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Original Research Article

Evaluation of ultrasound assisted peripheral nerve stimulator guided versus peripheral nerve stimulator guided lumbosacral plexus block for postoperative analgesia in patients undergoing lower limb surgery

Veena Chatrath[1], Joginder P. Attri[1], Anju Bala[1]*, Alisha Gupta[1], Malika Gupta[2]

[1]Department of Anaesthesiology and Critical Care, Government Medical College, Amritsar, Punjab, India
[2]Department of Anaesthesiology, Christian Medical College and Hospital, Ludhiana, Punjab, India

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***Correspondence:**
Dr Anju Bala,
E-mail: anjubala73@gmail.com

ABSTRACT

Background: The aim of the present study was to compare the efficacy of ultrasound (USG) assisted peripheral nerve stimulator (PNS) guided versus peripheral nerve stimulator (PNS) guided techniques of lumbosacral plexus block (LSPB) for postoperative analgesia.
Methods: This prospective, randomized, double-blind study was conducted on 60 ASA grade I-II patients of either sex, aged 20-60 years, undergoing unilateral lower limb surgery under spinal anaesthesia. On completion of surgery, group U (30 patients) received LSPB using USG assisted PNS guided technique and group P (30 patients) received LSPB using PNS guided technique, with 0.25% injection levobupivacaine (20 ml) + injection dexamethasone (4 mg) in lumbar plexus block and 0.25% injection levobupivacaine (20 ml) + injection dexamethasone (4 mg) in sacral plexus block.
Results: The mean procedure time of group U was significantly more (15.30±1.98 minutes) than that of group P (11.05±2.13 minutes) (p=0.001). The mean duration of postoperative analgesia was longer in group U (18.00±5.65 hours) as compared to group P (15.80±6.11 hours) (p>0.05). The mean number of doses of rescue analgesia with injection fentanyl in group U was 0.806±0.66 and in group P was 1.066±0.63 (p>0.05).
Conclusions: USG assisted PNS guided LSPB is a better choice as compared to PNS guided technique.

Keywords: Lumbar plexus block, Lumbosacral plexus block, Peripheral nerve stimulator, Postoperative analgesia, Sacral plexus block, Sciatic nerve block, Ultrasound-guided regional anaesthesia

INTRODUCTION

Major lower limb orthopedic surgery is often painful and requires aggressive treatment. Inadequate pain management following surgery can impede recovery, particularly when it interferes with physical therapy, causing joints to become rigid and hinder mobility. Numerous methods, such as parenteral NSAIDs, epidural analgesia, and patient-controlled intravenous analgesia with opioids, can be used to relieve postoperative pain.[1] Peripheral nerve blocks are suitable substitutes for analgesia for lower limb surgeries.

Lumbosacral plexus block (LSPB) has been widely applied in orthopaedic surgeries due to its advantages, including lowering the requirement of opiates, reducing the incidence of acute pain, promoting early ambulation and shortening the length of hospital stay.[2] Lumbar plexus block (LPB) can provide analgesia for anterior thigh, proximal femur, and hip surgeries, and when combined with sacral plexus block (SPB), it can be used to produce complete analgesia of the unilateral lower limb.

Traditionally LSPB has been performed using surface landmark and peripheral nerve stimulator techniques.

Ultrasonography-guided methods have been developed more recently to perform this block, enabling real-time visualization of the needle and relevant nearby anatomy. To ensure safe needle placement and minimize complications, a combined approach utilizing an ultrasound and a peripheral nerve stimulation technique can be used.[3]

The present study was designed to compare the efficacy of USG assisted PNS guided versus PNS guided techniques of LSPB for postoperative analgesia in terms of time taken for the procedure, number of pricks taken and inadvertent vessels punctured, duration of postoperative analgesia, postoperative analgesic requirement in first 24 hours, patient and surgeon satisfaction scores and haemodynamic parameters associated with the procedure in patients undergoing lower limb orthopaedic surgeries.

METHODS

After obtaining approval from institutional ethics committee (reference number: 10767/D-26/2021) along with written and informed consent of the patients enrolled, this prospective, randomized, double-blind study was conducted on 60 patients of either sex belonging to American Society of Anesthesiologists (ASA) grade I and II, 20-60 years of age, admitted in tertiary care hospital undergoing unilateral lower limb surgery under spinal anaesthesia. The study was registered on Clinical Trials Registry of India (CTRI) with CTRI registration number CTRI/2023/06/054154.

