Supraclavicular Block of the Brachial Plexus using Ultrasound Guidance Compared with Supraclavicular Block of the Brachial Plexus using Peripheral Nerve Stimulator Guidance

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ABSTRACT

Introduction: A supraclavicular approach for blockade of the brachial plexus can be employed in any upper limb surgery, but is associated with the risk of pneumothorax and a varied success rate. To circumvent the above, peripheral nerve stimulators and later ultrasound emerged. Aim of our study was to assess the quality and safety of supraclavicular block of brachial plexus with ultrasound guidance versus the block with peripheral nerve stimulator guidance.

Material and methods: 60 eligible patients who presented for surgery of the the upper limb were randomized into two groups of 30 each; Group ultrasound (U) received a supraclavicular block guided by ultrasonic landmarks and Group Peripheral nerve stimulator (P) guided by anatomical landmarks and nerve stimulation.

Results: Statistical analysis revealed a significant difference in the time taken for performance of the block, need for conversions to GA, the higher chances of arterial puncture and incidence of No blockade developing in ulnar and median nerve at the end of 30 mins in Group P. Total duration of block was more in Group U.

Conclusion: Ultrasound-guided supraclavicular block is more efficacious; providing a more complete block, increasing the proportion of successful blocks and with reduced complications, therefore providing a block of better quality compared to a peripheral nerve stimulator guided supraclavicular block.

Keywords: Ultrasound, Peripheral nerve stimulator, supraclavicular brachial blocks

INTRODUCTION

A supraclavicular approach for blockade of the brachial plexus can be employed in any upper limb surgery, but is associated with the risk of pneumothorax and a varied success rate. In order to increase the success rates and decrease the complications associated with this block, several researchers developed "peripheral nerve stimulators". Though the success rates improved with the use of peripheral nerve stimulators, the complications remained. Interest in supraclavicular blockade has been rekindled by the use of two-dimensional ultrasonic images to localize the brachial plexus.[1,2] Now, with the use of ultrasound, it is hypothesized that the proportion of successful blocks will increase, while incidence of complications such as pneumothorax will decrease.

Study aimed to assess the quality and safety of supraclavicular block of brachial plexus with ultrasound guidance versus a supraclavicular block of brachial plexus with peripheral nerve stimulator guidance.

MATERIAL AND METHODS

An Ethical committee clearance was obtained and study conducted in Tagore Medical College hospital, affiliated to Tamil Nadu Dr.MGR Medical University. Written informed consent was obtained from all the patients. 60 eligible patients who presented for surgery of the distal arm, forearm, or hand were randomized into two groups.

- Group ultrasound (U) received a supraclavicular block guided by ultrasonic landmarks.
- Group Peripheral nerve stimulator (P) received a supraclavicular block guided by anatomical landmarks and nerve stimulation.

Inclusion criteria

1. Patients of either sex, aged between 18-50 years.
2. Patients belonging to American Society of Anesthesiologists Grade I and II.
3. Surgeries involving upper limbs.

Exclusion criteria

1. Clinically significant Coagulopathy (BT > 15 seconds, INR > 1.5 or APTT prolonged by more than 8 seconds).
2. Severe pulmonary pathology.
3. Infection at the injection site.
4. Allergy to local anesthetics.
5. Mental incapacity.
6. Age <18 year.
7. A body mass index more than 35.
8. Preexisting neuropathy in the operative limb.

On arrival in the operation suite, the patient was connected to standard Monitors such as Pulse oximetry, Noninvasive blood pressure measurement / Heart rate and ECG. Intravenous access obtained in the upper limb which is not being operated upon with 18 G cannula. Ringer Lactate started.

Drug used for block was 15 ml 0.5% Bupivacaine + 15 ml 2% Lidocaine with adrenaline. Total volume being 30ml, given as a single injection.

Ultrasound Guided Block: Logic –E ultrasound machine which was equipped with a linear 7- to 13-MHz probe and color Doppler was used. The patient was kept lying supine and the head turned 45° to the contralateral side. The ultrasound probe was then placed in the coronal oblique plane in the supraclavicular fossa to visualize the subclavian artery and brachial plexus in its transverse sectional view. The brachial plexus is seen as a cluster of hypo echoic nodules, often found lateral to the round pulsating hypo echoic subclavian artery and lying on top of the hyper echoic first rib. After the scout scan, skin was sterilized

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How to cite this article: S. Sree Ranjini, A.C. Malarvizhi. Supraclavicular block of the brachial plexus using ultrasound guidance compared with supraclavicular block of the brachial plexus using peripheral nerve stimulator guidance. International Journal of Contemporary Medical Research 2016;3(12):3451-3455.

and a 22-gauge 50 mm Teflon coated needle was placed on the outer (lateral) end of the probe which is covered with a sterile covering and advanced along the long axis of the probe and in the same plane as the ultrasound beam. Needle movement was observed in real time. Once the needle reached the brachial plexus cluster, the drug was injected as a single injection.

