

Comparative Study of Ultrasound Guided Technique Versus Peripheral Nerve Stimulator Guided Technique for Supraclavicular Brachial Plexus Block in Upper Limb Surgeries

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Abstract

Background: The supraclavicular approach is considered to be the easiest and most effective approach to block the brachial plexus for upper limb surgeries. The classical approach using the anatomical landmark technique was associated with higher failure rates and complications. Ultra-sonography (USG) guidance and peripheral nerve stimulator (PNS) have improved the success rates and safety margin.

Aims: The aim of the present study is to compare USG with PNS in supraclavicular brachial plexus block for upper limb surgeries with respect to the procedure time,

onset of motor and sensory blockade, total duration of blockade, pro and complications. Study

Design: Prospective, randomized controlled study.

Subject and Methods: Hundred patients aged above 18 years scheduled for elective upper limb surgery were randomly allocated into two groups. Group USG patients received supraclavicular brachial plexus block under ultrasound guidance and in Group PNS patients, PNS was used. In both groups, local anesthetic mixture consisting of 20 ml of 0.5% bupivacaine used.

Statistical Analysis: Independent t-test used to compare mean between groups; Chi-square test for categorical variables.

Results: The procedure time was shorter with USG (10.54 ± 1.74 minutes) compared to PNS (20.28 ± 2.15 minutes). The onset time of sensory block (4.4 ± 1.10 min vs. 7.96 ± 1.24 min) and onset of motor block (6.32 ± 1.01 min vs. 10.66 ± 1.43 min) were significantly shorter in Group USG compared to Group PNS (P < 0.05). The duration of sensory block was significantly prolonged in Group USG (573.6 ± 143.8 minutes) compared to Group PNS (461.6 ± 122.5). **Conclusion:** The ultrasound-guided supraclavicular brachial plexus block can be done quicker, with a faster onset of sensory and motor block compared to nerve stimulator technique.

Keywords: Nerve Stimulator, Supraclavicular Block, Ultrasound

Introduction

Supraclavicular brachial plexus block is a popular mode of anesthesia for various upper limb surgeries, due to its effectiveness in terms of margin of safety, good post-operative analgesia and cost-effectiveness [1]. Brachial plexus block achieves ideal operating conditions by producing complete muscle relaxation, maintaining stable intra-operative hemodynamics and the associated sympathetic block which decreases post-operative pain, vasospasm and edema [2]. The supraclavicular approach is an ideal site to achieve anesthesia of the upper extremity just distal to the shoulder as the plexus remains relatively tightly packed at this level, resulting in a rapid and high-quality block. There are 3 techniques for the brachial plexus block: -

- Classical / blind technique
- Peripheral Nerve Stimulator (PNS) guided
- Ultrasonography (USG) guided

The classical approach of using paresthesia to identify the nerve cluster using anatomical landmarks may be associated with a higher failure rate and injury to the nerves or vascular structures. The peripheral nerve stimulator (PNS) allows better

localization of the brachial plexus by locating the nerves using a low-intensity electric current (up to 2.5 mA) for a short-duration (0.05–1 ms) with an insulated needle to obtain a defined response of muscle twitch or sensation and to inject local anesthetic solution in close proximity to the nerve. This technique, however, did not reduce the risk of injury to surrounding structures. The application of ultrasonography (USG) to localize the brachial plexus has revolutionized the field of regional anesthesia. However, the cost and the expertise required are the limiting factors. This study was done to compare the above two techniques with respect to procedure time, block characteristics and complication rates in upper limb surgeries.

Materials and Methods

A randomized prospective observational study was carried out at GCS Medical College, Hospital and Research Centre during the period of 2019 to 2021 after approval from Institutional Ethical Committee. Randomly selected 100 patients admitted to GCS Hospital, aged 18 to 60 years of either sex of ASA Grade I and II undergoing various scheduled upper limb surgery under PNS guided Supraclavicular Brachial Plexus Block or USG guided Supraclavicular Brachial Plexus Block.

Pre-Requisites

All patients underwent a thorough pre-anesthetic check-up. Routine investigations like CBC, Blood sugar, Blood urea, Serum creatinine, Serum electrolytes, Prothrombin time (PT) with International normalized ratio (INR) and liver function test were carried out for all the patients. Chest X-ray and ECG were also done. All patients were

explained regarding VAS score in detail for postoperative assessment of analgesia.

