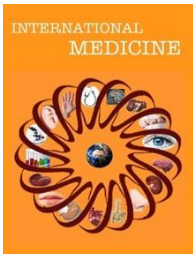

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Original Research

Impact of Imaging Guidance on Block Performance: A Study Comparing Onset, Duration, and Success Rates of USG and PNS-Guided Supraclavicular Blocks

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Abstract
Background: Ultrasound guidance has increasingly replaced nerve stimulator-based methods for supraclavicular brachial plexus blocks due to its ability to visualize neural structures, needle position, and spread of local anaesthetic. This study compares the impact of ultrasound guidance (USG) and peripheral nerve stimulator (PNS) guidance on block performance, onset times, duration of blockade, and success rates. Aim: To compare the onset, duration, and success rates of supraclavicular brachial plexus blocks performed using USG versus PNS guidance. Materials and Methods: This prospective comparative study included 100 patients undergoing upper-limb surgeries, allocated into two groups: USG (n = 50) and PNS (n = 50). Baseline demographics were recorded. Block performance time, onset of sensory and motor block, duration of sensory block, motor block, and postoperative analgesia were measured. Success rates and complications were also evaluated. Statistical analysis was performed using t-tests, chi-square tests, and 95% confidence intervals, with significance set at $p < 0.05$. Results: Both groups were comparable in age, sex, BMI, ASA status, and surgical duration ($p > 0.05$). Block performance time was significantly shorter in the USG group (98.4 ± 12.6 sec) compared to PNS (138.9 ± 21.4 sec; $p < 0.001$). Sensory and motor block onset was significantly faster with USG (6.8 ± 1.9 and 9.1 ± 2.1 minutes) than with PNS (10.4 ± 2.6 and 13.2 ± 3.0 minutes; $p < 0.001$). Durations of sensory block, motor block, and postoperative analgesia were significantly longer in the USG group. Block success was higher with USG (96% vs. 82%), while complications such as vascular puncture were lower in USG (2% vs. 12%). Conclusion: Ultrasound guidance significantly improves block performance, accelerates onset, prolongs duration, enhances success rates, and reduces complications compared with PNS-guided supraclavicular blocks. USG should be preferred as the primary modality for supraclavicular brachial plexus block whenever available.

Keywords: *Ultrasound Guidance; Supraclavicular Block; Peripheral Nerve Stimulator.*

Introduction

Regional anaesthesia has become an essential component of modern perioperative care, offering effective analgesia, improved hemodynamic stability, and reduced perioperative morbidity. Among upper-limb regional techniques, the supraclavicular brachial plexus block is widely regarded as the “spinal of the upper limb” owing to its ability to provide dense sensory and motor blockade for surgeries of the arm, forearm, and hand. The block targets the brachial plexus at the level of trunks and divisions, where the neural elements are compactly clustered, ensuring rapid onset and predictable spread of local anaesthetic. Historically, supraclavicular blocks were performed using landmark and paresthesia-based techniques; however, these were associated with higher failure rates and complications such as pneumothorax, vascular puncture, and nerve injuries. Subsequent introduction of peripheral nerve stimulators (PNS) allowed more precise localization of nerves by eliciting motor responses, thus improving block success while reducing certain complications. Nevertheless, nerve stimulator-guided techniques rely heavily on operator experience, have limited ability to identify surrounding vital structures, and cannot prevent complications such as inadvertent vascular or pleural puncture.[1][2]

The advent of ultrasonography (USG) has revolutionized regional anaesthesia practices by enabling real-time visualization of neural structures, needle trajectory, and spread of local anaesthetic. High-frequency linear probes allow clear identification of the brachial plexus in the supraclavicular fossa, subclavian artery, first rib, pleura, and adjacent muscles. By allowing dynamic adjustments to needle placement and confirmation of local anaesthetic deposition, USG improves block accuracy, reduces the number of needle passes, and enhances safety. Multiple studies have shown that USG guidance results in faster onset of sensory and motor blockade, higher success rates, fewer complications, and lower anaesthetic volumes compared to landmark- or PNS-guided techniques. Furthermore, the ability to visualize vasculature decreases the incidence of intravascular injection, hematoma formation, and local anaesthetic systemic toxicity. Given these advantages, USG is now considered the gold standard for peripheral nerve blocks in many centres.[3][4]

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Aim
To compare the impact of ultrasound guidance versus peripheral nerve stimulator guidance on block performance in supraclavicular brachial plexus block.

