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To Compare the Efficacy & Safety of Nerve Stimulation Method with Ultrasound Guidance along With Nerve Stimulation alone for Supraclavicular Brachial Plexus Block

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Abstract
There are several well-established techniques for performing peripheral nerve blocks including paresthesia, nerve stimulation and by using ultrasound. Those advocating the use of nerve stimulators claim that apart from a comparable success rate and shorter time for block placement this technique may be performed on heavily sedated or anesthetized patients and even in a patient who is not so cooperative since it provides exact needle localization without the elicitation of a paresthesia. However this technique needs skills, knowledge and expertise by routinely doing it. This study compared the success rate of classical supraclavicular approach of Brachial plexus block given with the aid of a nerve stimulator and nerve stimulator along with ultrasound. Eighty patients were randomized into two groups of forty each. In group 1, brachial plexus block was given by nerve stimulation and in group 2 with the aid of an Ultrasound along with nerve stimulation. The success rate of block was more in ultrasound group than nerve stimulation group though not statistically significant. There was completeness of the block of in 90 % of patients in group 2 and 75% of patients in group 1. The mean time taken for performance of block/time taken for the procedure was 10.375 min in group 1 while in group 2it was significantly shorter (6.25mins).Onset of sensory and motor blockade was shorter in ultrasound group than in nerve stimulation group. Duration of analgesia was longer in group US and it was statistically significant. It was also noted that there was no incidence of vessel punctures, nerve injuries and pneumothorax in the ultrasound group. In conclusion, ultrasound guided technique is safe and effective means of performing peripheral nerve blockade with a comparable success rate.
Keywords: *peripheral nerve blocks, paresthesia, supraclavicular, Brachial plexus, nerve stimulator, ultrasound.*

Introduction

The idea in the practice of regional anaesthesia would be the ability to precisely deliver to the target nerve exactly the right dose of local anaesthetic without incurring any risk of damage to the nerve or its related structures taking in

consideration that nerves are not blocked by the needle but by the local anaesthetic around**.** The introduction around 30 years ago of electric stimulation (ES) as an objective means for identifying needle-nerve proximity was an integral step towards transforming regional anesthesia into a'science'[1] .

Brachial plexus blockade is a time tested technique for upper limb surgeries. Among the various approaches of brachial plexus block, supraclavicular approach is considered easiest and most effective[2]. The first supraclavicular brachial plexus block (SCBPB) was performed by Kulenkampff in 1912[3]. The classical approach using paraesthesia technique is a blind technique& may be associated with higher failure rate and injury to the nerves and surrounding structures[4]. To avoid some of these problems use of peripheral nerve stimulator (PNS) was started which allowed better localization of the nerve/plexus[5]. However this technique may not be foolproof with persistent risk of injury to surrounding structures, especially vascular structures, nerves and pleura leading to pneumothorax[6].

The application of ultrasound technique for exact localization of nerves/plexus[7] has revolutionized the regional anesthesia field wherein ultrasound probes with suitable frequencies have been successfully tried.

Ultrasound (USG) for supraclavicular brachial plexus block has improved the success rate of block with excellent localization as well as improved safety margin[8]. While electro stimulation-guided SCBPB is a well established and well accepted procedure in routine daily clinical practice, the aim of the current study is to see if adding Ultrasound guidance to nerve stimulation improves the efficacy and safety of SCBPB than performing the block with nerve stimulation guidance alone for forearm surgery.

The objectives of this study were to compare the efficacy of SCBPB using nerve stimulator technique and nerve stimulator with ultrasound technique in terms of Time taken for performance of block, No. of attempts taken for successful motor response, Onset and duration of sensory blockade ,Onset and duration of motor blockade Overall block success i.e. complete anesthesia all the 4 nerve territories (Radial, Median, Ulnar & Musculocutaneous nerves), Incidence of block related complications, Procedure related pain.

Materials & Methods

Eighty patients aged between 18 years and 50 years admitted to Kamineni Hospitals, Hyderabad undergoing forearm and wrist surgery lasting less than or equal to 2 hours were included in the study. A sample size of 40 patients per group was calculated to show a significant difference in the proportion of surgical blocks between groups. Patients belonging to ASA I-II were included. Patients with surgery on elbow, arm and shoulder, Clinically significant coagulopathy, Infection at the injection site, Allergy to local anaesthetics, Severe pulmonary pathology, Age <18 years, Mental incapacity or language barrier precluding informed consent were excluded from the study. Group 1: Patients undergoing block by nerve stimulator technique and Group 2: Patients undergoing block by nerve stimulator along with ultrasound guidance. The study protocol was approved by the Institutional ethical committee.

