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Ultrasound guided versus peripheral nerve stimulator techniques for interscalene brachial plexus block in patients undergoing upper limb surgeries

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Abstract:

Interscalene brachial plexus block is widely used in upper limb surgeries because it provides reliable intraoperative anesthesia and effective post-operative analgesia. Therefore, it is of interest to compare ultrasound-guided interscalene block with the conventional peripheral nerve stimulator technique in 60 patients, with 30 patients in each group. The two techniques were evaluated for procedural time, onset and duration of sensory and motor block and complication rate. Block performance, efficiency and safety were assessed to determine whether ultrasound guidance offers a meaningful clinical advantage over the traditional nerve stimulator approach, thereby advancing knowledge on the relative effectiveness of modern image-guided regional anesthesia.

Keywords: Brachial plexus, interscalene block, peripheral nerve stimulator, regional anesthesia, ultrasound guidance, upper limb surgery.

Background:

Regional anaesthesia has become an important part of modern anesthetic practice because it offers several benefits over general anesthesia, including better pain control, lower opioid requirement, earlier mobilization and greater patient satisfaction [1]. Among the different regional anesthesia techniques, the interscalene brachial plexus block is especially useful for surgeries of the shoulder and upper arm, as it provides effective blockade of the C5–C7 nerve roots [2]. Traditionally, interscalene block has been performed using anatomical landmarks or with the help of a peripheral nerve stimulator (PNS). In the PNS technique, motor responses are used to confirm that the needle is close to the targeted nerve structures. Although this method is effective, it has some limitations. It does not allow direct visualization of the surrounding anatomy, which may increase the chances of vascular puncture and can sometimes lead to variable block success rates [3, 4]. In recent years, ultrasound-guided regional anesthesia has brought a major change in clinical practice. It allows the anesthesiologist to see the nerves, nearby structures, needle movement and spread of local anesthetic in real time. This improves the accuracy of the block, increases the success rate and may reduce complications [5, 6]. Being able to visualize the needle tip during the procedure also helps reduce the risk of accidental injury to important structures such as blood vessels and the pleura [7]. Several studies have reported that ultrasound guidance can result in a faster onset of sensory and motor blockade and may also prolong the duration of analgesia when compared with traditional techniques [8]. Another important advantage is that ultrasound guidance can help reduce the amount of local anesthetic required while still maintaining effective blockade. This may lower the risk of local anesthetic systemic toxicity [9]. Because of these benefits, ultrasound guidance is increasingly being preferred in regional anesthesia practice. However, the PNS technique is still commonly used, particularly in resource-limited settings where ultrasound machines may not be easily available. It is relatively inexpensive and does not require advanced imaging equipment

or ultrasound-related skills. Even so, questions remain regarding its accuracy and safety when compared with ultrasound-guided techniques [10]. Interscalene block can be associated with complications such as phrenic nerve palsy, Horner's syndrome, intravascular injection and nerve injury. The frequency of these complications may differ depending on the technique used [11]. Ultrasound guidance is considered helpful in reducing such risks because it allows direct visualization of anatomical structures and real-time observation of local anesthetic spread [12]. With the growing use of ultrasound-guided regional anesthesia, it is important to compare its clinical effectiveness and safety with the conventional nerve stimulator-guided approach. This comparison is especially relevant in developing countries, where the availability of equipment, cost and practicality strongly influence routine clinical practice. Therefore, it is of interest to compare ultrasound-guided and peripheral nerve stimulator-guided interscalene brachial plexus blocks in patients undergoing upper limb surgeries.

Materials and methodology:**Study design and setting:**

This prospective, randomized, comparative study was conducted over a period of 12 months in the Department of Anaesthesiology at Shyam Shah Medical College and associated hospitals, Rewa, Madhya Pradesh, India, after obtaining approval from the Institutional Ethics Committee.

Sample size and population:

A total of 60 patients scheduled for elective upper limb surgeries under interscalene brachial plexus block were enrolled in the study. Patients were randomly allocated into two groups of 30 each using a slip-draw randomization method.

