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A PROSPECTIVE COMPARATIVE STUDY BETWEEN ULTRASOUND-GUIDED COMBINED SCIATIC-FEMORAL NERVE BLOCK VERSUS SPINAL ANESTHESIA FOR THE PATIENTS UNDERGOING ELECTIVE BELOW-KNEE SURGERIES

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Abstract:

Background: Brachial plexus block is a commonly used regional anesthesia method for upper limb surgeries, increasingly preferred over general anesthesia. The advent of anatomical sonography has improved the precision and safety of ultrasound-guided techniques, allowing for real-time monitoring of needle placement and drug distribution.

Objective: This study aims to compare the efficacy of supraclavicular brachial plexus block using the landmark technique and ultrasound guidance in terms of procedural efficiency, onset and duration of sensory and motor blockade, block effectiveness, and complication rates.

Materials and Methods: A prospective, randomized controlled trial involved 60 patients aged 18 to 60 years, of ASA grades I and II, undergoing elective or emergency upper limb surgeries. Patients were divided into two groups: Group LM (landmark technique) and Group US (ultrasound technique). Each received a supraclavicular brachial plexus block using the assigned technique with 25ml of 0.5% ropivacaine, and relevant parameters were documented.

Results: The success rate was higher in Group US with no observed complications. Ultrasound-guided technique demonstrated faster onset and longer duration of blockade compared to the landmark technique, although administration time was longer.

Conclusion: Ultrasound-guided supraclavicular block emerges as a safer and more effective approach, offering superior success rates and prolonged block duration compared to the traditional landmark technique.

Keywords: *peripheral nerve block, clinical trial, epidemiological study, adverse effects, pain*

INTRODUCTION

The utilization of regional anesthesia and peripheral nerve blocks (PNBs) in outpatient settings aligns with patient care objectives [1]. PNBs offer advantages similar to neuraxial techniques, notably bypassing airway instrumentation, making them preferable for patients with marginal respiratory function. Additionally, PNBs contribute to shorter recovery times by reducing occurrences of nausea, vomiting, and severe pain, while also potentially mitigating chronic pain syndromes resulting from central nervous system sensitization post-acute injury. Furthermore, patients undergoing PNBs typically require minimal to no opioids immediately after surgery [2,3].

The rise in below-knee procedures owes much to the efficacy of anesthesia techniques that facilitate swift and safe discharge [4]. Regional anesthesia serves as a viable alternative to general anesthesia (GA) in these surgeries, with both PNBs and spinal anesthesia (SA) offering sufficient anesthesia, superior postoperative analgesia, and patient satisfaction compared to GA, while also being minimally invasive and resource-efficient [5].

Patients undergoing lower limb surgeries often prefer SA, as it selectively blocks only the intended region, allowing for early mobilization and heightened patient satisfaction [6]. PNBs find utility in patients scheduled for below-knee surgeries and those with critical comorbidities intolerant to hemodynamic alterations [1,2,7].

PNBs afford surgical anesthesia with greater cardiorespiratory stability compared to SA, which can induce hypotension, bradycardia, and other side effects [2,3]. Advancements like ultrasound (USG) have expanded the role of PNBs in below-knee surgeries, replacing GA and SA [2,3].

Although combined sciatic-femoral nerve block (SFNB) without USG is an option for below-knee surgeries, its use is less common due to longer procedure times, multiple needle insertions, anatomical variations, higher local anesthetic dosage, and potential postoperative paraesthesia [8]. USG-guided SFNB is preferred, offering advantages such as fewer needle insertions, enhanced block quality, shorter procedure times, reduced local anesthetic dosage, and faster onset of nerve blockade, while avoiding the drawbacks associated with landmark-guided SFNB [7,8].

OBJECTIVE

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To compare the onset time of sensory and motor blockade, total duration of sensory and motor blockade, and time to first analgesic requirement between USG-guided SFNB and SA in elective below-knee surgeries.

MATERIALS AND METHODS

This study, conducted at the Department of Anaesthesiology, protocol development, ethical approval, data collection, analysis, and reporting.

