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ASSESSMENT OF PREMIXED VERSUS SEQUENTIAL ADMINISTRATION OF HYPERBARIC LEVOBUPIVACAINE WITH FENTANYL FOR SENSORY EFFECT OF SPINAL ANAESTHESIA IN PATIENTS UNDERGOING LOWER ABDOMINAL SURGERIES

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ABSTRACT

Background: Spinal anaesthesia is widely employed for elective lower abdominal surgeries because of its rapid onset, reliable sensory blockade, excellent muscle relaxation, and favourable recovery profile. Hyperbaric levobupivacaine is increasingly preferred due to its reduced cardiotoxicity and improved safety profile compared with racemic bupivacaine. Intrathecal fentanyl is commonly used as an adjuvant to enhance block quality and postoperative analgesia. However, limited evidence exists regarding whether sequential administration of hyperbaric levobupivacaine and fentanyl offers advantages over premixed administration in terms of sensory block characteristics, haemodynamic stability, and postoperative analgesia.

Methods: This prospective observational comparative study was conducted in the Department of Anaesthesiology, Sree Balaji Medical College and Hospital, Chennai, between October 2024 and October 2025. A total of 58 patients aged 18–60 years belonging to ASA physical status I and II and undergoing elective lower abdominal surgeries under spinal anaesthesia were enrolled. Participants were allocated into two groups of 29 patients each. Group S received sequential intrathecal administration of hyperbaric levobupivacaine followed by fentanyl, whereas Group M received a premixed intrathecal solution of the same drugs. Sensory block characteristics, haemodynamic parameters, and postoperative analgesic outcomes were assessed and compared between the groups.

Results: Baseline demographic and clinical characteristics were comparable between groups. The onset of sensory block was significantly faster in Group S than in Group M (3.72 ± 0.81 vs. 4.45 ± 0.90 minutes; p=0.003). The duration of sensory blockade was significantly prolonged in Group S, with regression to the L1 dermatome occurring at 103.28 ± 11.98 minutes compared with 91.86 ± 10.95 minutes in Group M (p<0.001). Mean arterial pressure was significantly higher in Group S (83.52 ± 6.21 mmHg) than in Group M (79.90 ± 6.84 mmHg; p=0.031). The incidence of hypotension (17.24% vs. 37.93%) and vasopressor requirement (13.79% vs. 34.48%) were lower in Group S. Postoperative analgesia was significantly superior in Group S, with a longer time to first rescue analgesia (198.52 ± 26.21 vs. 162.48 ± 23.95 minutes; p<0.001) and lower total analgesic consumption (108.97 ± 27.84 vs. 146.21 ± 32.59 mg; p<0.001).

Conclusion: Sequential intrathecal administration of hyperbaric levobupivacaine and fentanyl provides faster onset and longer duration of sensory blockade, improved haemodynamic stability, prolonged postoperative analgesia, and reduced analgesic consumption compared with premixed administration. Sequential administration may therefore represent a simple and effective strategy for optimizing spinal anaesthesia in elective lower abdominal surgeries.

KEYWORDS: Spinal anaesthesia; Levobupivacaine; Fentanyl; Sequential administration; Premixed administration; Sensory block; Haemodynamic stability; Postoperative analgesia.

INTRODUCTION

Spinal anaesthesia remains one of the most widely practiced regional anaesthetic techniques for lower abdominal and lower limb surgeries because of its simplicity, rapid onset, dense sensory blockade, excellent muscle relaxation, and reduced requirement for systemic anaesthetic agents. Compared with general anaesthesia, spinal anaesthesia offers several advantages, including avoidance of airway manipulation, lower incidence of postoperative nausea and vomiting, superior

postoperative analgesia, and earlier recovery of physiological functions. Consequently, it has become the preferred anaesthetic technique for a large proportion of elective infraumbilical surgical procedures worldwide [1].

