The European Research Journal 2022;8(4):434-441 Original Article

DOI: 10.18621/eurj.881498 *Anesthesiology and Reanimation*

Selective C5 nerve root block versus combined interscalene block for clavicle surgery

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ABSTRACT

Objectives: The pain sensation of the clavicle is innervated by two separate plexuses. Regional anesthesia techniques for this area are challenging and complicated. Interscalene block, superficial cervical block, or a combination of these two is commonly used for regional anesthesia in clavicle surgery. The aim of this study was to investigate the efficacy of C5 nerve root block for clavicle surgery.

Methods: Patients were divided into two groups: Group C5B (patients who received C5 nerve root block + superficial cervical plexus block) and Group ISB (patients who received interscalene block + superficial cervical plexus block). Motor block was assessed by the Medical Research Council Scale for Muscle Strength, while the sensory block of the areas corresponding to the nerve trace was assessed using the pinprick and cold testing. Furthermore, ultrasound was employed to evaluate phrenic nerve paralysis.

Results: There was no difference between the groups in terms of mean age. The mean age of Group ISB was higher; however, the comparison of comorbidities revealed no significant difference between the groups. This statistically significant difference was clinically insignificant. Group C5B had lower 6-hour pain at rest, lower 0, 2, 4-hour pain on movement, and less postoperative analgesic consumption. Moreover, the time to first analgesic requirement was significantly longer in Group C5B. The motor examination of the peripheral nerves showed a significant difference in Group C5B.

Conclusions: We are of the opinion that C5 nerve root block can be used instead of interscalene block since it does not produce a motor block in hand movements and preserves diaphragmatic functions. C5 nerve root block may therefore be considered an alternative to conventional interscalene block for clavicle surgery.

Keywords: C5 root block, clavicle surgery, selective nerve root block, interscalene block, ultrasound, superficial cervical block

Clavicle fractures are one of the most common fracture types with an incidence of 22.4 per 100,000 people [1]. Clavicle fractures most commonly result from sports injuries and falls [1]. While the most frequent fracture location is the midshaft of the clavicle, medial fractures are the least common type of clavicle fractures [2].

Sclerotomally, the sensation of the clavicle originates from the C4-C5 nerve root. The cervical plexus is formed by the anterior rami of cervical spinal nerves C2-4. It is situated between the musculus longus capitis and musculus scalenus medius and lies underneath the prevertebral fascia. Perforating this fascia and passing through the interfascial region between the musculus sternocleidomastoideus (SCM) and the prevertebral muscles, it is divided into 4 branches at the

Received: ***February 17, 2021;*** *Accepted:* ***June 26, 2021;*** *Published Online:* ***February 1, 2022***

How to cite this article: *Çevikkalp E, Yapıcı F. Selective C5 nerve root block versus combined interscalene block for clavicle surgery. Eur Res J 2022;8(4):434-441. DOI: 10.18621/eurj.881498*

e-ISSN: 2149-3189

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midpoint of the SCM: n. auricularis magnus, n. occipitalis minor, n. transversus colli, and n. supraclavicularis. N. supraclavicularis is a sensory nerve originating from the C3-4 roots of the cervical plexus and provides sensation over the proximal clavicle, anteromedial shoulder, and proximal wall of the chest [3]. The subclavian nerve that arborizes from the upper trunk of the brachial plexus provides sensation over the clavicle region [3].

In clavicle surgery, anesthetic management is often maintained by general anesthesia. Regional anesthesia techniques for the clavicle, which receives sensation from two separate plexuses, are often complicated. Interscalene block, superficial cervical block, or a combination of these two is commonly used for regional anesthesia in clavicle surgery [4, 5].

There are publications reporting the use of selective cervical root blocks as an anesthetic technique for clavicle surgery to avoid the potential serious side effects of interscalene block on the distal clavicle and midshaft fractures [6].

The aim of this study was to retrospectively compare the intraoperative and postoperative efficacy (in terms of pain, movement, and diaphragm paralysis) of the selective C5 nerve root block plus superficial cervical plexus nerve block with interscalene block plus superficial cervical plexus nerve block for anesthesia in clavicle surgery.

METHODS

The approval for the study was obtained from the Clinical Research Ethics Committee of Erzincan Binali Yildirim University, Faculty of Medicine, with the number of 33216249-903.99-E.18831. The study was conducted by retrospectively evaluating patients who underwent open reduction internal fixation surgery for clavicle fractures at Ercis State Hospital between 1 December 2016 and 31 December 2018. The study included a total of 31 patients over 16 years of age with ASA scores of I-II. Patients who did not give written consent, had peripheral nerve disease, respiratory failure, brachial plexus injury, and did not accept to undergo surgery with peripheral block were excluded from the study.

