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ORIGINAL ARTICLE

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Comparison of para-vascular supraclavicular brachial plexus block and costo-clavicular approach of infraclavicular brachial plexus block in providing surgical anesthesia for below elbow surgery: a randomized, single blind study

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Abstract

Background: With better precision of the brachial plexus block (BPB) under real-time ultrasound guidance, supraclavicular BPB (SC-BPB) and infraclavicular BPB (IC-BPB) are being used interchangeably for upper limb surgeries. However, the number of anesthesiologists practicing SC-BPB is much more than those practicing IC-BPB.

Many studies have compared SC-BPB and IC-BPB, but a study comparing the para-vascular approach of SC-BPB and costo-clavicular approach of IC-BPB is missing. This prospective study compared the costo-clavicular approach of IC-BPB with the para-vascular approach of SC-BPB. A total of 80 patients (40 in each group), aged 18–65 years, belonging to ASA class I and II and undergoing hand, wrist and forearm surgery were randomly allocated to group S (receiving SC-BPB) and group I (receiving IC-BPB). The two groups were compared with respect to the block success rate, block performance time, time taken to achieve surgical anesthesia, efficacy, and safety in providing surgical anesthesia for below elbow upper limb surgeries.

Results: Block success was significantly higher in the IC-BPB (100%) vs SC-BPB (92.5%), *P* value 0.03. Scan time was significantly more in the SC-BPB, *P* value 0.001. The block performance time was comparable; time to achieve surgical anesthesia was significantly longer in the IC-BPB, *P* value 0.001. Time for first rescue analgesia was longer in the IC-BPB, *P* value 0. 001. The number of patients requiring intraoperative sedation was comparable, *P* value 0.99.

Conclusions: IC-BPB has greater success rate in providing surgical anesthesia in below elbow surgeries and provides longer postoperative analgesia.

Keywords: Brachial plexus block, Upper extremity, Analgesia, Anesthesia

Background

Among the various techniques of brachial plexus block (BPB), supraclavicular brachial plexus block (SC-BPB) is the most common. Incorporation of ultrasound guidance in regional anesthesia has led to many improvisations in the techniques of BPB. These improvisations have led to improved results and safety of BPB techniques (Chan et al. 2007; Yuan et al. 2012), and also reemergence of the interest in infraclavicular brachial plexus blocks (IC-BPB) (Fredrickson et al. 2009; Chin et al. 2013).

Although both SC-BPB and IC-BPB can be utilized for providing surgical anesthesia for forearm orthopedic surgeries, only few studies have compared ultrasound

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(USG)-guided IC-BPB and SC-BPB (Fredrickson et al. 2009). Most of these studies had utilized the corner pocket approach for SC-BPB and lateral parasagittal approach for IC-BPB (Fredrickson et al. 2009; Techasuk et al. 2014). However, there are no studies comparing USG guided paravascular approach of SC-BPB and USG-guided coracoclavicular approach of IC-BPB.

In the para-vascular approach (PV) of SC-BPB (Kapral et al. 1994), local anesthetic (LA) is injected at a single site and hence does not require needle repositioning. Similarly, costo-clavicular approach (CC) of IC-BPB requires a single site injection of LA (Leurcharusmee et al. 2017). Theoretically, a single site of injection should reduce the chances of needle malposition and increase the success rate of block. Hence, we hypothesized that the two techniques will have comparable success rate in providing surgical anesthesia for forearm orthopedic surgeries.

The aim of this study is to compare USG-guided paravascular approach of SC-BPB and USG-guided coracoclavicular approach of IC-BPB in providing surgical anesthesia for forearm orthopedic surgeries in terms of block success rate, block performance time, scan time, time to achieve surgical anesthesia, incidence of tourniquet pain, the proportion of patients requiring sedation for intraoperative comfort, and the proportion of patients requiring rescue analgesics at the end of 24 h.

Methods

This prospective, randomized, single-blinded study was conducted on 80 patients undergoing below elbow upper limb surgery at a tertiary care center, between June 2018 and February 2020, after obtaining Institutional Ethics Committee approval (IHEC-LOP/2018/MD0016). This was a MD thesis topic.

