

A comparative study between supraclavicular brachial plexus block and Infraclavicular brachial plexus block for upper limb orthopedic surgeries: A prospective, randomized, double-blind study

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ABSTRACT

Introduction: Supraclavicular brachial plexus block is a common approach as it provides faster and dense blockade. In the past few years, infraclavicular brachial plexus block has become a method of increased interest as it has a lower complication rate and near to equal efficacy. The goal of this study was to compare block performance time, block characteristics, quality of block, patient's satisfaction, and complications between infraclavicular and supraclavicular techniques for brachial plexus block.

Patients and methods: 100 subjects were randomized in a double-blind fashion, to receive either an infraclavicular block (Group I, n=50) or supraclavicular block (Group S, n=50) using nerve locator apparatus. Block performance time, onset, peak, duration of sensory and motor blockade, any change in hemodynamics, complications were recorded at scheduled intervals intra-operatively and post-operatively as per

study protocol. Data were analyzed using GraphPad INSTANT version 3.06 software by Chi-square test or Mann-Whitney U test to compare categorical variables.

Results: The block performance time was faster in the Group S compared to the Group I (4.8±4.4 minutes vs. 6.3±1.39 minutes, p <0.001). The sensory block onset time was faster in Group S compared to the Group I (6.9±1.58 minutes vs. 7.6±1.34 minutes, p=0.019). Other observed variables were considered statistically not significant.

Conclusion: From our study, it is inferred that nerve locator guided Infraclavicular block by a vertical coracoid approach using multineurostimulation method is less rapidly executed as nerve locator guided supraclavicular block with a similar degree of surgical anesthesia and lesser complication rate.

Keywords: supraclavicular block, infraclavicular block, nerve stimulation, comparison.

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INTRODUCTION

Regional anesthesia provides superior pain management and improves the patient outcomes to meet growing expectations for ambulatory, cost-effective surgery.¹ With modern anesthetic techniques, surgical recovery can be smooth, rapid, and complete.

Regional anesthesia may reduce or eliminate the risks of general anesthesia, like traumatic airway and sore throat. It also offers some benefits to outpatient surgery. It provides analgesia without sedation, prolonged postoperative pain relief, and allows earlier discharge. Regional anesthesia decreases the need of opioids and reduces the incidence of postoperative nausea and vomiting.² The introduction of electrical stimulation as an objective tool for identifying peripheral nerve landmarks was an important history towards building the science of regional anesthesia.³

Orthopedic upper limb surgeries are quite common and routine encounter for the anesthesiologist and brachial plexus block is an established

regional anesthetic technique for these surgeries. It is used as a better alternative to general anesthesia in most of the patients because of having advantages like minimal preoperative preparation, no need for specialized costly equipment, minimal physiological and metabolic alterations, less stress response, minimal monitoring, longer duration of postoperative analgesia, less postoperative nausea & vomiting, decreased incidence of deep vein thrombosis, low burden on hospital management.

Both supraclavicular and infraclavicular approaches have similar distributions of anesthesia.⁴ In general, proximal blocks (interscalene and supraclavicular) are believed to have a faster onset than distal blocks (infraclavicular and axillary), but there are little data and consensus.⁵

This aim of this study was to compare the supraclavicular and infraclavicular approaches using neurostimulation in patients undergoing upper limb orthopedic surgeries.

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PATIENTS AND METHODS

After institutional review board approval and written informed consent from the patient, this prospective, a randomized, double-blind study was carried out in 100 patients in the Department of Anesthesiology, Sir T Hospital, Bhavnagar. After thorough pre-anesthetic evaluation patients were included or excluded according to following criteria: aged 20 to 50 years, scheduled for elective and emergency upper limb orthopedic surgeries mainly hand, wrist, forearm, and elbow with ASA physical status I and II, and a BMI of ≤ 25 kg/m². The exclusion criteria include patient's refusal, presenting contraindications to regional anesthesia, previous nerve injury, history of drug allergy to local anesthetics, history of drug abuse/dependence, currently consuming analgesics and sedatives, currently on anticoagulants, history of bleeding disorders, psychiatric illnesses, uncooperative patients, any major systemic illness, and lactating mother.

