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Comparison of Nerve Stimulator Guided Technique and Ultrasound Guided Technique of Supraclavicular Brachial Plexus Block In Upper Limb Surgeries

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Abstract

Background: Brachial plexus blocks provide a wonderful alternative to general anesthesia for upper limb surgeries. Among the various approaches of brachial plexus block, supraclavicular approach is considered easiest and effective. This study was designed to compare the nerve stimulator guided and the recently popularizing ultrasound guided technique for supraclavicular brachial plexus block with regards to time taken for the procedure, onset and duration of the block, success rate, overall effectiveness of the block and incidence of complications involved.

Methods: We conducted a prospective, randomized, comparative study on 100 patients (50 in each group). We performed supraclavicular brachial plexus block by nerve stimulator technique in group A and by ultrasound guided technique in group B and compared the outcomes that followed. Primary outcome: duration of performing block. Secondary outcomes: time of onset of sensory and motor block, total duration of block, supplementation with general anesthesia, failure of block, complications associated.

Results: The duration of performing block was 15.92 ± 3.03 min in group A as compared to 8.04 ± 1.32 min in group B, the p value being <0.001 (statistically significant). The mean time of onset of sensory block in group A was 16.47 ± 4.05 min, whereas it was 14 ± 3.26 min for group B, p value being 0.001 (statistically significant). The total duration of block, cases supplemented with general anesthesia, failure of blocks were comparable among the two groups. There was no complication in either group.

Conclusion: The ultrasound guided technique offers advantage over nerve stimulator guided technique by significantly reducing the duration of performing block and time of onset of sensory block.

Keywords: Supraclavicular block; Local anesthetic; Sensory block

Introduction

Regional nerve blocks prevent the unwanted stress of laryngoscopy and tracheal intubation and the adverse effects of general anesthetic drugs [1]. They provide better intraoperative and prolonged postoperative pain relief. Brachial plexus blocks provide a wonderful alternative to general anesthesia for upper limb surgeries. They achieve near-ideal operative conditions by providing complete and prolonged pain relief, muscle relaxation, maintaining stable intra-operative hemodynamics and adequate sympathetic block. Among the various approaches of brachial plexus block, supraclavicular approach is considered easiest and effective. It is also known as "The spinal of arm" [2]. In nerve stimulator guided technique a nerve stimulator is connected to an insulated needle, allowing electric current emission from the tip of needle close to or contacts motor nerve with contraction of the muscle innervated.

Ultrasound guided technique is an advanced technique that allows noninvasive real time visualization of the nerves that has to be blocked, the pleura and the vessels along with the needle and the local anesthetic drug spread. This study was designed to compare the nerve stimulator guided and the recently popularizing ultrasound guided technique for supraclavicular brachial plexus block with regards to time taken for the procedure, onset and duration of the block, success rate, overall effectiveness of the block and incidence of complications involved.

Patients and Methods

Study design: This prospective, randomized, comparative study was conducted on 100 patients (50 patients in each group) at Mahatma Gandhi Medical College and Hospital, Jaipur during the period October 2016-September 2018 after getting clearance from the Institute Ethics Clearance Committee and written informed consent of all the patients. The randomization was done by chit and box method. The patients were not informed about the options of US and PNS.

Inclusion criteria: ASA grade 1 and 2 patients, age group between 18-75 years of either sex, elective surgery on upper extremity under supraclavicular block- including fracture surgeries of any etiology-road traffic accident, fall, malunion, non-union.

Exclusion criteria: ASA grade 3, 4 and 5, known hypersensitivity to local anesthetics, opioid addicts, systemic diseases, uncooperative

patients, bleeding disorders, pregnant women, anatomical abnormality at regional site, peripheral neuropathy

Routine investigations: Hematological- Hb%, TLC, platelet count, BT, CT, PT/INR, random blood sugar, blood urea, serum creatinine, chest X-ray, ECG were performed.

Routine preoperative assessments of all the patients were done and anesthetic procedure explained. I.v access and routine monitoring was done. The blocks were performed by the same person in each group.

On the operating table, the patient was given position for supraclavicular brachial plexus block, supine position with head resting on the ring, ipsilateral arm adducted, shoulder depressed, roller pack placed in between scapula and the head turned 45° to the contralateral side. Under all aseptic precautions, local site was prepared.

