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ORIGINAL ARTICLE

To Study the Efficacy of Supraclavicular and Infraclavicular Approach of Brachial Plexus Block for Traumatic Upper Limb Injuries.

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Abstract

Aim: Brachial plexus innervates the upper extremity. Upper limb surgeries can be performed by effectively blocking the brachial plexus. Supraclavicular and infraclavicular routes are the two approaches for blocking the brachial plexus. The purpose of the study was to compare the infraclavicular and supraclavicular approaches for blocking the brachial plexus with the help of both ultrasound and a nerve stimulator.

Methods: Hundred consecutive patients undergoing upper limb surgeries of the arm, elbow, forearm and hand scheduled for elective surgery were randomly assigned to Supraclavicular Group (S) and Infraclavicular Group (I). Ultrasound along with a nerve stimulator was used to perform all the blocks in both the groups. Block performance time, time to initiation of sensory and motor blockade, time to readiness for surgery, block success rate of each of the two different approaches, the block duration and complications. Statistical analysis was done by using descriptive and inferential statistics using Chi square test/Fisher exact test for nominal/categorical data and t-test to see the mean difference between the two groups. The statistical analysis of this study was done with the help of SPSS 20.0 version statistical software.

Results: The block performance time was relatively quicker in Group I (8.0 ± 2.9 min) than Group S (12.9 ± 2.8 min) (p=.01). The sensory blockade was achieved earlier in Group I (13.4 ± 5.5 min) than in Group S (15.3 ± 4.2 min). The onset of motor blockade was faster in Group I (25.4 ± 5.8 min) than in Group S (25.6 ± 5.8 min). The rate of success and satisfaction level of the patients were similar in both the groups. Although more complications were reported in Group S, they were not statistically significant. The duration of sensory block was higher in Group I (5.4 ± 0.9 hours) compared to Group S (4.0 ± 0.8 hours) (p<0.001).

Conclusion: The infraclavicular block is more rapidly executed compared to supraclavicular block with similar success rates and fewer complications in the presence of ultrasound and nerve stimulator and hence should be preferred.

Key words: Brachial plexus block, infraclavicular block, nerve stimulator, supraclavicular block, ultrasound

Introduction

Brachial plexus blocks are recognized as the cornerstone of regional anaesthesia for upper extremity surgical procedures. Several approaches have since long been employed to block the brachial plexus, axillary, supraclavicular and infraclavicular approaches. With the advent of ultrasound, the last two decades have shown a decadence of the nerve stimulation techniques in regional anaesthesia practice. Ultrasound guided blocks are now commonplace in regional anaesthesia as it allows direct visualization of the plexus of nerves, thereby reducing the volume of anaesthetic needed for an effective block as well as avoiding inadvertent adverse effects [1,2]. A recent meta-analysis concluded favourably towards use of ultrasonography with a higher success rate, reduced performance time, reduced local anaesthetic dosages and

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complications. [3]

Though both supraclavicular and infraclavicular approaches to the brachial plexus block are popular for upper extremity anaesthesia, supraclavicular approach has been more frequently employed owing to rapid establishment of an effective block due to the theoretical advantage of a compact anatomic arrangement of the brachial plexus in the supraclavicular fossa and high success rate [4]. Nevertheless, it is also marred by devastating complications as inadvertent vascular injection, pneumothorax, Horner's syndrome and phrenic nerve palsy. Another noteworthy problem is that supraclavicular approach, in about a third of patients, misses out on the ulnar nerve component sparing the medial (ulnar) aspect of the forearm, wrist and hand.

The infraclavicular approach was described as early as 1922 by Bazy and Labat, offers advantages over the supraclavicular approach in terms of musculocutaneous nerve blockade thus precluding tourniquet pain, applicability in situations where positioning is compromised by limited shoulder abduction as in trauma or frozen shoulder/arthritis and negligible risk of intravertebral, intrathecal, or epidural injection and phrenic nerve paralysis or stellate ganglion block.