For premedication, patients received 0.01 mg/kg intravenous midazolam in the operation room as a standard protocol. All patients who were placed on the operating table were monitored with standard monitoring methods including ECG, noninvasive blood pressure, peripheral oxygen saturation, end-tidal CO_2 pressure ($ETCO_2$), temperature (tympanic), and bispectral index (BIS, Aspect 1000TM, Aspect Medical Systems, Inc., Natick, MA, USA). The patients were divided into 2 groups: Group C5B and Group ISB. Group C5B included patients who received C5 nerve root block + superficial cervical plexus block (SCPB), while Group ISB included patients who received interscalene block + SCPB. Both peripheral block techniques were explained to patients. After establishing vascular access in all patients, the fluid infusion was administered by calculating the fluid deficit. The fluid requirement of patients was met with crystalloid by calculating fasting (with the 4/2/1 rule), maintenance (with the 4/2/1 rule), and insensible loss (4 mL/kg/h). A BIS probe was placed on the forehead of patients. An ultrasound-guided peripheral nerve block was performed in both groups for intraoperative analgesia and postoperative analgesia. To assess the location of the block and prevent intraneural injection, the block needle was connected to a nerve stimulator (Braun Stiumplex HNS11, Melsungen, Germany) delivering stimulation at a current of 1 mA with a frequency of 2Hz and 0.1 ms interval period. When the contraction of the musculus deltoideus indicated the correct location, the current was reduced to 0.3 mA. In both groups, 10 ml of 0.25% bupivacaine was administered under the SCM muscle at the C6 thyroid cartilage level

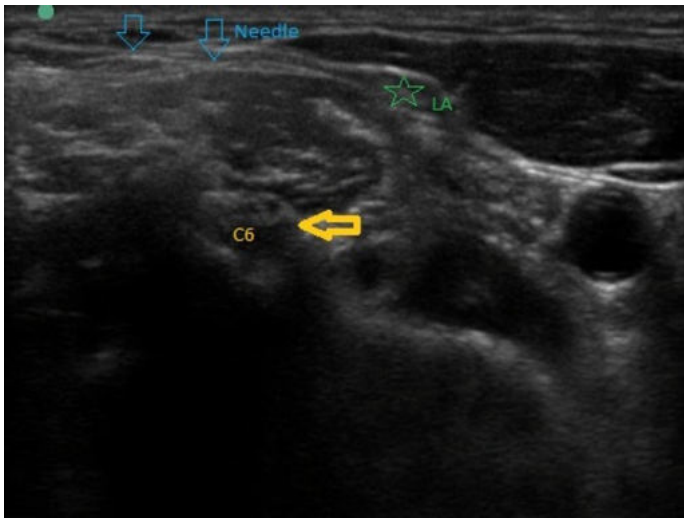

Fig. 1. Ultrasound-guided superficial cervical plexus block. LA = local anesthetic, C6 = C6 cervical nerve root.

using a linear USG probe, with the patient's head positioned straight upward at 30 degrees opposite to the block side to perform a superficial cervical plexus block (Fig. 1).

In Group C5B, the subclavian artery and the surrounding brachial plexus were identified in the supraclavicular region. The probe was moved cranially to distinguish the prominent posterior process of the C7, prominent anterior process of the C6, and double-edged tubercles of the C5. After identifying the C5 root, the block needle was guided using an in-plane technique and 4 ml of 0.25% bupivacaine was administered (Fig. 2). In Group ISB, the patient's head was positioned straight upward opposite to the block side. The sternocleidomastoid muscle was scanned laterally at the C6 cricoid cartilage level to visualize the carotid artery, internal jugular vein, anterior and middle interscalene muscles at the end of the SCM, and interscalene groove between them. After visualizing the typical "stoplight sign" of the C5-6-7 roots in the interscalene groove, 15 ml of 0.25% bupivacaine was administered.

Following the block, the sensory block of patients was assessed with pinprick and cold testing in the C5-T1 dermatomes. Those who could not abduct their shoulders and achieved sensory block were considered to have adequate anesthesia, thus surgical procedure was initiated. All patients received midazolam at a level to respond to verbal stimuli during surgery.

