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Original Research Article

COMPARISON OF ROPIVACAINE 0.75% AND BUPIVACAINE 0.5% FOR EPIDURAL ANESTHESIA IN PATIENTS UNDERGOING ELECTIVE LOWER ABDOMINAL SURGERIES

Nancy Singh[1], Ratan Pal Singh[2], Shruti Shukla[1]

[1]*Junior Resident, Department of Anesthesia, Rajshree Medical and Research Institute, Uttar Pradesh, India*
[2]*Professor, Department of Anesthesia, Rajshree Medical and Research Institute, Uttar Pradesh, India*

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Corresponding Author:
Dr. Nancy Singh
Junior Resident, Department of Anesthesia, Rajshree Medical and Research Institute, Uttar Pradesh, India
Email: naancysingh@gmail.com

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ABSTRACT

Background: Epidural anesthesia is a cornerstone technique for lower abdominal surgeries. While 0.5% bupivacaine has long been considered the gold standard, its cardiotoxicity profile has prompted the search for safer alternatives. Ropivacaine, a pure S(-)-enantiomer, offers potentially reduced toxicity with comparable efficacy. This study compares the clinical profiles of these two agents focusing on three key variables: sensory block characteristics, motor block characteristics, and hemodynamic parameters.

Materials and Methods: A randomized, double-blind controlled trial was conducted on 60 ASA I/II patients undergoing elective lower abdominal surgeries. Patients were randomly allocated to receive either 20 mL of 0.75% ropivacaine (Group R, n=30) or 20 mL of 0.5% bupivacaine (Group B, n=30) via epidural catheter. The three primary outcome variables assessed were: (1) sensory block characteristics (onset time, maximum level achieved, duration), (2) motor block characteristics (onset time, Bromage grade, duration), and (3) hemodynamic parameters (pulse rate, systolic/diastolic/mean arterial pressure, SpO_2) measured at predetermined intervals.

Results: Both groups were demographically comparable. No statistically significant differences were observed in sensory block onset (Group R: 11.89 ± 0.74 min vs. Group B: 10.50 ± 0.92 min; p=0.267), maximum sensory level achieved (T4-T6 in both groups; p=0.439), or sensory block recovery time. Motor block onset was similar between groups (Group R: 16.58 ± 0.90 min vs. Group B: 15.68 ± 0.74 min; p=0.125), with comparable Bromage grade distribution and motor recovery duration. Hemodynamic parameters remained stable throughout the procedure in both groups, with no clinically significant differences in pulse rate, blood pressure, or oxygen saturation at any measured time point (p>0.05 for all comparisons).

Conclusion: Epidural 0.75% ropivacaine provides sensory and motor block characteristics equivalent to 0.5% bupivacaine with comparable hemodynamic stability. Ropivacaine offers the additional advantage of a theoretically safer cardiotoxicity profile, making it a clinically effective and safe alternative for epidural anesthesia in lower abdominal surgeries.

Keywords: Epidural anesthesia, Ropivacaine, Bupivacaine, Sensory block, Motor block, Hemodynamic stability.

INTRODUCTION

Epidural anesthesia is one of the most versatile and widely used regional anesthesia techniques in modern surgical practice, particularly for lower abdominal, pelvic, and lower limb surgeries.[1] The technique involves administration of local anesthetic into the epidural space, producing segmental blockade of sensory and motor nerves while allowing for titration of anesthetic level and duration.[1]

Compared to spinal anesthesia, epidural anesthesia offers better cardiovascular stability and the capacity for continuous postoperative analgesia through an indwelling catheter.[2,3] Local anesthetics function by reversibly blocking nerve conduction through inhibition of sodium ion influx in neuronal membranes. Among amide-type local anesthetics, bupivacaine has been considered the gold standard due to its long duration of action, profound sensory block, and suitability for both intraoperative anesthesia and postoperative analgesia.[4] However, bupivacaine has been associated with significant cardiotoxicity, including arrhythmias and cardiac depression, particularly when administered in high concentrations or inadvertently injected intravascularly.[5] Ropivacaine was developed specifically to overcome the limitations associated with bupivacaine toxicity.[6] As the pure S(-)-enantiomer of propivacaine, it exhibits significantly lower potential for cardiotoxicity and central nervous system adverse effects. Pharmacologically, ropivacaine demonstrates a clinical profile similar to bupivacaine with comparable onset and duration of sensory anesthesia, but with reduced propensity for motor blockade, potentially allowing earlier postoperative mobilization.[7]

