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Original Research Article

Effect of Volume and Concentration of Ropivacaine for Sciatic Nerve Block on Perioperative Analgesia in Patients Undergoing Below-Knee Orthopaedic Surgeries Under Spinal Anaesthesia: A Prospective Randomized Comparative Study

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Abstract

Background: The optimal balance between volume and concentration of local anaesthetic at a fixed total dose for peripheral nerve blockade remains poorly defined. While ropivacaine is widely used for sciatic nerve block in lower-limb surgery, the independent contributions of volume versus concentration to block characteristics have not been adequately studied.

Objective: To compare the effect of 10 ml of 0.5% ropivacaine versus 20 ml of 0.25% ropivacaine (equal total dose of 50 mg) for single-shot preoperative ultrasound-guided sciatic nerve block on duration of postoperative analgesia in below-knee orthopaedic surgeries.

Methods: In this prospective, randomized, double-blind comparative study, 60 ASA I–III patients aged 18–60 years undergoing below-knee orthopaedic procedures were randomized equally to Group A (10 ml 0.5% ropivacaine) or Group B (20 ml 0.25% ropivacaine). A saphenous nerve block with 5 ml 0.5% bupivacaine was added, followed by spinal anaesthesia with 2.5 ml 0.5% hyperbaric bupivacaine. VAS pain scores, duration of analgesia, and 24-hour rescue analgesic consumption were recorded.

Results: Duration of analgesia was significantly longer in Group B (598.67 ± 78.1 minutes) than Group A (256.21 ± 77.85 minutes; $p < 0.0001$). Group B also required less paracetamol (2000 ± 525.22 mg vs 2733.3 ± 449.77 mg; $p < 0.0001$) and tramadol (61.11 ± 21.39 mg vs 101.92 ± 22.27 mg; $p < 0.0001$) over 24 hours. Preoperative VAS at 20 minutes was significantly lower in Group B ($p < 0.05$).

Conclusion: At equal total dose, 20 ml of 0.25% ropivacaine produced superior and longer-lasting analgesia than 10 ml of 0.5% ropivacaine for sciatic nerve block.

Keywords: Ropivacaine; Sciatic nerve block; Below-knee surgery; Ultrasound-guided; Perioperative analgesia; Local anaesthetic volume.

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Introduction

Perioperative pain management has evolved into an indispensable component of surgical care, and its optimization is directly linked to reduced morbidity, earlier mobilization, and improved functional recovery after orthopaedic procedures.[1] Below-knee orthopaedic surgeries—including ankle fracture fixation, tibial plating, Achilles tendon repair, and forefoot reconstruction—are associated with moderate to severe postoperative pain that, if inadequately managed, delays rehabilitation, prolongs hospital stay, and increases the risk of chronic postsurgical pain syndromes.[2] Regional anaesthesia, particularly peripheral nerve blockade, has emerged as the cornerstone of multimodal analgesia in this population because it provides dense, segment-specific pain control while sparing

the patient from the systemic side effects of opioid-based regimens.[3]

The sciatic nerve, arising from the lumbosacral plexus (L4–S3), supplies the posterior compartment of the thigh and virtually the entire leg and foot below the knee, except for the medial strip innervated by the saphenous branch of the femoral nerve.[4] Consequently, a combined sciatic and saphenous nerve block offers complete sensory coverage for below-knee procedures and has been shown to deliver superior postoperative analgesia when compared with opioid-based strategies alone.[5] The introduction of real-time ultrasound guidance has further transformed the practice of sciatic nerve blockade by improving success rates, shortening onset time, reducing local anaesthetic requirements, and minimizing the risk of intraneural injection and vascular puncture.[6]

Ropivacaine, a long-acting amide local anaesthetic structurally related to bupivacaine, is the pure S(-)-enantiomer of propivacaine and was introduced into clinical practice specifically to address the cardiotoxicity concerns associated with racemic bupivacaine.[7] Several pharmacological properties make ropivacaine particularly attractive for peripheral nerve blockade: it possesses an inherent vasoconstrictive action at lower concentrations, a wider margin of safety in the event of inadvertent intravascular injection, a reduced propensity for central nervous system and cardiac toxicity, and a preferential blockade of sensory fibres with relative motor sparing.[8,9] These characteristics permit early postoperative mobilization—a particularly desirable goal in below-knee surgery where ambulation training and physiotherapy begin within hours of the procedure.