This approach however failed to gain widespread acceptance owing to technical difficulty, increased depth and patient discomfort [5,6]. The advent of ultrasonography has simplified the procedure of administering the infraclavicular block and at the same time reduced the incidence of complications [7,8]. Supraclavicular and infraclavicular blocks have been compared in several studies in the literature by using either ultrasonography or neurostimulation [9,10]. In obese patients and in inexperienced hands, synchronized visualization of the relevant brachial plexus anatomy and the block needle can be challenging, particularly using the infraclavicular approach. Not many studies have compared the supraclavicular and infraclavicular approaches of brachial plexus block by simultaneously using both ultrasound and nerve stimulator [11].

Our Centre is a level 1 trauma center with large number of orthopedic trauma patients requiring emergent surgery and difficult patient positioning. Therefore to assess the efficacy and outcome of PNS- and ultrasound-guided supraclavicular and infraclavicular approach to brachial plexus blocks, we planned to conduct this prospective observer blinded study to evaluate the reliability for anaesthesia in orthopedic procedures of upper extremity.

Methodology

After obtaining the necessary approval by the Institutional Ethical Committee, this prospective, randomized and observer-blinded study was conducted on 100 consecutive adult patients undergoing elective surgeries with traumatic fractures of the upper limb below the shoulder in a tertiary care hospital. The primary objectives of this study was to compare the block performance time and success rate of two different approaches to brachial plexus block using both ultrasound and a nerve stimulator. The secondary aim was to compare the commencement of sensory and motor blockade, preparedness for surgery, patient contentment and complications associated with each approach.

Inclusion Criteria

Adult patients in the age group of 20–70 years of either sex, body mass index (BMI) between 20 and 35 kg/m^2 in American Society of Anesthesiologists (ASA) Physical status I or II, were enrolled in the study after obtaining written informed consent.

Exclusion Criteria

Patients who refused to participate in the study or were allergic to local anaesthetic/ adjuvants were excluded. Patients with any history suggestive of bleeding diatheses, patients on medication that can interfere with coagulation (e.g. acetylsalicylic acid, oral anti-coagulants, antiplatelet agents), insulin-dependent diabetes mellitus, neuropathy of any etiology in the affected extremity, hepatic or renal failure, chronic opioid use or active illicit substance use or pregnancy shall also be excluded.

Computer-generated random numbers and closed-envelope method was used to ensure that the patients were randomized to receive either infraclavicular (Group I) or supraclavicular (Group S) blocks. All the blocks were performed by an experienced Anaesthesiologist with experience of performing at least 50 supraclavicular and infraclavicular brachial plexus blocks each after obtaining approval from the Institutional Ethics Committee, patients were evaluated with a detailed relevant history, physical examination and laboratory investigations for their eligibility to be included in the study. The principal investigator obtained a written informed consent from eligible patients evening prior to planned surgery. Demographic data and ASA physical status grade of the patient was recorded. All patients were fasted overnight before the surgery and all essential medications continued as per the institutional protocol.

After patients arrived in the induction room, an intravenous line was started in a nonoperative extremity.

Before block placement, standard monitors applied, and oxygen (2 L/min) administered by nasal cannula. For anxiolysis, patients were sedated with up to 2 mg of midazolam and up to 1-2 mcg/kg of fentanyl. All blocks were performed by Consultant under ultrasound guidance using an ultrasound machine (Terrason U Smart 3200, USA) with 4-15 MHz linear transducer probe). An operating room assistant assisted in the block placement by helping to sedate and monitor the patient, and to inject the local anesthetic as requested. The local anesthetic chosen for all cases was 30 ml of 50: 50 mixtures of 0.25% bupivacaine and 1% lignocaine with 4 mg dexamethasone. Needles chosen for injection were 21G, 100 mm insulated short bevel needle (Stimuplex A, B Braun, Melsungen, Germany) with nerve stimulation. All patients were given a single shot ultrasound-guided posterior parasagittal in-plane approach infraclavicular brachial plexus block and supraclavicular block as per the assigned group. The patients were allocated to either Group I or Group S by randomly opening an envelope. The first Anaesthesiologist performed all the blocks after opening the envelope. Subsequently, the patient was transferred to the operating room and managed by the blinded anaesthesiologist, who was also responsible for recording the intraoperative parameters as specified in the detailed proforma.