Participants and Methodology: Patients scheduled for elective below-knee surgeries were asked to consent to participate. Those who met the inclusion criteria—aged 16 to 65 years, ASA grade I or II, and scheduled for elective below-knee surgeries—were enrolled. Exclusion criteria included allergies to local anaesthetics, bleeding disorders, localized infections, neurological diseases, spinal column abnormalities, respiratory or cardiac diseases, anterior cruciate ligament tear, and a BMI > 32 kg/m^2.

Participants were randomly assigned to two groups using computer-generated sampling and block randomization to ensure equal group sizes. Group A received USG-guided combined sciatic and femoral nerve blocks (SFNB), while Group B received spinal anaesthesia (SA).

Sample Size Calculation: The sample size was calculated considering the time-based differences between the two groups using repeated measures ANOVA (RM-ANOVA), with an alpha error of 0.05, a study power of 0.9, and 19 measurements. The formula used was:

$n{=}t2{\cdot}p{\cdot}(1{-}p)m2n{=}m2t2{\cdot}p{\cdot}(1{-}p)$

where t=1.96t=1.96 (95% confidence level), p=0.05p=0.05 (estimated prevalence of below-knee surgery), and m=0.05m=0.05 (margin of error). This resulted in a required sample size of 72.96, rounded up to 74, with 37 participants in each group.

Procedures: For the USG-guided SFNB group (Group A), a 25 ml mixture of 10 ml lignocaine adrenaline, 10 ml 0.5% bupivacaine, and 5ml saline was administered (10ml for the femoral nerve and 15 ml for the sciatic nerve) under ultrasound guidance. For the SA group (Group B), 2 ml (10 mg) of 0.5% hyperbaric bupivacaine was injected at the L3-L4 level using a 25-gauge Quincke spinal needle.

Outcome Measures: Primary outcomes included the time to first request for rescue analgesia and the total cumulative rescue analgesic requirements within 24 hours postoperatively, measured using the Visual Analog Score (VAS). Secondary outcomes included pain scores, hemodynamic parameters (blood pressure and heart rate), side effects, and grading of sensory and motor blockades. Data were collected using Magpi software and analyzed with Stata

Statistical Software: Release 12. Parametric tests analyzed normally distributed data, while non-parametric tests were used for non-normally distributed variables. RM-ANOVA was employed to compare hemodynamic measures over time within the groups.

Ethical and Practical Considerations: All blocks were performed by the Principal Investigator (PI) or Guide, with the PI's technique validated by the Guide. Failed blocks in the PNB group were ethically managed by administering GA/SA. Postoperative analgesia included IV paracetamol, with rescue analgesia provided by intermittent IV diclofenac boluses when VAS ≥ 4. Data collection and management were meticulous to ensure accurate analysis.

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Results

The study enrolled a total of 74 subjects, with 37 subjects in each group (Group A and Group B). Efforts were made to match participants in terms of age, gender, and BMI, confirmed through baseline parameter comparison. The gender distribution included 49 male subjects and 25 female subjects, with no significant difference between the groups ($p>0.05$). The mean age of the participants was 46.13 ± 10.23 years in Group A and 42.30 ± 7.64 years in Group B, with an overall mean age of 44.22 ± 9.18 years. Despite the non-normal distribution of age within the groups ($p<0.05$, Shapiro-Wilk Normality test), the median age comparison showed no statistically significant difference between the groups ($p=0.064$, Mann-Whitney U test). Similarly, BMI was comparable across both groups ($p>0.05$). Thus, the comparable baseline parameters of age and BMI ensured proper randomization (Table 1).

