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Original Research Article

Comparative Evaluation of Ultrasound-Guided Popliteal Sciatic with Adductor Canal Block versus Unilateral Subarachnoid Block for Anaesthesia in Below-Knee Surgeries: A Prospective Randomized Study

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Conflict of interest: Nil

Abstract:

Background: Regional anaesthesia techniques are widely employed for below-knee surgeries. While unilateral subarachnoid block provides rapid and reliable anaesthesia, peripheral nerve blocks, especially with ultrasound guidance, offer the advantages of haemodynamic stability and prolonged postoperative analgesia. This study compared the efficacy of ultrasound-guided popliteal sciatic block combined with adductor canal block versus unilateral subarachnoid block for below-knee procedures.

Materials and Methods: This prospective, randomized comparative trial was conducted on 60 ASA I–II patients aged 18–55 years undergoing elective unilateral below-knee surgery. Patients were randomly allocated into two groups of 30 each. Group A received an ultrasound-guided adductor canal block (10 ml of 0.5% levobupivacaine) and a popliteal sciatic block (20 ml of 0.5% levobupivacaine). Group B received a unilateral subarachnoid block with 2 ml of 0.75% hyperbaric levobupivacaine. Outcomes assessed included demographic comparability, onset of sensory and motor block, quality of block, haemodynamic stability, duration of postoperative analgesia, and complications.

Results: Demographic variables were comparable between the groups ($p > 0.05$). Onset of sensory (4.13 ± 0.68 min vs. 11.97 ± 4.25 min) and motor block (5.27 ± 0.94 min vs. 16.43 ± 6.21 min) was significantly faster in the subarachnoid group ($p < 0.001$). Duration of postoperative analgesia was markedly longer in the nerve block group (8.67 ± 2.59 h vs. 2.32 ± 0.61 h, $p < 0.001$). Quality of block was comparable, with a complete block achieved in 73.3% of Group A and 83.3% of Group B ($p = 0.319$). Haemodynamic stability and complication rates were similar in both groups.

Conclusion: Unilateral subarachnoid block remains superior in terms of rapid onset, while ultrasound-guided popliteal sciatic with adductor canal block provides significantly prolonged postoperative analgesia with comparable efficacy and safety. Peripheral nerve blocks are therefore a valuable alternative, especially where prolonged pain relief and opioid-sparing strategies are desired.

Keywords: Below-knee surgery; ultrasound-guided nerve block; popliteal sciatic block; adductor canal block; unilateral subarachnoid block; postoperative analgesia

Introduction

Lower limb surgeries below the knee are commonly performed procedures requiring effective anaesthetic strategies that ensure surgical comfort, patient safety, and optimal postoperative recovery. Anaesthetic options include general anaesthesia, central neuraxial blockade, and peripheral nerve blocks. Each technique carries distinct advantages and limitations. General anaesthesia, though reliable, may cause systemic complications such as hypotension, myocardial depression, respiratory suppression, and issues related to mechanical ventilation [1]. Neuraxial blocks, while frequently used, can lead to haemodynamic instability, post-dural puncture headache, backache, and nausea, and are relatively contraindicated in patients with coagulation abnormalities [2,3].

Unilateral subarachnoid block (SAB) is preferred for unilateral lower limb surgeries because it restricts anaesthesia to the operative limb while maintaining motor and sensory function in the contralateral limb. This selective approach reduces haemodynamic fluctuations and facilitates earlier mobilization, thereby lowering the risk of complications such as venous thromboembolism and pulmonary embolism [4]. However, the duration of analgesia following SAB is often limited, necessitating additional postoperative pain management.

Peripheral nerve blocks have emerged as attractive alternatives, particularly with the advent of ultrasound guidance. The combination of popliteal sciatic nerve block (PSNB) and adductor canal block (ACB) provides adequate surgical anaesthesia and prolonged postoperative analgesia for below-knee procedures [5]. Ultrasound guidance enables real-time visualization of anatomical structures, improving block accuracy, reducing local anaesthetic dosage, and minimizing risks such as paraesthesia, vascular puncture, and systemic toxicity [6,7]. Compared to conventional techniques, ultrasound-guided blocks enhance block quality, shorten onset time, and extend postoperative analgesia, thereby decreasing opioid consumption and related side effects [8].

Given these benefits, ultrasound-guided PSNB combined with ACB represents a promising alternative to unilateral SAB in lower limb surgeries. This study was designed to prospectively compare the efficacy of these two techniques in terms of block quality, haemodynamic stability, onset of sensory and motor block, duration of postoperative analgesia, and safety outcomes.

