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COMPARISON OF ULTRASOUND GUIDANCE, PERIPHERAL NERVE STIMULATOR GUIDANCE, AND COMBINED GUIDANCE FOR SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK IN PATIENTS UNDERGOING ELBOW AND BELOW-ELBOW SURGERY: A PROSPECTIVE NON-RANDOMIZED COMPARATIVE STUDY

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ABSTRACT

Background: Ultrasound guidance (USG) and peripheral nerve stimulation (PNS) are established methods for localizing the brachial plexus during supraclavicular block. Comparative evidence involving their combined use remains limited. Objective: To compare procedural performance, block characteristics, success, and supplementary anaesthesia across PNS-guided, USG-guided, and combined USG–PNS-guided supraclavicular brachial plexus block.

Methods: This prospective, non-randomised comparative study included 75 adults (American Society of Anesthesiologists physical status I–II) undergoing elective elbow or below-elbow surgery at a tertiary-care teaching hospital between October 2018 and October 2020. The treating anaesthesiologist selected the technique; 25 patients received each approach. Patient-level master-chart data were reanalysed, with blank or non-numeric observations treated as missing. Continuous outcomes were compared using the Kruskal–Wallis test and pairwise Mann–Whitney U tests with Holm adjustment; categorical outcomes were assessed using exact methods when appropriate.

Results: Block performance time differed across groups (10.50, 7.28, and 6.58 minutes for PNS, USG, and combined guidance, respectively; adjusted $P<0.001$). Sensory onset was shortest with combined guidance (6.62 minutes; adjusted overall $P=0.03$), while motor onset was shorter with both ultrasound-based approaches than with PNS alone (adjusted $P<0.001$). Sensory block duration was longest with combined guidance (9.28 hours), compared with USG (8.15 hours) and PNS (6.90 hours; adjusted $P<0.001$). Motor block duration did not differ significantly. Block success was 84%, 92%, and 96%, respectively (exact $P=0.49$); supplementary anaesthesia was required in 4, 2, and 1 patients. No complications were recorded.

Conclusion: Combined guidance was associated with the longest sensory block duration. Block success did not differ significantly among the three techniques.

KEYWORDS: Brachial plexus block; supraclavicular block; ultrasound guidance; peripheral nerve stimulator; regional anaesthesia; upper limb surgery; non-randomised study

INTRODUCTION

Regional anaesthesia is widely used for upper-limb surgery because it provides reliable surgical anaesthesia and postoperative analgesia while avoiding airway instrumentation. The supraclavicular approach targets the brachial plexus trunks and divisions, which lie in close proximity and can provide dense anaesthesia of the limb below the shoulder.[1,2]

Accurate localization of the plexus is central to block success. A peripheral nerve stimulator (PNS) identifies neural structures through an evoked motor response but does not display surrounding anatomy. Ultrasound guidance (USG) permits real-time visualization of the plexus, adjacent vessels, pleura, needle position, and local-anaesthetic spread.[2,3] A Cochrane review reported benefits of ultrasound guidance for peripheral nerve blocks, including improved block performance and reduced supplementation in several settings.[4] Comparative studies have evaluated USG and PNS for supraclavicular block, while other investigations have examined ultrasound-guided and combined localization strategies.[5–9]

We compared PNS-guided, USG-guided, and combined USG–PNS-guided supraclavicular brachial plexus block in patients undergoing elbow or below-elbow surgery. The primary outcomes were block performance time and block success. Secondary outcomes included time to complete block, sensory and motor onset and duration, supplementary anaesthesia, and complications.

MATERIALS AND METHODS

Study design and setting

This was a prospective, non-randomised comparative study conducted in the Department of Anesthesiology and Critical Care, Pravara Rural Hospital, Rural Medical College, Pravara Institute of Medical Sciences (Deemed to be University),

Loni, Maharashtra, India. It formed part of the first author's postgraduate MD dissertation. Recruitment took place from October 20, 2018, to October 20, 2020. The Institutional Ethics Committee UG/PG RMC approved the study (letter PMIS/RMC/IEC-UG-PG/2018/255; protocol registration DR/RMC/UG-PG/2018/70; September 27, 2018), and written informed consent was obtained from all participants. Reporting was guided by the TREND recommendations for non-randomised evaluations.[10]

Participants

Patients of either sex, aged 20-60 years, with American Society of Anesthesiologists (ASA) physical status I or II, who were scheduled for elective elbow or below-elbow surgery under supraclavicular brachial plexus block, were eligible. Patients were not included if they had infection at the injection site, diabetic neuropathy, allergy to local anaesthetics, a pre-existing neurological deficit, severe diabetes, or chronic pulmonary disease. The number of patients screened was not recorded.

