Original Article

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Anaesthesia Section

Supraclavicular Brachial Plexus Block by Nerve Stimulator or Ultrasound: An Observational Cross-sectional Study

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ABSTRACT

Introduction: Supraclavicular approach to the brachial plexus block is considered to be one of the most effective anaesthetic procedures for upper limb surgeries. Peripheral Nerve Stimulation (PNS) has traditionally been used as the gold standard technique for nerve location. More recently, Ultrasound (USG)-guided single injection supraclavicular block is used which allows direct visualisation of nerve, but its use is limited by cost constraints and the level of expertise needed.

Aim: To compare the efficacy of USG and PNS in supraclavicular brachial plexus block especially the onset of motor block in orthopaedic forearm surgeries.

Materials and Methods: An observational cross-sectional analytical study was conducted from January 2019 to January 2020 on 60 patients attending emergency operation theatre for orthopaedic forearm surgeries. They were allocated alternatively to one of the two groups (30 in each group) based on the technique of nerve block, either using USG or PNS. Block execution time (puncture time), the number of needle passes, time of onset of sensory block, time of onset of motor block, quality of sensory block, quality of motor block, the intraoperative requirement of opioids, complications, success, and failure were the exposure variables. The qualitative data were compared using Chi-square test and for comparison of the continuous variable, the student's t-test and Fisher's exact test were used. The p-value<0.05 was considered statistically significant.

Results: Patients in both groups were comparable concerning demographic parameters like age, sex, and American Society of Anaesthesiologists (ASA) physical status. The mean time of onset of a motor block using the USG-guided technique was 8.6±1.0 minutes, and using a PNS was 11.1±1.0 minutes (p-value<0.01). There was a 93.3% success rate in the USG-guided technique, compared to an 83.3% success rate in the PNS method (p-value of 0.222). No complications were seen in the USG-guided group. In the PNS-guided group, four complications were noted among 30 patients, the most common being vascular puncture (2 cases).

Conclusion: USG-guided supraclavicular block was superior to PNS technique in terms of rapid onset motor and sensory block, block quality, improved success rate, and fewer complications.

Keywords: Forearm, Local anaesthetics, Nerve block, Peripheral nerves

INTRODUCTION

Regional anaesthesia plays a crucial role in anaesthesia, both as an intrinsic component of the anaesthetic technique and for postoperative analgesia [1]. Recently the practice of peripheral nerve blockade has increased because of advancements in technique, equipment, and our understanding of how and when the procedure is indicated. These advances include mainly the usage of PNS and USG guidance for nerve localisation and the use of indwelling catheters for continuous techniques. The success of nerve block techniques depends on the training and experience of the anaesthesiologist in a particular procedure, either using a nerve stimulator or USG.

Brachial plexus block is an excellent anaesthesia option for upper limb surgery. Long-lasting pain relief, a low incidence of nausea and vomiting, and expedited hospital discharge are some of the clinical advantages among outpatients. Although PNS had been used as early as 1912 it was only in the 1980s that the method began to increase due to the importance of identification of individual components of the brachial plexus [2]. This method uses a low current provided through an insulated needle to produce motor stimulation of mixed peripheral nerves. Until the early 2000s brachial plexus block was done using either landmark, PNS, or paresthesia methods and with success rates ranging from 50-95% depending on the technique and approach used [3]. Many practitioners started using a large volume of local anaesthetics to increase the success rate and speed up the onset time at the cost of potential complications. Brachial plexus block remained a technique of use by trained specialists and a significant risk of failure of the block existed even in expert hands.

The first successful use of USG for examining brachial plexus block was in 1989 by Ting PL and Sivagnanaratnam V, among 10 patients [4]. One of the advantages of USG-guided techniques is the ability to identify the local anaesthetic spread as it is injected around the targeted peripheral nerve or nerve bundle [5]. This gives several potential advantages including visual confirmation of correct local anaesthetic spread and the ability to reduce local anaesthetic volume. Conversely, lack of visual spread on injection of local anaesthetic can indicate either poor visualisation of needle tip or misplacement in unintended areas like blood vessels or muscles.

