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Comparative Evaluation of Intrathecal Administration of Levobupivacaine (Hyperbaric) Alone and Low-Dose Levobupivacaine (Hyperbaric) in Combination with Fentanyl in Lower Limb Surgeries: A Prospective Randomized Controlled Trial

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ABSTRACT

Background: Spinal anaesthesia is a preferred method for lower limb surgeries. Levobupivacaine, an S-enantiomer of bupivacaine, is associated with fewer cardiotoxic effects. Fentanyl, an opioid adjuvant, may enhance the efficacy of local anaesthetics. The purpose was to compare the efficacy and safety of intrathecal hyperbaric levobupivacaine alone versus low-dose levobupivacaine with fentanyl in lower limb surgeries.

Methodology: Eighty ASA I-II patients undergoing elective lower limb surgeries were randomly divided into two groups. Group L received 15 mg hyperbaric levobupivacaine; Group LF received 12.5 mg levobupivacaine with 25 µg fentanyl intrathecally. Sensory/motor block characteristics, haemodynamic stability, and side effects were assessed.

Results: The onset of sensory block was faster in Group L (2.86 ± 0.97 min) than Group LF (3.42 ± 0.96 min) ($p = 0.011$). Sensory block lasted slightly longer in Group LF (102.37 ± 17.72 min vs. 96.88 ± 27.85 min; $p = 0.305$). Motor block durations were comparable ($p = 0.952$). Haemodynamic parameters remained stable and similar between groups. Side effects, including hypotension and bradycardia, were slightly more frequent in Group L, but not statistically significant.

Conclusion: Both regimens are effective and safe. Levobupivacaine alone provides faster onset, while the addition of fentanyl permits dose reduction without compromising efficacy. The combination is a clinically useful alternative for lower limb surgeries with minimal side effects.

Keywords: Levobupivacaine, Fentanyl, Spinal Anaesthesia, Lower Limbs Surgery, Haemodynamic Parameters

INTRODUCTION

Spinal anaesthesia is a commonly employed technique for lower limb surgeries, offering effective sensory and motor blockade with rapid onset and minimal systemic effects. Among the various local anaesthetic agents available, Levobupivacaine, the S-enantiomer of Bupivacaine, has gained popularity due to its reduced cardiotoxicity and favourable safety profile compared to racemic Bupivacaine.[1]

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Levobupivacaine provides reliable anaesthesia with prolonged duration, making it suitable for a wide range of surgical procedures. However, the requirement for a higher dose to maintain effective anaesthesia can increase the risk of haemodynamic disturbances such as hypotension and bradycardia.[2,3] To mitigate these issues and enhance block characteristics, intrathecal adjuvants like Fentanyl have been introduced.

Fentanyl is a lipophilic opioid that acts synergistically with local anaesthetics when administered intrathecally. It enhances analgesia, improves the quality of the block, and allows for a reduction in the dose of local anaesthetic required, thus potentially minimising side effects. [2,4,5] Several studies have demonstrated that the addition of Fentanyl to Bupivacaine or Levobupivacaine improves intraoperative analgesia without significantly affecting motor blockade or recovery time.[5-7]

Despite its widespread use, the optimal combination and dosage of Levobupivacaine with Fentanyl for spinal anaesthesia remains an area of clinical interest. Understanding how this combination affects sensory and motor block dynamics, haemodynamic stability, and postoperative outcomes is essential for improving patient safety and satisfaction in regional anaesthesia.

Therefore, this study was designed to perform a comparative evaluation of hyperbaric Levobupivacaine alone versus low-dose hyperbaric Levobupivacaine combined with Fentanyl in spinal anaesthesia for lower limb surgeries. The primary objective was to assess block characteristics and quality of anaesthesia, while the secondary objective included monitoring for side effects and haemodynamic variations.

MATERIALS AND METHODS

This prospective, randomized, single-blinded controlled trial was conducted at the Department of Anaesthesiology, SLBS Government Medical College, Ner Chowk, Mandi, Himachal Pradesh. Institutional ethical committee approval was received (No. HFW/SLBSGMCH/Student Sec/7149-55/2025). After considering an expected standard deviation of 1.2 with an accepted error of 5%, a study power of 90%, and a mean score difference of 0.2, a sample size of 39 is obtained for each group, hence patients were randomly allocated into study groups using a computer-generated randomisation sequence and informed consent was obtained from 80 patients aged 20-60 years with ASA physical status I or II undergoing elective lower limb surgeries (Figure 1). Exclusion criteria were refusal, known allergies to study drugs, coagulopathy, systemic disease, and infection at the puncture site.