Peripheral Nerve Stimulator Guided Block: The patient is made to lie supine and the head turned 45° to the contralateral side. Supraclavicular block was performed using a subclavian perivascular approach. The Land marks are Clavicle, pulsation of subclavian artery, cricoid cartilage and lateral border of sternocleidomastoid muscle. Approximately,1 cm above the midpoint of the clavicle, the pulsation of subclavian artery is felt. 22 guage 50 mm Teflon coated needles are used and the needle is inserted just above the pulsation. Initially there is resistance which gives way to a pop as the needle enters the fascia. Now stimulus starting at 2 mA is given to elicit a response i.e movement of any muscle in forearm, hand or arm. Then strength of current gradually reduced up to 0.5mA while response is being continuously obtained. Following this the drug is given as a single injection.

Measured outcomes

1. Block execution time
   U (Ultrasound) group: Interval between first imaging to needle removal after injection of the drug.
   P (Peripheral nerve stimulator) group: Interval between first needle insertion to its removal after injection of the drug.
2. Time of onset of sensory and motor block of the musculocutaneous, median, radial, and ulnar terminal nerves.
3. The proportion of blocks in which surgical anesthesia was achieved.
4. The proportion of blocks that were supplemented with local anaesthesia at the surgical site.
5. The proportion of cases in which general anesthesia was necessary.
6. The duration of postblock analgesia: Defined by the interval between block completion up to the time the patient complains of pain.
7. Postblock neurologic or respiratory complications:
   - Patient monitored for 2 hrs after surgery.
   - Patient assessed after 24 hrs for any complication – neurologic / respiratory.
   - Follow up after one week over telephone.

Evaluation of sensory and motor block was performed every 10 min in all nerve territories over a 30-min period beginning when the needle exited the patient. Musculocutaneous (MC), Radial, Median and Ulnar nerve territories were tested. Patient handed over to surgeon 30mins after giving the block.

Motor block evaluation

- Musculocutaneous (MC) nerve: Testing for forearm flexion-extension.
- Radial nerve: Testing for wrist extension.
- Median nerve: Testing for thumb and second digit pinch.
- Ulnar nerve: Testing for thumb and fifth digit pinch.

Scoring

0 = no loss of force = no block
1 = reduced force compared with the contralateral arm = partial block
2 = incapacity to overcome gravity = complete block.

Sensory block evaluation

By comparing the pin prick sensation elicited in the central sensory region of each nerve with the same stimulus delivered to the contralateral side.

- Musculocutaneous (MC) nerve: Testing over lateral aspect of forearm.
- Radial nerve: Testing in web between thumb and index finger.
- Median nerve: Testing over thenar eminence.
- Ulnar nerve: Testing over hypothenar eminence .

Scoring

0 = normal sensation (no block)
1 = reduced sensation (partial block)
2 = total loss of sensation (complete block).

Success rate in this study was defined as anesthesia sufficient for pain-free surgery without supplementation. If the patient still experienced pain at the site of incision, local supplementation given. If the patient still experienced pain despite supplementation, general anesthesia was given. A postblock chest radiograph was obtained if a patient complained of respiratory distress.

Post operative Recovery: Patients were observed in the recovery area for 2 hours after their surgery. Reassessed after 24 hrs. Patients were followed up by telephone one week later and asked if any region of the arm remained insensible or weak for a prolonged period of time, any respiratory difficulty encountered or any other comment. If a positive response was elicited, then details were obtained.

STATISTICAL ANALYSIS

This was performed using SPSS 16 software. We based the sample size calculation on similar previous studies[2,3] in the general patient population. The sample size was calculated to be 30 in each group (total 60) assuming an alpha error or confidence level of 95%. The statistical power being 92.2. The data was expressed as percentage of successful blocks. Test statistics were compared based on Negative ranks and Wilcoxon Signed Ranks Test. “P” values given for Group U versus Group P. Value of ‘p’ less than 0.05 is taken as significant.

