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Randomized controlled study between ultrasound versus peripheral nerve stimulator for supraclavicular brachial plexus block

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ABSTRACT

Supraclavicular brachial plexus (SCBP) block provides effective regional anaesthesia to upper extremity. SCBP block can be performed by peripheral nerve stimulator (PNS) guided or ultrasound (USG) guided technique. An attempt was made in the present study to compare efficacy of SCBP block administered by using USG guidance Vs. PNS guidance. Eighty patients scheduled for elective upper limb surgery were randomly divided into two groups. Group USG, and Group PNS received ultrasound guided and peripheral nerve stimulator SCBP block respectively using Inj. bupivacaine. Primary outcome measures were success rate, onset and duration of sensory neural blockade, and need for supplementation of analgesia. Secondary outcome measure was complications. Comparison of quantitative and qualitative variables was done using unpaired student's "t" test and chi-square test or Fisher's exact test respectively. Success rate was significantly higher in USG group (90.0 %) than PNS group (72.5 %). Mean time taken to give block was significantly longer in USG (15.6 minutes) than PNS (10.0 minutes) technique. Mean onset of sensory blockade was significantly earlier in USG (9.2 minutes) than PNS (10.6 minutes) group. Percentage of patients who required supplementary analgesia was significantly higher in PNS (27.5 %) than USG group (10.0 %). Four (10.0 %) and 11 (27.5 %) patients required conversion to general anaesthesia in USG group and PNS group respectively (p=0.001). USG guided SCBP block has high success rate, quick onset of sensory block, less requirement of supplementary analgesia, and less conversion to general anaesthesia as compared to PNS group.

INTRODUCTION

Supraclavicular brachial plexus (SCBP) block provides consistently effective regional anaesthesia to the upper extremity.[1] The SCBP block can be performed by blind; peripheral nerve stimulator (PNS)-guided or ultrasound (USG)-guided technique.

The classical approach using a blind technique may be associated with higher failure rate and injury to the nerves and vascular structures.[2] PNS has been the 'gold standard' for peripheral nerve blocks for determining adequate needle placement to produce regional anesthesia.[3] When a nerve block is performed with a nerve stimulator, a muscle twitch obtained at low output indicates close proximity to the nerve, and this translates into better success rates. Several advantages have been claimed with this technique, including a higher success rate, avoidance of vascular injury, avoidance of paresthesia's and associated neurological injury.[4-6] The failure rate in PNS assisted SCBP block varies from 1.2% to 12%.[7]

The use of USG with numerous artifacts (acoustic and anatomic) can result in prolonged procedure times, failed blocks, and patient injury.[8] The use of ultrasound for nerve blocks was first reported by La Grange P et al in 1978, who performed SCBP

block with the help of a Doppler USG blood-flow detector to aid identification of the subclavian artery and vein.[9] 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.[10,11]

Whether use of USG can improve practitioners' ability to successfully perform peripheral nerve blocks remains controversial. An attempt was made in the present study to compare efficacy of SCBP block administered by using USG guidance Vs PNS guidance.

MATERIALS AND METHODS

This randomized controlled study was conducted between July 2017 and July 2018. After approval from the scientific advisory committee and institutional ethics committee, written informed consent was obtained from all the patients. Patients aged 18 to 50 years of age scheduled for elective upper limb surgery belonging to American Society of Anaesthesiologist (ASA) grade I and II were included. Patients with coagulopathy, peripheral neuropathy, and patient with history of allergy to local anaesthetic agent were excluded from this study.

