Original Article

Comparison of ultrasound-guided costoclavicular and supraclavicular brachial plexus block for upper extremity surgery: a propensity score matched retrospective cohort study

Long Zhang, Rufa Pang, Liangguang Zhang

Department of Anesthesiology, Ningbo NO. 6 Hospital, Ningbo, China

Contributions: (I) Conception and design: All authors; (II) Administrative support: L Zhang; (III) Provision of study materials or patients: L Zhang, R Pang; (IV) Collection and assembly of data: L Zhang, R Pang; (V) Data analysis and interpretation: L Zhang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Liangguang Zhang. Department of Anesthesiology, Ningbo NO.6 Hospital, 1059 #Zhongshan East Road, Ningbo 315040, China. Email: lgzhang1987@163.com.

Background: Ultrasound-guided costoclavicular (CC) brachial plexus blocks (BPBs) are a novel approach for nerve block in upper extremity surgery. However, comparisons between CC-BPB and conventional supraclavicular (SC) BPB have not clearly delineated the benefits or costs of either method.

Methods: This retrospective cohort study enrolled patients receiving BPB due to upper extremity fracture between June 2019 and May 2020. Data were collected from the medical records of patients, including age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status, side of block, and operative location. Enrolled patients were matched in a 1:2 ratio using propensity score matching models. The primary outcomes in this study were the proportions of complete sensory and motor blocks and the secondary outcomes included other block-related outcomes, pain-related outcomes, and side effects or complications.

Results: The study enrolled 235 patients with upper extremity fracture and there was a significant difference in the side of block when comparing ultrasound-guided CC-BPB and SC-BPB. After propensity score matching, 62 patients receiving ultrasound-guided CC-BPB and 124 receiving ultrasound-guided SC-BPB were enrolled. The proportions of complete sensory and motor block at each interval after injection showed no significant difference when the groups were compared. Although CC-BPB involved a longer procedure time than SC-BPB (6.2±0.7 *vs.* 5.1±0.5 min, P<0.001), it provided a longer duration of nerve block (duration of sensory block: 468.2±103.5 *vs.* 396.5±83.4 min, P<0.001; duration of motor block: 554.6±99.5 *vs.* 469.7±96.0 min, P<0.001). Patients with Horner's syndrome were also more prevalent in the SC-BCB group (n=11) (8.9%) in comparison to one patient (1.6%) in CC-BPB group (P=0.04).

Conclusions: CC-BPB is a safe and efficient approach for upper extremity surgery.

Keywords: Ultrasound-guided costoclavicular brachial plexus block; ultrasound-guided supraclavicular brachial plexus block; upper extremity surgery; propensity score matched study

Submitted Nov 06, 2020. Accepted for publication Dec 29, 2020.

doi: 10.21037/apm-20-2376

View this article at: http://dx.doi.org/10.21037/apm-20-2376

Introduction

Supraclavicular (SC) and infraclavicular (IC) brachial plexus blocks (BPBs) are routinely performed for regional blockade in upper extremity surgery (1). Ultrasound-guided SC or IC-BPBs are increasingly used as an alternative for upper extremity surgery due to the reduced incidence of potential complications associated with their use including Horner's syndrome, pneumothorax and nerve injury (2,3).

Both ultrasound-guided SC-BPB and IC-BPB show a high success rate and fast block onset time (4-6). A systematic review involving 10 studies found a statistically higher incidence of incomplete sensory block within 30 minutes in an IC-BPB group compared with a SC-BPB group, although no differences were found in success rate, block onset time, and analgesia duration (7). Moreover, various adjuvants have been developed to increase the efficacy of blocks and reduce the adverse effects of local anesthetic in SC-BPB (8,9).