The patients were randomized to receive either an infraclavicular brachial plexus block using vertical coracoid approach (group I, n=50) or supraclavicular plexus block (group S, n=50). All the patients were assured and explained about the procedure to be performed and informed written consent was obtained before performing the block. A standard regional anesthesia trolley was prepared. Resuscitation equipment was kept ready.

All subjects were randomly allocated to one of the two groups of 100 patients each by distributing sealed envelopes. Those enrolled in Group S received 15 mL Bupivacaine 0.5% and 15 mL Lignocaine with adrenaline 2%, while those in Group I received 15 mL Bupivacaine 0.5% and 15 mL Lignocaine with adrenaline 2%. Standard monitoring for heart rate, ECG, systolic and diastolic blood pressure, peripheral oxygen saturation was established and baseline vital parameters were recorded. Ondansetron 0.08 mg/kg and midazolam 0.02 mg/kg were given as intravenous premedication 15 minutes before induction.

In group I, the operative limb was laid in a neutral position along the body. After sterile preparation, the coracoid process was identified by palpation. A point of 2 cm medial and caudal was established, and 2 ml of 0.5% lignocaine was infiltrated. 22 gauze insulated needle was inserted through the wheal perpendicular to the skin and connected to a nerve stimulator, which was programmed with current 1 mA and frequency 1 Hz. Twitches from the brachialis and coracobrachialis muscle were perceived and 20 ml of solution (10 mL bupivacaine 0.5% + 10 mL lignocaine with adrenaline 2%) was injected after decreasing frequency to 0.5mA and after repeated negative aspiration. Then the insulated needle was again redirected medially

and posteriorly to achieve flexion contraction of fingers. Here, the remaining 10 mL of the solution was injected after progressively decreasing frequency to 0.5 mA and repeated negative aspiration.

In group S, a sandbag under the shoulders was kept in supine position with the head turned in the opposite direction. The highest point of pulsation of the subclavian artery, along with the posterior border of the sternocleidomastoid muscle, was palpated and a wheal was raised lateral to it with 0.5% lignocaine. A 22 gauze with 5 cm insulating needle was inserted through the wheal caudally and posteriorly and current was set to 1.0 mA, the needle was advanced till twitches of muscles of the hand and fingers were achieved. Here, the current was progressively reduced to 0.5 mA and if twitches continued, 30 mL of the prepared solution (15 mL bupivacaine 0.5% + 15 mL Lignocaine with adrenaline 2%) was injected after repeated negative aspiration.

Block performance time, onset, peak, and duration of sensory and motor block, quality of block, patient's satisfaction, and complications were observed. Block performance time was defined as the time from needle insertion to needle withdrawal after completion of the injection.

Sensory block was assessed by a 3-point scale: 0 indicates normal sensation, 1 indicates a dull response to pinprick (analgesia), and 2 indicates no response to pinprick (anesthesia). The motoric block was evaluated by examining elbow flexion (musculocutaneous nerve), 3rd finger flexion (median nerve), thumb abduction (radial nerve), and little finger flexion (ulnar nerve).

For the sensory block, onset was defined as time duration from the end of injection to dull response to pinprick. Peak sensory block was defined as time duration from onset of sensory block to no response to pinprick. Duration was defined as the duration from onset of sensory block to the feeling of pinprick sensation (score 0).

For the motor block, onset was defined as time duration from the end of injection to decreased finger movements. Peak motor block was defined as time duration from the end of injection to complete abolition of finger movements. Duration was defined as time duration from onset of motor block to the reappearance of finger movements (score 0).

