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# A comparative study of spinal bupivacaine with fentanyl versus ultrasound-guided combined lumbar plexus and sciatic nerve block in lower limb orthopedic procedures: A prospective randomized controlled trial.

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## Abstract

### Background

Spinal anesthesia with bupivacaine and fentanyl is widely used for its rapid onset, while ultrasound-guided lumbar plexus and sciatic nerve blocks are gaining popularity for prolonged postoperative analgesia with fewer systemic side effects.

**Aim:** To compare the efficacy of spinal bupivacaine with fentanyl versus ultrasound-guided combined lumbar plexus and sciatic nerve blocks in lower limb orthopedic procedures.

### Methods

This prospective randomized controlled trial was conducted on 50 patients aged 18–65 years undergoing elective lower limb orthopedic surgeries. Patients were randomized into two groups: Group A received spinal bupivacaine (12.5 mg) + fentanyl (25 mcg); Group B received ultrasound-guided lumbar plexus block with 30 ml of 0.25% bupivacaine and sciatic nerve block with 25 ml of 0.25% bupivacaine. Primary outcomes included onset and duration of sensory and motor blocks, and duration of analgesia. Secondary outcomes included hemodynamic changes and complications.

### Results

Both groups were comparable in baseline demographics, with a mean age of 49 years and a similar distribution of sex and ASA physical status. The onset of sensory and motor block was significantly faster in Group A (5–8 min and 6–10 min) compared to Group B (10–20 min and 12–20 min; $p<0.001$). However, Group B had a significantly longer duration of sensory block (6–8 hrs), motor block (3–4 hrs), and analgesia (8–12 hrs) ($p<0.001$). Hypotension was more common in Group A (48%) than in Group B (32%). Two patients in Group B required conversion to general anesthesia due to technical difficulties.

### Conclusion

Ultrasound-guided lumbar plexus and sciatic nerve blocks provide longer postoperative analgesia with fewer hemodynamic changes, making them preferable in high-risk or prolonged orthopedic surgeries.

### Recommendations

For lower limb orthopedic surgeries, ultrasound-guided lumbar plexus and sciatic nerve blocks are recommended, particularly in patients at risk of hemodynamic instability or requiring prolonged analgesia.

***Keywords:*** *Spinal anesthesia, bupivacaine, fentanyl, lumbar plexus block, sciatic nerve block, regional anesthesia, orthopedic surgery*

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## Introduction

Effective anesthesia is a cornerstone of successful orthopedic procedures, particularly in surgeries involving the lower limb, where adequate intraoperative analgesia and postoperative pain control are essential. Spinal anesthesia using bupivacaine, a long-acting local anesthetic, is widely practiced due to its rapid onset and predictable sensory and motor blockade. The addition of intrathecal fentanyl further enhances analgesic efficacy, improves patient comfort, and reduces the need for supplemental opioids during the immediate postoperative period [1].

However, spinal anesthesia is not without limitations. It may lead to adverse effects such as hypotension, bradycardia, post-dural puncture headache, and limited duration of analgesia. These concerns are especially significant in elderly or high-risk patients undergoing prolonged surgical procedures [2,3]. In contrast, peripheral nerve blocks, particularly the combination of lumbar plexus and sciatic nerve blocks, have emerged as promising alternatives. These techniques provide targeted, long-lasting analgesia with minimal systemic side effects, improving both intraoperative conditions and postoperative recovery [2–4].

The use of ultrasound guidance has further improved the safety and precision of regional blocks by allowing real-time visualization of anatomical structures and accurate needle placement. The lumbar plexus block provides anesthesia to the femoral, obturator, and lateral femoral cutaneous nerves, whereas the sciatic nerve block ensures coverage of the posterior aspect of the thigh, the leg below the knee, and the foot. Together, they offer comprehensive anesthesia for lower limb surgeries, with superior postoperative pain control and fewer hemodynamic disturbances [4,5].

This study was designed to evaluate spinal anesthesia with bupivacaine and fentanyl against ultrasound-guided lumbar plexus and sciatic nerve blocks, focusing on block efficacy, onset and duration of analgesia, hemodynamic responses, and perioperative complications in patients undergoing lower limb orthopedic surgery.

