

Research Article

Comparative study between nerve stimulator guided technique and ultrasound guided technique of supraclavicular nerve block for upper limb surgery

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ABSTRACT

Background: Peripheral nerve stimulator (PNS) has been the 'gold standard' for peripheral nerve blocks for determining adequate needle placement to produce regional anesthesia/analgesia. Modern ultrasound (US) machines can be used to guide the injection needle while minimizing the risk of injury of adjacent structures. The main objective of the study was to compare nerve stimulator guided technique and ultrasound guided technique of supraclavicular brachial plexus block for upper limb surgery

Methods: This prospective randomized single blind comparative study was conducted in eighty patients under supraclavicular brachial plexus block using 0.5% Ropivacaine at a tertiary care teaching hospital of Rajasthan after taking approval from ethical committee. These patients were randomly allocated in either group PNS (n=40) or group US (n=40). Both the groups were assessed for procedure time, onset and duration of sensory and motor blockade and complications.

Results: The procedure time was 8.0 ± 1.53 minutes in group PNS and 6.27 ± 1.10 minutes in group US ($p < 0.0001$). The onset of sensory and motor block was 7.68 ± 1.33 minutes and 9.94 ± 1.28 minutes in group PNS and 6.46 ± 1.02 minutes and 8.10 ± 1.02 minutes respectively in group US ($p < 0.0001$). The time to achieve complete block was 16.11 ± 1.54 minutes in group PNS and 13.74 ± 1.11 minutes in group US ($p < 0.0001$). The duration of sensory and motor block was 7 hours and 6 hours for group PNS and 8 hours and 7 hours respectively in group US. The success rate was 90% in group PNS and 97.5% in Group US.

Conclusion: Ultrasound guided technique was found significantly better than PNS for supraclavicular brachial plexus block.

Key Words: Peripheral nerve stimulator, Supraclavicular brachial plexus block, Ultrasound, Upper limb surgery

INTRODUCTION

A variety of anaesthetic techniques have been used in the past in upper limb surgeries with their own advantages and disadvantages. Although modern general anaesthesia is more certain, safer, faster and acceptable; regional anaesthesia has advantages like less interference with normal metabolic process and vital functions of body as

compared to general anaesthesia. Kulenkampff first described the classical supraclavicular approach to the brachial plexus.¹ Various other approaches were later introduced like- axillary, interscalene, posterior approach and infraclavicular approach. Supraclavicular brachial plexus block provides consistently effective regional anaesthesia to the upper extremity.² Different technical modalities are being used for identifying and locating the

brachial plexus in the supraclavicular area. Conventional methods include electric stimulation and patient-reported paraesthesia which rely on surface landmark identification in a semi-blind manner.

Apart from individual and anatomical variations, the success rate here is dependent on equipment accuracy. The use of electrical stimulation to locate peripheral nerves was introduced in 1962.³ Several advantages have been claimed with this technique, including a higher success rate, the avoidance of vascular injury, and the avoidance of paresthesias and associated neurological injury.^{4,6}

These clinical data are further strengthened by recent animal studies in which stimulating needles were inserted into the nerves under direct vision, yet the electrical current required to achieve a motor response could exceed 1mA.⁷ Modern ultrasound machines are capable of imaging individual roots to their cords in the infraclavicular region. The sonographic image can be used to guide the injection needle while minimizing the risk of injury of adjacent structures.⁸ The use of Ultrasound for nerve blocks was first reported by La Grange P et al in 1978, who performed supraclavicular brachial plexus block with the help of a Doppler USG blood-flow detector to aid identification of the subclavian artery and vein.⁹ Abramowitz HB et al in 1981 used Doppler USG to identify and mark the location of the axillary artery for brachial plexus block in patients whose axillary artery was impalpable.¹⁰

The use of a peripheral nerve stimulator (PNS) has been the 'gold standard' for performing peripheral nerve blocks for the last two decades and has been shown to be a highly effective technique for determining adequate needle placement to produce regional anaesthesia/analgesia. Whether or not the use of USG can improve practitioners' ability to successfully perform peripheral nerve blocks remains controversial. So, this study was planned to compare nerve stimulator guided technique and ultrasound guided technique of supraclavicular brachial plexus block for upper limb surgery

METHODS

This prospective randomized single blind comparative study was carried out from October 2014 to October 2015 in the department of anaesthesiology and critical care of tertiary care teaching hospital of Rajasthan after getting approval from institutional ethical committee. This study was performed among patients scheduled for elective forearm and hand surgeries under supraclavicular brachial plexus block. A written informed consent was taken from the patients and patient's attendant. Patients of either sex, aged between 18 and 60 years and with ASA Grade I and II were included in study. Patients with ASA grade III, IV and V, known hypersensitivity to local anaesthetics, opiod addicts, systemic diseases, uncooperative patients, bleeding disorders, anatomical

abnormality at the regional site, pregnant women, and neurodeficit involving brachial plexus were excluded from the study.