The costoclavicular approach (CC-approach) was first used by Karmakar *et al.* in 2015 (10). Ultrasound-guided CC-BPB provides a rapid onset of sensory-motor blockade as it is performed at the CC space and targets the center of the three neural cords lateral to the axillary artery (11). Successful CC-BPB requires a low volume of local anesthetic for surgical anesthesia of no more than 25 mL (12) and it was reported that ultrasound-guided CC-BPB could provide faster onset of sensory blockade than IC-BPB (12). However, to date there are very few studies comparing the efficiencies of ultrasound-guided CC-BPB and SC-BPB in regional blockade in upper extremity surgery. The first of these was a randomized non-inferiority trial conducted by Luo *et al.* (13) using a modified double-injection technique which found ultrasound-guided CC-BPB and SC-BPB could result in similar block dynamics. As this technique improved the efficiencies of both approaches, a comparative study of conventional ultrasound-guided CC-BPB and SC-BPB is needed to determine the efficiencies, advantages, and disadvantages of the two methods.

The present study was retrospectively performed to compare ultrasound-guided CC-BPB and SC-BPB. To reduce the bias induced by the natural limitations of retrospective study, the data of enrolled patients were matched by propensity score matching models. We present the following article in accordance with the STROBE reporting checklist (available at http://dx.doi.org/10.21037/apm-20-2376).

Methods

The study was approved by the Institutional Review Board of the Ningbo NO.6 Hospital and performed in compliance with the ethical principles of the Declaration of Helsinki (as revised in 2013). Informed consent was not required due to the retrospective design of the study.

Patient enrollment and data collection

Patients who were admitted to the Ningbo NO.6 Hospital between June 2019 and May 2020 and received BPB due to upper extremity fracture were enrolled. Data including age, gender, body mass index (BMI), type of BPB (CC-BPB or SC-BPB), American Society of Anesthesiologists (ASA) physical status (I or II), side of block (left or right), and operative location (elbow, forearm, wrist, or hand) were collected from the medical records of patients by two independent investigators. Patients were excluded if they were older than 70 years or younger than 18 years, if they had ASA physical status of more than II, if the BPB was performed using approaches other than CC or SC, if they suffered from multiple fractures, and if their medical records were incomplete.

Ultrasound-guided BPB

All procedures were performed by a skilled anesthesiologist using a portable ultrasound machine (Sonosite M-turbo) with a linear probe (6–13 MHz) and 22-gauge stimulating needle. A local anesthetic consisting of 25 mL of a 1:1 mixture of 2% lidocaine and 1% ropivacaine was administered.

In the ultrasound-guided CC-BPB, patients were placed in a supine position with the surgical extremity abducted 90 degrees. The direction of the transducer was adjusted to direct the ultrasound beam towards the CC space (between the posterior surface of the clavicle and the second rib) following an initial scan of the clavicular midpoint. The ultrasound image was optimized to visualize the three cords (lateral, medial, and posterior) lateral to the axillary artery and a block needle advanced to locate its tip in the middle of the cords. Following the injection of a half volume of local anesthetic mixture to the targeted nerves, the block needle was withdrawn then the remaining half volume injected to the lateral cord.

In the ultrasound-guided SC-BPB group, patients were placed in a supine position with the head turned to the contralateral side. After obtaining a satisfactory image of the clavicle, the direction of the transducer was adjusted to direct the ultrasound beam toward the first rib. The block needle was advanced, and its tip located in the corner pocket (the intersection between the first rib and the subclavian artery). After a one-third volume of local anesthetic mixture was injected into the corner pocket the block needle was

repositioned to inject the remaining volume to the neural cluster formed by the trunks and divisions.

Outcomes

The primary outcomes in this study were the proportions of complete sensory and motor blocks. The sensory block was evaluated by a research anesthesiologist at 5, 10, 15, 20, 30 and 45 min after injection (0 = no block, 1 = analgesia, 2 = complete anesthesia) by means of cold tests in the cutaneous distribution of the musculocutaneous (MCN), median (MN), radial (RN), and ulnar (UN) nerves. The motor block was also evaluated by a 3-point scale (0 = no block; 1 = paresis; 2 = paralysis) according to elbow flexion (MCN), wrist flexion (MN), wrist extension (RN), and flexion and opposition of the fifth finger toward the thumb (UN). Overall, 7 or 8 points was considered as complete sensory or motor block and a total block score of 14 or more considered to indicate the patient was ready for surgery. The time of complete sensory or motor block was recorded as the onset time.