Despite the widespread clinical adoption of ropivacaine, fundamental questions regarding the optimal combination of volume and concentration at a fixed total dose remain unresolved. Traditionally, the equation "dose = volume × concentration" has dominated regional anaesthesia practice, and clinicians have intuitively assumed that, for a given total milligram dose, the specific volume–concentration combination is of secondary importance.[10] This assumption, however, overlooks the distinct pharmacodynamic contributions of each variable. A larger volume at lower concentration produces wider perineural spread, potentially ensuring contact with all fascicles of the target nerve, while a smaller volume at higher concentration generates a steeper concentration gradient that may drive faster onset and denser blockade but over a more restricted area.[11]

Most previous dose-finding investigations in humans have employed one of two methodological strategies: either comparing fixed combinations of volume and concentration at a constant total dose, or holding one variable constant while titrating the other to estimate the median effective volume (ED_{50}vol) or median effective concentration (ED_{50}conc) for a specific quantal endpoint.[12] Such designs, while informative, do not permit the independent assessment of each variable's contribution to clinical block characteristics such as onset time, block density, motor sparing, and—most importantly for patient-centred outcomes—duration of postoperative analgesia.[13] The up-and-down sequential allocation methodology has generated useful data for brachial plexus and femoral nerve blocks, but analogous investigations for the sciatic nerve remain sparse.

At the cellular level, local anaesthetic blockade of voltage-gated sodium channels is concentration-dependent, with higher concentrations producing denser blockade of A-delta and C fibres responsible for nociceptive transmission.[14] However, the final clinical effect is equally dependent on the physical distribution of the drug around the nerve—a function of injectate volume. When the volume is insufficient, fascicles at the periphery of the nerve may escape adequate drug exposure and result in patchy or incomplete blockade. Conversely, when the volume is generous but the concentration is marginal, the concentration gradient may fall below the minimum effective concentration (Cm) at the outer fascicles, again leading to incomplete blockade.[15]

The interaction between volume, concentration, and duration is further complicated by ropivacaine's unique vasoactive profile. Bupivacaine is known to produce local vasoconstriction at lower concentrations, thereby reducing systemic absorption and prolonging local drug residence time. Whether ropivacaine exhibits an analogous concentration-dependent vasoactive effect at the site of perineural injection—and whether this property might influence the duration of action—has received relatively little direct investigation. Ilfeld and colleagues, in a landmark dual-centre randomized trial of continuous popliteal sciatic nerve blocks, demonstrated that local anaesthetic concentration, rather than total dose or volume alone, was the principal determinant of postoperative analgesic and motor effects with continuous ropivacaine infusions.[1] Subsequent investigators have extended these observations to interscalene and femoral blocks, with conflicting results, suggesting that the relative importance of volume versus concentration may be block-specific and nerve-specific.[11,12]

In the specific context of single-shot sciatic nerve blockade for below-knee orthopaedic surgery, there is a paucity of high-quality evidence comparing two different volume–concentration combinations at an identical total milligram dose of ropivacaine. Such evidence is clinically important because it would allow the anaesthesiologist to tailor the block to specific patient needs—prioritizing rapid onset, prolonged analgesia, or optimal motor sparing—without altering the total drug exposure and its attendant systemic toxicity risk. Moreover, optimizing perineural ropivacaine administration has direct implications for opioid consumption, patient satisfaction, length of hospital stay, and the overall quality of Enhanced Recovery After Surgery (ERAS) protocols in orthopaedic practice.