All the patients underwent thorough pre anesthetic evaluation on the day prior to surgery. All systems were examined including airway and the surface anatomy where the block was going to be given, and the procedure to be carried out was explained and informed written consent taken. They were informed about development of paresthesia. Patients were reassured to alleviate their anxieties. All the patients were kept nil per oral as per the fasting guidelines. All of them received drugs T. Alprazolam on the night before surgery and Cap. Omeprazole on the day of surgery. All preoperative investigations were done. Patients were pre-medicated with Inj. Tramadol 50mg IM and Inj. Promethazine 25mg IM 30 minutes before shifting to operation room, starting of an intravenous line with 18G intravenous cannula on the contra lateral upper limb under aseptic

techniques. In the operating room patient will be monitored for heart rate, rhythm, blood pressure and oxygen saturation. Brachial plexus will be identified by either Nerve stimulator or nerve stimulator and ultrasound depending on the randomization and skin will be infiltrated with 1% Lignocaine Hydrochloride at the site of introduction of needle. 30ml of 0.5% Sensorcaine not exceeding 3mg/kg body weight used as *Local anaesthetic.*

Position- Patient was made to lie supine with head turned opposite to side of intended block and arm adducted & pulled down gently. A small pillow or folded sheet was placed below the shoulder to make the field more prominent.

Procedure- The patients were allocated to each group by computerized randomization. Parts are prepared for the block to be performed with iodine solution. Anatomical landmarks are identified &skin wheal is raised using lignocaine 1% 3ml solution. In group 1,Nerve stimulator guided supraclavicular brachial plexus block was performed by eliciting flexion of 3^{rd} and 4^{th} digits, when it was obtained we withdrawn the needle about 1 to 2mm, then the drug is injected. In group 2, block is performed after real time visualization of the vessels, nerve &bone along with nerve stimulation. In plane approach using 10ml syringe, local anesthetic in injected & the drug distribution in noted. This procedure was done by using sonosite ultrasound machine with 13-6MHz transducer using 22G needle.

The time taken for the procedure, No. of attempts, the onset of sensory blockade & motor blockade and procedure related pain were noted. Intra-operatively, haemodynamics were monitored at regular intervals. Following completion of surgery, the patients were monitored to assess the duration of post-operative analgesia. At the time of each subsequent assessment, patients were observed and/or questioned about any subjective and/or objective side effects (sedation, nausea, vomiting or respiratory depression, neurological injury).

Assessment for the presence of procedure-related pain immediately after block placement using a 10-cm visual analog scale. The day after surgery, complete recovery of neurologic function on the operated limb was checked, and the occurrence of untoward events, including paresthesia, dysesthesia or motor deficits, was recorded.

Grading of sensory blockade was as follows: I= No difference, II= Some difference but cold still sensed in blocked arm, III= No cold sensation in blocked arm . Grading of motor blockade as follows I= Normal power II= Reduce power, III= Complete loss of power. Following nerves will be tested for motor block- Musculocutaneous nerve- by flexion of arm, Radial nerve by extending the flexed arm & wrist, Median nerve by asking the patient to flex wrist & also opposing the thumb to 2nd & 3rd fingers, Ulnar nerve by flexing 4th & 5th fingers. Data was collected every 3mins for first 15 mins, every 5 mins for next 15mins and later every 10 mins for 30 mins and every 15 mins till the end of surgery. Assessment of complete recovery of both sensory and motor blockade was done post operatively.

Statistical Analysis

Continuous variables (age, weight) were presented as Mean $\pm$ SD. Categorical variables (sex, complications) were expressed in actual numbers and percentages. Continuous variables were compared between the two groups by performing un–paired t-test. Categorical variables were compared by performing Chi–Square test. For small numbers Fisher exact test was used wherever necessary. Statistical software OPEN EPI was used for data analysis. P value of > 0.05 – Statistically not significant and P value of < 0.05 – Statistically significant

Results

The prospective, randomized, comparative study was conducted in the Department of Anesthesiology & Critical Care, Kamineni hospitals ltd, Hyderabad on 80 patients aged between 18-50 years posted for upper limb

surgeries to compare the Nerve stimulator & combined Nerve stimulator &Ultrasound guided supraclavicular brachial plexus block in terms of No. of attempts, time taken for the procedure, onset & duration of sensory & motor blockade respectively, success rate, complications& Procedure related pain.

There were no clinical or statistically significant differences in the demographic profile of patients in either group.

