Original Article

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Effectiveness of Ultrasound-guided Adductor Canal Block for Postoperative Pain Management in below Knee Orthopaedic Surgeries: A Randomised Controlled Study

Anaesthesia Section

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ABSTRACT

Introduction: The sensory innervation below the knee is provided by the saphenous nerve and sciatic nerve. Drugs deposited in the Adductor Canal (AC) at the Adductor Hiatus (AH) level spread both proximally up to the mid-canal and distally to the popliteal fossa through the perivascular space. The Adductor Canal Block (ACB) is a newer technique by which both nerves can be blocked in a single procedure.

Aim: To evaluate the efficacy of ACB for postoperative pain management in below knee surgeries.

Materials and Methods: This randomised controlled study was conducted in a tertiary care hospital. A total of 81 patients with American Society of Anaesthesiologists (ASA) I and II physical status were randomly allocated to either group A (ACB) or group B (Control), scheduled for below knee orthopaedic surgery. Group A patients received a mixture of 40 mL of 0.125% bupivacaine and 8 mg dexamethasone in the AC at the hiatus level under ultrasound guidance. Group B patients received standard care for pain management. The duration of sensory and motor block, mean Visual Analogue Scale (VAS) scores, amount of opioid drug requirement, drug-related side-effects, and satisfaction scores were compared between the two groups. Data were presented as mean±Standard Deviation (SD) for continuous variables and frequency (%) for categorical data and were analysed using t-tests and Chi-square tests.

Results: The mean age in group A was 42.9±13.5 years and in group B was 46.3±13.1 years. In group A, there were 30 males and 11 females, while in group B, there were 32 males and 8 females. The mean Body Mass Index (BMI) between group A and B was 27.4±3.2 kg/m^2 and 26.3±3.1 kg/m^2, respectively. The mean duration of sensory block was longer in group A (12.3±4.6 hours) compared to group B (4.7±0.7 hours). The mean VAS scores (1.351±0.659 vs 3.240±0.590) were significantly lower in group A. The total opioid requirement was 42.9±73.6 mg vs 205.9±26.0 mg between the two groups, which was significantly lower in group A.

Conclusion: In distal ACB, a single procedure with 40 mL of 0.125% bupivacaine significantly reduces postoperative VAS scores and analgesic requirements while increasing patient satisfaction levels. Therefore, this block is safe and recommended for postoperative pain management in below knee surgeries.

Keywords: Analgesic, Opioid, Peripheral block

INTRODUCTION

Pain is a major contributing factor to delayed ambulation, decreased range of motion, and prolonged hospital stays. In lower limb orthopaedic surgeries, delayed ambulation can lead to deep vein thrombosis and subsequent thromboembolism, which may further result in delayed bone union. To address this issue, patients often require systemic analgesics, primarily opioids, which can be associated with side-effects such as nausea, vomiting, sedation, and drowsiness [1]. As a result, multimodal analgesia methods are commonly utilised, involving a combination of systemic and regional analgesia [2]. Among the regional techniques, epidural anaesthesia is commonly used for lower limb surgeries but can be linked to complications such as epidural haematoma, epidural abscess, urinary retention, and motor blockade of the non operative leg, which are relatively common [3]. Peripheral nerve block techniques do not present these side-effects associated with epidural injections [4].

Fascia Iliaca Compartment Block (FICB), Femoral Nerve Block (FNB), lateral femoral cutaneous nerve of the thigh block, sciatic nerve block, and obturator nerve blocks are some isolated or combined nerve blocks used for managing postoperative pain in knee or above knee orthopaedic surgeries [5-7]. The dermatomes below the knee are supplied by the sciatic nerve and saphenous nerve [8]. These two nerve blocks offer adequate postoperative analgesia in below knee orthopaedic surgeries. Since these two nerves are located in separate compartments of the thigh, two distinct procedures must be performed to block them. Additionally, performing these two blocks without changing the patient's position can be challenging.

