Original Article

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Comparison of Nerve Stimulator Guided and Ultrasound Guided Interscalene Brachial Plexus Block in Shoulder Surgery

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Abstract

Introduction: This study was conducted to compare the two techniques, Nerve stimulator guided and Ultrasound guidance for Interscalene brachial plexus block in shoulder and upper arm surgeries.

Methods: Total 80 patients were included in our study which were randomly allotted by sealed envelope technique two groups namely US-guided (Group US) or NS-guided (group NS). The drug mixture of 0.375% bupivacaine and 0.5% lignocaine with 1:200000 adrenaline was used.

Results: Comparison between the Nerve Stimulator (NS) and Ultrasound guided (US) technique of interscalene brachial plexus block revealed that the number of pricks(1-77.5%, 2-20%, 3-2.5% in US group and 1-52.5%, 2-35%, 3-12.5% in NS group), block execution time (5.32(0.50) min in US and 7.10 (0.62) min in NS group), time of onset of sensory and motor block was significantly less in US group ascompare to NS groups. The recovery from sensory (11.9 (1.19) hrs in US and 8.74(0.71) hrs in NS, p=0.0001) and motor block (6.76(0.63) hrs in US and 5.35 (0.48) hrs in NS group, p=0.001) also was significantly longer US group than in NS group. VAS scores were significantly lower in group US group than in NS group in post operative periods. The incidence blockade failure requiring general anesthesia was not significant. Block was successful in 95% of cases in US group and 85% of cases in NS group.

Conclusion: Effective quality of the block, execution time, onset of sensory and motor block, recovery from sensory and motor block and VAS scores were more satisfactory with ultrasound technique than the nerve stimulator technique.

Keywords: Interscalene block; Nerve stimulator; USG guidance.

Introduction

Winnie in 1970 popularized the interscalene approach to the brachial plexus. Interscalene brachial plexus block is recommended in the perioperative management of patients presenting for shoulder and upper arm surgery.[1] Benefits of this technique include excellent intraoperative anaesthesia and muscle relaxation, better postoperative VAS scores, and lower incidences of nausea and vomiting. Moreover, it is more cost effective compared to general anaesthesia.

The use of a peripheral nerve stimulator (PNS) had been considered 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

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needle placement to produce regional anaesthesia/ analgesia. However, with recent developments in high-frequency imaging, the use of ultrasound (US) technology has significantly increased for nerve localization.[2]

Ultrasonography seems to be the most suitable image modality for regional anaesthesia.[3] Perhaps the most significant advantage of ultrasound technology is the ability to provide anatomic examination of the area of interest in real time, allowing one to visualize neural structures (plexus and peripheral nerves) and the surrounding structures (e.g. blood vessels and pleura), navigate the needle toward the target nerves, and visualize the pattern of local anaesthetic spread, whereas, nerve stimulation guidance is useful only when a motor response is elicited. Nerve stimulator provides objective but indirect evidence of nerve location.[4]

We conducted the study to evaluate ultrasound-guided nerve detection in an interscalene brachial plexus block and to compare it with nerve stimulator-guided nerve detection and to compare ultrasound guided interscalene nerve block with nerve stimulator guided interscalene nerve block in terms of simplicity, safety, and efficacy.

Materials and Methods

The study was performed at the Department of Anaesthesiology at our hospital which is a rural tertiary care hospital and medical college. After clearance from the ethical committee of the institute, study was initiated on patients meeting the study requirements from a period spanning over 2019-2020.

Study Population & Design

A total of 80 patients aged between 18 and 60 years of either sex with ASA status I and II posted for elective upper arm and shoulder orthopedic surgeries (proximal humerus, shoulder) under interscalene brachial plexus block was randomized into two equal groups in a prospective randomized manner by sealed envelope technique. The participants were explained in details about the study and were included after written informed consent.

The groups were as follows:

A) "Group US(Ultrasound group)" received interscalene brachial plexus block under USG guidance.

B) "Group NS(Nerve stimulator)" received interscalene brachial plexus block under peripheral nerve stimulation.

Selection of Cases

Inclusion criteria:

- American Society of Anaesthesiologist I and II patients.
- Patients of age 18 years to 60 years posted for upper limb surgery including shoulder and upper arm surgeries.
- Either male or female.
- Haemodynamically stable patient with HR>60/min, SBP>110mmHg.

Exclusion criteria:

- Patients refusing to voluntarily participate in the study
- Pre-existing peripheral neuropathy of upper limb as well as any nerve injury due to trauma
- Patients with difficult airway coming under MPC grade III and above
- Patients with infection at injection site
- Patients with pneumothorax/ History of severe cardiac/ respiratory/ renal/hepatic or bleeding disorders.
- Pregnancy
- Known hypersensitivity to the study drugs.

