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Evaluation of Equipotent Dose of Ropivacaine Heavy 0.75% V/S Bupivacaine 0.5% For Subarachnoid Block in Lower Limb and Lower Abdominal Surgeries

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ABSTRACT

Background: Spinal anesthesia is widely used for lower limb and lower abdominal surgeries due to its rapid onset, reliable sensory and motor blockade, and minimal systemic drug exposure. Bupivacaine 0.5% heavy is commonly used for subarachnoid block; however, it is associated with prolonged motor blockade and potential cardiovascular toxicity. Ropivacaine, a newer long-acting amide local anesthetic, has been suggested as a safer alternative with less motor blockade and improved hemodynamic stability. This study was conducted to compare the characteristics of spinal anesthesia produced by equipotent doses of ropivacaine heavy 0.75% and bupivacaine heavy 0.5%.

Aim: To compare the characteristics of central neuraxial blockade produced by ropivacaine heavy 0.75% and bupivacaine heavy 0.5% for subarachnoid block in lower limb and lower abdominal surgeries.

Materials and Methods: A prospective, randomized, double-blinded comparative study was conducted on 60 patients belonging to ASA grade I and II, aged 18–75 years, undergoing lower limb and lower abdominal surgeries. Patients were randomly divided into two groups: Group I (n=30) received intrathecal ropivacaine heavy 0.75%, and Group II (n=30) received intrathecal bupivacaine heavy 0.5%. Parameters assessed included onset and duration of sensory and motor block, maximum sensory level achieved, time for two-segment regression, hemodynamic changes, and adverse effects.

Results: Both groups had comparable demographic characteristics and similar onset of sensory block. However, the duration of sensory block, time for two-segment regression, and duration of motor blockade were significantly longer in the bupivacaine group ($p < 0.001$). Hemodynamic parameters and oxygen saturation remained stable and comparable in both groups.

Conclusion: Intrathecal ropivacaine heavy 0.75% provides effective spinal anesthesia with shorter motor blockade and comparable hemodynamic stability compared with bupivacaine heavy 0.5%, making it a useful alternative for lower limb and lower abdominal surgeries.

Keywords: *Spinal anesthesia; Ropivacaine; Bupivacaine; Subarachnoid block; Sensory blockade; Motor blockade.*

INTRODUCTION

Spinal anesthesia, also known as subarachnoid block (SAB), is one of the most commonly used regional anesthesia techniques for lower limb and lower abdominal surgeries because of its rapid onset, reliable sensory and motor blockade, and minimal systemic drug exposure. It is widely preferred for procedures such as orthopedic surgeries of the lower extremities, urological interventions, and lower abdominal operations including hernia repair and gynecological

procedures. The technique involves the injection of a local anesthetic agent into the cerebrospinal fluid in the subarachnoid space, leading to reversible blockade of nerve conduction in spinal nerves. Compared with general anesthesia, spinal anesthesia offers several advantages including better intraoperative analgesia, reduced blood loss, decreased incidence of thromboembolic complications, lower postoperative nausea and vomiting, and early postoperative recovery. However, the choice of local anesthetic plays a crucial role in determining the quality, duration, and safety profile of the block. Therefore, identifying an appropriate drug with optimal anesthetic characteristics and minimal side effects is essential for successful spinal anesthesia. [1]

Bupivacaine has long been considered the gold standard local anesthetic for spinal anesthesia because of its potent sensory and motor blocking properties and relatively long duration of action. Hyperbaric bupivacaine 0.5% is widely used in clinical practice for subarachnoid block in lower abdominal and lower limb surgeries. Its high lipid solubility and protein binding contribute to prolonged anesthetic effect, making it suitable for moderately long surgical procedures. Despite its effectiveness, bupivacaine is associated with certain disadvantages such as significant motor blockade, prolonged recovery time, and potential cardiotoxicity and neurotoxicity, particularly when systemic absorption occurs in high concentrations. Hypotension and bradycardia are also frequently observed due to sympathetic blockade following spinal administration. These limitations have encouraged the exploration of safer alternatives with comparable anesthetic efficacy. [2,3]

