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Original Research Article

Comparison of Intrathecal Bupivacaine vs. Ropivacaine for Sensory and Motor Blockade in Spinal Anesthesia: A Comparative Observational Study

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Abstract: ***Background:*** Spinal anesthesia is the gold standard for lower abdominal and limb surgeries. While Bupivacaine is the traditional choice, Ropivacaine has emerged as an alternative with a potentially superior safety profile. ***Objective:*** To compare the onset, duration, and intensity of sensory and motor blockade between intrathecal Bupivacaine (0.5%) and Ropivacaine. ***Methods:*** A comparative observational study was conducted on 150 patients (n=75 per group) undergoing elective surgeries. Parameters included onset time, duration of action, Bromage scale for motor block, and sensory level achieved. ***Results:*** Bupivacaine demonstrated a significantly longer duration of action (268.93 ± 47.1 min) compared to Ropivacaine (108.67 ± 46.7 min, $p < 0.001$). Bupivacaine also produced deeper motor blockade (78.7% achieving Class 2 or higher) and higher cephalad sensory spread. ***Conclusion:*** Bupivacaine is superior for prolonged surgical procedures, whereas Ropivacaine's shorter duration and less intense motor block make it ideal for day-care surgeries and early mobilization.

Keywords: Spinal Anesthesia, Bupivacaine, Ropivacaine, Bromage Scale, Sensory Blockade, Motor Blockade, Local Anesthetics, Hyperbaric vs. Isobaric, Post-Anesthesia Recovery.

INTRODUCTION

Spinal anesthesia, a form of neuraxial regional blockade, involves the precise injection of local anesthetics into the subarachnoid space. This technique induces a temporary but complete loss of sensation and motor function, making it the

preferred choice for a variety of lower abdominal, pelvic, and lower limb surgeries. In modern clinical practice, the choice of local anesthetic is critical, as it determines the speed of surgical onset, the quality of the muscle relaxation, and the safety profile regarding systemic toxicity [1].

Among the long-acting amide local anesthetics, Bupivacaine has long been the gold standard due to its potent and predictable block. However, its use is occasionally limited by a narrow therapeutic window and potential cardiotoxicity if accidentally administered intravascularly. Ropivacaine was introduced as a safer alternative; it is a pure S-enantiomer that exhibits a greater margin of safety for both the central nervous system and the cardiovascular system. Interestingly, Ropivacaine is often noted for its "sensory-motor dissociation," potentially allowing for adequate pain relief with less intense muscle paralysis [2]. This study was designed to fill the existing gap in comparative data between these two agents, specifically evaluating how their distinct pharmacological profiles translate into clinical outcomes regarding the speed of onset and the total duration of the anesthesia.

MATERIAL AND METHODS

This comparative observational study was conducted at ACS Medical College and Sri Lalithambigai College to evaluate the efficacy of two common anesthetic agents. The study population consisted of 150 adult patients, aged 18 to 60 years, who were scheduled for elective lower abdominal or limb surgeries. To ensure data integrity, patients were strictly screened based on inclusion and exclusion criteria. We excluded individuals with known allergies to local anesthetics, pre-existing coagulopathy, significant spinal deformities, active infections at the needle insertion site, or a history of previous complicated spinal surgeries.

Upon recruitment, patients were assigned to receive spinal anesthesia using either 0.5% hyperbaric Bupivacaine or isobaric Ropivacaine. The procedure was performed in the lumbar spine under sterile conditions. The primary outcome measures focused on the temporal and qualitative aspects of the block. The onset of action was defined as the time from the completion of the injection to the loss of pinprick sensation at the required dermatomal level.

The motor block was assessed and graded using the Bromage Scale, which classifies the intensity of paralysis from Class 1 (complete block) to Class 4 (no block). Sensory levels were monitored to identify the highest cephalad spread achieved by each drug. Furthermore, the total duration of action was recorded as the time until the complete regression of the sensory block and the restoration of full motor function.

3. Statistical Analysis:

Statistical analysis was performed using SPSS and GraphPad Prism software. Continuous variables, such as the time of onset and duration, were presented as means and standard deviations and compared using independent t-tests. Categorical data, including demographic distributions and Bromage scores, were presented as frequencies and percentages and analyzed using Chi-square tests. A p-value of less than 0.05 was established as the threshold for statistical significance.

