

1 **A randomized comparison between ultrasound-guided costoclavicular and**
2 **infraclavicular block for upper extremity surgery**

3
4 **Abstract**

5 **Background/aim:** This study compared ultrasound guided costoclavicular (CC) and
6 lateral sagittal infraclavicular (LS) brachial plexus block in patients undergoing upper
7 extremity surgery.

8 **Materials and methods:** 80 patients undergoing upper extremity surgery were
9 randomized two groups: Group CC (costoclavicular (n=40)) or Group LS (lateral sagittal
10 infraclavicular (n=40)). Both groups received a 25 mL containing a mixture of 1%
11 lidocaine and 0.25% bupivacaine. A blinded observer recorded the block onset time and
12 decided which patients who were admitted to the operation room needed general
13 anesthesia or rescue block or without any iv. narcotics for the surgical procedure.

14 **Results:** The sensorimotor onset time was found to be faster in the CC group [(15.95
15 \pm 2.97) minutes] compared to the LS group [(17.72 \pm 4.15) minutes]. There was a
16 statistically significant difference between two groups in terms of sensorimotor onset time
17 ($p = 0.031$). There was no difference between two groups in terms of the block
18 performance times and post-block motor block dissolution times.

19 **Conclusion:** The CC approach faster onset of sensorimotor blockade than LS approach
20 when the 4 major terminal nerves of the brachial plexus were evaluated.

21 **Key words:** Costoclavicular approach, brachial plexus, infraclavicular block,
22 sensorimotor blockade, upper extremity surgery.

1 **1. Introduction**

2 Ultrasound-guided infraclavicular block is a regional technique frequently used by
3 anesthesiologists in upper extremity surgery by blocking the brachial plexus at the level
4 of cords at the second part of the axillary artery. Infraclavicular block can be applied with
5 different approaches. Lateral sagittal infraclavicular block (LS) has been defined as
6 effective and safe; however some limitations of the procedure have also been reported
7 such as deep location of the brachial plexus through LS approach, variational location of
8 cords around the axillary artery so that it might be impossible to see all three cords by
9 single sagittal ultrasound window [1-6]. In 2015, Karmakar et al. [3] have recently
10 described a new costoclavicular block (CC) by which the brachial plexus is targeted
11 immediately caudal to the clavicle in the costoclavicular space. CC has been defined as
12 some advantages that the cords are superficial and clustered together than LS [3].

13 In this study, our primary outcome was to compare the CC approach and the LS approach
14 in the terms of onset time the sensorimotor blockade. Our secondary outcomes were to
15 compare performance time according to LS which we frequently performed and to
16 evaluate the activity, effectivity and the incidence of adverse effects of both blocks.

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2. Materials and methods:

After obtaining an approval from the local ethics committee (Erzurum BEAH KAEK 2018/01-03), 80 patients aged 18 years and above and with ASA I-III and BMI 18-40 kg/m² and who had undergone an emergency and elective hand, wrist, forearm and elbow surgery were included in the study. The procedure was explained to each patient and a written informed consent was obtained. Patients who did not prefer the block procedure or who had skin infection at the location of the puncture, coagulopathy, sepsis, local anaesthetic (LA) allergy and musculocutaneous, radial, ulnar or median neuropathy were excluded from the study.

Patients were randomly allocated to two groups on a randomization computer programme' Group- CC (costoclavicular) and Group- LS (infraclavicular). Standardized monitoring was applied to all patients who were admitted to the regional anesthesia room and an intravenous (iv) access was placed on the contralateral upper extremity and patients were sedated with 0.03 mg.kg⁻¹ iv midazolam. All these blocks were performed by the same anaesthesiologist (SC).

2.1. Ultrasound- Guided Lateral Sagittal Approach

The skin through which the block would be performed was wiped using an antiseptic solution while the patient was in the supine position. The linear ultrasound probe was prepared in a sterile way. In the LS group, blocks were performed ultrasound-guided using a single needle entry. Sagittal ultrasound image revealed the second part of the axillary artery and the ultrasound image was optimized (Figure 1a). Using the in-plane technique the needle was entered to a site between the posterior cord and the axillary artery. After negative aspiration, 1-2 ml of saline 0.9% was injected to confirm the needle position. A LA of 25 mL containing a mixture of 1% lidocaine and 0.25% bupivacaine

1 was administered around the axillary artery in a 'U' shape wrapping the axillary artery.