Group allocation

Seventy-five patients were enrolled, 25 in each group. The anaesthesiologist performing the block chose the technique according to routine practice at the time. There was no randomisation, allocation concealment, or blinding. Group A received a PNS-guided block, Group B a USG-guided block, and Group C a block guided by USG and PNS together.

Sample size

The sample size was calculated for estimating the difference between two means of block performance time with the formula $n = 2Z^2S^2/d^2$, using $Z = 1.96$ (two-sided $\alpha = 0.05$), an assumed standard deviation (S) of about 2.6 minutes, and an absolute precision (d) of 1.59 minutes. This gave 21 patients per group, which was increased to 25 per group (75 in total). The SD was an assumption and was not taken directly from a prior study. The study was not powered for block success or the other secondary outcomes.

Anaesthetic technique

Routine monitors were applied and intravenous access secured before the block. All groups received the same type of local anaesthetic mixture: lignocaine (3-5 mg/kg), bupivacaine (2-3 mg/kg), 2 mL of hyaluronidase, and 2 mL of dexamethasone, diluted with distilled water to a total volume of 20-35 mL calculated according to body weight.

In the PNS technique, a stimulating needle connected to the nerve stimulator was used, with the stimulator grounded through an ECG lead. Stimulation started at 2.0 mA with a pulse width of 100 microseconds. After a clearly visible twitch of the fingers was obtained, the current was reduced gradually to 0.5 mA before injection.

In the USG technique, a 22-gauge, 5-cm insulated needle was used with a high-frequency linear probe (6-14 MHz; SonoSite, Bothell, WA, USA). The probe was moved laterally to show the plexus as it passes over the first rib. The needle was advanced in-plane from lateral to medial, entering about 1 cm from the probe, and spread of local anaesthetic was seen as a hypoechoic shadow around the plexus.

In the combined technique, ultrasound visualization of the needle and plexus was used together with nerve stimulation, and the drug was injected once the ultrasound image and the expected motor response agreed.

Outcomes and definitions

Block performance time was the time from needle insertion to needle removal. Sensory onset was assessed every 2 minutes by pinprick and was the time from needle removal until the patient first reported reduced sensation compared with the opposite limb. Motor onset was assessed every 2 minutes and was the time from needle removal until weakness of active movement was present at the shoulder, elbow, or wrist. Time to complete block was the time taken to achieve a complete nerve block. The quality of sensory block was assessed every 5 minutes after onset, and at 30 minutes each dermatome was graded as blocked, patchy, or not blocked. Motor block at the shoulder, elbow, and wrist was graded as blocked (no power), patchy (active movement possible), or not blocked (full power). Durations of sensory and motor block were recorded in hours.

A block was considered successful when there was complete sensory block in all tested dermatomes with no power at the shoulder, elbow, and wrist. Failure was recorded when full sensory block was absent in at least one dermatome. Supplementary anaesthesia was any additional general anaesthesia or intravenous dexmedetomidine needed to complete surgery. Average pulse rate, systolic, diastolic, and mean arterial pressure, and oxygen saturation (SpO2) were also recorded, together with any complications.

Data source and handling of missing data

Data were taken from the patient-level master chart completed during the study. Patients with failed or partial blocks, or who required general anaesthesia, did not have recorded times or durations for the affected outcomes. Blank and non-numeric entries were treated as missing and were not converted to zero; the number of patients contributing to each outcome is shown in the tables. Time-based outcomes therefore describe patients with a measurable block. Earlier aggregate dissertation tables had entered unavailable observations as zero, which affected the reported means and standard deviations; the present analysis instead uses available patient-level observations. A 2025 article by other authors reports a three-group comparison with summary values that closely resemble those earlier aggregate tables.[11] The present authors were not involved in that publication; the available documents do not establish whether the patient cohorts overlap.