Table 1

Comparison of baseline parameters in the study subjects between the groups (n=74; 37 in each group)

† Normally distributed data, compared using independent sample t-test; rest were compared using Mann-Whitney U test

*Statistically significant at p<0.05

**Statistically significant at p<0.01

Gr A=USG-guided sciatic-femoral nerve block group; Gr B=Spinal anaesthesia group

IQR: interquartile range; SpO2: oxygen saturation; P50: haemoglobin-oxygen affinity

Parameter	Group	Mean	SD	P50	IQR	p-value
Body mass index (kg/m^2)	Gr A	24.08	1.59	24.34	2.49	0.3413
	Gr B	24.54	2.88	24.68	2.78	
Haemoglobin (mg/dl) †	Gr A	12.77	1.47	12.60	2.10	0.515
	Gr B	12.99	1.37	13.30	1.80	
Heart rate (beats/ min)	Gr A	76.14	8.62	72.00	10.00	0.3364
	Gr B	76.59	5.65	78.00	10.00	
Systolic blood pressure (mm Hg) †	Gr A	131.11	14.19	130.00	20.00	0.04*
	Gr B	136.92	9.78	140.00	14.00	
Diastolic blood pressure (mm Hg) †	Gr A	77.71	9.15	78.00	8.00	0.0031**
	Gr B	83.68	7.54	82.00	10.00	
Mean arterial pressure (mm Hg)	Gr A	95.50	10.09	93.33	10.67	0.0028**
	Gr B	101.42	7.22	101.33	8.00	
SpO_2 (%)	Gr A	99.57	0.60	100.00	1.00	<0.001**
	Gr B	98.97	0.50	99.00	0.00	

Hemodynamic parameters were assessed for both groups at baseline (Table 1). Systolic blood pressure (SBP), diastolic blood pressure (DBP), and hemoglobin values displayed normal distribution in both groups ($p>0.05$). However, heart rate, mean arterial pressure, and oxygen saturation exhibited non-normal distribution ($p<0.05$) in one or both groups. Appropriate statistical tests were applied based on the data distribution, as indicated in the legend of Table

1. The baseline comparison revealed that systolic, diastolic, and mean arterial pressure were significantly higher in Group B (SA) compared to Group A (USG-guided combined SFNB). Conversely, oxygen saturation levels were significantly higher in Group A compared to Group B ($p<0.01$).

Table 2Indications for operations among subjects in the study by the group of anaesthesia (n=37 in each group)

Group A=USG-guided sciatic-femoral nerve block group; Group B=Spinal anaesthesia group

Indication	Group A n (%)	Group B n (%)	Total n (%)
Metatarsal fracture	12 (32.4)	8 (21.6)	20 (27.0)
Malleolar fracture	8 (21.6)	7 (18.9)	15 (20.3)
Calcaneum fracture	8 (21.6)	5 (13.5)	13 (17.6)
Split skin graft	2 (5.4)	3 (8.1)	5 (6.8)
Tibial fracture	2 (5.4)	3 (8.1)	5 (6.8)
Fibula fracture	2 (5.4)	1 (2.7)	3 (4.1)
Others	3 (8.1)	10 (27.0)	13 (17.6)
Total	37 (100.0%)	37 (100.0%)	74 (100.0%)

The most common indication among the study subjects was single or multiple metatarsal fractures (n=20, 27.0%), followed by malleolus fractures (n=15, 20.3%) and calcaneum fractures (n=13, 17.6%). Besides the various types of below-knee fractures, a few subjects also underwent split skin grafts (n=5, 6.8%) (Table 2).

Table 3**American Society of Anesthesiologists (ASA) grading of the study subjects (n=37 in each group)**

^ four cases (10.8%) of Group A included in Grade II had systemic disease but not incapacitating

ASA Grade	Group A n (%)	Group B n (%)	Total n (%)
I	24 (64.9)	35 (94.6)	59 (79.7)
II^	13 (35.1)	2 (5.4)	15 (20.3)
III and more than III	0 (0)	0 (0)	0 (0)
Total	37 (100.0)	37 (100.0)	74 (100.0)

The subjects in the study predominantly belonged to ASA grade II or lower. There were no subjects classified as ASA grade III or above. The majority of the subjects were classified as ASA grade I, accounting for 59 cases (79.7%) (Table 3).