Anesthesia Technique

Patients received supplemental oxygen through a nasal canula (3 l/min). A wide-bore, 18G intravenous canula was inserted and fluid Ringer's lactate was started at 100 ml/hr. Patients were sedated with inj. midazolam 1mg, intravenously and inj. fentanyl 1 mcg/kg or 50 micrograms whichever is maximum intravenously to maintain moderate sedation.

The sealed envelope was opened by non-participating Anaesthesiologist and the respective equipment (either US or PNS) accordingly was made ready and the drugs were loaded maintaining sterility.

The drug that was to be used is a mixture of 0.375% bupivacaine and 0.5% lignocaine with 1:200000 adrenaline. Doses used were 15 ml of 0.5% bupivacaine and 5ml of 2% lignocaine with adrenalin, mixed up in a syringeup to 20 ml, giving final concentration of 0.375% Bupivacaine and 0.5% Xyloacine Adrenaline (or up to 2 mg/ kg bodyweight of bupivacaine and 5mg/kg of

lignocaine adrenaline whichever is maximum volume made up to 20 ml with distilled water). The patients were positioned supine with the arms by the side and head turned to the opposite side by 45°. The proposed site of block was aseptically prepared with chlorhexidine 4% and draped with exposure allowed for the block site.

In the ultrasound group

Patient was placed in a supine position, with the patient's head facing away from the side to be blocked. A slight elevation of the head of the bed was done to make the the patient more comfortable and allows for better drainage and less prominence of the neck veins. The patient was asked to reach for the ipsilateral knee in order to lower the shoulder and provide more space for the block performance.

Scanning usually begins just below the level of the cricoid cartilage and medial to the sternocleidomastoid muscle with the goal of identifying the carotid artery.

A 5 cm 22 G short bevel needle was then inserted in-plane toward the brachial plexus, typically in a lateral-to-medial direction, after a local anesthetic infiltration of the skin. The needle was advanced along the long axis of the transducer in the same plane as the ultrasound beam. The needle aimed in between the roots instead of directly at them in order to minimize the risk of accidental nerve injury. As the needle passes through the prevertebral fascia, a "pop" can often be appreciated. After careful aspiration to rule out intravascular needle placement, the drug was injected in increments of 5 ml, with careful aspiration after each increment. The pattern of local anesthetic spread around the target nerves was observed in real time during the injection. It is necessary to ensure that high resistance to injection is absent to decrease the risk of intrafascicular injection. Injection of several milliliters of local anesthetic often displaces the brachial plexus away from the needle. Additional advancement of the needle 1–2 mm toward the brachial plexus may be beneficial to ensure the proper spread of the local anesthetic. The needle shaft and tip was visualized in real time as the needle is advanced toward the target nerves.

In the nerve stimulator group:

The interscalene brachial plexus blockade was performed using Meier's approach and the roots of the brachial plexus was identified with the aid of a nerve stimulator (Stimuplex HNS 12, B-Braun, Germany) and a 5cm 22G insulated stimulating needle with a stimulation frequency of 2Hz, a pulse duration of 0.15 ms, and an initial intensity of stimulating current of 1mA. Patient was placed in a supine position, with the patient's head facing away from the side to be blocked. The landmarks for low interscalene block were identified, i.e: clavicle, posterior border of the clavicular head of the sternocleidomastoid muscle and external jugular vein. The palpating hand was not be moved during the entire procedure to allow for precise redirections of the needle. Interscalene groove was identified by rolling the finger posterior to sternocleidomastoid muscle between the belly of the anterior and middle scalene muscle at the level of cricoid cartilage. Skin over the insertion site was infiltrated with local anesthetic. The stimulating needle (2-inch, 22-gauge Stimuplex insulated needle) was connected to a nerve stimulator at an initial current intensity of 1 mA was inserted between the palpating fingers and advanced at an angle almost perpendicular to the skin and in a slight caudal directionand advanced until it elicits motor responses in the distribution of the axillary, musculocutaneous or radial nerve.

The current was gradually decreased to a range of 0.4 mA, with a persistent acceptable motor response.

After careful aspiration to rule out intravascular needle placement, the drug was injected in increments of 5 ml, with careful aspiration after each increment. After the injection of the local anesthetic, the sensory and motor block was tested at a 5 min interval starting after the completion of injection of the local anesthetic as follows:

- Testing the sensory block by loss of sensation over the upper lateral aspect of the upper arm in the distribution of the C6 dermatome. The onset of sensory block was taken as the time interval between the completion of drug injection and the complete loss of pinprick sensation.
- Testing the motor block by inability to elevate the arm (deltoid sign). The onset of motor block was taken as the time interval between the completion of drug injection and the inability to elevate the arm.