Rationale for Variable Selection

This study focuses on three critical variables that determine the clinical utility of epidural anesthesia:

1. Sensory Block Characteristics: The primary goal of epidural anesthesia is to provide adequate surgical anesthesia. Onset time, maximum dermatomal level achieved, and duration of sensory blockade are essential parameters for determining whether a drug can provide sufficient anesthesia for the intended surgical procedure.
2. Motor Block Characteristics: The degree of motor blockade affects patient comfort, ability to mobilize postoperatively, and risk of complications such as deep vein thrombosis. The modified Bromage scale provides a standardized method for assessing motor block intensity and duration.
3. Hemodynamic Parameters: Cardiovascular stability is paramount during anesthesia. Monitoring pulse rate, blood pressure (systolic, diastolic, mean arterial pressure), and oxygen saturation provides insight into the safety profile of each drug and the body's physiological response to sympathetic blockade.

Aim and Objectives

Aim: To evaluate and compare the efficacy of 20 mL epidural 0.5% bupivacaine and 20 mL epidural 0.75% ropivacaine in patients undergoing elective lower abdominal surgeries, focusing on three key variables.

Objectives

- To determine and compare sensory block characteristics (onset time, maximum level achieved, duration)
- To determine and compare motor block characteristics (onset time, Bromage grade, duration)
- To monitor and compare hemodynamic parameters (pulse rate, blood pressure, SpO_2) during the procedure.

MATERIALS AND METHODS

Study Design and Setting

This randomized, double-blind controlled trial was conducted in the Department of Anesthesia and Critical Care, Rajshree Medical Research Institute, Bareilly, over a period of one year. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Study Population

A total of 60 patients aged 18-60 years, scheduled for elective lower abdominal surgeries under epidural anesthesia, were enrolled in the study.

Inclusion Criteria

- Age 18-60 years
- Both male and female patients
- Scheduled for elective lower abdominal surgeries
- ASA physical status I and II

Exclusion Criteria:

- ASA class III, IV, or V
- Emergency surgeries
- Pregnant women
- Raised intracranial pressure, severe hypovolemia, bleeding/coagulation disorders
- Local infection at injection site
- Refusal to consent

Preoperative Preparation

All patients underwent thorough pre-anesthetic evaluation including medical history, physical examination, and necessary laboratory investigations. On the night prior to surgery, patients received 0.5 mg alprazolam and 150 mg ranitidine orally. Upon arrival in the operating room, baseline hemodynamic parameters were recorded. An 18G intravenous cannula was inserted, and patients were preloaded with 500 mL Ringer's lactate solution over 30 minutes. Intravenous midazolam 1 mg was administered for mild sedation.

Epidural Technique

The L3-L4 or L2-L3 intervertebral space was identified using the midline approach. After confirming entry into the epidural space using loss of resistance to saline, an epidural catheter was advanced 4-5 cm and secured. A test dose of 3 mL lignocaine with adrenaline (1:200,000) was injected to exclude intrathecal or intravascular placement. After 3 minutes of observation, the study drug was slowly injected over 2 minutes.

Assessment of Study Variables

Sensory Block Characteristics

Onset of Sensory Block (OSB): Assessed using the pinprick method with a 27G hypodermic needle at 2-minute intervals until loss of sensation at the T10

dermatome. Time from completion of drug injection to loss of pinprick sensation at T10 was recorded as OSB.

Maximum Sensory Level: The highest dermatomal level of sensory blockade achieved was determined by testing in ascending order and recorded as the peak sensory level.

Recovery of Sensory Block (RSB): Time from drug injection to regression of sensory block by two dermatomes from the maximum level.

Motor Block Characteristics

Motor blockade was evaluated using the Modified Bromage Scale:

Grade Criteria Degree of Block

- 1 Unable to move feet Complete (100%)
- 2 Unable to flex knees, but with free movement of feet Almost complete (66%)
- 3 Just able to flex knee with free movement of feet Partial (33%)
- 4 Free movements of legs and feet Nil (0%)

Onset of Motor Block (OMB): Time from epidural injection until Bromage grade changed from 4 to 3 (onset of any motor weakness).

Maximum Motor Block Grade: The highest Bromage grade achieved.

Recovery of Motor Block (RMB): Time from drug injection to complete recovery of motor power (Bromage grade returning to 4).