The effectiveness of spinal anaesthesia depends on the successful deposition of local anaesthetic agents within the cerebrospinal fluid (CSF) of the subarachnoid space, where they act by reversibly blocking voltage-gated sodium channels in spinal nerve roots. This interruption of impulse transmission produces sensory, motor, and sympathetic blockade below the level of injection [2]. Accurate placement of the spinal needle, proper patient positioning, and understanding of spinal anatomy are essential for achieving a predictable and effective block. Standardized techniques for assessment of sensory block level and block regression are therefore critical when evaluating different spinal anaesthetic approaches [3].

Spinal anaesthesia continues to be extensively utilized for lower abdominal surgeries because it provides profound intraoperative analgesia while minimizing systemic drug exposure and facilitating early postoperative recovery. In modern anaesthetic practice, achieving an optimal balance between adequate surgical anaesthesia and haemodynamic stability remains a major objective. Excessive sympathetic blockade may result in hypotension and bradycardia, whereas inadequate spread of local anaesthetic may compromise surgical conditions. Therefore, considerable research has focused on factors influencing the extent and duration of spinal blockade [4].

Several anatomical and physiological variables influence intrathecal drug distribution, including cerebrospinal fluid volume, patient position, injection site, injection speed, and characteristics of the injected solution. Detailed anatomical studies have demonstrated that structural variability within the spinal canal may contribute significantly to differences in block spread among individuals [5]. Furthermore, magnetic resonance imaging-based investigations have shown that lumbosacral cerebrospinal fluid volume is one of the principal determinants of sensory block height and duration. Patients with lower CSF volumes often experience higher levels of sensory blockade and prolonged block duration compared with those having larger CSF volumes [6].

Among the factors influencing intrathecal drug distribution, baricity remains one of the most important determinants. Baricity refers to the density of an anaesthetic solution relative to cerebrospinal fluid and governs the gravitational movement of the drug within the subarachnoid space. Hyperbaric solutions tend to migrate toward dependent areas under gravitational influence, producing more predictable sensory levels than isobaric solutions. Reviews of intrathecal drug spread have emphasized that even minor alterations in solution density may significantly affect cephalad spread and block characteristics [7]. Experimental studies evaluating the distribution of local anaesthetic solutions within the subarachnoid space have similarly demonstrated that hyperbaric solutions provide more consistent and predictable block patterns due to their density-dependent movement [8].

Levobupivacaine, the pure S(-)-enantiomer of bupivacaine, has gained increasing popularity as an intrathecal local anaesthetic because of its favourable safety profile. Pharmacological studies have demonstrated that levobupivacaine produces sensory and motor blockade comparable to racemic bupivacaine while exhibiting lower cardiotoxicity and neurotoxicity. This improved safety profile has led to its widespread adoption in regional anaesthesia, particularly in patients where cardiovascular stability is an important consideration [10]. Subsequent reviews have further confirmed that levobupivacaine maintains effective anaesthetic efficacy while reducing the risk of adverse cardiovascular events associated with racemic bupivacaine [11]. Controlled volunteer studies have also demonstrated fewer cardiovascular effects with levobupivacaine when compared with racemic bupivacaine, supporting its use in neuraxial anaesthesia [12].

To enhance the quality and duration of spinal anaesthesia, opioids are frequently added as intrathecal adjuvants. Fentanyl is among the most commonly used intrathecal opioids because of its high lipophilicity, rapid onset of action, and limited rostral spread within the cerebrospinal fluid. Experimental studies have shown that fentanyl selectively enhances sensory analgesia without proportionately increasing sympathetic blockade, thereby improving analgesic quality while preserving haemodynamic stability [13]. Clinical investigations evaluating the addition of fentanyl to intrathecal local anaesthetics have demonstrated improved intraoperative analgesia, enhanced patient comfort, and reduced supplemental analgesic requirements [14]. Furthermore, fentanyl has been shown to prolong postoperative analgesia significantly when combined with bupivacaine, thereby improving the overall quality of spinal anaesthesia without substantially increasing motor blockade duration [15].

Recent interest has focused on the influence of drug preparation and administration techniques on intrathecal spread. Mixing fentanyl with hyperbaric local anaesthetic solutions may alter the final density of the injected mixture and consequently modify its baricity. Experimental densitometric analyses have demonstrated that the addition of fentanyl can reduce the density of hyperbaric local anaesthetic solutions, potentially affecting their gravitational behaviour within the subarachnoid space [9]. Therefore, the method of intrathecal administration—whether drugs are injected sequentially using separate syringes or premixed in a single syringe—may influence sensory block characteristics, haemodynamic responses, and postoperative analgesic outcomes.

