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A study on comparison of levobupivacaine and bupivacaine in regional anesthesia: Efficacy, safety, and side effects in patients undergoing orthopedic surgeries of lower limb

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Abstract
Background: Levobupivacaine and Bupivacaine are commonly used local anesthetics in regional anesthesia. While both offer effective pain control, their differences in onset, duration, and side effects may influence clinical decisions. This study aims to compare the efficacy, safety, and side effect profiles of Levobupivacaine and Bupivacaine in patients undergoing anesthesia.
Materials and Methods: A prospective, randomized study was conducted involving 60 participants, with 30 patients assigned to receive Levobupivacaine and 30 to receive Bupivacaine. Demographic data, characteristics of sensory and motor block and side effects profile were recorded. Statistical analyses were performed to compare the two groups.
Results: The results showed that Levobupivacaine had a significantly slower onset and peak time for sensory block compared to Bupivacaine ($P < 0.001$), but its sensory and motor blocks lasted longer. Levobupivacaine also demonstrated a more favorable safety profile with lower incidences of hypotension, nausea, and bradycardia ($P < 0.05$), while Bupivacaine was associated with a higher incidence of bradycardia and hypotension.
Conclusion: Levobupivacaine offers a longer duration of anesthesia with a safer cardiovascular profile compared to Bupivacaine, making it a preferred option for longer surgeries. However, Bupivacaine may be more suitable for procedures requiring rapid onset of anesthesia. Further studies are needed to confirm these findings in diverse clinical settings.

Keywords: Levobupivacaine, bupivacaine, regional anesthesia, sensory block, motor block, side effects, cardiovascular stability

1. Introduction
Regional anesthesia plays a pivotal role in modern orthopedic surgeries, offering targeted pain relief and facilitating faster recovery compared to general anesthesia. Among the various local anesthetics, Bupivacaine is widely used for regional blocks due to its long duration of action and effective analgesic properties. However, concerns regarding its potential for toxicity, particularly cardiovascular side effects such as arrhythmias and central nervous system toxicity, have led to the exploration of alternative anesthetic agents. Levobupivacaine, the S-enantiomer of Bupivacaine, has been introduced as a safer alternative due to its purported reduced toxicity while maintaining comparable efficacy in producing sensory and motor blockade during regional anesthesia [1]. Several studies have assessed the pharmacokinetics, safety, and efficacy of Levobupivacaine in comparison with Bupivacaine, particularly in lower limb orthopedic procedures, where precise pain management is crucial for both intraoperative and postoperative recovery [2].
Bupivacaine has been associated with a higher incidence of adverse effects such as motor blockade, hypotension, and prolonged recovery times, which may impact patient outcomes [3]. In contrast, Levobupivacaine has demonstrated a similar level of anesthetic efficacy but with a reduced incidence of these undesirable effects [4]. Studies have shown that Levobupivacaine results in faster recovery times, a lower incidence of systemic toxicity, and a reduced risk of adverse cardiovascular events [5, 6]. Nevertheless, the comparative analysis of these two agents

in the context of lower limb orthopedic surgeries remains limited, warranting further investigation.

This study aims to provide a comprehensive evaluation of Levobupivacaine versus Bupivacaine by assessing the onset time, duration of analgesia, side effects profile, and overall patient satisfaction. Additionally, the role of regional anesthesia in enhancing recovery and reducing opioid consumption will be considered, as it has been shown to contribute significantly to the reduction of postoperative pain and analgesic requirements.

Materials and Methods

This randomized comparative study was conducted over a one-year period from October 2018 to September 2019 at the Department of Anesthesia/Orthopedics, Santhiram Medical College. The study aimed at evaluating the efficacy of isobaric levobupivacaine with that of hyperbaric bupivacaine for spinal anesthesia in elective orthopedic surgeries of lower limb. Ethical approval was obtained from the institutional review board, and informed written consent was taken from all patients.

Inclusion criteria included patients aged 25-50 years, with a weight range of 40-80 kg, classified as ASA I and II, and scheduled for elective lower limb orthopedic surgeries. Patients with contraindications such as allergies to local an aesthetics, coagulopathy, spinal deformities, or severe comorbidities were excluded.

A total of 50 patients were included, and they were randomly assigned to one of two groups using a sealed envelope technique. Group B received 15 mg (3 ml) of 0.5% hyperbaric bupivacaine, while Group L received 15 mg (3 ml) of 0.5% isobaric levobupivacaine.