Hemodynamic Parameters

The following parameters were recorded at baseline (pre-block), immediately after block (0 minutes), and at 2, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, and 120 minutes:

- • Pulse Rate (PR) – beats per minute
- • Systolic Blood Pressure (SBP) – mmHg
- • Diastolic Blood Pressure (DBP) – mmHg
- • Mean Arterial Pressure (MAP) – mmHg (calculated)
- • Peripheral Oxygen Saturation (SpO_2) – percentage

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Quantitative variables (OSB, OMB, RSB, RMB, hemodynamic parameters) were expressed as mean ± standard deviation and compared using Student's t-test. Qualitative variables (maximum sensory level, Bromage grade) were expressed as frequencies and percentages and analyzed using Chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

Both groups were comparable in terms of age and gender distribution (p>0.05). In Group R, 40% were female and 60% male, while Group B had 60% female and 40% male. Mean age was 35.03 ± 12.04 years in Group R and 39.53 ± 11.41 years in Group B (p=0.412).

Sensory Block Characteristics

Table 1: Onset and Recovery of Sensory Block

Parameter	Group R (Ropivacaine) Mean ± SD	Group B (Bupivacaine) Mean ± SD	p value
Onset of Sensory Block (min)	11.89 ± 0.74	10.50 ± 0.92	0.267
Recovery of Sensory Block (hours)	4.48 ± 0.175	4.54 ± 0.172	0.838

Table 2: Maximum Sensory Level Achieved

Sensory Level	Group R (n = 30)	Group B (n = 30)	p value
T4	13 (43.3%)	18 (60%)	0.439
T6	17 (56.7%)	12 (40%)	—

Onset of sensory block was slightly faster in Group B (10.50 ± 0.92 min) compared to Group R (11.89 ± 0.74 min), but this difference was not statistically significant

Both groups achieved comparable maximum sensory levels (T4-T6)

Recovery time for sensory block was nearly identical between groups

Motor Block Characteristics

Table 3: Onset and Recovery of Motor Block

Parameter	Group R (Ropivacaine) Mean ± SD	Group B (Bupivacaine) Mean ± SD	p value
Onset of Motor Block (min)	16.58 ± 0.90	15.68 ± 0.74	0.125
Recovery of Motor Block (hours)	4.76 ± 0.144	4.79 ± 0.156	0.691

Table 4: Maximum Motor Block Grade (Bromage Scale)

Bromage Grade	Group R (n = 30)	Group B (n = 30)	p value
Grade 2	5 (16.7%)	13 (43.3%)	0.077
Grade 3	11 (36.7%)	8 (26.7%)	—
Grade 4	14 (46.7%)	9 (30.0%)	—

- Onset of motor block was similar between groups (p=0.125)
- A trend toward higher Bromage grades was observed in Group B, though this did not reach statistical significance (p=0.077)
- Motor block recovery times were comparable between groups

Hemodynamic Parameters

Pulse Rate

Table 5: Intraoperative Pulse Rate

Time Point	Group R (beats/min) Mean ± SD	Group B (beats/min) Mean ± SD	p value
Pre-block	78.33 ± 5.19	77.90 ± 5.24	0.939
5 min	76.30 ± 4.39	77.40 ± 5.36	0.090
15 min	77.43 ± 3.61	76.20 ± 3.71	0.952
30 min	78.26 ± 5.00	75.86 ± 3.87	0.567
60 min	79.00 ± 4.30	77.73 ± 4.71	0.686
90 min	75.80 ± 4.55	77.46 ± 4.53	0.847
120 min	78.50 ± 4.34	78.73 ± 4.91	0.137

Key Finding: Both groups maintained stable pulse rates throughout the procedure with no statistically significant differences at any time point.

Systolic Blood Pressure

Table 6: Intraoperative Systolic Blood Pressure

Time Point	Group R (mmHg) Mean ± SD	Group B (mmHg) Mean ± SD	p value
Pre-block	119.66 ± 5.45	120.66 ± 5.95	0.585
5 min	118.26 ± 5.69	118.76 ± 7.03	0.107
20 min	118.16 ± 5.43	112.53 ± 6.03	0.078
40 min	120.33 ± 6.04	120.96 ± 6.16	0.835
60 min	120.26 ± 5.74	119.24 ± 5.95	0.460
90 min	119.60 ± 6.16	117.73 ± 4.60	0.040*
120 min	119.56 ± 5.98	120.06 ± 6.26	0.560

*Statistically significant but clinically insignificant difference (1.87 mmHg)