Patients aged 18–65 years of either sex and belonging to American Society of Anesthesiologist (ASA) grade 1 and 2 were included in the study. Patient not willing for surgery under regional anesthesia (RA) or having contraindications to RA due to allergy to local anesthetics (LA), procedure site infection, any coagulation disorder, ASA grade 3–4, mental health issues were excluded.

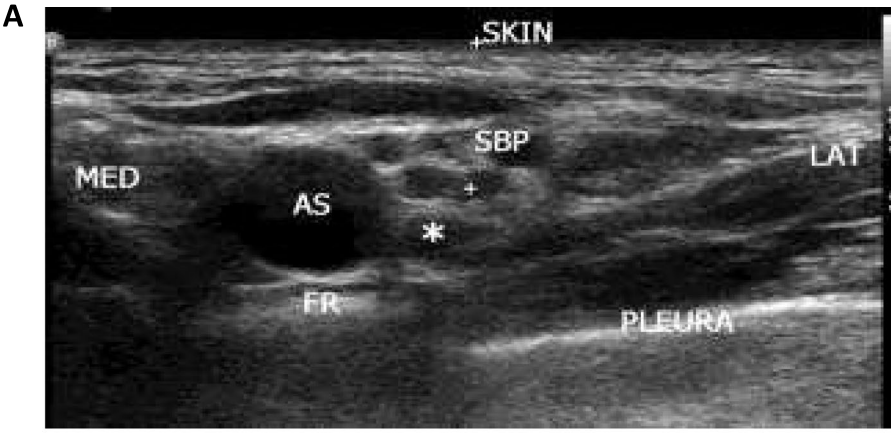
After detailed pre-anesthetic check-up, a written informed consent was taken. The patients were randomized to receive either PV-SC-BPB (group S, $n = 40$) or CC-IC-BPB (group I, $n = 40$). Simple block randomization was done using a computer-generated random number table and the block size was of 4 patients. All the patients were given tablet lorazepam 2 mg in the night and morning before surgery and standard fasting guideline were followed. After wheeling the patient into the theater, intravenous access was inserted, and standard monitors were attached. Strict aseptic precautions were taken. All the blocks were performed by a single operator (Author-CR having an experience of performing > 50 BPB under USG guidance) using Sonosite M-turbo; high frequency linear array probe (6–13 Hz) in both the study groups.

For PV-SC-BPB, technique described by Kapral et al was used (Chin et al. 2013). The block was performed with the patient lying supine with the head tilted to the opposite side, and the skin was disinfected and draped. A 6–13 Hz probe was placed in the supraclavicular region, in the transverse orientation, approximately 3 cm above the midclavicular point. At this site the, 3rd part of subclavian artery was visible. The probe was toggled in the cephalocaudal direction to see the subclavian artery in its cross-section. The upper and the middle trunks were visible lateral to the subclavian artery while the inferior trunk was visible just posterior to the artery. Theses trunks were visible as three hypoechoic structures in almost vertical orientation. After obtaining an adequate sonographic view, the needle was proceeded in-line from lateral to medial. Single injection was done near the middle trunk and spread of drug to the superior and inferior trunk was ensured. This technique looks similar to interscalene approach except than in interscalene approach, the subclavian artery is not an important landmark (Fig. 1A).