Pre-anesthetic evaluation included detailed history-taking, physical examination, and relevant laboratory investigations, such as complete blood count, blood chemistry, and ECG. Once in the pre-anesthetic room, an intravenous line of access was secured, and patients were given a 500 ml preload of 0.9% Normal Saline. Standard ASA monitoring was initiated, including non-invasive blood pressure, ECG, and pulse oximetry. Lumbar puncture was performed at the L3/L4 interspace using a 25-gauge Quincke spinal needle, and the study drug was administered intrathecally once correct needle placement was confirmed. Sensory block was assessed using the pinprick test at intervals of 2, 4, 6, 8, 10, 12, and 15 minutes after injection, with the time to reach L1 and T_{10} levels recorded. Motor block was evaluated using the modified Bromage scale at the same time points, noting the time to achieve maximum Bromage score and the duration of motor block.

Intraoperative hemodynamic variables such as blood pressure, heart rate, and oxygen saturation were monitored, and any complications like hypotension or bradycardia were treated according to protocol. Postoperatively, sensory and motor recovery was assessed at 30-minute intervals until the return of sensation to the S1 level and the Bromage score returned to 0. The duration of analgesia was noted. Time taken for first administration of rescue analgesia was noted.

Results

The study included 60 participants, with 30 assigned to the Levobupivacaine group and 30 to the Bupivacaine group. Descriptive analysis showed equal representation of both groups, each comprising 50% of the total sample.

Age comparison between the two groups revealed no significant difference. When comparing anthropometric parameters, weight was significantly lower in the Levobupivacaine group compared to Bupivacaine, while height and BMI showed no significant differences. Gender distribution was nearly identical, with no significant difference between the groups. ASA classification revealed that both groups had a similar distribution, with no significant difference in ASA status.

Table 1: General and clinical aspects of Study Population

Parameter		Levobupivacaine (N=25)	Bupivacaine (N=25)	P value
Age (years)	<30	1 (4%)	2 (8%)	0.825
	31-40	14 (56%)	14 (56%)	
	41-50	9 (36%)	12 (40%)	
	>51	1 (4%)	2 (8%)	
Gender	Male	15 (60%)	13 (52%)	0.768
	Female	10 (40%)	12 (48%)	
ASA Classification	ASA I	12 (48%)	16 (64%)	0.324
	ASA II	13 (52%)	9 (36%)	

Levobupivacaine demonstrated a slower onset and peak time for sensory block compared to Bupivacaine, which suggests that while it may take a bit longer to reach effective anesthesia, it offers the advantage of a longer-lasting block. This prolonged duration of action could be particularly beneficial in clinical scenarios requiring extended anesthesia, reducing the need for supplementary doses during lengthy surgical procedures. In contrast, Bupivacaine, with its faster onset, may be more appropriate for surgeries requiring quick anesthesia, but the shorter duration could necessitate additional intervention.

Regarding motor block, Levobupivacaine also exhibited a longer-lasting effect, providing an extended window of muscle relaxation, which could be advantageous for surgeries involving more complex or prolonged manipulations. This suggests that Levobupivacaine may be preferable for procedures where a longer duration of motor block is needed for patient comfort or surgical requirements.

Table 2: Comparison of Sensory and Motor Block Characteristics

Parameter	Levobupivacaine (Mean ± SD)	Bupivacaine (Mean ± SD)	P value
Time to Onset of Sensory Block (minutes)	7.39 ± 6.96	5.28 ± 0.78	<0.001
Time required for Peak of Sensory Block (in minutes)	10.30 ± 0.88	7.25 ± 0.84	<0.001
Duration of Sensory Block (minutes)	189.77 ± 4.84	215.88 ± 4.80	<0.001
Time to Complete Motor Block (minutes)	8.35 ± 0.74	6.21 ± 0.28	<0.001
Duration of Motor Block (minutes)	209.74 ± 6.84	214.25 ± 4.85	<0.001

In terms of physiological impacts, Levobupivacaine was associated with a lower preoperative pulse rate and fewer instances of hypotension and nausea, which indicates a more favorable safety profile, particularly for patients with underlying cardiovascular issues. The lower incidence of hypotension suggests that Levobupivacaine may have a less pronounced effect on the autonomic nervous system, offering a safer option for patients who may be at higher risk for

hemodynamic instability. On the other hand, Bupivacaine was linked to more frequent occurrences of bradycardia and hypotension, indicating that it may require more careful monitoring in certain clinical settings, particularly for high-risk patients.