Table 4Comparison of various time points after anaesthesia between the study groups (n=74, 37 in each group)

†Independent sample t-test were applied as data was normally distributed within the groups

**Statistically significant at p=0.001 levels

Group A=USG-guided sciatic-femoral nerve block group; Group B=Spinal anaesthesia

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Parameter†	Group	Mean	SD	P50	IQR	p-value
Time to onset of sensory blockade (in mins)	Gr A	8.08	2.11	8	4	<0.001**
	Gr B	3.03	0.50	3	0	
Time to onset of motor blockade (in mins)	Gr A	11.35	1.84	12	3	<0.001**
	Gr B	4.89	0.52	5	0	
Total anaesthesia time (in mins)	Gr A	339.43	53.49	360	60	<0.001**
	Gr B	137.30	34.21	130	30	
Total time to analgesic requirement (in mins)	Gr A	339.73	54.24	360	60	<0.001**
	Gr B	137.30	34.21	130	30	
Time to first urination (in mins)	Gr A	178.92	20.92	180	30	<0.001**
	Gr B	419.19	40.30	420	60	

The time taken for the onset of sensory blockade, motor blockade, total anaesthesia time, time to analgesic requirement, and time to first spontaneous urination were tested for normality and found to be normally distributed within the groups (p>0.05; Shapiro-Wilk normality test). The onset times for sensory and motor block were significantly longer in Group A (8.08±2.11 minutes and 11.35±1.84 minutes, respectively) compared to Group B (3.03±0.50 minutes and 4.89±0.52 minutes, respectively), with p<0.001 (independent sample t-test).

Conversely, the average total anaesthesia time and time to first analgesic requirement were significantly longer in Group A (349.43±53.49 minutes and 339.73±54.24 minutes, respectively) compared to Group B (137.30±34.21 minutes and 137.30±34.21 minutes, respectively), with p<0.001 (independent sample t-test).

Additionally, the mean time to first urination was significantly shorter in Group A (178.92±20.92 minutes) compared to Group B (419.19±40.30 minutes), with p<0.001 (independent sample t-test) (Table 4).

Table 5**Comparison of adverse events after anaesthesia between the study groups (n=74, 37 in each group)**

Group A=USG guided SFNB; Group B=Spinal Anaesthesia

Adverse event type	Group A n (%)	Group B n (%)	Chi-square	p-value
Pain	0 (0%)	0 (0%)	-	-
Nausea/ Vomiting	0 (0%)	19 (51.4%)	22.944	<0.001
Headache	0 (0%)	6 (16.2%)	4.534	0.033
Drowsiness	0 (0%)	0 (0%)	-	-
Hypotension	0 (0%)	19 (51.4%)	22.944	<0.001
Arrhythmia	0 (0%)	0 (0%)	-	-
Hypertension	0 (0%)	0 (0%)	-	-
Hypoxia	0 (0%)	0 (0%)	-	-
Total	0 (0%)	24 (64.9%)	35.520	<0.001

The mean heart rate during the intra-operative period was slightly higher in Group B (77.59) compared to Group A (75.80) after anaesthesia. However, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were higher in Group A subjects (SBP 128.6 and DBP 74.8) compared to Group B (SBP 113.3 and DBP 70.1). Oxygen saturation levels were almost similar in both groups (Table 6).

Hemodynamic parameters were compared for within-subject variation over time using repeated measures ANOVA (RM-ANOVA). Mauchly's sphericity test indicated significant sphericity for all values in both groups ($p<0.05$), so the Greenhouse-Geisser correction was applied. The analysis revealed that heart rate and oxygen saturation did not vary significantly over time in either group ($p>0.05$). However, SBP and DBP varied significantly over time in both groups ($p<0.05$), with a higher level of significance in the spinal anaesthesia group ($p<0.001$) compared to the USG-guided SFNB group ($p<0.05$).

