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Research Article

A Comparative Study of Hyperbaric Levobupivacaine and Hyperbaric Ropivacaine in Spinal Anaesthesia in Lower Limb Surgeries of Geriatric Patients

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ABSTRACT

Background and Aims: Levobupivacaine and Ropivacaine are both newer long-acting drugs increasing the spectrum of local anaesthetic armamentarium, developed following reports of bupivacaine-related severe cardiotoxicity. This study compares the onset and duration of sensory block, motor block, and haemodynamic stability in geriatric patients undergoing lower limb surgeries under spinal anaesthesia.
Methods: After obtaining Institutional Ethics Committee clearance and written informed consent, a double-blind prospective randomised controlled trial was conducted on 70 ASA I/II geriatric patients (aged 60–85 years) scheduled for elective lower limb surgeries. Patients were randomly allocated into two groups of 35 each: Group L received intrathecal 0.5% hyperbaric levobupivacaine (15 mg/3 ml), and Group R received 0.75% hyperbaric ropivacaine (22.5 mg/3 ml). Primary endpoints included onset and duration of sensory and motor blockade. Secondary endpoints were haemodynamic parameters and complications.
Results: Ropivacaine produced a significantly slower onset of sensory block (3.89 ± 0.76 min vs. 2.60 ± 0.55 min; $p < 0.001$) and motor block (13.00 ± 1.21 min vs. 10.00 ± 1.55 min; $p < 0.001$). Duration of sensory block (154.23 ± 8.16 min vs. 190.34 ± 6.76 min; $p < 0.001$) and motor block (122.46 ± 4.85 min vs. 188.74 ± 8.35 min; $p < 0.001$) were significantly shorter with ropivacaine. Haemodynamic parameters (heart rate, systolic BP, diastolic BP, MAP, SpO2) remained comparable between groups throughout ($p > 0.05$). No adverse events were recorded in either group.
Conclusion: In geriatric patients undergoing lower limb surgery, 0.75% hyperbaric ropivacaine is superior to 0.5% hyperbaric levobupivacaine by virtue of its shorter duration of sensory and motor blockade, facilitating earlier ambulation and thereby reducing complications of prolonged bed rest such as deep vein thrombosis, pulmonary embolism, and postoperative cognitive dysfunction.

Keywords*: Spinal anaesthesia, levobupivacaine, ropivacaine, hyperbaric, geriatric, sensory block, motor block.*

INTRODUCTION

August Bier introduced the concept of spinal anaesthesia (SA) in 1899, and the technique has since undergone considerable refinement. Lignocaine superseded cocaine, but was itself abandoned following reports of transient neurological symptoms. Bupivacaine became the gold standard for intrathecal use, but its propensity for life-threatening ventricular arrhythmias and refractory cardiac arrest prompted a search for safer alternatives with comparable clinical efficacy.

Ropivacaine is a pure S(-)-enantiomer and a long-acting aminoamide local anaesthetic that is structurally related to bupivacaine, differing only in the substitution of a propyl group for a butyl group on the piperidine nitrogen. It possesses approximately 30–40% lower potency than bupivacaine but carries a significantly improved cardiovascular and central nervous system safety profile. Because it is less lipophilic than bupivacaine, it preferentially blocks pain-conducting Aδ and C fibres over the large myelinated Aβ motor fibres, enabling a clinically useful degree of sensorimotor dissociation. Levobupivacaine, the pure S(-)-enantiomer of racemic bupivacaine, retains the potency of its parent compound but with substantially reduced cardiotoxic and neurotoxic potential.

Hyperbaric formulations of local anaesthetics (achieved by addition of dextrose to exceed CSF density) allow gravity-dependent, predictable block spread and are especially valuable in the elderly. The physiological changes of ageing—reduced CSF volume, progressive neurodegeneration, diminished myelin, narrowed intervertebral foramina, and polypharmacy—render geriatric patients more sensitive to neuraxial agents and more vulnerable to haemodynamic compromise. Despite this, comparative data on equipotent hyperbaric ropivacaine versus hyperbaric levobupivacaine specifically in geriatric patients are sparse, constituting the primary research gap addressed by this study.