Exclusion criteria

Refusal by patient for the procedure, patients with coagulation disorders or on anticoagulation therapy, patients with history of allergy to local anaesthetic drugs, local infection at the site of block, patients with known neuropathies, morbidly obese patients, pregnant females.

Procedure

A day before the surgery, thorough history was taken and general physical and systemic examination was done. The airway was assessed, and the back was examined. Written informed consent was obtained from all the patients after explaining the possible risks and benefits of the intervention. They were explained the visual analogue scale (VAS) of 0 to 10 for pain assessment, where 0 stands for least and 10 for most severe pain. All the patients were kept nil per oral as per the fasting guidelines and were premedicated with oral Alprazolam 0.25 mg night before surgery and intravenous Inj. Midazolam 1 mg 30 minutes before surgery.

On arrival to the operating room, an intravenous line was secured with a 20G intravenous cannula and preloading was done with Ringer Lactate (500 ml). Multipara monitor was attached to patient and baseline blood pressure (BP), pulse rate (PR), pulse oximetry (SpO_2), respiratory rate (RR) and electrocardiography (ECG) were noted. The subarachnoid block was administered to each patient under strict asepsis. Between 2.5 and 3.0 ml (12.5-15.0 mg) of 0.5% hyperbaric bupivacaine was administered. Intraoperative vital signs (BP, PR, SpO_2, RR, ECG) were monitored and maintained throughout the surgery.

On completion of surgery, when the level of subarachnoid block regressed to T10 level, patients were randomly divided by using a computer-generated software into two groups-U and P, of 30 patients each. Group U (30 patients): received LSPB using USG assisted PNS guided technique. Group P (30 patients): received LSPB using PNS guided technique.

The drug used was 20 ml of 0.25% injection levobupivacaine + injection dexamethasone 4 mg in the lumbar plexus block and 20 ml of 0.25% injection levobupivacaine + injection dexamethasone 4 mg in the sacral plexus block.

Randomization and blinding

After taking consultation with statisticians and monitoring parameters of the study, i.e., procedure time, duration of postoperative analgesia and total doses of rescue analgesia in 24 hours, sample size was calculated keeping in view at most 5% risk, with minimum 80% power and 5% significance level (significant at 95% confidence interval).

Randomization was performed centrally by independent statistician, not participating in data analysis, using a random number table generated by Microsoft Excel, sealed in separate envelopes to ensure proper concealment of study management from patients and investigators until the release of final statistical result. The block was performed on completion of surgery by independent expert anaesthesiologist who was well-trained in UGRA (ultrasound-guided regional anesthesia), and not involved in patient care or data collection.

Ultrasound assisted peripheral nerve stimulator guided technique (group U)

Shamrock lumbar plexus block

The patient was made to lie in lateral position with operative limb facing upwards. Under all aseptic precautions, a low frequency curvilinear transducer (2-6 MHz) was placed on flank of the patient in transverse plane, immediately above the iliac crest. The transverse process and vertebral body of L4 were located, and the pattern of shamrock with three leaves (with psoas muscle lying anteriorly, erector spinae muscle lying posteriorly and quadratus lumborum muscle attached to apex of the transverse process of L4) was identified. The nerve roots were visualized within the body of psoas muscle. The transducer was then shifted slightly caudally until acoustic shadow of the transverse process of L4 was no longer visualized in ultrasound image. The needle was inserted on

back of the patient, 4 cm lateral to midline on a line denoting the intersection of ultrasound beam with skin. A nerve stimulation needle was advanced in-plane and anteriorly. After positioning the needle tip lateral to L3 spinal nerve, electrical nerve stimulation was applied (with impulse duration of 0.1 millisecond, and frequency of 1 Hertz). The contractions provoked by <0.3 mA was not accepted so as to avoid intraneural injection of the drug. After confirming the correct positioning of needle, injection levobupivacaine 0.25% (20 ml) + injection dexamethasone 4 mg was administered with sonographic observation of perineural spread.[4]

