile of Study Participants

Parameter	Group L — Levobupivacaine (n=35)	Group R — Ropivacaine (n=35)
Age (years), Mean ± SD	43.2 ± 13.6	42.7 ± 11.2
Age range (years)	18 – 60	18 – 60
Gender	All Male (100%)	All Male (100%)
p-value	0.8 (Not significant)	

4.2 Sensory Block Characteristics

The onset of sensory block, defined as the time from intrathecal drug injection to loss of pin-prick sensation at the T10 dermatome, was comparable in both groups. Mean onset time in Group L was 4.6±1 minutes versus 4.3±1.7 minutes in Group R (p=0.354). Two-thirds of patients in both groups attained the highest sensory level at T6, while the remaining one-third reached T8. Mean time to achieve the highest sensory level was also statistically similar (Group L: 7.4±2.1 min; Group R: 7.6±2.5 min; p=0.731).

In contrast, the total duration of sensory block was markedly and significantly prolonged in Group L (266.3±24.1 min) compared to Group R (170.6±19.7 min; p<0.001), indicating a substantially longer sensory effect with levobupivacaine.

Table 3: Sensory Block Parameters

Parameter	Group L (Mean ± SD)	Group R (Mean ± SD)	p-value
Time to sensory onset at T10 (min)	4.6 ± 1.0	4.3 ± 1.7	0.354 (NS)
Highest sensory level achieved	T6: 20 (57.2%); T8: 15 (42.8%)	T6: 20 (57.2%); T8: 15 (42.8%)	1.0 (NS)
Time to highest sensory level (min)	7.4 ± 2.1	7.6 ± 2.5	0.731 (NS)
Duration of sensory block (min)	266.3 ± 24.1	170.6 ± 19.7	<0.001 (HS)

NS = Not Significant; HS = Highly Significant

4.3 Motor Block Characteristics

The onset of motor block, defined as the time from intrathecal injection to achieving Modified Bromage grade 1, was significantly faster in Group L (2.4±0.7 min) compared to Group R (3.1±1.2 min; p=0.01). All patients in both groups ultimately achieved the maximum motor block level of Modified Bromage grade 3. The mean time to achieve maximum motor block (grade 3) was 10.1±2.5 minutes in Group L and 9.1±2.3 minutes in Group R (p=0.083), which was not statistically significant. The total duration of motor block was substantially longer in Group L (238.8±19.6 min) compared to Group R (151.4±14.3 min; p<0.001). This prolonged motor effect in Group L was also reflected in the significantly delayed time to unassisted mobilisation (Group L: 426.5±23.7 min vs. Group R: 381±36.8 min; p<0.001) and time to spontaneous micturition post-anaesthesia (Group L: 489±30.4 min vs. Group R: 426±28.4 min; p<0.001).

Table 4: Motor Block Parameters

Parameter	Group L (Mean ± SD)	Group R (Mean ± SD)	p-value
Time to Bromage grade 1 (min)	2.4 ± 0.7	3.1 ± 1.2	0.01 (S)
Highest motor block level	Grade 3 (100%)	Grade 3 (100%)	—
Time to maximum motor block (min)	10.1 ± 2.5	9.1 ± 2.3	0.083 (NS)
Duration of motor block (min)	238.8 ± 19.6	151.4 ± 14.3	<0.001 (HS)
Time to unassisted mobilisation (min)	426.5 ± 23.7	381.0 ± 36.8	<0.001 (HS)
Time to micturition (min)	489.0 ± 30.4	426.0 ± 28.4	<0.001 (HS)

S = Significant; NS = Not Significant; HS = Highly Significant

4.4 Duration of Analgesia and Quality of Anaesthesia

The mean duration of post-operative analgesia, measured from the time of spinal block to the first patient report of pain (VAS ≥3), was significantly longer in Group L (202.47±19.35 min) than in Group R (164.14±32.25 min; p<0.001). Regarding quality of anaesthesia, 94.3% of patients in Group L achieved a 'Good' quality rating (no supplemental analgesia required) compared to 80% in Group R. Seven patients (20%) in Group R required intravenous fentanyl intraoperatively compared to only 2 patients (5.7%) in Group L. The intergroup difference in quality of anaesthesia was, however, not statistically significant by chi-square test (p=0.151).

