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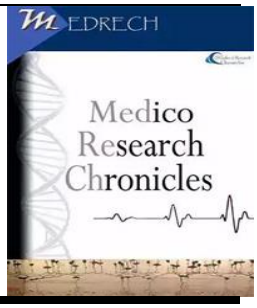

Precision Anesthesia: Nalbuphine-Levobupivacaine vs. Fentanyl-Levobupivacaine in Spinal Blocks

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ABSTRACT

Background: Intrathecal adjuvants enhance the efficacy of local anesthetics in spinal anesthesia. This study compared nalbuphine and fentanyl as adjuvants to hyperbaric levobupivacaine for lower abdominal surgeries.

Methods: In this prospective, randomized, double-blind study, 100 ASA I-II patients undergoing lower abdominal surgeries were allocated into two groups: Group LN (n=50) received 15 mg of 0.5% hyperbaric levobupivacaine with 0.8 mg nalbuphine intrathecally, and Group LF (n=50) received 15 mg of 0.5% hyperbaric levobupivacaine with 25 µg fentanyl intrathecally. Onset and duration of sensory and motor blockade, hemodynamic parameters, postoperative analgesia using Visual Analog Scale (VAS), and adverse effects were assessed.

Results: The onset of sensory block (2.795±0.599 min in Group LN vs. 2.625±0.562 min in Group LF; p=0.921) and time to complete motor block (10.38±1.081 min vs. 10.59±1.004 min; p=0.766) were comparable between groups. The duration of sensory block (282.29±23.09 min vs. 306.88±29.06 min; p=0.0001) and motor block (178.46±7.59 min vs. 242.96±39.17 min; p=0.0001) were significantly longer in Group LF. VAS scores were significantly lower in Group LN at 1.5, 2, 2.5, and 3.5 hours postoperatively ($p<0.05$). Hemodynamic parameters remained largely stable in both groups. The incidence of adverse effects was comparable, with pruritus observed exclusively in Group LF (4%).

Conclusion: Fentanyl provided prolonged sensory and motor blockade, while nalbuphine offered better early postoperative analgesia with faster motor recovery and absence of pruritus. Both adjuvants maintained hemodynamic stability with minimal adverse effects, suggesting their selection should be tailored to specific surgical requirements and desired recovery profiles.

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INTRODUCTION

Spinal anaesthesia is widely preferred for lower abdominal surgeries due to its rapid onset, cost-effectiveness, reduced incidence of postoperative nausea and vomiting (PONV), preserved protective airway reflexes, and decreased risk of aspiration compared to general anaesthesia[1,2]. Hyperbaric levobupivacaine has emerged as an attractive alternative to racemic bupivacaine for spinal anaesthesia owing to its lower potential for cardiotoxicity and faster recovery profile[3]. However, when used alone, the duration of spinal anaesthesia with levobupivacaine may be insufficient for prolonged surgical procedures, necessitating the use of adjuvants to enhance its efficacy[4].

Various adjuvants have been used with local anaesthetics in spinal anaesthesia to improve the speed of onset and prolong the duration of sensory and motor blockade. These adjuvants also reduce the requirement of local anaesthetics, thereby lowering the possibility of local anaesthetic toxicity and decreasing the need for rescue analgesia[5]. Among the commonly used adjuvants are opioids like fentanyl and nalbuphine, alpha-2 agonists such as clonidine and dexmedetomidine, vasoconstrictors, and other drugs including neostigmine, magnesium sulphate, midazolam, and preservative-free ketamine[6].

Fentanyl, a synthetic phenylpiperidine opioid μ-receptor agonist, is widely used as an adjuvant in spinal anaesthesia. It produces selective spinal analgesia through interaction with μ receptors at supraspinal sites[7]. Despite its effectiveness, fentanyl is associated with side effects including nausea, vomiting, pruritus, urinary retention, and respiratory depression[8].

Nalbuphine, a synthetic opioid structurally related to oxymorphone, has gained attention as an alternative adjuvant. It has a unique pharmacological profile with agonist activity at κ-opioid receptors and antagonist activity at μ-opioid receptors. This dual mechanism allows nalbuphine to provide significant analgesia while minimizing the side effects typically associated with pure μ-agonists, such as pruritus and respiratory depression[9,10]. Its lipid solubility further enhances its efficacy when administered intrathecally[11].

Several studies have compared the efficacy of fentanyl and nalbuphine as adjuvants to various local anaesthetics in different surgical settings. Thote et al. observed longer duration of analgesia with nalbuphine (0.5 mg) compared to fentanyl (25 μg) when combined with bupivacaine for lower abdominal surgeries[12]. Conversely, Prabhakaraiah et al. found that fentanyl provided better quality of analgesia in the early postoperative period compared to nalbuphine when used with bupivacaine for similar surgical procedures[13]. These conflicting findings highlight the need for further investigation.

