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Efficacy of a single injection compared with triple injections using a costoclavicular approach for infraclavicular brachial plexus block during forearm and hand surgery: An observational study

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Abstract
Background: The costoclavicular space (CCS), which is located deep and posterior to the midpoint of the clavicle, may be a better site for infraclavicular brachial plexus block than the traditional lateral paracoracoid site. The aim of this stdy was that triple injections in each of the 3 cords in the CC space would result in a greater spread in the 4 major terminal nerves of the brachial plexus than a single injection in the CC space without increasing the local anesthetic (LA) volume.

Materials and Methods: Seventy patients who underwent upper extremity surgery randomly received either a single injection (S group, n=35) or a triple injection (T group, n=35) using the CC approach. Ten milliliters of 1% xylocaine, 10 mL of 0.5% ropivacaine, and 5 mL of normal saline were used for BPB in each group (total 25 mL). Sensory-motor blockade of the ipsilateral median, radial, ulnar, and musculocutaneous nerves was assessed by a blinded observer at 5 minutes intervals for 30 minutes immediately after LA administration.

Results: Thirty minutes after the block, the blockage rate of all 4 nerves was significantly higher in the T group than in the S group (52.9% in the S group vs 85.3% in the T group, P=.004). But there was no significant difference in the anesthesia grade between the 2 groups (P=.262). The performance time was similar in the 2 groups (3.0±0.9 minutes in the SI group vs 3.2±1.2 minutes in the T group, respectively; P=.54).

Conclusion: The triple injection increases consistency in terms of blocking all 4 nerves without increasing the procedure time despite administering the same volume of the LA.

Keywords: brachial plexus block, costoclavicular approach, infraclavicular block, triple injection, ultrasound

Introduction
Costoclavicular approach of BPB is a modification of ultrasound-guided infraclavicular brachial plexus block. Its procedure and cadaveric anatomical study has been published by Sala Blanch *et al.* [1] in 2015. Under ultrasound guidance, the costoclavicular space (CCS) is visualized as a well-defined inter muscular space, lying deep and posterior to the mid-point of the clavicle. At the CCS, and in contrast to that at the LICF, the cords of the brachial plexus are clustered together lateral to the axillary artery [2] and share a consistent relation to one another and to the axillary artery [3, 4]. Ultrasound-guided ICBPB at the CCS, the "costoclavicular brachial plexus block (BPB)," has also been briefly described.[5] However, currently, there are limited data on the relevant sonoanatomy and no clinical data on block dynamics after a costoclavicular BPB.[6]Songthamwat *et al.* [7] reported that the CC approach induces a faster onset of a sensory blockade than the conventional approach, even with 25 mL of the LA. They performed the CC approach with a single injection, which was effective for induction of surgical anesthesia for all patients. However, the rate of blockage of all 4 nerves was not significantly high, with a complete sensory blockade rate of 50% 30 minutes after the block. The 3 cords of the brachial plexus are widely distributed laterally to the axillary artery, even though they are tightly clustered together [7]. Therefore, we considered that performing a single injection targeted at the center of the 3 cords could increase the chance of uneven spreading of LA. Considering this CC topography, we hypothesized that injections in each of the 3 cords, using one-third of the injection volume

for each cord, would result in an increased rate of blockage of all 4 nerves compared with a single injection, without an increase in the LA volume

Materials & Methodology

Seventy patients scheduled for surgery of the forearm and hand, were enrolled in the study. Study conducted between Dec 2019 to Jun 2021. Ethical committee approval, a single blinded (observer) randomized clinical study was carried out on patients aged between 18 to 80 years of ASA grade I, II and III scheduled for forearm and hand surgeries at our institution. Involved with the study were explained to the patient and a written informed consent was obtained. Patients with neuromuscular disease/nerve injury, prior surgery on the infraclavicular fossa, pregnant patients and with contraindications to peripheral nerve blocks were excluded from the study. Detailed pre- anesthetic evaluation. Routine investigations and specific investigations were done as per patient clinical evaluation. During the preoperative visit, patients were also instructed on the use of a visual analogue scale (VAS) for post-operative analgesia. Hemodynamic variables (BP, HR, and SPO2) were evaluated. All the patients were kept nil per oral 8 hours prior to surgery. The patients were randomly assigned to either the single injection group (S group, n=35) or the triple injection group (T group, n=35) using a random integer set generator. The ratio of allocation was 1:1. A researcher who was not involved in performing the block generated the randomization set and enrolled the participants.

Procedure

All infraclavicular BPBs were performed in the anesthesia procedure room, approximately 1 hour before the scheduled surgery. On arrival, supplemental oxygen and standard monitoring (noninvasive blood pressure, electrocardiogram, and pulse-oximetry) were applied, and a time-out procedure was performed. Intravenous premedication (50 µg fentanyl and 1 mg midazolam) was administered to all patients. The patients were placed in the supine position, with their ipsilateral arm abducted to 90° and palms facing the ceiling. The patient's head was turned slightly to the contralateral side for the BPB. The transducer was positioned immediately below the midpoint of the clavicle and over the medial infraclavicular fossa. The transducer was also tilted slightly cephalad to direct the US beam towards the CC space. In the CC space, the axillary artery was identified underneath the subclavius muscle. The US image was optimized until all 3 cords of the brachial plexus were visualized laterally to the axillary artery in one plane. All blocks were performed under LA infiltration (2 mL of 2% Xylocaine). The block needle was inserted in-plane and from a lateral-to-medial direction. The total volume of the LA mixture was 25 mL (10 mL of 1% xylocaine mixed with 10 mL of 0.5% ropivacaine and 5 mL of normal saline) in each group. The LA was injected in 2 to 3 mL increments after intermittent negative aspiration under direct US visualization of the LA spread. If paresthesia was induced during the procedure, the needle was withdrawn by 2 to 3 mm.