Several studies have compared the USG and PNS block technique for upper limb surgeries. Alfred VM et al., concluded that USG-guided supraclavicular block is significantly better in terms of procedure time and block characteristics during upper limb surgeries compared to the nerve stimulator technique [6]. Ratnawat A et al. also reported similar findings [7]. Singh S et al., concluded that the supraclavicular brachial plexus block had a longer duration, faster onset, and better quality when USG was used for guidance [8]. Omoregbe OR et al., showed that combining the two techniques resulted in a high success rate and better sensory and motor block within 15 minutes at C8 dermatome resulting in minimal waiting time before hand surgery [9]. Duncan M et al., found the two techniques comparable though the USG-guided technique seemed to be slightly better [10].

The aim of this study was to compare the efficacy of USG and PNS in supraclavicular brachial plexus block in terms of the onset of motor and sensory block in orthopaedic forearm surgeries.

MATERIALS AND METHODS

This was a cross-sectional analytical study conducted at the Government Medical College, Thiruvanathapuram, Kerala, India during the period January 2019 to January 2020. The study was done after getting approval from the Institutional Research and Ethics Committee (IREC-IEC.No.13/21/2017/MCT).

Sample size calculation: The sample size was calculated using the epi info sample calculator based on the mean and standard deviation of the parent study [6] using the formula:

$$N = \frac{2\times(Z_{1-\alpha/2}+Z_{1-\beta})\times\sigma^2}{d^2}$$

$$= \frac{2\times(1.96+0.84)^2\times(1.31)^2}{(11.14)^2} = 0.0138$$

$Z_{1-\alpha/2}$=1.96 at a 5% level of significance

$Z_{1-\beta}$=0.84

$$\sigma = \frac{\sigma 1+\sigma 2}{2}$$

Thirty patients were required as the sample size in each group; After obtaining written informed consent, patients were selected according to inclusion and exclusion criteria.

Inclusion criteria

- Patients attending emergency operation theatre for orthopaedic forearm surgeries.
- American Society of Anesthesiologists Physical Status (ASA-PS) I and II patients.
- Age-18-65 years.
- Patients with the informed written consent

Exclusion criteria

- Glassgow Coma Scale (GCS)<10
- Obesity (BMI>30)
- Any contraindication to regional anaesthesia
- Language barrier
- Significant psychiatric or cognitive disorder
- Pre-existing neurological deficit in the distribution to be anesthetised,

Data was collected using a structured proforma. The demographic variables were age, sex, weight, and ASA-PS. The outcome variables were block execution time (puncture time); in the group USG, which is calculated from the time of initial scanning to the removal of the needle, and in the group PNS, the time from insertion of the needle to its removal. The number of needle passes was defined as the number of times a needle was introduced after being completely taken out from the skin. The time of onset of sensory block was assessed by pinprick and cold application every two minutes till the onset of sensory block. The time from the removal of the block needle to the time when the patient first says he/she has reduced sensation when compared to the opposite limb was recorded. The time of onset of motor block was assessed every five minutes for 30 minutes by using the Modified Bromage scale for the upper extremity [Table/Fig-1] [11]. The time from the removal of the block needle to the time taken for each of the grades was noted. Time taken to reach Bromage grade 3 was considered the onset of complete motor blockade.

After the onset was ensured, the quality of the sensory block was evaluated every five minutes with the application of ice-cold water and pinprick test. The number of dermatomes with a full block at the end of 30 minutes served as a measure of the sensory block's effectiveness and was graded as blocked, patchy, and no block. Similarly, the quality of the motor block was evaluated every 5 minutes by asking the patient to perform active movements of each of the three joints-shoulder, elbow, and wrist. The motor block at each joint was graded as blocked, patchy, and no block. The opioid requirement was considered if intravenous fentanyl was given intraoperatively.

Grade	Criteria
0	Patient able to raise the extended arm to 90° for two seconds
1	The patient can flex the elbow and move the fingers but is unable to raise the extended arm
2	The patient is unable to flex the elbow but able to move the fingers
3	Patient unable to move the arm, elbow, and fingers

[Table/Fig-1]: Modified Bromage scale for upper extremity [11].