The present study aims to compare the efficacy of intrathecal nalbuphine (0.8 mg) and fentanyl (25 μg) as adjuvants to 0.5% hyperbaric levobupivacaine for spinal anaesthesia in lower abdominal surgeries. The primary objective is to evaluate their effects on the duration of postoperative analgesia. Secondary objectives include assessing their impact on sensory and motor blockade characteristics, hemodynamic stability, and adverse effects. The findings of this study will contribute to the ongoing efforts to identify the optimal adjuvant for enhancing the efficacy of spinal anaesthesia while minimizing associated side effects.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, double-blind study was conducted at the Department of Anaesthesiology, Apollo Institute of Medical Sciences and Research, Hyderabad, from September 2022 to March 2023, after

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obtaining approval from the institutional ethical committee (Ref. No.: EC/NEW/INST/1527/2022/08/026). The study adhered to the principles of the Declaration of Helsinki and followed good clinical practice guidelines.

Study Population

A total of 100 patients of American Society of Anesthesiologists (ASA) physical status I and II, aged between 18 and 60 years, scheduled for elective lower abdominal surgeries under spinal anaesthesia, were enrolled in the study after obtaining written informed consent. Patients with known allergy to the study drugs, coagulation disorders, local infection at the puncture site, raised intracranial pressure, pregnancy, or lactation were excluded. Additionally, patients on tranquilizers, hypnotics, sedatives, or other psychotropic drugs, and those who refused the procedure were excluded from the study.

Randomization and Blinding

Patients were randomly allocated into two groups of 50 each using a closed cover technique:

- Group LN: Received 15 mg of 0.5% hyperbaric levobupivacaine with 0.8 mg nalbuphine intrathecally
- Group LF: Received 15 mg of 0.5% hyperbaric levobupivacaine with 25 µg fentanyl intrathecally

The anaesthesiologist who prepared the drug solution was aware of the group allocation but was not involved in the subsequent assessment. Both the patient and the anaesthesiologist who administered the drug and assessed the parameters were blinded to the group allocation.

Preoperative Preparation

All patients underwent a thorough preoperative assessment. Baseline vital parameters including heart rate, blood pressure, oxygen saturation, and respiratory rate were recorded. Intravenous access was secured, and patients were preloaded with 10 ml/kg of Ringer's lactate solution 15 minutes prior to the subarachnoid block[14]. Standard monitoring including electrocardiography, non-invasive blood pressure measurement, and pulse oximetry was established.

Procedure

Spinal anaesthesia was administered with the patient in the sitting position. Under strict aseptic precautions, the L3-L4 intervertebral space was identified, and a 25-gauge Quincke spinal needle was inserted. After confirmation of free flow of cerebrospinal fluid, the study drug combination was injected at a rate of 0.2 ml/second. The time of intrathecal injection was noted as time zero, and all subsequent times were calculated from this point. Patients were immediately positioned supine after the injection.

Parameters Assessed

1. **Sensory Block:**
   - Onset of sensory block: Time from injection to loss of pin-prick sensation assessed using a 26G sterile needle along the midclavicular line
   - Duration of sensory block: Time from injection to regression of sensory blockade to S1
2. **Motor Block:**
   - Motor blockade was assessed bilaterally using the Modified Bromage Scale[15]:
     - 0: Able to move hip, knee, ankle
     - 1: Unable to move hip, but able to move knee and ankle
     - 2: Unable to move hip and knee but able to move ankle
     - 3: Unable to move hip, knee, and ankle
   - Onset of motor block: Time to achieve Bromage scale 1
   - Duration of motor block: Time from injection to return to Bromage score 0
3. **Hemodynamic Parameters:**
   - Heart rate, systolic and diastolic blood pressure were recorded at 0, 5, 10, 15, 20,

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30, 45, 60, 90, and 120 minutes after the injection

4. **Postoperative Analgesia:**
   - Postoperative pain was assessed using Visual Analog Scale (VAS)[16]
   - VAS was recorded at 30 min, 1 hr, 1 hr 30 min, 2 hr, 2 hr 30 min, 3 hr, 3 hr 30 min, 4 hr, 4 hr 30 min, and 5 hr postoperatively
   - VAS scoring: 0 = no pain, 10 = worst imaginable pain
5. **Adverse Effects:**
   - Hypotension (defined as a decrease in systolic blood pressure >20% from baseline)
   - Bradycardia (heart rate <50 beats/min)
   - Respiratory depression (respiratory rate <10 breaths/min)
   - Nausea and vomiting
   - Shivering
   - Pruritus

Statistical Analysis

Data were analyzed using SPSS version 24. Descriptive statistics including mean, standard deviation, and proportions were calculated for all values. The Chi-square test was used to study the association between categorical variables. Continuous variables were compared using Student's t-test or Mann-Whitney U test based on the normality of data distribution. A p-value ≤0.05 was considered statistically significant.

Sample size calculation was based on previous studies[12,13,17], with an anticipated difference of 30 minutes in the duration of sensory blockade between the two groups, power of 80%, and significance level of 5%. This yielded a minimum sample size of 45 patients per group, which was rounded up to 50 patients per group to account for potential dropouts.