This prospective, double-blind, randomised controlled trial was undertaken to compare 0.75% hyperbaric ropivacaine with 0.5% hyperbaric levobupivacaine for spinal anaesthesia in geriatric patients undergoing lower limb surgeries, with reference to sensorimotor block characteristics and haemodynamic stability.

MATERIALS AND METHODS

Study Design and Setting

A double-blind prospective randomised controlled trial was conducted at the Department of Anaesthesiology and Critical Care, Tezpur Medical College and Hospital, Tezpur, Assam, India, over a one-year period (January 2023–December 2024). The trial was registered prospectively with the Clinical Trials Registry – India (CTRI) on 12 February 2024 (Registration No. CTRI/2024/02/062549; https://ctri.nic.in). The study received clearance from the Institutional Human Ethics Committee (IHEC; Approval No. EC/NEW/INST/2022/1706, dated 12/12/2022) and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Patient Selection

Inclusion criteria: ASA physical status I–II, age 60–85 years, elective lower limb surgery, valid written informed consent. Exclusion criteria: patient refusal, spinal deformity, coagulopathy, local site infection, ASA III–IV, history of seizures or neurological deficit, significant hepatic/renal/cardiovascular/respiratory impairment, known allergy to local anaesthetics, and inability to obtain informed consent.

Randomisation and Blinding

Seventy patients were randomised using computer-generated random numbers and sequentially numbered opaque sealed envelopes (SNOSE method) into two groups of 35 each. An independent operating room technician prepared the study drugs; the attending anaesthesiologist and the outcome assessor remained blinded throughout.

Interventions

All patients received 500 ml crystalloid (normal saline) preload via an 18G intravenous cannula. Standard monitoring (ECG, NIBP, SpO2, pulse rate) was applied. Spinal anaesthesia was performed at the L3–L4 interspace in the sitting or lateral decubitus position using a 25G Quincke needle under strict asepsis following skin infiltration with 2 ml of 2% lignocaine with adrenaline (1:200,000).

Group L (Levobupivacaine): 15 mg (3 ml) of 0.5% hyperbaric levobupivacaine (Inj. Levo-Anawin Heavy®, Neon Laboratories). Group R (Ropivacaine): 22.5 mg (3 ml) of 0.75% hyperbaric ropivacaine (Inj. Ropin Heavy®).

Outcome Measures

Primary outcomes: (1) Time to onset of sensory block (TOS) to T10 dermatome by pinprick; (2) Time to onset of motor block (TOM) to Bromage 3; (3) Duration of sensory block (DOS) to regression to L1; (4) Duration of motor block (DOM) to Bromage 0. Secondary outcomes: haemodynamic parameters (PR, SBP, DBP, MAP, SpO2) recorded pre-operatively and at 1, 3, 5, 10, 15, 30, 45, 60, 75, 90, and 120 min post-injection; any adverse events.

Statistical Analysis

Data were analysed using IBM SPSS 20.0. Normally distributed quantitative variables were compared with the independent samples t-test; non-normally distributed variables with the Mann–Whitney U test. Categorical variables were compared using the chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

RESULTS

Demographic and Baseline Characteristics

Seventy patients were enrolled (35 per group). Groups were comparable for age, weight, height, sex, and ASA status (all $p > 0.05$). Table 1 summarises the demographic details.

Table 1. Demographic characteristics of study participants (N=70)

Parameter	Group	N	Mean	Std. Deviation
Age (years)	Ropivacaine	35	66.49	3.906
	Levobupivacaine	35	66.89	3.748
Weight (kg)	Ropivacaine	35	52.69	4.086
	Levobupivacaine	35	53.23	3.088
Height (cm)	Ropivacaine	35	164.91	7.660
	Levobupivacaine	35	151.83	5.953

Values are mean ± standard deviation. Groups were comparable on all parameters (p >0.05).

ASA Status

In Group R, 31 patients (88.57%) were ASA I and 4 (11.43%) were ASA II. In Group L, 29 patients (82.86%) were ASA I and 6 (17.14%) were ASA II. The difference was not statistically significant (p = 0.7913).

Primary Outcomes: Sensory and Motor Block

Table 2 summarises TOS, TOM, DOS, and DOM for both groups. All four primary outcomes showed highly significant differences (p <0.001).