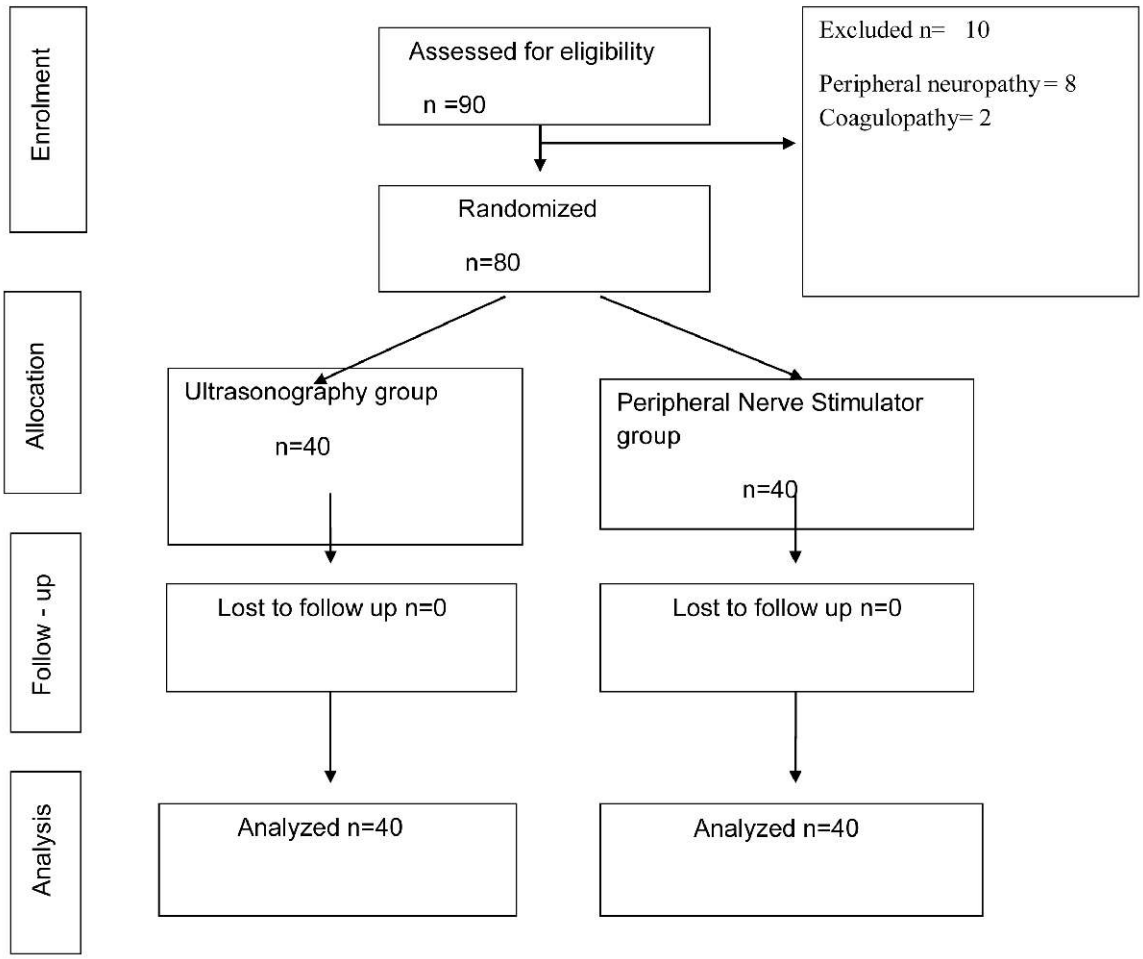
Out of 90 patients assessed for eligibility, after exclusion 80 patients were randomly divided into two equal groups of 40 each, using computer generated randomization code (Fig 1). We used sealed envelope for randomization with block size four. Group USG, and Group PNS received ultrasound guided and peripheral nerve stimulator SCBP block respectively using Inj. bupivacaine (0.25%). Ultra sound machine, Transducer of frequency 10-15 MHz, and peripheral nerve stimulator with 22-guage, 5cm, short-bevel insulated needle were used.

Patients underwent routine pre- anaesthetic evaluation and were premedicated with diazepam 10 mg (oral) on the previous night of surgery. Patients were explained about the procedure. On day of surgery, routine protocols were followed. Intravenous (IV) line was secured on the opposite side of the limb undergoing surgery. With all aseptic precautions SCBP block was performed using 25 mL 0.25% bupivacaine local anaesthetic drug by either of the approaches. Blocks were performed under standard monitoring with pulse oximetry, noninvasive blood pressure measurement, heart rate, and ECG.