Key Findings:

A transient, non-significant reduction in SBP was noted in Group B at 20 minutes

A statistically significant but clinically minor difference was observed at 90 minutes

Overall, both groups maintained stable SBP throughout the procedure

Diastolic Blood Pressure

Table 7: Intraoperative Diastolic Blood Pressure

Time Point	Group R (mmHg) Mean ± SD	Group B (mmHg) Mean ± SD	p value
Pre-block	77.13 ± 6.68	75.76 ± 6.52	0.859
5 min	73.80 ± 6.76	74.20 ± 6.10	0.205
20 min	76.36 ± 6.65	70.36 ± 6.82	0.089
40 min	74.00 ± 6.17	76.66 ± 6.20	0.489
90 min	76.50 ± 5.00	76.13 ± 7.15	0.002*
120 min	76.73 ± 6.32	75.26 ± 6.31	0.986

*Statistically significant but clinically insignificant difference (0.37 mmHg)

DBP remained stable and comparable between groups throughout the observation period.

Mean Arterial Pressure

Table 8: Intraoperative Mean Arterial Blood Pressure

Time Point	Group R (mmHg) Mean ± SD	Group B (mmHg) Mean ± SD	p value
Pre-block	91.31 ± 4.85	90.73 ± 4.53	0.715
5 min	88.62 ± 4.91	89.05 ± 4.99	0.823
20 min	90.30 ± 4.82	84.42 ± 3.91	0.052
40 min	89.44 ± 4.62	91.43 ± 4.38	0.803
60 min	89.26 ± 4.92	89.33 ± 4.32	0.519
90 min	90.86 ± 4.36	90.00 ± 5.45	0.102
120 min	91.01 ± 5.05	90.20 ± 4.94	0.955

MAP remained stable and comparable between groups, with no clinically significant differences at any time point.

Oxygen Saturation

Table 9: Intraoperative SpO_2 Values

Time Point	Group R (%) Mean ± SD	Group B (%) Mean ± SD	p value
Pre-block	99.04 ± 0.63	99.06 ± 0.59	0.734
5 min	99.06 ± 0.63	98.96 ± 0.56	0.332
20 min	98.92 ± 0.61	98.96 ± 0.66	0.628
40 min	98.90 ± 0.68	99.05 ± 0.62	0.574
60 min	98.89 ± 0.60	99.04 ± 0.59	0.618
90 min	98.91 ± 0.55	99.10 ± 0.58	0.908
120 min	99.00 ± 0.53	98.86 ± 0.58	0.227

Oxygen saturation remained >98% in both groups throughout the procedure, with no significant differences between groups.

DISCUSSION

Sensory Block Characteristics: The present study demonstrates that 0.75% ropivacaine and 0.5% bupivacaine produce comparable sensory block characteristics when administered epidurally for lower abdominal surgeries. The onset of sensory block was marginally faster in the bupivacaine group (10.50 ± 0.92 min vs. 11.89 ± 0.74 min), though this difference was not statistically significant (p=0.267). This finding aligns with the work of Wood and Rubin,[8] who reported comparable onset times for epidural ropivacaine and bupivacaine in gynecological surgeries, and McGlade et al,[9] who found similar results in orthopedic procedures.

The maximum sensory level achieved (T4-T6 in both groups) was comparable (p=0.439), consistent with findings from Christelis et al,[10] and Korula et al,[11] who reported similar sensory block heights with both agents. Recovery of sensory block was nearly identical between groups (4.48 ± 0.175 hrs vs. 4.54 ± 0.172 hrs; p=0.838), corroborating the work of Ommid et al,[12] and Geetha et al.[13]

Motor Block Characteristics: Motor block onset was similar between groups (16.58 ± 0.90 min vs. 15.68 ± 0.74 min; p=0.125), consistent with findings from Sridevi and Madhupriya,[14] and Deepak R.[15] However, a trend toward higher Bromage grades was observed in the bupivacaine group, with 43.3% of patients achieving Bromage grade 2 compared to 16.7% in the ropivacaine group, though this did not reach statistical significance (p=0.077).

This trend toward more intense motor blockade with bupivacaine has been well documented in the literature. Crosby et al,[16] and Penmetsa et al,[17] reported that bupivacaine tends to produce denser motor block compared to ropivacaine. Similarly, Sampath Kumar Reddy et al,[18] and Kumar et al,[19] observed that while sensory profiles were similar, bupivacaine was associated with more pronounced motor blockade. The slightly lower intensity of motor block with ropivacaine is attributed to its lower lipid solubility and preferential action on sensory fibers.[6]

Motor recovery times were comparable between groups (4.76 ± 0.144 hrs vs. 4.79 ± 0.156 hrs; p=0.691), suggesting that both drugs allow similar timing for return of motor function postoperatively.