Table 1: Comparision of Demoghraphic data

Group	Group 1	Group 2
Age (years)	34.775±9.75	34.7±9.14
Weight (Kgs)	64.65±10.66	64.9±10.45
Sex M/F	30/10	28/12
ASA I/II	19/21	20/20

The average age was 34.825 ± 9.83yrs in group 1, and 34.7± 9.14yrs in group 2. Youngest patient in our study group was 19 yrs and oldest was 50 years. The average weights of the patients were 64.65 ± 10.66kgs in group 1 and 64.9 ± 10.45kgs in group 2 respectively. There was no significant difference in age and weight between the two groups. There have been 6 different surgical procedures for which supraclavicular block was done in this study with a variable degree of surgical invasiveness and operative trauma.

Table 2: Type of Surgeries

Type of Surgery	Group 1 N0{%}	Group 2 N0{%}
ORIF with LCP	23(57.5%)	22(55%)
Implant removal	5(12.5%)	6(15%)
Debridement	5(12.5%)	3(7.5%)
Tendon repair	3(7.5%)	3(7.5%)
Skin grafting	3(7.5%)	3(7.5%)
Ex-fix of wrist	3(7.5%)	1(2.5%)

The mean operative time was 81(+ 17) minutes in Group 1 and 85 (+ 19) minutes in Group 2(P-Value- 0.3937). The time spent for plexus detection and injection of the local anaesthetic varied significantly between both groups (10.375 minutes in Group 1 and 6.25 minutes in Group 2). Regarding the number of attempts taken to get a successful motor response in Group 1, 24 patients experienced a successful motor response from the first attempt, whereas, in Group 2 in 34 patients only 1 attempt was needed (*p=0.01228).*This was statistically significant difference.

Table 3: Onset of motor and sensory blockade in the two groups

Parameter	**Group 1(min)**	**Group 2(min)**
Onset of motor blockade	15.9±3.93	14.4±3.2
Onset of sensory blockade	11.575±2.14*	10.35±2.43
Duration of sensory blockade	393.78±65.96	428.25±76.75
Duration of motor blockade	396.48±76.52	431.75±76.27

The onset of motor block was within 15.9 ± 3.93 min in group 1 and 14.4 ± 3.2 min in group 2. This was not statistically significant. The mean time of onset of sensory blockade in group 1 was 11.575 ± 2.147min. In group 2 it was 10.35 ± 2.43 min. The delayed onset of sensory blockade in group 1 is statistically significant. In group 1 the mean duration of sensory blockade was 393.78 ± 65.96 min and in group 2 428.25 ± 76.75 min. The duration of sensory blockade was shorter in group 1 when compared to group 2. It was statistically significant. In group 1 the mean duration of motor blockade was 396.48 ± 76.27 min where as in group 2 it was 431.75 ± 75.57min. The duration of motor blockade was shorter in group 1 when compared to group 2& it was statistically significant.

Table 4: Overall effectiveness of the block

		Group 1	Group 2	P Value
Totally effective		30(75%)	36(90%)	0.0775 Chi-square test
Failure	Partially effective	7(17.5%)	4(10%)	
	Total failure	3(7.5%)	0	0.2405 Chi-square
Total		40	40	

X2=3.117, P>0.05

The block was successful in 75 % of patients in group 1 compared to 90% in group 2(P-Value 0.0775). Of the remaining patients, partial block requiring additional sedation/analgesia was 17.5 % in group 1 and 10 % in group 2. Total failure of block occurred in 7.5 % in group 1 compared to nil in group 2 (P-Value 0.2405).These were comparable both clinically and statistically.

Table 5: Complications between two groups

Groups	Complications	Count	Percent	P Value
Group 1	Nerve injuries	1	2.5	Fisher's exact test 0.0053
	Vessel puncture	7	17.5	
	Pneumothorax	0	0	
	Nil	32	80	
Group 2	Nil	40	100	

Incidence of complications was 8(20%) in Group 1 compared to nil in Group 2 which was statistically significant with a P-Value of 0.0053. Incidence of vessel puncture/ hematoma was 17.5% in group 1 compared to nil in group 2. Incidence of nerve injury was 2.5% in group 1 compared to nil in group 2. Incidence of pneumothorax was nil in both groups.