The secondary outcomes included other block-related outcomes, pain-related outcomes, and side effects or complications. Other block-related outcomes included the procedure time, discomfort score during BPB (scoring from 0 to 100, 0 = no discomfort and 100 = extreme discomfort), and the duration of sensory and motor blocks. Pain related outcomes included pain scores at 2 and 24 hours after surgery (scoring from 0 to 10, 0 = no pain, 10 = extreme pain), time to first opioid request, and patient satisfaction (scoring from 0 to 10, 0 = not satisfied at all, 10 = very satisfied). Side effects or complications included nausea, vomiting, bradycardia, hypotension, vascular puncture, Horner's syndrome, pneumothorax, toxicity of local anesthetic, and nerve injury.

Statistical analysis

Enrolled patients were matched according to propensity score matching models using the matching package in R software (version 3.3.1). The propensity score of each patient was estimated with a multivariable logistic regression model by adjusting the variables including age, gender, BMI, ASA status, side of block, and operative location. Patients were then matched by propensity score in a 1:2 ratio using the nearest neighbor method within a caliper of 0.25. The absolute standardized difference was used to validate the balance between baseline variables after matching and a difference of less than 0.1 represented a negligible difference between the two included groups, indicating an adequate matching.

The remaining statistical analysis was performed using SPSS version 22, SPSS Inc., Chicago, IL, USA. Continuous data were presented as means with standard deviations and compared with a student t test. Categorical data were presented as counts and percentages and compared with the χ^2 test. All hypothesis tests were two-sided, and a p value less than 0.05 was considered as statistically different.

Results

Following the exclusion of 94 patients (*Figure 1*), the remaining 235 patients were allocated to a CC-BPB (n=62) and SC-BPB (n=173) group as shown in *Table 1*, which also lists the demographic and clinical characteristics of patients. There was no significant difference between the two groups in age, gender, BMI, ASA status and operative location. However, more patients (n=38) (61.3%) in the CC-BPB group underwent a right upper extremity block while more in the SC-BPB group (n=92) (53.2%) underwent a left-sided block. Patients were then matched according to propensity score matching models and the demographic and clinical characteristics of matched patients also listed in *Table 1*. The results indicated there was no significant difference between the two groups in all collected characteristics.

As the primary outcomes, the proportions of complete sensory and motor block at each interval after injection were compared between each group. As seen in *Figure 2*, the proportion of complete sensory block at 5 and 10 min after injection was less than 10% and more than 40% respectively in both groups while at 30 min, this had reached 98.4% in both groups. Overall, the proportion of complete sensory block at each interval after injection in the CC-BPB group was not statistically inferior to that seen in the SC-BPB group. The proportions of complete motor block at each interval after injection are shown in *Figure 3*, and also show no significant difference when the groups are compared.

Other block-related outcomes are listed in *Table 2*. Ultrasound-guided CC-BPB had a longer procedure time than SC-BPB (6.2±0.7 *vs.* 5.1±0.5 min, P<0.001) and patients in both groups reported mild discomfort. Interestingly, the durations of sensory and motor block in the CC-BPB group were much longer than those in the SC-BPB group (duration of sensory block: 468.2±103.5 *vs.* 396.5±83.4 min, P<0.001; duration of motor block: 554.6±99.5 *vs.* 469.7±96.0 min, P<0.001).