The femoral vessels and nerve are the main contents of the AC [8]. The posterior division of the femoral nerve continues as the saphenous nerve, which emerges from the AC before the AH and travels along the medial aspect of the tibia. The femoral vessels exit the AC through the AH and travel posteriorly to enter the popliteal fossa [9]. Cadaveric studies have shown that when dye is injected into the AC, it spreads to the popliteal fossa through this perivascular space. The dye stains the sciatic nerve in the popliteal fossa as well as the saphenous nerve in the mid AC [10,11]. In our institute, the standard procedure for below knee procedures involves spinal anaesthesia followed by standard care for pain management. There are few studies that highlight the role of ACB in managing postoperative pain in below knee orthopaedic surgeries. Recognising the potential benefits of ACB, the present study hypothesised that this technique may improve analgesic efficacy in such surgeries and provide a smoother postoperative experience for patients.

Therefore, the present study was conducted to evaluate the efficacy of ACB using a mixture of 40 mL of 0.125% bupivacaine and 8

mg of dexamethasone in managing postoperative pain in below knee orthopaedic surgeries. This study was carried out in these patients to assess the postoperative requirement for opioids and Non steroidal Anti-Inflammatory Drugs (NSAIDs), complications, and their impact on functional outcomes.

MATERIALS AND METHODS

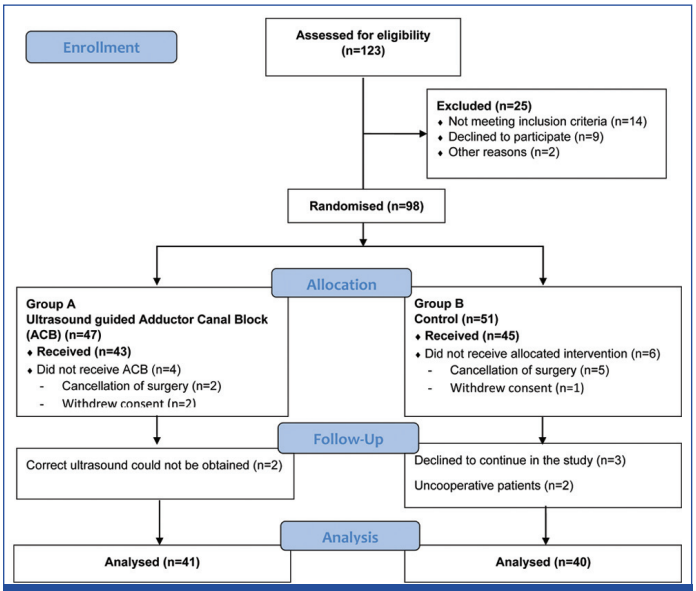
This randomised controlled study was conducted in the Department of Anaesthesiology, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India over a two-year period from November 2019 to October 2021. After obtaining approval from the Institutional Ethics Committee (IEC) (KIMS/KIIT/IEC/132/2019), the study was registered in the Clinical Trials Registry-India (CTRI) under registration number CTRI/2019/10/021787. Patients were enrolled in the study after meeting the inclusion and exclusion criteria, and written informed consent was obtained from each patient.

Inclusion criteria: All willing male and female patients meeting the American Society of Anaesthesiologists (ASA) physical status I and II criteria, scheduled for below knee orthopaedic surgeries under spinal anaesthesia, were included in the study.

Exclusion criteria: Patients with a history of allergy to the drugs used in the study, those undergoing foot surgeries, individuals with psychiatric disorders, those at high-risk for compartmental syndrome or nerve injury, and patients with neurological deficits in the operating limb were excluded from the study.

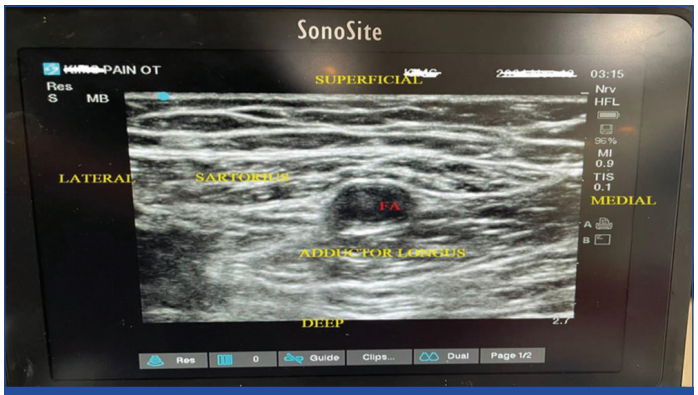
Sample size: Based on a previous study and with a relative precision of 20% at a 5% level of significance, the estimated sample size was 79 patients in each group [12].