Complications: Intraoperative occurrence of vascular puncture, pneumothorax, hypotension (Systolic Blood Pressure (SBP)<30% of baseline), bradycardia (Heart Rate (HR)<45), and vomiting were observed. The block was considered to be successful when the patient had a full block of all the sensory dermatomes (C5, C6, C7, C8 and T1 below the elbow) and no power to move mentioned joints (shoulder, elbow, and wrist). Failure was defined as the absence of full sensory block in atleast one dermatome.

STATISTICAL ANALYSIS

Analysis of data was done using Statistical Package for the Social Sciences (SPSS) software version 16.0 and Microsoft Excel. Data are expressed in their frequency and percentage as well as mean±standard deviation. The qualitative data between two groups were compared using the Chi-square test and for comparison of the continuous variable, the student's t-test and Fisher's exact test were used. The p-value<0.05 was considered statistically significant at a 95% confidence interval.

RESULTS

Patients in both groups were comparable concerning demographic parameters like age, sex, and ASA-PS [Table/Fig-2]. Time of motor block and sensory block onset was significantly less in the USG guided group compared to the PNS guided group. [Table/Fig-3]. The puncture time and the number of needle passes were significantly less in the USG-guided group compared to the PNS-guided group [Table/Fig-4].

parameters	USG-guided Mean±SD	PNS-guided Mean±SD	p-value
Age (years)	37.1±11.3	35.9±9.4	0.656*
Sex (M/F)	16/14	16/14	1.000*
ASA-PS (Grade1/Grade2)	20/10	22/8	0.573*

[Table/Fig-2]: Demographic features and ASA physical status.
*p-value<0.05 was significant

Parameter	USG-guided (Mean±SD)	PNS guided (Mean±SD)	t	p-value
The onset of motor block (minutes)	8.6±1.0	11.1±1.0	9.49	p<0.01
The onset of sensory block (minutes)	5.9±0.7	8.0±0.7	11.39	p<0.01

[Table/Fig-3]: Comparison of onset of motor and sensory block.

		USG-guided Mean±SD	PNS guided Mean±SD	t	p-value
Puncture time(minutes)		4.6±0.6	8.1±0.6	22.34	0.01
		Count (%)	Count (%)	χ^2	p-value
Number of needle passes	3	11 (36.7)	0	43.24	0.01
	4	18 (60)	4 (13.3)		
	5	1 (3.3)	11 (36.7)		
	6	0	15 (50)		

[Table/Fig-4]: Comparison of puncture time and number of needle passes.

The quality of sensory and motor blocks was significantly better in the USG-guided group compared to the PNS group [Table/Fig-5].

Parameter	Group	Blocked	Patchy	No block	Z	p-value
		Count (%)	Count (%)	Count (%)		
Quality of motor block	USG-guided	28 (93.3)	2 (6.7)	0	1.25	0.212
	PNS guided	25 (83.3)	3 (10)	2 (6.7)		
Quality of sensory block	The USG-guided	28 (93.3)	2 (6.7)	0	1.22	0.222
	PNS guided	25 (83.3)	4 (13.3)	1 (3.3)		

[Table/Fig-5]: Comparison of quality of the motor and sensory block.

The number of patients who needed supplementation of opioids was significantly less in the USG-guided group [Table/Fig-6].

Opioid use	USG guided	PNS guided	χ^2	p-value
	Count (%)	Count (%)		
No	26 (86.7)	23 (76.7)	1	0.317
Yes	4 (13.3)	7 (23.3)		

[Table/Fig-6]: Comparison of opioid use.

In PNS guided group, vessel puncture was noted in two patients (6.7%), and one patient (3.3%) had pneumothorax which was managed postoperatively by Implantable Cardioverter Defibrillator (ICD) insertion. Bradycardia and vomiting were seen in one patient (3.3%) each among 30 patients blocked using PNS guided technique. No complications were reported in the USG-guided group. Using the USG-guided technique nerve block failure was seen in two patients only and five patients in PNS guided group. The chi-square value was 1.46, and the p-value was 0.228.