Despite increasing use of hyperbaric levobupivacaine combined with fentanyl in elective lower abdominal surgeries, limited evidence exists regarding the impact of sequential versus premixed intrathecal administration on clinical outcomes. Understanding whether preservation of hyperbaricity through sequential administration improves sensory block performance and haemodynamic stability may help optimize spinal anaesthetic practice. Therefore, the present study was undertaken to compare the sensory block characteristics, haemodynamic parameters, and postoperative analgesic outcomes following sequential and premixed intrathecal administration of hyperbaric levobupivacaine with fentanyl in patients undergoing elective lower abdominal surgeries.

MATERIALS AND METHODS

This prospective observational comparative study was conducted in the Department of Anaesthesiology, Sree Balaji Medical College and Hospital, Chennai, India, over a period of one year from October 2024 to October 2025. The study

included adult patients aged 18–60 years belonging to the American Society of Anesthesiologists (ASA) physical status I and II who were scheduled to undergo elective lower abdominal surgeries under spinal anaesthesia. Institutional Ethics Committee approval was obtained before commencement of the study, and written informed consent was obtained from all participants prior to enrolment.

A total of 58 eligible patients were recruited consecutively using a purposive sampling technique until the required sample size was achieved. Patients were allocated into two groups comprising 29 participants each based on the technique of intrathecal drug administration.

Group S (Sequential Administration): Patients received 2.5 mL of 0.5% hyperbaric levobupivacaine (12.5 mg) followed immediately by 0.5 mL fentanyl (25 μg) administered sequentially using separate sterile syringes.

Group M (Premixed Administration): Patients received the same dose of 0.5% hyperbaric levobupivacaine (12.5 mg) and fentanyl 25 μg, premixed in a single sterile syringe with a total injectate volume of 3.0 mL.

Patients with known hypersensitivity to local anaesthetics or opioids, coagulation abnormalities, infection at the puncture site, severe cardiovascular disease, neurological disorders, spinal deformities, contraindications to spinal anaesthesia, pregnancy, or refusal to participate were excluded from the study.

Pre-anaesthetic Evaluation

All patients underwent a detailed pre-anaesthetic evaluation including medical history, physical examination, airway assessment, ASA physical status classification, and routine laboratory investigations. Appropriate fasting guidelines were followed. Intravenous access was secured using an 18-gauge intravenous cannula, and patients were preloaded with crystalloid solution according to institutional protocol.

Anaesthetic Technique

After shifting to the operating theatre, standard ASA monitoring consisting of continuous electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and heart rate monitoring was instituted. Baseline heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure (MAP), and oxygen saturation were recorded.

Under strict aseptic precautions, spinal anaesthesia was performed with the patient in the sitting position at the L3–L4 or L4–L5 intervertebral space using a 25-gauge Quincke spinal needle through the midline approach. Following confirmation of free flow of cerebrospinal fluid, the allocated intrathecal drugs were administered according to the study group. Immediately after completion of intrathecal injection, all patients were positioned supine, and supplemental oxygen was administered through a face mask at 4–6 L/min throughout the procedure.

Assessment of Sensory Block

Sensory blockade was assessed bilaterally using the pin-prick method with a 22-gauge hypodermic needle along the mid-clavicular line. Sensory assessment was performed every 2 minutes following intrathecal injection until the maximum sensory level was achieved and subsequently every 15 minutes until regression of the block.

The onset of sensory block was defined as the time from completion of intrathecal injection to loss of pin-prick sensation at the T10 dermatome. The highest sensory level achieved (T6, T8 or T10) and the duration of sensory blockade, defined as the time from intrathecal injection until regression of the sensory block to the L1 dermatome, were recorded.

Haemodynamic Monitoring

Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and peripheral oxygen saturation (SpO_2) were recorded at baseline, immediately after intrathecal injection, every 2 minutes for the first 10 minutes, every 5 minutes thereafter until completion of surgery, and immediately before transfer to the postoperative recovery area.