Patients were randomly assigned to either group A or B using a computer-generated randomisation list, as shown in [Table/Fig-1]. Due to the prevalence of Coronavirus Disease 2019 (COVID-19) during the study period, the anticipated number of patients could not be enrolled, and an interim analysis was conducted on the patients, as illustrated in the CONSORT flow diagram. Group A patients underwent ultrasound-guided ACB and group B patients served as the control group and received standard care treatment according to institutional protocol. Due to ethical considerations, the control group did not receive the placebo intervention. Only the study group received the USG-guided block. Therefore, the study could not be blinded. However, the data collector was blinded to the group allocation. Finally, data from 41 patients in group A and 40 patients in group B were analysed for the study.



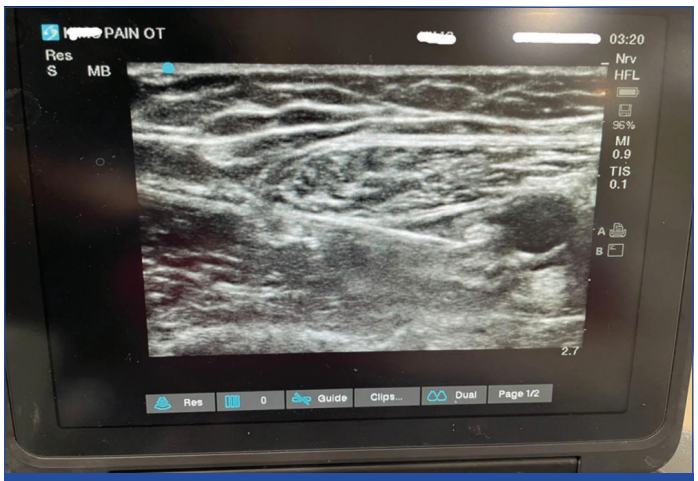
[Table/Fig-1]: Consolidated Standards of Reporting Trials (CONSORT) flow diagram depicting patient distribution.

All patients underwent surgery under spinal anaesthesia with 0.5% hyperbaric Bupivacaine Hydrochloride. The table position was adjusted to maintain the sensory block level up to T_{8-10} and the surgery was performed. Following the completion of the surgery and before transfer to the Post Anaesthesia Care Unit (PACU), patients in group A received Ultrasound-Guided ACB. The ACB procedure was performed with the patient in a supine position, with the knee flexed and the hip slightly abducted and externally rotated. A linear USG transducer (6-14 MHz) was placed in the anteromedial aspect of the thigh to identify the AC and its boundaries. Subsequently, the femoral artery was located and traced distally until it diverged from the sartorius muscle, as illustrated in [Table/Fig-2].



[Table/Fig-2]: Sono anatomy of Adductor Canal (AC) showing femoral artery.

Using a 20 G 10 cm StimuplexR Ultra 360R needle, an in-plane technique with a medial to lateral approach was employed for needling. After confirming the needle tip position and ensuring negative aspiration for blood, a mixture of 40 mL of 0.125% bupivacaine and 8 mg dexamethasone was injected lateral to the femoral artery below the sartorius muscle in the AC as shown in [Table/Fig-3]. The regression of the spinal block was monitored in the non operative limb. When the regression was observed below the L4 level, the adequacy of the block was assessed over the saphenous distribution of the operative limb. If there was no discrepancy in sensory regression between both legs over the anteromedial part of the leg below the knee, the block was considered failed, and the patient was excluded from the study.



[Table/Fig-3]: Deposition of drug in the Adductor Canal (AC) with stimuplex needle.

All participants in both study groups were given a 1 gm infusion of paracetamol after surgery and every 12 hours thereafter. The VAS was monitored, and when patients reported pain, they were treated with tramadol at a dose of 1 mg/kg. Subsequently, the VAS was reassessed every 30 minutes. An incremental dose of 0.25 mg/kg of tramadol was administered intravenously at 30-minute intervals until the VAS score was <3. If pain control was still inadequate, patients were treated with intramuscular diclofenac sodium.

Primary outcome measures: Postoperative pain was assessed every two hours for the first 24 hours following the administration of spinal anaesthesia. An 11-point VAS was utilised to measure pain intensity, with "0" indicating the least perceived pain and "10" representing the worst pain experience. The time of the first analgesic requirement was recorded and compared between both groups. The total opioid (tramadol) requirement was quantified and compared between the groups, as was the total paracetamol requirement.