RESULTS

Demographic Characteristics

All 100 patients completed the study without any exclusions. Table 1 presents the demographic characteristics of the patients in both groups.

Table 1: Demographic Characteristics

Parameter	Group LN (n=50)	Group LF (n=50)	P-value
Age (years), Mean ± SD	51.32 ± 6.00	41.28 ± 10.26	0.001*
Height (cm), Mean ± SD	163.4 ± 3.86	165.86 ± 5.19	0.121

*Statistically significant (P < 0.05)

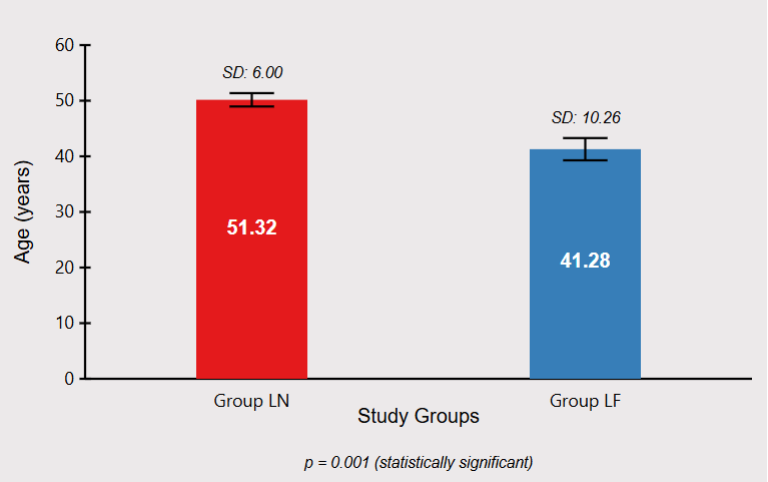

Figure 1: Bar graph comparing age distribution between Group LN and Group LF

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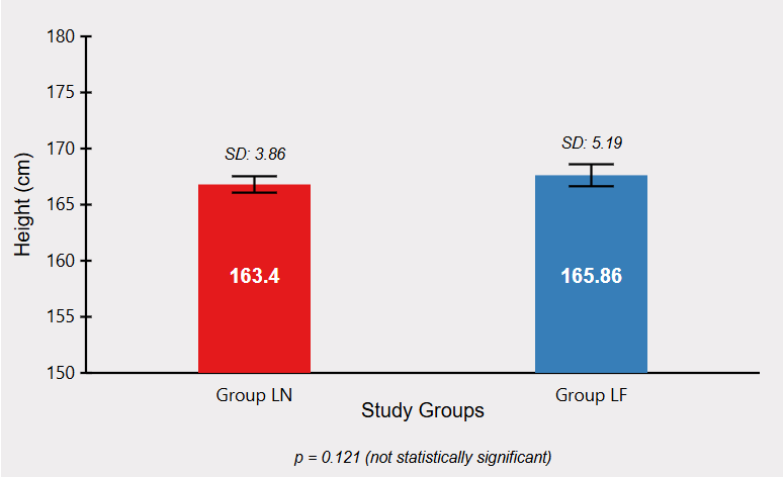

Figure 2: Bar graph comparing height distribution between Group LN and Group LF

The mean age was significantly higher in Group LN compared to Group LF (51.32 ± 6.00 years vs. 41.28 ± 10.26 years, P = 0.001). However, there was no significant difference in height between the two groups (163.4 ± 3.86 cm vs. 165.86 ± 5.19 cm, P = 0.121).

Characteristics of Sensory and Motor Block

The characteristics of sensory and motor block in both groups are summarized in Table 2.

Table 2: Sensory and Motor Block Characteristics

Parameter	Group LN (n=50)	Group LF (n=50)	P-value
Onset of sensory block (min), Mean ± SD	2.795 ± 0.599	2.625 ± 0.562	0.921
Time to achieve Bromage 3 (min), Mean ± SD	10.38 ± 1.081	10.59 ± 1.004	0.766
Duration of sensory block (min), Mean ± SD	282.29 ± 23.09	306.88 ± 29.06	0.0001*
Regression of motor block to Bromage 0 (min), Mean ± SD	178.46 ± 7.59	242.96 ± 39.17	0.0001*

*Statistically significant (P < 0.05)

