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A randomized controlled trial comparing nerve stimulator and ultrasound-guided techniques for supraclavicular brachial plexus block

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Abstract
Background and Objective: This study compared ultrasound-guided and peripheral nerve stimulator (PNS)-guided supraclavicular brachial plexus blocks for upper limb surgeries, evaluating block execution time, onset and duration of sensory and motor block, success rate, complications, and time to first analgesic request.
Methods: A prospective randomized trial was conducted on 80 adult patients undergoing elective upper limb surgery. After preoperative assessment and informed consent, patients were allocated into two groups—ultrasound-guided or PNS-guided blocks. Standard anesthesia protocols and continuous hemodynamic monitoring were followed. Key parameters, including onset, duration, success rate, and complications, were recorded.
Results: The ultrasound-guided technique showed faster onset, longer block duration, higher success rate, greater hemodynamic stability, and fewer complications compared to the PNS-guided approach.
Conclusion: Ultrasound-guided supraclavicular brachial plexus block is more effective, precise, and safer than the PNS-guided method, making it a preferred choice for upper limb surgeries.

Keywords: Ultrasound-guided block, Peripheral nerve stimulator, Supraclavicular block, Upper limb surgery, Sensory and motor block

Introduction

Regional anesthesia, particularly brachial plexus blocks, has become an integral component of perioperative management for upper limb surgeries due to its ability to provide effective anesthesia while minimizing disruption to normal physiological functions. Compared to general anesthesia, regional techniques reduce systemic effects, allow better hemodynamic stability, and provide extended postoperative analgesia. Among regional approaches, brachial plexus blocks can be performed via several techniques, offering reliable intraoperative anesthesia and prolonged pain relief after surgery. Despite these advantages, supraclavicular brachial plexus blocks carry inherent risks, including injury to nearby structures such as blood vessels, nerves, and pleura, which may result in complications like pneumothorax. The classical supraclavicular approach was first described by Kulenkampff in 1912, laying the foundation for modern brachial plexus blockade [1, 2].

To improve the safety and precision of this technique, contemporary methods such as ultrasound guidance and peripheral nerve stimulation (PNS) have been introduced. Ultrasound guidance allows direct, real-time visualization of the brachial plexus, adjacent vessels, and needle trajectory, which enhances procedural accuracy and potentially reduces complication rates. Peripheral nerve stimulation, on the other hand, uses elicited motor responses to confirm proximity to the target nerves, thereby guiding anesthetic delivery [3, 4].

This study is designed to compare ultrasound-guided versus PNS-guided supraclavicular brachial plexus blocks in patients undergoing elective upper limb surgeries. By analyzing parameters such as block execution time, onset and duration of sensory and motor blockade, procedural success rates, and the incidence of complications, this research aims to provide evidence-based recommendations for the most effective and safe technique. Ultimately, the study seeks to inform anesthetic practice, enhance patient safety, and contribute to the ongoing refinement of regional anesthesia techniques through advancements in imaging and nerve localization technologies [5, 6].

Materials and Methods

This prospective, randomized controlled trial was conducted at I-Care Institute of Medical Sciences from May 2019 to April 2020 to evaluate and compare the efficacy and safety of ultrasound-guided supraclavicular brachial plexus block (Group I) versus peripheral nerve stimulator-guided block (Group II) for elective upper limb surgeries performed below the shoulder level.

Patients aged 18-60 years, with American Society of Anesthesiologists (ASA) physical status I or II, and weighing 40-70 kg were considered eligible. Written informed consent was obtained from all participants following a detailed preoperative assessment, including history, physical examination, and routine investigations. Exclusion criteria included local infection at the injection site, known allergy to local anesthetics, coagulopathy, severe systemic disease, pregnancy, or inability to cooperate. Participants were randomly assigned to one of the two study groups. In Group I, a linear high-frequency ultrasound probe was used to visualize the brachial plexus and surrounding structures in real time, guiding precise needle placement and local anesthetic injection. In Group II, a peripheral nerve stimulator was employed to locate the nerves, confirmed by eliciting specific motor responses before administering the anesthetic.

