Original Research Article

COMPARATIVE STUDY OF EFFICACY, MOTOR, SENSORY BLOCKADE AND DURATION OF BLOCKADE OF INTRATHECAL HYPERBARIC LEVOBUPIVACAINE WITH FENTANYL AND HYPERBARIC ROPIVACAINE WITH FENTANYL IN LOWER ABDOMINAL AND LOWER EXTREMITY SURGERY

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ABSTRACT

Background: Spinal anesthesia is widely used for lower abdominal and lower extremity surgeries due to its rapid onset, reliable sensory and motor blockade, and favorable safety profile. Newer local anesthetics such as levobupivacaine and ropivacaine are increasingly preferred because of their lower cardiotoxicity and neurotoxicity compared to bupivacaine. The addition of opioids like fentanyl as an adjuvant enhances the quality and duration of spinal anesthesia.
Aim: To determine and compare the characteristics of subarachnoid block induced by hyperbaric levobupivacaine 0.5% with fentanyl and hyperbaric ropivacaine 0.75% with fentanyl in patients undergoing lower abdominal and lower extremity surgeries.
Materials and Methods: This comparative study included 80 patients who were randomly divided into two groups of 40 each. Group L received intrathecal hyperbaric levobupivacaine 0.5% with fentanyl, while Group R received hyperbaric ropivacaine 0.75% with fentanyl. The onset and level of sensory blockade, duration of sensory and motor blockade, motor block intensity using the Modified Bromage Scale, duration of analgesia, hemodynamic parameters, and adverse effects were recorded and analyzed.
Results: The mean age of patients was comparable between the groups ($p = 0.63$). Group L demonstrated significantly longer duration of sensory blockade (187 ± 16 min vs 134 ± 13.1 min, $p < 0.001$), longer motor block duration (145 ± 15.6 min vs 109 ± 9.44 min, $p < 0.001$), and prolonged analgesia compared to Group R. The onset of sensory block was faster in Group R (8.55 ± 2.80 min) than in Group L (10.7 ± 3.57 min, $p = 0.004$). Hemodynamic parameters were largely comparable between groups.
Conclusion: Both drug combinations provided effective spinal anesthesia; however, levobupivacaine with fentanyl produced longer sensory and motor blockade, while ropivacaine with fentanyl allowed earlier recovery, making it suitable for shorter procedures.
Keywords: Spinal anesthesia, Levobupivacaine, Ropivacaine, Fentanyl, Sensory blockade, Motor blockade.

INTRODUCTION

Spinal anesthesia is one of the most widely used regional anesthetic techniques for lower abdominal and lower extremity surgeries because of its simplicity, rapid onset of action, effective sensory and motor blockade, and reliable intraoperative analgesia. It also offers advantages such as reduced systemic drug exposure, minimal airway manipulation, early postoperative recovery, and decreased incidence of complications compared with general anesthesia. Due to these benefits, subarachnoid block is commonly preferred for procedures such as orthopedic surgeries, urological operations, and infra-umbilical abdominal surgeries. However, the success of spinal anesthesia depends largely on the choice of local anesthetic agent and the adjunct drugs used to enhance its efficacy and duration.[1,2]

Traditionally, bupivacaine has been the most commonly used local anesthetic for spinal anesthesia because it provides dense sensory and motor blockade with prolonged duration of action. Nevertheless, concerns regarding its cardiotoxicity and neurotoxicity have encouraged the development and use of safer alternatives. Levobupivacaine and ropivacaine are newer long-acting amide local anesthetics that were introduced to provide similar anesthetic efficacy with improved safety profiles. Levobupivacaine is the pure S-enantiomer of bupivacaine and has been shown to possess less cardiotoxic and neurotoxic potential while maintaining potent anesthetic properties. Similarly, ropivacaine, another long-acting amide anesthetic, demonstrates reduced lipid solubility and therefore produces less intense motor blockade with a lower risk of systemic toxicity.[3-5]

Both levobupivacaine and ropivacaine have been increasingly used in spinal anesthesia for infra-umbilical surgeries. Levobupivacaine is known to produce a faster onset and longer duration of sensory and motor blockade compared to ropivacaine, making it suitable for longer surgical procedures. In contrast, ropivacaine tends to produce a shorter duration of motor blockade and less intense motor impairment, which may facilitate early postoperative mobilization and is therefore beneficial for ambulatory or short-duration surgeries. These pharmacological differences have led to several comparative studies evaluating their relative efficacy in spinal anesthesia.[6,7]

