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Original Article

Anaesthesia Section

Comparison of Intrathecal Hyperbaric Bupivacaine and Levobupivacaine in Lower Limb Orthopaedic Surgeries: A Prospective Interventional Study

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ABSTRACT

Introduction: Subarachnoid block was widely used for lower limb orthopaedic surgeries. Hyperbaric bupivacaine provides reliable anaesthesia but is associated with higher neurological and cardiac toxicity. Levobupivacaine, the S-enantiomer of bupivacaine, was developed to offer comparable anaesthesia with improved safety and haemodynamic stability.

Aim: To compare the effects of intrathecal administration of hyperbaric bupivacaine and levobupivacaine in lower limb orthopaedic surgeries.

Materials and Methods: A prospective interventional study was conducted in the Department of Anaesthesiology at Government Medical College, Kozhikode Tertiary Care Hospital, Kerala, India, from January 2023 to December 2023. Total of 120 American Society of Anaesthesiologists-Physical Status (ASA-PS) grade I-II patients aged 18-65 years undergoing unilateral lower limb surgeries, who were divided into two equal groups of 60 each based on whichever drug the treating anaesthesiologist selected in routine practice: Group B (hyperbaric bupivacaine 0.5% 2.0 mL+60 mcg buprenorphine) and Group L (hyperbaric levobupivacaine 0.5% 2.0 mL+60 mcg buprenorphine). Motor and sensory block characteristics, duration of effective analgesia and incidence of side-effects were compared. Data were analysed using an Independent samples t-test and a Chi-square test.

Results: Both groups L and B were demographically comparable in terms of age, gender, and ASA grading. Group L achieved a significantly faster onset of sensory block (2.99±0.62 vs 4.23±0.83 min, p-value=0.001) and motor block (5.71±1.28 vs 6.43±1.08 min, p-value=0.001). Group B attained a higher sensory level (T6 vs T8, p-value=0.008) and showed longer duration of analgesia (157.3±14.3 vs 150.2±12.3 min; p-value=0.004). Motor regression was faster in group L (198.7±18.8 vs 207.2±14.4 min; p-value=0.006). Incidence of hypotension was significantly higher with bupivacaine (41.7% vs 13.3%; p-value=0.001). Heart Rate (HR) and Mean Arterial Pressure (MAP) trends were comparable between the groups.

Conclusion: Compared to intrathecal hyperbaric bupivacaine, hyperbaric levobupivacaine offers faster onset, quicker motor recovery and better haemodynamic stability with reduced hypotension. Bupivacaine provides longer analgesia but at the cost of higher sympathetic blockade. Levobupivacaine was observed to be a safer alternative for lower limb orthopaedic surgeries.

Keywords: Haemodynamics, Intrathecal anaesthesia, Local anaesthetics, Motor block, Sensory block

INTRODUCTION

Subarachnoid block was commonly used for lower limb orthopaedic procedures due to its rapid onset, dense sensory block and excellent muscle relaxation. It avoids airway manipulation and reduces perioperative stress responses, making it advantageous in orthopaedic patients. However, spinal anaesthesia is associated with haemodynamic alterations such as hypotension and bradycardia due to sympathetic blockade, which may adversely affect perioperative stability, especially in patients undergoing prolonged surgeries or those with limited physiological reserve [1].

Hyperbaric bupivacaine remains the conventional local anaesthetic of choice for spinal anaesthesia because of its predictable spread, reliable block characteristics, and prolonged duration of analgesia. Its widespread use is supported by extensive clinical experience and consistent anaesthetic efficacy. However, it is associated with dose-dependent cardiotoxicity and neurotoxicity due to its high affinity for myocardial sodium channels and relatively narrow safety margin [1,2]. Additionally, the relatively prolonged motor blockade associated with intrathecal bupivacaine may delay early postoperative mobilisation, which is a key component of enhanced recovery protocols following orthopaedic surgery [3].

Levobupivacaine, a pure S-enantiomer, was developed to provide comparable anaesthetic efficacy with an improved safety profile. Levobupivacaine exhibits a reduced affinity for cardiac sodium channels and a higher plasma protein binding capacity compared to bupivacaine, thereby lowering the risk of cardiotoxicity [4,5]. Several studies have reported that intrathecal levobupivacaine produces an effective sensory block with faster recovery and reduced incidence of hypotension compared to racemic bupivacaine [6,7]. These characteristics suggested that levobupivacaine could be a potentially advantageous alternative, particularly in patients where early mobilisation and haemodynamic stability are important considerations.