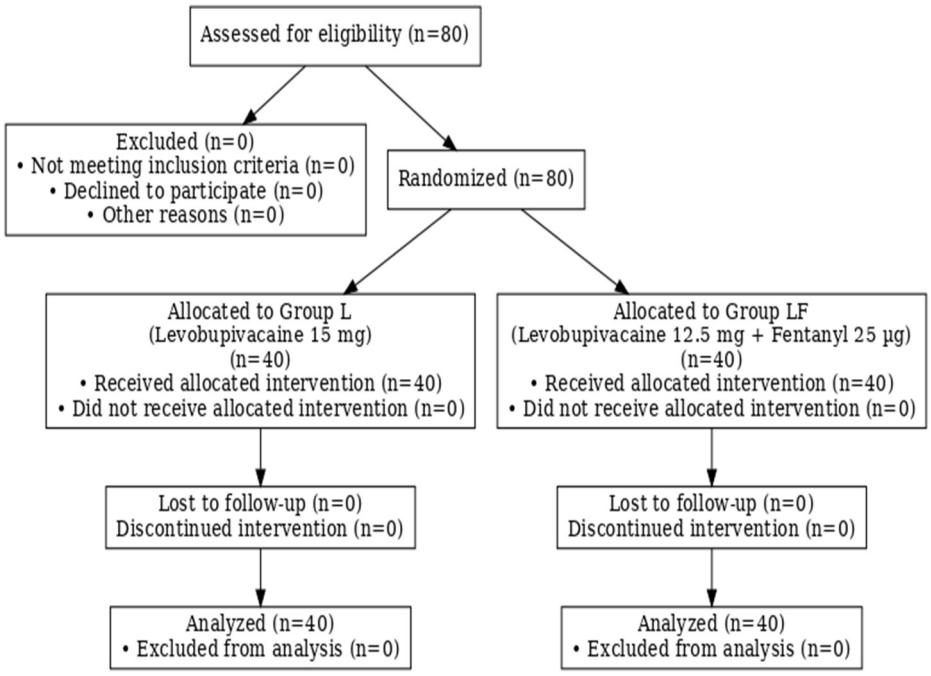

Figure 1: CONSORT flow diagram of patient enrolment and allocation

Participants were randomly assigned to two equal groups (n=40 each):

Group L (Levobupivacaine): 15 mg (3 mL of 0.5%) hyperbaric levobupivacaine intrathecally.

Group LF (Levobupivacaine + Fentanyl): 12.5 mg (2.5 mL of 0.5%) hyperbaric levobupivacaine with 25 µg (0.5 mL) fentanyl intrathecally.

Preoperative Preparation: All patients underwent a comprehensive pre-anaesthetic evaluation, which included a detailed medical history, physical examination, and necessary baseline investigations. Upon confirmation of fitness for anaesthesia and surgery, patients were advised nil per OS (NPO) for at least 8 hours before the scheduled procedure. On the night preceding surgery, all patients received oral Alprazolam 0.5 mg to reduce pre-

operative anxiety and facilitate sleep.

Anaesthetic Procedure: An intravenous (IV) access was established using an 18-gauge cannula. Standard non-invasive monitoring electrocardiography, non-invasive blood pressure (NIBP), and pulse oximetry was initiated, and baseline vital parameters were recorded. Patients were preloaded with crystalloid solution at a dose of 10 ml/kg body weight.

Subarachnoid block was administered via the midline lumbar approach at the L3-L4 interspace, using a 26-gauge Quincke spinal needle, under strict aseptic precautions. The procedure was performed with the patient in a sitting position. After intrathecal drug administration, patients were immediately positioned supine without head elevation.

During the intraoperative period, oxygen was administered at a flow rate of 3-4 L/min via a venturi mask, and patients were continuously monitored using non-invasive modalities.

Assessments and Observations

Sensory Block: Onset was recorded from intrathecal injection to sensory level T12. Sensory level was assessed bilaterally via pinprick (20G needle) every minute for 5 minutes, then at 10 and 15 minutes. Maximum level achieved was noted; C5-C6 served as the reference for intact sensation. Duration was defined as the time from onset to regression by two dermatomes.

Motor Block: Onset was evaluated every minute using the Modified Bromage Scale until Grade 3 was achieved. Duration was measured from complete block to recovery to Grade 1 (knee flexion restored).

Intraoperative Monitoring: HR, SBP, and DBP were recorded every minute for the first 5 minutes, every 5 minutes for 40 minutes, and every 10 minutes thereafter.

Adverse Events: Hypotension (SBP <100 mmHg or MAP drop >20%) was treated with IV fluids and vasopressors. Bradycardia (HR <50 bpm) was managed with IV atropine. Other side effects included nausea, vomiting, headache, backache, and arrhythmias.

Quality of Block: Adequate block required no supplemental anaesthesia. Inadequate block required fentanyl (1 µg/kg) or propofol (1 mg/kg). Failed blocks were converted to general anaesthesia.