DISCUSSION

The most common methods of giving supraclavicular brachial plexus block for anaesthesia of the upper limb include PNS and USG guidance of which the latter was introduced into clinical practice recently. This study was done to compare these two methods of brachial plexus block with regard to efficiency and safety. Previous studies have been done on the subject but most of them have not studied the number of needle passes and quality of sensory and motor blocks. In the present study, the motor and sensory block onset were more rapid using the USG guidance technique. Alfred VM et al., and Ratnawat A et al., reported similar findings regarding onset [6,7]. However Duncan M et al., found that the onset time of sensory and motor block was comparable between the USG and PNS groups [10]. Probable reason might be the relative experience in the old technique of PNS than in the new one with USG.

The puncture time was significantly less in the USG-guided group compared to the PNS-guided group (4.6±0.6 vs. 8.1±0.6 minutes respectively). The number of needle passes was also significantly less in the USG group. These findings have an impact on the safety profile of the block technique since an increased number of needle passes increases the chance of pneumothorax and increases patient discomfort and dissatisfaction.

The quality of sensory and motor blocks was significantly better in the US-guided group compared to the PNS group. The use of opioids for perioperative analgesia and sedation is a common strategy both in general and regional anaesthesia. In the present study, only four patients (13.3%) needed opioids in USG guided group, but seven patients (23.3%) required opioid supplementation in the PNS-guided group. In the study by Alfred VM et al., five out of 30 patients (16%) in the PNS group required supplementation of analgesia with intravenous fentanyl, whereas none of the patients in the USG group required supplementation [6].

The introduction of USG in the practice of peripheral nerve blockade significantly reduced the perioperative complications as compared to the landmark guided and nerve stimulator methods which were evident in the previous studies [12]. The main mechanisms of peripheral nerve block-related injuries include mechanical trauma, ischaemia, local anaesthetic toxicity, and inflammation. In the present study, none of the patients showed any signs and symptoms of complications from the USG method. But two patients (6.7%) demonstrated signs of vascular puncture and one patient (3.3%) each showed bradycardia, pneumothorax, and vomiting while using PNS method. Several studies have demonstrated the safety of USG as it helps in the direct visualisation of the needle in relation to the surrounding vital structures [13-15].

Block failure was seen in two patients in the USG-guided group and five patients in the PNS group. Some studies have reported no failures [8]. while others have reported failures in varying percentages [7,10]. Singh S et al., reported a success rate of 90% in patients with USG, compared to 73.1% using PNS, necessitating execution of other blocks [8].

The success rate in the present study using the US-guided technique was 93.3% and using PNS was 83.3% when taken as a complete sensory block. Duncan M et al., achieved a success rate of 90% in the USG group and 80% in the PNS group [10]. These values were similar to those obtained by other investigators [6-8].

The present study found that using the real-time USG increases the safety and efficacy of nerve blocks. Alfred VM et al., did a similar study comparing US and PNS in supraclavicular block and concluded that USG-guided supraclavicular block was significantly better in terms of procedure time and block characteristics during upper limb surgeries compared to the nerve stimulator technique [6]. Ratnawat A et al., found the PNS to be much less effective than the US-guided method for brachial plexus block through the supraclavicular approach [7]. Singh S et al., concluded that USG aide supraclavicular brachial plexus blockade results in a block that is quicker to start, better quality, and lasts longer. [8]. Duncan M et al., found both the techniques comparable with the USG technique slightly better [10].

In PNS technique, the local anaesthetic is injected by seeing the muscle twitches which are innervated by a particular nerve in which small and distal nerves may escape from the effect of the drug resulting in the inadequacy of motor and sensory block requiring supplementary general anaesthesia. The USG technique in contrast helps in the direct visualisation of the nerves and thus a safe and effective block.

Limitations(s)

The study did not follow-up patients with a postoperative chest radiograph to rule out asymptomatic pneumothorax and other complications such as nerve injury which is a possibility in the supraclavicular approach.

CONCLUSION(S)

The supraclavicular block is a reliable and rapid onset method of brachial plexus block for anaesthesia of the upper limb. Based on the present study, it can be concluded that the USG-guided technique of the supraclavicular brachial plexus block is superior to the PNS block. The USG-guided approach had a rapid onset of motor and sensory block, needed fewer needle passes, lesser block execution time, less opioid use, and improved quality of the motor and sensory block as compared to the PNS method. Direct visualisation of structures using the USG, enabled the procedure complication-free, but few complications were seen while using PNS. In conclusion, the USG-guided technique is better than the nerve stimulator method but requires a thorough understanding of sonography and skill in operating the USG machine.