2 **2.2. Ultrasound- Guided Costoclavicular Approach**

3 The extremity to be blocked was placed to abduction at 90 degrees while the patient was
4 in the supine position. The ultrasound probe was placed transversely just below the
5 middle of the clavicle and the probe was tilted to the cephalad to scan the costoclavicular
6 area. All 3 cords in a location lateral to the axillary artery were optimized in the ultrasound
7 image (Figure 1b). The in-plane technique was used to check the presence of blood in the
8 negative aspiration by passing through the gap between the lateral and posterior cords in
9 the brachial plexus cluster. The needle was directed from lateral to medial. 1-2 ml of
10 saline 0.9% was injected to confirm the position of the needle. Subsequently, 25 ml of
11 LA containing a mixture of 1% lidocaine and 0.25% bupivacaine was injected.

12 Performance time was defined as the time elapsed from the local skin infiltration to the
13 end of LA injection. After the local anaesthetic injection, sensory and motor blocks were
14 examined in every 5 minutes and recorded by a blind investigator for the onset time.
15 Sensory block was defined as the sensation loss to cold (ice) in the cutaneous distribution
16 of the median (MN), radial (RN), ulnar (UN) and musculocutaneous (MCN) nerves (cold
17 examination 2 cold, 0 = no sensation) Motor blockade of each of the 4 nerves in the
18 ipsilateral upper extremity was also rated and graded according to a 3-point qualitative
19 scale (2 = normal motor power, 1 = paresis, and 0 = paralysis). Motor blockage of MN,
20 UN, MCN, and RN was tested by thumb opposition with the index finger, thumb
21 opposition with the little finger, elbow flexion and wrist extension, respectively. The
22 block onset time, namely the primary endpoint was defined as the time needed to
23 achieve ≥ 14 points after the end of LA injection through the block needle [3].

1 The same blind observer decided which patients who were admitted to the operation room
2 needed general anesthesia or rescue block or without any iv. narcotics for the surgical
3 procedure. No sedation was used for the patients during the intraoperative period. The
4 patients were followed up for 24 hours postoperatively (Figure 2).

5 **2.3. Statistical Analysis**

6 G*Power (version 3.0.10)¹⁶ was used to estimate the sample size (a priori). The overall
7 “onset time the sensorimotor blockade” was used as the primary outcome variable. After
8 a pilot study, it was estimated that a sample size of 30 patients would provide 80% power
9 with an α error of 0.05. We recruited 40 patients per study group.

10 All statistical analyses were performed using the IBM SPSS for Windows version 20.0
11 (IBM Corp., Armonk, NY, USA) software. Kolmogorov-Smirnov test was used to assess
12 the assumption of normality. Continuous variables were presented depending on normal
13 distribution with either mean \pm standard deviation or (in case of no normal distribution)
14 median (25th-75th percentile). Categorical variables were summarized as counts
15 (percentages). Comparisons of continuous variables between groups were carried out
16 using independent samples t test/Mann-Whitney U test, whichever was
17 appropriate. Association between two categorical variables was examined by Chi-square
18 test. A value of $p < 0.05$ was considered to be statistically significant.

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1 **3. Results:**

2 The demographic data and surgical parameters of both groups are presented in Table 1.

3 No statistically significant difference was found between the two groups. Sensorimotor
4 onset time was found to be faster in the CC group [(15.95 ±2.97) minutes] compared to
5 the LS group [(17.72 ± 4.15) minutes]. There was a statistically significant difference
6 between two groups in terms of sensorimotor onset time (p = 0.031, Table 2). There was
7 no difference between two groups in terms of the block performance times and post-block
8 motor block dissolution times.

9 Optimization time of the ultrasound image and block performance time was found to be
10 faster in the CC group among the patients with BMI ≥30 in the study; however no
11 statistically significant difference was found between the two groups (Table 3).