USG guided SCBP block

Position of the patient was supine with head slightly turned to contralateral side of operative arm. After skin and transducer preparation, a linear 38 mm high frequency 10-15 MHz transducer was firmly placed over supraclavicular fossa in the coronal oblique plane to obtain the best possible transverse view of subclavian artery and brachial plexus. The machine imaging capability was optimized by selecting the appropriate depth of field (within 2-3cm), focus range and gain. Trunks or divisions,

Fig. 1 : CONSORT DIAGRAM



vascular structures, 1st rib and brachial plexus were identified. After visualisation of the nerve, drug was injected around the nerve.

PNS guided SCBP block

Position of the patient was supine with head slightly turned to contralateral side of operative arm. After identifying the lateral insertion of sternocleidomastoid muscle on clavicle, the plexus was located by palpation. Once the plexus was found, the point of needle insertion was located immediately cephalad to palpating finger. The nerve stimulator was connected to stimulating needle and 0.8 to 1.0 mA current was delivered at 1 Hz frequency and 0.1 ms of pulse duration. The needle was inserted first in an antero-posterior direction, perpendicularly to skin with a slight caudal orientation. The needle was slowly advanced until the upper trunk was identified by a twitch of the shoulder muscles or up to 1 cm, if there was no response. Then needle was advanced caudally with a slight posterior angle, this directed needle from the vicinity of upper trunk (shoulder twitch) to the front of medial trunk (biceps, triceps, pectoralis twitch) on its way to lower trunk (finger twitch).After location of brachial plexus, aspiration for the blood was performed before incremental injections of a total volume of 20-30 mL of local anaesthetic drug.

In the USG group, block execution time was calculated from the time of initial scanning to the removal of the needle, whereas in PNS group, it was the time from insertion of the needle to its removal. Sensory block onset time was assessed by pin prick and cold application every 2 minutes till the onset of sensory block. The time from the removal of block needle to the time when the patient first said he/she has reduced sensation when compared to the opposite limb. Patients were observed for intraoperative side effects, such as nausea, vomiting, dry mouth, hypotension, bradycardia, and vascular puncture. Intraoperative requirement of supplementation of analgesia was noted.

Onset of the sensory block was defined as the time between the injection and the complete abolition of pin prick sensation. Patient was asked to compare a pinprick sensation at every 5 min up to 30 min in the central sensory region of a presumably anaesthetized nerve with the same stimulus on the contralateral arm.

Sensory block score scale was defined as:

Normal sensation = 0, Blunted sensation = 1, No sensation = 2

Score 2 was taken as onset of sensory block.

Data was collected every 3 minutes for first 15 minutes. Next every 5 minutes for 15 minutes and after the completion of surgery sensory blockade was assessed every 30 minutes till the complete recovery of blockade.

Primary outcome measures were success rate, onset and duration of sensory neural blockade, and need for supplementation of analgesia. Secondary outcome measure was complications if any. On the basis of a previously published study, [12] a sample size of 30 patients in each group was calculated by a formula [13] with 80 % power and 5 % probability of Type I error to reject null hypothesis. Forty patients were included in each group to validate the result.

Statistical Analysis

Data collected were entered in Excel 2007 and analysis of data was done using Statistical Package for Social Sciences for Windows, Version 20.0. IBM Corporation Armonk, NY, USA. The comparison of quantitative variables between the groups such as mean age, mean time taken to give block, mean onset of sensory block, and mean duration of block was done using unpaired student's “t” test, whereas comparison of qualitative variables such as gender, supplementary analgesia requirement, and complications was done by using Chi-square test or Fisher's exact test. The confidence limit for significance was fixed at 95% level with p-value < 0.05.