Table 5: Duration of Analgesia and Quality of Anaesthesia

Parameter	Group L (n=35)	Group R (n=35)	p-value
Mean duration of analgesia (min)	202.47 ± 19.35	164.14 ± 32.25	<0.001 (HS)
Good quality anaesthesia	33 (94.3%)	28 (80.0%)	0.151 (NS)
Fair quality (fentanyl needed)	2 (5.7%)	7 (20.0%)	0.151 (NS)
Inj. Fentanyl 75 mcg required	2 (5.7%)	5 (14.3%)	—
Inj. Fentanyl 100 mcg required	0 (0%)	2 (5.7%)	—

4.5 Hemodynamic Parameters

Pulse rate declined progressively following spinal anaesthesia in both groups. On intragroup comparison, the changes in mean pulse rate from baseline were statistically significant in both groups (p<0.001) at most time points. However, intergroup comparison revealed no statistically significant difference at any monitored time interval, and the reductions remained within 20% of baseline values for all patients, making them clinically non-significant. No patients required atropine for bradycardia.

Mean systolic blood pressure showed a progressive decline in both groups after spinal anaesthesia administration. Intragroup comparison indicated significant reduction from baseline in both groups. Intergroup differences were initially non-significant but became statistically significant from 30 minutes post-anaesthesia onwards (p=0.034 at 30 min; p<0.001 at 90 min), with Group L exhibiting a somewhat greater degree of blood pressure reduction. Clinically significant hypotension (systolic BP <80 mmHg or >20% decrease from baseline) occurred in 4 patients (11.4%) in Group L and 2 patients (5.7%) in Group R, all treated successfully with intravenous ephedrine 6 mg bolus.

Diastolic blood pressure trends were comparable, showing a gradual decline that became non-significant from 60 minutes

onwards. No statistically significant intergroup difference in diastolic blood pressure was noted at any time point.

Table 6: Summary of Hemodynamic Changes and Adverse Events

Parameter	Group L (n=35)	Group R (n=35)	p-value
Baseline pulse rate (bpm)	77.2 ± 9.7	75.6 ± 8.5	0.469
Baseline SBP (mmHg)	120.5 ± 11.4	120.5 ± 11.8	0.984
Baseline DBP (mmHg)	75.9 ± 6.9	76.1 ± 5.3	0.878
Hypotension requiring ephedrine	4 (11.4%)	2 (5.7%)	NS
Nausea/Vomiting	None	None	—
Bradycardia requiring atropine	None	None	—
Mean surgery duration (min)	101.1 ± 15.6	96.1 ± 13.1	0.153 (NS)

5. Discussion

The quest for an ideal local anaesthetic agent for spinal anaesthesia in elective surgeries has directed clinical attention towards levobupivacaine and ropivacaine as safer alternatives to racemic bupivacaine. This prospective study systematically compared these two agents in equivolume hyperbaric formulations administered intrathecally for inguinal hernia repair.

In this investigation, the demographic profiles of both groups were well-matched, ensuring that observed differences in anaesthetic characteristics were attributable to the pharmacological properties of the drugs rather than patient variables. All study participants were adult males, which is consistent with the predominantly male presentation of inguinal hernia.

The onset of sensory block at T10 was comparable between the two groups (Group L: 4.6±1 min; Group R: 4.3±1.7 min; p=0.354). This finding aligns with pharmacological expectations, as both drugs belong to the amino-amide class and share similar pKa values of 8.1, resulting in analogous ionisation fractions at physiological pH. These results are consistent with published literature, which generally reports comparable sensory onset times for levobupivacaine and ropivacaine in intrathecal use.