Statistical Analysis:

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared between groups using the unpaired Student's t-test. Categorical variables were expressed as counts and percentages, and analysed using the Chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

Demographic Profile: The two groups were comparable for demographic variables such as age, sex, body mass index (BMI), and ASA physical status. No statistically significant differences were observed in these baseline characteristics. The mean age was 45.14 ± 14.11 years in Group L (Levobupivacaine) and 46.74 ± 13.75 years in Group LF, (Levobupivacaine + Fentanyl) with no statistically significant difference (p = 0.611). Gender distribution also showed no significant difference between the groups (p = 0.908). In the Levobupivacaine group (Group L), 67.5% were male and 32.5% female, while in the Levobupivacaine + Fentanyl group (Group LF), 57.5% were male and 42.5% female.

Haemodynamic Parameters: Table 1 summarises the comparison of baseline vital signs and laboratory parameters between the two groups. No statistically significant differences were observed in pulse rate, systolic and diastolic blood pressure, haemoglobin levels, fasting blood sugar, serum urea, or creatinine values between the Levobupivacaine and Levobupivacaine plus Fentanyl groups (all p-values > 0.05), indicating that both groups were comparable at baseline. Heart rate measurements taken at multiple time intervals throughout the procedure showed no statistically significant differences between the groups (p > 0.05), indicating a comparable cardiovascular response in both groups over time.

Table 1: Comparison of Vital Signs and Laboratory Parameters

Variable	Group L (n=40) (Mean ± SD)	Group LF (n=40) (Mean ± SD)	P Value
Pulse (per minute)	81.71 ± 11.73	80.11 ± 8.75	0.493
SBP (mm Hg)	129.24 ± 13.72	124.08 ± 11.76	0.076
DBP (mm Hg)	77.24 ± 8.27	76.26 ± 8.36	0.602
Haemoglobin (g/L)	12.91 ± 2.01	12.25 ± 2.07	0.153
FBS (mg/dL)	97.66 ± 19.09	92.44 ± 12.35	0.157
Urea	33.46 ± 10.17	37.57 ± 12.05	0.103
Creatinine	0.85 ± 0.19	0.89 ± 0.25	0.403

Table 2: Systolic and Diastolic Blood Pressure Across Intraoperative Time Intervals

Parameter	Group L(n=40) (Mean ± SD)	Group LF (n=40) (Mean ± SD)	p-value
Systolic BP (mm Hg)	119.48 ± 4.64	119.82 ± 4.11	0.732
Diastolic BP (mm Hg)	78.21 ± 3.87	77.62 ± 3.45	0.473

BP- Blood Pressure

Intraoperative systolic and diastolic blood pressure measurements remained stable and comparable between the groups. As shown in Table 2, the mean values across all time points did not differ significantly, with p-values consistently greater than 0.05, indicating similar haemodynamic responses in both groups. Heart rate measurements taken at multiple intraoperative time intervals were comparable between the two groups. The mean heart rate was 82.14 ± 3.35 beats per minute in the Levobupivacaine group and 81.10 ± 2.07 in the

Levobupivacaine + Fentanyl group, with p-values non-significant (p>0.05. T-test and Chi-square tests confirmed non-significant variations ($p > 0.05$).

Onset and Duration of Sensory and Motor Block: The onset and duration of sensory and motor blocks were compared between the Levobupivacaine group and the Levobupivacaine + Fentanyl group. The onset of sensory block was significantly faster in the Levobupivacaine group (2.86 ± 0.97 minutes) compared to the Levobupivacaine + Fentanyl group (3.42 ± 0.96 minutes), with a statistically significant p-value of 0.011. However, the onset of motor block showed no significant difference between the two groups (6.55 ± 14.94 vs. 11.63 ± 31.57 minutes; p = 0.353). Regarding the duration of blocks, the sensory block lasted slightly longer in the Levobupivacaine + Fentanyl group (102.37 ± 17.72 minutes) than in the Levobupivacaine group (96.88 ± 27.85 minutes), though this difference was not statistically significant (p = 0.305). Similarly, the duration of motor block was comparable between the two groups (243.97 ± 52.32 vs. 243.24 ± 54.65 minutes; p = 0.952). These results suggest that the addition of fentanyl to levobupivacaine modestly delays the onset of sensory block without significantly altering the onset or duration of motor block.