Table 6Haemodynamic parameters after anaesthesia between the study groups (n=74, 37 in each group)

p-value is calculated at 0.05 levels using RM-ANOVA (Wilk's lambda) incorporating within-subject variation by 18 time points

† grand mean with standard error (SE); ‡ Using Greenhouse-Geisser test as Mauchly's test of sphericity is significant and sphericity is not assumed

Group A=USG-guided sciatic-femoral nerve block group; Group B=Spinal anaesthesia

SBP: systolic blood pressure; DBP: diastolic blood pressure; SpO2: oxygen saturation; RM-ANOVA: repeated measures analysis of variance

Parameter	Mean †	SE †	F-statistics ‡	p-value
Heart rate				
Group A	75.80	0.96	1.059	0.393
Group B	77.59	0.46	1.532	0.132
SBP				
Group A	128.60	2.12	2.656	0.018
Group B	113.29	0.97	91.356	<0.001
DBP				
Group A	74.79	1.91	2.655	0.005
Group B	70.07	0.46	47.447	<0.001
SpO_2				
Group A	99.58	0.067	0.608	0.774
Group B	99.89	0.092	1.015	0.423

The study was a prospective randomized comparative study, using routinely employed anaesthetic interventions at the institute. Seventy-four subjects were randomly assigned to either intervention group, and all anaesthetic and operative procedures followed the hospital's standard protocols. There was no significant difference in gender distribution between the groups ($p>0.05$). The mean age was 46.13 ± 10.23 years for Group A and 42.30 ± 7.64 years for Group B, with no significant difference between the groups ($p>0.05$), indicating the absence of age and gender selection bias and ensuring comparability between the groups.

Baseline comparisons showed that systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure were significantly higher in Group B (SA group) than in Group A (USG-guided combined SFNB group). Oxygen saturation levels were significantly higher in Group A ($p<0.01$). These baseline differences were adjusted during the RM-ANOVA analysis.

The most common surgical indication was single or multiple metatarsal fractures (20 subjects, 27.0%), followed by malleolus (15 subjects, 20.3%) and calcaneum fractures (13 subjects, 17.6%). A smaller number of subjects underwent split skin grafts (5 subjects, 6.8%). Most subjects belonged to ASA grade I (59 cases, 79.7%).

The onset times for sensory and motor block were significantly longer for USG-guided SFNB (8.08±2.11 minutes and 11.35±1.84 minutes, respectively) compared to the SA group (3.03±0.50 minutes and 4.89±0.52 minutes, respectively), with $p<0.001$. However, the total anaesthesia duration and time to first analgesic requirement were significantly longer in the USG-guided SFNB group (349.43±53.49 minutes and 339.73±54.24 minutes, respectively) compared to the SA group (137.30±34.21 minutes for both), with $p<0.001$. The mean time to first urination was significantly shorter in the USG-guided SFNB group (178.92±20.92 minutes) compared to the SA group (419.19±40.30 minutes), with $p<0.001$. Therefore, while USG-guided SFNB had a longer onset time, it provided longer anaesthesia duration and faster recovery compared to spinal anaesthesia.

Supporting studies include Karaduman et al. (2020) in Turkey, which involved 60 patients aged 18-65 years. This study found that the SFNB group had significantly longer intervention durations, time to onset of sensory and motor block, motor block reversal time, and time to first postoperative analgesic compared to the SA group. Oberndorfer et al. (2007) in South Africa, involving 46 children, also found longer analgesia duration and reduced local anaesthetic.

Conclusion

Compared to SA, USG-guided SFNB takes longer for sensory and motor blockage to begin. But when it comes to USG-guided SFNB, the duration of total anaesthesia and the period before the first analgesic demand are much longer than with SA. In comparison to SA, the mean time to first spontaneous urination is likewise noticeably shorter in cases of USG-guided SFNB. Following anaesthesia, the trial subjects had adverse events in the SA group but not in the USG-guided SFNB group. Both groups exhibit hemodynamic variations, with the SA group likely to experience greater blood pressure swings. Likewise, the average rise in pain score from baseline is considerably higher in the SA group than in the USG-guided.

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