To further enhance the quality of spinal anesthesia, various adjuvants are often added to local anesthetics. Among these, opioids such as fentanyl are widely used because they act synergistically with local anesthetics to improve intraoperative analgesia and prolong postoperative pain relief. Intrathecal fentanyl enhances the sensory block without significantly prolonging motor block, thereby improving patient comfort while maintaining early recovery of motor function. Additionally, the use of opioid adjuvants allows a reduction in the dose of local anesthetics required, which may help decrease the risk of adverse effects such as hypotension, bradycardia, nausea, and delayed recovery.[8,9]

Several clinical studies have evaluated the combination of ropivacaine or levobupivacaine with fentanyl in spinal anesthesia. These studies suggest that the addition of fentanyl improves the quality of the sensory block and prolongs analgesia while maintaining hemodynamic stability. Ropivacaine with fentanyl has been reported to provide adequate anesthesia for lower abdominal and lower limb surgeries with relatively shorter duration of motor blockade, making it useful for day-care procedures. Conversely, levobupivacaine with fentanyl tends to produce a faster onset and longer duration of sensory and motor blockade, which may be advantageous for longer surgical interventions requiring prolonged anesthesia.[6,10]

Despite the increasing use of these agents, there is still limited evidence directly comparing hyperbaric levobupivacaine with fentanyl and hyperbaric ropivacaine with fentanyl for spinal anesthesia in lower abdominal and lower extremity surgeries. Differences in onset time, quality of sensory and motor blockade, duration of analgesia, and overall efficacy may influence the choice of anesthetic agent for specific surgical procedures. Therefore, a comparative evaluation of these two commonly used drug combinations is necessary to determine the most suitable anesthetic regimen for achieving optimal surgical conditions and postoperative recovery.

The present study aimed to determine and compare the characteristics of subarachnoid block produced by intrathecal hyperbaric levobupivacaine 0.5% with fentanyl and hyperbaric ropivacaine 0.75% with fentanyl in patients undergoing lower abdominal and lower extremity surgeries. The primary objectives were to compare the level of sensory blockade, duration of blockade, and the density of motor blockade using the Modified Bromage Scale. The secondary objective was to assess and compare the hemodynamic changes and the incidence of side effects associated with both drug combinations.

MATERIALS AND METHODS

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

Place of Study: Operation theatres of a tertiary care health centre.

Duration of Study: The study was conducted over a period of 18 months.

Methods:

- The study was conducted among ASA Grade I and ASA Grade II patients scheduled for lower abdominal and lower extremity surgeries under spinal anaesthesia.
- Eligible patients were randomly allocated into two groups using a computer-generated random number table.

Study Groups

- **Group L (n = 40):** Patients received Intrathecal Hyperbaric Levobupivacaine with Fentanyl.
- **Group R (n = 40):** Patients received Intrathecal Hyperbaric Ropivacaine with Fentanyl.

Inclusion Criteria

1. Patients belonging to American Society of Anesthesiologists (ASA) Grade I and II.
2. Patients aged 18–60 years.
3. Patients of either sex.
4. Patients scheduled for lower abdominal or lower extremity surgeries under spinal anaesthesia.

Exclusion Criteria

1. Patients with severe sepsis, hypovolemia, coagulopathy, or infection at the site of subarachnoid block.
2. Patients with known allergy to local anaesthetics or any component of the study drug.
3. Pregnant patients.

Sample Size: The final sample size was taken as 40 patients per group, resulting in a total of 80 patients.

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.