REFERENCES

[1] White PF, Smith I. Ambulatory anesthesia: Past, present, and future. Int Anesthesiol Clin. 1994;32(3):01-16.

[2] Sauter AR, Dodgson MS, Stubhaug A, Halstensen AM, Klaastad, et al. Electrical nerve stimulation or ultrasound guidance for lateral sagittal infraclavicular blocks: A randomized, controlled, observer-blinded, comparative study. Anesth Analg. 2008;106(6):1910-15.
[3] Tran DQ, Bertini P, Zaouter C, Muñoz L, Finlayson RJ. A prospective, randomized comparison between single-and double-injection ultrasound-guided infraclavicular brachial plexus block. Reg Anesth Pain Med. 2010;35(1):16-21.
[4] Ting PL, Sivagnanaratnam V. Ultrasonographic study of the spread of local anaesthetic during axillary brachial plexus block. Br J Anaesth. 1989;63(3):326-29.
[5] Aguirre J, Ekatodramis G, Ruland P, Borgeat A. Ultrasound-guided supraclavicular block: Is it really safer? Reg Anesth Pain Med. 2009;34(6):622; author reply 622-23.
[6] Alfred VM, Srinivasan G, Zachariah M. Comparison of ultrasound with peripheral nerves stimulator-guided technique for supraclavicular block in upper limb surgeries: A randomized controlled trial. Anesth Essays Res. 2018;12(1):50-54.
[7] Ratnawat A, Bhati FS, Khatri C, Srinivasan B, Sangwan P, Chouhan DS. Comparative study between nerve stimulator guided technique and ultrasound-guided technique of supraclavicular nerve block for upper limb surgery. Int J Res Med Sci. 2016;4(6):2101-06.
[8] Singh S, Goyal R, Upadhyay KK, Sethi N, Sharma RM, Sharma A, et al. An evaluation of brachial plexus block using a nerve stimulator versus ultrasound guidance: A randomized controlled trial. J Anaesthesiol Clin Pharmacol. 2015;31(3):370-74.
[9] Omoregbe OR, Idehen HO, Imarengiaye CO. Supraclavicular brachial plexus block for upper limb fracture fixation: A comparison of nerve stimulation, ultrasound-guided technique and a combination of both techniques. West African Journal of Medicine. 2020;37(7):757-62.
[10] Duncan M, Shetti AN, Tripathy DK, Roshansingh D, Krishnaveni N. A comparative study of nerve stimulator versus ultrasound-guided supraclavicular. Brachial plexus block. Anesth Essays Res. 2013;7(3):359-64.
[11] Farooq N, Singh RB, Sarkar A, Rasheed MA, Choubey S. To evaluate the efficacy of fentanyl and dexmedetomidine as adjuvant to ropivacaine in brachial plexus block: A double-blind, prospective, randomized study. Anesth Essays Res. 2017;11(3):730-39.
[12] Salam AA, Aamir R, Khan RI, Ahmed A, Rehman A. Safety and effectiveness of ultrasound-guided peripheral nerve blocks: Audit at tertiary care hospital. J Pak Med Assoc. 2021;71(6):1623-26. 10.47391/JPMA.447.
[13] Rupera KB, Khara BN, Shah VR, Parikh BK. Supra-clavicular brachial plexus block: Ultra-sonography guided technique offers advantage over peripheral nerve stimulator guided technique. Natl J Med Res. 2013;3(3):241-44.
[14] Yuan JM, Yang XH, Fu SK, Yuan CQ, Chen K, Li JY, et al. Ultrasound guidance for brachial plexus block decreases the incidence of complete hemi-diaphragmatic paresis or vascular punctures and improves success rate of brachial plexus nerve block compared with peripheral nerve stimulator in adults. Chin Med J (Engl). 2012;125(10):1811-16.
[15] Kapral S, Krafft P, Eibenberger K, Fitzgerald R, Gosch M, Weinstabl C. Ultrasound-guided supraclavicular approach for regional anesthesia of the brachial plexus. Anesth Analg. 1994;78(3):507-13.

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