Ropivacaine is a relatively newer long-acting amide local anesthetic that has gained increasing attention as a potential alternative to bupivacaine. Chemically, ropivacaine is the pure S-enantiomer of propivacaine and possesses lower lipid solubility compared with bupivacaine. This property results in a differential blockade with a greater degree of sensory block relative to motor block, which can facilitate early postoperative mobilization and recovery. Additionally, ropivacaine demonstrates significantly less cardiotoxicity and central nervous system toxicity than bupivacaine, making it a safer option for regional anesthesia. Because of these advantages, ropivacaine has been widely studied for epidural anesthesia, peripheral nerve blocks, and more recently for intrathecal administration. [4,5]

When used for spinal anesthesia, the baricity and concentration of the local anesthetic influence the spread of the drug within the cerebrospinal fluid and determine the extent of sensory and motor blockade. Hyperbaric solutions, often referred to as “heavy” preparations, contain added dextrose to increase their density relative to cerebrospinal fluid, allowing more predictable distribution under the influence of gravity. Hyperbaric ropivacaine 0.75% has been investigated as an alternative to hyperbaric bupivacaine 0.5% for subarachnoid block, with the aim of achieving comparable anesthetic effectiveness while minimizing adverse effects. Previous studies have suggested that ropivacaine may produce adequate sensory blockade with a shorter duration of motor block and improved hemodynamic stability compared with bupivacaine. These characteristics may be particularly advantageous in ambulatory or short-duration surgical procedures. [6,7]

Another important consideration in spinal anesthesia is the concept of equipotent dosing. Equipotent doses refer to the quantities of different drugs that produce equivalent clinical effects. Determining equipotent doses of ropivacaine and bupivacaine is essential to ensure fair comparison of their anesthetic efficacy and safety profiles. Several clinical investigations have attempted to identify the dose relationship between these two agents for intrathecal administration, but results have varied depending on study design, patient population, and surgical procedures. Therefore, further evaluation is necessary to clarify their relative potency and clinical performance. [8,9]

Given the increasing interest in safer local anesthetic alternatives and the need for optimal spinal anesthesia in lower limb and lower abdominal surgeries, comparative evaluation of hyperbaric ropivacaine 0.75% and hyperbaric bupivacaine 0.5% is clinically relevant. Assessing parameters such as onset of sensory and motor block, duration of anesthesia, hemodynamic stability, and incidence of adverse effects can help determine whether ropivacaine can serve as an effective substitute for bupivacaine in subarachnoid block. Hence, the present study aims to evaluate the anesthetic efficacy and safety of equipotent doses of ropivacaine heavy 0.75% versus bupivacaine 0.5% for spinal anesthesia in patients undergoing lower limb and lower abdominal surgeries. [10]

The present study aims to compare the characteristics of central neuraxial blockade produced by Inj. Ropivacaine Heavy 0.75% and Inj. Bupivacaine Heavy 0.5% when used for subarachnoid block in patients undergoing lower limb and lower abdominal surgeries. The primary objective is to evaluate and compare the level of sensory blockade achieved, the duration of the blockade, and the time required for complete regression of motor blockade between the two anesthetic agents. In addition, the study also seeks to assess secondary outcomes including the hemodynamic changes associated with each drug and the incidence of any adverse effects or side effects observed during the perioperative period. Through this comparison, the study intends to determine the relative efficacy and safety profile of these two commonly used intrathecal local anesthetics.

MATERIALS AND METHODS

Study Design: Prospective, randomized, double-blinded comparative study.

Ethical Considerations

- Institutional Ethics Committee approval obtained.

- Written informed consent taken from all patients.
- Patient confidentiality maintained and standard patient care not affected.

Study Population: Patients undergoing lower limb and lower abdominal surgeries under spinal anaesthesia.
Inclusion Criteria

- ASA Grade I and II patients.
- Age 18–75 years.
- Both sexes.
- Patients undergoing hernias, urological surgeries, LSCS and other lower abdominal or lower limb procedures.

Exclusion Criteria

- Refusal to participate.
- ASA Grade III and IV.
- Age <18 or >75 years.
- Sepsis, hypovolemia, coagulopathy or infection at puncture site.
- Allergy to local anesthetics.

Sample Size: Total 60 patients included in the study.

Study Groups

- **Group I (n = 30):** Inj. Ropivacaine Heavy 0.75%.
- **Group II (n = 30):** Inj. Bupivacaine Heavy 0.5%.

Place of Study: Operation theatres of T.N.M.C. and B.Y.L. Nair Hospital, Mumbai.

Duration of Study: One year.