Statistical analysis

Continuous data are presented as mean (standard deviation) with the number of available observations. Because group variances were unequal and group sizes were small, overall comparisons used the Kruskal-Wallis test, and pairwise comparisons used the Mann-Whitney U test with Holm adjustment; mean differences with 95% confidence intervals (Welch) are given for interpretation. Holm adjustment across the 11 outcome variables was used for the overall tests. Categorical variables were compared with the chi-square test, or with the Freeman-Halton exact test when expected counts were below 5. The unit of analysis was the individual patient. A two-sided P value below 0.05 was considered statistically significant. Analyses were run in Python 3 (SciPy).

RESULTS

Participants

All 75 enrolled patients were included in the analysis, 25 in each group (Figure 1). Age, sex, and ASA status were similar across groups, but weight differed (P=0.03), with the lowest mean weight in Group B (Table 1).

Table 1. Baseline characteristics

Variable	Group A (PNS), n=25	Group B (USG), n=25	Group C (USG+PNS), n=25	P value
Age, years, mean (SD)	37.84 (9.54)	37.40 (12.19)	37.64 (13.89)	0.85
Weight, kg, mean (SD)	64.16 (10.86)	56.20 (15.62)	58.36 (8.59)	0.03
Sex, male/female	19/6	19/6	18/7	0.93
ASA I/II	22/3	19/6	20/5	0.66

Continuous variables compared with the Kruskal-Wallis test; sex with the chi-square test; ASA status with the Freeman-Halton exact test. PNS, peripheral nerve stimulator; USG, ultrasound guidance; ASA, American Society of Anesthesiologists.

Block performance and characteristics

Block performance time differed among the groups (P<0.001): 10.50 minutes in Group A, 7.28 in Group B, and 6.58 in Group C (Table 2). Compared with Group A, performance was shorter by 3.2 minutes (95% CI 1.5 to 5.0) in Group B and by 3.9 minutes (95% CI 2.2 to 5.6) in Group C (both adjusted P<0.001). Groups B and C did not differ significantly (difference 0.70 minutes, 95% CI -0.05 to 1.45; adjusted P=0.12). Time to complete block showed the same pattern (Table 3).

Sensory onset differed among the groups (adjusted P=0.03). It was shorter in Group C than in Group A by 1.0 minute (95% CI 0.4 to 1.6; adjusted P=0.006), whereas the differences between Groups A and B and between Groups B and C were not significant after adjustment (Table 3). Motor onset was shorter in Groups B and C than in Group A (about 2.2 minutes each; adjusted P<0.001), with no difference between Groups B and C.

Sensory block lasted longer in Group B than in Group A by 1.2 hours (95% CI 0.7 to 1.8) and in Group C than in Group A by 2.4 hours (95% CI 1.8 to 3.0). Sensory block was also longer in Group C than in Group B by 1.1 hours (95% CI 0.5 to 1.8; adjusted P=0.001). Motor block duration did not differ among the groups (adjusted P=0.82).

Table 2. Block performance and block characteristics

Outcome	Group A (PNS)	Group B (USG)	Group C (USG+PNS)	P value	Holm-adjusted P
Block performance time (minutes)	n=21; 10.50 (3.60)	n=23; 7.28 (1.52)	n=24; 6.58 (0.93)	<0.001	<0.001
Time to complete block (minutes)	n=21; 17.88 (2.63)	n=23; 14.72 (1.06)	n=23; 14.67 (0.82)	<0.001	<0.001
Sensory onset (minutes)	n=24; 7.62 (1.11)	n=23; 7.15 (0.83)	n=21; 6.62 (0.74)	0.005	0.03
Motor onset (minutes)	n=21; 9.81 (1.54)	n=23; 7.57 (1.04)	n=24; 7.56 (0.70)	<0.001	<0.001
Sensory block duration (hours)	n=21; 6.90 (0.72)	n=24; 8.15 (1.06)	n=23; 9.28 (1.16)	<0.001	<0.001
Motor block duration (hours)	n=21; 6.43 (0.55)	n=23; 6.65 (0.51)	n=24; 6.73 (0.64)	0.16	0.82

Values are mean (SD) among patients with an available measurement. P values from the Kruskal-Wallis test; Holm adjustment across 11 outcome variables.