12 Brachial plexus block was successfully performed in all 80 patients included in the study
13 and surgical anesthesia was provided without any need for rescue block or additional
14 opioid administration. None of the patients had a major complication and any
15 neurological damage during the 24-hour follow-up period.

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1 **4. Discussion:**

2 Our study findings have shown that ultrasound guided the CC approach provided a faster
3 sensorimotor blockade compared to the LS approach. To the best of our knowledge this
4 study is the first study demonstrating that the CC approach provides a faster onset of a
5 sensorimotor blockade compared to the LS approach when a mixed LA fluid of 1%
6 lidocaine and 0.25% bupivacaine is used.

7 First described in 2015, the costoclavicular block the brachial plexus that lateral, medial
8 and posterior cords are tightly bundled together [3]. And the ultrasound image was
9 optimized to clearly view all three cords of brachial plexus lying lateral to axillary artery
10 and the needle was inserted with in plane technique from the lateral to medial direction.

11 In 2017, Nieuwveld et al. [7] defined the medial approach for the CC block. And while
12 defining the medial approach, it was stated that the coracoid process might be an obstacle
13 in the lateral approach and direct the needle towards the pleura. In the CC approach, there
14 are differences in the local anesthetic volume and dose as well as the differences in the
15 direction of needle.

16 Literature data to compare the results of this present study with revealed that
17 Leurcharusmee et al. [8] had stated that there was no difference between sensorimotor
18 blockade times between CC and LS whereas Karmakar et al. [9] reported that CC block
19 provided faster sensory blockade. However, methods of the studies differ from each other
20 at some points. The most important difference is the LA content and dose of the fluid
21 used for the blockade in the procedure. Leurcharusmee et al. [8] used in their study 35 ml
22 of 1% lidocaine and 0.25% bupivacaine as the local anesthetic whereas Karmakar et al.
23 [9] used 25 ml of 0.5% ropivacaine in their study. Karmakar et al. [9] reported in their
24 study that the use of high doses and mixed local anesthetic substances may affect the

1 advantage of CC approach in faster block formation and that the results may differ
2 accordingly. In our study, we observed that CC block and sensorimotor block were
3 performed in a faster fashion by using a mixed local anesthetic substance containing 25
4 ml of 1% lidocaine and 0.25% bupivacaine. We believe that the dose of local anesthetic
5 substance administered at this point is important whereas adding a fast-acting local
6 anesthetic substance such as lidocaine into the block fluid does not affect the potential
7 advantages of CC block.

8 In the minimum effective volume study conducted using the CC block, it was shown that
9 1.5% lidocaine with epinephrine 5 µg/mL and 34 ml for the minimum effective volume
10 in 90 % of patients (MEV90) was found to be adequate [10]. While defining the block, it
11 was stated that the block was active and effective with 20 ml of 0.5% ropivacaine, while
12 CC was reported to be efficient in a small volume (20 ml) in a sonoanatomy study of
13 block dynamics [3,11]. Ming et al. [12] reported that the MEV 90 of 0.5% ropivacaine
14 required to produce surgical anaesthesia with an ultrasound-guided CC-BPB is 20.9 ml.
15 Kewlani et al. [13] reported that the median effective dose for surgical anesthesia in 50 %
16 of the patients (ED 50) is 13.5 ml and ED 95 is 18.9 ml of 0.5 % ropivacaine. Both Ming
17 et al. [12] and Kewlani et al. [13] the standard block technique was used for the CC
18 approach in their study. Variable types and volumes of local anesthetics, ranging from
19 20 to 40 ml, have been used for administering a successful infraclavicular brachial plexus
20 block, without significant effect on surgical anesthesia [9-11]. However, randomized
21 controlled local anesthesia volume, dose-comparative studies are needed for the CC
22 approach.

23 In our study, sufficient sensorimotor block was provided for surgical anesthesia after the
24 block in both groups. However, there is not a standard definition of “onset time“ or "being
25 ready for the operation" after a peripheral nerve block. We also used the criteria frequently

1 used in regional anesthesia studies as it was the case in Karmakar et al. [9] and
2 Leurcharusmee et al. [8] ; however, there may be differences in terms of methods used in
3 the studies [11,14,15]. Despite these limitations and differences, we suggest that a faster
4 sensorimotor block in the CC block group is an advantage in shortening the waiting period
5 for the operation. In recent years, Leyare et al. [16] compared single injection and double
6 injection technique in CC block and stated that there was shorter onset time and total
7 anesthesia-related time in double injection technique. Considering in this context, future
8 studies are needed with the injection technique related to CC block.