Age and body mass index values of patients were recorded. Patients postoperatively underwent a digital examination for the motor examination of the radial, ulnar, and median nerves. Motor block was assessed by the Medical Research Council (MRC) Scale for Muscle Strength [7], while the sensory block of the areas corresponding to the nerve trace was assessed using the pinprick and cold testing (0: no block, 1: analgesia (no sensation of warmth, feel sensation of touch), 2: complete sensory block (no sensation of warmth, no sensation of touch). The Numeric Pain Rating Scale (NPRS) (0=no pain, 10=unbearable pain) was used to assess the 0, 2, 6, 24-hour pain of patients at rest and on movement. In the early postoperative rehabilitation phase, patients performed shoulder abduction up to 90 degrees. Postoperative analgesia was provided by intravenous 1mg\kg tramadol when the NPRS was >4. In the postoperative period, patients routinely received 50 mg intravenous dexketoprofen twice a day. The time to first analgesic requirement, analgesic consumption, duration of motor block (the time until the patients moved their shoulders for the first time) were recorded.

We also evaluated phrenic nerve paralysis after the block. We ruled out phrenic nerve paralysis with the M-mode ultrasound measurement of diaphragmatic movement using a convex probe during normal and deep breathing. Following the technique described by Boussuges *et al*., we started the evaluation in the 2-dimensional mode, placed the probe in the subcostal area between the midclavicular and anterior axillary lines, and directed the beam cranially to reach the posterior third of the hemidiaphragm on the block side. After switching to the M-mode, we identified the echoic line of the diaphragm and measured the inspiratory amplitudes from the base to the apex of the inspiration slope [8]. These measurements were performed when the patient arrived in the holding area, 15 minutes after the performance of the block, and immediately after surgery.

Statistical Analysis

Statistical analyses were performed using the SPSS version 25.0 software (SPSS Inc., IBM, NY, USA). Numerical variables were presented as mean and standard deviation, while categorical variables were given as frequency and percentage. The t-test or

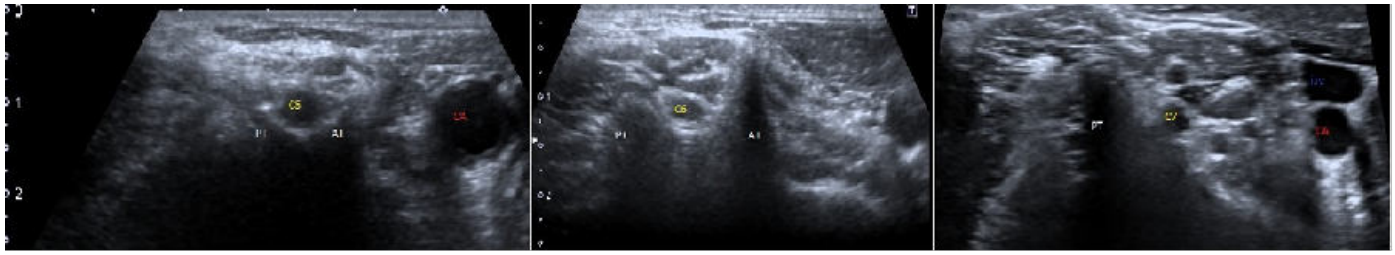

Fig. 2. Ultrasound-guided C5 nerve root block. AT = Anterior tubercle, PT = posterior tubercle, C5 = C5 cervical nerve root, C6 = C6 cervical nerve root, C7 = C7 cervical nerve root, CA = Carotis arteria, IJV = internal jugular vein.

Mann-Whitney U test was used to compare the means based on the results of the Kolmogorov-Smirnov normality test. The chi-square test was used to compare frequencies. A p - value of < 0.005 was considered statistically significant.

RESULTS

The comparison of the groups for homogeneity showed no statistically significant difference in terms of gender, male to female ratio, and body mass index. The mean age of Group C5B was lower than that of the Group ISB ($p < 0.001$) (Table 1). There was no statistically significant difference between the two groups in terms of operative time and anesthesia duration ($p > 0.05$).

There was no statistically significant difference between the groups in terms of postoperative 0, 2, and 24-hour pain scores at rest. There was a statistically significant difference between the groups in terms of 6-hour pain scores. Group C5B had lower pain at rest compared to Group ISB.

There was statistically significant difference between the groups in terms of 0, 2, and 6-hour postoperative pain scores on movement ($p < 0.001$, $p = 0.012$, $p = 0.001$). Group C5B had lower pain on movement compared to Group ISB.