Hemodynamic Parameters: The hemodynamic stability observed in both groups is a key finding of this study. Pulse rate remained stable throughout the procedure with no significant inter-group differences at any time point. This aligns with the work of Christelis et al,[10] who observed minimal heart rate alterations with both agents, and Kuthiala and Chaudhary,[6] who highlighted ropivacaine's favorable cardiovascular stability profile.

Blood pressure parameters (SBP, DBP, MAP) remained largely stable and comparable between groups. A transient, non-significant reduction in blood pressure was noted in the bupivacaine group at 20 minutes, consistent with the known pharmacologic effects of bupivacaine on sympathetic blockade.[5] However, this did not progress to clinically significant hypotension and normalized in subsequent readings.

A statistically significant difference in SBP was observed at 90 minutes (119.60 ± 6.16 mmHg vs. 117.73 ± 4.60 mmHg; p=0.040), but the magnitude of difference (1.87 mmHg) was clinically insignificant. Similarly, a statistically significant difference in DBP at 90 minutes (p=0.002) represented a clinically meaningless difference of 0.37 mmHg.

These findings are consistent with those of Kampe et al,[20] who demonstrated similar blood pressure profiles between epidural ropivacaine and bupivacaine in parturients, and Dharmendra Harjani et al,[21] who reported comparable hemodynamic parameters despite slightly lower blood pressure readings in bupivacaine-based regimens.

Oxygen saturation remained >98% in both groups throughout the procedure, with no significant differences. This confirms the respiratory safety of both agents and aligns with findings from Sridevi and Madhupriya,[14] and Kampe et al,[20] who reported preserved oxygenation with epidural anesthesia using either drug.

Clinical Implications: The comparable sensory and motor block profiles between ropivacaine and bupivacaine suggest that both agents can provide adequate surgical anesthesia for lower abdominal procedures. The trend toward less intense motor blockade with ropivacaine, while not statistically significant in this study, may offer clinical advantages in enhanced recovery protocols where early mobilization is desired.[7]

The excellent hemodynamic stability observed with both agents confirms their safety in ASA I-II patients. However, ropivacaine's well-documented lower cardiotoxicity profile,[6] provides an additional safety margin, particularly relevant in patients with cardiovascular comorbidities or when larger doses are required.

Limitations

- Single-center study limits generalizability of findings
- Sample size of 60 patients may not detect small but clinically relevant differences
- Homogeneous population (ASA I-II only) limits applicability to higher-risk patients
- Fixed drug concentrations and volumes limit extrapolation to other dosing regimens
- Short follow-up period (24 hours) does not capture long-term outcomes
- No pharmacokinetic data on plasma drug levels to correlate with observed effects.

CONCLUSION

This randomized controlled trial comparing 0.75% ropivacaine and 0.5% bupivacaine for epidural anesthesia in lower abdominal surgeries focused on three key variables: sensory block characteristics,

motor block characteristics, and hemodynamic parameters.

The study demonstrates that:

- **Sensory Block Characteristics:** Both agents provide comparable onset (p=0.267), maximum level (p=0.439), and duration (p=0.838) of sensory blockade, confirming that ropivacaine is equally effective in establishing surgical anesthesia.
- **Motor Block Characteristics:** Onset (p=0.125) and recovery (p=0.691) of motor block are similar between groups. A trend toward more intense motor blockade with bupivacaine was observed but did not reach statistical significance.
- **Hemodynamic Parameters:** Both drugs maintain excellent cardiovascular and respiratory stability throughout the procedure, with no clinically significant differences in pulse rate, blood pressure, or oxygen saturation at any measured time point.

In conclusion, epidural 0.75% ropivacaine provides sensory and motor block characteristics equivalent to 0.5% bupivacaine with comparable hemodynamic stability. Ropivacaine offers the additional advantage of a theoretically safer cardiotoxicity profile due to its pure S(-)-enantiomer structure. These findings support ropivacaine as a clinically effective and safe alternative to bupivacaine for epidural anesthesia in lower abdominal surgeries, allowing anesthesiologists to choose between agents based on individual patient factors and safety considerations.

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