Technique of Infraclavicular Block

The patient was placed in a supine position with the head turned to the contralateral side from the side to be blocked. The skin over the area of the block was disinfected with a surface disinfectant. The linear probe of the ultrasound transducer was placed just medial to the coracoid process and inferior to the clavicle so as to visualize the axillary artery [12]. The point of insertion of the nerve stimulator needle was inferior to the clavicle. The needle was aimed towards the posterior part of the axillary artery as it passed through the pectoralis muscles. Neurostimulation of the brachial plexus was done at a current intensity of 0.6 mA and motor response of the hand in the form of fasciculations was elicited as the needle approached the desired field. The current intensity was then lowered to 0.3 mA. At this intensity either the lowest twitch response was elicited, or the twitches disappeared and the local anaesthetic fixed combination was injected to obtain a U-shaped spread around the artery under ultrasonographic visualization [13].

Technique of Supraclavicular Block

The supraclavicular block was performed with the patient in supine position and the head turned to the contralateral to the side to be blocked and the skin was cleaned with a surface disinfectant and draped. The ultrasound transducer was placed in the transverse plane just above the clavicle at approximately its midpoint [14,15]. The brachial plexus along with subclavian artery, pleura and first rib were visualized. The aim was to place the needle in the sheath and inject the drug to visualize the spread within the brachial plexus and the also to observe the displacement of the trunks and divisions. The moment the needle entered the skin a current intensity of 0.6 mA was given using the peripheral nerve stimulator. Motor response of the hand was elicited to confirm proper needle placement. The current intensity was then lowered to 0.3 mA At this intensity either the lowest twitch response was elicited or the twitches disappeared. To achieve a brachial plexus block 30 ml of the drug mixture was injected.

The further management of the patient was decided by the second Anaesthesiologist who was blinded to the type of block given and monitored all the study parameters. During the course of surgery, all patients were sedated with Midazolam 2 mg.

The patients were observed every 5 min for 30 min to determine the onset and degree of sensory and motor block till complete blockade was achieved. If complete sensory blockade was not achieved after 30 minutes then it was a taken as a failed block and general anaesthesia was administered to the patient. To assess the sensory score needle-prick method was used by testing nerves of the arm, forearm and the hand. The sensory block was checked by scoring system adapted from Koscielniak-Nielsen et al [16]. The quality of motor block was checked by a four-point scale adapted from Lavoie *et al.* and Lahori *et al.* [17, 18]

The patient demographics i.e. age, gender, BMI, ASA physical status and type and duration of surgery were recorded. Block performance time, Time of commencement of sensory and motor block, Successful or Failed block, duration of the surgery, duration of block and any complications were noted. The block performance time was defined as the time interval between the placements of ultrasound probe on the skin surface to the removal of needle after successful injection of local anaesthetic. The sensory block onset was defined as the time taken for complete loss of pinprick sensation to occur after injection of the drug. The onset of motor blockade was defined as the time taken for complete motor block to occur after successful injection of the drug. The block was considered as successful if the surgery could be performed without any need for supplementation. Block was considered as failed block if the patient was administered general anaesthesia for completion of surgery. Duration of block was defined as the time elapsed

after completion of the block to the patients first request for additional analgesia. The need for intra-operative supplementary systemic medication or general anaesthesia and adverse effects (vessel puncture, seizure, new observed cardiac dysrhythmias, oxygen saturation lower than 90%, Horner's syndrome, signs of local anaesthetic toxicity, unintentional paraesthesia and pneumothorax) were recorded.

Statistical Analysis

The data was entered in the 2007 version of MS-Excel spreadsheet and was analyzed using the statistical package version SSPS 20. Descriptive statistics including measures of dispersion, measures of central tendency and proportions were used to describe the data. Chi-square test was used to compare proportions and Student's *t*-test was used to compare means between the groups.

Results

One hundred and twenty consecutive patients with upper extremity fracture below the shoulder were recruited into the study over a six month period (Jan 2018-July 2018). A Consort flow diagram showing the various steps of progress of participants through the study has been depicted in Figure 1.