Table 1 : Baseline characteristics

Characteristics	Group USG N = 40	Group PNS N = 40	Total	P value
Mean age in years ± SD	33.9± 8.1	34.5± 8.7		0.729*
Gender (%)				
Male	22 (55.0)	21 (52.5)	43 (53.7%)	0.823***
Female	18 (45.0)	19 (47.5)	37 (46.3%)	

*Unpaired 't' test was used

***Chi square test is used

USG- Ultrasonography

PNS- Peripheral nerve stimulator

SD- Standard deviation

RESULTS

Out of 90 patients assessed for eligibility, 10 were excluded because of peripheral neuropathy (8), and coagulopathy (2). In this study, 80 patients were randomized into two groups. USG group received USG guided SCBP block using Inj. bupivacaine (0.25%) whereas PNS group received SCBP block using Inj. bupivacaine (0.25%). There was no statistically significant difference between USG group and PNS group in relation to mean age, and gender (Table 1).

Mean time taken to give SCBP block was significantly higher in USG as compared to PNS technique. Mean onset of sensory blockade was significantly less in USG than PNS group. Percentage of patients who required supplementary analgesia was significantly higher in PNS than USG group. Percentage of patients who required conversion to general anaesthesia was significantly higher in PNS than USG group. Success rate was significantly higher in USG than PNS group. There was no statistically significant difference in mean duration of sensory blockade, and incidence of complications between the two groups (Table 2).

Table 2 : Comparison between USG and PNS groups

Characteristics	Group USG N = 40	Group PNS N = 40	Total	P value
Mean time taken to give block in minutes ± SD	15.6± 4.6	10.0± 3.6		0.001*
Mean onset of sensory block in minutes ± SD	9.2± 2.9	10.6± 2.7		0.021*
Mean duration of sensory blockade (in minutes) ± SD	499.5± 74.8	474.5± 127.5		0.288*
Supplementary requirement of analgesia (%)				
Yes	4 (10.0)	11 (27.5)	15 (18.7%)	0.045**
No	36 (90.0)	29 (72.5)	65 (81.3%)	
Complications (%)				
Yes	2 (5.0)	6 (15.0)	8 (10.0%)	0.136**
No	38 (95.0)	34 (85.0)	72 (90.0%)	
Success rate (%)				
Yes	36 (90.0 %)	29 (72.5 %)	65 (82.5 %)	0.001**
No	4 (10.0 %)	11(27.5 %)	15 (17.5 %)	
Conversion to general anaesthesia (%)				
Yes	4 (10.0 %)	11(27.5 %)	15 (17.5 %)	0.001**
No	36 (90.0 %)	29 (72.5 %)	65 (82.5 %)	

*Unpaired 't' test was used **Fisher's exact test was used

USG- Ultrasonography PNS- Peripheral nerve stimulator SD- Standard deviation

In our study, accidental vascular puncture was observed 2 and 6 patients in USG and PNS groups respectively. All the block failures were managed with general anesthesia. We monitored hemodynamic vital parameters such as pulse rate, systolic and diastolic blood pressure and oxygen saturation periodically with appropriate monitors. There was no statistically significant difference in hemodynamic vital parameters between two groups.

DISCUSSION

In our study, we found success rate was significantly higher in USG than in PNS group as ultrasound shows real time image of plexus and visualization of needle also confirms distribution of drug around plexus. Time taken to give SCBP block was significantly higher in USG as compared to PNS technique as use of ultrasound requires understanding of sono anatomy and technique of maneuvering the USG probe, image quality, image resolution, depth, gain of image hence require more time. Onset of sensory blockade was earlier with USG than PNS. Duration of blockade was similar in both groups. Complications were more with PNS than USG because ultrasound block is performed under vision but the difference was not statistically insignificant.