Parameters Assessed

- Level of sensory blockade.
- Duration of blockade.
- Time for complete regression of motor blockade.
- Hemodynamic changes (heart rate, blood pressure).
- Adverse effects and complications.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software version 27.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The unpaired t-test was used to compare continuous variables between independent groups, and the paired t-test was applied for within-group comparisons. Categorical variables were analyzed using the Chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant.

RESULT

Table 1: Comparison of Demographic Variables Between the Two Groups

Parameter	Group	N	Mean	SD	P value	Significance
Age (years)	Group 1 (Ropivacaine)	30	39.7	15.4	0.854	Not significant
	Group 2 (Bupivacaine)	30	39	12.4		
Height (cm)	Group 1 (Ropivacaine)	30	162.5	8.8	0.57	Not significant
	Group 2 (Bupivacaine)	30	163.8	8.4		
Weight (kg)	Group 1 (Ropivacaine)	30	59.3	8.6	0.01	Significant
	Group 2 (Bupivacaine)	30	65.6	9.5		

Table 2: Comparison of ASA Grading

ASA Grade	Group 1 (n=30)	Group 2 (n=30)	P value	Significance
Grade I	16 (53.3%)	13 (43.3%)	0.438	Not significant
Grade II	14 (46.7%)	17 (56.7%)		

Table 3: Comparison of Onset of Sensory and Motor Block

Parameter	Group	N	Mean (min)	SD	P value	Significance
Onset of Sensory Block	Group 1	30	1.8	0.9	0.28	Not significant
	Group 2	30	1.6	0.6		

Onset of Motor Block	Group 1	30	3.4	0.9	<0.001	Significant
	Group 2	30	4.3	0.8		

Table 4: Comparison of Maximum Height of Sensory Block

Sensory Level	Group 1 (n=30)	Group 2 (n=30)	P value	Significance
T6	6 (20.0%)	7 (23.3%)	0.612	Not significant
T8	5 (16.7%)	9 (30.0%)		
T10	14 (46.7%)	9 (30.0%)		
T12	5 (16.7%)	5 (16.7%)		

Table 5: Comparison of Sensory Block Characteristics

Parameter	Group	N	Mean (min)	SD	P value	Significance
Two Segment Regression	Group 1	30	48.8	12	<0.001	Significant
	Group 2	30	74.5	10.2		
Duration of Sensory Block	Group 1	30	143.8	17.2	<0.001	Significant
	Group 2	30	172.5	12.5		

Table 6: Comparison of Duration of Motor Block

Parameter	Group	N	Mean (min)	SD	P value	Significance
Two Segment Regression	Group 1	30	48.8	12	<0.001	Significant
	Group 2	30	74.5	10.2		
Duration of Sensory Block	Group 1	30	143.8	17.2	<0.001	Significant
	Group 2	30	172.5	12.5		

Table 7: Comparison of Hemodynamic Parameters and SpO_2

Parameter	Group	N	Mean (min)	SD	P value	Significance
Duration of Motor Block	Group 1	30	107.5	20.3	<0.001	Significant
	Group 2	30	146.2	13.3		