RESULTS

Table 1: Age Distribution of Study Groups

Parameter	Group L (n=40)	Group R (n=40)	p value
Mean age (years)	40.5	41.8	0.63
Standard deviation	11.9	8.62	
Median	42.5	42.5	
Minimum	19	19	
Maximum	59	58	

Table 2: Age and Sex Distribution

Age Group (Years)	Group L Female	Group L Male	Group R Female	Group R Male
18–30	3	7	3	2
31–40	3	6	10	3
41–50	6	7	10	6
51–60	1	7	5	1
Total	**13**	**27**	**28**	**12**

Table 3: Maximum Level of Sensory Block

Sensory Block Level	Group L (n=40)	Group R (n=40)	p value
T4	6	1	0.19
T5	0	2	
T6	24	20	
T8	10	17	

Table 4: Sensory Block Characteristics

Parameter	Group L Mean ± SD	Group R Mean ± SD	p value
Time to reach maximum sensory block (min)	10.7 ± 3.57	8.55 ± 2.80	0.004
Time to two-segment regression (min)	110 ± 12.4	93.5 ± 11.6	<0.001
Duration of sensory blockade (min)	187 ± 16	134 ± 13.1	<0.001

Table 5: Motor Block and Analgesia Characteristics

Parameter	Group L Mean ± SD	Group R Mean ± SD	p value
Time to achieve Bromage scale 3 (min)	5 ± 1.11	7.05 ± 1.11	<0.001
Regression to Bromage scale 0 (min)	145 ± 15.6	109 ± 9.44	<0.001
Time to first analgesic dose (min)	115	90.8 ± 10.2	<0.001

Table 6: Hemodynamic Comparison Between Groups

Parameter	Group L Mean ± SD	Group R Mean ± SD	p value
Baseline Heart Rate (bpm)	79.3 ± 12.1	79.5 ± 10.5	0.914
Baseline Systolic BP (mmHg)	136 ± 12.9	131 ± 13.3	0.127
Baseline Diastolic BP (mmHg)	83.4 ± 7.93	78.3 ± 7.28	0.004
Baseline MAP (mmHg)	101 ± 8.56	96 ± 8.91	0.014

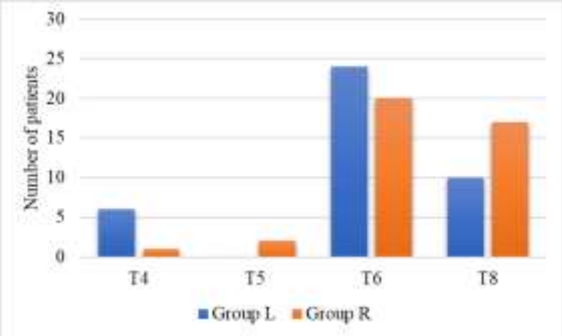

Figure 1: Maximum Level of Sensory Block

Table 1: Age Distribution of Study Groups
The mean age of patients in Group L was 40.5 years with a standard deviation of 11.9, while in Group R the mean age was 41.8 years with a standard deviation of 8.62. The median age in both groups was 42.5 years. The minimum age recorded was 19 years in both groups, while the maximum age was 59 years in Group L and 58 years in Group R. Statistical analysis showed no significant difference in age distribution between the two groups (p = 0.63), indicating that both groups were comparable with respect to age.

Table 2: Age and Sex Distribution
In Group L, among patients aged 18–30 years, 3 were females and 7 were males, while in Group R 3 were females and 2 were males. In the 31–40 years age group, Group L had 3 females and 6 males, whereas Group R had 10 females and 3 males. In the 41–50 years age group, Group L consisted of 6 females and 7 males, while Group R had 10 females and 6 males. Among patients aged 51–60 years, Group L had 1 female and 7 males, whereas Group R had 5 females and 1 male. Overall, Group L included 13 females and 27 males, while Group R had 28 females and 12 males, showing a higher proportion of males in Group L and females in Group R.

Table 3: Maximum Level of Sensory Block
The maximum level of sensory blockade achieved in the study groups varied from T4 to T8. In Group L, 6 patients reached T4, 24 patients reached T6, and 10 patients reached T8. In Group R, 1 patient achieved T4, 2 patients achieved T5, 20 patients reached T6, and 17 patients reached T8. The majority of patients in both groups achieved a sensory block level at T6. Statistical comparison showed no significant difference between the groups (p = 0.19) in terms of the maximum level of sensory blockade.

Table 4: Sensory Block Characteristics
The mean time to reach maximum sensory block was significantly longer in Group L (10.7 ± 3.57 minutes) compared to Group R (8.55 ± 2.80 minutes) with a statistically significant difference (p = 0.004). The time for two-segment regression was also significantly longer in Group L (110 ± 12.4 minutes) compared with Group R (93.5 ± 11.6 minutes) (p < 0.001). Similarly, the duration of sensory blockade was significantly prolonged in Group L (187 ± 16 minutes) compared to Group R (134 ± 13.1 minutes) (p < 0.001), indicating a longer lasting sensory block with levobupivacaine.