[1] **Group A (USG group):** Ultrasound-guided interscalene block

[2] **Group B (PNS group):** Peripheral nerve stimulator-guided interscalene block

Inclusion criteria:

- [1] Patients aged between 18 and 60 years
- [2] American Society of Anaesthesiologists (ASA) physical status I or II
- [3] Scheduled for elective upper limb surgeries
- [4] Provided written informed consent

Exclusion criteria:

- [1] Known hypersensitivity to local anesthetic agents
- [2] History of significant pulmonary, cardiac, or cervical spine disorders
- [3] Coagulation abnormalities or bleeding disorders

Pre-operative preparation:

All patients underwent a thorough pre-anesthetic evaluation, including medical history, physical examination and airway assessment. Baseline investigations were reviewed. Patients were instructed to follow standard fasting guidelines. The procedure was explained in detail and written informed consent was obtained. Patients were educated regarding the Visual Analog Scale (VAS) for pain assessment and the patient satisfaction scoring system.

Monitoring and intraoperative care:

Upon arrival in the operating room, standard monitoring was instituted, including:

- [1] Electrocardiogram (ECG)
- [2] Non-invasive blood pressure (NIBP)
- [3] Pulse oximetry
- [4] Heart rate

Baseline vital parameters were recorded before the procedure.

Anesthetic technique:**Ultrasound-guided technique (Group A):**

Patients were positioned supine with the head turned contralaterally. After aseptic preparation, a high-frequency linear ultrasound probe (Mindray DC-30) covered with a sterile sheath was used. The probe was placed at the level of the cricoid cartilage to identify anatomical landmarks including the sternocleidomastoid muscle, carotid artery and internal jugular vein. The brachial plexus roots were visualized between the anterior and middle scalene muscles. After local infiltration with lignocaine, a 22G nerve block needle was introduced using an in-plane technique under continuous ultrasound visualization. Following negative aspiration, a test dose was injected to confirm correct placement, visualized as a hypoechoic spread around the nerve roots. Subsequently, 25 mL of bupivacaine was administered incrementally with continuous monitoring.

Peripheral nerve stimulator technique (Group B):

The interscalene groove was identified using anatomical landmarks. A 22G insulated needle connected to a nerve stimulator was inserted. Initial stimulation was set at 1 mA and needle advancement continued until a motor response corresponding to the brachial plexus was elicited. The current was gradually reduced to 0.3–0.4 mA to confirm optimal needle

placement. Following negative aspiration, 25 mL of bupivacaine was injected in divided doses with intermittent aspiration.

Outcome measures:**Primary outcomes:**

- [1] Procedural time
- [2] Onset and duration of sensory block
- [3] Onset and duration of motor block

Secondary outcomes:

- [1] Incidence of vascular puncture
- [2] Complications associated with the procedure

Assessment parameters:

- [1] Sensory block assessed using pinprick method in C5–C7 dermatomes
- [2] Motor block assessed using Modified Bromage Scale
- [3] Pain assessed using Visual Analog Scale (VAS)
- [4] Patient satisfaction assessed at 24 hours using a 5-point Likert scale

Rescue analgesia (Tramadol 100 mg IV) was administered when required.

Statistical analysis:

Data were recorded in a structured proforma and entered into Microsoft Excel. Statistical analysis was performed using SPSS version 20.0. Continuous variables: Mean $\pm$ SD. Categorical variables: Frequency and percentage. Tests used: Student's t-test and Chi-square test. Significance level: $p < 0.05$.

