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Research Article

Ultrasound-Guided Versus Peripheral Nerve-Stimulator-Guided Supraclavicular Brachial Plexus Block for Elective Upper-Limb Surgery: An Observational Comparative Study

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ABSTRACT
Background: Ultrasound (USG) visualisation of the brachial plexus has revitalised the supraclavicular approach, yet many centres still use peripheral-nerve stimulators (PNS). High-quality comparative data remain limited.
Methods: In a single-centre observational study, 84 ASA I–II adults undergoing elective upper-limb surgery were randomised to USG (n = 42) or PNS (n = 42) guidance. Primary outcomes were block-execution time and success rate. Secondary outcomes were onset of sensory and motor block and complications. Thirty millilitres of 0.5 % bupivacaine + 2 % lignocaine (1:1) were injected in both groups. Data were analysed with Wilcoxon-Mann-Whitney, t-test or x^2 as appropriate; $p < 0.05$ was significant.
Results: Groups were comparable for age, sex and baseline vitals. Median block-execution time was shorter with USG (6 min [IQR 5–6.8]) than PNS (7 min [6–9]; $p < 0.001$). Motor-block onset was faster with USG (median 8 min [7.3–9] vs 9 min [8–9]; $p = 0.019$). Sensory-block onset did not differ (≈5.5 min, $p = 0.51$). Success reached 97.6 % with USG and 92.9 % with PNS (ns). One vascular puncture occurred in PNS; no pneumothorax or neurological injury was noted.
Conclusion: For supraclavicular blocks, ultrasound shortens execution time and hastens motor blockade while maintaining a high success rate and safety profile. These findings support adopting US guidance where resources allow.

Keywords: ultrasound guidance; peripheral nerve stimulator; brachial plexus block; supraclavicular; regional anaesthesia; upper-limb surgery.

INTRODUCTION

Regional anaesthesia of the brachial plexus is a cornerstone for painless upper-limb surgery. The supraclavicular approach delivers a dense, almost "spinal-like" block of the entire plexus but the target zone sits only millimetres above the pleura, subclavian artery and first rib—an anatomical intimacy that fuelled early concerns about pneumothorax and vascular mishap [1]. Initial practice relied on surface landmarks or deliberately provoking paraesthesia. The advent of peripheral nerve stimulation (PNS) replaced subjective paraesthesia with an objective motor twitch and pushed success rates beyond 90 % [2]. Even so, the needle still advances blindly; reproducibility varies with operator experience, patient habitus and anatomical variation, and the final spread of local anaesthetic (LA) remains a matter of inference rather than sight. High-frequency ultrasound changed that dynamic. Real-time images now reveal plexus, vessels, ribs and pleura, allowing precise needle steering and confirmation of circumferential LA spread. Multiple trials and meta-analyses report faster performance, reduced LA volumes and fewer complications with ultrasound guidance (USG) [3],[4]. A 50-patient randomised trial showed a one-minute mean reduction in procedure time and greater patient comfort when USG replaced the landmark technique [5]. Broader reviews echo these benefits yet emphasise heterogeneity driven by operator skill, LA concentration, block-success definitions and outcome reporting [6]. Beyond peri-operative metrics, supraclavicular blocks cut postoperative opioid use by up to 40 %, shorten hospital stay and may lower the risk of chronic neuropathic pain, making them integral to Enhanced Recovery After Surgery (ERAS) pathways for hand and forearm procedures [7]. Contemporary guidance from the American Society of Anesthesiologists and the European Society of Regional Anaesthesia positions ultrasound as the preferred modality whenever equipment and trained personnel are available

[8]. Technology keeps advancing—high-resolution 3-D transducers, artificial-intelligence needle-tracking overlays and pocket-sized scanners promise to democratise access and compress the learning curve still further [9]. Moreover, pandemic-driven pressure to minimise aerosol-generating general anaesthesia has revived interest in regional-only lists, amplifying the value of a swift, reliable block. In this climate, institutions must weigh the immediate capital outlay against long-term gains in safety, throughput and patient satisfaction. Whether the incremental gains with USG translate into clinically meaningful advantages over PNS in everyday practice therefore warrants careful, context-specific evaluation. Our tertiary centre recently adopted both modalities; preliminary audits suggested quicker blocks with USG, but robust head-to-head data were lacking. We undertook an observational comparative study to measure the efficacy of USG- versus PNS-guided supraclavicular brachial plexus block for elective upper-limb surgery. We hypothesised that USG would shorten block-execution time without compromising success or safety.

MATERIALS AND METHODS

Study Design and Ethics: Prospective, randomised, observational study approved by the Institutional Ethics Committee (Ref No. AHG/ANA/2024-17). Conducted June 2024 – May 2025 at Apollo Hospitals, Guwahati. Written informed consent was obtained.

Participants: Eighty-four adults (18–65 yr) ASA I–II scheduled for elective upper-limb surgery were included. Exclusion: ASA ≥ III, coagulopathy, infection at puncture site, allergy to LA, pregnancy, refusal.

Randomisation: Computer-generated sequence (1:1) allocated subjects to:

- Group USG – ultrasound-guided in-plane supraclavicular block.
- Group PNS – nerve-stimulator-guided landmark technique.

