



# Comparison Between the Two-Injection Technique and the Four-Injection Technique in Axillary Brachial Plexus Block with Articaine

Artikain Yapılan Brakial Pleksus Bloklarında İkili veya Dörtlü Enjeksiyon Tekniklerinin Karşılaştırılması

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**Objective:** In this study, we aimed to compare axillary brachial plexus block using the two-injection and four-injection techniques assisted with ultrasonography (USG) and nerve stimulator in patients operated for carpal tunnel syndrome with articaine. To evaluate which technique is more effective, we compared the onset time, effectiveness, and duration of block procedures, patient satisfaction, adverse effect of the drug, and complication rates of the motor and sensory blocks.

**Methods:** Sixty patients were randomly divided into two groups. A mixture of physiologic serum added to articain with NaHCO<sub>3</sub> (30 mL) was injected into the patients' axilla in both the groups. After the blockage of the musculocutaneous nerve in both the groups, the median nerve in the two-injection group and the median nerve, ulnar nerve, and radial nerve in the four-injection group were blocked. In brachial plexus nerves, sensorial blockage was evaluated with pinprick test, and motor block was evaluated by contraction of the muscles innervated by each nerve. The adverse effects and complications, visual analog scale (VAS) values during the operation, and post-operative patient satisfaction were recorded.

**Results:** Sufficient analgesia and anaesthesia were achieved with no need for an additional local anaesthetics in both the groups. Furthermore, additional sedation requirements were found to be similar in both the groups. A faster rate and a more effective complete block were achieved in more patients from the four-injection group. In the two-injection group, the block could not be achieved for N. radialis in one patient. All other nerves were successfully blocked. Whereas the blockage procedure lasted longer in the four-injection group, the VAS values recorded during the blockage procedure were higher in the four-injection group. No statistical difference was found with regard to patient satisfaction, and no adverse effects and complications were observed in any group.

**Conclusion:** Although the multi-injection method takes more time, it provides faster anaesthesia and more complete blockage than the two-injection method used with articaine. The two-injection method can also be used in specific surgery such as for carpal tunnel syndrome, as an alternative to multi-injection method.

**Keywords:** Brachial block, ultrasonography, neurostimulator, four-injection technique, articain

**Amaç:** Bu çalışmada ultrason ve sinir stimulatörü eşliğinde karpal tünel sendromu cerrahisi geçiren hastalarda, artikain ile yapılan aksiler brakial pleksus bloğunda ikili ve dörtlü enjeksiyon teknikleri karşılaştırılması amaçlanmıştır. Hangi tekniğin daha etkili olduğunu değerlendirebilmek için; blok etkisinin başlangıç zamanı, etkinliği, blok süresi, hasta memnuniyeti, ilacın yan etkisi ve motor ve duyu bloğunun komplikasyon oranları karşılaştırıldı.

**Yöntemler:** Altmış hasta randomize olarak iki gruba ayrıldı. Artikain, sodyum bikarbonat ve serum fizyolojik karışımı 30 mL'ye tamamlanarak her iki gruba uygulandı. Her iki grupta muskulo-kütan sinir blokajı sonrası, ikili enjeksiyon grubuna median sinir blokajı, dörtlü enjeksiyon grubuna median, ulnar ve radial sinir blokajı uygulandı. Brakial pleksus sinirlerinde duyu blok pinprick testi ile ve motor blok ise kasların kontraksiyonunun değerlendirilmesi ile belirlendi. Yan etkiler ve komplikasyonlar ameliyat süresince vizüel analog skala (VAS), postoperatif dönemde hasta memnuniyeti kayıt altına alındı.

**Bulgular:** Her iki grupta ek lokal anestezi ihtiyacı olmadan yeterli anestezi ve analjezi sağlandı. Bununla beraber ek sedatif ihtiyacı her iki grupta benzer bulunurken, dörtlü enjeksiyon grubunda daha fazla sayıda hastada daha hızlı ve daha etkin bir tam blok olduğu gözlemlendi. İkili enjeksiyon grubunda bir hastada nervus radialste blok sağlanamadı. Bunun dışındaki bütün sinirlerde blok başarı ile sağlandı. Dörtlü enjeksiyon grubunda blok prosedürü süresi daha uzun iken, bu prosedür esnasında gözlenen vizüel analog skala skorlarının dörtlü enjeksiyon grubunda daha yüksek olduğu görüldü. Her iki grupta da hasta memnuniyeti açısından istatistiksel bir farklılık gözlenmezken, herhangi bir ilaç yan etkisi ve komplikasyonu iki grupta da görülmedi.