Using a computer-generated sequence of random numbers and a sealed envelope technique, patients were randomly allocated into two groups to receive supraclavicular brachial plexus block using either nerve stimulation (group PNS, n= 40) or ultrasound (group US, n=40) guidance. After routine pre anaesthetic evaluation, all patients were pre medicated with injection Midazolam 0.03mg/kg, given 5 minutes before procedure. No analgesic drugs were given during pre-medication. Both the groups were injected with ropivacaine (0.75%) 20 ml + Normal saline 10 ml.

In PNS group intravenous access was established in the non-operative upper limb and standard monitoring was applied. The patient was kept in the recumbent position without a pillow, arms at his/her sides and head turned to the opposite side to be blocked. Small roll pad was placed below shoulder. The patient was asked to lower the shoulder and flex the elbow, so that the forearm rests on his/her lap. The wrist was supinated so that the palm faces the patient face.

This manoeuvre was done to allow detection of any subtle finger movement produced by nerve stimulation. The point of needle entrance was about 1inch (2.5 cm) lateral to the insertion of the sternocleidomastoid (SCM) in the clavicle or one thumb breath lateral to SCM. Palpation of the subclavian artery at this site confirmed the landmark. The palpating index finger was then placed at this site. Local infiltration of 1ml of 2% lignocaine was done at the proposed puncture site. We used an insulated needle to perform this technique.

The needle was connected to nerve locator by the electrodes and was properly grounded with the help of ECG leads. We started the stimulation with an intensity of 2.0 mA and a pulse width of 100 μ s. Once the desired response was obtained (i.e. a muscle twitch of the fingers that is clearly visible), we started decreasing the current gradually to 0.5mA. If still, we get the desired response the drug 30 ml solution was injected. If the response was obtained at 0.4mA also, then the needle was repositioned again so as to get response at 0.5mA but not at 0.4mA. In the presence of inadequate response repositioning of the needle was done in the anteroposterior plane, either slightly more posterior or slightly more anterior, but always parallel to the midline.

In US group the patient is placed in the semi seated position seated with the shoulder down and the head turned the opposite side. A 5cm, 22-G, insulated needle was used. This was a superficial block for which a linear high frequency US probe (M turbo 11mm broad band linear array, 6-14MHz Sonosite Bothell Washington, USA) covered with sterile cover was used. The probe was moved laterally to visualize the plexus as it passes over

the 1st rib. After taking all aseptic precautions the needle is advanced in plane, from lateral to medial, the entrance point was located at about 1 cm away from the probe to decrease the angle of insertion and improve needle visualization.

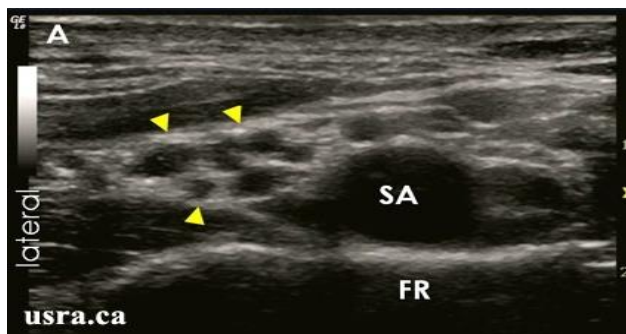


Figure 1: The subclavian vein and pleural dome seen with the probe over the SCM.

The needle was then slowly advanced under direct visualization, towards the angle formed by the first rib and the subclavian artery. The local anaesthetic spread should be seen reaching the angle formed by the 1st rib (vertical arrows pointing up) and the subclavian artery

(SA). The local anaesthetic is seen as a hypoechoic (dark) shadow projecting from the tip of the needle. Figure 1 show the probe is placed over the SCM and above and parallel to the clavicle. Procedure time, block start time (needle insertion), time to achieve complete sensory blockade, motor blockade, and duration of surgical procedure and duration of analgesia were also recorded. Any adverse effects or complications were also recorded.