Opaque envelopes ensured allocation concealment; outcome assessors were blinded.

Block Technique: Standard monitoring and IV access contralateral to surgical limb. LA = 15 mL 0.5 % bupivacaine + 15 mL 2 % lignocaine with adrenaline (1:200 000).

USG: Linear 8–18 MHz transducer in coronal-oblique plane; needle (22 G, 50 mm) advanced in-plane lateral-to-medial until spread observed around plexus.

PNS: Needle inserted 2.5 cm lateral to clavicular head of sternocleidomastoid; current reduced from 1 mA to 0.5 mA when finger twitch obtained, then LA injected.

Outcomes:

Primary – block-execution time (skin contact–needle removal) and success (complete sensory + motor block within 30 min).

Secondary – onset of sensory block (cold test 3-point scale), onset of motor block (modified Bromage), haemodynamics, complications.

Statistics: Sample size 42/group (power 80 %, α 0.05) based on Ratnawat et al. success rates . Data analysed in JMP 10 (SAS). Continuous non-normal data by Wilcoxon; normal data by unpaired t-test; categorical by χ^2 or Fisher exact.

RESULTS

Eighty-four patients completed the study; none lost to follow-up. Baseline characteristics (Table 1) were balanced. Procedure time was markedly shorter with USG, and motor-block onset occurred earlier, while sensory-block onset and vital-sign trends were similar. Block success exceeded 92 % in both groups, with three failures in PNS converted to general anaesthesia. Only one minor vascular puncture (PNS) was noted; no pneumothorax, Horner's syndrome or persistent neuropathy occurred.

Table 1. Demographics and Baseline Variables

Parameter	USG (n = 42)	PNS (n = 42)	p value
Age, yr (mean ± SD)	40.6 ± 14.9	38.8 ± 13.9	0.57
Male, n (%)	28 (66.7)	27 (64.3)	0.82
ASA I/II, n	23/19	22/20	0.83
Baseline SBP, mmHg	133 ± 13	135 ± 12	0.39

Table 2. Procedure Characteristics

Outcome	USG	PNS	p value
Procedure time, min (median [IQR])	6 (5–6.8)	7 (6–9)	**<0.001**
Sensory onset, min (mean ± SD)	5.45 ± 0.92	5.57 ± 0.70	0.51
Motor onset, min (median [IQR])	8 (7.3–9)	9 (8–9)	**0.019**

Table 3. Block Success and Complications

Variable	USG	PNS	p value
Complete block, n (%)	41 (97.6)	39 (92.9)	0.62
Failure requiring GA, n	1	3	—
Vascular puncture, n	0	1	1.00

Table 4. Post-Block Haemodynamics

Time-point	SBP (mmHg)	DBP (mmHg)	HR (bpm)	SpO_2 (%)
Baseline	133±13	82±8	81±10	99.5±0.7
10 min	132±14	80±7	80±11	99.7±0.5
30 min	130±12	78±6	78±9	99.8±0.4