9 In this present study performance time and US optimization times were similar in both
10 groups. However, during this study, we realized that image optimization was achieved
11 for obese patients in a shorter period of time using the CC block; therefore, we compared
12 the performance and US optimization times between CC and LS groups in patients with
13 a BMI of ≥ 30 . Although there was not any statistically significant difference, durations
14 were shorter in the CC group. The advantages of the CC are that the cords are more
15 superficial and related and they can be seen in a single US window in the CC block
16 approach. However, an important limitation of our study is that the number of patients
17 with BMI ≥ 30 was limited in the study. Although the case report stating that the
18 costoclavicular approach is advantageous and safe in obese patients in the literature
19 supports this conclusion, randomized controlled studies are needed on this subject [17].

20 No significant complications was observed directly related to the technique or local
21 anesthetic injection in the two study groups.

22 The main limitation of our study is that all patients monitored only for the first 24 hours
23 postoperatively, follow-up might be inadequate to determine neurological dysfunction.

24 The body mass index of patients studied was low. Therefore, the results of our study may

1 not apply to the obese, and future research should compare block dynamics between the
2 CC and LS approaches in the obese. In addition, in this study, 25 ml of LA containing a
3 mixture of 1% lidocaine and 0.25% bupivacaine used for the LS approach and the CC
4 approach may be considered suboptimal, but there is no MEV90 data for bupivacaine and
5 MEV90 for 1,5 % lidocaine is 34 ml. We chose to use 25 mL because this is the volume
6 we typically use for the LS approach at our institution.

7 **5. Conclusion**

8 Ultrasound guided LS approach is a frequently used regional technique that has been
9 shown to be effective and safe. However, we have demonstrated that the CC approach
10 faster onset of sensory blockade and earlier readiness for surgery than the LS approach.
11 It is important to evaluate the effectiveness and safety of the CC block in adult, pediatric
12 and obese patient groups using randomized controlled trials.

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1 **Acknowledgements**

2 The authors declare that they have no conflict of interest.

3 Informed consent was obtained from all individual participants included in the study.

4 All procedures involving human participants were performed in accordance with the
5 ethical standards of the institutional and / or national research committee and with the
6 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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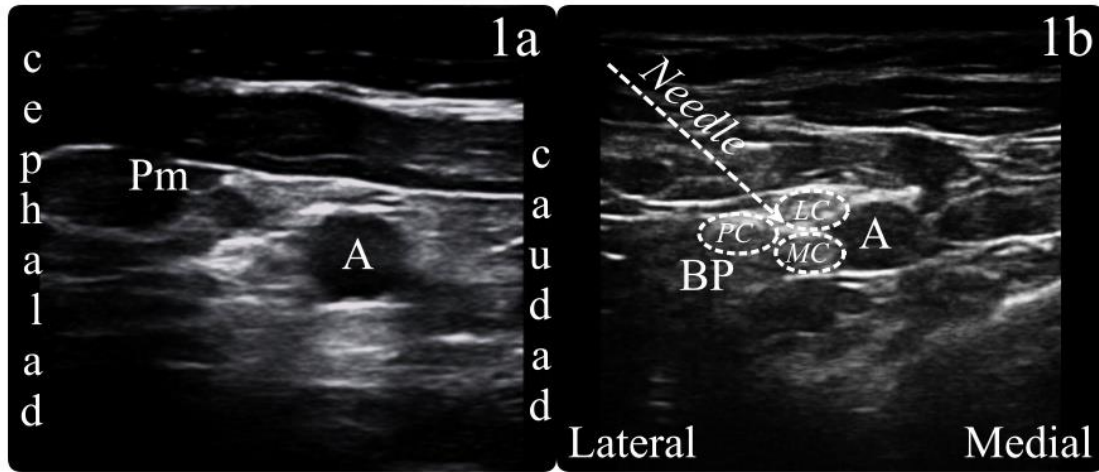
References