Approach for sacral plexus block

This was performed with the patient lying in same position. The low frequency curvilinear transducer (2-6 MHz) was aligned between posterior superior iliac spine (PSIS) and midpoint of the line joining PSIS and greater trochanter (GT). After identifying iliac bone line, the transducer was moved inferomedially with a parasacral parallel shift (PSPS). On arrival of transducer beam at sciatic notch, the ultrasonographic continuity of iliac bone line was interrupted, indicating the point of exit of sacral plexus from the pelvis. The transducer was tilted slightly caudal to visualize the hyperechoic sacral plexus between sacrum and ischial bone, beneath the triangular piriformis muscle. The needle was advanced in-plane from lateral end of transducer until the needle tip reached sacral plexus. The identification of sacral plexus was confirmed by nerve stimulation with a sciatic motor response in the range of 0.3 to 0.5 mA. Then injection levobupivacaine 0.25% (20 ml) + injection dexamethasone 4 mg was administered with sonographic observation of perineural spread.[5]

Peripheral nerve stimulator guided technique (group P)

The patient was made to lie in lateral decubitus position with the operative limb facing upwards. After taking proper antiseptic and aseptic precautions, the landmarks for the lumbosacral plexus block were marked with a sterile marker and the skin was infiltrated with local anaesthetic at the points of needle entry.[6]

Landmarks

Midline (spinous processes), iliac crest, posterior superior iliac spine (PSIS), ischial tuberosity (IT).

Capdevila's approach for lumbar plexus block

Firstly, a line joining the spinous processes (midline) was drawn. After that, the PSIS was marked and a line parallel to the first line was drawn cranially from the PSIS. Then a line joining the highest points of the two iliac crests (the intercristal line) was drawn. The junction between the medial two thirds and lateral one thirds of the part of the intercristal line between the first two lines is the entry point for the lumbar plexus block. The stimulating needle was introduced at this point (with the nerve stimulator set at a current of 3 mA, impulse duration of 0.1 millisecond, and frequency of 1 Hz) till transverse process was hit. Needle was redirected and then advanced not more than 1.8 cm deep to the transverse process, either caudally or cranially, by the "walked off" technique until the twitches of the quadriceps femoris muscle were obtained. The current in the nerve stimulator was gradually reduced to 0.5 to 0.7 mA. The contractions provoked by <0.3 mA were not accepted in order to avoid intraneural injection of the drug. Then injection levobupivacaine 0.25% (20 ml) + injection dexamethasone 4 mg was injected after confirming negative aspiration at every 3 ml.

Approach for sacral plexus block

This was performed with the patient lying in the same position. The stimulating needle was introduced perpendicular to the gluteal muscle at the junction of upper one-third and lower two-thirds of the line joining the PSIS and the ischial tuberosity (IT). In case the needle hit the sacral plate, the needle tip was advanced not more than 1.5-2 cm. The response was observed in the form of plantar/dorsi flexion of the foot. Then injection levobupivacaine 0.25% (20 ml) + injection dexamethasone 4 mg was injected after confirming negative aspiration at every 3 ml.

Block assessment

The following parameters were assessed: 1) procedure time taken to complete the block- In group U, procedure time was defined as the interval from the time of placement of the ultrasound probe to completion of local anaesthetic injection. In group P, procedure time was defined as the interval from needle insertion to completion of local anaesthetic injection. 2) Number of pricks taken. 3) Number of inadvertent vessel puncture. 4) Duration of postoperative analgesia- It was determined from the injection of local anaesthetic to the time when patient received the first dose of rescue analgesia. Postoperative analgesia was assessed using VAS score. VAS was assessed postoperatively at every 1-hour interval for first 4 hours and then 2-hourly till 24 hours. Rescue analgesia: when VAS>4, rescue analgesia was given with injection fentanyl 1 µg/kg slow intravenously up to maximum 200µg in 24 hours. If pain persisted, injection diclofenac 75 mg intramuscularly was given to the patients. 5) Total doses of rescue analgesia in first 24 hours. 6) The patient and surgeon satisfaction scores were assessed and graded as- very satisfied: 5, somewhat satisfied: 4, neither satisfied nor dissatisfied: 3, somewhat dissatisfied: 2, very dissatisfied: 1. 7) Hemodynamic changes, side effects and complications of the procedure.

Statistical analysis

Data was recorded in a Microsoft Excel spread sheet and analysed using Statistical Package for the IBM SPSS Statistics for Windows, version 23.0. Armonk, NY: IBM Corp., Chicago. Continuous data was presented as mean

with standard deviation. Categorical data was expressed as percentages. Numerical variables were normally distributed and were compared using chi square test for non-parametric data and 't' test for parametric data. The p value was then determined to evaluate level of significance. The results were analysed and compared to previous studies to draw relevant conclusions.