Hypotension was defined as a decrease in mean arterial pressure of more than 20% from the baseline value or MAP below 65 mmHg. Hypotensive episodes were managed with intravenous crystalloid boluses and intravenous mephentermine 6 mg, repeated as required.

Bradycardia was defined as a heart rate below 50 beats per minute and was treated with intravenous atropine 0.6 mg.

The incidence of hypotension, bradycardia, vasopressor requirement, nausea, vomiting, pruritus, respiratory depression, and other adverse events was documented throughout the study period.

Postoperative Analgesia

Postoperative pain was assessed using the Visual Analogue Scale (VAS) at predetermined intervals in the postoperative recovery room.

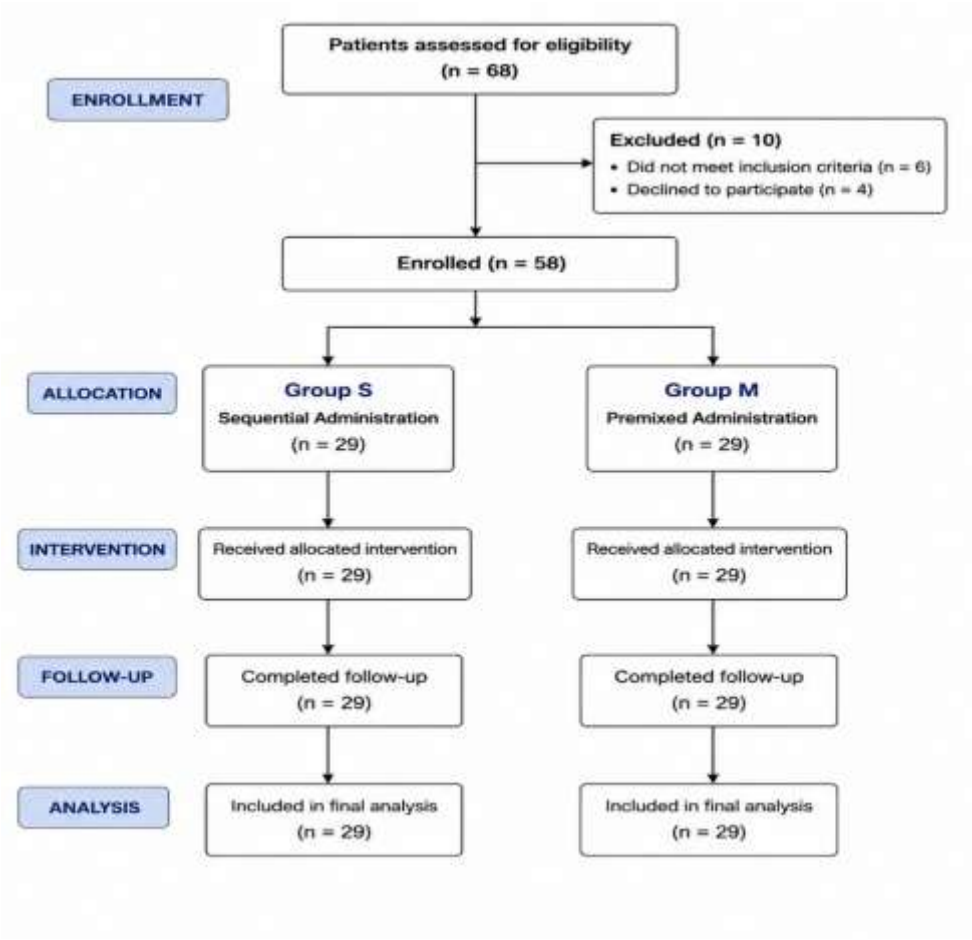
Rescue analgesia was administered when the VAS score was ≥4. The first rescue analgesic consisted of Inj. Paracetamol 1 g administered intravenously over 15 minutes. If pain persisted despite paracetamol administration, additional analgesia was provided according to the institutional postoperative pain management protocol.