1. Tran DQ, Dugani S, Dyachenko A, Correa JA, Finlayson RJ. Minimum effective volume of lidocaine for ultrasound-guided infraclavicular block. *Regional Anesthesia & Pain Medicine*. 2011; 36 (2): 190–194. doi:10.1097/AAP.0b013e31820d4266
2. Sandhu NS, Capan LM. Ultrasound-guided infraclavicular brachial plexus block. *British Journal of Anaesthesia*. 2002; 89 (2): 254–259. doi: 10.1093/bja/aef186
3. Karmakar MK, Sala-Blanch X, Songthamwat B, Tsui BC. Benefits of the costoclavicular space for ultrasound-guided infraclavicular brachial plexus block: description of a costoclavicular approach. *Regional Anesthesia & Pain Medicine*. 2015; 40 (3): 287–288. doi: 10.1097/AAP.0000000000000232
4. Bigeleisen P, Wilson M. A comparison of two techniques for ultrasound guided infraclavicular block. *British Journal of Anaesthesia*. 2006; 96 (4): 502–507. doi: 10.1093/bja/ael024
5. Sauter AR, Smith HJ, Stubhaug A, Dodgson MS, Klaastad O. Use of magnetic resonance imaging to define the anatomical location closest to all three cords of the infraclavicular brachial plexus. *Anesthesia & Analgesia*. 2006; 103 (6): 1574–1576. doi: 10.1213/01.ane.0000242529.96675.fd
6. Di Filippo A, Orando S, Luna A, Giancesello L, Boccaccini A et al. Ultrasound identification of nerve cords in the infraclavicular fossa: a clinical study. *Minerva Anestesiologica*. 2012; 78 (4): 450–455. Epub 2012 Jan 12.
7. Nieuwveld D, Mojica V, Herrera AE, Pomés J, Prats A et al. Medial approach of ultrasound-guided costoclavicular plexus block and its effects on regional

- 1 perfussion. *Revista Española de Anestesiología y Reanimación*. 2017; 64 (4):
2 198-205. doi: 10.1016/j.redar.2016.09.010
- 3 8. Leurcharusmee P, Elgueta MF, Tiyaprasertkul W, Soththisopha T, Samerchua
4 A et al. A randomized comparison between costoclavicular and paracoracoid
5 ultrasound-guided infraclavicular block for upper limb surgery. *Canadian*
6 *Journal of Anesthesia*. 2017; 64 (6): 617–625. doi: 10.1007/s12630-017-0842-
7 z
- 8 9. Songthamwat B, Karmakar MK, Li JW, Samy W, Mok LYH. Ultrasound-
9 Guided Infraclavicular Brachial Plexus Block: Prospective Randomized
10 Comparison of the Lateral Sagittal and Costoclavicular Approach. *Regional*
11 *Anesthesia & Pain Medicine*. 2018; 43 (8): 825-831. doi:
12 10.1097/AAP.0000000000000822
- 13 10. Soththisopha T, Elgueta MF, Samerchua A, Leurcharusmee P, Tiyaprasertkul
14 W et al. Minimum Effective Volume of Lidocaine for Ultrasound-
15 Guided Costoclavicular Block. *Regional Anesthesia & Pain Medicine*. 2017;
16 42 (5): 571-574. doi: 10.1097/AAP.0000000000000629
- 17 11. Li JW, Songthamwat B, Samy W, Sala-Blanch X, Karmakar MK.
18 Ultrasound-Guided Costoclavicular Brachial Plexus Block: Sonoanatomy,
19 Technique, and Block Dynamics. *Regional Anesthesia & Pain Medicine*.
20 2017; 42 (2): 233-240. doi: 10.1097/AAP.0000000000000566
- 21 12. Wong MH, Karmakar MK, Mok LYH, Songthamwat B, Samy W. Minimum
22 effective volume of 0.5% ropivacaine for ultrasound-
23 guided costoclavicular brachial plexus block: A dose finding study. *European*
24 *Journal of Anaesthesiology*. 2020; 37 (9): 780-786. doi:
25 10.1097/EJA.0000000000001287