Secondary outcome measures: Patients were monitored for signs of complications such as nausea, vomiting, and sedation. Sedation status was assessed using a 3-point scoring system, with a score >2 indicating sedation and a score <2 indicating alertness. Patient satisfaction was assessed based on three-point Likert scale (1 for most satisfactory, 2 for satisfactory, and 3 for not satisfactory). Feedback was obtained via telephone one day after the patient's discharge from the hospital.

STATISTICAL ANALYSIS

Data were presented as mean±SD for continuous variables and frequency (%) for categorical data. The Chi-square test was used to compare categorical data, whereas Independent t-test was used to compare continuous data between the two groups. Statistical software statistical Package for Social Sciences (SPSS) version 23.0 was used and a p-value <0.05 was considered statistically significant.

RESULTS

The demographic characteristics and the mean duration of surgery (all below knee orthopaedic surgeries conducted except foot surgery) between the two groups were comparable, as illustrated in [Table/Fig-4]. There was no significant difference in the mean age and BMI of the patients assigned to group A and group B.

Parameters		Group A	Group B	p-value
Age (years)	Mean±SD	42.9±13.5	46.3±13.1	0.25
Gender	Male:Female n (%)	30:11 (73.2:26.8)	32:8 (80:20)	0.468
BMI (kg/m^2)	Mean±SD	27.4±3.2	26.3±3.1	0.12
Duration of surgery (minutes)	Mean±SD	86.8±24.8	90.0±18.7	0.518

[Table/Fig-4]: Comparison of demographic data and duration of the surgery.
BMI: Body Mass Index; SD: Standard Deviation; kg: Kilogram; m^2: Meter Square; n: Number; %: Percentage; Unpaired t-test was used to compare the continuous data between two groups; Chi-square test was used to compare the categorical data

[Table/Fig-5] demonstrates that the mean duration of sensory block in group A was significantly longer compared to group B, whereas the duration of motor block in the two groups was nearly equivalent.

Duration	Group A (Mean±SD)	Group B (Mean±SD)	p-value
Duration of sensory block (h)	12.3±4.6	4.7±0.7	<0.001**
Duration of motor block (h)	3.8±1.5	3.5±2.5	0.516

[Table/Fig-5]: Comparison of the duration of sensory and motor blocks.
*Significant; SD: Standard Deviation; A: Adductor Canal Block; B: Control; h: hours; Test used is unpaired t-test; p<0.001** statistically highly significant

The mean VAS scores in group A patients were significantly lower than those in group B patients at all time intervals when assessed every two hours during the first 24 hours following the administration of spinal anaesthesia. However, approximately six patients in group A required rescue analgesics, whereas all patients in group B needed rescue analgesics at some point during the observation period. The analgesic consumption was significantly lower in group A compared to group B as depicted in [Table/Fig-6].

In group A, the mean time to first analgesic demand was significantly later compared to group B. Additionally, the requirement for both paracetamol and tramadol was significantly lower in group A patients compared to group B, as demonstrated in [Table/Fig-7]. The total number of patients who experienced nausea was 11, with six patients developing vomiting and 11 patients exhibiting sedation. The incidence of these side-effects was comparable between the groups. Patient satisfaction was significantly higher in group A than in group B, as shown in [Table/Fig-8].

Visual Analogue Scale (VAS) in mean±SD at various time intervals (hours)	Group A (Mean±SD)	Group B (Mean±SD)	p-value
At 2	0.829±1.181	2.825±1.448	<0.001**
4	1.365±1.44	3.925±1.517	<0.001**
6	1.219±0.612	3.825±1.107	<0.001**
8	1.909±0.77	3.725±1.012	<0.001**
10	1.707±1.00	3.95±0.904	<0.001**
12	1.351±0.659	3.24±0.590	<0.001**
14	1.17±0.380	3.225±0.479	<0.001**
16	1.39±0.833	3.075±0.266	<0.001**
18	1.21±0.474	2.3±0.563	<0.001**
20	1.48±0.869	2.425±0.635	<0.001**
22	1.48±0.925	2.75±0.742	<0.001**
24	1.341±0.49	2.212±0.331	<0.001**
Number of patients required rescue analgesic n (%)	6 (14.6)	40 (100)	<0.001**