Data were analysed using IBM SPSS Statistics software. The qualitative data between two groups were compared using Chi Square test and for comparison of the continuous variable, student t-test and fisher exact test were used. Comparison of success rate was done with percentage. $p < 0.05$ was considered statistically significant at 95% confidence interval.

RESULTS

The mean age, weight, gender and ASA grade of the patients in both the groups was comparable and the p value between the groups was > 0.05 i.e. statistically insignificant. The mean duration of surgery in group PNS and group US was 58.97 ± 18.52 minutes, 62.05 ± 16.66 minutes respectively. The p value between the two groups was > 0.05 i.e. statistically insignificant.

Table 1: Comparison of the both the study groups.

Parameters	Group PNS (n=40)	Group US (n=40)	P value
Mean Age (in Years)	33.52 ± 12.80	35.27 ± 13.93	0.560
Mean weight (in Kg)	63.63 ± 9.73	61.75 ± 6.55	0.315
Gender	Male	30	1.203
	Female	10	
ASA	Grade I	34	0.567
	Grade II	6	
Duration of Surgery (in minutes)	58.97 ± 18.52	62.05 ± 16.66	0.437
Duration of procedure (in minutes)	8.0 ± 1.53	6.27 ± 1.10	< 0.0001
Onset of sensory block (in minutes)	7.68 ± 1.33	6.46 ± 1.02	< 0.0001
Onset of motor block (in minutes)	9.94 ± 1.28	8.10 ± 1.02	< 0.0001
Time to achieve complete block (in minutes)	16.11 ± 1.54	13.74 ± 1.11	< 0.0001
Duration of sensory block (in hours)	6.14 ± 2.36	8.13 ± 1.63	< 0.0001
Duration of motor block (in hours)	5.14 ± 2.36	7.13 ± 1.63	< 0.0001

PNS- Peripheral nerve stimulator group, US- ultrasound group

The mean duration of procedure in group PNS was 8.0 ± 1.53 minutes and in group US, it was 6.27 ± 1.10 minutes. The p value in both the groups was < 0.0001 i.e. statistically significant.

The mean duration of onset of sensory and motor block was 7.68 ± 1.33 minutes and 9.94 ± 1.28 minutes in group PNS where as in group US onset of sensory and motor block was 6.46 ± 1.02 minutes and 8.10 ± 1.02 minutes. The p value in both the groups was < 0.0001 i.e. statistically

significant. The mean duration of time to achieve complete block in group PNS was 16.11 ± 1.54 minutes and in group US, it was 13.74 ± 1.11 minutes. The p value in both the group was < 0.0001 i.e. statistically significant.

The median duration of sensory and motor block in group PNS was 7 hours and 6 hours and in group US, it was 8 hours and 7 hours. The p value in both the groups was < 0.0001 i.e. statistically significant. All the parameters are shown in Table 1. The block was successful in 90% in

group PNS and 97.5% in group US. Total failure of block occurred in 10% in group PNS and 2.5% in group US. This difference was found statistically insignificant ($p=0.358$). (Table 2) Incidence of artery puncture was 10% in PNS group compared to nil in US group. Nausea and respiratory distress in 7.5% in PNS group compared to nil in US group. There was no significant difference in HR, SBP, DBP, MAP, and SpO₂ during the intra/post-operative period.

Table 2: Success and failure of block in both the groups.

Groups	Successful block	Failed block	P value
PNS group (n=40)	36 (90%)	4 (10%)	0.358
US group (n=40)	39 (97.5%)	1 (2.5%)	

PNS-Peripheral nerve stimulator group, US- ultrasound group

DISCUSSION

Recently interest has grown in peripheral nerve blocks (PNB). These blocks are associated with good regional anaesthesia, lower complication rate and better postoperative analgesia.¹¹⁻¹³ Supraclavicular block provides a rapid, dense, and predictable anaesthesia of the entire upper extremity in the most consistent manner of any brachial plexus technique.¹⁴ Efforts were made to improve upon the technique of nerve blocks. Mechanical nerve stimulation and electric stimulation were steps in this direction. With the advances in imaging and wider availability, USG made its application in PNBs. It is a guided technique which helps in PNB in real time. USG is portable, inexpensive and radiation free modality can be taught and learned with relative ease.