Rupera KB et al [14] reported that mean procedure time in USG group and PNS group was 4.55 ± 0.74 minutes and 5.71 ± 0.92 minutes respectively (p <0.0001). Williams SR et al[11] reported that the block was performed in an average of 9.8 minutes in Group PNS and 5.0 minutes in Group USG (P = 0.0001). Revathi K [15] reported that the mean time required to administer a block was 5.4 minutes and 10.1 minutes in PNS and USG group respectively. Ahamed. Daba et al [16] reported that time for procedure was 7.3 minutes and 12.5 minutes for USG guided and PNS guided SCBP block respectively (p <0.05), In our study, time taken to give SCBP was 15.6± 4.6 minutes and 10.0± 3.6 minutes in USG and PNS group respectively (p=0.001).

Rupera KB et al [14] reported that onset time for sensory block was 2.97 ± 0.72 minutes and 3.63 ± 0.76 minutes in USG group and PNS group respectively (p =0.002). In our study, we observed that the mean onset time of sensory blockade was significantly less in USG group (9.2 minutes) than PNS group (10.6 minutes) [p=0.021].

Rupera KB et al [14] reported that duration of sensory block in USG group and PNS group was 5.29 ± 0.82 h and 4.73 ± 0.81 h respectively (p =0.015). Revathi K [15] reported that the mean duration of blockade was significantly higher in Group USG group (286.2 ± 42.3 minutes) than PNS group (204.4 ± 28.5 minutes). In our study, there was no statistically significant difference in mean duration of blockade between USG (499.5 minutes) and PNS group (474.5 minutes).

Rupera KB et al [14] reported that success rate in USG group and PNS group was 29/30 (96.67 %) and 24/30 (80.0 %) respectively (p =0.047). Ahamed. Daba et al [16] reported that success rate was 24/25 (96.0 %) and 10/25 (40.0 %) for USG guided and PNS guided SCBP block respectively (p <0.05), Revathi K [15] reported that in USG group overall success rate was higher than PNS group but there was no statistically significant difference between the groups. In our study success rate was 36/40 (90.0%) and 29/40 (72.5%) in USG group and PNS group respectively (p=0.001). The data from other studies were consistent with our findings and suggestive of an improvement in block success rates with USG. [17,18]

Williams SR et al [11] reported that no patient in Group USG and 8% of patients in Group PNS required general anesthesia (P=0.12). In our study 4/40 (10.0%) and 11/40 (27.5 %) patients required conversion to general anaesthesia in USG group and PNS group respectively (p=0.03).

Williams SR et al [11] reported that no major complication occurred in either group. Ahamed. Daba et al [16] reported that complications were 0 and 2/25 (8.0 %) for USG guided and PNS guided SCBP block respectively. Kapral et al [19] reported that there were no complications such as vessel puncture, paresthesia or pneumothorax in their study of USG guided SCBP block. Revathi K [15] reported that there were fewer complications in USG group, but the difference was not statistically significant. Similar studies with no or less incidence of complications by USG technique have been reported. [14,19] In our study, accidental vascular puncture was observed 2/40 (5.0 %) and 6/40 (15.0 %) patients in USG and PNS groups respectively (p=0.136). The data from other study was consistent with our findings with lesser rate of complication within USG group.[20]

Limitations: Only 80 patients were included in this study. There was unfeasibility to blind patients and anesthesiologists. Variations in skill of the anesthesiologists were also not taken into account. A study with a large number of patients will give us better idea about the efficacy of USG over PNS technique for SCBP block.

CONCLUSION

Success rate was significantly more in USG group than PNS group. Mean time taken to give block was longer in USG than PNS technique. Mean onset of sensory blockade was earlier in USG than PNS group. Duration of sensory blockade was similar in both groups. Percentage of patients who required supplementary analgesia was significantly higher in PNS than USG group. Percentage of patients who required conversion to general anaesthesia was significantly lower in USG group and PNS group. Though there was no statistically significant difference in incidence of complication between the two groups, vessel puncture was more in PNS technique.

Conflict of interest: Dr. Sumeet Patil, Dr. Sucheta Lokare, Dr. Rajendra Gosavi, and Dr. Deepak Phalgune declare that they have no conflict of interest

The manuscript has been read and approved by all the authors, that the requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work

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