Materials and Methods

Study Design and Ethical Approval: This was a prospective, randomized, comparative clinical trial designed to evaluate the efficacy of ultrasound-guided popliteal sciatic nerve block combined with adductor canal block versus unilateral subarachnoid block as a sole anaesthetic technique for below-knee surgeries. The study was conducted after obtaining ethical approval from the Institutional Ethics Committee of Chaudhary Charan Singh University, Meerut (Approval No. SC-1/2024/4485). It was prospectively registered with the Clinical Trial Registry of India (CTRI/2024/07/087192).

Study Setting and Duration: The trial was carried out at SVBP Hospital, affiliated with LLRM Medical College, Meerut, Uttar Pradesh, over a period of 18 months from July 2023 to December 2024.

Sample Size Calculation: The sample size was calculated based on prior published data, assuming a 90% success rate for nerve blocks and 65% for spinal anaesthesia, corresponding to a clinically relevant difference of 25%. With a power of 80% and an alpha error of 0.05, the minimum requirement was 25 patients per group. To allow for attrition, 30 patients were enrolled in each group, making a total of 60 participants.

Patient Selection: Patients aged between 18 and 55 years, belonging to ASA grade I or II, and scheduled for unilateral below-knee surgery were included after providing informed written consent. Exclusion criteria were patient refusal, infection at the injection site, coagulopathy, heart block, peripheral neuropathy, allergy to local anaesthetic agents, peripheral vascular disease, contraindications to regional anaesthesia, and major comorbidities such as uncontrolled diabetes, hypertension, or ischemic heart disease. All patients underwent pre-anaesthetic evaluation a day before surgery, and confidentiality was maintained throughout the study.

Randomization and Group Allocation: Eligible patients were randomized using a computer-generated randomization table into two groups of 30 each. Group A received an ultrasound-guided adductor canal block with 10 ml of 0.5% levobupivacaine, along with a popliteal sciatic nerve block using 20 ml of 0.5% levobupivacaine (total 30 ml). Group B received a unilateral subarachnoid block with 2 ml of 0.75% hyperbaric levobupivacaine.

Anaesthetic Techniques: All patients were monitored with standard non-invasive blood pressure, ECG, and pulse oximetry on arrival in the operating room. Baseline parameters were recorded, and intravenous access was secured with Ringer's lactate infusion. For the adductor canal block, patients were placed supine with the limb slightly externally rotated. Using a high-frequency linear ultrasound probe (6–13 MHz), the sartorius muscle and femoral vessels were identified at mid-thigh level, and 10 ml of levobupivacaine was injected around the femoral artery under the sartorius muscle with an in-plane technique. For the popliteal sciatic nerve block, patients were placed laterally, and the tibial and common peroneal nerves were identified in the popliteal fossa. At the level of convergence into the sciatic nerve, 20 ml of levobupivacaine was deposited under ultrasound guidance. In Group B, unilateral spinal anaesthesia was performed with the patient in the lateral decubitus position, using a 25-gauge Quincke needle at the L3–L4 interspace. After confirming free CSF flow, 2 ml of hyperbaric levobupivacaine was injected, and the patient was kept lateral for 10 minutes before being positioned supine.

Outcome Measures: The primary outcome was the quality of block, which was categorised as complete (no need for supplemental anaesthesia), incomplete (supplementation required), or failed (conversion to general anaesthesia). Secondary outcomes included

onset of sensory and motor block, intraoperative haemodynamic stability, time to first rescue analgesia postoperatively, and complications such as vascular puncture, nerve injury, infection, or local anaesthetic systemic toxicity.

Pain and Block Assessment: The onset of sensory block was assessed by cold sensation testing, graded from 0 (normal sensation) to 3 (complete loss of sensation). Motor block was assessed using the modified Bromage scale, ranging from 0 (no block) to 3 (complete block). Postoperative pain was evaluated using a Visual Analog Scale (VAS, 0–10), and rescue analgesia was provided with intravenous tramadol 100 mg when VAS ≥ 4.

Statistical Analysis: Data were analysed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical data were presented as frequencies or percentages and compared using the Chi-square test. Non-parametric variables were analysed using the Mann-Whitney U test. A p-value < 0.05 was considered statistically significant.

Results

A total of 60 patients were randomized equally into two groups: Group A (ultrasound-guided adductor canal block + popliteal sciatic nerve block) and Group B (unilateral subarachnoid block).

Demographic Data: The two groups were comparable in terms of age, weight, height, and BMI, with no statistically significant differences (p > 0.05).