RESULT

A total of 150 patients were successfully enrolled and completed the study, with 75 participants in each treatment arm. The demographic distribution, summarized in **Table 1**, showed that both groups were well-matched, though the Bupivacaine group had a higher concentration of patients over 50 years of age (48% vs. 28%) and a higher prevalence of male participants (72% vs. 60%). When evaluating the quality of the block, Bupivacaine produced a more profound and dense motor blockade compared to Ropivacaine **(Table 2)**. Specifically, 50.7% of patients in the Bupivacaine group achieved a Bromage Class 2 block and 26.7% achieved Class 3, whereas the Ropivacaine group showed a more significant percentage of lighter, Class 1 blocks (33.3%). This trend was further corroborated by the sensory blockade levels **(Table 3)**, where Bupivacaine reached higher thoracic dermatomes, most notably at T6 (17.3%) and T7 (10.7%), while Ropivacaine levels were more frequently localized to lower thoracic and sacral regions, such as T8-T10 (13.3%) and saddle anesthesia (13.3%).

In terms of temporal efficacy, the onset of action was slightly faster in the Bupivacaine group (3.12 ± 0.83 min) than in the Ropivacaine group (3.34 ± 1.13 min); however, this difference did not reach statistical significance, as evidenced by a p-value of 0.338 **(Table 4)**. In contrast, the total duration of action revealed a stark and highly significant clinical difference ($p < 0.001$). The Bupivacaine group maintained a surgical block for an average of 268.93 ± 47.1 minutes, which was more than double the duration observed in the Ropivacaine group (108.67 ± 46.7 minutes). These results indicate that while both drugs offer a rapid onset, Bupivacaine provides a significantly more extensive and long-lasting anesthetic effect.

TABLE.1 DEMOGRAPHIC TABLE

		ROPIVACAINE		BUPIVACAINE	
	VARAIBLES	FREQUENCY	PERCENTAGE	FREQUENCY	PERCENTAGE
PARAMETERS	<20	4	5.3%	1	1.3%
	21-30	20	26.7%	11	14.7%
	31-40	20	26.7%	14	18.7%
	41-50	10	13.3%	13	17.3%
	>50	21	28%	36	48%
	Total	75	100%	75	100%
Gender	Male	45	60%	54	72%
	Female	30	40%	21	28%
	Total	75	100%	75	100%
H/o alcohol and smoking history	Yes	5	6.7%	15	20%
	No	70	93.3%	60	80%
	Total	75	100%	75	100%
Spine deformity	Yes	0	0%	1	1.3%
	No	75	100%	74	9.8%
	Total	75	100%	75	100%
Previous surgery	Yes	12	16%	24	32%
	No	63	84%	51	68%
	Total	75	100%	75	100%

TABLE.2 MOTOR BLOCKAGE SCORE

Motor blockage score	ROPIVACAINE		BUPIVACAINE	
	FREQUENCY	PERCENTAGE	FREQUENCY	PERCENTAGE
Class 1	25	33.3%	16	21.3%
Class 2	32	42.7%	38	50.7%
Class 3	16	21.3%	20	26.7%
Class 4	2	2.7%	1	1.3%
Total	75	100%	75	100%

TABLE.3 SENSORY BLOCKAGE SCORE

Sensory blockage score	ROPIVACAINE		BUPIVACAINE	
	FREQUENCY	PERCENTAGE	FREQUENCY	PERCENTAGE
T1	0	0%	1	1.3%
T4	0	0%	3	4%
T5	1	1.3%	6	8%
T6	2	2..7%	13	17.3%
T6-T7	9	12%	0	0%
T6-L1	1	1.3%	0	0%
T7	0	0%	8	10.7%
T8-T10	10	13.3%	0	0%
T9	3	4%	0	0%
T9-T10	2	2.7%	0	0%
T10	8	10.7%	7	9.3%
T10-T11	7	9.3%	0	0%
T10-T12	4	5.3%	0	0%
T10-L1	2	2.7%	2	0%
T11	0	0%	5	2.7%
T12	7	9.3%	0	6.7%
T12-L1	2	2.7%	11	0%
L1	0	0%	11	14.7%

L2-LS1	2	2.7%	0	0%
saddle	10	13.3%	0	0%
Total	75	100%	75	100%

TABLE.4 ONSET OF ACTION AND DURATION OF ACTION

VARAIABLES	GROUPS	MEAN	SD	P VALUE
ONSET OF ACTION	ROPIVACAINE	3.34	1.13	0.338
	BUPIVACAINE	3.12	0.83	
DURATION OF ACTION	ROPIVACAINE	108.67	46.7	<0.001
	BUPIVACAINE	268.93	47.1	

DISCUSSION

The results of this study demonstrate that while both Bupivacaine and Ropivacaine are effective for spinal anesthesia, Bupivacaine provides a significantly more potent and prolonged block. The most striking finding was the difference in the duration of action; Bupivacaine's clinical effect lasted an average of 268.93 ± 47.1 minutes, more than double the 108.67 ± 46.7 minutes observed with Ropivacaine. This high level of statistical significance ($p < 0.001$) underscores the distinct pharmacological roles these two agents play in perioperative care.