- 1 13. Kewlani A, Bhatia N, Makkar JK, Kumar V. Median Effective Volume of 0.5%
2 Ropivacaine for Ultrasound-guided Costoclavicular Block. *Anesthesiology*.
3 2021; 134 (4): 617-625. doi: 10.1097/ALN.0000000000003731
- 4 14. Tran DQ, Bertini P, Zaouter C, Muñoz L, Finlayson RJ. A prospective,
5 randomized comparison between single- and double-injection ultrasound-
6 guided infraclavicular brachial plexus block. *Regional Anesthesia & Pain*
7 *Medicine*. 2010; 35 (1): 16–21. doi: 10.1097/AAP.0b013e3181c7717c
- 8 15. Marhofer P, Schrögenderfer K, Koinig H, Kapral S, Weinstabl C et al.
9 Ultrasonographic guidance improves sensory block and onset time of three-
10 in-one blocks. *Anesthesia & Analgesia*. 1997; 85 (4): 854–857. doi:
11 10.1097/00000539-199710000-00026
- 12 16. Layera S, Aliste J, Bravo D, Fernández D, García A et al. Single-versus
13 double-injection costoclavicular block: a randomized comparison. *Regional*
14 *Anesthesia & Pain Medicine*. 2020; 45 (3): 209-213. doi: 10.1136/rapm-
15 2019-101167
- 16 17. Silva GR, Borges DG, Lopes IF, Ruzi RA, Costa PRRM et al. Ultrasound-
17 guided costoclavicular block as an alternative for upper limb anesthesia in
18 obese patients. *Revista Brasileira de Anestesiologia*. 2019; 69 (5): 510-513.
19 doi: 10.1016/j.bjan.2019.01.004

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2 **Figure 1.** Sonographic view of both blocks

3 1a. Sonographic view of the brachial plexus in the lateral infraclavicular fossa;

4 1b. Sonographic view of the brachial plexus in the costoclavicular space.

5 Pm: pectoralis minor muscle; A: axillary artery; BP: brachial plexus

6 LC: Lateral cord; MC: Medial cord; PC: Posterior cord

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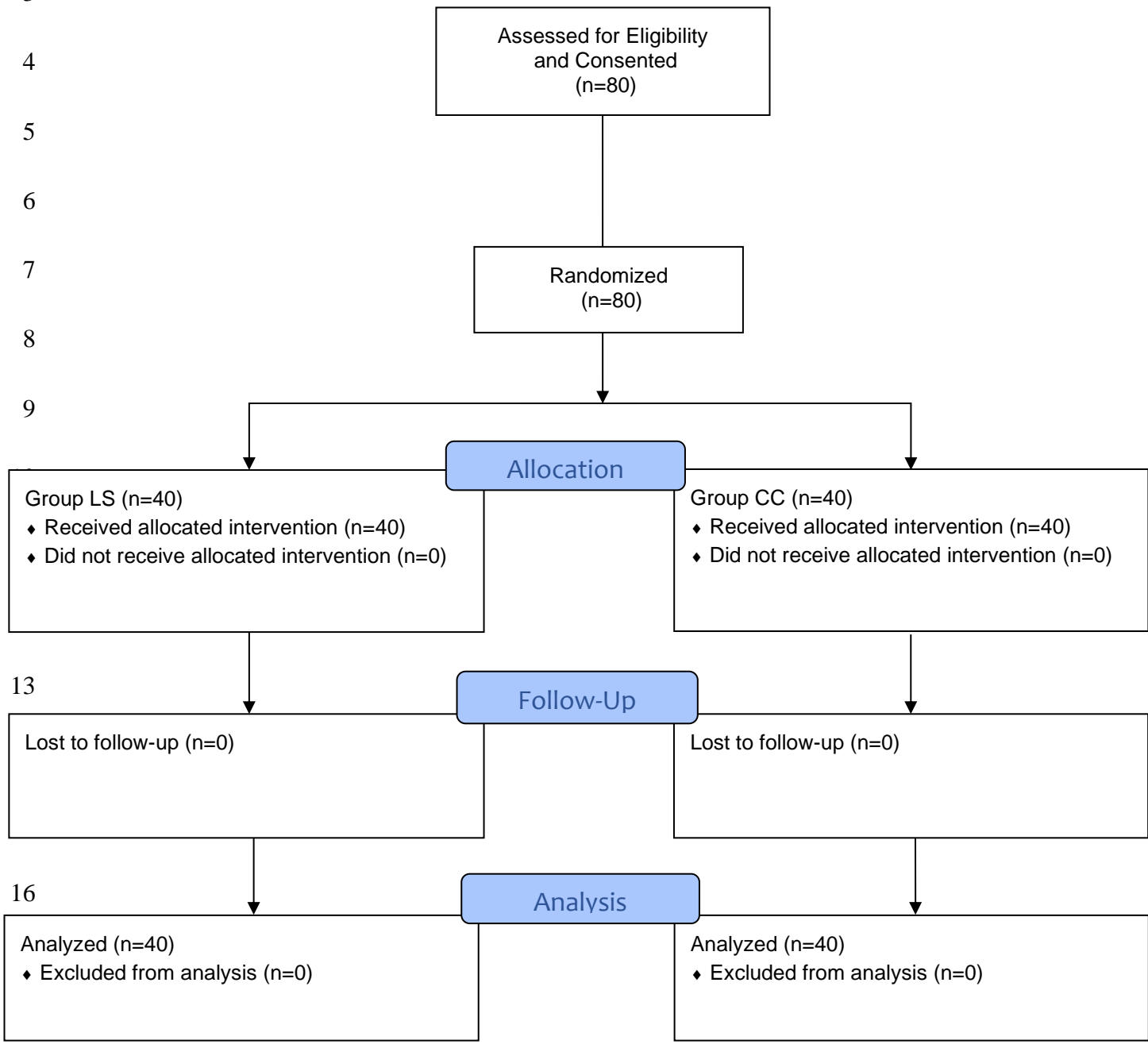