Table 3. Pairwise differences between groups

Outcome	Group B minus Group A	Group C minus Group A	Group C minus Group B
Block performance time (minutes)	-3.22 (-4.96 to -1.48); P<0.001	-3.92 (-5.59 to -2.24); P<0.001	-0.70 (-1.45 to +0.05); P=0.12
Time to complete block (minutes)	-3.16 (-4.43 to -1.90); P<0.001	-3.21 (-4.44 to -1.97); P<0.001	-0.04 (-0.61 to +0.52); P=0.93

Sensory onset (minutes)	-0.47 (-1.05 to +0.10); P=0.16	-1.01 (-1.57 to -0.45); P=0.006	-0.53 (-1.01 to -0.05); P=0.06
Motor onset (minutes)	-2.24 (-3.05 to -1.43); P<0.001	-2.25 (-2.99 to -1.50); P<0.001	0.00 (-0.53 to +0.52); P=1.00
Sensory block duration (hours)	+1.24 (+0.70 to +1.78); P<0.001	+2.38 (+1.80 to +2.96); P<0.001	+1.14 (+0.48 to +1.79); P=0.001
Motor block duration (hours)	+0.22 (-0.10 to +0.55); P=0.27	+0.30 (-0.06 to +0.66); P=0.27	+0.08 (-0.26 to +0.42); P=0.91

Mean difference (95% CI, Welch); P value from the Mann-Whitney U test with Holm adjustment within each outcome.

Block success and supplementary anaesthesia

Block success was recorded in 21 of 25 patients (84%) in Group A, 23 of 25 (92%) in Group B, and 24 of 25 (96%) in Group C (exact P=0.49; Table 4). Every patient with a failed or partial block needed supplementation: general anaesthesia in 2, 2, and 1 patients and intravenous dexmedetomidine in 2, 0, and 0 patients in Groups A, B, and C, respectively.

Table 4. Block success and supplementary anaesthesia

Outcome	Group A (PNS)	Group B (USG)	Group C (USG+PNS)	P value
Successful block, n (%)	21 (84%)	23 (92%)	24 (96%)	0.49
Failed or partial block, n (%)	4 (16%)	2 (8%)	1 (4%)	
Supplementary anaesthesia, n (%)	4 (16%)	2 (8%)	1 (4%)	0.49
General anaesthesia	2	2	1	
Intravenous dexmedetomidine	2	0	0	

P values from the Freeman-Halton exact test.

Hemodynamics and complications

Average pulse rate and blood pressure did not differ among the groups (Table 5). Average SpO2 was slightly higher in Group A, but all groups had mean values above 98% (adjusted P=0.01), which is not clinically important. No complications or adverse effects were recorded in any group.

Table 5. Hemodynamic parameters

Parameter	Group A (PNS)	Group B (USG)	Group C (USG+PNS)	P value	Holm-adjusted P
Average pulse rate (beats/minute)	n=21; 83.8 (14.3)	n=23; 86.5 (12.9)	n=24; 86.3 (11.3)	0.80	1.00
Average systolic BP (mmHg)	n=21; 126.6 (10.4)	n=23; 127.4 (10.2)	n=24; 126.2 (10.3)	0.93	1.00
Average diastolic BP (mmHg)	n=21; 82.4 (8.3)	n=23; 83.2 (8.2)	n=24; 81.7 (8.2)	0.91	1.00
Average mean arterial pressure (mmHg)	n=21; 97.2 (8.9)	n=23; 97.6 (9.0)	n=24; 96.6 (8.8)	0.97	1.00
Average SpO2 (%)	n=21; 99.4 (1.0)	n=23; 98.1 (1.5)	n=24; 98.2 (1.5)	0.002	0.01

Values are mean (SD) among patients with available values; Kruskal-Wallis test with Holm adjustment. BP, blood pressure; SpO2, oxygen saturation.