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Age (years)	35.8 ± 10.53	37.6 ± 9.47	0.489
Weight (kg)	64.6 ± 8.01	65.9 ± 8.53	0.535
Height (cm)	165.8 ± 3.06	165.4 ± 4.69	0.697
BMI (kg/m²)	23.0 ± 2.36	23.9 ± 2.16	0.159

Onset of Sensory and Motor Block: The onset of sensory and motor blocks was significantly faster in Group B compared to Group A. Sensory block occurred at 4.13 ± 0.68 min in Group B versus 11.97 ± 4.25 min in Group A (p < 0.001). Motor block onset was 5.27 ± 0.94 min in Group B compared to 16.43 ± 6.21 min in Group A (p < 0.001).

Quality of Block: Complete surgical block was achieved in 73.3% of Group A and 83.3% of Group B patients. Incomplete blocks were recorded in 20.0% and 16.7%, respectively, while two patients in Group A experienced block failure requiring conversion to general anaesthesia. The difference was not statistically significant (p = 0.319).

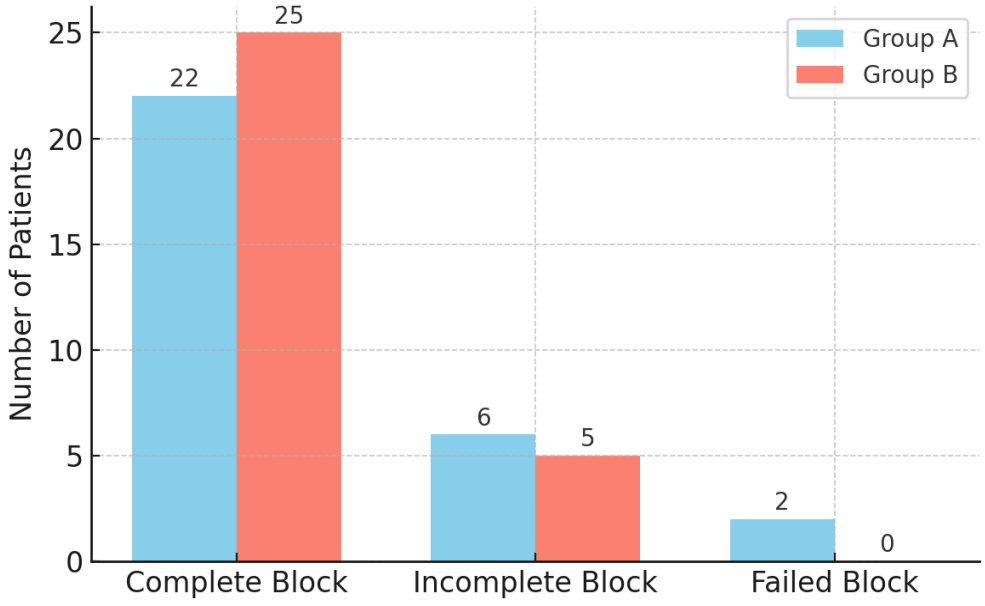

Figure 1. Quality of Block Distribution

Postoperative Analgesia: Time to first rescue analgesia was significantly prolonged in Group A (8.67 ± 2.59 hours) compared to Group B (2.32 ± 0.61 hours, p < 0.001).

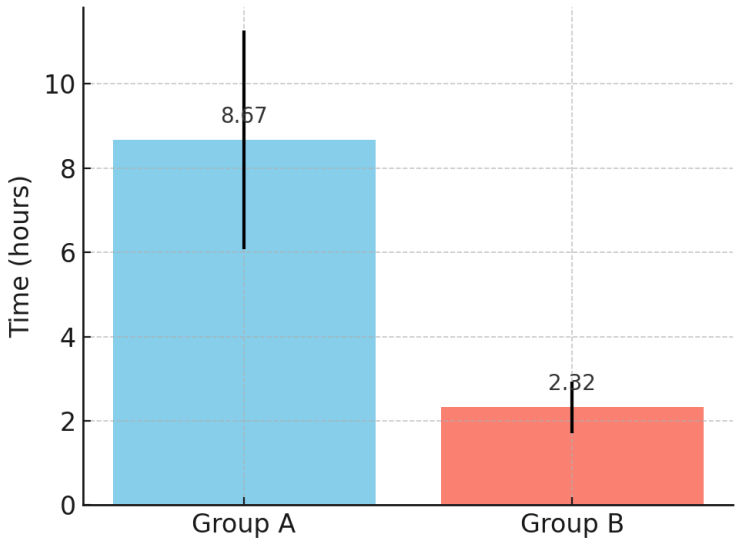

Figure 2. Time to First Rescue Analgesia (VAS ≥4)

Hemodynamic Parameters and Safety: Hemodynamic parameters, including heart rate, systolic and diastolic blood pressure, and mean arterial pressure, were comparable between groups across all recorded intervals ($p > 0.05$). Both groups maintained intraoperative stability. No complications such as nerve injury, vascular puncture, infection, or local anaesthetic systemic toxicity were observed.

