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A Comparative Study: Peripheral Nerve Stimulator-Guided Supraclavicular Brachial Plexus Block vs Ultrasound-Guided Supraclavicular Brachial Plexus Block for Upper Limb Surgery

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ABSTRACT
Upper limb surgeries frequently use the brachial plexus block for anesthetizing the limb. The conventional approach by eliciting paresthesia is a blind procedure that may have a higher failure rate and can cause damage to the nerves and nearby structures. Peripheral nerve stimulator and ultrasound techniques were introduced to aid in better localization of the nerve/plexus avoiding tissue damage. With excellent localization and increased safety margin, ultrasound has increased the success rate of supraclavicular brachial plexus block. The purpose of this study was to compare the effectiveness of a Peripheral nerve stimulator withUltrasound for giving Supraclavicular brachial plexus block. Following the acquisition of patient consent, a cohort of 120 individuals were recruited for participation in this prospective randomised study. These participants were subsequently divided into two groups, namely Group PNS and Group USG, in a random manner. The Supraclavicular brachial plexus block procedure was administered to both groups, with Group PNS receiving the treatment guided by a Peripheral nerve stimulator and Group USG receiving the treatment guided by Ultrasound. Both experimental groups were administered a solution consisting of 15 mL of Bupivacaine with a concentration of 0.5%, along with an additional 10 mL of Lignocaine containing Adrenaline at a concentration of 2% (1:200,000). The primary factors taken into account were the timing of the onset of sensory and motor block, the length of time that analgesia was maintained, instances of block failure and any complications that arose subsequent to the block. The average duration of block administration was 10.17±1.58 min in the group receiving ultrasound guidance (group-US) and 10.67±2.58 min in the group receiving peripheral nerve stimulation (group PNS) ($p = 0.57$). Therefore, the difference in the time taken to administer the block between Group US and Group PNS was found to be statistically insignificant. The duration of sensory block in group-US was found to be 10.12±1.14 hrs, while in group PNS it was 7.41±0.68 hrs ($p<0.0001$). The success rate of the block was 96.67% in the US group and 80% in the PNS group, demonstrating statistical significance ($p<0.05$). The study's findings indicate that the ultrasound guided supraclavicular brachial plexus block is superior to the peripheral nerve stimulator guided brachial plexus block in terms of efficiency, accuracy and safety. This is due to its shorter onset time and longer duration of sensory and motor block.

INTRODUCTION

The utilization of brachial plexus block is commonly observed in the administration of anesthesia for the upper extremity. The blockade of the plexus can be accomplished at different levels using various approaches, such as interscalene, supraclavicular, infraclavicular and axillary techniques. The supraclavicular approach is frequently employed by anaesthesiologists to administer a brachial plexus block during surgical interventions that involve the elbow and forearm. Within this specific methodology, the administration of medication occurs in the brachial plexus trunk. This trunk plays a crucial role as the primary pathway for sensory, motor and sympathetic innervation of the upper extremity. The present geographical area encompasses solely three neural structures within a confined space, leading to a localized blockage. The utilization of this particular methodology poses certain challenges, such as the inadvertent puncture of the subclavian vasculature and the potential development of pneumothorax. These challenges arise due to the methodology's close proximity to both the subclavian vasculature and the pleura[1,2]. A variety of techniques and instruments were implemented with the aim of mitigating complications. The ultrasound guided approach is a frequently employed and globally recognized technique. The utilization of ultrasound technology in the domain of anesthesia has undergone substantial advancements, leading to significant transformations in practice within recent years. The nerves located at the supraclavicular level are in close proximity to the surface and can be easily identified by employing a high frequency linear probe with a frequency range of 8-18 megahertz. The nerve plexus can be identified as areas with decreased echogenicity, surrounded by areas with increased echogenicity. These regions are located laterally to the subclavian artery, which is positioned superior to the first rib. The visual manifestation of this particular attribute is frequently denoted as a 'honeycomb' pattern. The pulsatile nature of the subclavian artery can be observed in its anatomical position, which is superior to the first rib. In general, the ultrasound probe is commonly oriented in a transverse fashion, while the needle is inserted utilizing a 'in plane' approach. This methodology is favored due to its capability to facilitate a comprehensive visualization of both the complete length of the needle and its tip. The augmentation of drug deposition in close proximity to nerve plexus has yielded heightened accuracy, resulting in enhanced block effectiveness and reduced incidence of complications. According to the Bendtsen *et al*.[2], Anaesthesiologists utilize different methodologies to administer drugs in close proximity to the brachial plexus, such as the single point, double point and multiple point injection techniques. The user's text is too brief to be rewritten in an academic manner. The multiple point injection technique is widely acknowledged as the most prevalent method among the available options. Nevertheless, a substantial body of research has provided evidence to support the notion that the frequency of nerve injury can be increased when multiple punctures are employed during the administration of the block.The user's text does not contain any information to be rewritten. One potential strategy for addressing this complication entails reducing the frequency of needle insertions during the administration of the block. The implementation of the single point technique can bestow specific benefits. A restricted number of studies have been undertaken to compare these techniques. Despite the extensive research conducted on the comparison between single point and two point injection techniques, which has shown favorable success rates for both methods, there is still an ongoing debate regarding the superiority of these aforementioned techniques. The user has provided a list of numbers[3-8]. There is a lack of adequate data pertaining to the Indian subpopulation in relation to the specific subject matter at hand. The hypothesis put forth in this study suggests that the effectiveness of the single point injection technique is similar to that of the two point injection technique in relation to the occurrence, thoroughness and efficiency of the ultrasound-guided supraclavicular brachial plexus block in patients undergoing surgeries on the forearm.