The time to first rescue analgesia and the total postoperative analgesic consumption during the first 6 postoperative hours were recorded for all participants.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 22.0; IBM Corp., Armonk, NY, USA).

Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequency and percentage. Intergroup comparisons of continuous variables were performed using the independent Student's t-test, while categorical variables were analysed using the Chi-square test or Fisher's exact test, wherever appropriate. A p-value of less than 0.05 was considered statistically significant.



RESULTS

Table 1. Baseline Characteristics of Study Participants (n = 58)

Variable	Group S (n=29) Mean ± SD	Group M (n=29) Mean ± SD	p value
Age (years)	38.93 ± 9.84	40.17 ± 10.12	0.612
BMI (kg/m²)	24.68 ± 2.74	25.10 ± 2.99	0.558

Description:
The baseline demographic characteristics were comparable between the two study groups. The mean age was 38.93 ± 9.84 years in Group S and 40.17 ± 10.12 years in Group M (p=0.612). Similarly, mean BMI was 24.68 ± 2.74 kg/m² in Group S and 25.10 ± 2.99 kg/m² in Group M (p=0.558). The absence of statistically significant differences indicates that both groups were homogeneous at baseline and suitable for comparison.

Table 2. Distribution of Gender and ASA Grade Among Study Groups (n = 58)

Variable	Group S n (%)	Group M n (%)	p value
Male	17 (58.62)	16 (55.17)	0.792
Female	12 (41.38)	13 (44.83)	
ASA I	19 (65.52)	18 (62.07)	0.781
ASA II	10 (34.48)	11 (37.93)	

Description:
Gender distribution was similar between the two groups, with males constituting 58.62% in Group S and 55.17% in Group M (p=0.792). Likewise, ASA Grade I patients accounted for 65.52% in Group S and 62.07% in Group M, while ASA Grade II patients constituted 34.48% and 37.93%, respectively (p=0.781). These findings demonstrate comparable preoperative characteristics between the study groups.

Table 3. Comparison of Onset of Sensory Block Between Study Groups

Variable	Group S Mean ± SD	Group M Mean ± SD	p value
Onset of sensory block (minutes)	3.72 ± 0.81	4.45 ± 0.90	0.003

Description:
The onset of sensory block was significantly faster in the sequential administration group. The mean onset time was 3.72 ± 0.81 minutes in Group S compared with 4.45 ± 0.90 minutes in Group M. This difference was statistically significant (p=0.003), indicating that sequential administration facilitates earlier establishment of effective sensory anaesthesia.

Table 4. Highest Sensory Level Achieved Among Study Groups

Level	Group S n (%)	Group M n (%)	p value
T6	10 (34.48)	6 (20.69)	
T8	13 (44.83)	14 (48.28)	
T10	6 (20.69)	9 (31.03)	0.284

Description:
The highest sensory level achieved was similar in both groups. In Group S, the most frequently attained level was T8 (44.83%), followed by T6 (34.48%) and T10 (20.69%). Comparable findings were observed in Group M, with T8 being the commonest level (48.28%). The difference between groups was not statistically significant (p=0.284), suggesting that the method of drug administration did not influence the maximum sensory block level attained.

Table 5. Duration of Sensory Block (Time to Regression to L1)

Variable	Group S Mean ± SD	Group M Mean ± SD	p value
Time to regression to L1 (minutes)	103.28 ± 11.98	91.86 ± 10.95	<0.001

Description:
The duration of sensory blockade was significantly prolonged in the sequential administration group. The mean time to regression to L1 dermatome was 103.28 ± 11.98 minutes in Group S compared with 91.86 ± 10.95 minutes in Group M. This difference was highly statistically significant (p<0.001), indicating superior maintenance of sensory anaesthesia with sequential intrathecal administration.