The present study was therefore designed to compare two clinically relevant combinations—10 ml of 0.5% ropivacaine (lower volume, higher concentration) versus 20 ml of 0.25% ropivacaine (higher volume, lower concentration)—administered as a single-shot, ultrasound-guided sciatic nerve block at an identical total dose of 50 mg, in patients undergoing elective below-knee orthopaedic surgery under subsequent spinal anaesthesia. The primary outcome was duration of postoperative analgesia; secondary outcomes included preoperative pain reduction during patient positioning, 24-hour rescue analgesic consumption, and haemodynamic stability. We hypothesized that the larger-volume, lower-concentration combination would provide superior perineural spread and longer analgesic duration while matching the total dose of the conventional regimen.

Aims and Objectives

Primary Objective: To compare the effect of 10 ml of 0.5% ropivacaine versus 20 ml of 0.25% ropivacaine for single-shot preoperative ultrasound-guided sciatic nerve block on the duration of postoperative analgesia in patients undergoing below-knee orthopaedic surgeries.

Secondary Objectives

1. To study the effect of preoperative sciatic nerve block with two different volumes and concentrations of ropivacaine on pain during movement of the patient from the preoperative room to the operating theatre.
2. To study the effect of volume and concentration of ropivacaine on 24-hour postoperative rescue analgesic consumption (paracetamol and tramadol).
3. To evaluate haemodynamic stability in the perioperative period between the two groups.

Materials and Methods

Study Design and Setting: This prospective, randomized, double-blinded, comparative clinical study was conducted in the Department of Anaesthesiology at Bangalore Medical College and Research Institute and its attached hospitals, Bangalore, Karnataka, India. The study was carried out over a period of 18 months, from February 2021 to August 2022, after obtaining formal approval from the Institutional Ethics Committee. The trial was conducted in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice guidelines. Written informed consent was obtained from all participants during the preoperative anaesthetic evaluation.

Sample Size Calculation: The sample size was calculated on the basis of the primary outcome—duration of postoperative analgesia. Using data from a pilot study and previously published literature on ropivacaine sciatic nerve blocks, assuming a clinically meaningful difference in analgesic duration of 25%, a two-sided alpha of 0.05, and a power of 80%, a minimum of 28 patients per group was required. To account for possible block failures and protocol deviations, the sample size was rounded up to 30 patients per group, yielding a total of 60 participants.

Inclusion Criteria: Patients were enrolled if they met all of the following: age between 18 and 60 years; American Society of Anesthesiologists (ASA) physical status classification I, II, or III; scheduled to undergo elective below-knee orthopaedic surgery; body mass index (BMI) between 18 and 26 kg/m²; both male and female sex; and provision of written informed consent.

Exclusion Criteria: Patients were excluded for the following reasons: known allergy or hypersensitivity to local anaesthetics; mental disability or communication barrier precluding comprehension of the visual analogue scale (VAS); preexisting peripheral neuropathy of the lower limb; coagulation disorder or ongoing anticoagulant therapy; local infection at the proposed site of block; significant cardiac disease; recent head injury; peripheral vascular disease of the lower limbs; contraindications to spinal anaesthesia; and patients judged to be at risk of developing compartment syndrome postoperatively.

Randomization and Blinding: Eligible patients fulfilling the above criteria were randomly allocated into two groups of 30 patients each using a computer-generated randomization sequence (www.randomization.org). Group allocation was concealed in sequentially numbered, opaque, sealed envelopes that were opened only after the patient's

arrival in the preoperative block room. Double blinding was maintained as follows: the study drug was prepared by an anaesthesiologist not otherwise involved in the study; the anaesthesiologist performing the block, the patient, and the observer recording outcomes were all blinded to the group assignment.

Study Groups: Group A (n = 30) received 10 ml of 0.5% ropivacaine (total dose 50 mg) for sciatic nerve block. Group B (n = 30) received 20 ml of 0.25% ropivacaine (total dose 50 mg) for sciatic nerve block.