The sensory examination of the radial nerve revealed a significant difference between the two groups. No sensory block was observed in Group C5B. The evaluation of the radial nerve motor muscle strength showed a statistically significant difference between the two groups in favor of Group C5B ($p < 0.001$). The sensory examination of the median nerve revealed a significant difference between the two groups. No sensory block was observed in Group C5B. The evaluation of the median nerve motor mus-

Table 1. Baseline characteristics and comparison of groups

	Group C5B (n = 16)	Group ISB (n = 15)	*p* value
Gender, n (%)			
Female	1 (6)	1 (6)	0.919
Male	15 (94)	14 (94)	
BMI (kg/m^2)	24.10 ± 1.77	24.85± 1.25	0.184
Age (years)	24.1 ± 6.7	46.8 ± 21.2	**< 0.001***
Operative time (min)	75.19 ±6.32	76.33 ±5.36	0.590
Anesthesia duration (min)	186.0 ± 26.8	199.2 ± 7.1	0.077
Analgesic duration (min)	418.63 ± 12.08	392.40 ± 7.93	**< 0.000***
Analgesic consumption	31.25 ± 34.79	73.33 ± 30.91	**< 0.001***
NPRS static (at rest)			
0 hour	0.25 ± 044	0.26 ± 0.45	0.919
2 hours	1.25 ± 0.44	1.26 ± 0.45	0.919
6 hours	3.81 ± 0.65	4.46 ± 0.51	**0.004***
24 hours	2.25 ± 0.93	2.66 ±0.89	0.215
NPRS dynamic (on movement)			
0 hour	2.5 ± 0.51	3.06 ± 0.59	**< 0.001***
2 hours	3.31 ± 0.60	3.93 ± 0.45	**0.012***
6 hours	4.62 ± 0.61	5.33 ± 0.48	**0.001***
24 hours	3 ± 0.81	3.33 ± 0.72	0.23

Data are shown as mean±standard deviation. BMI = body mass index, NPRS = Numeric Pain Rating Scale
**p* values according to t-test or Mann-Whitney U test

Table 2. The effect of the block on hand movements

	Group C5B (n = 16)	Group ISB (n = 15)	*p* value
Radial Nerve Sensory Block			
No block	16	1	
Analgesia	0	13	**< 0.001****
Complete sensory block	0	1	
Median Nerve Sensory Block			
No block	16	7	
Analgesia	0	6	**0.003****
Complete sensorial block	0	2	
Ulnar Nerve Sensory Block			
No block	16	6	
Analgesia	0	9	**< 0.001****
Complete sensorial block	0	0	
Radial Nerve Motor Block			
0/5			
1/5	0	0	
2/5	0	0	
3/5	16	0	**< 0.001****
4/5	0	15	
5/5	0	0	
Median Nerve Motor Block			
0/5			
1/5	0	0	
2/5	0	1	
3/5	0	13	**< 0.001****
4/5	6	0	
5/5	10	1	
Ulnar Nerve Motor Block			
0/5			
1/5	0	0	
2/5	0	0	
3/5	0	2	**< 0.001****
4/5	0	10	
5/5	16	3	

BMI = body mass index, VAS = visual analog scale

**p* values according to Chi-Square test

cle strength showed a statistically significant difference between the two groups in favor of Group C5B ($p = 0.003$). The sensory examination of the ulnar nerve revealed a significant difference between the two groups. No sensory block was observed in Group C5B. The evaluation of the ulnar nerve motor muscle strength showed a statistically significant difference between the two groups in favor of Group C5B ($p < 0.001$) (Table 2).

Furthermore, the comparison of the groups for time to first postoperative analgesic requirement and analgesic consumption showed that Group C5B had a significantly longer time to first analgesic requirement compared to Group ISB and less postoperative analgesic consumption ($p < 0.001$). Diaphragm paralysis was not observed in Group C5B. All patients in Group ISB had diaphragm paralysis. None of the patients developed intraoperative intraneural injection or local anesthetic toxicity. Moreover, none of the patients developed postoperative neurological complications associated with the block. Patients did not require additional opioid analgesic or sedation intraoperatively.