RESULTS

Reviewing the results of our study, we found no significant statistical difference in the demographic variables such as Age (p-0.304) and Sex (p-0.184) of the patients in either Group U (Ultrasound guided) or Group P (Peripheral nerve stimulator guided). There was no significant statistical difference in either the ASA grades (p-0.438) or patient parameters such as Weight (p-0.246), Respiratory rates (p-0.321), Heart rate (p-0.079) or Blood pressure systolic (p-0.707) and Blood pressure diastolic (p-0.692) of the patients in either Group U or Group P. There was no significant statistical difference in the total duration of surgery (p-0.07) in either group. Need for local infiltration in either group was not statistically significant (p-0.532).

The time taken for performance of the block was 4.18 +/- 0.95 minutes in group U compared to 5.43 +/- 1.09 minutes in group P. This was statistically significant (p< 0.001). Need for General Anaesthesia amongst the groups was highly significant statistically (p- <0.001) as none in Group U but 3 patients in Group P needed conversion to GA.

Regarding Complications; Arterial puncture occurred in 7 patients in group P and none in group U in our study, the result being highly significant statistically (p-<0.001).

In our study, no Pneumothorax occurred in Group U and only

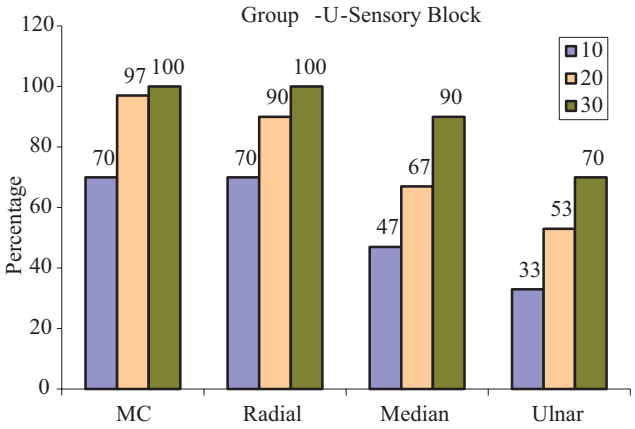

Figure-1: Sensory block in group – U. "X Axis is Time in minutes; Y Axis is Percentage of nerve fibres blocked. MC - Musculocutaneous nerve".

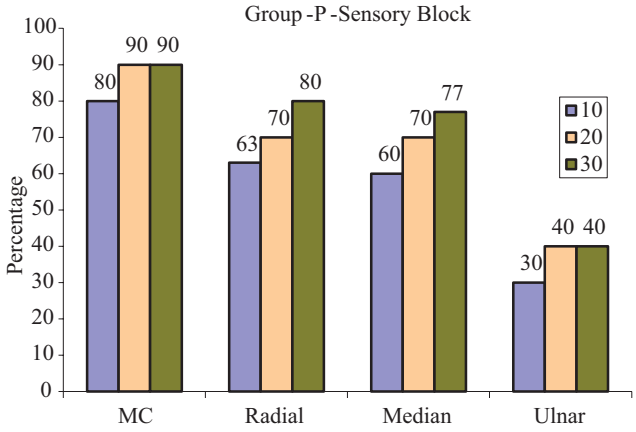

Figure-2: Sensory block in group – P. "X Axis is Time in minutes; Y Axis is Percentage of nerve fibres blocked. MC - Musculocutaneous nerve".

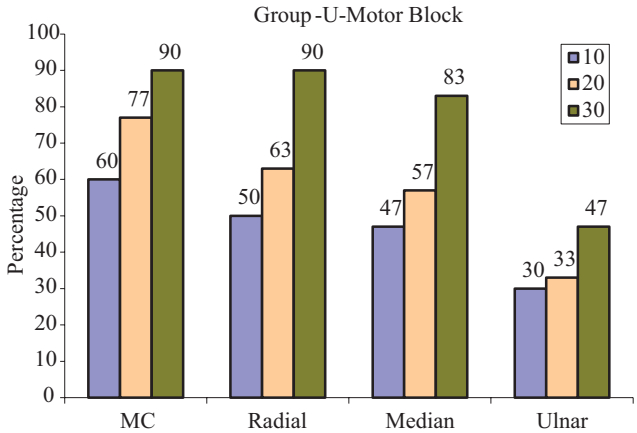

Figure-3: Motor block in group - U. "X Axis is Time in minutes; Y Axis is Percentage of nerve fibres blocked. MC - Musculocutaneous nerve".