Inclusion criteria

- Patient's consent for block
- Patients with ASA I and II physical status
- Aged 18-60 years of either gender
- Elective Upper limb surgery

Exclusion Criteria

- Uncooperative patients
- Allergy to study drug
- Peripheral nerve injury
- Coagulopathy
- Infection at site of block
- Lactating / Pregnant female

Consent

The procedure was explained to the patient and written informed consent was taken.

Preparation

All patients were kept nil by mouth (NBM) for at least 6 hours before surgery. An intravenous line was secured with an intravenous cannula in the unaffected limb. Pulse oximeter, non-invasive blood pressure cuff and ECG electrodes were applied. Baseline pulse rate, blood pressure, oxygen saturation and respiratory rate were recorded. Drugs and equipment, necessary for resuscitation and general anesthesia were kept ready.

Pre-medication to be administered at 0-minute:

- Inj. Midazolam 0.02 mg/kg IV
- Inj. Glycopyrrolate 0.004 mg/kg IV
- Inj. Ondansetron 0.08 mg/kg IV
- Intra operative analgesia in the form of fentanyl was given if patient had discomfort or pain.

Anesthetic Technique

Group A: Brachial plexus block was performed using a supraclavicular approach by classic technique using peripheral nerve stimulator (PNS). The patient was kept in the supine position, with the head turned away from the side to be blocked, sandbag placed under the shoulder and the ipsilateral arm adducted. The interscalene groove and midpoint of the clavicle was identified and a mark 1.5-2.0 cm above and posterior to the midpoint of the clavicle was made. Palpation of the subclavian artery at this site confirmed the landmark.

After proper aseptic preparation of the supraclavicular region, a skin wheal was raised at the marked point using 1-2ml of Inj. Lignocaine 2% subcutaneously using 24G needle. 22G and 5cm Stimuplex insulated peripheral nerve stimulator needle is attached to the peripheral nerve stimulator. Afterwards, standing on the head end of the patient, stimuplex needle is directed just lateral to subclavian artery in a caudal direction, 1st medially, then laterally and finally posteriorly to block all the three cords of the brachial plexus sequentially. The location end point was considered a distal motor response with an output lower than 0.8mA. On proper localization of the brachial plexus and negative aspiration of the blood, the study medication was injected.

The assessment for onset of sensory and motor block was done every minute from the time of injection of test drug until the block was established. Sensory block was evaluated using 3 – point scale by the pinprick method in hand and forearm whereas motor block was assessed by abducting the shoulder and flexing the forearm and hand against gravity.

Group B: block was performed after real time visualization of the vessels, nerves and bones with “in-plane approach”. This procedure was done using Sonosite USG machine with 10-6 MHz transducer by the “in-plane

approach” using 25G spinal needle. After sterile preparation of the skin and ultrasound probe, procedure site was draped. The brachial plexus was visualized by placing the transducer in the sagittal plane in the supraclavicular fossa behind the middle-third of the clavicle. Two distinct appearances of the brachial plexus were seen at the supraclavicular region, it either appeared as 3 hypoechoic circles with hyperechoic outer rings or as a grape like cluster of 5 to 6 hypoechoic circles, located lateral and superior to the subclavian artery between the anterior and middle scalene muscles at the lower cervical region.

A 25 G spinal needle was inserted from the lateral end of transducer from the lateral to medial direction and the needle movement was observed in real time. Once the needle reached the plexus, predetermined volume of 20 ml of local anesthetic solution was administered inside the brachial plexus sheath after negative aspiration of blood to avoid accidental intravascular needle puncture and the spread of local anesthetic drug was observed in tissue planes. Initially, the needle was placed deep to the more caudal elements of the plexus so that the brachial plexus rises closer to the skin surface with the injection of local anesthetic solution.