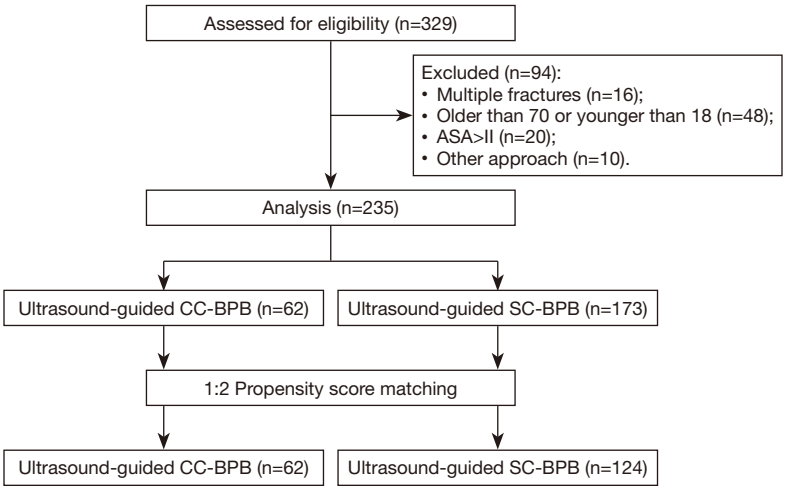

Figure 1 Flow chart.

Table 1 Demographic and clinical characteristics of patients in CC-BPB and SC-BPB groups before and after propensity score matching

Characteristics	Unmatched			Matched		
	CC-BPB	SC-BPB	P value	CC-BPB	SC-BPB	P value
Number	62	173		62	124	
Age, year	43.2±12.9	45.1±13.5	0.42	43.2±12.9	43.9±12.4	0.60
Gender (male/female)	35/27	102/71	0.73	35/27	75/49	0.60
BMI, kg/m^2	21.9±3.8	22.6±4.3	0.81	21.9±3.8	22.3±4.2	0.54
ASA status (I/II)	33/29	94/79	0.88	33/29	67/57	0.92
Side of block (left/right)	24/38	92/81	0.05	24/38	55/69	0.46
Operative location			0.81			0.99
Elbow	14	48		14	28	
Forearm	16	41		16	31	
Wrist	16	36		16	30	
Hand	16	48		16	35	

BMI, body mass index; ASA, American Society of Anesthesiologists; CC-BPB, costoclavicular brachial plexus blocks; SC-BPB, supraclavicular brachial plexus blocks.

Pain-related outcomes are shown in *Table 3*. Pain scores at 2 or 24 hours after surgery were similar in both groups and patients were relatively satisfied with the treatments. In addition, patients in the CC-BPB group first requested opioids later than those in SC-BPB groups (502.8±83.3 *vs.* 423.7±102.8 min, P<0.001).

There were few side effects or complications in the study as shown in *Table 4*. While bradycardia was seen in two patients in each group and vascular puncture in one CC-BPB and three SC-BPB patients, no significant difference in these parameters was seen between groups However, 11 patients (8.9%) were diagnosed with Horner's syndrome in the SC-BPB group in comparison to one in in the CC-BPB group (P=0.04).

Discussion

This retrospective study revealed that ultrasound-guided

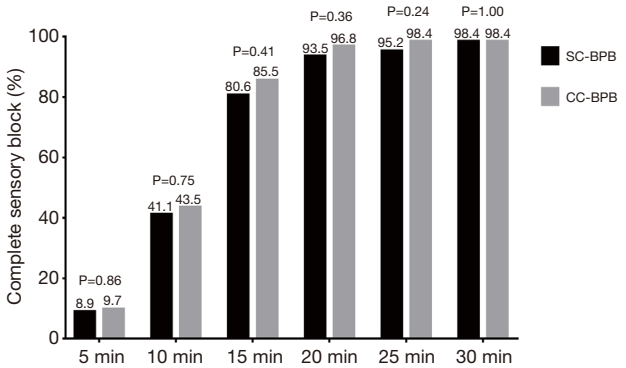

Figure 2 Proportions of complete sensory block at each interval.