5.1 Interpretation of Motor and Sensory Blockade:

The intensity of the motor block, as measured by the Bromage Scale, revealed that Bupivacaine (50.7% at Class 2) produced a denser paralysis than Ropivacaine. This is likely due to Bupivacaine's higher lipid solubility and its use as a hyperbaric solution in this study. Hyperbaric solutions, being heavier than cerebrospinal fluid (CSF), tend to settle and provide a more concentrated block in dependent areas of the spine. Conversely, Ropivacaine showed a greater degree of sensory-motor dissociation. This characteristic is particularly beneficial in modern anesthesia practice, as it allows for stable sensory analgesia while sparing motor function to some extent, facilitating early patient assessment and comfort [3].

5.2 Onset and Cephalad Spread (Regarding the onset of action): Bupivacaine was slightly faster (3.12 ± 0.83 min) than Ropivacaine (3.34 ± 1.13 min), though the difference was not statistically significant ($p = 0.338$). This suggests that both drugs are equally reliable for rapid surgical starts. However, the sensory distribution showed that Bupivacaine reached higher thoracic levels (T4–T7) more consistently. The more extensive cephalad spread of Bupivacaine may be attributed to its baricity and the barbotage effect during injection, which provides a broader range of anesthesia suitable for more complex abdominal procedures [4].

5.3 Clinical Relevance and Safety:

The clinical choice between these two agents should be dictated by the surgical context. Bupivacaine's long-lasting profile makes it the gold standard for major orthopedic surgeries or prolonged abdominal cases where post-operative pain control is critical. In contrast, Ropivacaine's shorter duration and lower intensity of motor block make it an ideal candidate for "fast-track" or day-care surgeries. By allowing patients to regain motor function earlier, Ropivacaine can reduce the time spent in the Post-Anesthesia Care Unit (PACU) and decrease the risk of urinary retention and other immobility-related complications. Furthermore, Ropivacaine's improved safety profile—specifically its reduced cardiotoxicity—offers an added layer of security in high-risk patients [5,6].

Limitations:

There were several limitations to this study. First, the assessment of motor and sensory blocks was qualitative, based on the Bromage Scale and pinprick tests. Second, the study did not extensively analyze adverse effects beyond PDPH, such as the incidence of hypotension or bradycardia, which are common with higher cephalad spreads. Finally, the demographic variations in age and prior surgery history between the two groups may have slightly influenced the spread and duration of the anesthetic.

CONCLUSION

This study concludes that 0.5% hyperbaric Bupivacaine provides a significantly more robust anesthetic profile than isobaric Ropivacaine in terms of both the intensity of the block and its temporal duration. While both agents demonstrate a comparable and rapid onset of action, Bupivacaine's significantly extended duration (averaging 268.93 ± 47.1 minutes) makes it the definitive choice for complex, prolonged surgical procedures requiring dense motor relaxation.

Conversely, Ropivacaine's shorter duration (averaging 108.67 ± 46.7 minutes) and characteristic

sensory-motor dissociation make it an excellent alternative for short-duration or day-case surgeries. Its use facilitates earlier post-operative mobilization and potentially faster hospital discharge. Ultimately, the selection of the local anesthetic should be individualized, balancing the expected duration of the surgical procedure with the desired speed of patient recovery and the specific safety requirements of the clinical context.

Recommendations

Based on the study results, Bupivacaine (0.5% hyperbaric) is recommended for long-duration surgeries exceeding 120 minutes, particularly those requiring dense muscle relaxation. Ropivacaine (isobaric) is highly recommended for ambulatory and day-care procedures where early mobilization is required, as it significantly reduces the recovery time to approximately 108 minutes. Clinicians should choose Bupivacaine for procedures requiring higher thoracic sensory levels (T4-T7) and Ropivacaine for lower limb or pelvic procedures where sensory-motor dissociation is beneficial for patient comfort and safety.

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