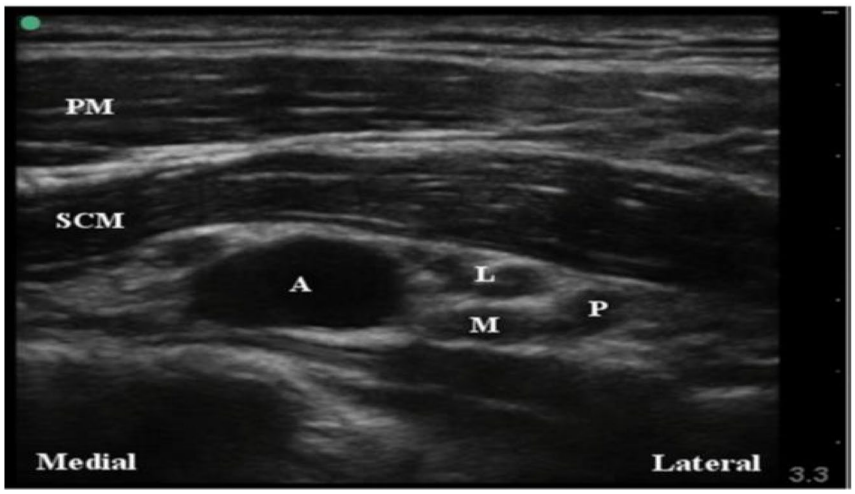
For CC-IC-BPB, the patient was placed in supine position with the head turned away from the side of block. The skin was disinfected and draped. The transducer probe was placed below the middle third of the clavicle to visualize the costo-clavicular (CC) space in the medial infra-clavicular fossa. In the CC space, the axillary artery (AA) was identified underneath the subclavius muscle. The three cords of the brachial plexus were visualized lateral to the AA (Fig. 1B) (Leurcharusmee et al. 2017; Songthamwat et al. 2018).

Under USG guidance, both PV-SC-BPB and CC-IC-BPB were performed using a 10-cm, 22-G, echogenic needle (Pajunk, Geisingen, Germany, or B. Braun, Bethlehem, PA). Needle was inserted in-plane with the US probe. LA solution contained 0.5% Bupivacaine (Anawin) and 2% lignocaine with adrenaline (1,200000) in 1: 2 ratios. One micrograms per kilograms of fentanyl was also added to the drug mixture. 0.5 ml/kg drug volume, up to a maximum of 35 ml was used for both the blocks (Abhinaya et al. 2017). The drug mixture was deposited at the desired location after checking for negative aspiration of blood.

Assessment of sensory and motor block was done by an observer who was blinded to the group allocation. Assessment was done every 1 min after the needle removal, for 20 min. Sensory evaluation was done by using pin prick stimulation in the areas supplied by



AS, subclavian artery; FR, first rib; SBP, supraclavicular brachial plexus



A, axillary artery; PM, pectoralis major muscle; SCM, subclavius muscle; M, L, P stands for medial, lateral and posterior cords of the brachial plexus respectively

Fig. 1 **A** Ultrasonography image for Supraclavicular brachial plexus block (SC-BPB). Brachial plexus is seen as hypoechoic nodules lateral to the subclavian artery. **B** Ultrasonography image for Infraclavicular brachial plexus block (IC-BPB). Brachial plexus is seen as hypoechoic nodules lateral to the axillary artery

the radial nerve-dorsum of hand, median nerve-thenar eminence, ulnar nerve-hypo-thenar eminence and musculo-cutaneous nerve-lateral aspect of the forearm. At each point of assessment, a score (0–2) was given to each territory. 0—implying normal sensation, 1—loss of pain sensation but pressure sensation intact, 2—loss and pain and pressure sensation. Motor evaluation was done by elbow flexion (musculo-cutaneous nerve), 3rd finger flexion (median nerve), thumb abduction (radial nerve), little finger flexion (ulnar nerve). At each point of assessment, a score (0–2) was given to each territory. 0—no weakness (normal contraction), 1—indicating paresis (reduced power), 2—indicates complete loss of motor power.

We considered the block successful and the patient ready for surgery when the sum of the sensori-motor scores was more than or equal to 14 points, with the sensory block score equal or superior to 7.

In case of block failure or insufficient blocks, the patients were administered general anesthesia with standard institutional protocol and surgery was proceeded. Tourniquet pain, if any was managed by injection fentanyl 0.5 mcg/kg up to 1 mcg/kg; if the tourniquet still persisted GA was given and airway was secured.

USG imaging time was defined as the time (in seconds) to obtain adequate USG image. Block performance time was defined as the time (in minutes) from the point of the needle insertion till the removal of the needle after drug deposition. Time for onset of block was defined as the time (in minutes) from the removal of needle to the achievement of combined sensory-motor score of 14. After the completion of surgery, patients were assessed for surgical site pain every four hourly on a 11-point numerical rating scale (NRS) where 0—meant no pain, while 10—denoted worst imaginable pain. [0—no pain,1–3 mild pain, 3–5—moderate pain and 6 or more—severe pain]. A rescue pain medication (Injection Tramadol 100 mg in 100 mL normal saline) was administered if the pain was more than 3 on NRS. Patients were followed-up for 24 h after the surgery.