The quality of block is the decision of labeling the block satisfactory/ unsatisfactory/complete failure was made by the performing anesthetist after a short psychometric analysis using a numeric rating scale for pain assessment (0- 10). The satisfactory block was defined as the numeric rating scale (NRS) of < 3 . No analgesic supplementation was needed throughout the surgery. The unsatisfactory block

was defined as when the patient experienced pain or discomfort at the surgical site (NRS >3). Thus, a continuous infusion of propofol at 50µg/kg/min and fentanyl 1-2µg/kg was needed as per requirement. A complete failure was defined as when the patient still experienced pain despite supplementation. Thus, general anesthesia was started by the attending anesthesiologist.

Sample size calculation was determined using the proportion sample size estimates based on a projected difference of 20% in rates of complete sensory block at 50 min among two groups. Based on this we calculated a sample size of a minimum of 50 patients per group, which permitted a type 1 error of alpha= 0.05, a type error of beta= 0.5 and power of 0.8.

Data analysis was done using GraphPad INSTANT version 3.06 computer software. Intergroup comparison of qualitative data was done by Unpaired t-test and nonparametric tests like Chi-square test or Mann-Whitney U test to compare categorical variables. A p-value of <0.05 was considered statistically significant.

RESULTS

The mean age of the subjects were 35.86 ± 9.23 and 35.56 ± 9.04 years in Group I and S, respectively. Group I consisted of 31 men and 19 women, and Group S consisted of 39 men and 11 women. The characteristic of the subjects is displayed in [Table 1](#).

Table 1 Characteristic of the subjects

Patient's characteristics	Group I (mean ± SD)	Group S (mean ± SD)
Age (years), mean±SD	35.86 ± 9.23	35.56 ± 9.04
Gender		
-Male, n(%)	31 (62)	39 (78)
-Female, n(%)	19 (38)	11 (22)
Weight (kg), mean±SD	58.26 ± 7.45	59.96 ± 5.93
Height (cm), mean±SD	164.44 ± 8.71	165.46 ± 6.52
ASA physical status		
- I	16 (32)	14 (28)
- II	34 (68)	36 (72)

SD: standard deviation; ASA: American Society of Anesthesiologists

Table 2 Variables observed regarding block performance

Variables observed	Group I	Group S	p-value
Block performance time (minutes), mean±SD	6.3 ± 1.39	4.8 ± 4.4	<0.001
Sensory block onset (minutes), mean±SD	7.6 ± 1.34	6.9 ± 1.58	0.019
Motor block onset (minutes), mean±SD	9.2 ± 1.69	9.08 ± 1.96	0.745
Peak sensory block (minutes), mean±SD	14.52 ± 1.66	14.38 ± 1.86	0.692
Peak motor block (minutes), mean±SD	16.32 ± 2.01	16.7 ± 1.74	0.315
Duration of sensory block (minutes), mean±SD	222.30 ± 24.90	213.30 ± 24.49	0.122
Duration of motor block (minutes), mean±SD	268.10 ± 30.95	258.60 ± 26.86	0.104
Duration of surgery (minutes), mean±SD	60.6 ± 31.84	58.0 ± 26.35	0.647
Quality of block			
-Satisfactory, n(%)	46 (92)	46 (92)	
-Unsatisfactory, n(%)	3 (6)	4 (8)	
-Complete failure, n(%)	1 (2)	0 (0)	
Patient's satisfaction			
-Satisfied, n(%)	46 (92)	46 (92)	
-Unsatisfied, n(%)	4 (8)	4 (8)	
Complications arose			
-Nausea and vomiting, n(%)	1 (2)	2 (4)	
-Vascular puncture, n(%)	1 (2)	5 (10)	

There are two variables that were significantly different between the two groups in terms of block performance. First, the block performance time was faster in the Group S compared to the Group I (4.8 ± 4.4 minutes vs. 6.3 ± 1.39 minutes, $p < 0.001$). Second, the sensory block onset time was faster in Group S compared to the Group I (6.9 ± 1.58 minutes vs. 7.6 ± 1.34 minutes, $p = 0.019$). The rest of the observed variables were statistically not significant as seen in [Table 2](#).