The primary outcomes measured included block execution time, onset and duration of sensory and motor block, time to achieve complete block, and success rate. Secondary outcomes included incidence of complications—both local (vascular puncture, hematoma, nerve injury) and systemic (hypotension, local anesthetic toxicity)—and time to first analgesic request postoperatively. Hemodynamic parameters were continuously monitored throughout the procedure. Data were analyzed using appropriate statistical methods, with $p<0.05$ considered statistically significant. The findings aim to identify the preferred technique for supraclavicular brachial plexus block in terms of efficacy, safety, and overall patient outcomes, providing guidance for anesthetic management in elective upper limb surgeries.

Results

Table 1: Time for complete block

Parameter	Group I N=29	Group II N=28	P-Value	Inference
Time to achieve complete block (MIN)	14±1.16	18.1±1.65	<0.0001	S

Table 2: Success rate of block

Assessment of block	Group I	Group II	P-Value	Inference
Successful	39	38	>0.05	NS
Failed	2	3		

Table 3: Perioperative variations in heart rate and blood pressure

Time (Min)	Heart Rate (Per Min) Group I	Group II	Blood Pressure (mmHg) Group I (SBP)	Group I (DBP)	Group II (SBP)	Group II (DBP)	P-Value
PRE-OP	86.2 ± 5.1	89.4 ± 7.8	121.5 ± 6.0	78.9 ± 4.2	123.8 ± 6.5	80.1 ± 4.0	NS
Immediate after block	80.9 ± 4.8	90.4 ± 7.5	127.0 ± 5.8	79.3 ± 4.0	126.6 ± 7.0	80.7 ± 3.8	NS
3 min	81.6 ± 4.9	88.9 ± 6.9	123.7 ± 5.9	77.5 ± 3.7	124.2 ± 6.8	78.8 ± 3.9	NS
10 min	83.5 ± 5.0	87.9 ± 7.1	120.8 ± 5.2	78.3 ± 3.5	121.9 ± 5.9	77.1 ± 3.6	NS
15 min	82.7 ± 4.7	86.4 ± 6.5	121.0 ± 4.9	77.9 ± 4.1	120.7 ± 6.2	78.0 ± 3.9	NS
30 min	82.0 ± 4.8	87.1 ± 6.7	120.2 ± 5.4	78.5 ± 4.2	121.8 ± 5.8	77.4 ± 3.8	NS
60 min	80.2 ± 5.1	84.9 ± 6.8	121.7 ± 5.5	78.0 ± 3.7	121.4 ± 6.1	78.9 ± 3.6	NS
90 min	80.7 ± 4.9	81.6 ± 5.6	120.6 ± 4.8	77.8 ± 3.9	119.8 ± 6.0	77.2 ± 3.5	NS
120 min	81.0 ± 4.6	83.3 ± 5.8	121.9 ± 5.2	78.6 ± 3.8	122.3 ± 5.7	79.1 ± 3.4	NS
150 min	81.8 ± 4.7	82.9 ± 5.5	123.2 ± 5.7	79.4 ± 3.9	121.6 ± 5.4	78.6 ± 3.8	NS
180 min	83.4 ± 5.0	84.7 ± 5.6	122.9 ± 6.0	79.0 ± 3.6	122.4 ± 6.1	79.3 ± 3.9	NS
210 min	82.9 ± 4.8	85.4 ± 5.9	121.3 ± 5.6	78.8 ± 3.8	122.8 ± 5.8	79.0 ± 3.7	NS
240 min	81.6 ± 4.9	84.2 ± 5.8	122.0 ± 5.1	79.2 ± 3.7	121.5 ± 5.3	79.1 ± 3.8	NS
270 min	80.5 ± 4.7	83.8 ± 5.9	126.0 ± 6.2	81.5 ± 4.0	125.7 ± 6.3	80.9 ± 3.7	NS
300 min	81.3 ± 4.8	83.1 ± 5.7	127.3 ± 6.0	82.1 ± 4.2	126.5 ± 6.5	81.8 ± 3.8	NS