Table 3: Comparison of Sensory Block Level Distribution Between Levobupivacaine and Levobupivacaine + Fentanyl Groups at Different Time Intervals

Time Point	Significant Levels Showing Difference	p-Value	Interpretation
1 min	None	0.106	NSD (No Significant Difference)
2 min	None	0.216	NSD
3 min	None	0.460	NSD
4 min	T5-L2 (wider and higher block levels in Fentanyl group)	0.017	Statistically significant
5 min	None	0.694	NSD
10 min	T3-T12 (higher levels more frequent in Fentanyl group)	0.032	Statistically significant
15 min	None	0.275	NSD

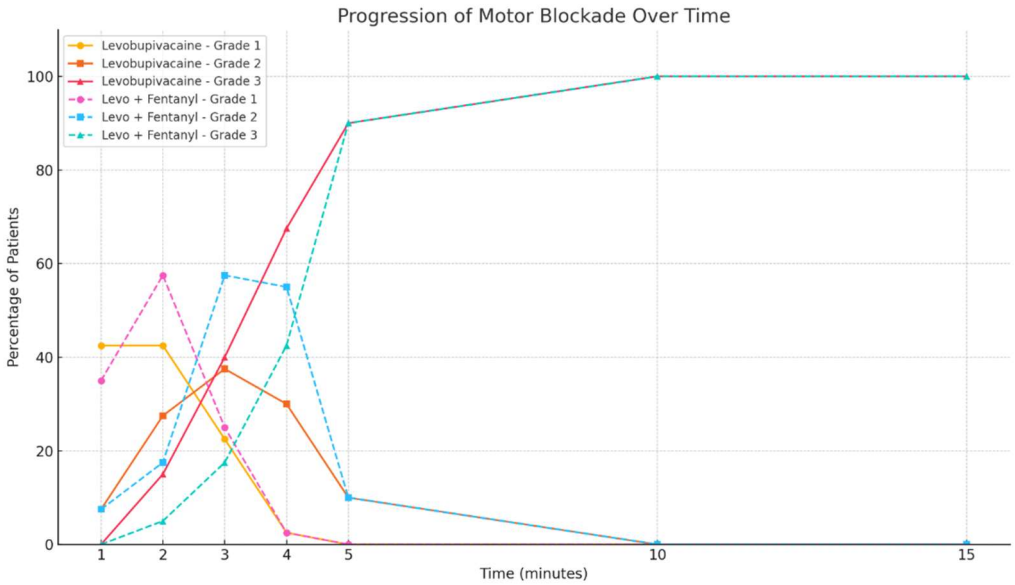

Figure 2: Motor Blockade Progression

Table 4: Motor Block Grade Progression Over Time

Time (min)	Group	Grade 1 (%)	Grade 2 (%)	Grade 3 (%)	p-value
1	Group 1 (n=40)	42.5	7.5	0.0	0.476
	Group 2 (n=40)	35.0	7.5	0.0	
2	Group 1 (n=40)	42.5	27.5	15.0	0.087
	Group 2 (n=40)	57.5	17.5	5.0	
3	Group 1 (n=40)	22.5	37.5	40.0	**0.024**
	Group 2 (n=40)	25.0	57.5	17.5	
4	Group 1 (n=40)	2.5	30.0	67.5	**0.027**
	Group 2 (n=40)	2.5	55.0	42.5	
5	Group 1 (n=40)	0.0	10.0	90.0	1.000
	Group 2 (n=40)	0.0	10.0	90.0	
10	Group 1 (n=40)	0.0	0.0	100.0	1.000
	Group 2 (n=40)	0.0	0.0	100.0	
15	Group 1 (n=40)	0.0	0.0	100.0	1.000
	Group 2 (n=40)	0.0	0.0	100.0	

Table 5: Comparison of Quality of Spinal Anaesthesia

Quality of Spinal Anaesthesia	Group L (n=40) (Count, %)	Group LF (n=40) (Count, %)	P Value
Sufficient block	38 (95.00%)	40 (100.00%)	0.519
Insufficient block	2 (5.00%)	0 (0.00%)	0.519

Table 6: Comparison of Side Effects between Levobupivacaine and Levobupivacaine + Fentanyl Groups

Side Effect	Levobupivacaine (%)	Levobupivacaine + Fentanyl (%)
Hypotension	3 (7.5)	1 (2)
Bradycardia	1 (2)	0 (0)
Nausea	1 (2)	0 (0)
Vomiting	0 (0)	0 (0)
Headache	1 (2)	1 (2)
Pruritis	0 (0)	0 (0)

Comparison of Sensory Block Level Distribution Across Time Intervals: The progression of sensory block levels between the Levobupivacaine group and the Levobupivacaine + Fentanyl group was assessed at multiple time points (Table 3). During the initial 1-3 minutes post-intrathecal administration, no statistically significant differences were observed in the distribution of sensory block levels across spinal segments (p>0.05). However, at 4 minutes, a significant difference emerged (p=0.017), with the Fentanyl group demonstrating a broader spread of sensory block, including higher thoracic levels. This trend continued and was again evident at 10 minutes (p=0.032), where the Fentanyl group showed higher cephalad spread of anaesthesia. By 15 minutes, the sensory levels had stabilised, and no significant differences were found between the groups (p=0.275). These findings suggest that the addition of Fentanyl to Levobupivacaine facilitates a faster and higher sensory block spread in the early phase of spinal anaesthesia.