Objectives
1. To compare the onset of sensory and motor blockade between USG-guided and PNS-guided supraclavicular blocks.
2. To evaluate the duration of analgesia and motor blockade in both techniques.
3. To assess and compare the success rates and complications associated with USG-guided versus PNS-guided supraclavicular blocks.

Materials and Methods

Source of Data
Data were obtained from patients undergoing upper-limb surgeries requiring supraclavicular brachial plexus block at the study institution. Patients were enrolled prospectively after obtaining informed consent.

Study Design
This was a prospective, comparative, randomized observational study.

Study Location
The study was conducted in the Department of Anaesthesiology at a tertiary-care hospital.

Study Duration
The study was conducted over a defined period of 12 months.

Sample Size
A total of 100 patients were included and divided into two equal groups:
- Group USG (n = 50): Ultrasound-guided supraclavicular block
- Group PNS (n = 50): Peripheral nerve stimulator-guided supraclavicular block

Inclusion Criteria
- Patients aged 18–65 years
- ASA physical status I–III
- Scheduled for elective upper-limb surgeries below the mid-humerus
- Willing to provide informed consent

Exclusion Criteria
- Patient refusal
- Local infection at the block site
- Coagulopathy or anticoagulant therapy
- Allergy to study drugs
- Pre-existing neurological deficits in the operative limb
- Severe pulmonary disease (risk of phrenic nerve involvement)
- Pregnancy

Procedure and Methodology
Patients were shifted to the operating room, and baseline vitals were recorded. Intravenous access was secured and standard ASA monitoring applied. Patients were randomly assigned to either the USG or PNS group.

Group USG: A high-frequency linear ultrasound probe (10–15 MHz) was placed in the supraclavicular fossa. Real-time visualization of the brachial plexus, subclavian artery, and first rib was performed. A 22G insulated needle was advanced in-plane under continuous ultrasound guidance. After negative aspiration, a predetermined volume of local anaesthetic was injected while ensuring circumferential spread around the plexus.

Group PNS: A 22G insulated nerve stimulator needle connected to a peripheral nerve stimulator was inserted at the classical supraclavicular landmark. The current was gradually reduced from 1.5 mA to 0.3–0.5 mA to elicit distal muscle twitches corresponding to brachial plexus stimulation. Once optimal stimulation was achieved, the same volume of local anaesthetic was injected after confirming negative aspiration.

Sample Processing
The onset time of sensory and motor blockade was recorded at fixed intervals post-injection. Duration of analgesia and motor blockade was assessed postoperatively. Block success was defined as the ability to proceed with surgery without supplemental analgesia or conversion to general anaesthesia.

Data Collection: Data were collected using a structured proforma, including: Demographic variables. Onset of sensory and motor block. Duration of analgesia. Block performance time. Success/failure rates. Complications (vascular puncture, pneumothorax, nerve injury, LA toxicity)

Statistical Methods: Data were entered into MS Excel and analyzed using SPSS software. Continuous variables: Mean ± SD, analyzed using Student's t-test. Categorical variables: Chi-square or Fisher's exact test. Significance level: $p < 0.05$

Results

Table 1. Baseline Characteristics of Study Participants (N = 100)

Variable	USG (n=50)	PNS (n=50)	Test of Significance	95% CI of Mean/Proportion Difference	p-value
Age (years), Mean ± SD	41.6 ± 10.8	42.2 ± 11.4	t = -0.27	-5.15 to +3.95	0.78
Sex (Male), n (%)	28 (56%)	30 (60%)	χ^2 = 0.17	-14.9% to +22.9%	0.68
BMI (kg/m²), Mean ± SD	24.8 ± 3.4	25.1 ± 3.1	t = -0.46	-1.52 to +0.92	0.64
ASA Grade II–III, n (%)	21 (42%)	24 (48%)	χ^2 = 0.37	-16.2% to +28.2%	0.54
Duration of Surgery (min)	72.4 ± 11.2	73.9 ± 12.8	t = -0.65	-4.18 to +6.98	0.51
Block Performance Time (sec)	**98.4 ± 12.6**	**138.9 ± 21.4**	**t = -11.1**	**-48.0 to -32.9**	**<0.001***