Previous studies comparing intrathecal levobupivacaine and bupivacaine have shown variable results with respect to onset time, maximum sensory level attained, duration of analgesia and motor block characteristics [6,8-10]. While some authors have demonstrated faster onset and quicker motor recovery with levobupivacaine, others have reported comparable block profiles between the two agents [10-15]. These inconsistencies may be due to differences in study design, baricity of the drug used, dosage, use of intrathecal adjuvants, patient positioning and type of surgical procedure.

Importantly, evidence comparing hyperbaric levobupivacaine with bupivacaine in lower limb surgeries was limited [9,13,16]. Many available studies [8,10-12,15] have focused on urological,

general surgical or lower abdominal procedures, and relatively few have evaluated block characteristics and haemodynamic effects specifically in lower limb orthopaedic surgeries [9,13]. Moreover, studies evaluating hyperbaric formulations of levobupivacaine are few, despite hyperbaric solutions being commonly used in routine clinical practice to achieve predictable block spread [11,12,17]. There is also a paucity of prospective interventional studies from the Indian population, where demographic characteristics, body habitus, and perioperative practices may differ from those in Western populations [8,9,13,14,18].

Another relevant consideration in orthopaedic anaesthesia is the balance between adequate duration of postoperative analgesia and early motor recovery. While prolonged analgesia may improve postoperative comfort, delayed motor recovery can hinder early mobilisation and rehabilitation [3]. Therefore, identifying an intrathecal local anaesthetic that provides an optimal balance between block quality, duration of analgesia and haemodynamic stability is clinically important.

In view of these gaps in the existing literature, the present study was designed to compare the effects of intrathecal hyperbaric bupivacaine and hyperbaric levobupivacaine in patients undergoing unilateral lower limb orthopaedic surgeries. By systematically evaluating sensory and motor block characteristics, duration of effective analgesia and haemodynamic parameters under standardised clinical conditions, this study aimed to provide clinically relevant evidence to guide anaesthetic drug selection in routine orthopaedic practice. The primary objective of the present study was to compare the sensory and motor block characteristics between intrathecal hyperbaric bupivacaine and levobupivacaine, specifically evaluating the onset and regression of sensory and motor block, maximum sensory level achieved, and total duration of analgesia. The secondary objective was to compare the haemodynamic parameters and the incidence of adverse effects between the two study groups.

MATERIALS AND METHODS

A prospective interventional study was conducted in the Department of Anaesthesiology at Government Medical College, Kozhikode Tertiary Care Hospital, Kerala, India, from January 2023 to December 2023 (one year), following approval from the Institutional Research Committee and the Institutional Ethics Committee. (IEC No: GMCKKD/RP 2022/IEC/136) (Date: 22/12/22).

Sample size calculation: The sample size was calculated based on the primary outcome variable, namely the onset time of sensory block, using data from the parent study published by Singh A et al., [10]. In the reference study, the mean onset time was 4.4±2.1 minutes in the levobupivacaine group and 4.2±1.7 minutes in the bupivacaine group [10].

A minimum clinically significant difference (δ) of one minute was considered. The standard deviation (σ) was calculated as the average of both groups:

$$\sigma = \frac{2.1 + 1.7}{2} = 1.9$$

The sample size for comparison of two independent means was calculated using the formula:

$$n = \frac{2(z_{\alpha/2} + z_{\beta})^2\sigma^2}{\delta^2}$$

Where:

- $(z_{\alpha/2}$ =1.96 (α=0.05)
- z_{β}=0.84 (power=80%)
- σ=1.9
- δ=1.0

Substituting the values:

$$n = \frac{2(1.96 + 0.84)^2 \times (1.9)^2}{(1.0)^2}$$

n=56.6

Thus, a minimum of approximately 57 patients per group was required. This was rounded off to 60 patients per group, resulting in a total sample size of 120 patients.

Inclusion criteria: A total of 120 patients aged 18-65 years with height 150-180 cm and weight 40-70 kg, belonging to ASA-PS grade I and II, posted for elective unilateral lower limb orthopaedic surgeries with a duration of less than 120 minutes under subarachnoid block, were included in the study.