Table 6. Comparison of Haemodynamic Outcomes Between Study Groups

Variable	Group S	Group M	p value
Mean MAP (mmHg)	83.52 ± 6.21	79.90 ± 6.84	0.031
Hypotension n (%)	5 (17.24)	11 (37.93)	0.074
Vasopressor Requirement n (%)	4 (13.79)	10 (34.48)	0.061

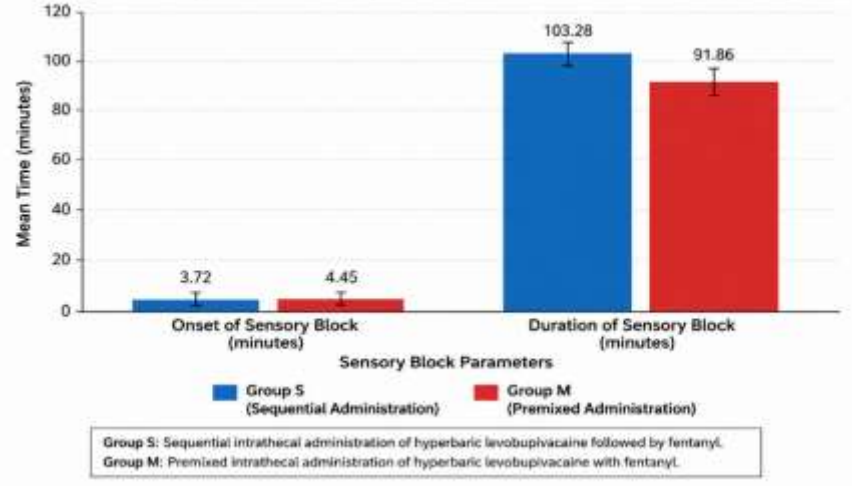
Description:
Group S demonstrated significantly higher mean intraoperative MAP values (83.52 ± 6.21 mmHg) compared with Group M (79.90 ± 6.84 mmHg) (p=0.031). The incidence of hypotension and vasopressor requirement was lower in Group S (17.24% and 13.79%, respectively) than in Group M (37.93% and 34.48%, respectively), although these differences did not reach statistical significance. These findings suggest improved haemodynamic stability with sequential administration.

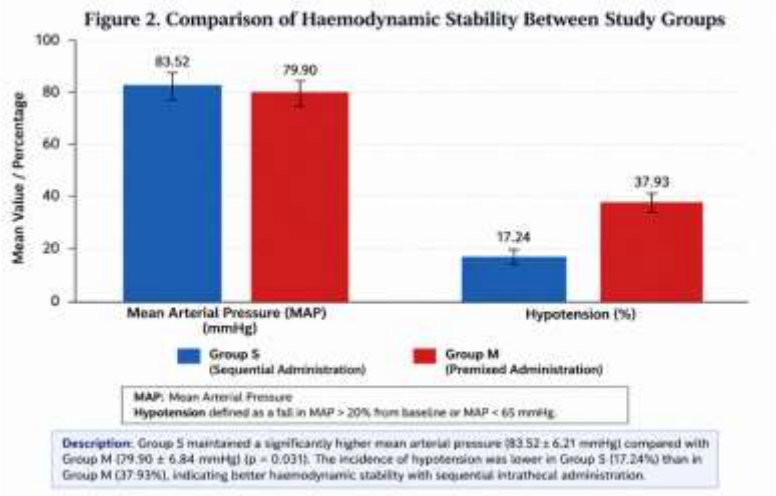
Table 7. Comparison of Postoperative Analgesic Outcomes

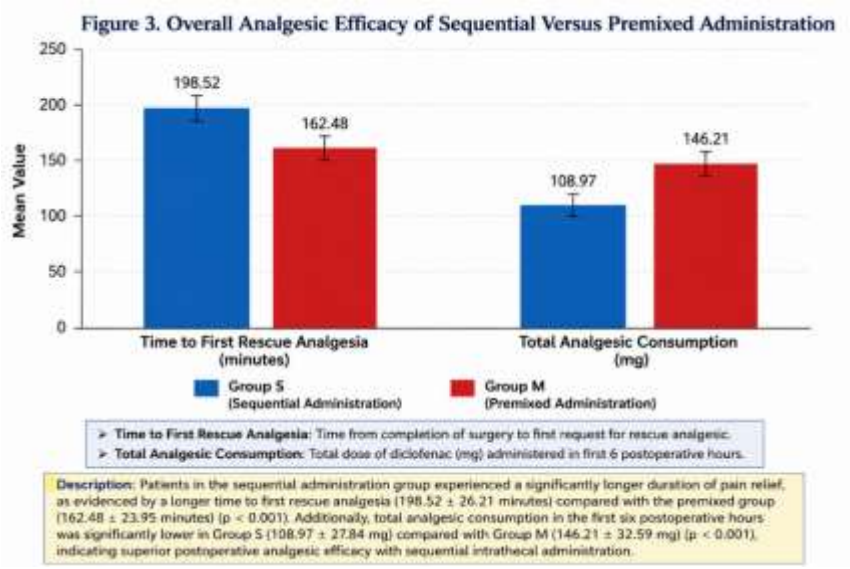
Variable	Group S Mean ± SD	Group M Mean ± SD	p value
Time to first rescue analgesia (minutes)	198.52 ± 26.21	162.48 ± 23.95	<0.001
Total analgesic consumption (mg)	108.97 ± 27.84	146.21 ± 32.59	<0.001