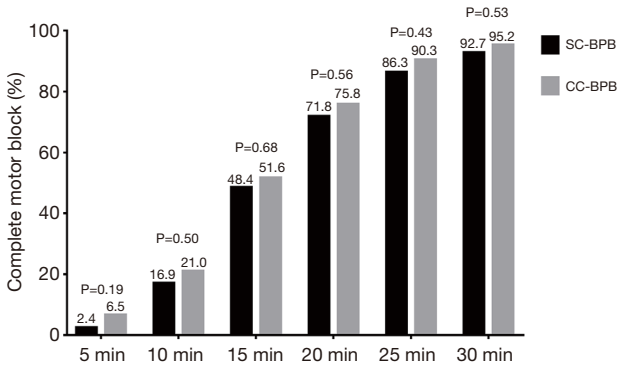

Figure 3 Proportions of complete motor block at each interval.

CC-BPB was not inferior to conventional SC-BPB in the efficiency of nerve block. Moreover, the postoperative analgesia and safety of CC-BPB was better than SC-BPB. Several studies have attempted to analyze the principle and efficiency of CC-BPB. Sala-Blanch *et al.* firstly explained the anatomical basis for BPB at the CC space by showing that the brachial plexus cords are clustered lateral to the axillary artery here, closely linking the two and enhancing block efficiency (14). Furthermore, in evaluating the spread of CC-BPB, Koyyalamudi *et al.* demonstrated that injection in the CC space firstly spread to the brachial plexus, reaching all its trunks and cords and sparing the phrenic nerve (11).

Several clinical studies have confirmed the efficiency of CC-BPB in different types of surgery. A 2017 paper reported that two patients successfully undergoing 2nd stage transposition of a basilic vein fistula received CC-BPB, without the need of further local anesthetic (15). In a larger study of hand or forearm surgery, CC-BPB was successfully performed in all 30 patients with a median onset time for complete sensory and motor block of 5 min (16). Complete sensory block was achieved in 30 minutes, and the success rate was 97%, with no reported side effects or complications (16). There is also debate on whether simple or double injection techniques should be used in CC-BPB. Monzó *et al.* described a double injection technique in their

Table 2 Block-related outcomes after propensity score matching

Characteristics	CC-BPB	SC-BPB	P value
Procedure time, min	6.2±0.7	5.1±0.5	<0.001
Discomfort score during BPB	39.8±11.2	41.6±15.9	0.46
Duration of sensory block, min	468.2±103.5	396.5±83.4	<0.001
Duration of motor block, min	554.6±99.5	469.7±96.0	<0.001

CC-BPB, costoclavicular brachial plexus blocks; SC-BPB, supraclavicular brachial plexus blocks.

Table 3 Pain-related outcomes after propensity score matching

Characteristics	CC-BPB	SC-BPB	P value
Pain score at 2 hours after surgery	0.6±0.1	0.5±0.1	0.41
Pain score at 24 hours after surgery	1.4±0.3	1.6±0.5	0.09
Time to first opioid request	502.8±83.3	423.7±102.8	<0.001
Patient satisfaction	8.6±0.6	8.8±1.0	0.52

CC-BPB, costoclavicular brachial plexus blocks; SC-BPB, supraclavicular brachial plexus blocks.

Table 4 Side effects or complications after propensity score matching

Characteristics	CC-BPB	SC-BPB	P value
Nausea	0	0	–
Vomiting	0	0	–
Bradycardia	2 (3.2%)	2 (1.6%)	0.49
Hypotension	0	0	–
Vascular puncture	1 (1.6%)	3 (2.4%)	0.71
Horner's syndrome	1 (1.6%)	11 (8.9%)	0.04
Pneumothorax	0	0	–
Toxicity of local anesthetic	0	0	–
Nerve injury	0	0	–

study, which resulted in successful anesthesia for middle and distal upper extremity surgery with a success rate of 97.5% (17).

Comparisons between CC-BPB and other techniques have also been made. Songthamwat *et al.* compared Ultrasound-Guided IC-BPB with CC-BPB in 40 patients undergoing elective upper extremity surgery (12). They found the overall sensory onset time was 10 min using CC-BPB, which was faster than the 20 min seen in IC-BPB (12). Time to readiness for surgery was also faster in the CC-BPB (10 min) in comparison to IC-BPB (20 min) (12).