The proper spread of local anesthetic solution around the considered nerves was continuously evaluated under sonographic vision, and needle tip position was continuously adjusted with minimum movements during injection under sonographic vision to optimize the impregnation of nerve structures. The multiple injection technique was used to deposit the total amount of drug. 3-minutes massage was performed to facilitate an even drug distribution

Assessment of Parameters

- Time taken for the procedure
- Onset and duration of sensory neural block
- Onset and duration of motor block
- Success Rate
- Incidence of complications.

Grading of motor block is as follows:

- Grade 0 – complete flexion / extension movement in hand & arm against resistance
- Grade 1 – movement of arm & hand against gravity but not against resistance
- Grade 2 – flickering movement in hand but not in arm
- Grade 3 – No movement (Complete motor block)

Grading of sensory block is as follows:

- Grade 0 – all sensory sensations present
- Grade 1 – analgesia (loss of sensation to pinprick)
- Grade 2 – loss of touch

After the establishment of block, surgery was started and time of beginning of surgery was noted. Intra-operatively IV fluids were started at a rate of 2ml/kg/hour. Intra-operatively, heart rate, systolic/diastolic/mean blood pressure, SpO₂ and RR were monitored every half hourly. During the procedure, anesthesia was considered satisfactory if patient did not complain of any pain or discomfort. All 100 patients were monitored for anesthesia and analgesia for 24 hours in the post-operative period.

Statistical analysis

Statistical analysis was done using SPSS (Statistical package for social sciences) version 20 for windows. The profile of the cases was compared with the treatment allocation in order to check if there was any significant difference. Descriptive statistics were presented as mean \pm SD. Component bar and line diagrams were drawn as and when required. Two sides independent student's test

to analyze continuous data and Chi-square test for association was used to compare categorical variables between treatment allocations.

P<0.05 was considered as statistically significant.

Results

The mean age, weight, gender and ASA physical state classification of the patients in both groups were comparable. The mean heart rate, systolic and diastolic blood pressure were comparable in both groups.

As shown in Table 1, the mean time taken to perform a USG guided block was 10.54 ± 1.74 minutes and in PNS guided block, it was 20.28 ± 2.15 minutes. The statistical analysis by student’s unpaired ‘t’ test showed that, USG guided technique was significantly faster to perform.

The mean onset of sensory block in USG group was 4.4 ± 1.10 minutes and in PNS 7.96 ± 1.24 minutes, and onset of motor block in USG group it was 6.32 ± 1.01minutes and in PNS group 10.66 ± 1.43minutes. it shows that in group USG onset of sensory and motor block was significantly early, when compared to group PNS.

As shown in Table 1, the mean duration of sensory block in group USG was 551.0 ± 142.6 minute and in PNS group was 451.1 ± 117.59 minute. The statistical analysis showed that the duration of motor block in group USG was significantly longer when compared to group PNS with p value of 0.0002 (p < 0.01).

The mean duration of motor block in group USG was 573.6 ± 143.8 minute and in group PNS was 461.6 ± 122.5 minute, which showed that the duration of sensory block in group USG was significantly longer when compared to group PNS with p value of <0.0001.

Table1: Block parameters

Parameter	Group USG (n=50)	Group PNS (n=50)	P value
Time taken for procedure in minutes	10.54 ± 1.74	20.28 ± 2.15	<0.0001
Onset of Sensory Blockage(minutes)	4.4 ± 1.10	7.96 ± 1.24	<0.0001
Onset of Motor Blockage(minute)	6.32 ± 1.01	10.66 ± 1.43	<0.0001
Duration of motor blockage (min)	551.0 ± 142.6	451.1 ± 117.59	<0.0002
Duration of sensory blockage	573.6 ± 143.8	461.6 ± 122.5	<0.0001

Time taken for procedure in minutes	10.54 ± 1.74	20.28 ± 2.15	<0.0001
Onset of Sensory Blockage(minutes)	4.4 ± 1.10	7.96 ± 1.24	<0.0001
Onset of Motor Blockage(minute)	6.32 ± 1.01	10.66 ± 1.43	<0.0001
Duration of motor blockage (min)	551.0 ± 142.6	451.1 ± 117.59	<0.0002
Duration of sensory blockage	573.6 ± 143.8	461.6 ± 122.5	<0.0001

In our study we used intra operative Analgesia (Inj fentanyl 2 mcg/kg iv) in 14% in USG group and 20% in PNS group.