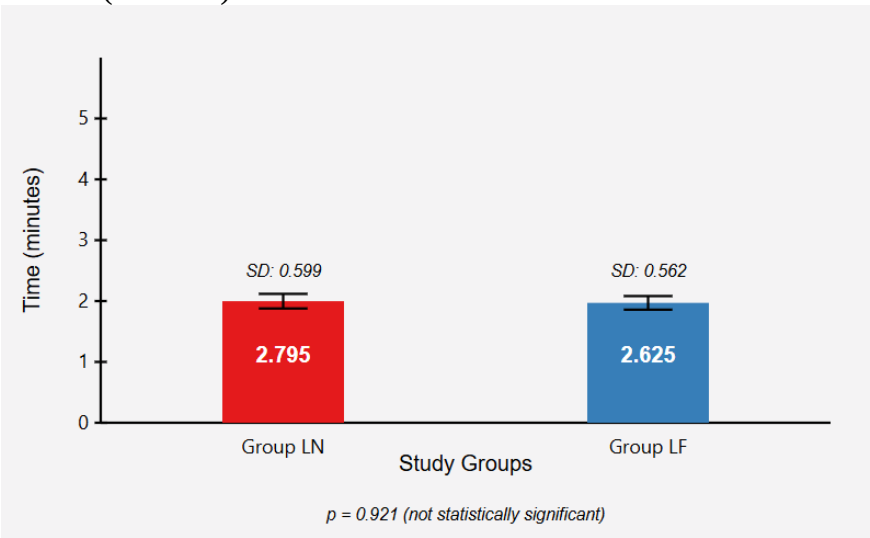

Figure 3: Bar graph depicting onset of sensory blockade in both groups

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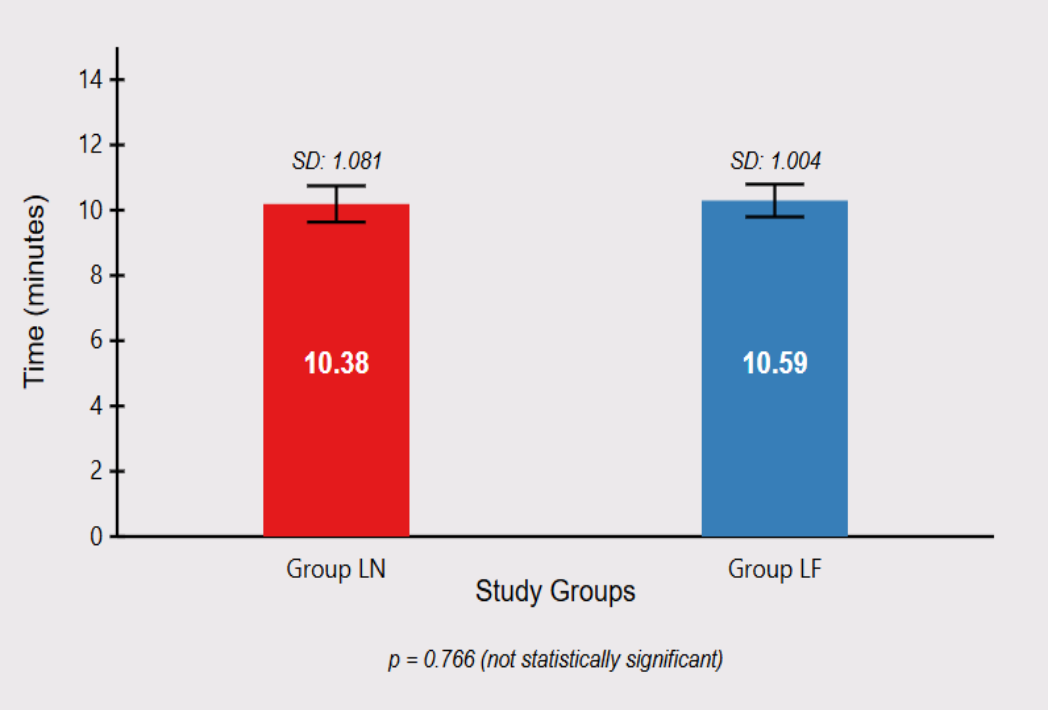