Graphical presentation of key outcomes

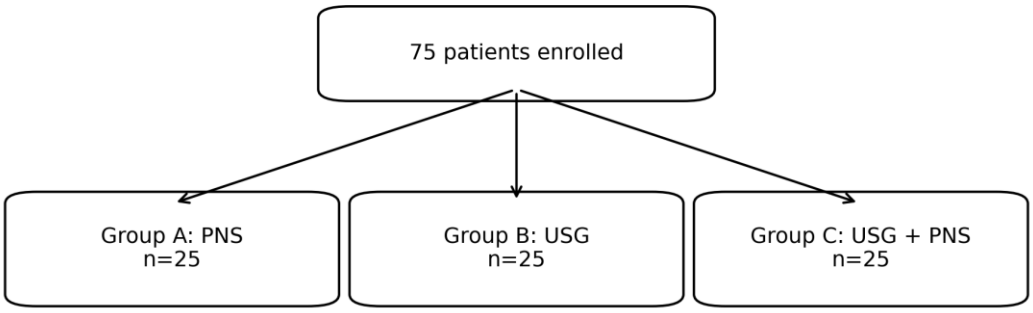


Figure 1. Participant flow. Seventy-five patients were enrolled and allocated by the treating anaesthesiologist to the three technique groups (25 per group). The number screened was not recorded.

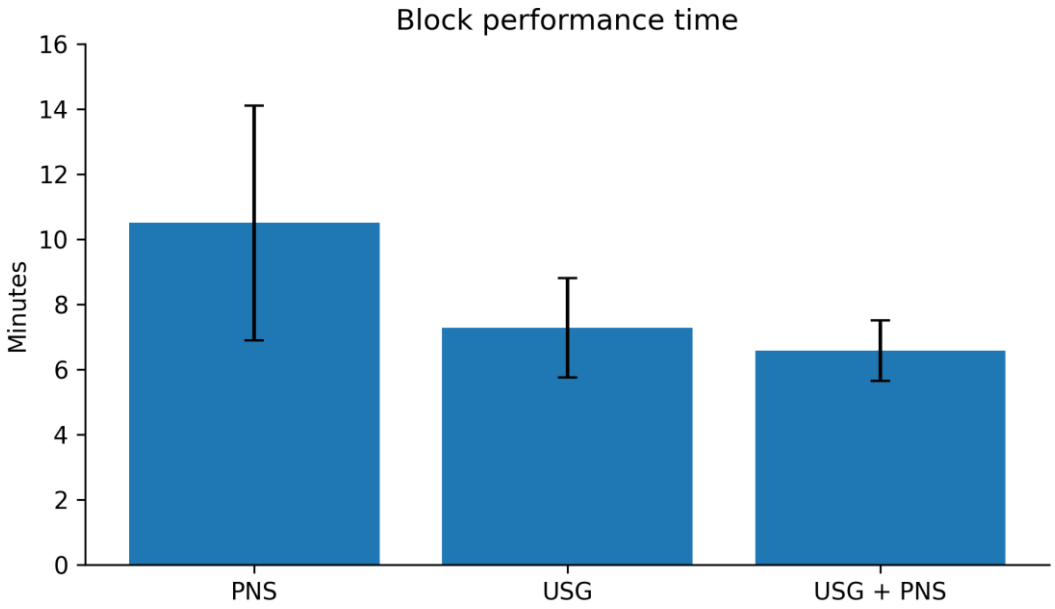


Figure 2. Block performance time by guidance technique. Bars show mean and error bars show standard deviation; available observations: n=21, 23, and 24, respectively. Overall Holm-adjusted P<0.001.