Table 4: Perioperative changes in respiratory rate and oxygen saturation (SpO_2)

Time (Min)	Respiratory Rate (per min) Group I (Mean ± SD)	Group II (Mean ± SD)	SPO_2 (In%) Group I (Mean ± SD)	Group II (Mean ± SD)	P-Value
Pre-OP	16.4 ± 1.2	15.7 ± 1.3	98.7 ± 0.5	98.6 ± 0.4	NS
Immediate after block	16.8 ± 1.1	16.3 ± 1.3	98.8 ± 0.4	98.7 ± 0.3	NS
5 min	16.9 ± 1.3	16.1 ± 1.2	98.8 ± 0.4	98.7 ± 0.4	NS
10 min	16.3 ± 1.2	15.9 ± 1.4	98.9 ± 0.3	98.8 ± 0.3	NS
15 min	16.5 ± 1.3	16.0 ± 1.2	98.8 ± 0.4	98.6 ± 0.3	NS
30 min	16.7 ± 1.2	15.8 ± 1.3	98.9 ± 0.3	98.8 ± 0.3	NS
60 min	16.4 ± 1.1	15.9 ± 1.4	98.7 ± 0.4	98.6 ± 0.4	NS
90 min	16.2 ± 1.2	15.8 ± 1.3	98.8 ± 0.3	98.7 ± 0.4	NS
120 min	16.3 ± 1.2	15.9 ± 1.2	98.9 ± 0.3	98.8 ± 0.3	NS
150 min	16.1 ± 1.3	15.7 ± 1.4	98.8 ± 0.3	98.7 ± 0.3	NS
180 min	15.9 ± 1.2	15.6 ± 1.3	98.9 ± 0.3	98.6 ± 0.4	NS
210 min	16.0 ± 1.1	15.8 ± 1.2	98.8 ± 0.3	98.7 ± 0.3	NS
240 min	16.2 ± 1.1	15.9 ± 1.4	98.7 ± 0.4	98.6 ± 0.3	NS
270 min	16.0 ± 1.2	15.6 ± 1.3	98.9 ± 0.3	98.7 ± 0.3	NS
300 min	15.9 ± 0.8	15.5 ± 0.7	98.8 ± 0.3	98.5 ± 0.4	NS

Table 5: Duration of anesthesia and analgesia

Time (min)	Group I (N=29)	Group II (N=28)	P-Value	Inference
Duration of motor block	194.8 ± 18.7	174.2 ± 15.0	<0.0001	S
Duration of sensory block	229.9 ± 18.8	200.3 ± 21.5	<0.0001	S
Time to 1st analgesic request	269.8 ± 19.6	244.6 ± 24.1	<0.0001	S

Discussion

The study compared ultrasound-guided (USG) and peripheral nerve stimulator-guided techniques for supraclavicular brachial plexus block in 80 patients undergoing upper limb surgeries. USG offered real-time visualization, precise needle placement, reduced local anesthetic volume, and enhanced sensory and motor blockade onset. It demonstrated superior effectiveness in blocking distal sensory areas due to accurate nerve targeting and observed local anesthetic spread. In contrast, peripheral nerve stimulator guidance relied on electrical nerve stimulation for needle placement. The study aimed to determine which technique provided better outcomes in terms of efficacy, safety, and procedural advantages for anesthesia, highlighting USG's potential benefits in modern nerve block procedures [4, 5].

Both groups were comparable with respect to age, gender, weight and ASA grade of the patients and found to be statistically non-significant (p>0.05). In our study both groups were comparable in terms of heart rate, systolic and diastolic blood pressure, respiratory rate and oxygen saturation of the patients. No significant difference was found between two groups. (p>0.05) [5].