## Methodology

### Study design

This was a prospective, randomized controlled trial conducted to compare the efficacy of spinal anesthesia with bupivacaine and fentanyl versus ultrasound-guided combined lumbar plexus and sciatic nerve block in patients undergoing elective lower limb orthopedic surgeries.

### Study setting and duration

The study was carried out in the Department of Anesthesiology at Government Mohan Kumaramangalam Medical College, Salem, Tamil Nadu, India, between December 2022 and March 2024.

### Sample size and randomization

A total of 50 patients were enrolled and randomly assigned into two equal groups (n = 25 each). The sample size was determined pragmatically based on the expected surgical caseload during the study period and the availability of resources. Although no formal power calculation was performed, the chosen number was considered sufficient to demonstrate clinically meaningful differences in block characteristics and analgesia, in line with prior studies of similar scope.

Randomization was performed using a computer-generated random sequence. Allocation concealment was ensured by sequentially numbered, opaque, sealed envelopes prepared by an independent anesthesiologist not involved in recruitment or outcome assessment. The envelopes were opened just before the procedure to assign patients to study groups.

### Inclusion criteria

Patients aged 18 to 65 years
ASA physical status I or II
Weight between 40–70 kg
Scheduled for elective lower limb orthopedic procedures
Provided informed written consent

### Exclusion criteria

Patient refusal
Known allergy to study drugs
Spinal deformities or pre-existing neurological deficits
History of spinal surgery
Coagulopathy or contraindications to regional anesthesia
ASA physical status III or above
Pregnancy or lactation
Psychiatric illness

### Interventions

All procedures were performed in the operating theatre under strict aseptic precautions by experienced anesthesiologists trained in regional anesthesia.

**Group A (Spinal Anesthesia – SAB):** Patients received intrathecal injection of 12.5 mg of 0.5% hyperbaric bupivacaine with 25 mcg of fentanyl at the L3–L4

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interspace using a 25G Quincke spinal needle, with the patient in the sitting position.

**Group B (Lumbar Plexus Block + Sciatic Nerve Block – LPB + SNB):** Patients received 30 ml of 0.25% bupivacaine for ultrasound-guided lumbar plexus block using the Shamrock method and 25 ml of 0.25% bupivacaine for parasacral sciatic nerve block. Blocks were administered with the patient in the lateral decubitus position, using a high-frequency linear probe and in-plane technique.

## Blinding

Due to the inherent nature of the interventions, blinding of anesthesiologists performing the procedures was not feasible. However, outcome assessors and patients were blinded to group allocation. Postoperative block assessment and pain scoring were carried out by independent investigators who were unaware of the anesthetic technique used.

## Outcomes and assessments

### Primary outcomes

Onset time of sensory block (assessed by pinprick method every 2 minutes until complete block)

Onset time of motor block (assessed using the Modified Bromage Scale every 2 minutes until maximum score)

Duration of sensory and motor block

Duration of postoperative analgesia (time to first rescue analgesic, with VAS > 4 as the trigger)

### Secondary outcomes

Hemodynamic changes (heart rate, blood pressure, $SpO_2$) were recorded at baseline and every 5 minutes intraoperatively

Perioperative complications: hypotension, bradycardia, nausea, vomiting, shivering, post-dural puncture headache, and technical difficulties

Requirement for conversion to general anesthesia

Postoperative assessments were continued up to 24 hours after surgery.

## Monitoring and data collection

Standard intraoperative monitoring included heart rate, non-invasive blood pressure, electrocardiography, and peripheral oxygen saturation. Data collection was performed prospectively using structured case record forms.

## Statistical analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical variables were expressed as frequencies and percentages and analyzed using the Chi-square or Fisher's exact test as appropriate. A p-value $< 0.05$ was considered statistically significant.

## Ethical considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of Government Mohan Kumaramangalam Medical College, Salem. Written informed consent was obtained from all participants after explaining the study objectives, procedures, potential risks, and benefits. Confidentiality of patient data was maintained throughout the study, and participation was voluntary with the right to withdraw at any time without affecting standard care.

## Results

### Participant flow

A total of 58 patients were screened for eligibility. Eight were excluded (three declined consent, two had ASA III status, one had coagulopathy, and two had spinal deformities). Fifty patients meeting the inclusion criteria were randomized into two groups (25 each).