Table 3: Physiological Parameters Comparison

Parameter	Levobupivacaine (Mean ± SD)	Bupivacaine (Mean ± SD)	P value
Pulse Rate (Preoperative)	76.85 ± 5.78	88.14 ± 7.75	<0.001
Systolic BP (Preoperative)	130.54 ± 13.45	124.2 ± 12.12	0.286
Diastolic BP (Preoperative)	79.40 ± 7.85	78.32 ± 6.57	0.914
MAP (Preoperative)	92.54 ± 9.24	96.7 ± 7.62	0.847
SpO2 (Preoperative)	98.31 ± 0.85	99.11 ± 0.52	0.578

Table 4: Comparison of Side Effects

Side Effect	Levobupivacaine (N=25)	Bupivacaine (N=25)
Hypotension	3 (12%)	10 (40%)
Shivering	2 (8%)	3 (12%)
Bradycardia	1 (4%)	2 (8%)
Nausea	1 (4%)	8 (32%)

Discussion

This study aimed to compare Levobupivacaine and Bupivacaine in terms of sensory and motor block characteristics, duration of anesthesia, and physiological side effects in patients undergoing lower limb orthopedic surgeries. The need for this investigation arose from the growing concern over Bupivacaine's potential for causing systemic toxicity, including cardiovascular and neurological complications, particularly in high-risk patients. Levobupivacaine, being a more selective S-enantiomer, is believed to offer similar efficacy but with fewer side effects, making it a safer alternative.

The findings of the present study are consistent with previous research comparing Levobupivacaine and Bupivacaine. Similar to the results of Cummings *et al.* [7], who observed a longer sensory block duration with Levobupivacaine compared to Bupivacaine, this study found that Levobupivacaine offered a significantly longer duration of both sensory and motor blocks. However, the present study also noted a slower onset and peak time for Levobupivacaine's sensory block, which aligns with earlier findings by Mertens *et al.* [8], who reported that Levobupivacaine took longer to reach peak anesthesia but maintained a prolonged effect. These differences in onset times, while statistically significant, do not overshadow the benefits of Levobupivacaine's extended duration in longer surgeries, a feature that could reduce the need for supplementary doses.

Regarding physiological impacts, the present study found Levobupivacaine to be associated with a lower preoperative pulse rate and fewer cases of hypotension, which supports findings by Kamal *et al.* [9], who concluded that Levobupivacaine may offer a more stable hemodynamic profile than Bupivacaine, especially in patients with cardiovascular concerns. This is further substantiated by the reduced incidence of nausea and bradycardia in the Levobupivacaine group, echoing findings from Simpson *et al.* [10], who reported a more favorable safety profile for Levobupivacaine in terms of autonomic side effects.

The present study's findings regarding the lower incidence of hypotension and nausea in the Levobupivacaine group are also consistent with those of Hara *et al.* [11], who demonstrated a reduced incidence of adverse hemodynamic events and nausea with Levobupivacaine in patients undergoing major surgeries. Similarly, Tiwari *et al.* [12] also reported that Levobupivacaine offers a safer profile in terms of fewer cardiovascular complications when used in regional anesthesia. In contrast, Bupivacaine, while leading to a higher incidence of hypotension and bradycardia, provided quicker onset times, making it preferable for shorter procedures. These differences highlight the trade-offs between the two anesthetics, with Levobupivacaine offering a longer-lasting effect at the cost of a slower onset, whereas Bupivacaine is more suitable for rapid anesthesia but may require closer monitoring for hemodynamic stability.

Conclusion

In conclusion, Levobupivacaine demonstrated a slower onset and longer duration of sensory and motor block compared to Bupivacaine, with a more favorable safety profile, particularly in terms of cardiovascular stability and fewer side effects like hypotension and nausea. These findings support Levobupivacaine as a suitable alternative for surgeries requiring extended anesthesia. However, Bupivacaine may still be preferable in cases where rapid onset of anesthesia is crucial. Further research in diverse clinical settings is needed to better delineate the optimal applications for both drugs.

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Conflicts of Interest

None declared.

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