A total of one hundred patients were finally included in the study. The demographic profile and intraoperative characteristics were comparable between the groups. (Table1)

The mean age of patients included in this study was 40.7 ± 14.2 years in group S and 41.7 ± 13.5 years in group I. Majority of the patients in the two groups were males and in ASA physical status I.

The site of surgeries and duration of surgery (Fig. 2) was similar between the two groups. [Table 1]. There was no skewed distribution and all the data obtained showed a normal distribution.

Outcome Measurements

The sensory blockade was achieved earlier (13.4 ± 5.5 min) in Group I than Group S (15.3 ± 4.2 min) but was not found to be statistically significant (p= 0.052).The onset of motor blockade was faster in Group I (25.4 ± 5.8

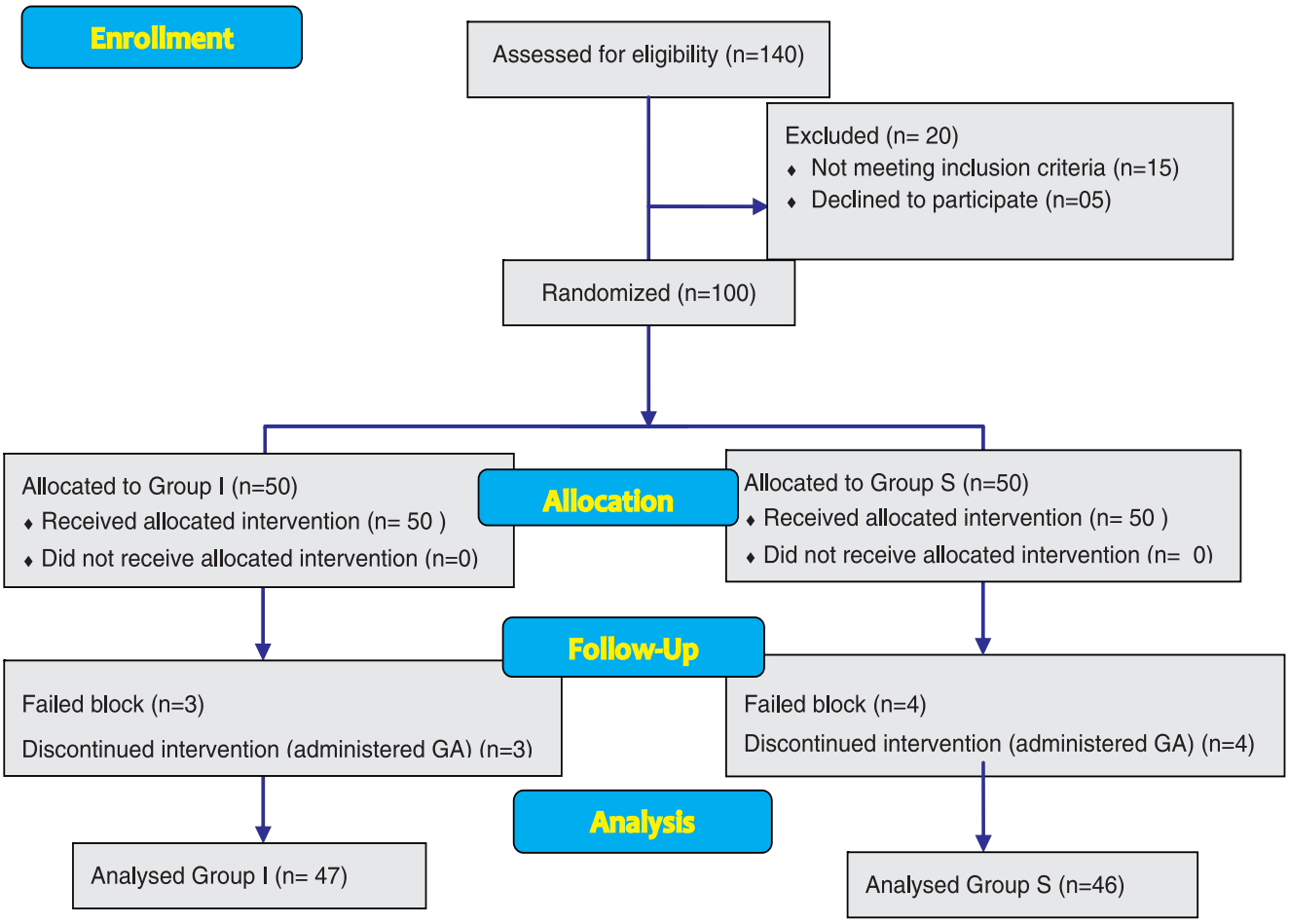