Vessel puncture, intravascular injection, hematoma formation and any feature of LA toxicity were considered significant complications and were recorded. Post-operative complications included any feature suggestive of nerve injury or breathing difficulty.

The primary outcome of this study was to compare the success rate of CC-IC-BPB and PV-SC-BPB in providing surgical anesthesia for below elbow orthopedic surgeries. Secondary outcomes were to compare the block performance time, scan time, time to achieve surgical anesthesia, incidence of tourniquet pain, the proportion of patients requiring sedation for intraoperative comfort, and the proportion of patients requiring rescue analgesics at the end of 24 h.

Based on the study done by Yazer et al. (2015), 72 patients would be required to achieve an alpha error of 5% and 80% as power of study. We considered a drop out of 10% and hence included 40 patients in each group. Sample size calculation was done using G∗Power 3 for Windows (Franz Faul, Universität Kiel, Germany).

Data analysis was done using SPSS-16 software. The data was checked for normality using the Shapiro-Wilk test. Parametric data was compared using independent sample Student's *t* test. Non-parametric data was analyzed using chi-square test/Fisher's exact test/Mann Whitney test as per their applicability. A *P* value of less than 0.05 was considered significant.

Results

Ninety patients were assessed for eligibility to participate in the study, the CONsolidated Standards of Reporting Trials flow of participants is show in Fig. 2.