Figure 2. CONSORT flow diagram of the study

Group LS: Infraclavicular; Group CC: Costoclavicular

1 **Table 1.** Demographic Data

	Group- LS	Group- CC	p
Age (year)	33.98 ± 11.74	35.55 ± 17.36	0.636 ^a
Sex (male/female)	18 / 22	21 / 19	0.502 ^a
Weight (kg)	72.02 ± 14.69	70.95 ± 13.47	0.734 ^a
BMI, kg/m ²	24.35 (21.85 – 31.20)	23,50 (25.85 – 30.35)	0.513 ^b
ASA (I/II/III)	32 / 6 / 2	31 / 7 / 2	0.955 ^c
Types of surgery (hand/wrist/forearm/elbow)	17 / 9 / 8 / 6	15 / 10 / 11 / 4	0.789 ^c
Duration of surgery (min)	59.50 ± 13.19	65.25 ± 22.86	0.172 ^a

2 Data are presented as median (25-75 percentile), mean ± sd and patient numbers.

3 a: T-test ; b: Mann-Whitney U test ; c: Chi-square test, ASA: American Society of

4 Anesthesiologists Score, BMI: body mass index, min: minute

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1 **Table 2.** Clinical parameters

	Group-LS n = 40	Group-CC n = 40	p
Imaging time (sec)	8.00 (6.00-10.00)	7.00 (5.50-8.00)	0.207 ^a
Performance time (sec)	96.72 ±30.23	90.02 ± 20.63	0.251 ^b
Onset time (min)	17.72 ± 4.15	15.95 ±2.97	0.031 ^{b*}
Motor block durations (h)	4.50 (4.00-6.00)	5.00 (4.00-6.50)	0.137 ^a

2 Data are presented as median (25-75 percentile) and mean ± sd, * p < 0.05,

3 a : Mann-Whitney U test ; b: T-test, sec: second, min: minute, h: hour

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1 **Table 3.** Clinical parameters of patients with body mass index ≥ 30

	LS Approach n = 13	CC Approach n = 10	p
BMI ≥ 30 Imaging time (sec)	8.38 \pm 3.01	7.80 \pm 3.58	0.675 ^a
BMI ≥ 30 Performance time (sec)	94.69 \pm 28.79	89.60 \pm 22.56	0.650 ^a

2 Data are presented as mean \pm sd

3 a: T-test , BMI: body mass index , sec: second

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