Intraoperative sedation was provided with intravenous inj. fentanyl 25 micrograms every hourly with the first dose of 25 micrograms being given after half an hour of the first dose of 50 micrograms given before performing the nerve block on patient, titrated to achieve moderate sedation. Intraoperative oxygen saturation monitoring was continued. Hemodynamics monitoring standard

observed every 5 minutes and recording was done every 10 minutes in the chart.

In case of failure of block to achieve adequate sensory and motor blockade is noted, the patient received General Anesthesia with Endotracheal tube and operation was performed under general anesthesia. The same was noted in data sheet. The time given for deciding failure of block and using general anesthesia for the patient was 30 minutes after the block is performed.

At the conclusion of surgery, patients were transferred to the postanesthetic care unit. When patients had fulfilled the standard postanesthetic care unit discharge criteria, they were transferred to the unit. Patients were asked to rate their pain using a visual analogue pain scale (VAS) (0=no pain to 10=worst pain imaginable) on arrival in PACU and every 2 hourly thereafter till rescue analgesia is needed. The time for rescue analgesic was noted. The patient was monitored for recovery from nerve blockade both in terms of sensory and motor blockade.

Definitions

Block execution time: In the group US, time is started after the time of initial scanning and identification of anatomical structures from insertion of 22g Stimuplex needle and ended at the removal of the needle after local anaesthetic drug has been administered.

In the group NS, the time is started after identification of anatomical landmark for interscalene block and interscalene groove palpated from insertion of 22G Stimuplex insulated stimulating needle needle attached to PNS machine and ended at the removal of the needle after local anaesthetic drug has been administered.

Time of onset of sensory block: It was assessed by pin prick and cold application every 2 min till the onset of sensory block. The time from the removal of block needle to the time when the patient first says he/she has reduced sensation when compared to the opposite limb.

Time of onset of motor block: The onset of motor blockade was assessed every 3 min till the onset of motor block. It is the time of removal of the block needle to the time when the patient had weakness of any of the two joints – Shoulder and elbow upon trying to perform active movements.

Recovery fron sensory and motor block: Postoperatively, patients were supplemented with analgesics when they complained of pain or had a VAS score of more than 4, and the duration of analgesia was recorded. The recovery from sensory block was defined as the interval between the onset of sensory block and the first dose of analgesic medication. The recovery from motor block was defined asthe interval between the onset of motor block and regain of motor power of 4/5 was achieved at elbow and shoulder joints.

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 was defined as the absence of full sensory block in at least one dermatome and conversion of regional anaesthesia to general anaesthesia as assessed after 30 minutes of performing block.

Patient satisfaction criteria: Patient satisfaction score for anesthesia and comfort at the end of surgery (after 1 hour of shifting in the post operative ICU) was noted on a numerical subjective scale of 1-5 with 1 being dissatisfied and 5 being completely satisfied.

Statistical Analysis

A structured data entry form was utilized to record the findings at various points in the study. Excel spreadsheet (Microsoft Corp) was used for electronic data entry. All statistical analysis was done by using descriptive and inferential statistics using chisquare test and student's unpaired t test and software used in the analysis were SPSS 24.0 version and GraphPad Prism 7.0 version and $p<0.05$ is considered as level of significance.

The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000.

Results

A total of 80 patients aged between 18 and 65 years of either sex with ASA status I and II posted for elective upper arm and shoulder orthopedic surgeries (proximal humerus, shoulder) under interscalene brachial plexus block was randomized into two equal groups in a prospective randomized manner by sealed envelope technique.

Mean age of the study population was 40.4years and 70% were men. Demographic details have been explained in Table 1.

Table 1: Comparison of the baseline demographic characteristics

of US group and NS group.

Variables	US group (n-40)	NS group(n-40)	p value
Age in years, n(SD)	39.42(12.28)	40.60(13.57)	0.77
Gender,male n(%)	31(77.5)	29(72.5)	0.26
BMI, n(%)	29.10(3.20)	29.20(3.27)	0.14
MPS grading, grade 1, n(%)	27(67.5%)	30(75%)	0.54
Baseline Heartrate, mean(SD)	86.28(8.30)	89.08(7.92)	0.127
Systolic Blood Pressure, mean(SD)	136.45(6.32)	137.05(6)	0.664
Diastolic Blood Pressure, mean(SD)	84.38(5.27)	87.90(4.06)	0.001
Oxygen saturation, mean(SD)	98.20(0.72)	97.65(2.95)	0.257
Respiratory rate, mean(SD)	15.65(1.08)	15.43(1.11)	0.35

Vital parameters were monitored throughout the procedure (Table 2).