[Table/Fig-6]: Comparison of mean VAS and number of patients requiring rescue analgesics.
SD: Standard Deviation; n: Number; %: Percentage; h: hours; Test used for comparison of mean VAS between the groups is unpaired t-test; Test used for comparison of patients required rescue analgesia is Chi-square; p<0.001** statistically highly significant

Variables	Group A (Mean±SD)	Group B (Mean±SD)	p-value
Time to first Analgesic demand (h)	8.0±4.9	4.7±0.7	<0.001**
Total Tramadol requirement (mg)	42.9±73.6	205.9±26.0	<0.001**
Total Paracetamol requirement (gm)	1.203±2.098	3.622±6.354	<0.05*

[Table/Fig-7]: Comparison of time to first analgesic demand as well as total Tramadol and Paracetamol requirements.
SD: Standard Deviation; h: hours; mg: Milligram; gm: Gram; Test used is unpaired t-test; p<0.05* statistically significant; p<0.001** statistically highly significant

Satisfaction	Group A, n (%)	Group B, n (%)	p-value
Most satisfied	29 (70.7)	4 (10)	<0.001**
Satisfied	12 (29.3)	27 (67.5)	<0.001**
Not satisfied	0	9 (22.5)	<0.001**

[Table/Fig-8]: Comparison of satisfaction score.
N: Number; %: Percentage; A: Adductor Canal Block; B: Control; Test used is Chi-square; p<0.001** statistically highly significant

DISCUSSION

The pain sensation from below the knee is carried out through the common peroneal nerve, tibial nerve, and saphenous nerve. In the popliteal fossa, the sciatic nerve divides into two terminal branches: the common peroneal and tibial nerves. These two nerves provide sensory innervation to all parts of the leg below the knee except the anteromedial part of the leg. The anteromedial part of the leg up to the medial malleolus is supplied by the saphenous nerve, a terminal branch of the femoral nerve. The utilisation of peripheral nerve blocks, which can be given as a single injection or as a continuous infusion using a perineural catheter, is growing in multimodal analgesia [13]. The quality of pain control is better with peripheral nerve blocks than with opioids or any other analgesics. The side-effects of opioids and NSAIDs can also be managed with peripheral nerve blocks. In below-knee surgeries, postoperative pain can be reduced by blocking three nerves [7]. Epidural catheter placement can manage postoperative pain, but it blocks sensations in both legs and has some limitations. The

sciatic nerve can be blocked at different levels, but blocking the saphenous nerve requires a separate procedure. An ACB at the hiatus of AC will block both the saphenous and sciatic nerves simultaneously in a single procedure without the need to change positions. A previous cadaveric study showed that injecting 10 mL of dye into the distal part of the AC reaches the popliteal fossa and stains the popliteal plexus and the genicular branch of the posterior obturator nerve [14]. In another study, 35 mL of 0.2% ropivacaine was deposited under ultrasound guidance at the level of the AH [7]. Scanned images of pre and post-block in the AC and popliteal fossa were compared. They found that the drug spread in both the AC and popliteal fossa through the perivascular space, which was confirmed by fluoroscopic study. A case report of below-knee amputation managed postoperative pain with continuous ACB [15]. They administered a continuous infusion of a mixture of 0.25% bupivacaine and fentanyl 2 µg/mL at 5 mL/hr using a syringe pump for three weeks postoperatively. The authors concluded that placing an AC catheter for continuous analgesia is a good alternative for managing postamputation stump pain and, most importantly, preventing the development of phantom limb syndrome. With this background, the use of ACB as a measure to decrease the pain component following below-knee surgery is justified.