Luo *et al.* were the first to compare the efficiency of ultrasound-guided SC-BPB and CC-BPB in similar block dynamics (13) and found similarity between the two. However, they applied a novel modified double-injection technique, which may have affected the results. We used a conventional single injection technique in the present study and found that SC-BPB and CC-BPB had a similar efficiency of nerve block. Whilst no hemidiaphragmatic paralysis was observed in the present study, several others have found a reduced incidence of hemidiaphragmatic paralysis in CC-BPB when compared with SC-BPB in upper extremity surgery (18-20). Our study also showed a lower incidence of other side effects or complications, especially Horner's syndrome, in the CC-BPB group compared with the SC-BPB group. At present, the developmental history of CC-BPB is relatively short, and modifications must be made to further improve its efficiency and safety (21-23).

This study has several limitations, the first of which is its retrospective design. Although we have tried to minimize this limitation by propensity score matching, some bias due to data error may remain. The second is the small sample size. As seen in *Figures 1* and *2*, the proportions of complete sensory and motor block at each interval in the ultrasound-guided CC-BPB group are higher than those in SC-BPB group. Although no significant difference was found, a larger sample size is required to thoroughly compare the two. In conclusion, this retrospective cohort study enrolled 235 patients receiving upper extremity surgery and matched 186 using propensity score matching models in a 1:2 ratio. The results from matched patients indicated that ultrasound-guided CC-BPB had a similar capacity of complete sensory and motor block to ultrasound-guided SC-BPB. Moreover, the duration of nerve block using CC-BPB lasted significantly longer than ultrasound-guided SC-BPB although the procedure time of ultrasound-guided CC-BPB was much longer. In addition, ultrasound-guided CC-BPB reduced the incidence of Horner's syndrome comparing with SC-BPB. The results indicated that ultrasound-guided CC-BPB was a feasible approach for nerve block in upper extremity surgery.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at http://dx.doi.org/10.21037/apm-20-2376

Data Sharing Statement: Available at http://dx.doi.org/10.21037/apm-20-2376

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/apm-20-2376). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the Institutional Review Board of the Ningbo NO.6 Hospital and performed in compliance with the ethical principles of the Declaration of Helsinki (as revised in 2013). Informed consent was not required due to the

retrospective design of the study.