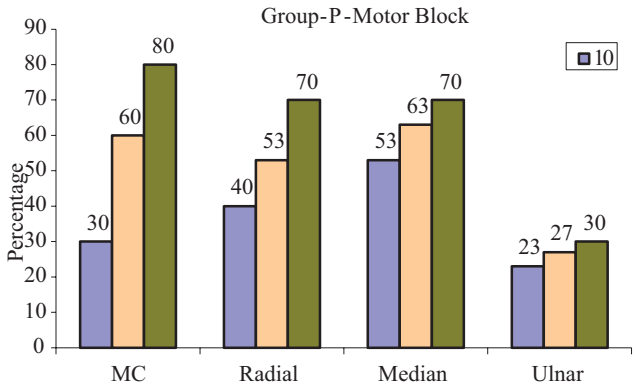

Figure-4: Motor block in group - P. "X Axis is Time in minutes; Y Axis is Percentage of nerve fibres blocked. MC - Musculocutaneous nerve".

one clinically significant pneumothorax occurred in Group P, though this was not statistically significant (p-0.114)

At 30 min 90% of patients in Group U (Figure 1) and 71.75% of patients in Group P (Figure 2) had a complete sensory block of all nerve territories (p =0.157) and 77.50% of patients in Group U (Figure 3) and 62.50% of patients in Group P (Figure 4) had a complete motor block of all nerve territories (p = 0.207) and was not statistically significant.

At 30mins, no block occurring in Musculocutaneous, Radial, Median and Ulnar nerves were 0, 0, 7% and 13% respectively in group U compared to 10%, 13%, 23% and 33% respectively in Group P; with this being highly significant statistically (p<0.001).

DISCUSSION

In 1879 the first successful supraclavicular brachial plexus block was performed by George W. Crile using a weak solution of cocaine for shoulder joint disarticulation. In 1911, Professor KullenKampff[4], a German doctor, after experimenting on himself, made an attempt at 'blind' infiltration of brachial plexus by supraclavicular route.

The brachial block is not without its share of side Effects and complications[5] which include- Pneumothorax, rate being 0.5% to 6% .The onset of symptoms is usually delayed and may take up to 24 hours. Routine chest radiography after the block is not justified. Other complications such as phrenic nerve block (40% to 60%), Horner's syndrome and neuropathy can occur. The presence of phrenic or cervical sympathetic nerve block usually requires only reassurance. Although nerve damage can occur, it is uncommon and usually is self-limited.

In order to increase the success rates and decrease the complications associated with this block, several researchers developed electrical nerve stimulation techniques to aid percutaneous location of peripheral nerves.

In the 1960's several researchers like Sweet and Wepsic, developed electrical nerve stimulation techniques to aid

percutaneous location of peripheral nerves. In subsequent decades with the advent of microprocessors, small, accurate, battery operated, hand held devices were introduced offering sophisticated help in finding peripheral nerves[6,7]

In 1912, Von Perthes was the first to describe the technique of peripheral nerve stimulation as a means to localize a particular nerve. In 1962, Greenblatt and Denson constructed a portable nerve stimulator that wright made commercially available in 1969. Raj et al[8] and Vester-Andersen et al.[9], reported a higher success rate with the nerve stimulator use and varied complication rates.

Advantage of peripheral nerve stimulator (PNS) is that it provides objective evidence that the needle tip is close to the nerve and it may be used in the unconscious patient. With most needles a muscle twitch initiated at a current of around 0.5 mA suggests that the needle tip is 1-2 mm from the motor nerve and that injection of local anesthetic solution is likely to provide a satisfactory block. But the disadvantage is that it cannot be used after paralysis with neuro-muscular blocking drugs and the stimulation may be painful. But though the success rates improved with the use of peripheral nerve stimulators, the complications remained.

Interest in supraclavicular blockade has been rekindled by the use of two-dimensional ultrasonic images to localize the brachial plexus.[1] In 1930, pioneers of medical ultrasound, Karl Theodore Dussik, a psychiatrist and neurologist, began studying ultrasonography in conjunction with his brother Friederich, a physicist. It was based on an important discovery made by Pierre and Jacques Curie in 1880 a phenomenon was called "piezoelectricity" from the Greek word meaning "to press."[10] This eventually led to the development of the modern-day ultrasound transducer.

Ultra sound waves are produced by 'Piezo electric effect', wherein an alternating current when applied to a crystal will produce an oscillating change in the crystal and generate ultrasonic waves. On ultrasound, air and vessels are anechoic; hypoechoic structures include fat and muscle, Bone is hyperechoic. Peripheral nerves may have a hypo echoic (dark structures) or hyper echoic (bright structures) sonographic appearance[11,12], depending on the size of the nerve, the sonographic frequency, and the angle of the ultrasound beam. Nerve block applications require frequencies in the range of 8–14 MHz which offer excellent resolution of superficial structures in the upper and good penetration depth in the lower frequency.