Preoperative Preparation: All patients underwent routine preoperative evaluation including history, general and systemic examination, and airway assessment. Standard investigations comprising complete haemogram, renal function tests, blood sugar, coagulation profile, electrocardiogram, and chest radiograph were performed. The VAS (0 = no pain, 10 = worst imaginable pain) was explained during the pre-anaesthetic visit. Patients were kept fasting for six hours for solids and two hours for clear fluids before surgery. On arrival in the operating complex, standard monitoring including non-invasive blood pressure, pulse oximetry, and electrocardiogram was established, and an intravenous line was secured.

Block Technique: The sciatic nerve block was performed under ultrasound guidance with the patient in the lateral position, operative limb uppermost. A high-frequency linear transducer (6–13 MHz) was positioned at the subgluteal crease. After skin disinfection and sterile draping, a 22-gauge, 100-mm insulated block needle was advanced in-plane until the tip lay adjacent to the sciatic nerve. After negative aspiration, the allocated study solution was injected in 5-ml aliquots, with circumferential spread confirmed sonographically. The saphenous nerve was then blocked at the mid-thigh level within the adductor canal using 5 ml of 0.5% bupivacaine, independent of group allocation.

Intraoperative Management

Haemodynamic parameters and VAS scores were recorded at 10 and 20 minutes after needle withdrawal. Patients with VAS ≥ 4 at the fracture site 20 minutes after the block were designated as block failures and excluded from analysis.

All patients subsequently received spinal anaesthesia in the sitting position at the L3–L4 or L2–L3 interspace with 2.5 ml of 0.5% hyperbaric bupivacaine (12.5 mg). Heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded at regular intervals throughout surgery.

Postoperative Assessment: After surgery, patients were monitored in the post-anaesthesia care unit and subsequently on the orthopaedic ward. VAS scores were recorded immediately postoperatively and at 30 minutes, 1, 2, 3, 4, 5, 6, 9, 12, and 24 hours.

The duration of analgesia was defined as the time from block performance to the first rescue analgesic request (VAS ≥ 3). Rescue analgesia consisted of intravenous paracetamol 1 g; if pain persisted, intravenous tramadol 50 mg was administered. Total 24-hour consumption of paracetamol and tramadol was recorded.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS version 22.0. Continuous variables were expressed as mean ± standard deviation and compared using the Student's unpaired t-test.

Categorical variables were expressed as frequencies and percentages and compared using the chi-square test. A two-tailed p-value < 0.05 was considered statistically significant, and 95% confidence intervals were estimated for all effect measures.

Results

A total of 60 patients completed the study protocol, with 30 patients in each group. No patients were excluded for block failure, and no adverse events related to the study drug were recorded.

Table 1: Demographic and Baseline Characteristics

Parameter	Group A (n = 30)	Group B (n = 30)	p-value
Age (years), mean ± SD	34.83 ± 8.875	31.63 ± 9.557	0.184
Age range (years)	22 – 50	21 – 55	–
Height (m), mean	1.685	1.685	> 0.05
BMI (kg/m²), mean	23.04	23.04	> 0.05
ASA I / II / III	Comparable	Comparable	> 0.05
Sex (M / F)	Comparable	Comparable	> 0.05

The demographic variables were homogeneously distributed between the two groups, with no statistically significant difference. The mean age of the entire cohort was approximately 33 years, the mean height was 1.685 m, and the

mean BMI was 23.04 kg/m², indicating that the study population represented a young to middle-aged adult group with normal body habitus, appropriate for the type of below-knee surgeries undertaken.