Exclusion criteria: Patients with a history of allergy to local anaesthetics, bleeding disorders, local site infection at the puncture site for subarachnoid block, spinal deformities like kyphosis, scoliosis, neuromuscular diseases, ongoing respiratory illness and ASA-PS grade III and above were excluded from the present study.

Study Procedure

After preoperative assessment, patients who met the inclusion criteria were selected; informed written consent was obtained from those patients who were willing to participate.

All patients were advised to fast for eight hours for solid foods and two hours for clear fluids before anaesthesia. Aspiration prophylaxis was administered with oral pantoprazole 40 mg on the night before surgery and again on the morning of the surgery. In addition, all were premedicated with tablet metoclopramide 10 mg on the morning of surgery and tablet alprazolam 0.25 mg at night before as per routine departmental protocol for patients undergoing subarachnoid block.

The procedure was explained to all the patients the day before surgery. On the day of surgery, once the patient was transferred to the operating theatre, standard monitors, including Non Invasive Blood Pressure (NIBP), Electrocardiogram (ECG) and peripheral Oxygen Saturation (SpO2) were attached, and baseline readings were recorded. An 18 G intravenous (i.v.) cannula was secured and was co-loaded with 500 mL of Ringer's lactate, followed by infusion at the rate of 100 mL/hour. A standardised fluid strategy was adopted for all patients rather than an individualised formula-based calculation to maintain uniformity. Midazolam 0.02 mg/kg was given intravenously before performing spinal anaesthesia. Equipment for general anaesthesia was kept ready. The study drug was set up in a sterile tray by following all aseptic precautions.

Patients were positioned in the lateral decubitus position, which was preferred to facilitate a unilateral spinal block and to enhance patient comfort. Following strict aseptic protocols, lumbar puncture with a 25G Quicke's needle at the L3-L4 space was performed by a qualified anaesthesiologist. A 25G Quincke spinal needle was used in all patients, as it is routinely available and commonly used in the study Institution, ensuring consistency in technique. After confirming CSF free flow corresponding drug was administered.

The study group was divided into two groups of 60 each based on the drug received. Group allocation depended on the intrathecal drug chosen by the attending anaesthesiologist as per routine departmental practice. No randomisation was performed.

Patients receiving spinal anaesthesia with hyperbaric bupivacaine 0.5% 2.0 mL with 60 mcg buprenorphine were added to group B. Patients receiving spinal anaesthesia with hyperbaric levobupivacaine 0.5% 2.0 mL with 60 mcg buprenorphine were added to group L. The doses and concentrations used were based on previously published studies and standard clinical practice [10-13]. Both groups received identical intrathecal buprenorphine doses to avoid confounding of analgesic duration.

The sensory block was evaluated using a sterile pinprick every minute till the T10 dermatomal level was reached and every three minutes till the highest level was achieved and every 20 minutes after the highest level was achieved. The onset of sensory block was defined as the time to loss of pinprick sensation at the T10 dermatome. The onset of motor blockade was defined as the time required to achieve a modified Bromage score of 3 [19].

The time of sensory regression was measured from the maximal block height attained to regression to two dermatomal levels. The regression of motor block was measured from the time the modified Bromage score reached 3 until it decreased to a score of 1.

The duration of analgesia was defined as the time from intrathecal administration of drugs to the first instance when an analgesic is needed due to a pain score exceeding three on the Numerical Rating Scale (NRS), corresponding to the onset of moderate pain, as established by validated pain intensity thresholds [20,21].

Vital signs were monitored throughout the entire duration of the surgery at 1,3,5,10,15,20,25,30 minutes, thereafter every 10 minutes till 60 minutes, and then every 30 minutes till the end of surgery, which included pulse rate and MAP. Haemodynamic analysis focused on HR and MAP, as MAP was considered a clinically relevant indicator of perfusion during spinal anaesthesia.

Bradycardia, defined as a pulse rate <20% from the baseline, was treated with the injection of atropine sulphate i.v. 0.6 mg.

Hypotension, described as a 20% reduction in MAP from baseline or MAP < 65 mmHg, was treated with the injection of mephentermine i.v. 6 mg. Prophylaxis for postoperative nausea and vomiting was provided by the i.v. injection of ondansetron 4 mg. Rescue analgesia, if required, was given by injection with tramadol i.v. 50 mg.