In this study, one subject from Group I didn't achieve any sensory and motor blockade. Hence was considered a complete failure of the block and we finally went on to general anesthesia. Three subjects from Group I and four subjects from group S achieved incomplete sensory and motor blockade (unsatisfactory block) and were supplemented with propofol $50 \mu\text{g}/\text{kg}/\text{min}$ or fentanyl $1-2 \mu\text{g}/\text{kg}$. Forty-six subjects from each group attained satisfactory block. In this study, four subjects from each group were overall not satisfied with the block procedure.

Both the groups had no serious block-related complications like pneumothorax, Horner's syndrome, neurological complications like convulsions, seizures or any nerve injury. However, five subjects in Group S had incidents of vascular puncture while performing the block, only one subject in Group I was noticed with a vascular puncture.

Both groups were comparable with regards to heart rate, mean arterial blood pressure and oxygen saturation, $p > 0.05$. No adverse effects like bradycardia, tachycardia, hypotension, hypertension, tachypnoea and any significant change in peripheral oxygen saturation were noted in the study.

DISCUSSION

Regional anesthesia has been widely used in orthopedic surgery procedure. In many clinical studies, it has been reported that regional anesthesia technique provided important advantages when compared with general anesthesia in orthopedic surgeries. Regional anesthesia techniques are not only performed for only adequate anesthesia and orthopedic surgical procedures, but they have also other advantages, including excellent postoperative pain control, reduced side effect, decreased blood loss, and shorten stay in the post-anesthesia care unit.³

Infraclavicular brachial plexus block was introduced in the early 20th century as an alternative to axillary and supraclavicular approaches. However, this approach was not utilized despite its advantages of fewer complications and more consistent block until Raj *et al.* introduced this in 1973.⁶ But the technique could also not gain widespread use probably due to unreliable results and lack of precision

in needle placement.⁵ Since then several variations on the technique of infraclavicular block have been described with various surface landmarks, site of needle insertion and recommendations for needle direction. In 2010, Trehan *et al.*⁷ compared clavicular and coracoid approaches of infraclavicular brachial plexus block and inferred that coracoid approach was a relatively better approach in terms of consistent better identification of bony landmark, patient's positioning, and successful blocks.

Double neurostimulation technique has maximum efficacy of infraclavicular block using the coracoid approach. Hence this inspired us to use vertical coracoid approach using multineurostimulation method while performing infraclavicular brachial plexus block. In 2017, Kumar *et al.*⁸ performed a randomized comparative study on brachial plexus block using nerve stimulator, infraclavicular coracoid approach v/s supraclavicular approach, mean time to perform infraclavicular block was 3.9 ± 1.028 minutes. In our study mean block performance time was calculated to 6.3 ± 1.39 min which was comparable to the above clinical studies.

In this study, block performance time was found to be longer in Group I due to factors such as multineurostimulation technique, the unfamiliarity of the methodology and inexperience in performing infraclavicular brachial plexus block. Moreover, the infraclavicular brachial plexus block was not routinely practiced in our institution. But as the study progressed block performance time improved in Group I.

In a clinical study of Yang *et al.*⁹ and Kumar *et al.*⁸ showed that there were no significant differences in the evolution of sensory blockade. In 2013, Satani *et al.*¹⁰ performed a clinical study to compare the efficacy of both the blocks using neurostimulation in upper limb surgeries, also showed no important differences in the sensory blockade.

Shah *et al.*¹¹ reported that supraclavicular block was better in terms of quality of block when compared with the infraclavicular block. In our study, one subject from Group I didn't achieve any sensory and motor blockade. Hence was considered a complete failure of the block and finally, general anesthesia was given to the subject. Three subjects from Group I and four subjects from group S achieved incomplete sensory and motor blockade (unsatisfactory block). Forty-six subjects from each group attained a Satisfactory block. Out of 50 subjects in each group, 4 subjects from each group were found unsatisfied with the overall procedure.