Group A (Spinal Anesthesia): All 25 patients received the allocated intervention and were analyzed for the primary outcome.

Group B (Lumbar Plexus + Sciatic Nerve Block): All 25 patients received the allocated intervention. Two patients required conversion to general anesthesia due to technical difficulty in block administration, but were still included in the analysis (intention-to-treat principle).

No patients were lost to follow-up or excluded after randomization.

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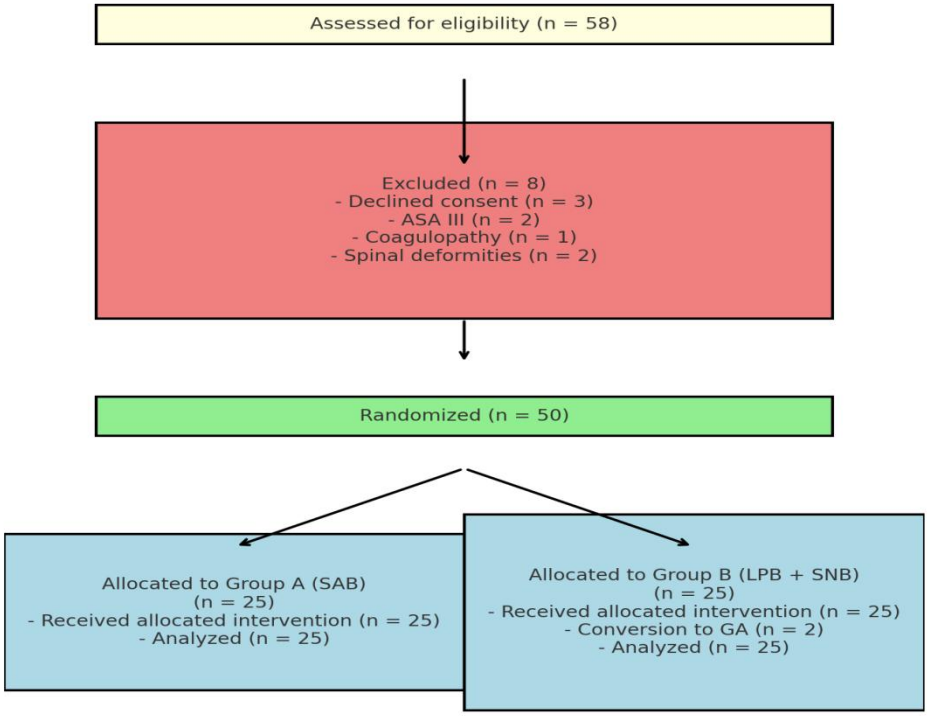


**Figure 1: participant flow diagram**

A total of 50 patients undergoing lower limb orthopedic procedures were enrolled and randomized equally into two groups: Group A (Spinal Anesthesia with Bupivacaine and Fentanyl) and Group B (Ultrasound-Guided Combined Lumbar Plexus Block and Sciatic Nerve Block).

## Demographic and baseline characteristics

The demographic parameters, including age, weight, height, and BMI, were comparable between the two groups with no statistically significant differences ($p > 0.05$). The mean age in Group A was 49.5 ± 8.5 years and 49.2 ± 7.8 years in Group B. Similarly, other variables such as weight (56.3 ± 7.2 vs. 57.1 ± 8.3 kg), height (170.2 ± 7.5 vs. 171.6 ± 6.9 cm), and BMI (26.6 ± 5.6 vs. 27.0 ± 4.8 kg/m²) were not significantly different between the groups. ASA physical status distribution was also similar (Table 1).

**Table 1: demographic and baseline characteristics**

| Parameter | Group A (SAB) | Group B (LPB + SNB) | *p*-value |
|---|---|---|---|
| Age (years) | 49.5 ± 8.5 | 49.2 ± 7.8 | 0.90 |
| Weight (kg) | 56.3 ± 7.2 | 57.1 ± 8.3 | 0.72 |
| Height (cm) | 170.2 ± 7.5 | 171.6 ± 6.9 | 0.49 |
| BMI (kg/m²) | 26.6 ± 5.6 | 27.0 ± 4.8 | 0.79 |
| ASA Class I | 11 | 10 | 0.776 |
| ASA Class II | 14 | 15 | 0.776 |