RESULTS

Both the groups were comparable with respect to demographic parameters including mean age, gender, ASA grade and mean weight. The duration of surgery was also comparable in both the groups (Table 1).

Table 1: Demographic profile of patients and duration of surgery.

Variables	Group U (n=30)	Group P (n=30)	P value
Age (years) (mean±SD)	40.86±10.61	40.70±10.42	0.951 (NS)
Gender (male/female) (n)	21/9	22/8	0.774 (NS)
ASA Grade (I/II) (n)	21/9	23/7	0.559 (NS)
Weight (kg) (mean±SD)	67.73±8.45	65.43±6.17	0.234 (NS)
Duration of surgery (minutes) (mean±SD)	98.50±13.14	96.16±15.23	0.528 (NS)

ASA: American Society of Anesthesiologists; SD: standard deviation; NS: nonsignificant (p>0.05)

Table 2: Comparison of block profile.

Parameters	Group U (n=30)	Group P (n=30)	P value
Procedure time (minutes) (mean±SD)	15.30±1.98	11.05±2.13	0.001 (HS)
Number of inadvertent vessel puncture (0/1) (n)	30/0	27/3	0.076 (NS)
Number of pricks (1/2) (n)	29/1	24/6	0.044 (S)

NS: nonsignificant (p>0.05); S: significant (p<0.05); HS: highly significant (p<0.001)

Table 3: Postoperative analgesia.

Parameter	Group U (n=30)	Group P (n=30)	P value
Duration (hours) (mean±SD)	18.000±5.6569	15.800±6.1105	0.153 (NS)
Mean number of doses of rescue analgesia in 24 hours (mean±SD)	0.806±0.660	1.066±0.639	0.119 (NS)

NS: Nonsignificant (p>0.05)

The mean procedure time of group U was 15.30±1.98 minutes, and of group P was 11.05±2.13 minutes. On comparison, the difference between both the groups was highly significant (p=0.001). No vessel punctures were seen in group U, while inadvertent vessel punctures were seen in three patients (10% patients) in group P (p=0.076). Needle pricks were repeated twice in six patients in group P and in one patient in group U (p=0.044) (Table 2).

The mean duration of analgesia in group U was 18.00±5.65 hours and in group P was 15.80±6.11 hours. The duration of analgesia was clinically prolonged in group U as compared to group P, but the difference between the two groups was statistically not significant (p=0.153) (Table 3).

The mean VAS scores remained less than 3 in both the groups till 10 hours and the difference in the VAS scores was statistically non-significant. In group P, VAS started increasing after 12th hour and was more than 4 at 16 hours and the difference in the mean VAS at 16th hour was significant between the two groups. In group U, VAS started increasing after 14th hour but the difference between the mean VAS scores of both the groups remained statistically non-significant. Later on, VAS remained comparable between both the groups at all measured intervals till 24 hours (Figure 1).

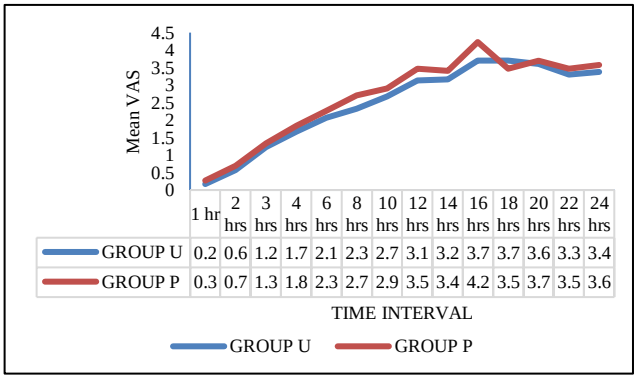

Figure 1: Visual analogue scale score.

Number of doses of rescue analgesia with injection fentanyl in group U was 0.806±0.66 and in group P was 1.066±0.63 (p=0.119) (Table 3).

Patient and surgeon satisfaction scores were similar and the difference was statistically non-significant in both the groups (Figures 2 and 3).