Figure: 1. Comparison of Maximum Height of Sensory Block

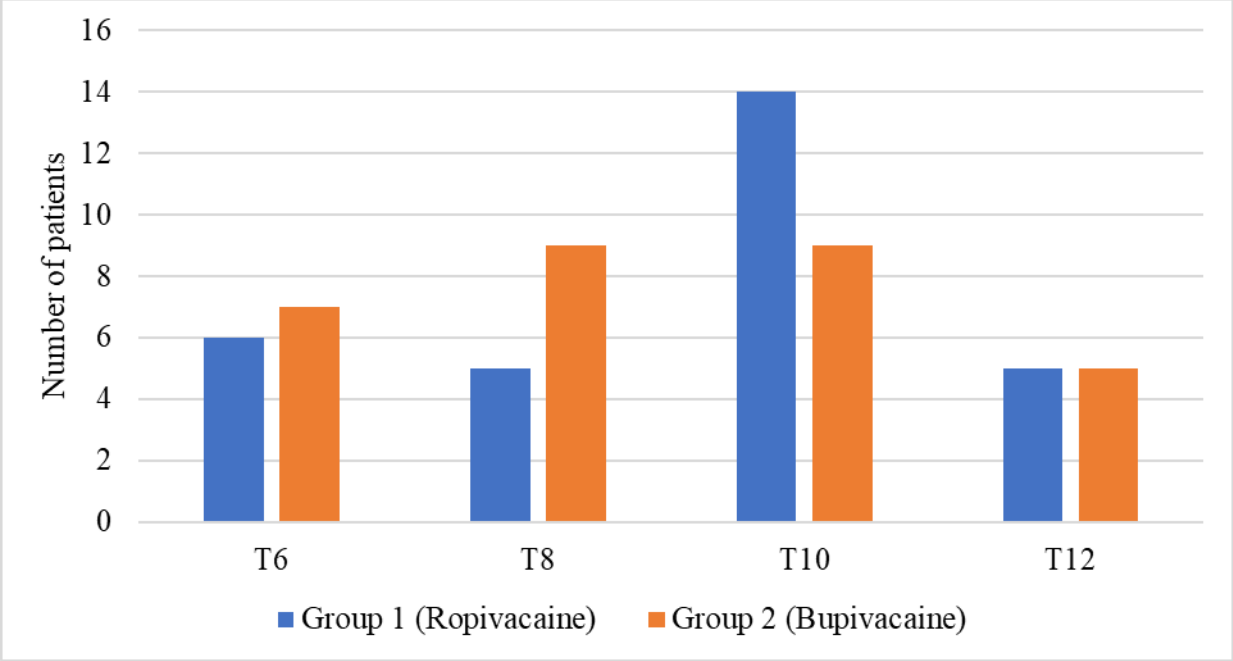

Table 1: Comparison of Demographic Variables

The mean age of patients in Group 1 (Ropivacaine) was 39.7 ± 15.4 years, while in Group 2 (Bupivacaine) it was 39.0 ± 12.4 years. The difference in age distribution between the two groups was statistically not significant (p = 0.854). The mean height of patients in Group 1 was 162.5 ± 8.8 cm, whereas in Group 2 it was 163.8 ± 8.4 cm, and the difference was not statistically significant (p = 0.570). The mean weight of patients in Group 1 was 59.3 ± 8.6 kg, while in Group 2 it was 65.6 ± 9.5 kg. The difference in weight between the two groups was statistically significant (p = 0.010); however, this difference was clinically insignificant and did not influence the surgical duration or anesthetic outcomes. Overall, the demographic characteristics of the patients in both groups were comparable.

Table 2: Comparison of ASA Grading
In Group 1, 16 patients (53.3%) belonged to ASA Grade I and 14 patients (46.7%) belonged to ASA Grade II. In Group 2, 13 patients (43.3%) were classified as ASA Grade I, while 17 patients (56.7%) were classified as ASA Grade II. The distribution of ASA grading between the two groups was comparable and statistically not significant ($p = 0.438$), indicating that the baseline physical status of patients in both groups was similar.

Table 3: Comparison of Onset of Sensory and Motor Block
The mean time of onset of sensory blockade in Group 1 was 1.8 ± 0.9 minutes, whereas in Group 2 it was 1.6 ± 0.6 minutes. The difference between the two groups was not statistically significant ($p = 0.280$), indicating comparable onset of sensory block. However, the mean time of onset of motor blockade in Group 1 was 3.4 ± 0.9 minutes, while in Group 2 it was 4.3 ± 0.8 minutes. This difference was statistically highly significant ($p < 0.001$), suggesting that motor block occurred earlier in the ropivacaine group compared to the bupivacaine group.

Table 4: Comparison of Maximum Height of Sensory Block
In Group 1, the maximum level of sensory block achieved was T6 in 6 patients (20%), T8 in 5 patients (16.7%), T10 in 14 patients (46.7%), and T12 in 5 patients (16.7%). In Group 2, 7 patients (23.3%) achieved T6, 9 patients (30%) achieved T8, 9 patients (30%) achieved T10, and 5 patients (16.7%) achieved T12 sensory level. The distribution of maximum sensory block levels between the two groups was comparable and statistically not significant ($p = 0.612$). In Group 1, the majority of patients achieved T10 sensory level, whereas in Group 2 an equal number of patients achieved T8 and T10 levels.

Table 5: Comparison of Sensory Block Characteristics
The mean time for two-segment regression in Group 1 was 48.8 ± 12.0 minutes, whereas in Group 2 it was 74.5 ± 10.2 minutes. The duration of two-segment regression was significantly longer in Group 2 ($p < 0.001$). The mean duration of sensory block in Group 1 was 143.8 ± 17.2 minutes, while in Group 2 it was 172.5 ± 12.5 minutes. This difference was statistically highly significant ($p < 0.001$), indicating that bupivacaine produced a longer sensory block compared to ropivacaine.