In group A patients, the nerve stimulator (Inmed NSML-100) was connected to the stimulating needle and set to deliver 0.8-1 mA current at 1 Hz frequency and 0.1 msec of pulse duration. In this group, the positive electrode of the NS was attached to an ECG lead and stuck on the ipsilateral arm. The subclavian artery was then palpated 1-1.5cm above the midclavicular point and immediately lateral to it, an intradermal wheal was raised with 1% lignocaine (2 ml) using a 24 G needle. A 20 G insulated needle attached to the negative electrode of the NS was then inserted through the skin wheal in a backward, inward, and downward direction. NS was set to deliver a current of 1 mA in the internal mode.

After finger flexion was elicited by stimulation, the current was reduced in steps of 0.2 mA till the presence of a muscle twitch with 0.6 mA was observed and no twitch with a current of 0.2 mA was observed. This confirms the proximity of the needle tip to the nerve and the drug was injected after negative aspiration of air or blood. Once the elicited motor response of fingers was obtained at 0.5mA, 25-35 ml (2.5mg/kg) of 0.5% levobupivacaine was injected after gentle aspiration (Figure 1).

Figure 1: shows procedure of peripheral nerve stimulator guided supraclavicular brachial plexus block.

In group B patients, ultrasound machine (M-TURBO SONOSITE) was prepared and checked. A high frequency linear array ultrasound 9-18 MHz was used. The probe was inserted into a sterile plastic sheath so as to maintain sterility. The probe was positioned in a coronal oblique plane in supraclavicular fossa just above the midpoint of clavicle. The subclavian artery, vein, and the brachial plexus were visualized. The brachial plexus and its spatial relationship to the surrounding structures were scanned. The plexus was identified superolateral to the subclavian artery consistently in all the cases. The skin was anesthetized at the proposed site of entry with 1% lignocaine (1-2 ml) and a 20 G, 90 mm spinal needle was connected to a 50 cm extension line and primed with the drug. The pulsating subclavian artery located, the needle was inserted from lateral side of probe perpendicular to skin to penetrate skin and then at a shallow angle under the probe. The needle then advanced inside the ultrasound beam by inplane technique till the plexus was seen. When necessary, the needle was repositioned to achieve an ideal perineural distribution of the drug. Once the needle reached the plexus, after negative aspiration, 25-35 ml (2.5mg/kg) of 0.5% levobupivacaine was injected and the spread of the drug was observed. The peripheral nerves when grouped together and viewed in the transverse plane gives classic "honey comb" appearance, the nerve fascicles appear hypoechoic within hyperechoic and homogenous perineurium and endoneurium. The visualization of the spread of drug surrounding the nerves is predictor of successful block. It was a single injection technique (Figure 2).

Figure 2: Procedure of performing ultrasound guided supraclavicular brachial plexus block.

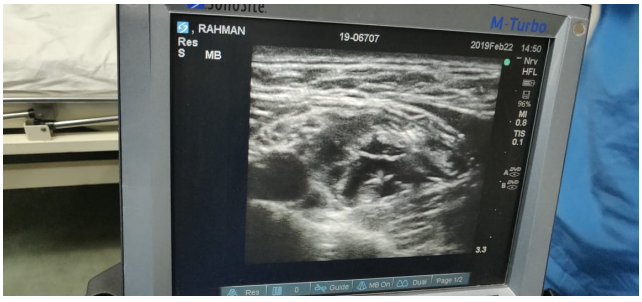

Figure 3: Ultrasound visualization of brachial plexus just lateral to subclavian artery.

There was no adjunct (e.g. dexamethasone) used in any patient in either group.

Following parameters were compared between group A and group B:

Primary outcome: duration of performing block- Td- time from starting the procedure to completion of levobupivacaine injection:

In the group NS, it is the time from the time of insertion of the needle to its removal.

In the group US, it is calculated from the time of initial scanning to the removal of the needle.

Secondary outcomes: demographic characteristics, hemodynamic variables, time of onset of sensory and motor block, total duration of block, supplementation with general anaesthesia, failure of block or patchy block, any complications or adverse effects.