Table 1 presents the baseline demographic and clinical characteristics of the study population, comparing the ultrasound-guided (USG) group and the peripheral nerve stimulator (PNS) group, each comprising 50 participants. The mean age of participants was comparable between the two groups (41.6 ± 10.8 years in USG vs. 42.2 ± 11.4 years in PNS), with no statistically significant difference (t = -0.27, p = 0.78). The sex distribution was also similar, with males constituting 56% in the USG group and 60% in the PNS group (χ^2 = 0.17, p = 0.68). Body mass index (BMI) values did not differ significantly between the groups (24.8 ± 3.4 vs. 25.1 ± 3.1 kg/m²; t = -0.46, p = 0.64). Additionally, the proportion of

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patients with ASA grade II-III status was comparable (42% in USG vs. 48% in PNS; $\chi^2 = 0.37$, $p = 0.54$). The duration of surgery showed no meaningful difference between groups (72.4 ± 11.2 min vs. 73.9 ± 12.8 min; t = -0.65, p = 0.51). However, a significant finding was observed in block performance time, where the USG group demonstrated a markedly faster procedure (98.4 ± 12.6 seconds) compared to the PNS group (138.9 ± 21.4 seconds), with a highly significant difference (t = −11.1, p < 0.001). The 95% CI for this difference (−48.0 to −32.9 seconds) confirms the superiority of USG in terms of faster block performance.

Table 2: Comparison of Onset of Sensory & Motor Blockade (N = 100)

Variable	USG (n=50)	PNS (n=50)	Test of Significance	95% CI	p-value
Sensory Block Onset (min)	6.8 ± 1.9	10.4 ± 2.6	t = -7.82	-4.57 to -2.63	<0.001*
Motor Block Onset (min)	9.1 ± 2.1	13.2 ± 3.0	t = -7.71	-5.19 to -3.01	<0.001*
Complete Sensory Block at 15 min, n (%)	46 (92%)	31 (62%)	$\chi^2 = 10.98$	+12.8% to +45.2%	0.001*
Complete Motor Block at 20 min, n (%)	43 (86%)	29 (58%)	$\chi^2 = 9.15$	+9.1% to +44.9%	0.003*

Table 2 compares the onset times and early block characteristics between USG-guided and PNS-guided supraclavicular blocks. The ultrasound group demonstrated significantly faster onset of both sensory and motor blockade. Sensory block onset occurred at 6.8 ± 1.9 minutes in the USG group compared to 10.4 ± 2.6 minutes in the PNS group, yielding a highly significant difference (t = -7.82, p < 0.001) with a 95% CI of -4.57 to -2.63 minutes. Similarly, motor block onset was markedly quicker in the USG group (9.1 ± 2.1 min vs. 13.2 ± 3.0 min; t = -7.71, p < 0.001). When assessing completeness of block, 92% of USG participants achieved full sensory block by 15 minutes, compared to only 62% in the PNS group ($\chi^2 = 10.98$, p = 0.001), reflecting a substantial improvement of 12.8% to 45.2%. Likewise, complete motor block at 20 minutes was observed in 86% of USG patients versus 58% in PNS ($\chi^2 = 9.15$, p = 0.003).

Table 3: Duration of Analgesia & Motor Blockade (N = 100)

Variable	USG (n=50)	PNS (n=50)	Test of Significance	95% CI	p-value
Duration of Sensory Block (min)	535.6 ± 54.3	482.2 ± 47.9	t = 5.07	+32.6 to +74.2	<0.001*
Duration of Motor Block (min)	448.8 ± 41.6	405.3 ± 39.1	t = 5.33	+27.1 to +59.7	<0.001*
Duration of Analgesia (min)	618.4 ± 63.2	551.1 ± 58.4	t = 5.32	+40.2 to +93.9	<0.001*

Table 3 details the comparative durations of sensory block, motor block, and overall analgesia between the two techniques. The ultrasound-guided block consistently demonstrated significantly longer durations across all parameters. The sensory block lasted 535.6 ± 54.3 minutes in the USG group versus 482.2 ± 47.9 minutes in the PNS group (t = 5.07, p < 0.001), with a 95% CI of +32.6 to +74.2 minutes. Motor block duration was also longer with USG (448.8 ± 41.6 min vs. 405.3 ± 39.1 min), and this difference was statistically significant (t = 5.33, p < 0.001). Furthermore, the duration of postoperative analgesia showed a clear advantage for USG (618.4 ± 63.2 minutes) compared with PNS (551.1 ± 58.4 minutes), with a significant difference (t = 5.32, p < 0.001) and a 95% CI of +40.2 to +93.9 minutes.