Discussion

This prospective randomized comparative study evaluated the efficacy of ultrasound-guided popliteal sciatic and adductor canal blocks versus unilateral subarachnoid block as sole anaesthetic techniques for below-knee surgeries. Both methods provided satisfactory surgical conditions, but important differences were observed in block characteristics and postoperative outcomes.

In our study, the onset of sensory and motor block was significantly faster with unilateral subarachnoid block, consistent with the pharmacokinetic profile of intrathecal local anaesthetics, which provide a rapid onset due to direct deposition into cerebrospinal fluid. Similar findings have been reported by Devarci et al. [9], who demonstrated a quicker onset of anaesthesia with spinal techniques compared to peripheral nerve blocks. Recent studies also confirm that spinal techniques consistently achieve quicker onset compared with peripheral nerve blocks in lower limb surgeries [10].

Although spinal anaesthesia had a faster onset, the duration of postoperative analgesia was markedly prolonged in the nerve block group. Patients receiving ultrasound-guided popliteal sciatic and adductor canal blocks experienced a mean analgesia duration of 8.6 hours compared to only 2.3 hours in the subarachnoid group. This finding is supported by Pujari et al. [11], who showed that peripheral nerve blocks provided superior analgesic duration and reduced rescue analgesic requirements compared to spinal anaesthesia in below-knee procedures. Chauhan et al. [12] also observed that combining popliteal and adductor canal blocks resulted in longer pain-free intervals and greater patient satisfaction. A 2023 review further emphasized that ultrasound-guided peripheral blocks extend analgesia duration, aligning with ERAS protocols by reducing opioid requirements [13].

Haemodynamic stability was maintained in both groups, with no significant differences in heart rate, blood pressure, or mean arterial pressure. However, peripheral nerve blocks are known to offer greater haemodynamic stability, especially in high-risk patients, as reported by Amiri et al. [14] and Arjun et al. [15]. Our results align with this observation, as patients in the nerve block group exhibited comparable stability without hypotensive episodes, making this technique advantageous in patients with cardiovascular compromise. Additionally, recent analyses underscore that ultrasound-guided blocks are especially beneficial in high-risk cardiovascular patients, as they minimize sympathetic blockade and improve perioperative stability [16].

The quality of block was comparable between the two groups, with complete block rates of 73.3% in the nerve block group and 83.3% in the spinal group. While block failures occurred only in two patients of the nerve block group, this limitation may be attributed to technical factors or anatomical variations. Previous studies have shown that ultrasound guidance enhances success rates by enabling real-time visualization of neural structures, reducing the number of needle passes, and minimizing complications [6,7]. Our findings support the utility of ultrasound in improving block efficacy and safety.

Importantly, no major complications such as nerve injury, vascular puncture, local anaesthetic systemic toxicity, or infection were noted in either group, reinforcing the safety of both approaches. This is in agreement with prior studies, such as those by Dufour et al. [6] and Danelli et al. [7], which demonstrated low complication rates when nerve blocks were performed under ultrasound guidance.

From a clinical perspective, unilateral subarachnoid block remains a reliable choice when a rapid onset of anaesthesia is required. However, for patients where prolonged postoperative analgesia and opioid-sparing effects are desired, ultrasound-guided popliteal sciatic and adductor canal blocks provide a superior option. These findings are particularly relevant in the current era of enhanced recovery after surgery (ERAS) protocols, where early mobilization and reduced opioid consumption are key goals.

Conclusion

Both unilateral subarachnoid block and ultrasound-guided popliteal sciatic with adductor canal block proved effective for below-knee surgeries, but they differed in their clinical profiles. Subarachnoid block offered a faster onset of sensory and motor blockade, making it suitable when rapid surgical anaesthesia is required. In contrast, the peripheral nerve block technique provided significantly longer postoperative analgesia with comparable block quality and haemodynamic stability, highlighting its role as a valuable alternative, especially in patients where prolonged pain relief and opioid sparing are desired. The use of ultrasound further enhanced the accuracy and safety of peripheral blocks. Overall, the choice of technique should be tailored to the surgical context, patient comorbidities, and postoperative pain management needs.

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