Figure 4: Bar graph depicting time to onset of Bromage 3 in both groups

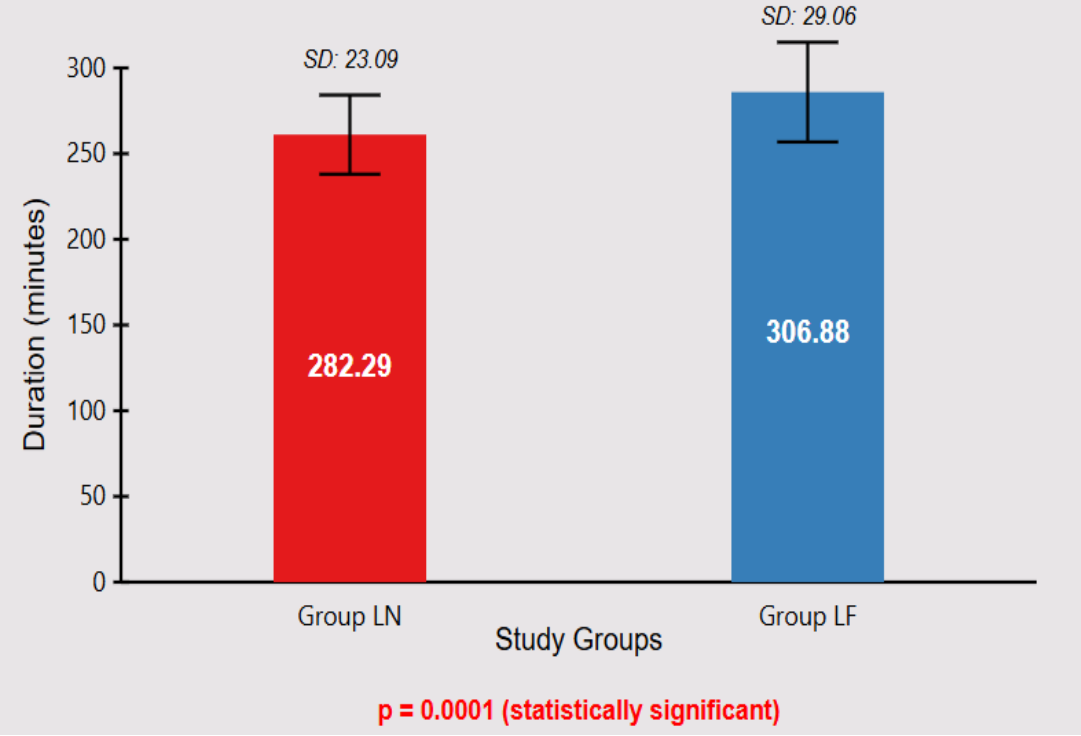

Figure 5: Bar graph depicting duration of sensory block in both groups

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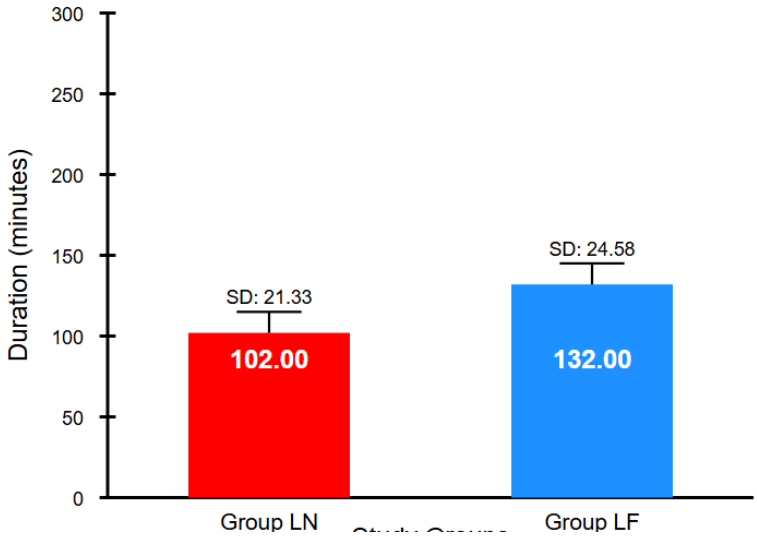

Figure 6: Bar graph depicting regression of motor blockade to Bromage 0 in both groups

The onset of sensory block and time to achieve complete motor block (Bromage 3) were comparable between the two groups (P > 0.05). However, the duration of sensory block was significantly longer in Group LF compared to Group LN (306.88 ± 29.06 min vs. 282.29 ± 23.09 min, P = 0.0001). Similarly, the regression of motor block to Bromage 0 was significantly prolonged in Group LF compared to Group LN (242.96 ± 39.17 min vs. 178.46 ± 7.59 min, P = 0.0001).

Hemodynamic Parameters

The hemodynamic parameters recorded at various time intervals are presented in Table 3, Table 4, and Table 5.

Table 3: Comparison of Heart Rate

Time (min)	Group LN (n=50)	Group LF (n=50)	P-value
5	81.5 ± 12.70	84.28 ± 13.20	0.286
10	80.36 ± 12.05	84.42 ± 13.85	0.241
15	79.44 ± 11.03	83.78 ± 13.27	0.078
20	78.56 ± 9.66	80.8 ± 11.97	0.306
30	77.84 ± 8.70	78.67 ± 9.81	0.654
45	76.42 ± 8.14	77.58 ± 9.83	0.522
60	75.46 ± 7.70	76.42 ± 9.98	0.592
90	74.56 ± 7.73	75.52 ± 8.22	0.549
120	73.42 ± 7.56	75.64 ± 7.97	0.156

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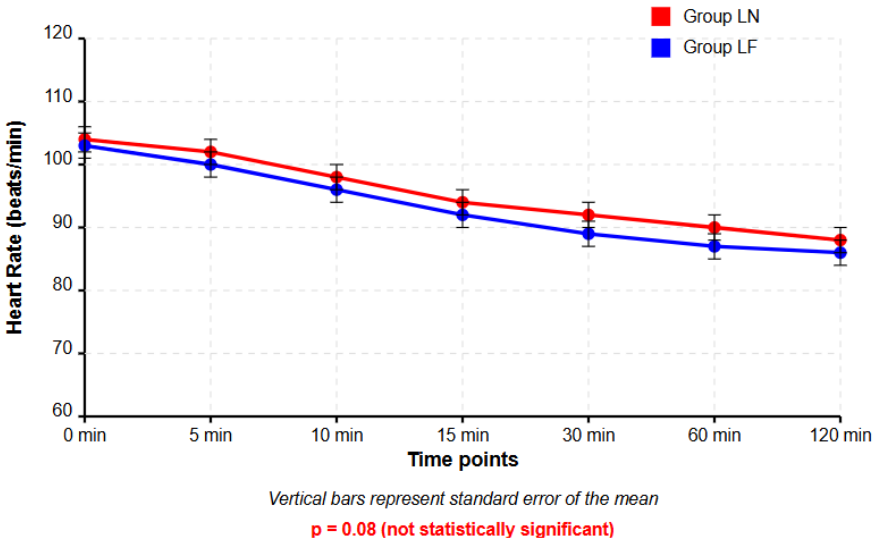