MATERIALS AND METHODS

A study was conducted in the Department of Anesthesiology in Central, India over a period of 1 year and 6 months. The study aimed to compare the effectiveness of ultrasound-guided and peripheral nerve stimulator-guided supraclavicular brachial plexus block in adult patients undergoing elective upper limb orthopedic surgeries. The study included a total of 120 patients.

Each patient underwent a comprehensive pre-anesthesia assessment that encompassed a detailed collection of medical history, a comprehensive physical examination and a thorough evaluation of systemic functions. Standard diagnostic tests including hemoglobin levels, urine analysis, blood glucose levels, blood urea levels, serum creatinine levels, bleeding time and clotting time were conducted for all individuals. Electrocardiography (ECG) and chest radiography (X-ray) were performed on individuals aged 40 years and older. In both experimental groups, a total of 30 milliliters of a 1:1 mixture containing 0.5% bupivacaine and 2% lidocaine with adrenaline was administered. The participants were divided into two distinct cohorts based on the specific technique they were scheduled to undergo for the administration of the brachial plexus block.

RESULTS

The study was conducted on a sample of 120 patients who were scheduled for elective upper limb surgeries. The participants were allocated into two groups of equal size, with 60 subjects in each group. The brachial plexus was located using a peripheral nerve stimulator, specifically belonging to the Group PNS. In the present study, the brachial plexus was located using an ultrasound machine within the US group (Table 1).

The block execution time is defined as the duration between the initiation of probe placement and the subsequent removal of the needle following the administration of local anaesthesia. The time of initiation of motor block is defined as the interval between needle removal and the onset of weakness in any of the three joints (shoulder, elbow, or wrist) when attempting to perform movements. The time at which the sensory block begins is determined by the moment the needle is withdrawn until the patient first reports a decrease in sensation in any of the four nerves-median, radial, ulnar and musculocutaneous in comparison to the corresponding limb. The duration of sensory block was determined as the period of time between the administration of local anaesthetic to the brachial plexus and the initial post-operative visual analogue scale (VAS) score of 4 or higher, indicating the need for additional analgesia. The duration of motor blockade was defined as the period of time between the administration of the local anaesthetic and the complete restoration of motor function in all nerve distributions. The average duration of block administration was 10.17±1.58 min in the US group and 10.67±2.58 min in the PNS group ($p = 0.57$). Therefore, the statistical analysis revealed that there was no significant difference in the time taken to administer the block between Group US and Group PNS. The average time for the initiation of the sensory block was 3.63±1.33 min in the group that received ultrasound guidance (group-US) and 6.79±1.76 min in the group that received peripheral nerve stimulation (group PNS) ($p<0.0001$). Therefore, the initiation of sensory block demonstrated statistical significance in the US group. In group-US, the average time for the onset of the motor block was 6.17±1.82 min, while in group PNS, it was 8.79±1.61 min ($p<0.0001$). Therefore, the initiation of motor block demonstrated statistical significance in the US group (Table 2).