DISCUSSION

The innervation of the clavicular nerve is complex and has not been fully elucidated. A group of nerves originates from the cervical plexus, while a group of nerves originates from the brachial plexus. Combinations of interscalene block are commonly used as regional anesthesia techniques. In this study comparing interscalene block with C5 nerve root block, there was no difference between the groups in terms of mean age. The mean age of Group ISB was higher; however, the comparison of comorbidities revealed no significant difference between the groups. This statistically significant difference was clinically insignificant. Group C5B had lower 6-hour pain at rest, lower 0, 2, 4-hour pain on movement, and less postoperative analgesic consumption. Moreover, the time to first analgesic requirement was significantly longer in Group C5B. The motor examination of the peripheral nerves showed a significant difference in Group C5B.

It has been shown that the use of superficial cervical block alone can be effective in relieving acute pain in midshaft clavicle fractures [9]. In clavicle fractures, superficial cervical block and interscalene block are combined to relieve postoperative pain and to provide intraoperative anesthesia [4, 5]. The postoperative analgesic efficacy of interscalene block has been demonstrated in distal clavicle and shoulder surgeries [10].

Interscalene block blocks the C5-8 nerve roots, making patients experience weakness in hand movements. In this case, it may be difficult to evaluate early postoperative neurological damage that may result from surgery. A study by Dobbie *et al*. [10] showed that interscalene block performed at the level C5-6 nerve root did not cause a motor block in hand movements. A study by Deng *et al*. [11] comparing conventional interscalene block with interscalene block performed at the level of the C5 nerve root showed similar postoperative analgesia. A study by Shin *et al*. [12] showed that interscalene block with the C5 approach provided equivalent motor postoperative analgesia to the conventional approach with a minimal motor block. In our study, no motor block was observed in the radial, median, and ulnar nerves of Group C5B postoperatively. Group C5B had a difference in postoperative 6-hour pain scores at rest, but it was clinically insignificant. We are of the opinion that the reason for higher pain on movement in Group ISB is the excessive load on the distal clavicle due to the absence of a motor block.

Patients at risk of undergoing general anesthesia can be operated using the regional anesthesia techniques with the combination of interscalene block and superficial cervical block. Valdepitte *et al*. provided successful intraoperative anesthetic management in a case where they performed combined interscalene and superficial cervical block on a 15-week pregnant woman [13]. Interscalene block causes phrenic nerve paralysis. C5 nerve root block can be performed in cases where general anesthesia poses a risk and interscalene block is contraindicated due to phrenic nerve paralysis. There is a publication by Shanthanna [14] showing that a patient with severe emphysema and respiratory failure was successfully operated with a selective C5 nerve root block and superficial cervical block. Kline *et al*. [15] used 2 separate perineural catheters to perform a selective C5 nerve root block and superficial cervical block on their patient who refused to undergo general anesthesia and demonstrated its efficacy for pain relief. Salvatores *et al*. [16] suc-

cessfully performed clavicle midshaft fracture surgery with C5 nerve root block and superficial cervical block on a high-risk patient with morbid obesity, heart failure, diabetes, and COPD. In our study, diaphragmatic functions on the block side were preserved in Group C5B.

It is known that postoperative opioid consumption is significantly less in patients undergoing ISB for clavicle surgery compared to general anesthesia [5]. It has been shown that patients undergoing C5 block for shoulder surgery with arthroscopic distal clavicle resection had less opioid consumption compared to the ISB group [17]. Our study also demonstrated that postoperative opioid consumption was less in the C5B group.

The most commonly used regional anesthesia technique as an alternative to general anesthesia for clavicle surgery is combinations of interscalene block. We are of the opinion that C5 nerve root block can be used instead of interscalene block since it does not produce a motor block in hand movements and preserves diaphragmatic functions. C5 nerve root block may therefore be considered an alternative to conventional interscalene block for clavicle surgery. There is a need for larger-scale prospective randomized controlled studies to determine the difference in functional outcomes of these two anesthesia techniques.

CONCLUSION

We are of the opinion that C5 nerve root block can be used instead of interscalene block since it does not produce a motor block in hand movements and preserves diaphragmatic functions. C5 nerve root block may therefore be considered an alternative to conventional interscalene block for clavicle surgery.

Authors' Contribution

Study Conception: EÇ, FY; Study Design: EÇ; Supervision: FY; Funding: EÇ, FY; Materials: EÇ, FY; Data Collection and/or Processing: EÇ, FY; Statistical Analysis and/or Data Interpretation: EÇ, FY; Literature Review: EÇ; Manuscript Preparation: EÇ, FY and Critical Review: EÇ.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The authors disclosed that they did not receive any grant during conduction or writing of this study.

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