Figure 1: Consort Diagram Depicting the Progress of Patients through the Study.

Table 1: Demographic and Intra Operative Characteristics between the Two Groups

Demographic Data	Group S (n=46)	Group I (n=47)	P value
Age (yrs)	40.7 ± 14.2	41.7 ± 13.5	0.729
Weight (kg)	67.7 ± 9.6	67.5 ± 9.2	0.891
Sex (male/female)	35/15	33/17	0.668
ASA (I/II)	30/20	35/15	0.295
Duration of Surgery (min)	64.8 ± 23.8	68 ± 24.8	0.512
Site of Surgery (arm/elbow/forearm/hand)	11/9/18/12	14/6/24/6	0.874

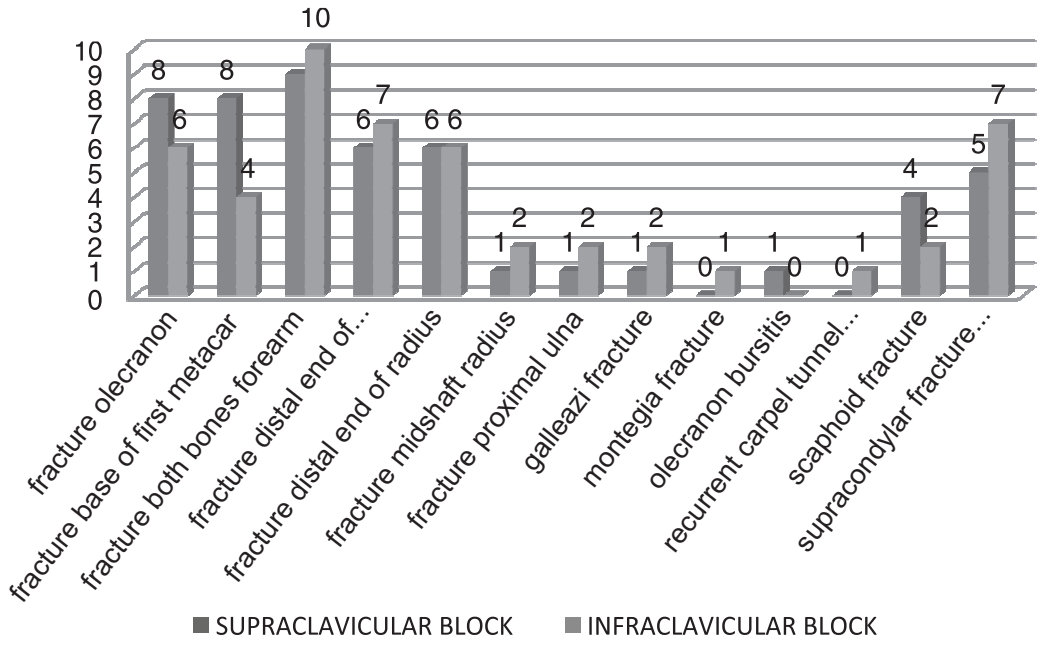

Figure 2: Site of Surgery

Table 2: Outcome measures in the Supraclavicular and Infraclavicular approach

ANAESTHETIC DATA	GROUP S (n=46)	GROUP I (n=47)	P value
Block performance time (min)	12.9 ± 2.8	8.0 ± 2.9	<0.015
Onset of sensory block (min)	15.3 ± 4.2	13.4 ± 5.5	0.052
Onset of motor block (min)	25.6 ± 5.8	25.4 ± 5.8	0.89
Duration of block (hours)	4.0 ± 0.8	5.4 ± 0.9	<0.001