Table 6: Comparison of Duration of Motor Block
The mean duration of motor block in Group 1 was 107.5 ± 20.3 minutes, whereas in Group 2 it was 146.2 ± 13.3 minutes. The duration of motor block was significantly longer in Group 2 ($p < 0.001$). This finding suggests that bupivacaine produces a longer duration of motor blockade compared to ropivacaine, which may allow earlier postoperative mobilization in patients receiving ropivacaine.

Table 7: Comparison of Hemodynamic Parameters and SpO_2
The heart rate values were generally comparable between the two groups throughout the study period. However, at certain intervals such as 30 minutes, 60 minutes, and 120 minutes, the heart rate in Group 1 was slightly lower compared to Group 2, and this difference reached statistical significance ($p < 0.05$). Despite these differences, the variations were not clinically significant and did not require therapeutic intervention. The systolic and diastolic blood pressure remained largely comparable between the two groups during most of the study period, with occasional statistically significant variations that were clinically insignificant. The SpO_2 values remained stable in both groups, with mean values around 99% throughout the observation period, and the difference between the groups was not statistically significant ($p > 0.05$). Overall, both anesthetic agents demonstrated comparable hemodynamic stability and oxygen saturation levels during the study period.

DISCUSSION
In the present study, the demographic characteristics of patients in both groups were comparable. The mean age of patients in the ropivacaine group was 39.7 ± 15.4 years, while in the bupivacaine group it was 39.0 ± 12.4 years, and the difference was not statistically significant ($p = 0.854$). Similarly, the mean height of patients in Group 1 was 162.5 ± 8.8 cm and in Group 2 was 163.8 ± 8.4 cm, which was also statistically not significant ($p = 0.570$). Although the mean weight was slightly higher in Group 2 (65.6 ± 9.5 kg) compared to Group 1 (59.3 ± 8.6 kg), the difference was statistically significant ($p = 0.010$) but clinically insignificant in relation to surgical duration and anesthetic outcomes. These findings indicate that the baseline demographic parameters were well matched between the two groups. Similar observations were reported by Whiteside et al. who found no significant difference in age, height, or weight between patients receiving intrathecal ropivacaine and bupivacaine in lower limb surgeries [11]. Likewise, McNamee et al. also demonstrated comparable demographic characteristics between study groups when comparing ropivacaine and bupivacaine for spinal anesthesia, supporting the validity of comparisons between the two drugs [12].

The distribution of ASA grading was also comparable in the present study. In Group 1, 53.3% patients belonged to ASA Grade I and 46.7% to ASA Grade II, whereas in Group 2 43.3% were ASA Grade I and 56.7% were ASA Grade II, with no statistically significant difference ($p = 0.438$). This indicates that the physical status of patients in both groups was similar and unlikely to influence anesthetic outcomes. Similar findings were reported by Gautier et al., who noted comparable ASA status among patients receiving intrathecal ropivacaine and bupivacaine in ambulatory surgery [13]. Malinovsky et

al. also reported that the ASA distribution was similar in both groups in their comparative study of intrathecal ropivacaine and bupivacaine [14].

The time of onset of sensory blockade was 1.8 ± 0.9 minutes in the ropivacaine group and 1.6 ± 0.6 minutes in the bupivacaine group, and the difference was not statistically significant ($p = 0.280$). This indicates that both drugs provide a rapid onset of sensory anesthesia suitable for surgical procedures. Similar findings were reported by McNamee et al., who observed no significant difference in the onset of sensory block between intrathecal ropivacaine and bupivacaine [12]. Kallio et al. also reported comparable onset times of sensory block when comparing ropivacaine and bupivacaine for lower limb surgeries, indicating that ropivacaine can provide an equally effective sensory blockade [15].

In contrast, the time of onset of motor blockade in the present study was 3.4 ± 0.9 minutes in Group 1 and 4.3 ± 0.8 minutes in Group 2, and the difference was statistically significant ($p < 0.001$). This suggests that ropivacaine produced an earlier onset of motor block compared to bupivacaine in this study. However, several authors have reported that ropivacaine generally produces a slightly slower or less intense motor blockade due to its lower lipid solubility. Whiteside et al. reported that ropivacaine produced a less intense motor block compared with bupivacaine, which may facilitate earlier postoperative mobilization [11]. Similarly, Van Kleef et al. observed that ropivacaine produces a differential block with greater sensory blockade and relatively less motor blockade, which can be advantageous for early recovery after surgery [16].