Table 2. Comparison of sensory and motor block parameters between ropivacaine and levobupivacaine groups (N=70)

Parameter	Group	N	Mean	Std. Deviation	p value
TOS (min)	Ropivacaine	35	3.89	0.758	**<0.001***
	Levobupivacaine	35	2.60	0.553	
TOM (min)	Ropivacaine	35	13.00	1.213	**<0.001***
	Levobupivacaine	35	10.00	1.553	
DOS (min)	Ropivacaine	35	154.23	8.160	**<0.001***
	Levobupivacaine	35	190.34	6.765	
DOM (min)	Ropivacaine	35	122.46	4.847	**<0.001***
	Levobupivacaine	35	188.74	8.347	

*TOS = Time to onset of sensory block; TOM = Time to onset of motor block; DOS = Duration of sensory block; DOM = Duration of motor block. *Statistically significant (p <0.001). Values are mean ± SD.*

Ropivacaine showed a significantly delayed onset of both sensory block (3.89 ± 0.76 vs. 2.60 ± 0.55 min) and motor block (13.00 ± 1.21 vs. 10.00 ± 1.55 min). Conversely, the duration of both sensory block (154.23 ± 8.16 vs. 190.34 ± 6.76 min) and motor block (122.46 ± 4.85 vs. 188.74 ± 8.35 min) was significantly shorter in the ropivacaine group, facilitating earlier ambulation.

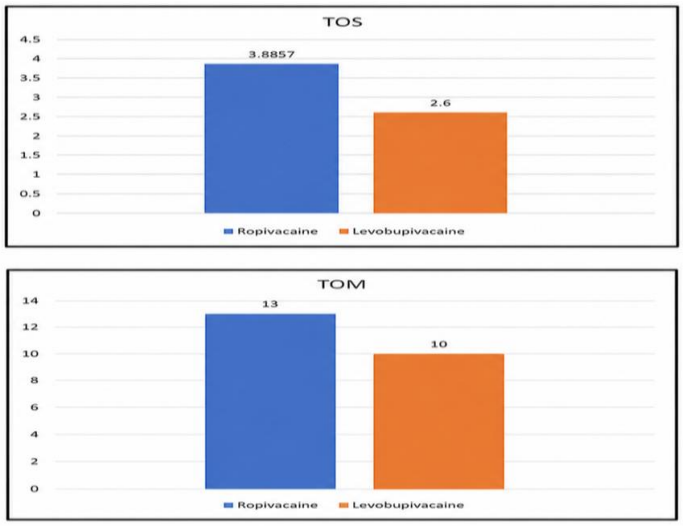

Figure 1. Bar charts comparing mean time to onset of sensory block (TOS, upper panel) and motor block (TOM, lower panel) between ropivacaine (Group R) and levobupivacaine (Group L).