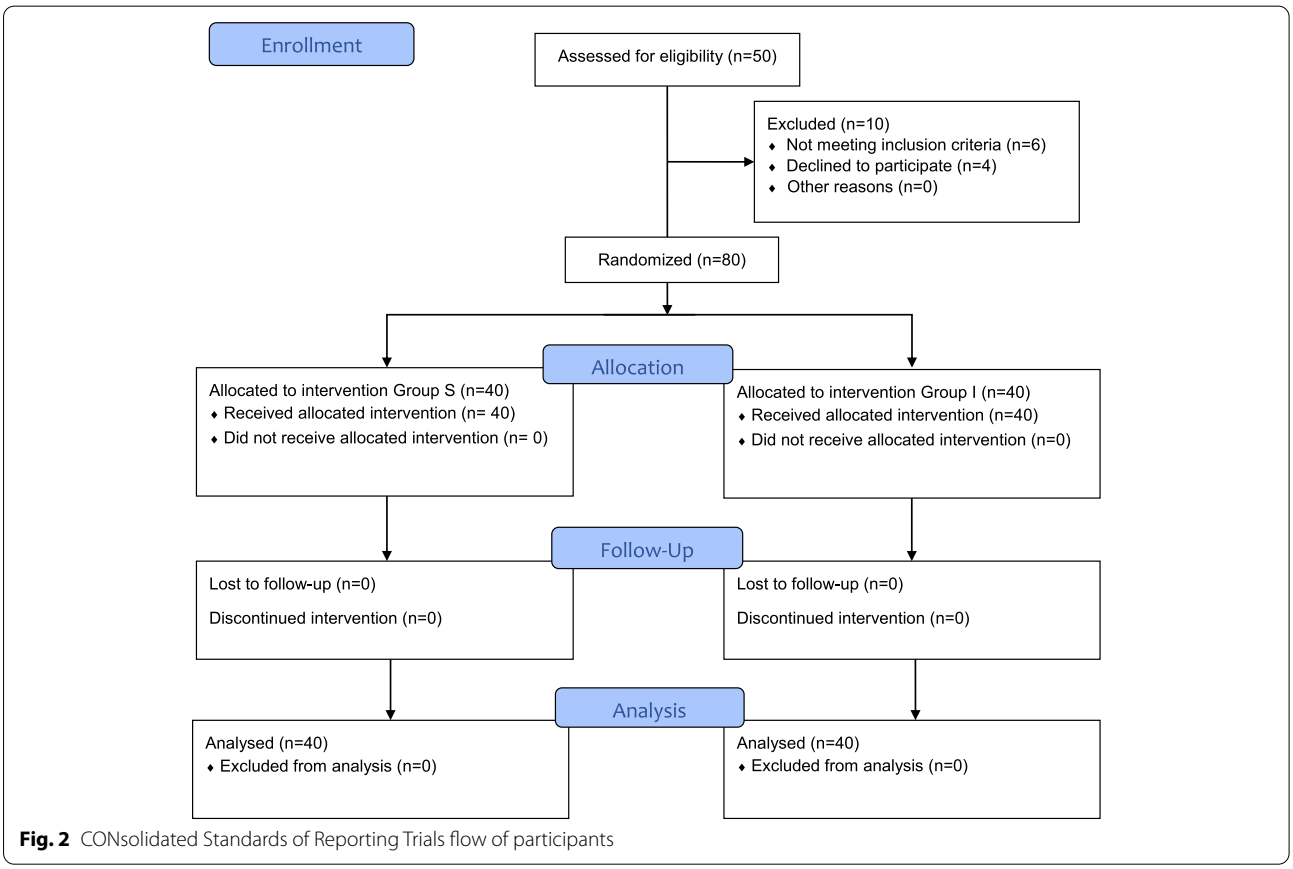


Fig. 2 CONsolidated Standards of Reporting Trials flow of participants

Table 1 Demographic data between the two groups

Demographic data	Group SC-BPB (*N*:40)	Group IC-BPB (*N*:40)	*P* value
Age (years)	31.25 ± 10.81	30.5 ± 10.9	0.80
Weight (kg)	55.9 ± 9.4	59.6 ± 7.9	0.06
Gender (male: female)	32:8	33:7	0.77
Mean tourniquet inflation time (min)	85.25 ± 22.13	82.5 ± 16.1	0.5
Mean duration of surgery (min)	113.4 ± 18.2	109.6 ± 21.9	0.4
Mean volume of LA (mL)	30 ± 3.7	30.6 ± 2.8	0.6

Age, weight, tourniquet time, duration of surgery, and volume of local anesthetic are presented as mean ± SD, comparison done using Independent sample Student's *t* test. Gender is presented numbers and is compared using chi-square test. A *P* value of 0.05 or less is significant

The demographic data of the study participants was comparable between the two groups (Table 1). The site of surgery, duration of surgery, tourniquet inflation time and the mean volume of LA used were also found to be comparable between the two study groups.

The block success rate was 100% (40/40) in the IC-BPB group as compared to 92.5% (37/40) in SC-BPB, the difference was statistically significant (*P* value 0.03). In the SC-BPB, ulnar nerve territory was spared in all the failed cases [3/40 (7.5%)]. The block performance time was comparable between the two groups (7.6 ± 1.44 vs 8.1 ± 1.39 min in SC-BPB and IC-BPB respectively, *P* value 0.1).

The mean scan time was significantly faster in IC-BPB (102.38 ± 22.22 vs 126.75 ± 33.59 s, *P* value 0.001). The time to onset of surgical anesthesia was significantly shorter in the SC-BPB (14.48 ± 1.78 vs 17.05 ± 2.28 min, *P* value 0.001), and time to rescue analgesia was significantly longer in the IC-BPB group (288 ± 28.9 vs 262.2 ± 23.1 min, *P* value 0.001) (Table 2). Incidence of tourniquet pain was comparable in both the groups 0% (0/40) vs 5% (2/40) in SC-BPB and IC-BPB respectively (*P* value 0.15), proportion of patients needing sedation for intra-operative comfort was also comparable between the two groups [7/40 (17.5%) vs 8/40 (20%) in SC-BPB and IC-BPB respectively, *P* value 0.99]. Proportion of patients requiring rescue analgesic at the end of 24 h was comparable between the two groups [30/40 (75%) vs 24/40 (60%) in SC-BPB and IC-BPB respectively, *P* value 0.15] (Table 2). None of the patients had any serious peri-operative complications.