Motor Blockade Progression: The progression of motor blockade over time is illustrated in Figure 2. At 1-2 minutes post-administration, there were no statistically significant differences in motor blockade grades between the Group L and the Group LF (p > 0.05). However, by 3 and 4 minutes, significant intergroup differences emerged. Group LF showed a higher proportion of patients in Grade 2 motor block (57.5% at 3 min and 55.0% at 4 min) compared to the group L (37.5% and 30.0%, respectively), with p-values of 0.024 and 0.027, suggesting faster progression in motor block.

From 5 to 15 minutes, both groups achieved complete motor blockade (Grade 3) in 90-100% of participants, with no statistically significant differences between them (p = 1.000). These findings indicate that the addition of Fentanyl accelerates the onset of motor block initially but ultimately leads to similar efficacy compared to Levobupivacaine alone (Table 4).

Quality of Spinal Anaesthesia: Table 5 presents the comparison of the quality of spinal anaesthesia between Group L and Group LF. The quality was categorised as either a sufficient or an insufficient block. Although the sufficiency rate was marginally higher in Group LF, the difference between the groups was not statistically significant (p = 0.519). These findings indicate that both regimens are similarly effective in achieving adequate spinal anaesthesia.

Side Effects: Both groups demonstrated a low incidence of adverse effects. The Levobupivacaine group recorded slightly more cases of hypotension and bradycardia than the combination group. Nausea and headache were infrequently observed and equally distributed, while no cases of vomiting or pruritus were reported in either group. The overall side effect profile is summarised in Table 6. While overall side effect rates were low and similar across groups, the addition of fentanyl did not appear to significantly increase adverse effects.

DISCUSSION

This prospective randomised study compared intrathecal hyperbaric levobupivacaine alone (15 mg) versus low-dose levobupivacaine (12.5 mg) with 25 µg fentanyl in patients undergoing lower limb surgery. The primary aim was to evaluate hemodynamic parameters, onset and duration of sensory and motor block, and associated side effects. Our findings indicate that while the fentanyl adjunct altered certain block characteristics, both regimens offered comparable efficacy and safety.

Both groups maintained stable systolic and diastolic blood pressures intraoperatively, with no statistically significant differences at most time intervals. These results are consistent with Bajwa et al. (2011), who reported that levobupivacaine offers greater cardiovascular stability compared to racemic bupivacaine during spinal anaesthesia.[8] The addition of fentanyl, a lipophilic opioid, did not exacerbate hypotension or bradycardia, supporting its safe intrathecal use in low doses.

Our study found that the onset of sensory block was slightly delayed in the levobupivacaine + fentanyl group compared to the levobupivacaine-only group. However, the duration of sensory block was longer in the combination group, though not statistically significant. These findings align with Dinesh et al. [9] and Sheetal et al. [10], who reported faster onset and prolonged analgesia with fentanyl as an adjuvant.

Motor block onset and duration were not significantly different between the groups, except at isolated time intervals (3 and 4 minutes), where block grades showed statistical variation. This transient change may reflect a potentiation of local anaesthetic action by fentanyl without meaningful prolongation of motor block duration, which is desirable for ambulatory procedures.[11]

Over the observation period (1 to 15 minutes), sensory block levels were comparable between groups, although statistically significant differences appeared at certain time points (e.g., 4 and 10 minutes). These trends are consistent with the findings of Choi et al., who reported that intrathecal opioids like fentanyl do not significantly

alter the spread of spinal block when combined with hyperbaric or isobaric local anaesthetics.[12]

All patients in the combination group achieved adequate spinal anaesthesia, compared to 95% in the levobupivacaine-alone group. The improved quality of the block is supported by previous literature demonstrating that opioid adjuvants enhance sensory blockade.[1,13-15]

Hypotension occurred in both groups but was slightly less frequent in the levobupivacaine + fentanyl group, which may be attributed to the reduced local anaesthetic dose and the addition of fentanyl that allowed for effective anaesthesia without sympathetic over-blockade. This observation is consistent with prior studies that suggest intrathecal fentanyl does not significantly increase the incidence of hypotension when used in low doses. [16-19]

Other side effects such as bradycardia, nausea, and pruritus were minimal and statistically similar between the groups, further supporting the safety of low-dose intrathecal fentanyl. All patients in the combination group achieved adequate spinal anaesthesia, compared to 95% in the levobupivacaine-alone group. Side effects such as hypotension, bradycardia, nausea, and pruritus were minimal and statistically similar between the groups, further supporting the safety of low-dose intrathecal fentanyl. A study highlighted that the addition of intrathecal fentanyl to low-dose hyperbaric bupivacaine enhances the quality of sensory block while maintaining hemodynamic stability and avoiding prolonged recovery time, which supports our findings regarding improved block characteristics without delayed motor recovery. [20]