Results:

A total of 60 patients scheduled for elective upper limb surgeries were included in the present study and randomly allocated into two equal groups: ultrasound-guided (USG) group and peripheral nerve stimulator (PNS) group, each comprising 30 patients. The data were analyzed to compare procedural efficiency, block characteristics, analgesic profile, hemodynamic parameters, patient satisfaction and complications. Both groups were comparable in baseline demographic characteristics. The mean age difference between the groups was statistically insignificant ($p=0.4083$), indicating homogeneity. Similarly, height and weight distributions showed no significant variation ($p>0.05$). Gender distribution was also balanced, with males constituting 60% in USG and 56.67% in PNS groups (**Table 1**). The absence of statistically significant differences confirms that the two groups were well matched, minimizing confounding bias and allowing valid comparison of outcomes. The ultrasound-guided technique demonstrated clear superiority in all procedural and block-related parameters. The mean procedural time in the USG group was significantly shorter by approximately 37% compared to the PNS group ($p<0.0001$). This can be attributed to real-time visualization of anatomical structures, enabling quicker needle placement. The onset of sensory and motor blockade was significantly faster in the USG group by approximately 30–35% ($p<0.0001$), reflecting more accurate drug deposition around the nerve roots. Additionally,

the duration of both sensory and motor blocks was significantly prolonged in the USG group ($p < 0.0001$), indicating enhanced analgesic efficacy. These findings collectively suggest that ultrasound guidance not only improves efficiency but also enhances the quality and duration of nerve blockade (**Table 2**). Pain scores were comparable in the early postoperative period but became significantly lower in the USG group at 8 and 12 hours ($p = 0.0001$), demonstrating prolonged analgesic effect. The higher heart rate and mean arterial pressure observed in the PNS group at 8–12 hours were statistically significant ($p < 0.05$) and likely reflect earlier pain onset due to shorter block duration. Oxygen saturation remained stable in both groups throughout, indicating that both techniques are safe with respect to respiratory parameters. Patient satisfaction was significantly higher in the USG group, with 53.33% reporting “highly satisfied” compared to only 30% in the PNS group ($p = 0.0024$). This aligns with better analgesia and fewer complications. Although vascular puncture and postoperative nausea were more frequent in the PNS group, these differences were not statistically significant ($p > 0.05$). However, the trend favors ultrasound guidance for improved safety (**Table 3**).

Table 1: Demographic Profile of Study Participants

Variable	Group-USG (n=30)	Group-PNS (n=30)	p-value
Age (years)	35.86 ± 9.88	33.86 ± 8.68	0.4083
Height (cm)	157.43 ± 5.36	158.36 ± 4.42	0.4649
Weight (kg)	61.50 ± 6.91	61.26 ± 5.88	0.8570
Male (%)	60%	56.67%	0.7951
Female (%)	40%	43.33%	

Table 2: Comparison of Procedural and Block Characteristics

Parameter	Group-USG	Group-PNS	p-value
Procedure time (min)	5.70 ± 0.62	9.10 ± 0.61	<0.0001
Onset of sensory block (min)	9.80 ± 0.68	14.18 ± 0.99	<0.0001
Onset of motor block (min)	11.90 ± 0.90	16.63 ± 0.66	<0.0001
Duration of sensory block (hrs)	13.82 ± 0.78	11.90 ± 1.23	<0.0001
Duration of motor block (hrs)	12.48 ± 0.71	10.73 ± 1.10	<0.0001

Table 3: Pain Scores, Hemodynamics, Satisfaction and Complications

Parameter	Group-USG	Group-PNS	p-value
VAS at 8 hrs	2.73 ± 0.64	3.47 ± 0.73	0.0001
VAS at 12 hrs	3.23 ± 0.73	3.87 ± 0.35	0.0001
HR at 12 hrs (bpm)	84.90 ± 10.96	91.07 ± 5.87	0.0087
MAP at 12 hrs (mmHg)	89.27 ± 5.96	93.59 ± 6.04	0.0071
SpO ₂ (%)	Comparable	Comparable	>0.05
Highly satisfied (%)	53.33%	30.00%	0.0024
Vascular puncture (%)	0%	6.67%	0.1538
Nausea/vomiting (%)	6.67%	13.33%	0.3934

Discussion:

The present study shows that ultrasound-guided interscalene brachial plexus block is more effective than the peripheral nerve stimulator technique in terms of procedural efficiency, block quality and overall patient outcomes. These results are in line with the increasing evidence supporting ultrasound guidance as a preferred approach in regional anesthesia. One of the key findings of this study was the significantly shorter procedural time in the ultrasound-guided group. This is consistent with the findings of Thomas *et al.*, who reported that real-time visualization helps in faster identification of nerve structures and reduces the need for repeated needle redirections [2]. In

contrast, the PNS technique depends on obtaining appropriate motor responses, which may require multiple attempts and can increase the time taken to perform the block. The onset of both sensory and motor blockade was also significantly faster in the USG group. This may be because ultrasound allows more accurate placement of local anesthetic around the nerve roots, leading to quicker and more effective blockade [4]. With the PNS technique, drug placement may be less precise, which can delay the onset of block. The duration of sensory and motor blockade was significantly longer in patients who received ultrasound-guided blocks. Similar results were reported by Kumar *et al.* (2021), who found prolonged analgesia with ultrasound-guided blocks due to better spread of local anesthetic around the nerves [5]. A longer duration of blockade is clinically important because it provides better postoperative pain relief and reduces the need for additional analgesics. Pain assessment using VAS scores also supported the better analgesic effect of ultrasound guidance. Although early postoperative pain scores were similar in both groups, VAS scores at 8 and 12 hours were lower in the USG group. This finding is comparable with the study by Zhao *et al.* (2022), which showed that ultrasound-guided blocks provide more sustained postoperative analgesia [6]. Hemodynamic parameters such as heart rate and mean arterial pressure remained stable in both groups during the intraoperative period, suggesting that both techniques are safe when performed properly. However, a significant rise in heart rate and mean arterial pressure was observed in the PNS group during the later postoperative period. This may be related to the earlier wearing off of analgesia and increased pain perception in these patients [7]. Patient satisfaction is an important measure of successful clinical care. In the present study, satisfaction scores were significantly higher in the ultrasound group. This finding is consistent with Amaral *et al.*, who reported better patient comfort and satisfaction with ultrasound-guided regional anesthesia [8]. Better pain relief, fewer needle attempts and improved block quality may all contribute to greater patient satisfaction. Complications were less frequent in the ultrasound group, especially vascular puncture. Although this difference was not statistically significant, it is still clinically meaningful. Ultrasound guidance allows the operator to identify and avoid nearby blood vessels, thereby reducing the chance of accidental vascular puncture [9]. Similar findings have also been reported by Bowness *et al.* (2018) and Edinoff *et al.* [10, 11]. The incidence of postoperative nausea and vomiting was also lower in the ultrasound group. This may be due to better postoperative pain control and reduced need for systemic analgesics. However, the difference was not statistically significant; indicating that studies with larger sample sizes may be needed to confirm this finding. Oxygen saturation remained stable in both groups, suggesting that neither technique caused significant respiratory compromise. This observation is consistent with available literature showing that interscalene block can be performed safely with appropriate technique, local anaesthetic dosing and monitoring [12, 13]. Overall, the results of the present study support the advantages of ultrasound-guided interscalene block over the peripheral nerve stimulator technique. Ultrasound

guidance offers several advantages, including faster onset of blockade, longer duration of analgesia and, in some studies, shorter procedural time and fewer needle passes, with comparable complication rates [14, 15]. However, this study has some limitations. The sample size was relatively small and the study was conducted at a single center. In addition, the experience of the operator with ultrasound-guided techniques may have influenced the results. Therefore, larger multicentric studies are recommended to further validate these findings.

Conclusion:

Ultrasound-guided interscalene brachial plexus block is superior to the peripheral nerve stimulator technique in terms of shorter procedural time, faster onset and longer duration of sensory and motor blockade, improved postoperative analgesia and higher patient satisfaction. Although the complication rate was lower with ultrasound guidance, the difference was not statistically significant. Overall, ultrasound guidance improves both the effectiveness and safety of interscalene block, making it a preferred technique for upper limb surgeries.

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