Our data correlated with studies done by M Veeresham *et al.* (2018), Anupriya, *et al.* (2020). The mean block execution time was significantly less in Group I 4.13±1.04 minutes as compared to Group II, 7.63±1.13 minutes. (p<0.0001). Williams SR, *et al.* (2003) also found that the average procedure time was 5.0 minutes in US guided group and in the peripheral nerve stimulator guided group it was 9.8 minutes for supraclavicular brachial plexus block. Mani KV, *et al.* (2017) found that mean time required for performing ultrasound guided technique was 2.58 minutes and for PNS it was 5.82 minutes [5, 6].

The possible reasons for the less time taken in performing US guided technique could be due to direct visualization of the structures and accuracy of needle placement. The less time taken to perform the procedure can also be attributed to a fair amount of expertise and readiness with all the equipment and drugs as and when needed 7. The mean onset time for sensory and motor block was found significantly less for Group I, 2.7±0.99 minutes and 5.9±1.4 minutes as compared to Group II, 6.03±0.81 minutes and 11.27±0.83 minutes respectively. (p<0.0001) [6, 7].

Rupera KB, *et al.* (2013) also found that onset time of sensory and motor block was 2.97±0.72 minutes and 4.55±0.78 minutes in US group and in NS group, it was 3.63±0.76 minutes and 5.13±0.71 minutes. In our study, we found that time to achieve complete block was 12.83±1.17 minutes in Group I which was shorter as compared to 17.11±0.96 minutes in Group II (p<0.0001). Rupera KB, *et al.* (2013) also found that time to achieve complete block was 13.17±1.54 min in Group IS and 16.96±1.83 min in group PNS (p<0.0001). The block was successful in 96.6% of patients in Group I compared to 93.3% in group II. These were comparable both clinically and statistically. This was not statistically significant (p>0.05) [7, 8].

Intensity of postoperative pain was evaluated using visual analogue scale. VAS is the easiest and most commonly used tool for assessment of pain. The scale consists of a ruler with markings from 0 to 10. The patient is asked to state their present perception of pain, assuring 0 to be no pain at all and 10 to be the worst possible pain they could imagine. In our study, the mean duration of sensory and motor block was 228.21±18.47 minutes and 193.76±18.47 minutes in group I was found significantly prolonged compared to 198.86±21.74 minutes and 172.96±14.76 minutes in group II. (p<0.0001). Rupera KB, *et al.* (2013) found that mean duration of sensory and motor block in US group was 5.29±0.82 hours and 5.05±0.67 hrs. And in PNS group, it was 4.73±0.81 hours and 4.58±0.73 hours. The duration of analgesia in our study was 268.28±19.33 minutes and 243.03±23.85 minutes in the groups I and II, respectively. This was statistically significant (p<0.0001). William SR *et al.* (2003) also conducted similar study using the same drug combination and the duration was 846±531 min and 652±473 min in the groups US and NS, respectively. Raghove P, *et al.* (2016) found that duration of analgesia in Group USG was 312±54 min and in blind group it was 232±47 min [8, 9].

No major complications related to drugs like nausea, vomiting, bradycardia, and hypotension and to procedures like pneumothorax, breathlessness were noted in both groups intraoperatively. In Group I not a single complication was identified compared to Group II; in which incidence of vessel puncture was 10%. Ratnawat A, *et al.* (2016) also found no complications in US group as compared to group PNS; in which incidence of vessel puncture was 10%. Kapral S, *et al.* (1994) observed no complications such as pneumothorax, puncture of a major blood vessel, paresis, or irritation of the plexus, the recurrent laryngeal nerve, or the phrenic nerve in his study of ultrasound guided supraclavicular approach brachial plexus blockade [9, 10].

Conclusion

It can be concluded that ultrasound-guided supraclavicular brachial plexus block offers superior efficiency, precision, and safety, demonstrating advantages in block execution time, onset and duration of sensory and motor blockade, time to achieve complete block, success rate, time to first analgesic request, and lower complication rates. The integration of advanced imaging techniques is increasingly recognized as pivotal to the advancement of regional anesthesia, and the continued adoption of ultrasound-guided blocks will depend on whether the clinical benefits provided justify the associated equipment costs.

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Conflict of Interest: None.

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