A study based on knee arthroscopy studies with low-dose levobupivacaine (4 mg) + fentanyl (10 µg) achieved excellent block characteristics and faster ambulation, informing dose reduction strategies. [21] A recent meta-analysis by Gupta et al. confirmed that while onset was comparable, dexmedetomidine provided longer postoperative analgesia than fentanyl, offering perspective for selecting adjuvants based on surgical duration.[22] In anorectal saddle blocks, Honca et al. found that both 12.5 and 25 µg fentanyl doses produced effective anaesthesia without motor block, though pruritus increased at higher doses.[23] Akan et al. in TURP patients reported faster sensory block and shorter motor recovery with fentanyl or sufentanil added to levobupivacaine, coupled with prolonged analgesia and stable haemodynamics.[24] Similarly, Goyal et al. showed no compromise in block quality or haemodynamic when adding 15 µg fentanyl to levobupivacaine in urological surgery.[25] Our findings are consistent with a growing body of literature evaluating intrathecal adjuvants with levobupivacaine. Gupta et al. conducted a randomised controlled trial comparing dexmedetomidine and fentanyl as intrathecal adjuvants with hyperbaric levobupivacaine. They observed that while dexmedetomidine significantly prolonged both sensory and motor blockade, fentanyl provided a faster onset of anaesthesia, closely reflecting our findings where fentanyl hastened sensory onset without significant extension of block duration.[26] Similarly, Raghavi et al. compared intrathecal dexmedetomidine and fentanyl in patients undergoing lower limb surgeries and concluded that fentanyl resulted in quicker onset but had a comparatively shorter block duration. This supports the clinical applicability of fentanyl in shorter-duration procedures where rapid onset is preferred and prolonged motor blockade is undesirable.[27] Our findings are consistent with the results reported by Sabertanha et al. (2023), who investigated the effects of intrathecal bupivacaine combined with 5% dextrose and fentanyl versus bupivacaine alone in patients undergoing lower limb orthopaedic surgery. Their study demonstrated that the addition of fentanyl significantly prolonged the duration of analgesia and enhanced postoperative pain control, as evidenced by lower VAS scores at 6 and 24 hours postoperatively in the intervention group. Moreover, their results indicated a higher sensory block level at the onset of surgery and reduced analgesic requirements in the fentanyl group. While haemodynamic parameters showed variability at specific time points, the overall safety profile of the combination remained favourable. These observations align with our study, which also found that fentanyl, when added to hyperbaric levobupivacaine, improved the quality of sensory block without causing significant haemodynamic instability or an increased incidence of side effects.[28]

Clinical Implications: Low-dose hyperbaric levobupivacaine combined with 25 µg fentanyl offers a favourable profile for spinal anaesthesia in lower limb surgeries. It provides effective analgesia with rapid onset, prolonged sensory block, stable haemodynamics, and minimal side effects, without unnecessarily extending motor blockade.

LIMITATIONS

This study was limited by a relatively small sample size and a single-centred design. The long-term neurological safety of intrathecal fentanyl was not assessed. Future multicentric trials with larger sample sizes are warranted.

CONCLUSION

This prospective randomised study demonstrates that intrathecal administration of a lower dose of hyperbaric levobupivacaine combined with fentanyl offers anaesthetic efficacy and safety comparable to a higher dose of levobupivacaine alone in lower limb surgeries. Both regimens maintained stable haemodynamic parameters and showed no statistically significant differences in adverse effects, including hypotension and bradycardia. Although the onset of sensory block was slightly delayed in the combination group, the duration of sensory block was marginally prolonged, contributing to improved postoperative analgesia. Therefore, the use of fentanyl as an intrathecal adjuvant permits a reduction in the dose of local anaesthetic without compromising the quality of

anaesthesia or patient safety, supporting its utility in regional anaesthesia for infraumbilical procedures.

Author's Contribution: SS was involved in all aspects of the study, including the conception, design, data collection, data analysis and interpretation, and manuscript preparation. **VS** contributed to the study conception, data collection, data analysis and interpretation, and manuscript preparation. **SJ** participated in the study conception and data analysis and interpretation. **SS** contributed to the study design. **MS** was involved in the study conception, study design, and data analysis and interpretation.

Availability of Data: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of Non-use of generative AI Tools: No generative AI tool was used in the preparation of the manuscript. The authors take full responsibility for the content of the publication.