Description:
Postoperative analgesia was significantly better in the sequential administration group. The mean time to first rescue analgesia was prolonged in Group S (198.52 ± 26.21 minutes) compared with Group M (162.48 ± 23.95 minutes) (p<0.001). Additionally, total analgesic consumption during the first six postoperative hours was significantly lower in Group S (108.97 ± 27.84 mg) than in Group M (146.21 ± 32.59 mg) (p<0.001). These findings demonstrate superior postoperative pain control with sequential intrathecal administration.

Figure 1. Comparison of Sensory Block Characteristics Between Study Groups







DISCUSSION

In the present study, sequential intrathecal administration of hyperbaric levobupivacaine with fentanyl resulted in significantly superior sensory block characteristics compared with premixed administration. The onset of sensory block was significantly faster in Group S (3.72 ± 0.81 minutes) than in Group M (4.45 ± 0.90 minutes; p=0.003), indicating earlier establishment of surgical anaesthesia. Furthermore, the duration of sensory blockade was significantly prolonged in Group S (103.28 ± 11.98 minutes) compared with Group M (91.86 ± 10.95 minutes; p<0.001).

Desai et al. [16] evaluated sequential and premixed administration of hyperbaric bupivacaine with intrathecal opioids during spinal anaesthesia for caesarean section and reported superior sensory block characteristics with sequential administration. Their findings suggested that preserving the original characteristics of the hyperbaric solution improved block performance. Similarly, Malhotra et al. [17] demonstrated that succedent administration of fentanyl and bupivacaine produced earlier sensory blockade and improved block quality during lower limb surgeries. Chekole et al. [18] further observed that sequential administration achieved effective sensory anaesthesia more rapidly and provided improved intraoperative conditions compared with premixed administration. The findings of these studies are consistent with the present investigation and support the hypothesis that maintaining drug density and baricity influences intrathecal spread and sensory block onset.

The choice of levobupivacaine in the present study was supported by previous comparative investigations. Glaser et al. [19] reported that levobupivacaine provided spinal anaesthesia comparable to racemic bupivacaine while maintaining a favourable cardiovascular profile. Fattorini et al. [20] similarly demonstrated effective sensory and motor blockade with reduced cardiovascular adverse effects. Lee et al. [21] found levobupivacaine to provide reliable surgical anaesthesia and stable haemodynamic conditions during urological procedures. Alley et al. [22] further confirmed that hyperbaric levobupivacaine produced satisfactory sensory blockade with predictable regression characteristics. Collectively, these studies support the safety and efficacy of levobupivacaine and justify its use in the present investigation.

Postoperative analgesia was significantly improved in the sequential administration group. The mean time to first rescue analgesia was prolonged from 162.48 ± 23.95 minutes in Group M to 198.52 ± 26.21 minutes in Group S (p<0.001), while total postoperative analgesic consumption was significantly reduced from 146.21 ± 32.59 mg to 108.97 ± 27.84 mg (p<0.001). Ben-David et al. [23] demonstrated that intrathecal fentanyl enhanced perioperative analgesia and prolonged postoperative pain relief when added to spinal local anaesthetic solutions. Similarly, Kuusniemi et al. [24] reported

reduced postoperative analgesic requirements and improved patient comfort with fentanyl-containing spinal anaesthesia. The improved analgesic profile observed in the present study therefore supports the established role of fentanyl as an effective intrathecal adjuvant.