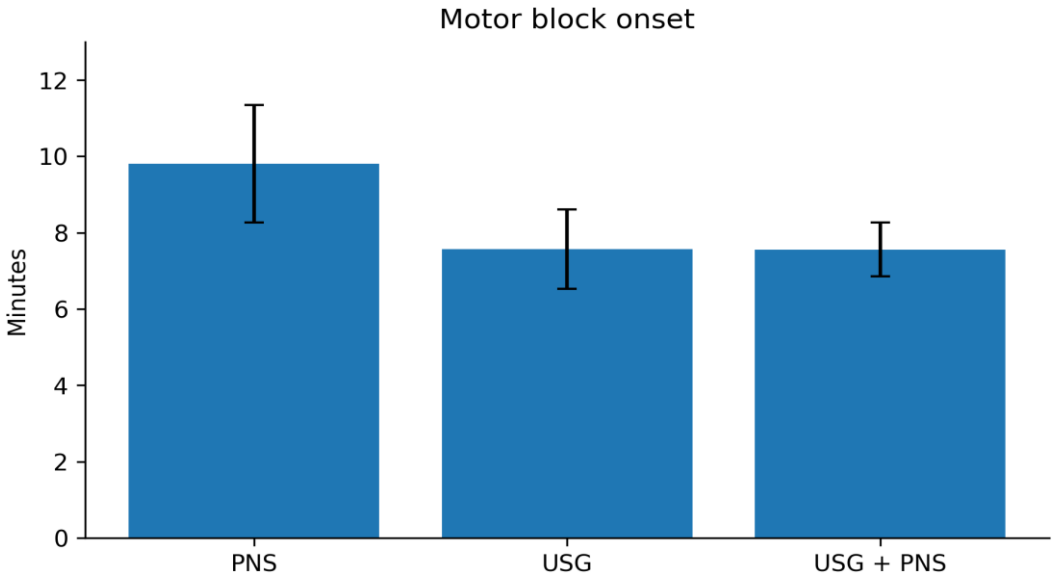


Figure 3. Motor block onset by guidance technique. Bars show mean and standard deviation; available observations: n=21, 23, and 24. Overall Holm-adjusted P<0.001.

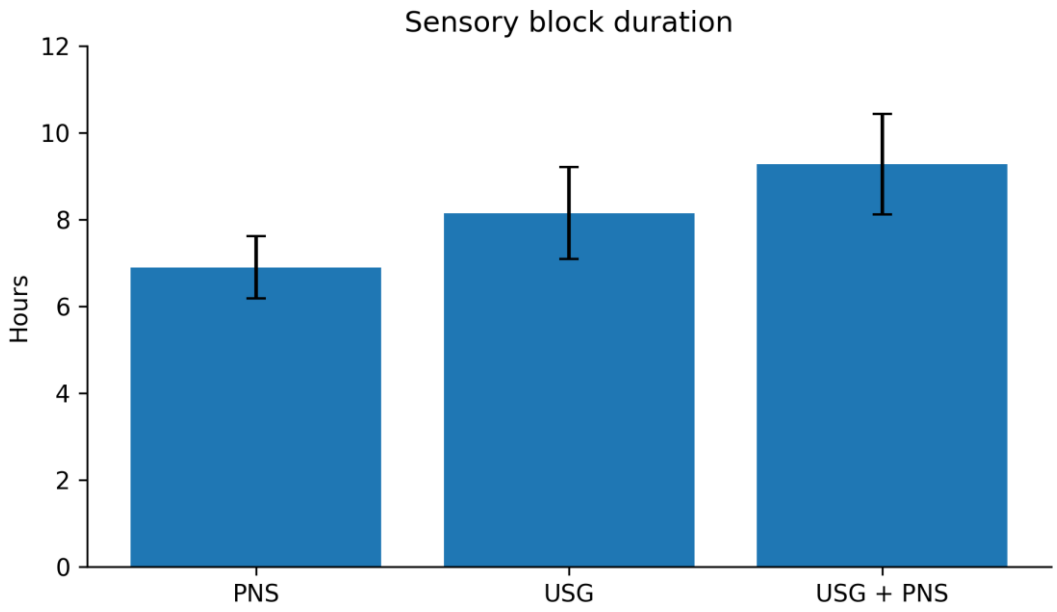


Figure 4. Sensory block duration by guidance technique. Bars show mean and standard deviation; available observations: n=21, 24, and 23. Overall Holm-adjusted P<0.001.