Table 5: Motor Block and Analgesia Characteristics
The time required to achieve complete motor blockade (Bromage scale 3) was significantly shorter in Group L (5 ± 1.11 minutes) compared to Group R (7.05 ± 1.11 minutes) with a highly significant difference (p < 0.001). The time for regression to Bromage scale 0 was also significantly longer in Group L (145 ± 15.6 minutes) compared with Group R (109 ± 9.44 minutes) (p < 0.001). Additionally, the time to first analgesic requirement was longer in Group L (115 minutes) compared with Group R (90.8 ± 10.2 minutes), which was statistically significant (p < 0.001), suggesting prolonged analgesic effect with levobupivacaine.

Table 6: Hemodynamic Comparison Between Groups
The baseline heart rate was comparable between the two groups, with 79.3 ± 12.1 bpm in Group L and 79.5 ± 10.5 bpm in Group R, showing no statistically significant difference (p = 0.914). The baseline systolic blood pressure was 136 ± 12.9 mmHg in Group L and 131 ± 13.3 mmHg in Group R, which was also not statistically significant (p = 0.127). However, the baseline diastolic blood pressure was 83.4 ± 7.93 mmHg in Group L compared with 78.3 ± 7.28 mmHg in Group R, showing a statistically significant difference (p = 0.004). Similarly, the baseline mean arterial pressure (MAP) was 101 ± 8.56 mmHg in Group L and 96 ± 8.91 mmHg in Group R, which was statistically significant (p = 0.014). Overall, baseline heart rate and systolic blood pressure were comparable, while diastolic blood pressure and MAP showed significant differences between the groups.

DISCUSSION

The present study compared the characteristics of spinal anesthesia produced by hyperbaric levobupivacaine 0.5% with fentanyl (Group L) and hyperbaric ropivacaine 0.75% with fentanyl (Group R) in patients undergoing lower abdominal and lower extremity surgeries. The results demonstrated differences in onset, duration, and quality of sensory and motor blockade between the two drug combinations.

In the present study, the mean age of patients was 40.5 ± 11.9 years in Group L and 41.8 ± 8.62 years in Group R, and the difference between the groups was not statistically significant (p = 0.63). This indicates that both groups were comparable in terms of demographic distribution, reducing the possibility of age-related bias influencing the outcomes. Similar demographic comparability was reported by Mantouvalou et al., who compared spinal anesthesia with levobupivacaine and ropivacaine and found no significant difference in age distribution between the groups studied.[11] Likewise, Kallio et al. reported comparable demographic characteristics when evaluating intrathecal levobupivacaine and ropivacaine in lower limb surgeries, suggesting that both drugs can be reliably compared in clinical trials without demographic influence on anesthetic outcomes.[12]

Regarding the maximum level of sensory block, most patients in the present study achieved a sensory level around T6, with some patients reaching T4 and T8, and there was no statistically significant difference between the two groups (p = 0.19). These findings indicate that both hyperbaric levobupivacaine and ropivacaine with fentanyl provide adequate sensory blockade for infra-umbilical surgeries. Similar results were reported by Whiteside et al., who found that both levobupivacaine and ropivacaine produced effective sensory block levels suitable for lower limb surgeries without significant differences in block height.[13] Gautier et al. also reported comparable maximum sensory levels with these two agents, concluding that both drugs are capable of achieving sufficient spinal anesthesia for lower abdominal procedures.[14]

In the present study, the time to reach maximum sensory block was significantly longer in Group L (10.7 ± 3.57 minutes) compared with Group R (8.55 ± 2.80 minutes), p = 0.004, indicating a slightly faster onset with ropivacaine. However, the time to two-segment regression and the total duration of sensory blockade were significantly longer in Group L (110 ± 12.4 minutes and 187 ± 16 minutes respectively) compared with Group R (93.5 ± 11.6 minutes and 134 ± 13.1 minutes), p < 0.001. This suggests that levobupivacaine provides a longer lasting sensory block than ropivacaine. Similar findings were reported by Mantouvalou et al., who observed that levobupivacaine produced a longer duration of sensory blockade compared with ropivacaine in spinal anesthesia.[11] Luck et al. also reported prolonged sensory block with levobupivacaine compared with ropivacaine, attributing this difference to variations in lipid solubility and protein binding characteristics of the drugs.[15]