Figure 7: Line graph showing heart rate trends in both groups

Table 4: Comparison of Systolic Blood Pressure

Time (min)	Group LN (n=50)	Group LF (n=50)	P-value
5	96.88 ± 7.29	92.74 ± 5.39	0.002*
10	118.34 ± 12.55	114.04 ± 11.26	0.074
15	115.24 ± 9.77	112.76 ± 10.84	0.233
20	112.42 ± 9.05	110.92 ± 10.87	0.455
30	110.22 ± 9.87	110.5 ± 10.50	0.891
45	108.56 ± 9.70	109.38 ± 10.78	0.690
60	107.66 ± 9.49	108.34 ± 10.57	0.736
90	108.98 ± 9.75	107.82 ± 9.21	0.542
120	111.24 ± 9.57	108.6 ± 8.88	0.156

*Statistically significant ($P < 0.05$)

Table 5: Comparison of Diastolic Blood Pressure

Time (min)	Group LN (n=50)	Group LF (n=50)	P-value
5	77.38 ± 9.68	73.54 ± 9.36	0.046*

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10	72.46 ± 8.57	70.5 ± 9.35	0.277
15	69.04 ± 8.65	69.0 ± 9.34	0.982
20	65.76 ± 7.88	67.74 ± 10.31	0.283
30	62.3 ± 8.40	66.68 ± 10.31	0.022*
45	60.92 ± 9.24	65.12 ± 9.97	0.031*
60	60.92 ± 9.24	64.8 ± 9.66	0.043*
90	62.98 ± 8.79	65.16 ± 8.91	0.221
120	65.76 ± 7.54	65.62 ± 8.31	0.932

*Statistically significant (P < 0.05)

The heart rate was comparable between the two groups at all time intervals (P > 0.05). The systolic blood pressure was significantly lower in Group LF at 5 minutes (P = 0.002). Diastolic blood pressure showed significant differences at 5, 30, 45, and 60 minutes, with lower values in Group LN at 30, 45, and 60 minutes (P < 0.05).

Visual Analog Scale (VAS) Scores

The VAS scores recorded at various postoperative time intervals are presented in Table 6.

Table 6: Comparison of Visual Analog Scale Scores

Time	Group LN (n=50)	Group LF (n=50)	P-value
30 min	0	0	-
1 hr	0.32 ± 0.68	0.58 ± 0.93	0.114
1 hr 30 min	1.12 ± 1.22	1.88 ± 1.24	0.003*
2 hr	1.62 ± 1.32	2.32 ± 1.43	0.013*
2 hr 30 min	2.62 ± 1.29	3.24 ± 1.71	0.043*
3 hr	3.3 ± 1.54	3.9 ± 1.87	0.083
3 hr 30 min	3.46 ± 1.47	4.08 ± 1.64	0.050*
4 hr	3.68 ± 1.30	4.16 ± 1.56	0.098
4 hr 30 min	3.92 ± 1.16	4.3 ± 1.04	0.087
5 hr	4.6 ± 0.99	4.66 ± 1.06	0.771

*Statistically significant (P < 0.05)

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The VAS scores were significantly lower in Group LN compared to Group LF at 1 hour 30 minutes, 2 hours, 2 hours 30 minutes, and 3 hours 30 minutes postoperatively ($P < 0.05$), indicating better early postoperative analgesia in the nalbuphine group. However, by 5 hours postoperatively, there was no significant difference in VAS scores between the two groups.

Adverse Effects

The incidence of adverse effects in both groups is summarized in Table 7.

Table 7: Comparison of Adverse Effects

Adverse Effect	Group LN (n=50)	Group LF (n=50)
Bradycardia	0	0
Respiratory depression	0	0
Hypotension	3 (6%)	4 (8%)
Nausea and Vomiting	1 (2%)	2 (4%)
Postoperative shivering	5 (10%)	7 (14%)
Pruritus	0	2 (4%)