Procedure-related pain

Table 6: Procedure related pain

Group	Group 1	Group 2	P-Value
Pain reported by	19(47.5%)	7(17.5%)	0.004177 Chi-square test
Pain not reported by	21(52.5%)	33(82.5%)	

The median (range) degree of anesthesia- related pain was reported as VAS 2 in group 2 and VAS 3 in group 1. It was not a significant difference. However only 21 patients in group NS (52.5%) reported no procedure-related pain as compared with 33 patients in group 2 (82.5%)

Discussion

The two most commonly used conventional techniques for nerve localization during PNB are peripheral nerve stimulation (PNS) and mechanical elicitation of paresthesia. The introduction of peripheral nerve stimulators into clinical practice was a major advance in regional anaesthesia. Unfortunately, even with these tools, performance is still far from perfect. Despite the time-tested record of safety of these "blind" techniques, an inherent rate of block failure exists. Nerve stimulator is also no help in avoiding puncture of blood vessels, the pleura, and other vulnerable structures, the anatomical relations of which to the target nerves show considerable variability, and complications including local anaesthetic toxicity due to intravascular injection and nerve damage from the mechanical trauma and/ intraneural injection have been reported[9].

Imaging guidance for nerve localization holds the promise of improving block success and decreasing complications. Multiple radiologic modalities, including MRI, CT scan and fluoroscopy have been used to guide needle placement for PNB. However, these modalities are limited by costs, prohibitive space requirements, static images, and need for contrast dye. Ultrasonography may represent just such a method for providing a "sufficient close examination of anatomy"[10]. It is non invasive, causes no radiation exposure, is more affordable and portable compared to other imaging techniques, requires little preparation for immediate use, and can be taught and learned with relative ease. Perhaps the most significant advantage of ultrasound technology is the ability to provide anatomic examination of the area of interest in real-time[11]. For regional anaesthesiologists, this development is probably as significant as the introduction of laparoscopic surgery for general surgery almost 20 years ago. As Bodenham in[12] suggests, the majority of senior colleagues will learn from their peers, but training in ultrasound techniques needs rapidly to become part of the core of every anaesthesiologist, just as laparoscopic work is for surgeons.

Most studies comparing ultrasound imaging and nerve stimulation techniques for upper extremity plexus anaesthesia have demonstrated the superiority of US with respect to block completeness at 30 minutes, overall block success (surgical anaesthesia), rapid block performance, shorter onset times, prolongation of block and reduced complications.

This study is intended to compare the efficacy & safety of nerve stimulation method with ultrasound guidance along with nerve stimulation for supraclavicular brachial plexus block. This study was done in patients undergoing upper limb surgeries with similar demographic profile. In this study the time taken to perform the block was significantly longer in group 1 when compared to

group 2. This is similar to a studies done by Stephan Williams et al[13] and Vincent chan[14] in which the average time necessary to perform the block was significantly shorter in Group USNS than in GroupNS. In contrast, Gurkan *et al.*[15] found that a combined ultrasound-stimulation technique (7.2 ± 1.0 min) prolonged block performance time compared with stimulation alone (6.4 ± 1.0 min) (*P*-0.05), with performance time measured from the time of placing the ultrasound probe on the skin to the time of needle removal. The difference in the time for the block performance between studies can be explained by the difference in experience & skills in using the ultrasound and difference in the end points taken for assessing the time of performance. The study done by Morros C, et al[16] suggest that the use of ultrasound in regional anesthesia requires the acquisition of new knowledge and skills not only by anesthesiologists in training but also by anesthesiologists experienced in neuro stimulation-guided peripheral nerve blocks. Casati et al[17] in their study observed that the median (range) number of needle passes was 4 (3–8) in group US and 8 (5–13) in group NS (*P* - 0.002). The onset of sensory blockade in all the major nerve distributions was shorter in the Group 2 compared to group 1. Similar results were shown by Marhofer et al[18] and was in contrast to the study done by Danelli et al[19]. They found that the sensory and motor block onset times and success rate were similar whether NS or US was used, although US guidance allowed shorter procedural times, fewer needle punctures, and fewer vascular punctures. The onset of motor blockade occurred within 14.4 ±3.2 mins in Group 2 compared to 15.9 ± 3.93mins in Group 1, these were similar to Williams et al[20] studies.

The results of Duration of sensory & motor blockade were in contrary to, Williams et al[20] and in accordance with Abrahams[21] studies. Their study observed that there were no significant differences in the duration of post-block analgesia (Group US: mean 846± 531 min, median 662 min; Group NS: mean 652±473 min, median511 min; *P* - not significant). MS Abrahams, MF Aziz, RF Fu and JL Horn in a meta-analysis observed that the US group had longer block duration than the PNS group, with a combined mean difference of 25% increased block duration (95% CI 12–38%, P,0.001).