In the S group, after the skin puncture, the block needle was advanced to the brachial plexus sheath. After the sheath was penetrated, a small amount (0.5–1 mL) of 0.9% normal saline was then incrementally injected to "open" the perineural space until the needle tip was positioned at the center of the cord cluster. After the correct needle tip position was confirmed, 25 mL of the LA was slowly injected. The spread of the LA from the center of the 3 cords was observed. In the T group, after the skin puncture, the block needle was advanced to the medial cord similar to the description above (hydrodissection). One-third of the LA volume was then injected into the medial cord. The needle tip was then redirected to the lateral and posterior cords, with one-third of the LA volume being slowly injected in each cord. Subsequent advancement of the needle was preceded by withdrawal of the needle by approximately 10 to 15 mm; however, the needle was not withdrawn to the subcutaneous tissue. The spread of the LA around each of the 3 cords was observed.

Results

A skin puncture was performed once in both groups, except for 1 case in the T group, where 2 skin punctures were performed due to an out-of-plane injection in 1 cord. The performance time of the T group and S group was similar. The block onset time of the T group was not significantly different from that of the S group. However, the rate of blockage of all 4 nerves was significantly higher in the T group than in the S group. The proportion of patients with complete sensory block and complete motor block at each evaluation time up to 30 minutes after the block was similar in both groups, except for the patients with the radial nerve block at 15 minutes, those with the musculocutaneous nerve block at 20 minutes, and those with the median nerve at 25 and 30 minutes. No vascular or pleural punctures occurred during the procedures. Other complications were ptosis (1 case), and paresthesia (2 cases) in the S group and nausea (1 case), and hoarseness (2 cases) in the T group. Complete recovery of sensory and motor function was confirmed in all patients. No neurologic complications were reported at the 1-week follow-up.

Table 1: Shows Type of surgery (fracture vs non fracture) S group(n=35), t group (n=35) and P

	S group(n=35)	t group (n=35)	P
Type of surgery (fracture vs non fracture)	13/21	18/16	.223
Image time, min	28.3 ±14.9	30.2±19.3	.665
Needling time, min	2.5±0.8	2.6±1.1	.648
Performance time, min	3.0±0.9	3.2±1.2	.540
Tourniquet time, min	46.6±21.5	51.5±26.9	.392
Surgery time	49.9±23.0	53.3±26.5	.572
Onset time	22.2±3.2	21.9±5.1	.807
Rate of all 4 nerves blockades	18(52.9%)	29(85.3)	.004
Anaesthesia grade	22/3/8/1	28/3/3/0	.262
Hemi diaphragmatic paralysis	29/5/0	33/1/0	.087

Discussion

The primary finding of this study was that the T group increased the consistency of infraclavicular BPB in terms of the rate of blockage of all 4 nerves compared with the group, without an increase in the procedure time using the same volume (25 mL) of the LA for US-guided infraclavicular BPBs with a CC approach.

Karmakar *et al.* [6] recently introduced the CC approach with the aim of targeting the CC space where the 3 cords are tightly clustered together. While effective surgical anesthesia was provided, the rate of blockage of all 4 nerves was about 50% 30 minutes after the block, which was similar to the results of the SI group in this study (52.9%).

In our study, the rates of “excellent” anesthesia grade (when surgery was finished with only a BPB) were similar in the 2 groups (S group 64.7% vs T group 82.4%, $P=.99$). But we primarily focused our study on the successful rate of all 4 nerves blockage because failure in blocking 1 nerve completely can lower the anesthesia grade if surgery is performed in an area innervated by an incompletely blocked nerve [9]. Furthermore, it was thought to be more meaningful than shortening the onset time [8].

Layera *et al.* [10] recently compared a single injection technique with the double injections technique using the CC approach. In their study, the double injection technique displayed a shorter block onset time. However, this might be partially explained by a relatively larger LA volume than the amount used in the first CC approach (35 mL). An increase in the volume can enhance the block quality, but the probability of LA toxicity can also increase [9]. In the current study, we used triple injections to target specific cords. However, the LA was divided so that only one-third of the total volume was injected in each of the cords.

The median, radial, and musculocutaneous nerves were blocked faster at certain time intervals in the T group. However, this did not lead to a decrease in the onset time. The median nerve emerges from the medial and the lateral cords, the radial nerve from the posterior cord, and the musculocutaneous nerve from the lateral cord, so triple injections seem to be effective in ensuring the even distribution of LA to each of the 3 cords.

In the conventional approach, all 3 cords are rarely visualized in a single sagittal US scan.[7]In all cases in this study, we saw 3 cords in 1 US plane. Therefore, we believe that the CC approach is advantageous in the clinical setting. However, it can be challenging to advance the needle to the desired site. In 1 female patient (159 cm tall and weighing 39 kg [underweight]) in the T group, the needle could not be advanced to the medial and lateral cords using the in-plane technique due to the angle. Therefore, we used the out-of-plane technique, and the needle could be inserted at the center of the medial cord and the lateral cord. The LA spread towards these 2 cords was confirmed by US. Subsequently, we could advance the needle to the posterior cord using the in-plane technique. The out-of-plane technique can be principally used in situations where the in-plane technique is challenging or the needle direction is not clear.

Conclusion

In conclusion, the Triple injection of CC approach increased the consistency of US-guided infraclavicular BPB in terms of the rate of blocking all 4 nerves without increasing the procedure time, despite administration of the same volume (25 mL) of LA.

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