REFERENCES

1. Wang C, Chakrabarti MK, Whitwam JG. Specific enhancement by fentanyl of the effects of intrathecal bupivacaine on nociceptive afferent but not on sympathetic efferent pathways in dogs. Anesthesiology. 1993;79(4):766-773. DOI: https://doi.org/10.1097/00000542-199310000-00019 PMid:8214756
2. Neal JM. Hypotension and bradycardia during spinal anesthesia: significance, prevention, and treatment. Tech Reg Anesth Pain Manag. 2000;4(4):148-154. DOI: https://doi.org/10.1053/trap.2000.20600
3. Choi WS, Samman N. Risks and benefits of deliberate hypotension in anaesthesia: a systematic review. Int J Oral Maxillofac Surg. 2008;37(8):687-703. DOI: https://doi.org/10.1016/j.ijom.2008.03.011 PMid:18511238
4. Cheung CC, Martyn A, Campbell N, et al. Predictors of intraoperative hypotension and bradycardia. Am J Med. 2015;128(5):532-538. DOI: https://doi.org/10.1016/j.amjmed.2014.11.030
5. Salinas F V, Sueda LA, Liu SS. Physiology of spinal anaesthesia and practical suggestions for successful spinal anaesthesia. Best Pract Res Clin Anaesthesiol. 2003;17(3):289-303. DOI: https://doi.org/10.1016/S1521-6896(02)00114-3 PMid:14529003
6. Attri J, Kaur G, Kaur S, Kaur R, Mohan B, Kashyap K. Comparison of levobupivacaine and levobupivacaine with fentanyl in infraumbilical surgeries under spinal anaesthesia. Anesth Essays Res. 2015;9(2):178-184. DOI: https://doi.org/10.4103/0259-1162.152148 PMid:26417124 PMCid:PMC4563977
7. Sawhney KY, Kundra S, Grewal A, Katyal S, Singh G, Kaur A. A Randomized Double Blinded Comparison of Epidural Infusion of Bupivacaine, Ropivacaine, Bupivacaine-Fentanyl, Ropivacaine-Fentanyl for Postoperative Pain Relief in Lower Limb Surgeries. J Clin Diagn Res. 2015 Sep;9(9):UC19-23. DOI: https://doi.org/10.7860/JCDR/2015/15157.6459 PMid:26500984
8. Bajwa SJS, Arora V, Kaur J, Singh A, Parmar SS. Comparative evaluation of dexmedetomidine and fentanyl for epidural analgesia in lower limb orthopedic surgeries. Saudi J Anaesth. 2011;5(4):365-370. DOI: https://doi.org/10.4103/1658-354X.87264 PMid:22144922 PMCid:PMC3227304
9. Naik D, Koppal R, Mathpati V, Hulkund S. A comparative study of intrathecal 0.5% isobaric levobupivacaine with fentanyl and 0.5% isobaric levobupivacaine with nalbuphine in infraumbilical surgeries: A randomized double blind clinical trial. Indian J Clin Anaesth. 2019;6(2):203-208. DOI: https://doi.org/10.18231/j.ijca.2019.038
10. Jagtap S, Chhabra A, Dawoodi S, Jain A. Comparison of intrathecal ropivacaine-fentanyl and bupivacaine-fentanyl for major lower limb orthopaedic surgery: A randomised double-blind study. Indian J Anaesth. 2014;58(4):442-446. DOI: https://doi.org/10.4103/0019-5049.138985 PMid:25197113 PMCid:PMC4155290
11. Choi DH, Ahn HJ, Kim MH. Bupivacaine-sparing effect of fentanyl in spinal anesthesia for cesarean delivery. Reg Anesth Pain Med. 2000 May-Jun;25(3):240-5. doi: 10.1016/s1098-7339(00)90005-1. PMID: 10834777.
12. Jørgensen H, Wetterslev J, Møiniche S, Dahl JB. Epidural local anaesthetics versus opioid-based analgesic regimens on postoperative gastrointestinal paralysis, PONV and pain after abdominal surgery. Cochrane Database Syst Rev. 2000;(4):CD001893. DOI: https://doi.org/10.1002/14651858.CD001893. Update in: Cochrane Database Syst Rev. 2016 Jul 16;7:CD001893. DOI: https://doi.org/10.1002/14651858.CD001893.pub2. PMID: 11034732.
13. Uike DS, Choudhary DS, Jain DA. Comparative study of analgesic effect of intrathecal bupivacaine and bupivacaine with fentanyl during and after cesarean delivery. Int J Med Res Rev. 2015;3(3):256-262. DOI: https://doi.org/10.17511/ijmrr.2015.i3.045
14. Singh V, Gupta LK, Singh GP. Comparison among intrathecal fentanyl and butorphanol in combination with bupivacaine for lower limb surgeries. J Anaesthesiol Clin Pharmacol. 2006;22(4):371-375.
15. Chanchayanon T, Chearong M, Vasinanukorn P, Withayanuphakorn N, Sangkaew T. Incidence of hypotension between intrathecal hyperbaric bupivacaine with and without fentanyl in geriatric patients undergoing urological surgeries. J Heal Sci Med Res. 2019;37(2):93-99. DOI: https://doi.org/10.31584/jhsmr.201944
16. Khosravi F, Sharifi M, Jarineshin H. Comparative study of fentanyl vs dexmedetomidine as adjuvants to intrathecal bupivacaine in cesarean section: A randomized, double-blind clinical trial. J Pain Res. 2020;Volume 13:2475-2482. DOI: https://doi.org/10.2147/JPR.S265161 PMid:33116789 PMCid:PMC7548853
17. Shah VR, Mehta S, Khan DA. Comparative study of intrathecal fentanyl with bupivacaine and fentanyl midazolam with bupivacaine in spinal anaesthesia. Indian J Clin Anaesth. 2021;8(2):302-309. DOI: https://doi.org/10.18231/j.ijca.2021.056
18. Malawat A, Sachdeva S, M Parekh K, Jethava D, Mansuri T. Comparison of intrathecal dexmedetomidine and intrathecal fentanyl as an adjuvant with hyperbaric bupivacaine for spinal anaesthesia in lower limb surgeries: A prospective randomized clinical trial. Indian J Clin Anaesth. 2020;7(2):226-232. DOI: https://doi.org/10.18231/j.ijca.2020.041
19. Routray SS, Ravi K, Mishra D. Effect of intrathecal dexmedetomidine and fentanyl as adjuvant to hyperbaric bupivacaine for orthopaedic lower limb and lower abdominal procedures: A double blind control Study. Indian J Clin Anaesth. 2015;2(4):204-208. DOI: https://doi.org/10.5958/2394-4994.2015.00030.X
20. Ben-David B, Solomon E, Levin H, Admoni H, Goldik Z. Intrathecal fentanyl with small-dose dilute bupivacaine. Anesth Analg. 1997;85(3):560-565. DOI: https://doi.org/10.1097/00000539-199709000-00014 PMid:9296409
21. De Santiago J, Santos-Yglesias J, Giron J, Jimenez A, Errando CL. Low-dose, low-concentration levobupivacaine plus fentanyl selective spinal anesthesia for knee arthroscopy: a dose finding study. Anesth Analg. 2011;112(2):477-480. DOI: https://doi.org/10.1213/ANE.0b013e318202cd03 PMid:21127284
22. Gupta M, Pratap R, Singh GP. Efficacy and duration of analgesia with levobupivacaine combined with fentanyl or dexmedetomidine in lower extremity surgery: A meta-analysis. Asian J Med Sci. 2025;16(3):15-23. DOI: https://doi.org/10.71152/ajms.v16i3.4352
23. Honca M, Dereli N, Kose EA, et al. Low-dose levobupivacaine plus fentanyl combination for spinal anesthesia in anorectal surgery. Brazilian J Anesthesiol (English Ed). 2015;65(6):461-465. DOI:

https://doi.org/10.1016/j.bjane.2014.01.007 PMid:26614142

24. Akan B, Yagan O, Bilal B, Erdem D, Gogus N. Comparison of levobupivacaine alone and in combination with fentanyl and sufentanil in patients undergoing transurethral resection of the prostate. J Res Med Sci. 2013;18(5):378-382. http://www.ncbi.nlm.nih.gov/pubmed/24174940.

25. Goyal A, Shankaranarayan P, Ganapathi P. A randomized clinical study comparing spinal anesthesia with isobaric levobupivacaine with fentanyl and hyperbaric bupivacaine with fentanyl in elective cesarean sections. Anesth Essays Res. 2015;9(1):57-62. DOI: https://doi.org/10.4103/0259-1162.150169 PMid:25886422

26. Gupta P, Chouhan RS, Jangir KG, Rathore VS, Audichya PC, Goyal S. A Comparison of Intrathecal Dexmedetomidine and Fentanyl as Adjuvants to 0.5% Hyperbaric Levobupivacaine for Lower Abdominal Surgeries: A Prospective, Double-Blinded, Randomized Controlled Trial. Cureus. 2024 Dec 23;16(12):e76292. DOI: https://doi.org/10.7759/cureus.76292. PMID: 39850166; PMCID: PMC11754921.

27. Raghavi.R, Balamurugan B, Saravanakumar.R VJ. Comparative study of intrathecal isobaric levobupivacaine (0.5%) 3ml with dexmedetomidine 0.5ml (5 mcg) and isobaric levobupivacaine (0.5%) 3ml with fentanyl 0.5ml (25 mcg) in patients undergoing surgeries under subarachnoid block: a prospective randomize. J Chem Heal Risks. 2024;14(2):1656-1666.

28. Sabertanha A, Makhmalbaf GR, Bayati M, Meshkini A. The Effect of Intrathecal Bupivacaine Plus Dextrose 5% and Fentanyl Compared with Bupivacaine Alone on the Onset and Duration of Analgesia in Patients Undergoing Lower-Limb Orthopedic Surgery. Adv Orthop. 2023 Feb 14;2023:2496557. DOI: https://doi.org/10.1155/2023/2496557 PMid:36824661 PMCid:PMC9943617