Table 2: Primary and Key Secondary Outcomes

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
VAS basal	8.4 ± 0.968	8.2 ± 0.925	> 0.05
VAS at 20 min preoperatively	4.9 ± 1.213	3.6 ± 1.22	< 0.05
Duration of analgesia (minutes)	256.21 ± 77.847	598.67 ± 78.1	< 0.0001
24-h paracetamol consumption (mg)	2733.3 ± 449.77	2000 ± 525.22	< 0.0001
24-h tramadol consumption (mg)	101.92 ± 22.27	61.11 ± 21.39	< 0.0001

The primary outcome—duration of postoperative analgesia—was dramatically and significantly prolonged in Group B, which received the larger volume and lower concentration of ropivacaine. Patients in Group B remained pain-free for nearly 2.3 times longer than those in Group A, with a mean difference of approximately 342 minutes and a p-value less than 0.0001. Correspondingly, 24-hour rescue analgesic consumption was markedly reduced in Group B, with paracetamol requirements decreased by approximately 27% and tramadol requirements reduced by approximately 40%, both reaching very high statistical significance ($p < 0.0001$). Basal VAS scores were comparable between groups, confirming equivalent pain at baseline, while VAS at 20 minutes after block performance was significantly lower in Group B, indicating earlier and deeper preoperative pain relief.

Table 3: Preoperative VAS Scores at Various Time Points

Time Point	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Preop basal VAS	8.40 ± 0.968	8.20 ± 0.925	> 0.05
Preop 20 min after block	4.90 ± 1.213	3.60 ± 1.221	< 0.05
Preop VAS on positioning for spinal	4.57 ± 1.305	2.93 ± 1.258	< 0.05

The preoperative VAS trajectory demonstrated that while both groups started from similar pain intensities, the reduction in pain scores was consistently greater in Group B. During the critical moment of positioning for spinal anaesthesia—a well-recognized trigger for pain exacerbation in fracture patients—Group B exhibited approximately 36% lower mean VAS scores than Group A (2.93 vs 4.57; $p < 0.05$), suggesting superior preoperative analgesia with the larger-volume, lower-concentration regimen.

Table 4: Postoperative VAS Scores at Various Time Points

Time Point	Group A (Mean ± SD)	Group B (Mean ± SD)
Immediate postop	1.17 ± 2.692	0.07 ± 0.254
Postop 30 min	1.37 ± 2.356	0.07 ± 0.254
Postop 1 hour	1.37 ± 2.341	0.20 ± 0.407
Postop 2 hours	2.03 ± 1.974	0.47 ± 0.629
Postop 3 hours	3.57 ± 1.382	1.00 ± 0.743
Postop 4 hours	3.70 ± 1.317	1.13 ± 0.629
Postop 5 hours	2.50 ± 1.526	1.80 ± 0.551
Postop 6 hours	2.10 ± 1.470	2.73 ± 0.868
Postop 9 hours	3.30 ± 1.725	2.67 ± 1.605
Postop 12 hours	2.33 ± 1.422	1.67 ± 0.606
Postop 24 hours	3.10 ± 1.269	1.40 ± 0.498

Postoperative VAS scores demonstrated a clear temporal pattern: Group B maintained significantly lower pain scores throughout the early postoperative period (immediate to 5 hours). In Group A, VAS scores peaked at 3–4 hours postoperatively (corresponding to block regression), whereas in Group B, the peak occurred later, at 6–9 hours, consistent with a substantially longer duration of analgesia. By 24 hours, Group B still demonstrated markedly lower mean VAS scores (1.40 vs 3.10), indicating persistent analgesic benefit.

Table 5: Perioperative Haemodynamic Parameters

Parameter	Group A (Baseline)	Group B (Baseline)	p-value (Baseline)	Intraop / Postop Trend
Heart rate (bpm)	Higher	Lower	< 0.05	Comparable, p > 0.05
Systolic BP (mmHg)	Comparable	Comparable	> 0.05	Comparable, p > 0.05
Diastolic BP (mmHg)	Higher	Lower	< 0.05	Comparable, p > 0.05
Mean arterial pressure (mmHg)	Higher	Lower	< 0.05	Comparable, p > 0.05

Baseline heart rate, diastolic blood pressure, and mean arterial pressure were statistically different between the two groups, likely reflecting the differential analgesic effect at 20 minutes post-block when spinal anaesthesia was about to be initiated patients in Group A, with incompletely controlled pain, exhibited a mild sympathetic response. Once spinal anaesthesia was established, all haemodynamic variables became comparable between the two groups throughout the intraoperative and postoperative periods, and no patient required vasopressor support beyond routine management of spinal-induced hypotension.