The maximum height of sensory block achieved in the present study was comparable between the two groups. In Group 1, the majority of patients achieved T10 level (46.7%), while in Group 2 equal numbers of patients achieved T8 and T10 levels (30% each), and the difference was not statistically significant ($p = 0.612$). These findings suggest that both ropivacaine and bupivacaine provide adequate cephalad spread of spinal anesthesia for lower abdominal and lower limb surgeries. Similar results were reported by Malinovsky et al., who found comparable maximum sensory levels between intrathecal ropivacaine and bupivacaine groups [14]. Gautier et al. also reported similar levels of maximum sensory blockade with both drugs in ambulatory surgery patients [13].

In the present study, the time for two-segment regression was significantly shorter in the ropivacaine group (48.8 ± 12 minutes) compared to the bupivacaine group (74.5 ± 10.2 minutes) with a highly significant p value (<0.001). Similarly, the duration of sensory blockade was 143.8 ± 17.2 minutes in Group 1 and 172.5 ± 12.5 minutes in Group 2, indicating a significantly longer sensory block with bupivacaine ($p < 0.001$). These findings suggest that bupivacaine produces a more prolonged sensory blockade compared with ropivacaine. Comparable results were reported by McNamee et al., who observed that intrathecal bupivacaine produced a longer duration of sensory block than ropivacaine [12]. Kallio et al. also found that the duration of spinal anesthesia with bupivacaine was significantly longer compared to ropivacaine, supporting the findings of the present study [15].

The duration of motor blockade was also significantly longer in the bupivacaine group (146.2 ± 13.3 minutes) compared with the ropivacaine group (107.5 ± 20.3 minutes) with $p < 0.001$. This indicates that ropivacaine provides a shorter duration of motor block, which may be advantageous for early ambulation and postoperative recovery. Similar findings were reported by Whiteside et al., who observed that ropivacaine produced a shorter duration of motor blockade compared to bupivacaine [11]. Van Kleef et al. also demonstrated that ropivacaine causes less intense and shorter motor block due to its lower lipid solubility and differential blockade properties [16].

Regarding hemodynamic parameters, the heart rate and blood pressure remained generally stable in both groups during the study period. Although some statistically significant variations were observed at certain intervals, these differences were not clinically significant and did not require intervention. The SpO_2 values remained stable around 99% in both groups throughout the study period. These findings indicate that both ropivacaine and bupivacaine provide satisfactory hemodynamic stability when used for spinal anesthesia. Similar findings were reported by Gautier et al., who found comparable hemodynamic stability between ropivacaine and bupivacaine groups [13]. Kuthiala and Chaudhary also reported that ropivacaine demonstrates good cardiovascular stability and lower cardiotoxicity compared to bupivacaine [17]. Additional studies by Lee et al., Singh et al., and Agarwal et al. also demonstrated comparable hemodynamic parameters between the two drugs during spinal anesthesia for lower limb surgeries [18–20].

Overall, the findings of the present study are consistent with previously published literature demonstrating that intrathecal ropivacaine provides adequate sensory anesthesia with shorter duration of motor blockade and comparable hemodynamic stability compared with bupivacaine, making it a useful alternative for spinal anesthesia in lower limb and lower abdominal surgeries.

CONCLUSION

The present study compared the characteristics of spinal anesthesia produced by Ropivacaine Heavy 0.75% and Bupivacaine Heavy 0.5% in patients undergoing lower limb and lower abdominal surgeries. Both drugs produced an effective and reliable subarachnoid block with comparable onset of sensory anesthesia and similar maximum sensory levels. However, bupivacaine demonstrated a significantly longer duration of sensory block, longer two-segment regression

time, and prolonged motor blockade compared to ropivacaine. In contrast, ropivacaine produced a relatively shorter duration of motor blockade, which may facilitate earlier postoperative mobilization and recovery. Hemodynamic parameters such as heart rate, blood pressure, and oxygen saturation remained stable and comparable in both groups, indicating good cardiovascular stability with either drug. Although some statistical variations were observed at certain time intervals, they were not clinically significant. Overall, the findings suggest that intrathecal ropivacaine is a safe and effective alternative to bupivacaine for spinal anesthesia, particularly in procedures where faster recovery and early ambulation are desirable.

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