A block is considered successful by most authors when analgesia is present in all areas subjected to surgical intervention. Casati et al. in 2007[17] investigated, in a study involving 60 patients, the challenging question of whether nerve stimulator or ultrasound guidance will selectively affect success rate, incidence of complications, and patients' satisfaction and acceptance of the procedure after axillary brachial plexus block. No failed block was reported in either group. Insufficient block was observed in 1 patient (3%) of group US and 2 patients (6%) of group NS (*P* _ 0.61).Their results showed that in experienced hands, nerve stimulator and ultrasound-guided blocks provide similar success rates, onset times, a comparable incidence of complication and patients satisfaction and acceptance for both groups.

According to Brull et al. in 2007[22] the displacement of nerves by injection of local anaesthetics can be a cause of failure of block when only nerve stimulation is used. Ultrasound allows the operator to confidentially advance or reposition the needle after administering an initial injection of local anaesthetic. The operator can thereby distribute local anaesthetic uniformly around the plexus. Thus, Ultrasound-guided PNB translates into faster onset, longer duration, and improved block quality with reduced amounts of local anaesthetics compared with blocks using the peripheral nerve stimulator. Yuan Jia-min et al[23] studied complications of US and Peripheral nerve stimulator guidance for upper-extremity peripheral nerve blocks (brachial plexus) and he found that US 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. Neurological complications

following peripheral nerve blocks i.e. post block neuralgia show an incidence of 1.7%-12.5%**.** Symptoms mostly are moderate and transitory with a tendency of spontaneous recovery within times related to nerve regeneration and repair mechanisms. Interestingly, Kaufman et al [24] reported a series of seven patients suffering from severe, debilitating chronic pain states after peripheral nerve blocks. However, in the present study there was one case of neuropraxia and weakness in radial nerve distribution of the blocked arm post operatively. This patient was in nerve stimulation group & the patient was started on steroids. The patient followed up for 1 month & the patient recovered well. Stephan Kapral[25] et.al in 1994observed no complications such as pneumothorax, puncture of a major blood vessel, paresis, or irritation of the plexus, the recurrent laryngeal nerve, or the phrenic nerve in his study of ultrasound guided supraclavicular approach brachial plexus blockade.

In this study the median (range) degree of anesthesia- related pain were reported as VAS 2 in group 2 and VAS 3 in group 1. However only 19 patients in group 1 (47.5%) reported procedure-related pain as compared with 7 patients in group 2. This is almost in accordance with the study done by Casati***92*** et al in which 24 patients in group US (80%) reported no procedure-related pain as compared with only 15 patients in group NS (52%).

In summary in the present study addition of ultrasound to nerve stimulation in group 2 resulted in shorter time of performance of block, shorter onset times and longer duration times, no difference in block success, fewer complications and less procedure related pain than performing the block with only nerve stimulation in group 1.

Though recent technological advances in the application of nerve stimulation, the availability of bevelled, insulated needles and the description of new approaches have made nerve stimulation a highly successful technique in experienced hands in up to 95 - 98% of cases with a low incidence of severe complication[26]. Ultrasound-guided brachial plexus anaesthesia "brings light" into regional anaesthesia and can be applied to everyday clinical practice. Ultrasonography provides anatomic information and can allow the attending anaesthesiologist to see local anaesthetic spread around the plexus in addition to the real-time visual guidance to navigate the needle toward the target nerve while the motor response to nerve stimulation provides functional information about the nerve in question.

Apart from block success, cost-effectiveness and practicality need to be demonstrated in order to fully support Ultrasound guidance in regional anaesthesia. Ultrasound may not reduce costs if nerve stimulation is still required to provide additive confirmation of needle-nerve proximity or for the initial learning stages of US-guidance. On the other hand, routine application of this technology may ultimately increase the overall utilization rate of regional anaesthesia. Ultrasound appears to offer better accuracy and safety in addition to giving the anaesthesiologist self-confidence being observing the block needle and guiding its advancement to the desired depth and direction toward the target nerve and visualising the spread of the local anaesthetic injected around the plexus. Finally, it will be important to develop unique training standards to guide residency training programs and teaching institutions and to establish evaluation criteria for performing US-guided regional anaesthesia.

Conclusions

This study shows that, success rate/quality of the block was more with ultrasound group than nerve stimulation though it was not statistically significant. Time taken for the block performed by nerve stimulation was longer than with ultrasound guidance technique. Onset of sensory and motor blockade was shorter and duration of sensory and motor blockade was more in Ultrasound group compared to Nerve stimulation group. Incidence of complications like vessel puncture, nerve injury was seen only in nerve stimulation method. No. of attempts and no. of patients complaining

procedure related pain was significantly more in nerve stimulation group. In conclusion, ultrasound guided technique is safe and effective means of performing peripheral nerve blockade with a comparable success rate.

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