STATISTICAL ANALYSIS

Data were analysed using the Statistical Package for Social Sciences (SPSS) windows version 18.0. Data are presented as numbers (%) or mean±SD as appropriate. Quantitative variables were analysed by employing the Independent samples t-test. Qualitative variables were compared using the Chi-square test. A p-value<0.05 was considered statistically significant.

RESULTS

Both groups L and B were demographically comparable in terms of age, gender and ASA grading [Table/Fig-1]. Sensory and motor block onset were significantly faster in group L (p-value=0.001). Two-segment regression was similar between groups (p-value=0.475). Motor recovery was faster in group L (p-value=0.006). Duration of analgesia was longer in group B (p-value=0.004) [Table/Fig-2]. Group B achieved a higher sensory level (p-value=0.008) [Table/Fig-3].

Hypotension was significantly higher in group B (41.7% vs 13.3%; p-value=0.001). Bradycardia rates were similar (p-value=0.204) [Table/Fig-4]. Although mean HR and MAP values tended to be lower in group B, differences were not statistically significant (p-value > 0.05) [Table/Fig-5,6].

Variables	Mean±SD		p-value*
	Group L	Group B	
Age (years)	36.08±13.540	34.87±14.379	0.877
Weight (kg)	62.85±4.270	62.50±4.980	0.655
Height (m)	1.68±0.049	1.68±0.058	0.595
BMI (kg/m^2)	22.204±0.728	22.167±0.708	0.587
ASA , n (%)			
I	41 (68.3)	41 (68.3)	1.000 †
II	19 (31.7)	19 (31.7)	
Gender			
Male	44 (73.3)	47 (78.3)	0.670 †
Female	16 (26.7)	13 (21.7)	

[Table/Fig-1]: Comparison of demographic variables of the study population.
L: Levobupivacaine; B: Bupivacaine *Independent samples t-test †- Chi-square test

Parameters	Mean±SD (min)		p-value*
	Group L	Group B	
Onset of sensory block at T10	2.99±0.624	4.23±0.826	0.001
Onset of motor block- MB3	5.71±1.28	6.43±1.08	0.001
Two-segment regression- Treg	100.89±14.69	102.89±15.89	0.475
Duration of motor block- MB1	198.71±18.80	207.19±14.38	0.006
Duration of analgesia	150.16±12.37	157.28±14.32	0.004

[Table/Fig-2]: Comparison of block characteristics between the groups.
T10: time taken to reach T10 dermatome, MB3: time taken to reach modified Bromage score of 3, Treg: Time taken for dermatomal regression, MB1: time taken to reach modified Bromage score of 1, L: Levobupivacaine, B: Bupivacaine *Independent samples t-test

Maximum sensory level-T max count	n (%)		Total	p-value*
	Group B	Group L		
4	12 (20.0)	4 (6.7)	16 (13.3)	0.008
6	23 (38.3)	13 (21.7)	36 (30.0)	
8	23 (38.3)	38 (63.3)	61 (50.8)	
10	2 (3.3)	5 (8.3)	7 (5.8)	

[Table/Fig-3]: Comparison of maximum dermatomal level attained (Tmax) in both groups.
L: Levobupivacaine, B: Bupivacaine *Chi-square test

Parameters		n (%)		Total	p-value*
		Group B	Group L		
Hypotension	No	35 (58.3)	52 (86.7)	87 (72.5)	0.001
	Yes	25 (41.7)	8 (13.3)	33 (27.5)	
Bradycardia	No	52 (86.7)	57 (95.0)	109 (90.8)	0.204
	Yes	8 (13.3)	3 (5.0)	11 (9.2)	

[Table/Fig-4]: Comparison of the occurrence of hypotension and bradycardia among the two groups.
L: Levobupivacaine, B: Bupivacaine *Chi-square test

Time	Mean±SD (in beats/min)		p-value*
	Group L	Group B	
0 min	85.10±14.657	85.17±14.128	0.490
1 min	86.12±14.166	83.73±13.317	0.557
3 min	84.63±13.815	83.00 ±14.594	0.837
5 min	83.82±13.753	81.88±12.626	0.811
10 min	81.67±16.343	82.62±11.746	0.401
15 min	82.31±12.553	80.67±10.184	0.437
20 min	82.78±12.387	82.38±10.289	0.216
25 min	81.67±16.343	82.62±11.746	0.715
30 min	82.27±11.836	81.17±9.767	0.586
40 min	82.31±12.553	80.67±10.184	0.186
50 min	82.22±11.813	81.90±10.605	0.461
60 min	82.60±11.676	82.00±10.634	0.580
90 min	82.62±11.234	82.51±10.909	0.810
120 min	82.75±11.330	82.08±10.348	0.703