In our study both groups were comparable with respect to age, gender, weight and ASA grade of the patients. No significance difference was found in between two groups. Therefore, clinically insignificant variations in age simply helped us to alleviate confounding factors like distribution, metabolism, excretion and action of drug.

Clinically insignificant variations in weight simply helped us to alleviate a point of controversy because obesity as well as cachexia has clinically significant effect on the clinical action of drug. Similar demographic results were found in earlier study.¹⁵ There was male preponderance in both the groups in our study. This could be because of more numbers male patients to undergo surgery in our institution in this study period. However this male preponderance had no clinical relevance on the results of the study.

The mean time for procedure was significantly less in group US (6.27 ± 1.10 minutes) as compared to group PNS (8.0 ± 1.53 minutes). Similar results were found by Rupera

KB et al study, in that procedure time in US group was 4.55 ± 0.74 minutes and in group PNS, it was 5.71 ± 0.92 minutes.¹⁶ The similar study also done by Williams SR et al who reported the average procedure time of 9.8 min in nerve stimulator guided group and 5.0 min in USG guided group for supraclavicular brachial plexus block.¹⁷

The mean onset time for sensory and motor block was found significantly less for group US (6.46 ± 1.02 minutes and 8.10 ± 1.02 minutes respectively) as compared to group PNS (7.68 ± 1.33 minutes and 9.94 ± 1.28 minutes respectively). Similar results were found by Rupera KB et al in which onset time of sensory and motor block was 2.97 ± 0.72 minutes and 4.55 ± 0.78 minutes in US group and in PNS group, it was 3.63 ± 0.76 minutes and 5.13 ± 0.71 minutes.¹⁶ Another study done by Singh G et al, they found that onset of sensory and motor block was 10.86 ± 3.19 minutes and 14.56 ± 3.85 minutes in US group, in conventional group it was prolonged i.e. 11.60 ± 2.45 minutes and 16.8 ± 3.42 minutes.¹⁵ Mean time to achieve complete block in US group (13.74 ± 1.11 minutes) was shorter as compared to PNS group (16.11 ± 1.54 minutes).

Similar results were found by Rupera KB et al in that mean time to achieve complete block in US group was 13.17 ± 1.54 minutes and in PNS group mean time was 16.96 ± 1.83 minutes.¹⁶

The likely explanation for shorter procedure time, fast onset for sensory as well as for motor blockade could be that ultrasound can determine the size, depth and exact location of the brachial plexus and its neighbouring structures. Also with USG guidance, positioning and if required repositioning of the needle is performed under direct vision and in real time as opposed to blind redirection and repositioning of needle with PNS.¹⁸

That median duration of sensory and motor block was significantly more in US group (8 and 7 hours) than in PNS group (7 and 6 hours). Similar study carried by Rupera KB et al, they found 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.¹⁶ Another study carried out by Singh G et al, found mean duration of sensory and motor block in US group was 397.931 ± 67.325 minutes and 343.448 ± 60.843 minutes and in PNS group, it was 352.22 ± 87.501 minutes and 305.19 ± 60.088 minutes.¹⁵ It could be due to the deposition of the right drug, in the right dose, in the right place in ultrasound.

In our study, the block was successful in 90% in group PNS and 97.5% in group US. Rupera KB et al found success rate 96.67% in group US as compared to 80% in group PNS.¹⁶ The difference was statistically significant. Similar results obtained by Singh G et al, they found block was successful in 90% in US Group 1 and 73.33% of patients in Group 2.¹⁵

In our study not a single complication was identified in US group as compared to group PNS; in which incidence of artery puncture was 10% and nausea and respiratory distress in 7.5%. Similar result of 10% incidence of vessel puncture/hematoma in Group 2 compared to 3.33% in US group was shown by the study done by Singh G et al.¹⁵

There was no incidence of nerve injury and pneumothorax in both the groups. Similar studies with no or less incidence of complications by US technique has been shown by other studies.^{16,19,20} This could be because ultrasound facilitates the identification and avoidance of important structures, and direct visualization of local anaesthetic spread may reduce dosages and result in selective blocks with higher accuracy and fewer complications.^{18,21}

CONCLUSION

Procedure time, onset of sensory and motor block and time to achieve complete block were found significantly shorter in US group than PNS group. Duration of sensory and motor block, success rate of block were found significantly more in US group than PNS group, and incidence of complications like artery puncture, respiratory distress and nausea was also seen more in PNS guided technique than US group. So, ultrasound guided technique was found significantly better than PNS for supraclavicular brachial plexus block.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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