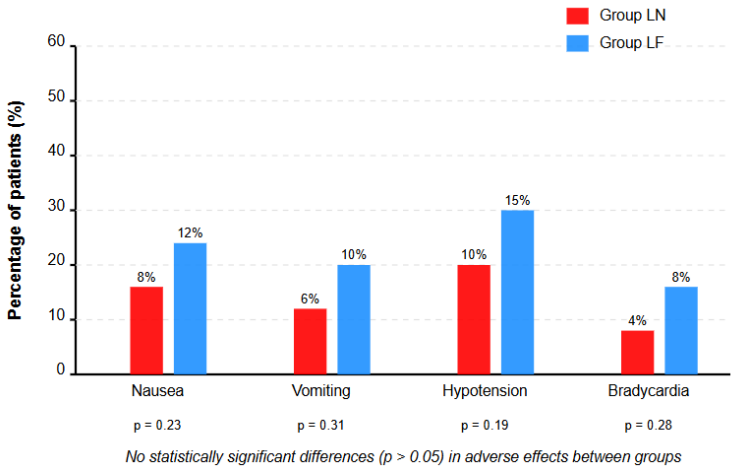

Figure 8: Bar graph comparing adverse effects between the two groups

No instances of bradycardia or respiratory depression were observed in either group. Hypotension occurred in 3 patients (6%) in Group LN and 4 patients (8%) in Group LF. Nausea and vomiting were reported in 1 patient (2%) in Group LN and 2 patients (4%) in Group LF. Postoperative shivering was observed in 5 patients (10%) in Group LN and 7 patients (14%) in Group LF. Pruritus was reported only in Group LF (2 patients, 4%). The differences in adverse effects between the two groups were not statistically significant.

DISCUSSION

This prospective, randomized, double-blind study compared the efficacy of

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intrathecal nalbuphine and fentanyl as adjuvants to hyperbaric levobupivacaine for spinal anesthesia in lower abdominal surgeries. The primary findings revealed differences in the duration of sensory and motor blockade, postoperative analgesia, and adverse effect profiles between the two adjuvants.

Demographic Characteristics

The demographic analysis revealed a significant difference in age distribution between the two groups, with Group LN having a higher mean age (51.32 years) compared to Group LF (41.28 years). This difference could potentially influence the outcome parameters, as age-related changes in the spinal cord and nerve roots might affect the spread and duration of spinal anesthesia[18]. Despite this limitation, the height distribution was comparable between the groups, which is important since height is a known factor affecting the spread of local anesthetics in the subarachnoid space[19].

Sensory and Motor Block Characteristics

In our study, the onset of sensory blockade was similar in both groups (2.795 minutes in Group LN vs. 2.625 minutes in Group LF), with no statistically significant difference. This finding is consistent with Thote et al.[12], who observed comparable onset times when comparing nalbuphine and fentanyl as adjuvants to bupivacaine. Similarly, Gupta et al.[20] reported no significant difference in the onset of sensory blockade when comparing various doses of intrathecal nalbuphine.

However, our study revealed that the duration of sensory blockade was significantly longer in the fentanyl group (306.88 minutes) compared to the nalbuphine group (282.29 minutes). This finding contradicts some previous studies. Mukherjee et al.[21] observed longer sensory block duration with nalbuphine compared to control, while Gomaa et al.[22] also reported findings similar to ours, with longer sensory block duration in the fentanyl group compared to the nalbuphine group in patients undergoing cesarean section.

Regarding motor blockade, the time to achieve complete motor block (Bromage 3) was comparable between the two groups. However, the regression of motor blockade to Bromage 0 was significantly prolonged in Group LF (242.96 minutes) compared to Group LN (178.46 minutes). This finding differs from Mavaliya et al.[23], who reported significantly longer duration of motor block with nalbuphine compared to fentanyl when used as an adjuvant to ropivacaine. The differences in our results could be attributed to the different local anesthetics used (levobupivacaine vs. ropivacaine or bupivacaine) and variations in the study population.

The faster recovery from motor blockade in the nalbuphine group could be advantageous in ambulatory surgery, allowing earlier mobilization and discharge. This characteristic of nalbuphine might be explained by its dual agonist-antagonist action, which could potentially modulate the effect of local anesthetics on motor fibers[24].

Hemodynamic Parameters

The heart rate remained stable and comparable between both groups throughout the observation period. This hemodynamic stability reflects the safety profile of both adjuvants when used at the specified doses. However, there were significant differences in blood pressure at specific time points.

The systolic blood pressure was significantly lower in Group LF at 5 minutes, while diastolic blood pressure showed significant differences at multiple time points (5, 30, 45, and 60 minutes), with lower values in Group LN at 30, 45, and 60 minutes. These findings align with Sapote et al.[25], who reported changes in hemodynamic parameters with nalbuphine. The lower diastolic blood pressure in Group LN during the intermediate

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phase (30-60 minutes) could be attributed to the differential effects of κ-receptor agonism on peripheral vascular resistance[26].

Despite these statistical differences, the changes in blood pressure remained within clinically acceptable limits, not requiring intervention in most cases. The incidence of hypotension requiring treatment was low in both groups (6% in Group LN vs. 8% in Group LF), suggesting that both adjuvants maintain reasonable hemodynamic stability when combined with levobupivacaine.