A critical distinction emerged in the duration of sensory block. Levobupivacaine produced significantly longer sensory analgesia (266.3±24.1 min) compared to ropivacaine (170.6±19.7 min; p<0.001). This difference is pharmacologically attributable to the greater lipid solubility and higher protein-binding affinity of levobupivacaine (97%) compared to ropivacaine (94%), which results in deeper neural penetration and a more sustained blockade. Similar findings have been reported in other comparative studies examining these agents for lower limb and lower abdominal surgery.

Motor block onset (time to Bromage grade 1) was significantly faster with levobupivacaine (2.4±0.7 min) than with ropivacaine (3.1±1.2 min; p=0.01). However, the time to achieve maximum motor blockade (Bromage grade 3) did not differ significantly between groups (p=0.083). The duration of motor block was markedly prolonged with levobupivacaine (238.8±19.6 min) compared to ropivacaine (151.4±14.3 min; p<0.001). Ropivacaine's lower lipid solubility relative to levobupivacaine is believed to contribute to its preferential sensory blockade over motor blockade, which is a clinically advantageous property for ambulatory settings.

The extended motor block with levobupivacaine was further reflected in delayed unassisted mobilisation (426.5 vs. 381.0 min; p<0.001) and later spontaneous micturition (489 vs. 426 min; p<0.001). These parameters are clinically important determinants of hospital stay and patient turnover, particularly in day-care surgical units. From this perspective, ropivacaine offers a clear practical advantage.

The mean duration of post-operative analgesia was significantly longer with levobupivacaine (202.47±19.35 min) than with ropivacaine (164.14±32.25 min; p<0.001). Additionally, a greater proportion of patients in Group L achieved good quality anaesthesia without supplemental intraoperative analgesia (94.3% vs. 80%), further reinforcing the superior analgesic potency of levobupivacaine in this setting.

Hemodynamic stability was maintained in both groups with no clinically critical adverse events. The comparable hemodynamic profiles observed in this study are consistent with the known pharmacological property of both agents-namely, their reduced cardiotoxic potential compared to bupivacaine. The slightly higher incidence of hypotension in Group L (11.4% vs. 5.7%) may be related to the more pronounced and prolonged sympathetic blockade associated with levobupivacaine, though this difference was not statistically significant and all cases were managed promptly with ephedrine.

The surgical duration was comparable in both groups (Group L: 101.1±15.6 min; Group R: 96.1±13.1 min; p=0.153), confirming that both drugs provided adequate anaesthesia for the entire duration of inguinal hernia repair. No cases of post-dural puncture headache, nausea, vomiting, neurological symptoms, or other significant complications were recorded in the postoperative period.

6. Conclusion

This prospective observational study demonstrates that both hyperbaric levobupivacaine (0.5%) and hyperbaric ropivacaine (0.75%) are clinically effective and hemodynamically well-tolerated agents for spinal anaesthesia in adult patients undergoing inguinal hernia repair. The key differentiating factor lies in the duration of their pharmacological effects. Levobupivacaine provides a longer duration of sensory analgesia, motor blockade, and post-operative pain relief, making it better suited for surgeries of extended duration or where prolonged analgesia is desirable. Conversely, hyperbaric ropivacaine, by virtue of its shorter and more predictable block duration, earlier motor recovery, and faster mobilisation, represents the superior choice for ambulatory and day-care surgical settings. Clinicians should individualise the selection of intrathecal local anaesthetic based on anticipated surgical

duration, care setting, and patient-specific clinical factors.

7. Limitations

The study was limited by its relatively small sample size (n=35 per group), which may restrict the generalisability of findings to larger and more heterogeneous populations. The study population was restricted to inguinal hernia surgery in adult male patients; therefore, the conclusions may not be directly extrapolated to other surgical procedures, female patients, or different patient age groups. Additionally, only single doses of each agent (3.5 mL) were evaluated, precluding any dose-response analysis. Post-discharge follow-up was not undertaken, and thus long-term outcomes were not assessed. Larger multicentre randomised controlled trials are recommended to validate these observations.

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