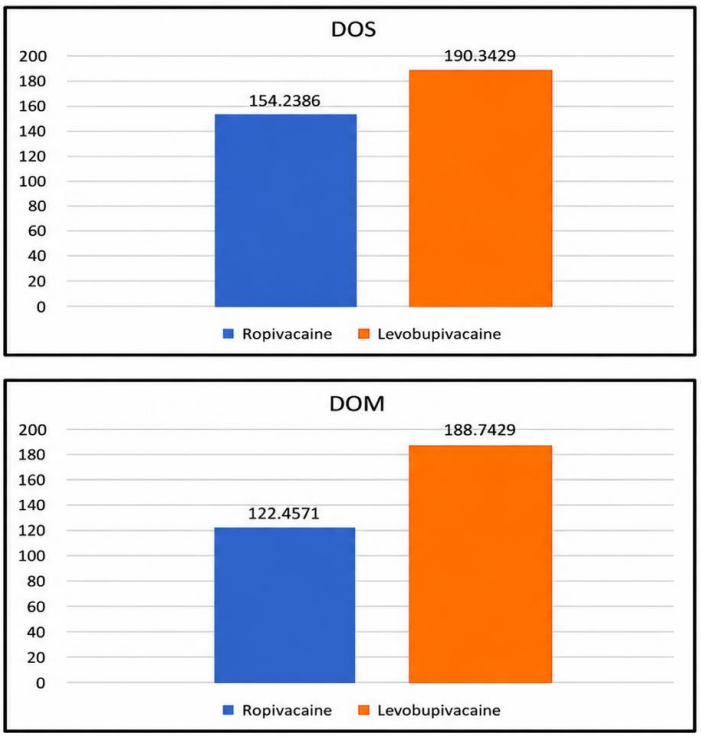

Figure 2. Bar charts comparing mean duration of sensory block (DOS, upper panel) and motor block (DOM, lower panel) between ropivacaine (Group R) and levobupivacaine (Group L).

Secondary Outcomes: Haemodynamic Parameters

Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and SpO2 remained stable and within normal limits in both groups throughout the observation period. No statistically significant intergroup difference was detected at any time point ($p > 0.05$ for all). No patient in either group required ephedrine for hypotension or atropine for bradycardia. SpO2 remained ≥98% throughout in both groups.

Complications

No adverse events (hypotension, bradycardia, high spinal block, respiratory depression, nausea, vomiting, or neurological complications) were recorded in either group during the intraoperative or immediate postoperative period.

DISCUSSION

This double-blind RCT compared equipotent doses of intrathecal hyperbaric ropivacaine 0.75% (22.5 mg) and hyperbaric levobupivacaine 0.5% (15 mg) in elderly patients undergoing lower limb surgery. The principal finding is that ropivacaine

produced a significantly shorter duration of both sensory and motor block, at the cost of a modestly delayed onset, while haemodynamic profiles were indistinguishable between groups.

The delayed onset of sensory block with ropivacaine (3.89 min vs. 2.60 min) is consistent with its lower lipophilicity and reduced potency relative to levobupivacaine. This aligns with the observations of Kulkarni et al. (4.5 vs. 3.2 min for ropivacaine and bupivacaine), Kalbande et al. (2024), and Chatterjee et al. (2.94 vs. 1.74 min), all of whom noted a slower sensory block onset with ropivacaine formulations. Critically, the delayed onset did not compromise surgical adequacy in any patient.

The substantially shorter duration of motor block with ropivacaine (122.46 vs. 188.74 min, a difference of approximately 66 min) is of paramount clinical importance in the geriatric population. Prolonged immobility in the elderly carries well-documented risks: deep vein thrombosis, pulmonary embolism, pressure ulcers, atelectasis, urinary retention, and postoperative cognitive dysfunction. Ferris et al. demonstrated that early mobilisation is an independent predictor of reduced in-hospital mortality following hip fracture surgery. The early motor recovery afforded by ropivacaine directly enables earlier physiotherapy and ambulation.

The comparable haemodynamic stability between both agents is clinically significant given the known susceptibility of elderly patients to sympathetic blockade-induced hypotension. The age-related reductions in cardiac output, baroreceptor sensitivity, and vasomotor tone make this population uniquely vulnerable. The finding that neither drug caused significant haemodynamic perturbation supports their safe use in this age group, consistent with the reports of Gulec et al. and Herrera et al.

A limitation of the study is the single-centre design with a relatively modest sample size. Furthermore, post-discharge outcomes such as incidence of DVT or long-term POCD were not assessed. Future multicentre trials with larger samples and patient-reported outcomes would strengthen these findings.

CONCLUSION

In geriatric patients undergoing lower limb surgery under spinal anaesthesia, 0.75% hyperbaric ropivacaine provides reliable and effective surgical anaesthesia with a significantly shorter duration of sensory and motor blockade compared to 0.5% hyperbaric levobupivacaine. This translates into earlier ambulation, thereby mitigating the complications of prolonged bed rest that disproportionately afflict the elderly. Haemodynamic stability and safety profiles are comparable for both agents. Hyperbaric ropivacaine may therefore be the preferred choice for intermediate-duration lower limb procedures in geriatric patients.

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Conflicts of Interest: None declared.

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Ethical Approval: Approved by the Institutional Human Ethics Committee, Tezpur Medical College and Hospital (Approval No. EC/NEW/INST/2022/1706, dated 12 December 2022). Trial registered prospectively with CTRI: CTRI/2024/02/062549.

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