The duration of sensory block was found to be 10.12±1.14 hrs in the group receiving ultrasound (group-US) and 7.41 ± 0.68 hours in the group receiving peripheral nerve stimulation (group PNS) ($p<0.0001$). Therefore, the duration of the sensory block exhibited a statistically significant difference in the US group. The duration of motor block in group-US was found to be 8.50±0.93 hrs, while in group PNS it was 6.58±0.68 hrs ($p<0.0001$). Therefore, the statistical significance of the duration of motor block was found to be highly significant in the US group.

A successful block is defined as the attainment of comprehensive sensory and motor block in the regions innervated by all four nerves, as indicated by a Bromage scale score of 2. The success rate of the block was 96.67% in patients belonging to the US group and 80% in patients belonging to the PNS group, with statistical significance ($p<0.05$) (Table 3).

No complications were observed in either of the groups. Therefore, both groups exhibited similar characteristics in terms of complications. The χ^2 test was employed to analyse all of the qualitative data. The quantitative data were analysed using an unpaired t-test. The results were presented as the mean value plus or minus the standard deviation (Mean±SD). Statistical significance was determined by p-values less than 0.05, indicating significance and p-values less than 0.001, indicating high significance. The statistical analyses were conducted using SPSS version 2.0 software.

DISCUSSIONS

The supraclavicular brachial plexus block is a widely recognized and effective technique for providing regional anesthesia during surgical interventions that involve the upper limbs. In addition to being regarded as a commendable alternative, it offers a multitude of perioperative advantages when compared to general anesthesia. The aforementioned benefits include a reduction in stress response, a decrease in blood loss, enhanced surgical conditions and optimal postoperative pain management. The

Table 1: Socio-demographic profile of the study subjects

Socio-demographic profile	Group PNS	Group US	p-value
No. of patients	60	60	
Age (years, Mean±SD)	32.80±14.01	16.99	>0.05
Sex (Male: Female)	52:8	44:16	>0.05

Table 2: Comparison of study parameters in both the groups

Particular	Group	Mean	Standard deviation	p-value
Block execution time* (min)	PNS	10.67	2.48	0.57
	US	10.17	1.58	
Time of onset of sensory blockade[+] (min)	PNS	6.79	1.76	<0.0001
	US	3.63	1.33	
Time of onset of motor blockade[†] (min)	PNS	8.79	1.61	<0.0001
	US	6.17	1.82	
Total duration of sensory blockade** (hrs)	PNS	7.41	0.80	<0.0001
	US	10.12	1.14	
Total duration of motor blockade[§] (hrs)	PNS	6.58	0.68	<0.0001
	US	8.50	0.93	

Table 3: Outcome of the study

Assessment of block	Group PNS	Group US	p-value
Successful (%)	48 (80)	58 (96.67)	0.047
Failed (%)	12 (20)	2(3.33)	0.043

Table 4: Modified bromage scale

Grade 0	Fully functional motor function elbow, wrist and finger flexion/extension
Grade 1	Motor strength decreases, limiting finger and wrist movements
Grade 2	The person has a complete motor blockade, preventing finger movement

implementation of the intervention leads to a reduction in the frequency of postoperative nausea and vomiting, which in turn promotes early mobilization and shorter hospital stays. As a result, patients report higher levels of satisfaction and experience improved clinical outcomes. Multiple techniques have been devised for the administration of peripheral nerve blocks, encompassing the paresthesia method, the peripheral nerve stimulator guided technique and the ultrasound guided technique. In recent times, there has been an increasing inclination towards the utilization of ultrasound guidance in the delivery of regional anesthesia. This preference stems from its correlation with decreased complications and enhanced success rates.

The current study found no statistically significant disparity between the two groups in terms of patient age, gender and ASA grade. The demographic outcomes obtained from the studies conducted by Shetti *et al*.[9], Ratnawat *et al*.[10] and Rupera *et al*.[11] were found to be similar. The utilization of this method facilitated the reduction of potential confounding factors, such as drug distribution, metabolism, excretion and action, that may otherwise be subject to influence by the patients' age.