When the complication rates between the supraclavicular and infraclavicular approaches are compared, an impairment in diaphragmatic

movements can be rated as 100% for interscalene, 50% to 77% for supraclavicular, 24% to 26% for proximal infraclavicular, and 0% for more distal infraclavicular blocks.

Yang *et al.*¹⁰ reported that pneumothorax occurred in two patients with the supraclavicular approach but in none using the infraclavicular approach. Pneumothorax is a serious complication associated with the supraclavicular approach. This has also been reported after interscalene, coracoid and vertical infraclavicular blocks. The incidence of vessel puncture was similar in both groups. None of them resulted in serious complications, such as seizures or hematoma. There was no incidence of vessel puncture in Group I. In 2013 study by Satani *et al.*¹⁰ showed a high incidence of Horner's syndrome and the pneumothorax in patients with the supraclavicular approach, the incidence of vessel puncture was similar in both groups. None of them resulted in any other complications such as seizures or hematoma.

In our study, there were no major block-related complications like pneumothorax, Horner's syndrome, convulsions in any of the subjects from both the groups. However, five subjects in Group S had incidents of vascular puncture while performing the block, only one subject in Group I was noticed with a vascular puncture. Thus our results were in agreement with those obtained by Shah *et al.*¹¹ and Kumar *et al.*⁸

No adverse effects like bradycardia, tachycardia, hypotension, hypertension, tachypnea, or peripheral oxygen desaturation were noted in our study. In this study, a tourniquet was well tolerated by most patients without any additional infiltration with a successful block, suggesting a proximal extension of the blockade of the medial cutaneous nerve of the arm.

Infraclavicular block has distinct advantages like easily palpable coracoid process, low risk of pneumothorax compared to the supraclavicular approach, avoidance of vascular structures of the neck, and the arm to be blocked does not need to be abducted to 90 degrees as in axillary block. Infraclavicular brachial plexus block with the coracoid approach is a safe alternative to conventional supraclavicular brachial plexus block by having minimum risk of pleural or vascular puncture. However, in infraclavicular brachial plexus block, the level of analgesia obtained is at a distal level compared to Supraclavicular block.

The ideal technique for localization of brachial plexus is its identification by ultrasonography. Ultrasound guidance permits a dynamic vision of nerves, vessels, muscles, needle maneuvers and allows the volume distribution to be controlled,

while with nerve stimulator a large volume is to be injected for spread near all nerves for the effective and successful block. Due to non-availability of equipment in the department, we used nerve locator to localize the brachial plexus.

Nerve locator is a better technique than blind approach as the drug solution is deposited in close proximity of neurons. The deposition of drug close to the neuron bundles is the prime requirement while studying the effect of any drug. The initial stimulus while advancing the needle was set at 1mA current. The current was decreased in 0.02mA decrements while advancing the needle further till we get maximum contraction of muscles with a minimum amount of current. This technique ensures close proximity of needle tip with the brachial plexus trunks and maximizes the chances of satisfactory blocks. We found that to start with, 1 mA of current is safe level and there is no advantage of increasing the current further. Increase in current above 1mA is of no advantage and will cause discomfort and pain to the patient.

From this study, we can conclude that Infraclavicular brachial plexus block with the vertical coracoid approach with multineurostimulation technique using nerve stimulator can be preferred over Supraclavicular brachial plexus block for distal upper limb surgeries by having minimal risk of pleural or vascular puncture. Moreover for better success rates of the block, needs precise knowledge of the anatomical position and landmarks, dexterity in needle manipulation, skill and routine practice of performing the block.

CONCLUSION

Nerve stimulator guided infraclavicular block by a vertical coracoid approach using multineurostimulation method is less rapidly executed compared to nerve locator guided supraclavicular block with a similar degree of surgical anesthesia.

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