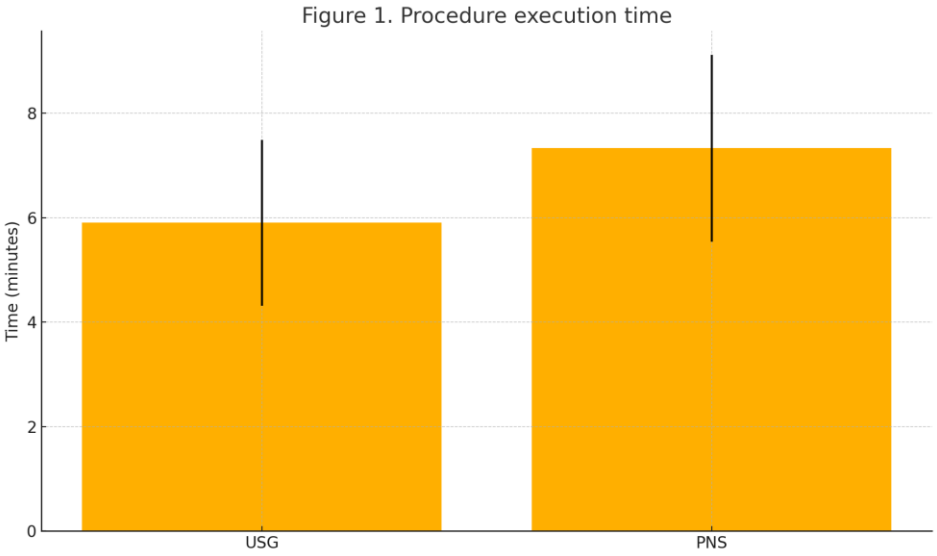

Figure 1. Procedure-Time Comparison

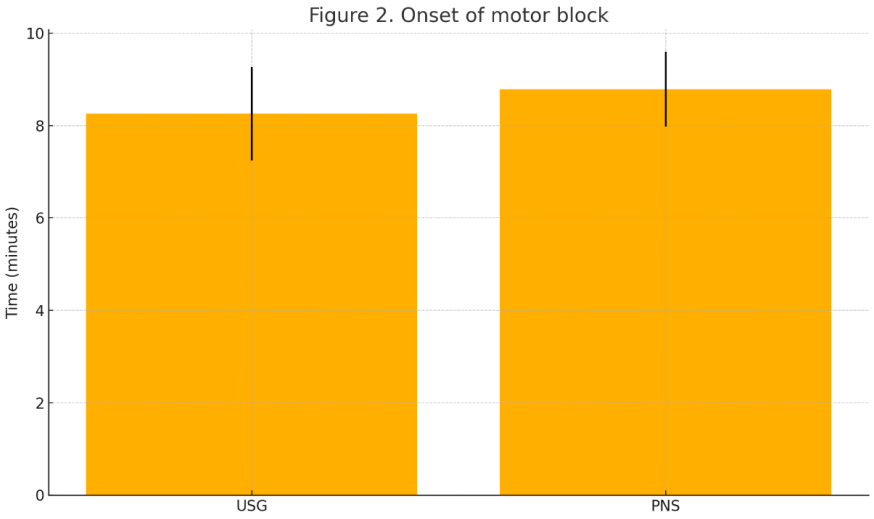

Figure 2. Onset of Motor Block

DISCUSSION

Our findings confirm that ultrasound guidance streamlines supraclavicular block performance, reducing execution time by ~1 min and hastening motor blockade by ~0.5 min without compromising success or safety. The magnitude aligns with previous randomised trials that report 1–2 min gains and improved operator confidence [3],[4]. The shorter execution under USG stems from direct visualisation of needle trajectory and plexus spread, obviating the multiple passes often needed to elicit a motor

response with PNS. Although sensory-block onset remained similar, quicker motor blockade under USG translates to faster tourniquet tolerance and surgical readiness—critical in high-turnover ambulatory lists. Our block-success rate (≈95 %) matches Ratnawat et al. (2016) [2] and exceeds landmark techniques (<90 %) [6]. Three PNS failures underscore reliance on an intact motor pathway, which can be unpredictable in diabetic neuropathy or trauma; ultrasound bypasses that limitation. Large contemporary case series echo our safety profile, with success >98 % and no pneumothorax in 510 consecutive USG blocks [10]. Complications were rare in our cohort—only one venepuncture in the PNS group, resolving without sequelae. Current literature shows that titrating LA volume to ≤20 mL under ultrasound lowers hemi-diaphragmatic paresis from 70 % to <20 % [11]. Emerging registry data strengthen the safety argument. A 2024 U.S. cohort of 7 128 ultrasound-guided nerve blocks performed in emergency departments reported a major-complication rate of just 0.35 % alongside a median pain-score reduction of five points [12-13]. Such "real-world" evidence complements controlled trials and reassures clinicians working outside specialist theatres. Beyond efficiency, USG enhances educational yield. Real-time anatomy allows trainees to correlate sono-images with clinical endpoints, accelerating competency and reducing intraneural or intravascular injections, benefits highlighted in a 2023 *BJA* review [9]. Artificial-intelligence overlays are the next frontier: a 2024 scoping review catalogued 22 algorithms that automatically identify plexus anatomy and predict needle trajectory, with early clinical pilot studies showing a 28 % reduction in block time for novice operators [14]. Simulation studies suggest AI-assisted needle-tracking may further trim the learning curve by 30 %, which is likely to make USG attractive even to medium-volume hospitals. Economic considerations often drive modality choice. A 2022 single-blinded cost-effectiveness trial found that, when only direct costs were considered, USG saved €18 per case through shorter set-up time and reduced LA usage; cost neutrality was reached after 230 blocks. When extrapolated to an orthopaedic suite performing 500 upper-limb procedures annually, this translates into yearly savings of roughly €9 000, exclusive of downstream advantages such as fewer conversions to general anaesthesia or reduced postoperative opioid consumption. Patient-centred outcomes also tilt the balance toward ultrasound. Meta-analyses show USG blocks reduce postoperative morphine equivalents by 30–40 % and improve satisfaction scores—an important component of Enhanced Recovery After Surgery pathways and hospital quality metrics. In emergency departments, ultrasound-guided supraclavicular blocks have recently been adopted for rapid analgesia in complex forearm fractures, shortening median discharge time by 45 min compared with Bier blocks. Limitations. Our single-centre design, inability to blind operators, and use of a fixed LA dose rather than minimum effective volume titration may limit external validity. We also lacked patient-reported outcome measures such as numeric pain scores or block comfort, which future trials should capture. Finally, rare complications like persistent neuropathy require larger multicentre datasets and longer follow-up. Future work. Multi-centre randomised studies with embedded cost analyses, ultrasound-based volume titration protocols, and long-term respiratory follow-up will help define the optimal role of USG in diverse practice settings.

CONCLUSION

Ultrasound guidance for supraclavicular brachial plexus block shortens procedure time, accelerates motor blockade and maintains a high success rate with negligible complications compared with peripheral-nerve stimulation. The technique offers tangible clinical and workflow advantages that justify its incorporation into routine anaesthetic practice wherever equipment and expertise are available.

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