## Onset and duration of block

Group A exhibited a significantly faster onset of both sensory and motor block compared to Group B. The onset of sensory block occurred within 5–8 minutes in Group A versus 10–20 minutes in Group B ($p = 0.001$), and motor block onset was achieved in 6–10 minutes in Group A versus 12–20 minutes in Group B ($p = 0.001$). However, the duration of both sensory block and analgesia was

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significantly prolonged in Group B. Sensory block lasted 6–8 hours in Group B compared to 4–6 hours in Group A ($p = 0.001$), while the duration of analgesia extended to 8–12 hours in Group B versus 6–8 hours in Group A ($p = 0.001$). Motor block duration was also slightly longer in Group B (3–4 hours) compared to Group A (2–4 hours) ($p = 0.05$) (Table 2).

**Table 2: onset and duration of block**

| Parameter | Group A (SAB) | Group B (LPB + SNB) | *p*-value |
|---|---|---|---|
| Onset of Sensory Block (min) | 5–8 | 10–20 | 0.001** |
| Onset of Motor Block (min) | 6–10 | 12–20 | 0.001** |
| Duration of Sensory Block (hrs) | 4–6 | 6–8 | 0.001** |
| Duration of Motor Block (hrs) | 2–4 | 3–4 | 0.05* |
| Duration of Analgesia (hrs) | 6–8 | 8–12 | 0.001** |

## Type of surgeries and surgery duration

The distribution of surgeries varied slightly between groups. Femur repairs were more common in Group A (11 vs. 7), whereas knee repairs were more frequent in Group B (9 vs. 2). Hip repairs were nearly equal (12 in Group A vs. 9 in Group B). The average duration of surgery was comparable between the two groups (89.0 minutes in Group A vs. 87.5 minutes in Group B, $p = 0.60$), indicating that the type of anesthesia did not significantly affect surgical time (Table 3).

**Table 3: types of surgeries and surgery duration**

| Surgery Type | Group A (SAB) | Group B (LPB + SNB) | *p*-value |
|---|---|---|---|
| Femur Repair | 11 | 7 | - |
| Knee Repair | 2 | 9 | - |
| Hip Repair | 12 | 9 | - |
| Average Surgery Duration (min) | 89.0 | 87.5 | 0.60 |

## Complications and technical challenges

Hypotension was more frequently observed in Group A (12 patients) compared to Group B (8 patients), though the difference was not statistically significant ($p = 0.37$). Other complications such as bradycardia, nausea/vomiting, and shivering were comparable between the two groups ($p > 0.05$). Notably, two patients in Group B required conversion to general anesthesia due to difficulty in positioning for femur fractures in the lateral decubitus position, highlighting technical challenges in administering ultrasound-guided blocks in certain anatomical scenarios (Table 4).

**Table 4: complications and technical challenges**

| Complication | Group A (SAB) | Group B (LPB + SNB) | *p*-value |
|---|---|---|---|
| Hypotension | 12 | 8 | 0.37 |
| Bradycardia | 4 | 4 | 1.0 |
| Nausea/Vomiting | 6 | 6 | 1.0 |
| Shivering | 6 | 4 | 0.52 |
| Technical Difficulties | None | 2 patients required GA conversion | - |

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## Discussion

This prospective randomized controlled study compared the efficacy of spinal anesthesia using bupivacaine with fentanyl (Group A) versus ultrasound-guided combined lumbar plexus and sciatic nerve block (Group B) in lower limb orthopedic procedures. Key outcomes assessed included onset and duration of sensory and motor block, postoperative analgesia, hemodynamic stability, and associated complications.

Demographic characteristics such as age, weight, height, BMI, and ASA physical status were similar between the two groups, ensuring baseline comparability and reducing potential confounding variables (Table 1). The faster onset of sensory (5–8 minutes) and motor blockade (6–10 minutes) observed in Group A compared to Group B (10–20 and 12–20 minutes, respectively) is consistent with the pharmacokinetics of intrathecal bupivacaine, which allows for rapid neural uptake and action [6].

In contrast, Group B exhibited a significantly prolonged duration of sensory block (6–8 hours) and postoperative analgesia (8–12 hours), as compared to Group A (4–6 and 6–8 hours, respectively), reflecting the sustained action of peripheral nerve blocks [7]. The slightly longer duration of motor blockade in Group B (3–4 hours) may delay early mobilization but is beneficial for extended pain relief [8].