References

1. Stav A, Reytman L, Stav MY, et al. Comparison of the Supraclavicular, Infraclavicular and Axillary Approaches for Ultrasound-Guided Brachial Plexus Block for Surgical Anesthesia. Rambam Maimonides Med J 2016;7:e0013.
2. Kakazu C, Tokhner V, Li J, et al. In the new era of ultrasound guidance: is pneumothorax from supraclavicular block a rare complication of the past? Br J Anaesth 2014;113:190-1.
3. Pester JM, Varacallo M. Brachial Plexus Block Techniques. In: StatPearls. Treasure Island (FL): StatPearls Publishing; April 26, 2020.
4. Bharathi B, Praveena BL, Krishnaveni KN. Supraclavicular Brachial Plexus Block: Comparison of Varying Doses of Butorphanol Combined with Levobupivacaine - A Double-Blind Prospective Randomized Trial. Anesth Essays Res 2019;13:174-8.
5. Amitani K, Tanioka S, Ishiyama M, et al. Treatment of Transradial Angiogram Catheter Entrapment by Axillary Artery Spasm With Supraclavicular Brachial Plexus Block: A Case Report. A A Pract 2018;11:131-3.
6. Hsu AC, Tai YT, Lin KH, et al. Infraclavicular brachial plexus block in adults: a comprehensive review based on a unified nomenclature system. J Anesth 2019;33:463-77.
7. Park SK, Lee SY, Kim WH, et al. Comparison of Supraclavicular and Infraclavicular Brachial Plexus Block: A Systemic Review of Randomized Controlled Trials. Anesth Analg 2017;124:636-44.
8. Kang SH, Sim WS, Park HJ, et al. Efficacy of adjuvant dexmedetomidine in supraclavicular brachial plexus block for intractable complex regional pain syndrome: A case report with a 3-year follow-up. J Clin Pharm Ther 2020;45:365-7.
9. Kumari A, Chhabra H, Gupta R, et al. Comparative Study of Effectiveness of Tramadol and Butorphanol as Adjuvants to Levobupivacaine for Supraclavicular Brachial Plexus Block. Anesth Essays Res 2019;13:446-51.
10. Karmakar MK, Sala-Blanch X, Songthamwat B, et al. Benefits of the costoclavicular space for ultrasound-guided infraclavicular brachial plexus block: description of a costoclavicular approach. Reg Anesth Pain Med 2015;40:287-8.
11. Koyyalamudi V, Langley NR, Harbell MW, et al. Evaluating the spread of costoclavicular brachial plexus block: an anatomical study. Reg Anesth Pain Med 2021;46:31-4.
12. Songthamwat B, Karmakar MK, Li JW, et al. Ultrasound-Guided Infraclavicular Brachial Plexus Block: Prospective Randomized Comparison of the Lateral Sagittal and Costoclavicular Approach. Reg Anesth Pain Med 2018;43:825-31.
13. Luo Q, Yao W, Chai Y, et al. Comparison of ultrasound-guided supraclavicular and costoclavicular brachial plexus block using a modified double-injection technique: a randomized non-inferiority trial. Biosci Rep 2020;40:BSR20200084.
14. Sala-Blanch X, Reina MA, Pangthipampai P, et al. Anatomic Basis for Brachial Plexus Block at the Costoclavicular Space: A Cadaver Anatomic Study. Reg Anesth Pain Med 2016;41:387-91.
15. Beh ZY, Hasan MS. Ultrasound-guided costoclavicular approach infraclavicular brachial plexus block for vascular access surgery. J Vasc Access 2017;18:e57-61.
16. Li JW, Songthamwat B, Samy W, et al. Ultrasound-Guided Costoclavicular Brachial Plexus Block: Sonoanatomy, Technique, and Block Dynamics. Reg Anesth Pain Med 2017;42:233-40.
17. Monzó E, Hadzic A. Costoclavicular approach to the brachial plexus block: simple or double injection? Reg Anesth Pain Med 2019. [Epub ahead of print].
18. Oh C, Noh C, Eom H, et al. Costoclavicular brachial plexus block reduces hemidiaphragmatic paralysis more than supraclavicular brachial plexus block: retrospective, propensity score matched cohort study. Korean J Pain 2020;33:144-52.
19. Sivashanmugam T, Maurya I, Kumar N, Karmakar MK. Ipsilateral hemidiaphragmatic paresis after a supraclavicular and costoclavicular brachial plexus block: A randomised observer blinded study. Eur J Anaesthesiol 2019;36:787-95.
20. Miao Y, Zhang H. Ipsilateral hemidiaphragmatic paresis after a supraclavicular and costoclavicular brachial plexus block. Eur J Anaesthesiol 2020;37:416-7.

21. Parthasarathy S, Surya R. Use of a pre-injection technique to identify neural elements in the costoclavicular space for brachial plexus block for upper limb orthopaedic surgery. Indian J Anaesth 2020;64:347-8.
22. Kumari P, Kumar A, Sinha C, et al. Ultrasound-guided continuous costoclavicular brachial plexus block. Indian J Anaesth 2020;64:637-8.
23. Tulgar S, Ugutmen E. A modified technique for the application of ultrasound-guided costoclavicular brachial plexus block for elbow surgery leading to differential block. J Clin Anesth 2018;47:65-6.

(English Language Editor: B. Draper)

Cite this article as: Zhang L, Pang R, Zhang L. Comparison of ultrasound-guided costoclavicular and supraclavicular brachial plexus block for upper extremity surgery: a propensity score matched retrospective cohort study. Ann Palliat Med 2021;10(1):454-461. doi: 10.21037/apm-20-2376