The duration of block execution in our study was observed to be comparable to the findings reported by Shetti *et al*.[9]. The study found that the mean time taken for block execution was 7.27±3.88 min in Group US and 8.8±1.73 min in Group NS. Based on a study conducted by Williams *et al*.[12], it was observed that the average duration for block execution was significantly shorter in Group US (5.0±2.4 min) in comparison to Group NS (9.8±7.5 min). The duration between the initial insertion of the needle and its subsequent removal at the conclusion of the block was defined as the block execution time in the study conducted by Williams *et al*.[12]. In our investigation, however, the measurement of block execution time was conducted using a different approach. In Group US, the duration was determined by measuring the time from the initial scanning to the removal of the needle. Conversely, in Group PNS, the duration was assessed by measuring the time from the insertion of the needle to its removal. Therefore, the average duration of block execution demonstrated similarities with the studies conducted by Shetti *et al*.[9] and William *et al*.[12].

The initiation of the sensory block was found to be consistent with the observations reported by Tran *et al*.[13]. The researchers recorded the onset time for sensory block as 2.97±0.72 min and 3.63±0.76 min in the US group and PNS group, respectively, as reported in their study. The study conducted by Jamwal *et al*.[14] yielded similar results, demonstrating a significant decrease in the onset time of sensory block when utilizing the ultrasound-guided technique. The study conducted by Rupera *et al*.[11] revealed a notable disparity in the average time for the initiation of motor block between group US (4.55±0.78 min) and group PNS (5.13±0.71 min). In a similar vein, Ratnawat *et al*.[10] found that the average duration for the initiation of motor block was 8.10±0.02 min and 9.94±1.28 min in the US group and PNS group, respectively. The statistical significance of these findings was observed, despite the fact that the values recorded were greater than those observed in our own study.

In a study conducted by Ratnawat *et al*.[10], it was observed that the mean duration of sensory and motor block in the US group was 8 and 7 hrs, respectively, while in the PNS group, it was 7 and 6 hours, respectively. The observed results exhibited statistical significance and were in alignment with the outcomes obtained from our own investigation. Singh *et al*.[15] conducted a study that produced comparable results, demonstrating that the duration of the sensory block was significantly greater in the ultrasound-guided technique when compared to the peripheral nerve stimulator technique.

Singh and Mohammed[16] conducted a study to investigate the average duration of sensory and motor block in a specific group. The researchers reported that the mean duration of sensory block was 397.931±67.325 min, while the mean duration of motor block was 343.448±60.843 min. The mean duration in the paresthesia group was determined to be 352.22±87.501 min and 305.19±60.088 min, respectively. The results obtained were deemed to be statistically significant and in alignment with the outcomes of our own investigation.

A study conducted by Rupera *et al*.[11] revealed that the success rate of percutaneous nephrostomy (PNS) was 80%, whereas the success rate of ureteroscopy (US) was 96.67%. The observed discrepancy demonstrated statistical significance and was determined to be similar to the results obtained in our study. Singh and Mohammed[16] documented a success rate of 90% in the ultrasound-guided group and 73.33% in the paresthesia group during the block procedure.

The technique known as nerve stimulator guidance entails the administration of a pharmaceutical agent while closely monitoring the muscle twitches that are innervated by the particular nerve being focused on. Concurrently, it is plausible for smaller and more remote nerves within the particular nerve bundle to remain unaltered by the pharmacological effects of the drug. Furthermore, it is plausible that the medication could be deposited in close proximity to the brachial sheath, resulting in an inadequate or irregular blockage. The present circumstances may require the administration of rescue analgesia or general anesthesia. In contrast, the application of ultrasound guidance in brachial plexus block entails the utilization of live imaging to accurately observe the needle's precise placement and the distribution of medication in the proximity of the targeted nerve plexus. This technique has been associated with a higher rate of favorable results.

CONCLUSION

The study's findings indicate that the ultrasound guided supraclavicular brachial plexus block is superior in terms of efficiency, accuracy and safety compared to the peripheral nerve stimulator guided brachial plexus block. This is due to its shorter onset time and longer duration of sensory and motor block. Additionally, the former technique exhibits a higher rate of success and a lower incidence of complications when compared to the latter technique.

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