Table 2: Comparison of the vital measures at the different time points of US group and NS group.

Variables	US group (n-40)	NS group(n-40)	p value
Respiratory rate, (breaths/min)			
RR@10min	13.53(1.09)	13.35(0.89)	0.433
RR@30min	11.40(1.13)	12.18(1.08)	0.002
RR@60min	12.08(1.29)	12.30(1.09)	0.402
Heartrate, (beats/min)			
HR@10min	81.60(7.85)	85.63(7.89)	0.025
HR@30min	77.78(7.59)	79.33(5.71)	0.305
HR@60min	69.35(5.57)	71.93(8.08)	0.101
Systolic Blood Pressure, (mm Hg)			
SBP@10min	134.40(6.47)	135.93(6.21)	0.285
SBP@30min	116.88(6.31)	119.43(6.34)	0.075
SBP@60min	120.45(7.27)	117.80(6.65)	0.093
Oxygen Saturation, (%)			
Spo2@10min	98.27(0.55)	97.67(2.62)	0.161
Spo2@30min	98.45(0.84)	98.32(2.52)	0.767
Spo2@60min	98.52(0.75)	98.42(2.38)	0.801

We observed time taken for identification of anatomical structure, time to perform block, time to onset of sensory and motor block was significantly lower in Ultrasound group compared to nerve stimulator group(Table 3)

Table 3: Comparison of the operative data of the studied cases of US group and NS group.

Variables	US group (n-40)	NS group (n-40)	P value
Time taken for Identification of anatomical structure and landmarks (min), mean(SD)	1.93(0.46)	2.36(0.37)	0.0001, S
Number of pricks	one in 31(77.5%) two in 8(20%) three in 1(2.5%)	one in 21(52.5%) two in 14(35%) three in 5(12.5%)	0.04, S
Time to perform block (min),mean(SD)	5.32(0.50)	7.10(0.62)	0.0001, S
Onset of sensory block (min) ,mean(SD)	6.80(1.31)	10.80(1.06)	0.0001, S
Onset of motor block (min)	7.76(0.50)	12.30(0.83)	0.0001, S
Duration of surgery(hours), mean(SD)	2.04(0.29)	2.38(0.30)	0.41, NS

During the postoperative period, we found time to recovery of patient from sensory block and motor block was significantly lower in ultrasound group compared to nerve stimulator group. Sucess rate of both US group and NS group were comparable (Table 4).

Table 4: Comparison of the postoperative data of the studied cases of US group and NS group.

Variables	US group (n-40)	NS group (n-40)	P value
Recovery from sensory block(min), mean (SD)	11.90(1.19)	8.74(0.71)	0.0001, S
Recovery from motor block(min), mean(SD)	6.76(0.63)	5.35(0.48)	0.0001, S
Conversion to GA	2(5%)	6(15%)	0.13, NS
Complication rate, n(%)	3(7.5%)	6(15%)	0.28, NS
Patient satisfaction score, mean(SD)	4.62(0.49)	3.82(0.55)	0.0001, S

We found VAS scores were lower with in ultrasound guided interscalene brachial plexus block than with nerve stimulator guided interscalene brachial plexus block. (Figure 1)

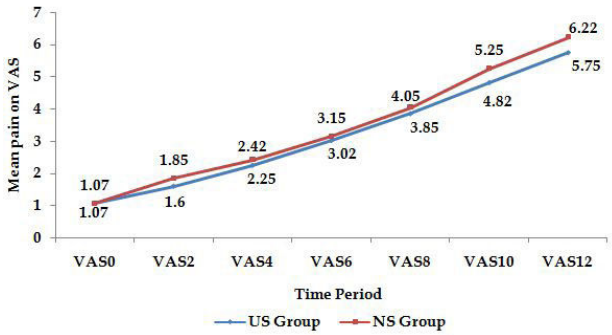

Fig. 1: The VAS score in group US was less than group NS, which is statistically significant at post-operative 2nd hour, 10th hour and 12th hour.(p value 0.0001).