Postoperative Analgesia

The assessment of postoperative analgesia using VAS scores revealed interesting temporal patterns. The VAS scores were significantly lower in Group LN compared to Group LF at 1 hour 30 minutes, 2 hours, 2 hours 30 minutes, and 3 hours 30 minutes postoperatively, indicating better early postoperative analgesia with nalbuphine. This finding is consistent with Sujata et al.[27], who found nalbuphine to be more effective than fentanyl in providing postoperative analgesia in lower limb orthopedic surgeries.

However, by 5 hours postoperatively, there was no significant difference in VAS scores between the two groups. This suggests that while nalbuphine provides superior early postoperative analgesia, the long-term analgesic effects of both adjuvants are comparable. These findings align with Shah et al.[28], who concluded that intrathecal nalbuphine in a 1.6 mg dose effectively enhances the duration of analgesia when combined with hyperbaric bupivacaine.

The superior early analgesic effect of nalbuphine might be attributed to its action on κ-opioid receptors in the spinal cord, which are particularly involved in visceral pain modulation[29]. Lower abdominal surgeries often involve manipulation of visceral structures, making nalbuphine potentially more effective in this context.

Adverse Effects

The safety profile of both adjuvants was favorable, with no instances of severe adverse effects such as bradycardia or respiratory depression. The incidence of hypotension, nausea, vomiting, and shivering was slightly lower in Group LN compared to Group LF, though the differences were not statistically significant.

Notably, pruritus occurred exclusively in Group LF (4% of patients), which is consistent with the known side-effect profile of intrathecal fentanyl. Bindra et al.[30] also reported a similar incidence of pruritus with intrathecal fentanyl. The absence of pruritus in Group LN supports the advantage of nalbuphine's partial μ-antagonist activity, which may counteract the pruritus-inducing effects typically associated with pure μ-agonists like fentanyl[31].

The overall lower incidence of adverse effects in the nalbuphine group corroborates the findings of Culebras et al.[32], who reported fewer adverse effects such as pruritus and postoperative nausea and vomiting with intrathecal nalbuphine compared to morphine. This favorable side-effect profile makes nalbuphine an attractive option, particularly in patients with a history of opioid-related side effects.

Clinical Implications

The findings of our study have several clinical implications. The prolonged duration of sensory and motor blockade with fentanyl makes it suitable for longer surgical procedures where extended anesthesia is required. Conversely, nalbuphine offers advantages in terms of earlier motor recovery, better early postoperative analgesia, and fewer side effects, making it potentially preferable for ambulatory surgeries or patients at higher risk of opioid-related adverse effects.

The selection between these adjuvants should be individualized based on the specific requirements of the surgical procedure, patient

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characteristics, and the desired postoperative course. For instance, in elderly patients or those with comorbidities who are more vulnerable to hemodynamic instability, nalbuphine might be preferred due to its relative hemodynamic stability[33].

Limitations and Future Directions

Our study has several limitations. First, the significant age difference between the two groups could potentially confound the results. Second, we did not assess the long-term postoperative outcomes beyond 5 hours. Third, the study was conducted at a single center with a relatively homogeneous patient population, which might limit the generalizability of the findings.

Future research should address these limitations by ensuring better demographic matching, extending the observation period, and including a more diverse patient population. Additionally, studies comparing different doses of nalbuphine and fentanyl could help identify the optimal dose-response relationship for each adjuvant. Investigating the efficacy of these adjuvants in specific surgical procedures or patient populations (e.g., geriatric patients, obese patients) would also be valuable.

Exploring the combination of these adjuvants with other local anesthetics or investigating multimodal approaches incorporating other analgesic modalities could further advance our understanding of optimal pain management strategies for lower abdominal surgeries.

CONCLUSION

This prospective, randomized study comparing nalbuphine (0.8 mg) and fentanyl (25 µg) as adjuvants to 0.5% hyperbaric levobupivacaine for spinal anesthesia in lower abdominal surgeries demonstrated distinct characteristics for each adjuvant.

Fentanyl significantly prolonged both sensory and motor blockade compared to nalbuphine, making it potentially more suitable for extended surgical procedures. In contrast, nalbuphine provided superior early postoperative analgesia with lower VAS scores in the first 3.5 hours and facilitated earlier motor recovery, which may be advantageous for ambulatory surgeries or enhanced recovery protocols.

Hemodynamic parameters remained largely stable with both adjuvants, with minor variations in systolic and diastolic blood pressure at specific time points. The adverse effect profile was favorable in both groups, though nalbuphine demonstrated advantages with the absence of pruritus and slightly lower incidence of nausea, vomiting, and shivering.

The choice between these adjuvants should be tailored to the specific requirements of the surgical procedure, expected duration, patient characteristics, and desired recovery profile. Nalbuphine appears to be a viable alternative to fentanyl as an adjuvant to levobupivacaine, offering comparable efficacy with some potential advantages in terms of recovery profile and side effect incidence.

Further studies with larger sample sizes, better demographic matching, and extended observation periods would enhance our understanding of the optimal use of these adjuvants in various clinical scenarios.

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