In the current study, the duration of sensory block was significantly higher in patients who received ACB. Previously, a prospective study was conducted to explore alternatives for central neuraxial blockade in 20 patients aged between 30 and 80 years with ASA III and IV, experiencing considerable perioperative morbidity, and undergoing below-knee surgeries. All patients received an ultrasound-guided popliteal sciatic block with 20 mL of 0.5% ropivacaine and ACB with 10 mL of 0.375% ropivacaine. Surgery was effectively performed in all patients without the need for additional analgesics [16]. The mean onset time for sensory and motor blocks was 3.35±0.49 minutes (mean±SD) and 4.65±0.48 minutes (mean±SD), respectively. The study concluded that ultrasound-guided combination popliteal, sciatic, and ACB is an efficacious substitute anaesthetic method for below-knee surgeries, especially in patients with haemodynamic stability and in high-risk patients requiring pain management. A systematic review and meta-analysis of nine randomised placebo-controlled trials compared Brachial Plexus Block (BPB) performed with Local Anaesthetic (LA) alone to that performed with LA and perineural dexamethasone [17]. The meta-analysis, using a random effects model with subgroup analysis stratified by LA type (long vs intermediate acting), aimed to determine the efficacy of dexamethasone as an adjuvant for long-acting and intermediate-acting LAs in BPB. The study concluded that perineural administration of dexamethasone with long-acting LA extended the duration from 730 to 1306 minutes and with intermediate-acting LA from 168 to 343 minutes, with no observed adverse events [17].

In a systematic review, meta-analysis, meta-regression, and trial-sequential analysis of 10 randomised double-blind trials comparing the outcomes of perineural and intravenous dexamethasone with controls without dexamethasone, it was found that perineural administration of dexamethasone significantly prolonged the duration of analgesia compared to intravenous dexamethasone [18]. The analgesia duration was 241 minutes longer in the perineural group, and the sensory block duration was 139 minutes longer in the perineural group. A comparative study was conducted between erector spinae block and oblique subcostal transverse abdominis plane block using low-concentration LA and dexamethasone as part of multimodal analgesia in patients undergoing elective laparoscopic cholecystectomy. The study concluded that adding dexamethasone to ropivacaine significantly increased the duration of the block [19]. In this study, dexamethasone was added to the ACB group, and the sensory block duration was 12.3±4.6 hours, significantly longer than the control group.

In the current study, the VAS scores remained significantly low, and the need for analgesics was also significantly less in patients from the ACB group during the first 24 hours postoperatively. This aligns with a previous study where there was a notable reduction in pain scores (NRS: 7/10 to NRS: 1/10) by employing continuous ACB [15], indicating the effectiveness of ACB in managing postoperative pain. Another researcher in a placebo-controlled randomised controlled trial administered ACB at the mid-thigh level [20]. A single-shot ultrasound-guided ACB was given to group A with 30 mL of 0.5% ropivacaine and 30 mL of 0.9% saline to group C. Pain levels were assessed for 24 hours postsurgery using a VAS, and analgesic consumption during that period was also evaluated. Motor function was assessed with a straight leg raise test. The study results showed lower analgesic consumption in the ropivacaine group compared to the control group, with more favourable VAS scores in the ropivacaine group. There was no prolonged loss of motor function in either group. The study concluded that ACB significantly reduces pain and analgesic consumption without affecting motor function, making it a valuable complement to spinal anaesthesia for lower limb surgeries. In the current study, patients received 40 mL of 0.125% bupivacaine along with 8 mg of dexamethasone for below-knee orthopaedic surgery. The block was performed postsurgery. Patients who received ACB required significantly fewer analgesics, and there was no motor weakness in the operated limb, consistent with the previously mentioned study [20]. Patients in the ACB group reported higher satisfaction with their postoperative pain management experience. This study did not encounter any block-related complications like haematoma, infection, Local Anaesthetic Systemic Toxicity (LAST), or nerve paralysis.

Limitation(s)

Due to the prevalence of COVID-19 during the study period, the expected number of participants could not be recruited for the study. An interim survey was conducted before the completion of the study. The assessment of block failure was challenging as the block was administered towards the end of surgery, before the regression of spinal anaesthesia. Further studies are needed to evaluate the efficacy of ACB in below-knee surgeries. It is also essential to assess whether this block can be used as the sole anaesthetic technique for below-knee surgeries in high-risk patients.

CONCLUSION(S)

Postoperative pain management is crucial for patients undergoing below-knee orthopaedic surgeries to reduce postoperative morbidity. Currently, intravenous analgesics are commonly used for pain management. In the present study, the distal ACB technique was applied, where the drugs reach the popliteal fossa, subsequently blocking the popliteal sciatic nerve and the saphenous nerve. A single procedure with 40 mL of 0.125% bupivacaine significantly reduces postoperative VAS scores and analgesic requirements, while also increasing patient satisfaction levels. Therefore, this block is safe and recommended for postoperative pain management in below-knee surgeries.

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