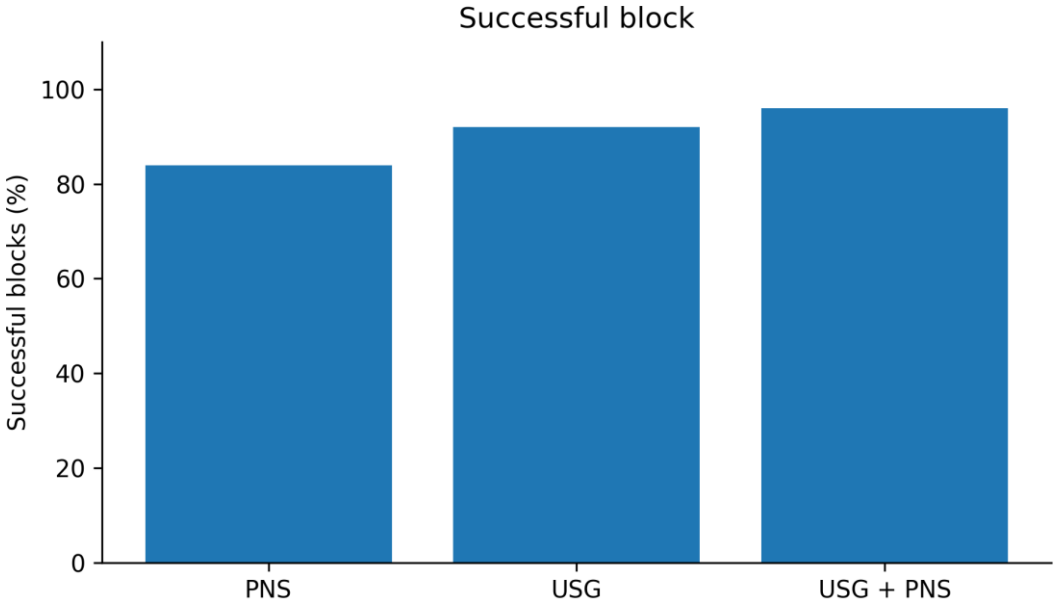


Figure 5. Proportion of successful blocks by guidance technique (21/25, 23/25, and 24/25). Exact P=0.49.

DISCUSSION

In this prospective, non-randomised comparison of three guidance techniques for supraclavicular brachial plexus block, ultrasound-based guidance, alone or combined with nerve stimulation, was associated with shorter block performance time and motor onset than PNS alone. Sensory block duration was longest with combined guidance. Block success did not differ significantly among groups.

The shorter performance time observed with ultrasound is consistent with previous comparisons of ultrasound and nerve-stimulator guidance.[5–9] In a randomized trial, Alfred et al. reported a shorter procedure time with ultrasound than with nerve stimulation and a longer sensory block with ultrasound.[7] A Cochrane review also identified benefits of ultrasound guidance across peripheral nerve blocks, although the magnitude of benefit varies by block and clinical setting.[4] Differences in absolute procedure times between studies may reflect operator experience and variation in the start and end points used for timing. In the present study, PNS took approximately three minutes longer than USG.

Combined guidance had the shortest mean performance time and earliest sensory onset, although its performance-time difference from ultrasound alone was small and not statistically significant. Sensory block lasted approximately 1.1 hours longer with combined guidance than with USG alone. A plausible explanation is that anatomical visualization together with functional confirmation may facilitate local-anaesthetic deposition; however, this observational design cannot establish that mechanism. Selection by the treating anaesthesiologist, operator experience, and residual confounding may have influenced the findings.[12–15]

Block success was high in all groups (84%, 92%, and 96%) but did not differ significantly. The study was not powered to detect differences in this outcome, and a clinically relevant difference cannot be excluded. All failed or partial blocks required supplementation, predominantly general anaesthesia. No complications were recorded; however, a sample of 75 patients is insufficient to compare uncommon adverse events.[13],[14]

LIMITATIONS

First, allocation was determined by the treating anaesthesiologist rather than randomisation, and there was no blinding; selection bias and confounding by operator experience cannot be excluded. Second, the study was single-centre and modest in size; the standard deviation used for sample-size estimation was assumed, and the study was not powered for block success or secondary outcomes. Third, time and duration outcomes were available only for patients with measurable blocks, so these comparisons are conditional on block adequacy. Fourth, some master-chart entries were missing or non-numeric (including sensory-onset data in four Group C patients), and original case records could not be rechecked. Fifth, body weight differed among groups and multiple outcomes were compared, although Holm adjustment was applied. The number of patients screened was not recorded. Patient satisfaction, long-term neurological outcomes, and costs were not assessed.