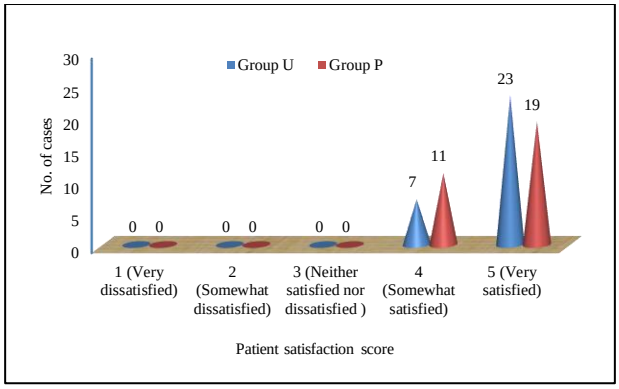

Figure 2: Patient satisfaction score.

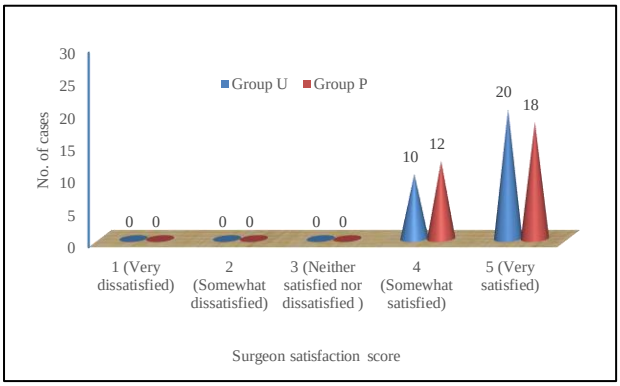

Figure 3: Surgeon satisfaction score.

All the hemodynamic parameters (HR, BP, RR, SpO_2) in postoperative period were comparable between both groups. No side effects or complications were noted in any patient in both the groups.

DISCUSSION

Postoperative pain after orthopaedic lower limb surgery is a very distressing symptom and a major component of postoperative morbidity.[7] Perioperative pain management is a crucial part of anaesthesia practice. It facilitates quick recovery, promotes early ambulation as well as reduces postoperative complications. Lumbar plexus block is often used in combination with a sciatic nerve block for anaesthesia or analgesia in patients undergoing unilateral hip or lower extremity surgery.

In the present study, both groups were similar with regard to patient characteristics i.e. age, sex, ASA grade, duration and type of surgery.

The mean procedure time of group U was 15.30±1.98 minutes and of group P was 11.05±2.13 minutes, and the difference between the two was highly significant with p value 0.001(HS). The results were comparable to a study conducted by Xiao et al in 2021 where it was observed that the performance time was 658±87 seconds in group U-N (combined ultrasound and nerve stimulation guidance) and 528±97 seconds in group N (nerve stimulation alone) for performing LPB ($p<0.001$).[8] The block performance time in the combined US-NS group included both the imaging time as well as the needling time, thus increasing the total time required to perform the block. The results could also be compared to a study conducted by Dufour et al in 2008, where it was demonstrated that the procedure time in the group US-NS was 304±94 seconds while in the group NS was 261±75 seconds for performing SNB, indicating that the mean time to perform the block using dual modality was longer.[9]

No vessel punctures were seen in group U, while there were three vessel punctures (10% patients) seen in group P. The difference between the two groups was non-significant with p value 0.076 (NS). Using ultrasonography, it is possible to decrease the number of needle direction changes, which also results in decreased injury and pain associated with performing the procedure. The results were in accordance with a study conducted by Marhofer et al in 1997, where it was seen that incidental arterial puncture (n=3) was seen only in the neurostimulation assistance group.[10]

Needle prick was repeated twice in one patient in group U (3.33%), and in six patients in group P (20%). On comparison, the difference between two groups was observed to be statistically significant ($p<0.05$). In PNS guided technique, to achieve satisfactory muscle twitch, needle redirection was done. This was not with the use of ultrasound because the exact position of the needle in real time could be seen, so lesser number of pricks were seen in this group. This was in accordance with a study conducted by Xiao et al in 2021 where it was demonstrated that there was no (0%) patient in group U-N who required 5 or more needle passes, and 6 patients (27.3%) in group N while performing LPB ($p=0.028$).[8]

The technique of ultrasonography appears to be an effective method used to localize nerve structures, which increases the efficiency of blocks and safety of patients. Although the use of combined neurostimulation and ultrasound guidance does not decrease the block time, it offers several other advantages like shortening the block onset time, preventing inadvertent vascular puncture and multiple needle passes, prolonging duration of blockade and improving the success rate.