The block performance time was relatively quicker in Group I (8.0 ± 2.9 min) than Group S (12.9 ± 2.8 min) (P = 0.015).(Fig 3)

min) than Group S (25.6 ± 5.8 min) but with a $p = 0.89$ which was not significant statistically. The success rate of 92 % in group S and 94 % in group I was similar in both the groups ($p = 0.695$). There were seven cases of block failure with 4 in group S and 3 in group I and it was supplemented with general anaesthesia. The patient satisfaction assessed on a five-point Likert scale was similar in both groups.

Five patients in Group S developed Horners syndrome against none in Group I. All the cases were managed conservatively with reassurance, and they recovered well within 24 h. Diaphragmatic paralysis developed in one of the patients who had breathing difficulty and had a saturation of 90% at room air. He was managed conservatively with oxygen by the face mask and was observed continuously in the ICU. The patient recovered

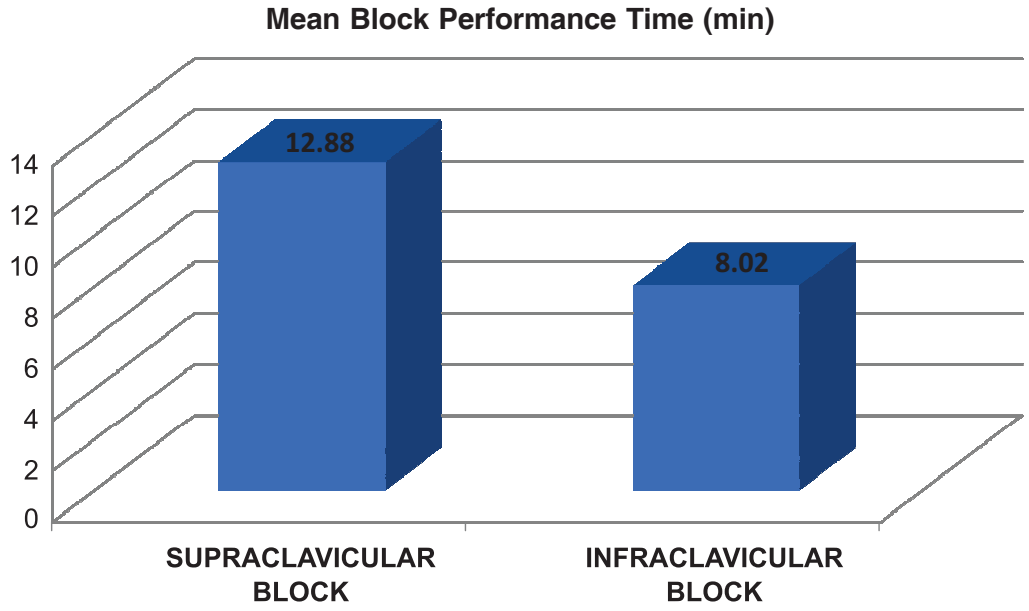

Figure 3 : Mean Block Performance Time in the Two Approaches of Brachial Plexus Block.

well within 24h. There were two cases of vascular puncture in Group S compared to one case in Group I. Although more complications were reported in Group S, they were not statistically significant (p =0.704). The duration of sensory block was higher in group I (5.4 ± 0.9 hours) compared to group S (4.0 ± 0.8 hours) and was found to be statistically significant (p <0.001).

Discussion

In this observer-blinded, randomized and prospective study, supraclavicular and infraclavicular blocks performed with the help of ultrasound-guided neurostimulation were compared. The success rate was excellent and comparable between groups. Patients who received infraclavicular brachial plexus block had faster block performance time, quicker onset of sensory and motor block and prolonged duration of block compared to the supraclavicular approach.