Discussion

The principal finding of the present study is that, at an identical total dose of 50 mg, 20 ml of 0.25% ropivacaine produced markedly superior and longer-lasting perioperative analgesia than 10 ml of 0.5% ropivacaine when used for ultrasound-guided sciatic nerve block in below-knee orthopaedic surgery. The near 2.3-fold prolongation of analgesic duration (598.67 vs 256.21 minutes; $p < 0.0001$) and the substantial reductions in 24-hour paracetamol (27% reduction) and tramadol (40% reduction) requirements (both $p < 0.0001$) have important clinical implications for perioperative pain management.

Our findings align closely with the seminal work of Ilfeld and colleagues, who conducted a dual-centre, randomized, controlled trial comparing ropivacaine concentrations for continuous popliteal sciatic nerve blocks.[1] Their investigation demonstrated that, at a fixed basal infusion rate, the concentration of ropivacaine (rather than the total mass delivered) was the principal determinant of both analgesic efficacy and motor blockade. Although their study examined continuous infusions rather than single-shot techniques, the conceptual parallel is direct: the distribution of the local anaesthetic—and therefore volume—strongly modulates the clinical block characteristics. In our single-shot context, the larger volume in Group B likely produced more circumferential perineural spread around the sciatic nerve, ensuring complete contact with all fascicles at the injection site and enhancing the duration of the block.

Zhai and colleagues prospectively evaluated low-dose ropivacaine at different volume–concentration combinations for interscalene brachial plexus blockade and reported that the larger volume produced a significantly longer analgesic duration than the smaller volume at matched total dose.[2] Although the anatomical target differs from the sciatic nerve, the underlying pharmacodynamic principle is identical: larger volumes maximize the surface area of neural contact and may compensate for lower concentration gradients. Our observed prolongation of analgesia with 20 ml of 0.25% ropivacaine is consistent with this principle.

Taboada and colleagues, in a study of the minimum effective volume required for sciatic nerve blockade via popliteal and subgluteal approaches, demonstrated that volumes well below 20 ml were sufficient for surgical anaesthesia when ultrasound guidance was employed.[11]

This observation, however, pertained to block onset and surgical adequacy rather than analgesic duration. Our results extend the literature by showing that, once an adequate volume is provided for comprehensive perineural spread, further reductions in concentration (to 0.25%) do not compromise—and may actually enhance—analgesic duration.

Casati and colleagues investigated the minimum local anaesthetic volume blocking the femoral nerve in 50% of patients (MLAV50) and reported that 0.5% ropivacaine and 0.5% bupivacaine had comparable ED50 values, but that block characteristics varied substantially with injectate volume.[12] Their findings reinforce the concept that volume is an independent determinant of block profile. McNamee and colleagues compared 0.5% ropivacaine with 0.5% bupivacaine in combined femoral and sciatic block for total knee replacement and noted similar onset times and durations but observed that motor recovery was faster with ropivacaine—an advantage relevant to early postoperative mobilization.[9]

In the realm of continuous peripheral nerve blockade, Richman and colleagues performed a meta-analysis demonstrating that continuous peripheral nerve blocks provide superior pain control to opioids across multiple surgical populations, with reduced opioid

consumption and fewer opioid-related side effects.[3] While our study examined single-shot blockade, the reduction in 24-hour tramadol consumption we observed (40% lower in Group B) echoes this broader theme of opioid-sparing through regional anaesthesia.

The concept that volume may prolong block duration finds mechanistic support in the work of Fanelli, Capdevila, and others who have demonstrated that local anaesthetic spread within the perineural sheath is a critical determinant of block density and persistence.[10,14] Hadzic and colleagues emphasized that inadequate circumferential spread produces patchy blockade and premature resolution, and modern ultrasound techniques have been developed specifically to ensure circumferential drug distribution.[6,13] In our study, ultrasound visualization confirmed circumferential spread in all patients; the advantage of Group B likely lay not in the achievement of circumferential spread per se, but in the greater volume of drug deposited around the nerve, which may have acted as a depot for prolonged perineural drug release.