Discussion

Peripheral nerve blocks are cost effective anesthetic techniques used to provide good quality anesthesia and analgesia while avoiding airway instrumentation and hemodynamic consequences of general anesthesia. Patient satisfaction, a growing demand for cost effective anesthesia and a favorable postoperative recovery profile have resulted in increased popularity for regional techniques. Regional anaesthesia has many benefits including reduced morbidity and mortality as compared to general anesthesia.[5,6] superior postoperative analgesia,[7] cost-effectiveness,[8] and a lower rate of serious complications. Brachial plexus block is an easy and relatively safe procedure for upper limb surgeries. Various approaches like supraclavicular, interscalene, infraclavicular and axillary have been used for blocking the brachial plexus. Interscalene approach to brachial plexus block is associated with rapid onset and reliable anesthesia.[9]

A study done in 2008 by Kapral et al on 160 patients to compare success rate of interscalene block ultrasound guidance vs PNS in patients with trauma related shoulder and upper arm surgeries found that Surgical anesthesia was achieved in 99% of patients in the ultrasound vs 91% of patients in the nerve stimulation group (P <.01). Sensory, motor, and extent of blockade was significantly better in the ultrasound group when compared with the nerve stimulation group.[10]

Marhofer et al compared onset time of block and sensory block between ultrasound guidance and PNS and found that the onset time and the quality of a regional anesthesia is improved by ultrasonographic nerve identification compared with PNS.[11]

A randomized controlled prospective study done by sauter et al on 80 patients found block performance time was comparable between ultrasound guidance and PNS (4.3 min vs 4.1) and Onset time for sensory block was also comparable between the two (13.7 min vs 13.9 min). The time until readiness for surgery was also comparable between both groups (18.1 min). There was no statistical difference in median discomfort related to the block procedure and median tourniquet time. There was no statistical differences in success rates between USG group vs PNS group(85% vs 95%).[12]

Yuan Jia-min, et al (2012) studied success rate and complications in the ultrasound guided brachial plexus blockade. They included Sixteen trials involving 1321 adults blocks performed using US guidance were more likely to be successful (risk ratio (RR) for block success 0.36, 95% CI 0.23–0.56, P <0.00001). There was decreased incidence of vascular puncture during block performance (RR 0.13, 95% CI 0.06–0.27, P <0.00001) & decreased the risk of complete hemi-diaphragmatic paresis (RR 0.09, 95% CI 0.03–0.52, P=0.0001). They concluded that Ultrasound decreases risks of complete hemi-diaphragmatic paresis or vascular puncture and improves success rate of brachial plexus nerve block compared with techniques that utilize PNS for nerve localization. Larger studies are needed to determine whether or not the use of US can decrease risk of neurologic complications.[13]

McNaught A et al (2011) concluded that ultrasound reduces the number of attempts, LA volume, and postoperative pain when compared with NS for interscalene block.[14]

A prospective randomized trial done by casati et al found lower number of needle passes in US group compared to NS group (4 vs 8) and onset of sensory block was shorter in group US than in group NS whereas no statistical differences were observed in onset of motor block and readiness to surgery. Procedure-related pain was reported lesser in US group; patient acceptance was similarly good in the two groups.[15]

A systematic review and meta-analysis done by Abrahams et al. [16] which included 13 RCTs found Ultrasound improves efficacy of peripheral nerve block compared with PNS technique for nerve localization and further larger studies are needed to determine whether Ultrasound can decrease the number of complications such as nerve injury or systemic local anaesthetic toxicity.

Similarly another meta-analysis done by Walker et al which included 18 studies concluded that in experienced hands, ultrasound provides at least as good success rates as other methods of peripheral nerve location and ultrasound may reduce complication rates and improve quality, performance time, and time to onset of blocks.[17] In contrast to above studies, a study done by Liu et al[18] on 250 patients found no difference between needle stimulator and USG guidance in terms of time to perform the procedure however there was less number of needle passes in USG guidance group. Study done by Caseti et al found rapid onset of block and prolonged duration of block in Ultrasound guidance group.[19]

Numerous studies have been done comparing success rates between nerve stimulator and US guidance. Study done by Maher et al[4] found no statistically significant difference in the success rate in both groups. In agreement with this study, studies done by Schwemmer U et al[20], Marhofer P et al[21], Williams SR et al[22] also found no difference in success rates between both groups. In contrast Kapral et al[10] and Chan et al[23] found higher success rate among USG group compared to nerve stimulator group 99% vs 91% and 95% vs 85% respectively.

Conclusion

It may be reasonable to conclude that USG guided interscalene block characteristics gave superior results when compared with PNS guided interscalene block in terms of parameters like identification of anatomical structures - landmarks, block execution times, faster onset as well as prolonged duration time of sensory and motor blocks and lower pain scores. However the success rates and conversion to General Anesthesia rates were comparable between the USG and PNS guided blocks.

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