Surgical durations and procedure types were not significantly different between groups (Table 3), although femur repairs, generally associated with more intense pain, were more frequent in Group A. Hemodynamic stability was better maintained in Group B, with lower incidence of hypotension (32% vs. 48% in Group A), likely due to the absence of significant sympathetic blockade typical of spinal anesthesia [9].

Group B also presented certain technical challenges. Two patients required conversion to general anesthesia due to difficulty in positioning and ultrasound-guided block performance—especially in those with higher BMI—highlighting the procedural complexity of regional blocks [10].

Overall, these findings support the use of combined lumbar plexus and sciatic nerve blocks as a valuable alternative to spinal anesthesia for lower limb surgeries, offering longer analgesia and greater hemodynamic stability. However, their success depends on operator skill and ultrasound proficiency, which may limit widespread use in some clinical settings [11].

## Generalizability

The findings of this study are most applicable to adult patients aged 18–65 years with ASA physical status I–II undergoing elective lower limb orthopedic surgeries in a tertiary care setting. Since the study was conducted in a single institution with a relatively small sample size, the results may not fully represent populations with higher surgical risk (ASA III and above), pediatric or elderly patients, or those undergoing emergency procedures. However, the consistency of our findings with previous trials on regional anesthesia techniques suggests that the observed advantages of ultrasound-guided lumbar plexus and sciatic nerve blocks, particularly longer postoperative analgesia and better hemodynamic stability, are likely to be generalizable to similar patient populations in comparable clinical settings. Future multicenter studies with larger and more diverse cohorts are warranted to enhance external validity and broaden applicability.

## Conclusion

This study demonstrates that while spinal anesthesia using bupivacaine with fentanyl provides a faster onset of sensory and motor block, the ultrasound-guided combined lumbar plexus and sciatic nerve block offers significantly longer duration of postoperative analgesia with better hemodynamic stability. Although technically more challenging and requiring expertise, especially in patients with higher BMI, the combined nerve block technique reduces the need for additional analgesics and is associated with fewer complications such as hypotension. Therefore, it may be a preferable option for patients undergoing prolonged lower limb orthopedic procedures or those with cardiovascular comorbidities. Individual patient characteristics and surgical requirements should guide anesthetic technique selection.

## Limitations

This study was conducted at a single tertiary care center with a relatively small sample size, which may limit the generalizability of the findings. The technical expertise required for ultrasound-guided nerve blocks may vary among practitioners, potentially influencing outcomes. Additionally, blinding was not feasible due to the nature of the procedures, which could introduce observer bias. Long-term outcomes such as chronic pain relief and functional recovery were not assessed and warrant further investigation in future studies.

## Recommendations

Based on the findings of this study, ultrasound-guided combined lumbar plexus and sciatic nerve blocks are recommended for lower limb orthopedic procedures, particularly in patients requiring prolonged postoperative analgesia or those at risk of hemodynamic instability. Training programs should be implemented to enhance

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proficiency in ultrasound-guided regional anesthesia techniques among anesthesiologists. Future multi-center studies with larger sample sizes and longer follow-up periods are warranted to validate these findings and evaluate long-term outcomes such as functional recovery, patient satisfaction, and incidence of chronic postoperative pain. Individual patient profiles should guide anesthetic selection for optimal perioperative care.

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## List of abbreviations
SAB – Subarachnoid Block
LPB – Lumbar Plexus Block
SNB – Sciatic Nerve Block
ASA – American Society of Anesthesiologists
BMI – Body Mass Index
VAS – Visual Analog Scale
USG – Ultrasound-Guided
GA – General Anesthesia
ECG – Electrocardiogram
$SpO_2$ – Peripheral Oxygen Saturation
HR – Heart Rate
BP – Blood Pressure
CSF – Cerebrospinal Fluid
PACU – Post Anesthesia Care Unit
PDPH – Post-Dural Puncture Headache

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## Conflict of interest
The authors declare no conflict of interest.

## Author contributions
**LG**-Concept and design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. **RM**-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript, revision of the manuscript.**EG-**Review of literature and preparing the first draft of the manuscript. Statistical analysis and interpretation. **PP-**Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript.

## Data availability
Data Available

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