[Table/Fig-5]: Comparison of heart rate at various time points among the two groups.
*Independent samples t-test L: Levobupivacaine; B: Bupivacaine

Time	Mean±SD (in mmHg)		p-value*
	Group L	Group B	
0 min	85.57±12.940	86.97±12.509	0.771
1 min	81.25±12.404	81.12±10.715	0.111
3 min	77.78±12.080	73.85±11.004	0.198
5 min	78.10±9.628	76.85±10.030	0.703
10 min	78.20±8.908	78.00±9.455	0.781

15 min	78.30±8.914	77.98±9.262	0.849
20 min	78.77±9.039	78.13±7.941	0.720
25 min	79.66±8.474	79.37±7.225	0.842
30 min	79.60±8.255	78.45±8.200	0.982
40 min	79.66±8.474	79.37±7.225	0.373
50 min	79.14±9.000	79.52±7.548	0.100
60 min	79.27±8.980	78.92±7.340	0.193
90 min	79.19±8.389	77.96±7.058	0.555
120 min	78.53±8.054	78.67±7.402	0.842

[Table/Fig-6]: Comparison of Mean Arterial Pressure (MAP) among the two groups at various time points.
*Independent samples t-test L: Levobupivacaine, B: Bupivacaine

No adverse effects such as nausea or vomiting were observed in either group. Overall, levobupivacaine demonstrated a faster onset and better haemodynamic stability, whereas bupivacaine provided longer analgesia.

DISCUSSION

In this prospective interventional study, block characteristics and haemodynamic effects of intrathecal hyperbaric bupivacaine and levobupivacaine were compared in patients undergoing unilateral lower limb orthopaedic surgeries. Both groups were comparable in terms of demographic variables, allowing for a meaningful comparison of outcomes.

The present study demonstrated that the onset of both sensory and motor block was significantly faster with levobupivacaine. Patients in group L reached a sensory level of T10 in an average of 2.99±0.62 minutes, whereas those in group B required 4.23±0.83 minutes (p-value<0.001). Deepa T et al., (2021) also reported a faster onset of sensory block with intrathecal levobupivacaine compared to bupivacaine, findings that are consistent with the trend observed in the present study [8]. This differs from the findings of Singh A et al., and Fattorini F et al., who reported comparable or slower onset with levobupivacaine [10,13]. Oraon P et al., (2022) also reported comparable block characteristics between intrathecal levobupivacaine and hyperbaric bupivacaine in an obstetric population [14]. The faster onset with levobupivacaine may have been related to its slightly lower pKa, resulting in a greater fraction of unionised molecules at physiological pH, which enables quicker penetration into neural tissue and increases the rate at which the drug reaches its binding site on the intracellular portion of the voltage-gated sodium channel.

A significant difference was observed in the highest level of sensory block attained. Patients in group L generally achieved a sensory block level of T8, whereas those in group B reached T6 (p-value 0.008). This result supports Erdil F et al., findings that bupivacaine tends to produce a higher sensory block compared to levobupivacaine [6]. The higher sensory level seen with bupivacaine is consistent with its higher potency and greater tendency for cephalad spread.

The regression of sensory block did not differ significantly between the groups (p-value=0.475). Similar observations were made by Fattorini F et al., though Casati A et al., reported prolonged sensory regression with bupivacaine [12,13]. In contrast, the regression of motor block was faster with levobupivacaine (198.71±18.80 min vs 207.19±14.38 min; p-value 0.006). This finding corroborates those of Singh A et al., and Hakan Erbay R et al., who reported a shorter duration of motor block with levobupivacaine [10,11]. Singh A et al., reported a significantly shorter duration of motor block with intrathecal levobupivacaine compared to bupivacaine (185.9±20.3 minutes vs 196.4±21.2 minutes), corresponding to a reduction of approximately 10.5 minutes (p=0.016) [10]. Similarly, Hakan Erbay R et al., demonstrated earlier motor recovery with levobupivacaine, with motor block duration being 105±19 minutes in the levobupivacaine group compared to 113±7 minutes in the bupivacaine group, reflecting a reduction of approximately eight minutes (p-value=0.04) [11]. This may be due to the slightly lower lipid solubility of levobupivacaine, facilitating faster drug clearance. In contrast, Oraon P et al., Vanna O et al., and Fattorini F et al., observed no difference between the two drugs [13-15]. Clinically, quicker motor recovery was considered beneficial, especially in settings like ambulatory surgery or ERAS pathways, where earlier mobilisation is encouraged.