In a study by Koscielniak et al, significantly more patients in the infraclavicular brachial block group were ready for surgery 20 and 30min after the block was performed using ultrasound guidance. The mean block performance time shorter in the Infraclavicular approach group, though the difference was not statistically significant. The block effectiveness was noted to be superior in the Group I as compared to Group S (93% vs 78%) (p=0.017). The authors also noted that axillary nerve was blocked better whereas the median and ulnar nerves were blocked poorly in the Group S patients compared to the infraclavicular approach group. Additionally, more complications were noted in the supraclavicular approach (p<0.0001). Patients' acceptance of the block was similar in both the groups. The findings are congruent to our study [16].

Similar, findings were noted by Bowens et al, where the overall success rate of infraclavicular block performed with combined ultrasound guidance and neurostimulation was 96% with injection of local anaesthetic at the posterior cord. Central placement of a single injection of local anesthetic targeted at the posterior cord resulted in a higher success rate for infraclavicular block which was similar to the results obtained in our study [19].

In a study by Tran et al, which was a prospective randomised comparison between ultrasound guided supraclavicular, infraclavicular and axillary brachial plexus blocks, no differences were observed between the 3 groups in terms of total anaesthesia-related time, success rate, block-related pain scores and complications. Supraclavicular blocks resulted in a higher rate of Horner syndrome (37.5%; p < 0.001) which was similar to the result in our study [20].

The supraclavicular approach has been associated with a significantly high incidence of diaphragmatic paresis when using sensitive methods of assessment such as ultrasound, plethysmography and pulmonary function tests [16,21,22]. The low reported incidence in our study was owing to the fact that only clinical assessment was used to assess diaphragmatic paresis. In a study by Yang et al, pneumothorax was reported in two patients (4%) in supraclavicular block performed blindly [23]. The incidence of vascular puncture was more in

supraclavicular block in our study. The vascular puncture incidence was reported from 2% to 2.5% in other studies.

In a cohort study by Lecours et al, few complications were associated with a single-injection ultrasound-guided infraclavicular block and a high success rate regardless of the operator's expertise [6]. The technique was found to be reliable, easy to perform, and safe. The study reviewed 627 infraclavicular block procedures. Most patients were males who had undergone either plastic or orthopaedic surgery. Mepivacaine 1.5% was used in 96% of cases with a median volume of 30 ml. 131 cases of neurological signs or symptoms were identified. Four cases were retained as possible links to the infraclavicular block, but they underwent complete resolution of symptoms at the time of evaluation. Two possible cases of local anaesthetic toxicity were observed. There was a 93% success rate and the results were comparable between the experienced and the non-experienced operators (94% vs 93%, respectively) [24,25]. Our study also shows similar success rate for supraclavicular and infraclavicular approaches using both ultrasound and nerve stimulator guidance.

In 2013, Chin et al conducted a systematic review of randomised controlled trials to evaluate the efficacy and safety of infraclavicular block compared to other approaches to the brachial plexus in providing regional anaesthesia on the lower arm. A total number of 22 studies with 1732 participants were included. Nine studies employed ultrasound guided infraclavicular block and six studies compared infraclavicular with supraclavicular blocks. The authors concluded that infraclavicular block is as safe and effective as any other brachial plexus blocks regardless of whether ultrasound or neurostimulation guidance were used. The advantages of infraclavicular block included a reduced risk of pain from tourniquet applied to upper arm during surgery and a faster block performance time. Side effects were uncommon and no difference was seen between infraclavicular block and all other blocks in this regard [7]. Similar results were obtained in our study which showed that infraclavicular block was equally effective as supraclavicular block with lesser complications when performed using both ultrasound and nerve stimulator guidance.

The findings in our study and others support the hypothesis that combined ultrasound- and nerve stimulator-guided infraclavicular approach to brachial plexus is as efficacious as the supraclavicular approach to brachial plexus block, with a faster block performance time, longer duration of sensory block and fewer complications when performed using both ultrasound and nerve stimulation.

Conclusion

The infraclavicular approach to brachial plexus with combined use of Ultrasound with nerve stimulation is efficacious and safe technique in surgical procedures on the upper extremity with a shorter block performance time, longer duration of sensory block and fewer complications compared to supraclavicular approach.

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Ethics:	There is no ethical violation as it is based on voluntary anonymous interviews
Funding:	No external funding
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