CONCLUSIONS

In this prospective, non-randomised comparison, ultrasound-based guidance, alone or combined with nerve stimulation, was associated with shorter block performance time and motor onset than PNS alone. Combined guidance was associated with the longest sensory block duration. Block success did not differ significantly among the three techniques. Given the non-randomised design and limitations of the source data, these findings should be considered hypothesis-generating and require confirmation in larger randomized studies.

REFERENCES

1. Chan VW, Perlas A, Rawson R, Odukoya O. Ultrasound-guided supraclavicular brachial plexus block. Anesth Analg. 2003;97:1514-1517.
2. Bowness JS, Pawa A, Turbitt L, et al. International consensus on anatomical structures to identify on ultrasound for the performance of basic blocks in ultrasound-guided regional anesthesia. Reg Anesth Pain Med. 2022;47:106-112. doi:10.1136/rapm-2021-103004.
3. Ashken T, Bowness J, Macfarlane AJR, et al. Recommendations for anatomical structures to identify on ultrasound for the performance of intermediate and advanced blocks in ultrasound-guided regional anesthesia. Reg Anesth Pain Med. 2022;47:762-772. doi:10.1136/rapm-2022-103738.
4. Lewis SR, Price A, Walker KJ, McGrath K, Smith AF. Ultrasound guidance for upper and lower limb blocks. Cochrane Database Syst Rev. 2015;2015:CD006459. doi:10.1002/14651858.CD006459.pub3.
5. Williams SR, Chouinard P, Arcand G, et al. Ultrasound guidance speeds execution and improves the quality of supraclavicular block. Anesth Analg. 2003;97:1518-1523.
6. Liu GY, Chen ZQ, Jia HY, Dai ZG, Zhang XJ. The technique comparison of brachial plexus blocks by ultrasound guided with blocks by nerve stimulator guided. Int J Clin Exp Med. 2015;8:16699-16703.
7. Alfred VM, Srinivasan G, Zachariah M. Comparison of ultrasound with peripheral nerve stimulator-guided technique for supraclavicular block in upper limb surgeries: a randomized controlled trial. Anesth Essays Res. 2018;12:50-54. doi:10.4103/aer.AER_211_17.
8. Kapral S, Krafft P, Eibenberger K, et al. Ultrasound-guided supraclavicular approach for regional anesthesia of the brachial plexus. Anesth Analg. 1994;78:507-513.
9. Greenblatt GM, Denson JS. Needle nerve stimulator locator: nerve blocks with a new instrument for locating nerves. Anesth Analg. 1962;41:599-602.
10. Des Jarlais DC, Lyles C, Crepaz N; TREND Group. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: the TREND statement. Am J Public Health. 2004;94:361-366.
11. Reshmi S, Dattatraya AR, Kaushik V, Dhotre M. To assess and compare between ultrasound guided (USG), peripheral nerve stimulator (PNS) and combined technique (PNS+USG) for supraclavicular brachial plexus block in patients undergoing elbow and below elbow surgeries. Int J Pharm Qual Assur. 2025;16:249-255. doi:10.25258/ijpqa.16.1.37.
12. Ratnawat A, Bhati FS, Khatri C, Srinivasan B, Sangwan P, Chouhan DP. Comparative study between nerve stimulator guided technique and ultrasound guided technique of supraclavicular nerve block for upper limb surgery. Int J Res Med Sci. 2016;4:2101-2106.
13. Singh S, Goyal R, Upadhyay KK, Sethi N, Sharma RM, Sharma A. An evaluation of brachial plexus block using a nerve stimulator versus ultrasound guidance: a randomized controlled trial. J Anaesthesiol Clin Pharmacol. 2015;31:370-374.
14. Duncan M, Shetti AN, Tripathy DK, Roshansingh D, Krishnaveni N. A comparative study of nerve stimulator versus ultrasound-guided supraclavicular brachial plexus block. Anesth Essays Res. 2013;7:359-363.
15. Soeding PE, Sha S, Royse CE, Marks P, Hoy G, Royse AG. A randomized trial of ultrasound-guided brachial plexus anaesthesia in upper limb surgery. Anaesth Intensive Care. 2005;33:719-725.