Discussion

Block success rate was significantly more in the IC-BPB group; block performance time was comparable between the two groups. Although, the scan time was significantly shorter in the IC-BPB group, this advantage was offset by a longer time to onset of surgical anesthesia time. The number of patients having tourniquet pain, requiring sedation for intra-operative comfort was comparable between the two groups.

In this study, we used the para-vascular approach of SC-BPB. It was developed by Kapral et al. reported

Table 2 Comparison of study parameters between the two groups

Study parameters	Group-S (*N*:40)	Group-I (*N*:40)	*P* value
USG scan time (s)	126.75 ± 33.59	102.38 ± 22.22	**0.001***
Block performance time (min)	7.6 ± 1.44	8.1 ± 1.39	0.10
Time for onset of surgical anesthesia (min)	14.48 ± 1.78	17.05 ± 2.28	**0.001***
Number of patients having inadequate block%	3/40 (7.5%)	0/40 (0%)	**0.03***
Number of patients having tourniquet pain (%)	0/40 (0%)	2/40 (5%)	0.15
Number of patients requiring sedation for intraoperative comfort (%)	7/40 (17.5%)	8/40 (20%)	0.99
Number of patients requiring rescue analgesia at the end of 24 h (%)	30/40 (75%)	24/40 (60%)	0.15
Mean time to rescue analgesia (min)	262.2 ± 23.1	288 ± 28.9	**0.001***

USG scan time, block performance time, time to surgical anesthesia, and mean time to rescue analgesia is presented as mean ± SD, comparison done using independent sample Student's *t* test. Number of patients having inadequate block, tourniquet pain, requiring sedation were compared using Fisher's exact test, patients requiring rescue analgesia was compared using chi-square test. * indicates *P* value is significant

satisfactory surgical anesthesia in 95% patients (Kapral et al. 1994). The success rate of PV-SC-BPB has been found to be higher than the Corner pocket approach of SC-BPB (95% vs 83%) (Soares et al. 2007) and our results are in sync with the available literature.

In order to increase the success rate of Corner pocket approach of SC-BPB, a two-injection technique has been proposed which achieves a success rate of 96.7%, but this technique needs identification of neural clusters, which makes this technique more time consuming and technically challenging (Techasuk et al. 2014).

In this study we used the costo-clavicular approach of IC-BPB (Techasuk et al. 2014; Hsu et al. 2019). In costoclavicular (CC) approach all the three cords are located on the lateral aspect of the AA and displays a more compact topography and thus a single site injection of LA is required; whereas, in the lateral sagittal (LS) approach, the three cords are located medial, lateral and posterior to the AA, requiring multiple needle manipulations (Songthamwat et al. 2018). Songthamwat et al. found that the CC approach was faster to perform and had a higher success rate than the LS approach (Songthamwat et al. 2018). In LS approach, the needle trajectory is steeper and the target is deeper in comparison to the CC approach, making the procedure technically more difficult (Songthamwat et al. 2018). The LS approach becomes even more difficult as it requires multiple needle redirections to cover the lateral, medial and the posterior cords. The success rate of CC approach ranges from 70 to 97% (Songthamwat et al. 2018; Leurcharusmee et al. 2017; Arcand et al. 2005). The volume of local anesthetic used in the IC-BPB block can be an important determinant of success; incomplete fascial planes seem to be the most plausible reason for this observation (Tran et al. 2011). In this study, we used a drug volume that was in sync with the study that demonstrated the highest success rates, our results were also in sync with the available literature (Leurcharusmee et al. 2017).

Studies have demonstrated that block failure in IC-BPB is mostly attributed to arterial puncture and radial nerve is most commonly spared (Arcand et al. 2005; Koscielniak-Nielsen et al. 2009). In our study, none of the patients undergoing IC-BPB had an arterial puncture. In the SC-BPB, ulnar nerve was the most commonly spared nerve which is in sync with the available literature (Williams et al. 2003).

Similar to finding of Arcand et al., scan time was lower in the IC-BPB (Arcand et al. 2005). Lesser scan time in IC-BPB as compared to SC-BPB can be due to anatomical feasibility of this approach and easy localization of the nerve cords due to their compact tomography at this place.