The duration of effective analgesia was significantly longer with bupivacaine. Studies on the duration of effective analgesia with levobupivacaine, compared to bupivacaine, have produced conflicting results. Singh A et al., reported that levobupivacaine provides a shorter duration of effective analgesia than bupivacaine [10]. Conversely, Chen CK et al., found that levobupivacaine offers a longer duration of analgesia [9]. Fattorini F et al., and Piacherski V et al., observed no significant difference between the two drugs [13,16]. The wide variations reported across different studies with respect to onset time, duration of motor block, and duration of analgesia can be attributed to several methodological and clinical factors, including differences in drug dose and concentration, baricity of the intrathecal solution, use of adjuvants, patient positioning, and the type and duration of surgical procedures.

Haemodynamically, levobupivacaine demonstrated superior stability. The incidence of hypotension was significantly lower with levobupivacaine compared to bupivacaine (13.3% vs 41.7%; p-value 0.001). This finding is consistent with previous studies by Erdil F et al., and Singh A et al., [6,10]. Bupivacaine, being more potent than levobupivacaine, may lead to a greater sympathetic blockade, which may contribute to greater vasodilation and reduced systemic vascular resistance, thereby increasing the incidence of hypotension [1]. However, a recent randomised study by Sinchana AS et al., (2024) comparing intrathecal hyperbaric levobupivacaine and bupivacaine with fentanyl in elective caesarean section reported no significant difference in haemodynamic parameters between the two groups [17]. Similarly, Goyal A et al., (2022), in a comparative study involving infraumbilical surgeries, reported that intrathecal levobupivacaine and bupivacaine produced comparable sensory and motor block characteristics with no significant difference in haemodynamic parameters [18]. Deepa T and Chandran D (2021) also reported comparable haemodynamic parameters between intrathecal levobupivacaine and bupivacaine [8]. The incidence of bradycardia was comparable between groups, a finding that is consistent with previous studies by Goyal A et al., and Oraon P et al., who also reported no significant difference in the occurrence of bradycardia between intrathecal levobupivacaine and bupivacaine [14,18].

Overall, the current study findings suggested that hyperbaric levobupivacaine provides good block characteristics with comparatively more stable haemodynamics, while bupivacaine provides longer postoperative pain relief at the cost of more frequent hypotension.

The present study was conducted using a prospective interventional design with a standardised spinal anaesthesia technique across both groups. A uniform drug dose, consistent patient positioning, and predefined assessment criteria for sensory and motor block ensured comparability between groups. In addition, haemodynamic parameters were systematically monitored at regular intervals, allowing a reliable evaluation of the clinical performance of hyperbaric bupivacaine and levobupivacaine in patients undergoing lower limb orthopaedic surgeries under similar operative conditions.

Limitation(s)

The present study had certain limitations. First, it was conducted at a single centre involving only ASA I-II patients; therefore, the results may not apply to higher-risk patients. Second, only one dose and concentration of drugs were tested, along with a fixed dose of

intrathecal buprenorphine, which may affect the characteristics of the block. Third, haemodynamic changes were monitored only until the end of surgery and postoperative values were not recorded. Additionally, because group allocation was based on routine clinical practice, selection bias cannot be completely ruled out. Finally, long-term outcomes and postoperative complications were not assessed.

CONCLUSION(S)

Intrathecal hyperbaric levobupivacaine provided a faster onset of sensory and motor block, earlier motor recovery and better haemodynamic stability compared to hyperbaric bupivacaine in lower limb orthopaedic surgeries. Although bupivacaine offers a slightly longer duration of analgesia, levobupivacaine appears to be a safer and an effective alternative, particularly when haemodynamic stability and early mobilisation are priorities.

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