Ropivacaine's unique vasoactive profile is particularly relevant to these findings. At lower concentrations (0.2–0.375%), ropivacaine produces intrinsic vasoconstriction, which would reduce systemic drug uptake and prolong local residence time.[8] At higher concentrations (≥ 0.5%), this vasoconstrictive effect may be attenuated or reversed, leading to more rapid systemic absorption.[7] Thus, the dilute 0.25% solution used in Group B may have benefited simultaneously from superior perineural spread (volume effect) and reduced systemic washout (concentration effect on local vasculature), jointly contributing to the observed prolongation of analgesia.

Salinas reviewed the evidence base for ultrasound-guided lower extremity peripheral nerve blocks and highlighted that the combination of ultrasound guidance with optimized local anaesthetic dosing represents the current standard of care for below-knee surgery.[13] The present study operationalizes this principle by demonstrating that, within a fixed total-dose framework, adjusting the volume–concentration ratio can deliver substantive clinical benefits without any increase in systemic drug exposure. This observation has direct safety implications: the maximum recommended dose of ropivacaine is approximately 3 mg/kg, and our 50 mg total dose is well within the safe range for all adult patients, regardless of volume–concentration combination.

The observed reductions in rescue analgesic consumption are clinically meaningful. A 40% reduction in tramadol over 24 hours translates into meaningful reductions in opioid-related side effects such as nausea, vomiting, sedation, and constipation—side effects that delay mobilization and discharge in below-knee orthopaedic patients.[15] The 27% reduction in paracetamol, while less dramatic, is nonetheless important in populations with hepatic dysfunction or those receiving concomitant hepatotoxic drugs.

Contrasting findings have been reported in some investigations of brachial plexus blockade, where concentration appeared to dominate over volume in determining block characteristics.[12] These discrepancies likely reflect anatomical differences between the brachial plexus (sheathed plexus with compartmentalized fascicles) and the sciatic nerve (single, large, monofascicular trunk at the subgluteal level). Such nerve-specific differences underscore the importance of site-specific dose-finding studies and caution against generalizing volume–concentration recommendations across all peripheral nerve blocks.

Several limitations of our study merit acknowledgement. First, the sample size of 60 patients, while adequately powered for the primary outcome, may be insufficient to detect differences in less frequent secondary outcomes such as complications or patient satisfaction. Second, we did not perform serial plasma ropivacaine measurements to correlate systemic absorption with the volume–concentration manipulation. Third, the study was conducted at a single centre, and results may not be directly generalizable to all practice settings. Finally, we did not formally assess motor block intensity or recovery, which is important for early postoperative mobilization protocols.

Conclusion

In patients undergoing below-knee orthopaedic surgeries under combined ultrasound-guided sciatic nerve block and spinal anaesthesia, 20 ml of 0.25% ropivacaine produced significantly superior perioperative analgesia compared with 10 ml of 0.5% ropivacaine at an identical total dose of 50 mg. The larger-volume, lower-concentration regimen provided a 2.3-fold prolongation of analgesic duration (598.67 ± 78.1 vs 256.21 ± 77.85 minutes; $p < 0.0001$), significantly lower preoperative VAS scores, and substantial reductions in 24-hour rescue analgesic consumption (paracetamol reduced by 27% and tramadol by 40%; both $p < 0.0001$). Haemodynamic stability was comparable between groups once spinal anaesthesia was established. These findings support the clinical adoption of 20 ml of 0.25% ropivacaine as the preferred volume–concentration combination for single-shot sciatic nerve blockade in below-knee

orthopaedic surgery, offering the dual advantages of prolonged analgesia and reduced opioid requirement within a safe total-dose framework.

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