In our study, time to onset of surgical anesthesia was significantly shorter in the SC-BPB (14.48 ± 1.78 vs 17.05 ± 2.28 min), which is consistent with the results of Yazer et al. (2015) in which they found that time to onset of surgical anesthesia was quicker in SC-BPB (8.9 min) as compared to IC-BPB (17.6 min). Murray et al. had used the inter-truncal approach of SC-BPB, where each trunks were localized and LA was deposited, resulting in relatively quick time to onset of surgical anesthesia (8.9 min), whereas our study utilized the para-vascular approach of SC-BPB and time to onset of surgical anesthesia was 14.48 min. This can be explained by the fact that, depositing LA by directly targeting BPB trunks results in early onset of blockage.

In our study, block performance time was comparable between the two groups which is inconsistent with the study done by Abhinaya et al. (2017) in which they found that block performance time for IC-BPB was significantly less than SC-BPB. This can be explained by the fact that, Abhinaya et al. had used Corner pocket approach of SC-BPB and needle was targeted at two points, whereas in our study we used para-vascular approach of SC-BPB where needle is targeted at one point.

Tourniquet pain occurred in only 5% patients of the IC-BPB group which is lower than in the available literature (12%) (Chin et al. 2013; Bharti et al. 2015). A higher drug volume, a proximal approach could be the reason for more complete blockade of the axillary and musculo-cutaneous nerves.

The time to rescue analgesia was longer in the IC-BPB, although the difference is of little significance clinically.

In this study, we did not encounter any serious procedure-related adverse events like pneumothorax, vessel puncture, intravascular injection, hematoma formation, and any feature of LA toxicity. This is consistent with the study done by Arcand et al. in which no anesthetic technique associated complications were noted (Arcand et al. 2005).

Although supraclavicular and infraclavicular approaches of brachial plexus blocks have been extensively compared, we did not find any study comparing PV-SC-BPB and CC-IC-BPB, both of which are single site injection techniques. Hence, this study, may be a useful addition to the available literature.

There are some limitations to this study. First, this study was single-centered with a small sample size. A multi-centered study with a large sample size is required to achieve a statistical difference.

Second, the blocks were performed by a resident (Author CR) with a minimum experience of 50 BPB under USG guidance. If all the blocks would have been performed by a more experienced anesthesiologist, the scan time and performance time would have been decreased.

Conclusions

Based on this study, we can conclude that, in below elbow orthopaedic surgeries, USG-guided IC-BPB by the costo-clavicular approach provides superior quality of surgical anesthesia. The time taken to perform the block, incidence of tourniquet pain, and need for intraoperative sedation were comparable. Time for rescue analgesia was significantly longer in the IC-BPB group.

Abbreviations

BPB: Brachial plexus block; PV-SC-BPB: Para-vascular supraclavicular brachial plexus block; CC-IC-BPB: Costo-clavicular infraclavicular brachial plexus block; USG: Ultrasonography; ASA: American Society of Anaesthesiologists; LA: Local anesthetics; RA: Regional anesthesia; CC: Costo-clavicular; AA: Axillary artery; NRS: Numerical rating scale.

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Nil.

Authors' contributions

All authors (VW, CR, AJ, ST) are anesthesiologists involved, and who had contributed to this study. Concept and design of study was made by CR and AJ. VW, AJ, CR, and ST were involved in defining intellectual content, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, and manuscript review of the article. All authors have read and approved the final manuscript.

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Nil.

Availability of data and materials

The material and data related to the study is available with the author and mentioned in tabular form in the manuscript.

Declarations

Ethics approval and consent to participate

Institutional Human Ethics Committee approval (IHEC-LOP/2018/MD0016) was obtained from the ethical committee of AIIMS, Bhopal. A copy of IHEC approval is available for review by the Editor of this journal. A written informed consent to participate in the study was provided by all the study participants.

Consent for publication

Written informed consent for publication of the clinical details and was obtained from the study participants.

Competing interests

The authors declare that they have no competing interests.

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