Haemodynamic stability represents a major determinant of successful spinal anaesthesia. In the present study, Group S maintained significantly higher mean arterial pressure than Group M (83.52 ± 6.21 mmHg versus 79.90 ± 6.84 mmHg; p=0.031). Additionally, hypotension occurred less frequently in Group S (17.24%) than in Group M (37.93%), while vasopressor requirement was lower (13.79% versus 34.48%). Critchley et al. [25] emphasized that hypotension remains one of the most frequent complications of spinal anaesthesia due to sympathetic blockade and altered venous return. Carpenter et al. [26] identified hypotension as a major adverse effect associated with neuraxial blockade and highlighted the relationship between block spread and cardiovascular instability. The lower incidence of hypotension observed in the present study may therefore be related to a more controlled distribution of hyperbaric levobupivacaine following sequential administration.

Sun et al. [27], in a systematic review and meta-analysis, concluded that fentanyl is an effective intrathecal adjuvant that prolongs analgesic duration and improves the quality of spinal anaesthesia. Likewise, Singh et al. [28] demonstrated that intrathecal fentanyl significantly prolongs sensory blockade and enhances postoperative analgesia when combined with local anaesthetic agents. These observations are in agreement with the present findings, where sequential administration resulted in prolonged sensory block duration and delayed requirement for rescue analgesia.

Keera and Elnabtity [29] evaluated a two-syringe spinal anaesthesia technique and reported improved block quality, better patient satisfaction, and reduced haemodynamic disturbances compared with conventional administration methods. Their observations closely resemble the findings of the present study, where sequential administration resulted in superior sensory block performance and improved haemodynamic stability. Similarly, Hussien and Rabie [30] investigated sequential intrathecal injection of fentanyl and hyperbaric bupivacaine and reported enhanced sensory block characteristics together with favourable haemodynamic outcomes. The findings of Hussien and Rabie are particularly relevant because they directly support the concept that preservation of hyperbaricity through sequential administration improves the clinical performance of spinal anaesthesia.

Overall, the studies consistently support the major findings of the present study. Sequential administration was associated with faster onset of sensory blockade, prolonged duration of anaesthesia, improved postoperative analgesia, reduced analgesic consumption, and better haemodynamic stability. These advantages are likely attributable to preservation of the physical characteristics of the hyperbaric local anaesthetic solution, resulting in more predictable intrathecal spread and enhanced interaction between levobupivacaine and fentanyl within the cerebrospinal fluid.

CONCLUSION

The present study demonstrated that sequential intrathecal administration of hyperbaric levobupivacaine followed by fentanyl provided superior spinal anaesthetic characteristics compared with premixed administration in patients undergoing elective lower abdominal surgeries. Sequential administration resulted in a significantly faster onset of sensory blockade (3.72 ± 0.81 minutes versus 4.45 ± 0.90 minutes; p=0.003) and a significantly prolonged duration of sensory block (103.28 ± 11.98 minutes versus 91.86 ± 10.95 minutes; p<0.001).

In addition, patients receiving sequential administration exhibited better haemodynamic stability, as evidenced by higher mean arterial pressure values and lower incidences of hypotension and vasopressor requirement compared with the premixed group. Although the highest sensory level achieved was comparable between groups, sequential administration produced more favourable block characteristics and improved maintenance of sensory anaesthesia.

Postoperative analgesic outcomes were also significantly improved with sequential administration. The time to first rescue analgesia was prolonged, while total postoperative analgesic consumption was substantially reduced, indicating superior postoperative pain control and enhanced patient comfort.

Based on these findings, sequential intrathecal administration of hyperbaric levobupivacaine and fentanyl appears to be a simple, safe, and effective technique that enhances sensory block quality, prolongs postoperative analgesia, and promotes haemodynamic stability. Therefore, sequential administration may be considered a preferable alternative to premixed administration for spinal anaesthesia in elective lower abdominal surgeries.

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