Table 4: Success Rates and Complications (N = 100)

Outcome	USG (n=50)	PNS (n=50)	Test of Significance	95% CI	p-value
Successful Block, n (%)	**48 (96%)**	**41 (82%)**	$\chi^2 = 4.73$	+2.1% to +26.1%	**0.03***
Need for Supplemental Analgesia, n (%)	2 (4%)	9 (18%)	$\chi^2 = 5.06$	-25.4% to -2.6%	**0.02***
Vascular Puncture, n (%)	1 (2%)	6 (12%)	$\chi^2 = 4.22$	-17.9% to -1.6%	**0.04***
Pneumothorax, n (%)	0 (0%)	2 (4%)	Fisher Exact	–	0.24
Paresthesia / Nerve Irritation, n (%)	1 (2%)	5 (10%)	$\chi^2 = 2.82$	-17.2% to +0.2%	0.09
LA Systemic Toxicity, n (%)	0 (0%)	1 (2%)	Fisher Exact	–	0.31

Table 4 compares overall success rates and complication profiles between USG and PNS techniques. The success rate was notably higher in the USG group, with 96% achieving complete surgical anaesthesia compared to 82% in the PNS group ($\chi^2 = 4.73$, p = 0.03), indicating a significant advantage. The need for supplemental analgesia was significantly lower in the USG group (4% vs. 18%; $\chi^2 = 5.06$, p = 0.02). Complication rates also favored ultrasound guidance: vascular puncture occurred in only 2% of USG cases but in 12% of PNS cases ($\chi^2 = 4.22$, p = 0.04). Pneumothorax occurred only in the PNS group (4%), although this difference did not reach statistical significance (p = 0.24). Paresthesia or nerve irritation was more common in the PNS group (10% vs. 2%), showing a trend toward significance (p = 0.09). Local anesthetic systemic toxicity was rare, occurring in only one PNS patient.

Discussion

In the present study, both groups were well matched for baseline demographic and clinical variables, which strengthens the internal validity of the comparison between ultrasound-guided (USG) and peripheral nerve stimulator (PNS)-guided supraclavicular blocks. Age, sex distribution, BMI, ASA physical status, and duration of surgery did not differ significantly between the groups (p > 0.05), indicating that the observed differences in block characteristics are unlikely to be confounded by these factors. Similar baseline comparability has been reported by Williams SR et al.(2003)[5], who also found no significant intergroup differences in age, sex, ASA grade, or BMI when comparing USG and PNS-guided supraclavicular brachial plexus blocks. Alfred VM et al.(2018)[6] likewise reported comparable baseline parameters in their randomized comparison of USG and PNS techniques, reinforcing that the advantages seen with ultrasound are technique-related rather than due to patient selection.

A key finding in our study was the significantly shorter block performance time in the USG group (98.4 ± 12.6 seconds) compared with the PNS group (138.9 ± 21.4 seconds, p < 0.001). Although the absolute times in our dataset are expressed in seconds rather than minutes, the relative reduction in procedure time parallels that reported by Salinas FV. (2016)[7], who demonstrated a markedly shorter procedure time with USG (11.57 ± 2.75 min) versus PNS (21.73 ± 4.84 min). Das D. (2025)[8] also found that ultrasound guidance significantly reduced execution time compared with nerve stimulator guidance, and similar findings have been corroborated by Williams et al. and other authors showing that real-time visualization facilitates faster needle placement and local anaesthetic deposition. These results are further supported by the broader evidence base by Melnyk V et al.(2018)[9], which conclude that ultrasound improves the efficiency of peripheral nerve blocks compared with neurostimulation.