SENSORY BLOCK:

0-NORMAL SENSATION, 1-LOSS OF SENSATION OF PIN PRICK, 2-LOSS OF SENSATION OF TOUCH

MOTOR BLOCK (Bromage 3 point score):

0-NORMAL MOTOR FUNCTION, 1-REDUCED MOTOR STRENGTH BUT ABLE TO MOVE FINGER, 2-COMPLETE MOTOR BLOCK

VISUAL ANALOGUE SCALE

SCORE 0- NO PAIN,1-3:MILD PAIN,4-6: MODERATE PAIN,7-9: SEVERE PAIN, 10: WORST IMAGINABLE PAIN

Sensory characteristics were assessed by response to pinprick to 23G hypodermic needle. Motor power of block was assessed by asking the patient to flex the forearm and hand against gravity and to abduct the shoulder

The sensory block in each dermatome was graded as follows:

Blocked: Complete absence of sensation

Patchy: Reduced sensation when compared to the opposite limb

No block: Normal sensation.

The motor block at each joint was graded as follows:

Blocked: No power

Patchy: Able to move actively

No block: Full power.

Success: We considered our block to be successful when the patient had a full block of all the sensory dermatomes and no power to move above-mentioned joints.

Failure: Failure of block was defined as the absence of full sensory block and motor block in all the dermatomes involved.

Postoperatively, pain was assessed using visual analogue scale (VAS) score every 60 mins. Patients were supplemented with analgesics when they complained of pain with VAS score of more than 4 was recorded, and the duration of analgesia was noted. The patients were also asked if any region of the limb remained insensible/weakened or generated abnormal sensations for a prolonged period of time.

Statistical Analysis

Statistical analysis was performed with the SPSS, version 21 for Windows statistical software package (SPSS inc., Chicago, IL, USA). The Categorical data were presented as numbers (percent) and were compared between groups using the Chi square test. The quantitative data were presented as mean and standard deviation and were compared by students t-test. Probability was considered to be significant if less than 0.05.

For significance cutoff values are as follows →

$p \geq 0.05$ = not significant; $p < 0.05$ = significant

Results

The duration of performing block was 15.92 ± 3.03 min in group A as compared to 8.04 ± 1.32 min in group B, the p value being <0.001 (statistically significant) (Table 1).

	Group A		Group B		P value
	Mean	SD	Mean	SD	
Duration of Performing Block	15.92	3.03	8.04	1.32	p<0.001

Table 1: Duration of performing block.

The mean time of onset of sensory block in group A was 16.47 ± 4.05 min, whereas it was 14 ± 3.26 min for group B, p value being 0.001 (statistically significant) (Table 2).

	Group A		Group B		P value
	Mean	SD	Mean	SD	
Time of onset of Sensory	16.47	4.05	14	3.26	0.001

Table 2: Time of onset of sensory block.

The mean time of onset of motor in group A was 21.74 ± 4.49 min, whereas it was 21.26 ± 3.62 min for group B, p value being 0.569 (statistically insignificant) (Table 3).

	Group A		Group B		P value
	Mean	SD	Mean	SD	
Time of onset of motor block	21.74	4.49	21.26	3.62	0.569

Table 3: Time of onset of motor block.

The duration of sensory block in group A was 898.89 ± 270 min as compared to 917.07 ± 252.35 min in group B with a p value of 0.740. The duration of motor block in group A was 847.45 ± 310.82 min as compared to 886.76 ± 250.57 min, with a p value of 0.504 (statistically insignificant) (Table 4).

	Group A		Group B		P value
	Mean	SD	Mean	SD	
Sensory	898.89	270	917.07	252.35	0.74
Motor	847.45	310.82	886.76	250.57	0.504

Table 4: Duration of block.

In group A, 5 out of 50 (10%) patients required supplementation with general anesthesia, whereas in group B 4 out of 50 patients (8%) required supplementation with general anesthesia.

	Group A		Group B	
	No.	%	No.	%
Yes	5	10	4	8
No	45	90	46	92
Total	50	100	50	100
Chi-square=0.000 with 1 degree of freedom; P=1.000				

Table 5: Supplementation with general anesthesia.

In group A, out of 50 patients, 44 had complete block, 4 patients had a patchy effect, whereas 2 patients had a failure of the block. In group B, 46 patients experienced complete block, 3 had a patchy effect and 1 patient had a failure of the block (Table 6).

	Group A		Group B	
	No	%	No	%
Complete Effect	44	88	46	92
Patchy Effect	4	8	3	6
Complete Failure	2	4	1	2
Total	50	100	50	100
Chi-square=0.521 with 2 degrees of freedom; P=0.771				

Table 6: Failure of block.