In our study, the time taken for performance of the block was 4.18 +/- 0.95 minutes in group U compared to 5.43 +/- 1.09 minutes in group P. This was because ultrasonic landmarks proved to be an extremely reliable guide and block succeeded often on the first needle probe. But in Group P, before appropriate neuro stimulation was elicited, withdrawal and redirection of the stimulating needle was frequently needed. Though patient discomfort during block placement was not formally evaluated in this study, withdrawal and redirection of the stimulating needle are known to decrease patient acceptance of regional anesthesia techniques.[13]

In our study, Need for local infiltration in either group was not statistically significant (p-0.532) but Need for General Anaesthesia amongst the groups was highly significant statistically (p- <0.001) as 30 mins after the injection of the drug, when the patients were handed over to the surgeons, 3 patients in group U and 9 patients in group P complained of pain. The 3 patients in the ultrasound group and 4 patients in the nerve stimulator group settled with local infiltration and the surgery continued uneventfully but 5 patients in group P did not respond to the local infiltration and needed General Anaesthesia.

In our study, no Pneumothorax occurred in Group U (Ultrasound guided) and only one clinically significant pneumothorax occurred in Group P (Peripheral Nerve Stimulator guided), but was not statistically significant. The patient had developed mild breathlessness and a chest radiograph revealed a small pneumothorax. It spontaneously resolved within two days and did not require any ICD insertion.

The possibility of creating a Pneumothorax is a concern when attempting supraclavicular block. The published incidence of Pneumothorax by De Jong RH et al[14] varies between 1% and 4% using the classical supraclavicular approach and paraesthesia for nerve localization . Several alternative supraclavicular approaches have been described. One of them by Fortin G and Tremblay L[15] using a short needle for brachial plexus block in an attempt to minimize the incidence of pneumothorax .The subclavian perivascular approach has been shown in a large series by Fanelli G[16] to have an incidence of clinically significant pneumothorax less than the classical approach. To minimize patient risk in our study, the subclavian perivascular approach was used in Group P.

Ultrasonic guidance is also thought to decrease the incidence of pneumothorax during supraclavicular blockade by Moorthy SS, Schmidt SI and Dierdorf SF[17] who had no clinically significant pneumothorax with ultrasound-guided supraclavicular block, similar to our study.

The success rate in this study was defined as anesthesia sufficient for pain-free surgery without supplementation. Success in Group U is not significantly different from the published success rate (19 of 20 based on similar criteria) in the previous study of single-shot ultrasound-guided supraclavicular blockade by Moorthy SS, Schmidt SI, Dierdorf SF, et al.[17] in 1991.

In both series, sensory block in the median and ulnar territories often completed more than 30 minutes after the block. The longer evaluation period in Kapral et al.'s study[1] showed that up to 50 minutes may be necessary to attain maximal blockade with single-shot ultrasound-guided supraclavicular block.

For Group P, the success rate as defined above in our study was comparable to that of another series of neurostimulator-guided supraclavicular blocks by Lanz et al[18] using a different anatomical approaches.

A successful block may also be defined as one providing complete anesthesia of all target nerves. The proportion of blocks in our study in which all territories were completely anesthetized at 30 minutes was 77.50% in Group U and 62.50% in Group P; In contrast, Franco and Vieira[19], performing subclavian perivascular blocks (as in Group P of this study) and using complete block of all dermatomes before surgery commenced as their criteria for success, achieved the most frequent success rates ever reported in a large series for any peripheral nerve block (973 of 1003). This series clearly shows that extensive experience with subclavian perivascular block, and perhaps a longer evaluation period, can lead to increased success rates.

Ultrasound helps in identifying the target nerve , surrounding structures ,helps in determining the best approach to target nerve ,offers real time guidance , observes local anaesthetic distribution and helps in faster onset of block[20] as the drug is deposited very close to the target nerve while at the same time avoiding intraneural injections. The disadvantages of ultrasound is that greater anatomical knowledge is required and it is relatively expensive. Peripheral nerve stimulaton helps in localizing the nerve but being a 'blind' procedure, it has

decreased success rates and more complications as compared to an ultrasound guided block.

CONCLUSION

We conclude that ultrasound-guided supraclavicular block is more efficacious; providing a more complete block, increasing the proportion of successful blocks and with reduced complications, therefore providing a block of better quality compared to a peripheral nerve stimulator guided supraclavicular block.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 08-11-2016; **Published online**: 22-12-2016