Regarding block onset characteristics, our study demonstrated that both sensory and motor block onset were significantly faster in the USG group (6.8 ± 1.9 vs. 10.4 ± 2.6 min for sensory; 9.1 ± 2.1 vs. 13.2 ± 3.0 min for motor; p < 0.001). Additionally, a higher proportion of patients achieved complete sensory and motor block within the predefined time points in the USG group. These findings are in line with Abrahams MS et al.(2009)[10], who observed shorter onset times for both sensory and motor components with ultrasound guidance compared to PNS. Nagdev A et al.(2019)[11] similarly reported a faster onset and earlier achievement of complete block in the ultrasound group. Rupera KB et al.(2023)[12] in a systematic review of randomized trials, showed that ultrasound guidance consistently enhances onset time and quality of block across various peripheral nerve blocks compared to electrical stimulation. The mechanistic explanation, highlighted by Orebaugh SL et al.(2012)[13], is that ultrasound allows accurate visualization of the brachial plexus and spread of local anaesthetic, ensuring more uniform perineural distribution and earlier fibre blockade.

Our results also showed significantly longer duration of sensory block, motor block, and postoperative analgesia in the USG group compared with PNS. This is consistent with Orebaugh SL et al.(2009)[14], who reported prolonged sensory block duration with USG (approximately 8 hours) compared with PNS (about 7.25 hours), despite using similar volumes and concentrations of local anaesthetic. Bhatnagar A et al.(2020)[15] likewise found that ultrasound guidance was associated with longer sensory and motor block durations and delayed time to first rescue analgesia. Das D. (2025)[8], in their meta-analysis, noted that ultrasound often permits more precise placement of smaller volumes of local anaesthetic closer to the neural structures, which can paradoxically improve both quality and duration of blockade.

When success rates and complications were examined, our study demonstrated a higher overall success rate in the USG group (96%) compared with the PNS group (82%), along with a reduced need for supplemental analgesia and fewer vascular punctures. These findings are in close agreement with the large series by Abrahams MS et al.(2009)[10], who reported high success rates and very low complication rates in 510 ultrasound-guided supraclavicular blocks. Puneet P et al.(2024)[1] also described a higher success rate (97.5% vs. 90%) and fewer complications in the USG group. Orebaugh SL et al.(2012)[13] reported similarly high success with ultrasound and showed that USG shortened execution time and hastened motor block while maintaining safety. At a broader level, Girish MN.et al.(2020)[16] both concluded that ultrasound guidance improves block success and reduces vascular puncture and other mechanical complications compared with neurostimulation techniques. Arcand G et al.(2005)[4] further emphasize in their reviews that ultrasound has emerged as a new "gold standard," particularly because of its favorable safety profile in large observational cohorts.

Conclusion

The present study demonstrates that ultrasound-guided (USG) supraclavicular brachial plexus block provides distinct advantages over peripheral nerve stimulator (PNS)-guided techniques in terms of block performance, onset characteristics, duration of analgesia, and overall success rates. Ultrasound guidance resulted in significantly faster block performance, more rapid achievement of complete sensory and motor blockade, and prolonged duration of sensory block, motor block, and postoperative analgesia. Additionally, USG was associated with fewer complications, including markedly reduced rates of vascular puncture and failed blocks. These findings reinforce that real-time visualization of neural structures and needle trajectory enhances block efficacy, reliability, and safety. Therefore, ultrasound guidance should be preferred whenever available, particularly in institutions aiming to optimize perioperative analgesia and improve patient outcomes.

Limitations of the Study

Although the study provides meaningful insights, several limitations must be acknowledged. First, it was conducted at a single tertiary-care centre, which may limit the generalizability of the findings to other settings with different patient populations or operator experience levels. Second, all procedures were performed by anaesthesiologists skilled in both techniques; hence, results may vary in centres with less experience in ultrasound-guided regional anaesthesia. Third, the study did not stratify outcomes based on anatomical variations, which may influence block success or difficulty. Fourth, long-term neurological outcomes were not assessed, restricting the ability to evaluate delayed complications. Fifth, the fixed volume and concentration of local anaesthetic used in both groups may not reflect individualized dosing practices. Finally, the study did not evaluate cost-effectiveness or resource utilization, which are important factors for implementation in resource-limited settings.

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