The study also demonstrated differences in motor blockade characteristics. The time to achieve complete motor block (Bromage scale 3) was significantly shorter in Group L (5 ± 1.11 minutes) compared with Group R (7.05 ± 1.11 minutes), p < 0.001, indicating a faster onset of motor blockade with levobupivacaine. Additionally, the time for regression to Bromage scale 0 was significantly longer in Group L (145 ± 15.6 minutes) compared with Group R (109 ± 9.44 minutes), p < 0.001. These findings suggest that levobupivacaine produces a denser and more prolonged motor block. Similar observations were made by Kallio et al., who reported that levobupivacaine produced a stronger and longer lasting motor block compared with ropivacaine.[12] Casati et al. also found that ropivacaine resulted in a shorter and less intense motor blockade, which may facilitate earlier postoperative mobilization.[16]

The duration of postoperative analgesia, assessed by the time to first analgesic requirement, was also significantly longer in Group L (115 minutes) compared with Group R (90.8 ± 10.2 minutes, p < 0.001). This suggests that levobupivacaine with fentanyl provides more prolonged postoperative pain relief than ropivacaine with fentanyl. Similar findings were reported by Gautier et al., who observed longer postoperative analgesia with levobupivacaine compared with ropivacaine during spinal anesthesia.[14] McNamee et al. also reported prolonged analgesia with levobupivacaine due to its higher potency and stronger sensory blockade properties.[17]

In terms of hemodynamic parameters, the present study showed that baseline heart rate and systolic blood pressure were comparable between the groups (p = 0.914 and p = 0.127 respectively), indicating similar cardiovascular stability with both drug combinations. However, baseline diastolic blood pressure and mean arterial pressure were slightly higher in Group L compared with Group R (p = 0.004 and p = 0.014 respectively). Despite this difference, both groups remained hemodynamically stable during the perioperative period. Similar findings were reported by Whiteside et al., who observed minimal hemodynamic variations between levobupivacaine and ropivacaine spinal anesthesia.[13] Fattorini et al. also reported comparable cardiovascular stability with both drugs during spinal anesthesia for lower limb surgeries.[18]

The addition of intrathecal fentanyl in both groups likely enhanced the quality of sensory blockade and postoperative analgesia without significantly affecting motor block characteristics. Ben-David et al. demonstrated that fentanyl added to spinal local anesthetics improves intraoperative analgesia and prolongs postoperative pain relief while maintaining hemodynamic stability.[19] Similarly, Singh et al. reported that intrathecal fentanyl enhances the quality of spinal anesthesia and prolongs sensory blockade without causing significant adverse effects.[20]

Overall, the findings of the present study are consistent with previous research demonstrating that levobupivacaine produces a longer duration of sensory and motor blockade, whereas ropivacaine provides a relatively shorter block with faster recovery, which may be advantageous for shorter procedures or ambulatory surgeries. Both drug combinations with fentanyl provided effective and safe spinal anesthesia for lower abdominal and lower extremity surgeries.

CONCLUSION

The present study demonstrated that both intrathecal hyperbaric levobupivacaine 0.5% with fentanyl and hyperbaric ropivacaine 0.75% with fentanyl provide effective and reliable spinal anesthesia for lower abdominal and lower extremity surgeries. However, significant differences were observed in the characteristics of sensory and motor blockade between the two groups. Levobupivacaine with fentanyl produced a longer duration of sensory blockade, prolonged motor block, and extended postoperative analgesia, whereas ropivacaine with fentanyl showed a faster onset of sensory block with relatively shorter duration of both sensory and motor blockade. The maximum level of sensory block achieved was comparable between the groups, indicating adequate anesthesia with both drug combinations. Hemodynamic parameters remained stable in both groups, with minimal adverse effects observed. Overall, levobupivacaine with fentanyl appears to be more suitable for longer surgical procedures requiring prolonged anesthesia, while ropivacaine with fentanyl may be advantageous for shorter procedures where earlier motor recovery is desired.

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