There was accidental vascular puncture of subclavian artery in 4% in USG group & 10% in PNS group which were resolved immediately with compression for 10 to 15 minutes. There was no incidence of pneumothorax, nerve injury or local anesthetic toxicity in any groups.

The difference between the two groups was statistically not significant with p value 0.2397 (p>0.05).

Discussion

Even though modern general anesthesia is safer, faster and acceptable, regional anesthesia has its own advantages like less interference with normal metabolic process and vital functions of body as compared to general anesthesia. The most commonly used regional anesthetic technique to provide surgical anesthesia for upper extremity surgeries is supraclavicular brachial plexus block.

Different technical modalities are being used for locating and identifying the brachial plexus in the supraclavicular area. Conventional methods include patient reported paresthesia and PNS guided block which rely on surface landmark identification in semi blind manner. Both these

techniques may require multiple attempts which increases the procedure time and delays onset of anesthesia. It also carries the risk of damage to surrounding anatomical structures like blood vessels and pleura by direct puncture with needle tip. So, an ideal regional anesthesia technique which offers safety, accuracy and patient acceptance was constantly looked for. Ultra-sonography allows the operator to visualize the neural structures and the sensitive anatomy like pleura, blood vessels etc. It also guides the needle under visualization and navigates the needle away from the sensitive anatomy.

Hence, a study is required to compare the USG and PNS guided technique for upper limb surgery

The mean time taken for USG guided supraclavicular block in our study was 10.54 ± 1.74 minutes and for PNS guided technique it was 20.28 ± 2.15 minutes. The p value was <0.0001 . Hence, USG guided technique is significantly faster to perform than PNS guided technique ($p < 0.005$) similar to Anju Jamwal et al [3] the mean procedure time in group US was 7.1 ± 2.08 minutes while in group NS was 14.75 ± 2.58 minutes. Similarly, Mithun Duncan et al [4] found to be statistically significant. The block execution time in their study was comparable between the two groups (7.27 ± 3.88 min in group US and 8.8 ± 1.73 min in group NS).

The mean onset time for sensory block in ultrasound group (USG) was 4.4 ± 1.10 minutes and in PNS group it was 7.96 ± 1.24 minutes. Mean onset time for motor block in ultrasound group (USG) was 6.32 ± 1.01 minutes and in PNS group it was 10.66 ± 1.43 minutes. The difference between the 2 groups was statistically significant with a p value of 0.0001 ($p < 0.05$), Similar to our study Shweta S. Mehta et al [5] found that the onset of sensory block was significantly faster in ultrasound guided technique (6.64 ± 0.89 minutes) than conventional nerve stimulator

technique (9.64 ± 1.14 minutes), suggesting that onset of sensory and motor block was early in USG group which proves the superiority of the technique over PNS.

The mean duration of sensory block was 573.6 ± 143.8 minutes in USG group and 461.6 ± 122.5 minutes in PNS group. The mean duration of motor block in group USG was 551.0 ± 142.6 minutes and in group PNS, it was 451.1 ± 117 minutes. These difference between the two groups were statistically significant with p value 0.001 ($p < 0.05$) similarly Krutika B Rupera et al [6] studied that, the duration of sensory block in group A (USG) and group B (PNS), 5.29 ± 0.82 hr & 4.73 ± 0.81 hr respectively. motor block in group A (USG) and group B (PNS) 5.05 ± 0.67 hr & 4.58 ± 0.73 hr respectively. was significantly prolonged in group A (USG) compared to group B (PNS) (p -Value < 0.05) also similar study done by Bidyut Borah et al [7] they found that duration of motor block (1272.88 min in group US vs 899.25 min in group PA, $p < 0.0001$) and sensory block (1343.88 min in group US vs 996.75 min in group PA, $p < 0.0001$).

Conclusion

From our study, we observed that time requirement for performing supraclavicular block was less and onset of sensory and motor block was faster in USG guided technique compared to PNS guided technique. There was high success rate with fewer complication in USG technique. We conclude USG guided supra clavicular block to be significantly better in terms of procedure time & block characteristics for UL surgeries compared to the PNS technique. Only limitation of USG guided technique is that it requires longer learning curve to perform the block.

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