The mean duration of postoperative analgesia in group U was 18.00±5.65 hours and in group P was 15.80±6.11 hours. The duration of analgesia was clinically prolonged in group U when compared with group P, but difference between both the groups was statistically not significant ($p>0.05$). The mean number of doses of rescue analgesia in first 24 hours in group U was 0.806±0.660, and in group P was 1.066±0.63, and the difference was statistically nonsignificant ($p>0.05$). The results were comparable to study by Shah et al, where the mean duration of postoperative analgesia after PNS guided LSPB was 14±2.17 hours.[6]

Contrary to some previous studies like those conducted by Naeem et al and Ahamed and Sreejit, this study demonstrated longer duration of analgesia in our study, even longer than the expected duration of injection levobupivacaine.[11,12] This was attributed to the summative impact of pre-emptive analgesic effect of spinal anaesthesia, and the use of injection dexamethasone as an adjuvant, that significantly prolongs the duration of action of local anaesthetic drug used in peripheral nerve blockade.[1] Dexamethasone has been widely used as an adjuvant to local anaesthetics for the past decade in both peripheral and neuraxial nerve blocks. Although the exact mechanism of its action on local anaesthetics is still not known, studies have indicated that it may have an effect on the K+ channels present on nociceptive C fibers through the glucocorticoid receptors, thus affecting the activity of the fibers.[13] The Cochrane review (2017) determined that the use of perineural dexamethasone as adjuvant increased duration of sensory blockade by 6.7 hours (CI=95%) when compared with a placebo along with significant reduction in pain scores and opioids consumption postoperatively.[14]

Postoperative heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), oxygen saturation (SpO_2) and respiratory rate (RR) monitoring was done every hour until 4 hours, and then at 2-hours interval until 24 hours. No sudden or intense variation was seen in the haemodynamic parameters in both the groups ($p>0.05$). This was similar to study by Shah et al where the perioperative HR (heart rate) and MAP (mean arterial pressure) remained within 20% of the baseline values in all the patients receiving LSPB.[6]

Both the patients as well as surgeons in both the groups were satisfied with the block outcomes. This was comparable to a study conducted by Marhofer et al in 1997 where it was seen that a good analgesic effect was attained in 95% patients in group US (ultrasound) and in 85% patients in group NS (neurostimulation).[10] Similarly, a study conducted by Vinod et al showed that the surgeons' and patients' satisfaction was 95.7% and 96.8% respectively in patients receiving LSPB.[15]

The possible procedure related complications were haematoma formation, infection, urinary retention, backache, local anaesthetic toxicity from either direct intravascular injection or systemic absorption of drug resulting in seizures or cardiac arrest, postoperative paraesthesia due to nerve injury. There were no such postoperative complications related to the procedure and drug seen in our study. Amiri et al demonstrated that frequent negative aspiration of the drug during injection, suspension of the injection against resistance and <0.3 mA twitch response are the three important key factors to avoid major complications while performing LPB.[16]

The limitation of this study is the that time of onset of the block could not be assessed because of residual effect of subarachnoid block. Also, VAS score was used as a pain measurement method which is a subjective method and could have some variability in patients' ability to use that scale. This study was aimed to observe the patient postoperatively for 24 hours only. Hence, the duration of analgesia exceeding 24 hours could not be noted. Another limitation of this study is small sample size but it has significantly important results, so future studies should be conducted with a larger population size.

CONCLUSION

Single shot lumbosacral plexus block (LSPB), by both the techniques, was effective in providing prolonged postoperative analgesia and reducing the pain scores and requirement of supplemental analgesics in lower limb orthopaedic surgeries in majority of the patients during first 24 hours. Ultrasound assisted peripheral nerve stimulator guided LSPB is a better choice as compared to peripheral nerve stimulator guided technique as the use of ultrasound guidance, owing to its ability to provide direct visualization of the needle, the nerves, and the spread of local anaesthetic, has shown to prevent inadvertent vascular puncture and multiple needle passes. Although the nerve stimulator guidance with ultrasound assistance has a longer mean block performance time, it has shown to prolong the duration of postoperative analgesia with less requirement of rescue analgesia, resulting in better pain management, thereby increasing the patient and surgeon satisfaction scores.

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