Discussion

In recent years, peripheral nerve blocks have gained a lot of interest among the anesthetists as they are associated with good regional anesthesia, lower complication rates, cost effectiveness and better postoperative analgesia [3,4]. Mechanical nerve stimulation and electric stimulation were steps in this direction and more recently, advances in imaging and their wider availability have made the application of ultrasound in peripheral nerve blocks easier. The ultrasound provides a guided technique which helps in performing peripheral nerve blocks by direct visualization.

In our study, both groups were comparable with respect to age, gender and weight of the patients and no significant difference was found between the two groups (p-value >0.05) and this helped us to alleviate confounding factors like age and gender which would indirectly have an effect on drug distribution, metabolism and excretion. Weight among the two groups in our study subjects showed a statistical insignificant difference which had helped us to alleviate a point of controversy as obesity as well as cachexia has clinically significant effect on the action of the drug. Similar type of demographic results was found in the study done by Singh G et al. [5], Mani K V et al [6].

In our study, the mean age was 35.7 years among group A and 36.08 years among group B and the majority of patients were in the age group of 30-40 years and there was no statistical significant difference in age between the two groups.

In the year 2017 a study was conducted by Mani K V et al. [6] They also reported that minimum age was 18 years and the maximum age was 68 years and the mean age was 34.5 years among group A and 36.2 years among group B and the majority of patients were in the age group of 30-40 years and there was no statistical significant difference in age between the two groups.

In the present study, we found a male predominance in both the groups. This could be because more number (39 patients in each group) of the male patients had undergone surgery in our institution in this study period. However, this male preponderance had no clinical relevance on the results of the study. A study conducted by Dureja J et al. [7] also found male predominance. Mean weight was 70.96 Kg among group A and 68.46 Kg among group B and the majority of patients were in the 60-70 kg and there was no statistical significant difference in weight between the two groups in our study.

A study conducted by Dureja J et al. [7] found that the majority of patients were between 50-60 kg weights in both groups. There was no statistically significant difference among both the groups in terms of heart rate, systolic blood pressure, diastolic pressure pressure and mean blood pressure at all points of study. The mean time required for performing ultrasound guided technique was 8.04 mins and for PNS, it was 15.92 mins and the difference was found to be statistically highly significant (P<0.001) in our study.

This is supported by study conducted by Ratnawat et al where the procedure time was 8.0 ± 1.53 minutes in group PNS and 6.27 ± 1.10

minutes in group US ($p<0.0001$), thus statistically significant. In another study done by Leslie C. Thomas et al. [8] the time taken for performing PNS (mean=10 mins) was much higher than the USG guided technique (mean=4.3 mins), statistically significant.

The possible reasons for the less time taken in performing ultrasound guided technique could be due to direct visualization of the structures, confidence and accuracy of needle placement and reduction in the number of attempts of needle insertion as supported by Vincent W. S. Chan et al. [9]. It proves that ultrasound guided technique is much faster than the PNS technique. The mean time of onset of sensory block in group A was 16.47 ± 4.05 min, whereas it was 14 ± 3.26 min for group B, p value being 0.001 (statistically significant).

This is supported by the study conducted by Alfred et al [10] in which the mean onset time for sensory and motor block was found to be significantly shorter in Group US (12.83 ± 3.640 min and 23 ± 4.275 min, respectively) when compared to Group PNS (16 ± 3.572 min and 27 ± 3.851 min, respectively).

In our study the duration of analgesia was 823 ± 384 min and 861 ± 353 min in the groups NS and US respectively, with a p value of 0.606 (statistically insignificant). This is supported by another study conducted by Duncan et al where they noted that the duration of analgesia was 429.5 ± 90.79 min and 401.1 ± 105.65 min in the groups US and NS, respectively (statistically insignificant). The mean duration of sensory and motor block was found insignificantly less for group A (898.89 ± 270 seconds and 847.45 ± 310.82 seconds respectively) as compared to group B (917.07 ± 252.35 seconds and 886.76 ± 250.57 seconds respectively) in our study. A similar study carried by Rupera KB et al, they found the 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. 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.

The sonographic imaging-guided supraclavicular block helps in assessing the size, depth, and the exact location along with the anatomy of the adjacent structures. Ultrasound assists in the exact placement of the needle and helps in depositing the local anesthetic in the accurate site and also helps in visualizing the spread of the drug. This, in turn, hastens the onset of the block and may explain the prolonged duration of block seen in our study.

4 patients in the ultrasound guided technique required a supplementation of analgesics for the maintenance of anesthesia, whereas 5 patients in the PNS group had received supplementary analgesia and this difference was found to be statistically insignificant (p-value=0.05) in our study. In our study 2 cases of complete failure of block in PNS group and one case in US group. The difference between both groups was found statistically insignificant.

In a study conducted by Alfred VM et al. [10], five out of thirty patients in Group B (PNS group) required supplementation of analgesia with intravenous Fentanyl, whereas none of the patients in Group A (US group) required supplementation. After applying Fisher's exact t-test, this was not found to be statistically significant (P=0.052). None of the patients in both the groups required conversion to general anesthesia, and hence there was no failure of blocks in both groups.

Singh et al [5] have observed that out of 102 patients, 45 out of 50 (90%) patients had developed successful block with USG, compared to 38 of 52 (73.1%) in Group PNS requiring additional nerve blocks (P=0.028), thus statistically significant.

No clinically significant ECG abnormalities or serious CNS events occurred with the dose of the study drug used. There was no incidence of significant hypotension, bradycardia, arrhythmias or convulsions in either group.

Moore et al noted that the incidence of pnuemothorax using the supraclavicular technique of brachial plexus block is 4% [11-13]. The other complications being hematoma and intravascular injections.

Singh G et al. [11] observed 10% incidence of vessel puncture/ hematoma in Group 2 compared to 3.33% in US group.

One of the most important advantages of using US for brachial plexus block is the direct visualization of the needle tip in relation to the cervical pleura, thus minimizing the chances of an accidental pleural puncture.

In our study, there were no cases of accidental puncture of the subclavian vessels, nor were there any cases of recurrent laryngeal nerve or phrenic nerve blocks. The phrenic nerve palsy was ruled out in all the patients by ultrasound (M mode) and chest X-ray postoperatively.

Renes et al. [14] in their study proved that hemidiaphragmatic paresis can be avoided by US guidance.

In the study done by Liu et al. [15] which compared US-guided axillary block with NS-guided axillary block, they concluded that the incidence of adverse events was significantly higher in the NS group (20%) compared with that in the US group (0%); (P=0.03).

There are various advantages of US guidance in brachial plexus blocks, as it can determine the size, depth, and exact location of the plexus and its neighboring structures. A pre-block anatomical estimation can be done, which can help avoid complications and improve success rates as well as provide confidence to the anesthesia provider.

Yet another advantage of US guidance is that, due to the correct needle placement and visualization of the spread of drug, smaller than usual amount and volume of drug can be used to achieve a satisfactory and dense blockade.

In the study conducted by Searle and Niraj [16], the volume of drug used was as low as 25.7 ± 5 ml, with 84% of the patients reporting that the quality of anesthesia was excellent. Another study was conducted by Harikumar where he observed that 15 ml drug was required for successful block in the group US as compared 25 ml drug for group NS [17].

This will not replace the conventional techniques as the machine itself is not cost-effective and in developing and underdeveloped countries cost is a one of the important factors.

In our study, there was no incidence of nerve injury and pneumothorax in both the groups. This could be because ultrasound facilitates the identification and avoidance of important structures, and direct visualization of local anesthetic spread may reduce dosages and result in selective blocks with higher accuracy and fewer complications and also the peripheral nerve stimulator guides the location of brachial plexus and thus avoids injury to other structures.

Conclusion

The upper limb surgeries performed under the supraclavicular brachial plexus block provides better outcomes as it avoids complications of general anesthesia. Various techniques have been used to make them more safe and precise, that include peripheral nerve stimulator and ultrasound guided technique. Their use reduce the time of the procedure as well as prevents complications like hematoma, pneumothorax as well as ensuring more complete block effect.

Among the two, ultrasound provides more promising effects in terms of significantly reducing the duration of performing the block and also spread of drug can be appreciated under vision. There was significantly lesser duration of performing block in the ultrasound group than nerve stimulator group. The onset of sensory block was also significantly less in the ultrasound group compared to nerve stimulator group. All other parameters including demographic characteristics, hemodynamic parameters, time for rescue analgesia, supplementation with general anesthesia, adverse effects (like bradycardia, hypotension), complications were comparably insignificant among the two groups.

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