**Sonuç:** Artikain ile çoklu enjeksiyon yöntemi daha fazla süre alan bir prosedür olmasına rağmen, dörtlü enjeksiyon tekniği ikili enjeksiyona göre daha hızlı bir anestezi ve daha fazla sayıda tam blokaj sağlamaktadır. İkili enjeksiyon yöntemi aynı zamanda karpal tünel gibi spesifik cerrahilerde multi enjeksiyon yöntemine alternatif olarak kullanılabilir.

**Anahtar Sözcükler:** Brakial blok, ultrasonografi, nörostimülatör, dörtlü enjeksiyon tekniği, artikain

## Introduction

Within the axillary region, the brachial plexus divides into three major nerves: the median, radial and ulnar within the same neurovascular sheath. As shown in studies with single injection and ultrasonography, the administration of a local anesthetic within the sheath can block all of these nerves. Local anaesthetic spreads partially on median, ulnar and radial nerves because of the septal structure of the neurovascular sheath (1). Blockage obtained with single injection can cause insufficient anaesthesia in forearm surgeries, because the musculocutaneous nerve leaves brachial plexus proximally and is thus insufficiently blocked. For this reason, musculocutaneous nerve blockage is recommended separately to prevent tourniquet pain. As is known, blockage with multiple injections takes much longer and causes more pain, which negatively affects the patient's comfort. There are studies indicating that the success of blockage increases with the administration of the local anaesthetics to two or more nerves in divided doses (2, 3).

Articaine (Maxicaine Fort VEM Drug, İstanbul, Turkey) can be used in all nerve blocks. Its biological half-life is about 60 minutes when in pure form (4). It is metabolized rapidly by the plasma esterases and excreted in urine. It dissolves in water at pH 5 and can be alkalinized with  $\text{NaHCO}_3$  in order to increase the duration of its effect.

Articaine in the ten-fold clinical blood concentration is less cardio-depressant as compared to the five-fold blood concentration of bupivacaine (5, 6). Articaine and lidocaine have similar pharmacodynamic effects in axillary brachial plexus blocks, but pharmacokinetically, articaine is eliminated more rapidly (7). Its toxicity is lower than the toxicity of lidocaine and higher than the toxicity of procaine (8).

In this study, our aim was to compare the starting and ending times of the sensory and motor block, effectiveness of the blockage, complications and satisfaction of patients operated for carpal tunnel syndrome with axillary blockage using two- and four-injection techniques with ultrasonography and nerve stimulator.

As a result of power analyses, it was determined that the sample size include 60 individuals, with at least 30 individuals in each group, so that the strength of test could be 80% and confidential- safety interval could be 90%.

## Methods

Our study was a prospective, randomized and single-blind study.

Following the approval from ethical committee of the Ankara University Medical School issued on May 23, 2011, number 31-667, patients who were planned to be included in the study were informed about the study, and their consent was obtained.

There were 60 adult patients with ASA I–II group who were to be operated at the Ankara Oncology Training and Research Hospital. Patients aged between 18 and 65 years were included in the study. Patients with serious hepatitis, hematologic, metabolic, respiratory, cardiac, neurologic, psychiatric or neuromuscular diseases, patients who were pregnant or lactating, and patients with local infection risk, allergic to local anaesthetics, and with body weight under 50 kg or over 100 kg were excluded from the study.

Patients were taken to the preparation room 45 minutes before the operation. Venous access was established on the dorsal side of the hand that was not to be operated with a 20 gauge intravenous cannula, and crystalloid infusion was started. Sedation was provided for the patients with midazolam 2 mg before the block. The ECG, heart rate (HR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP) and peripheral oxygen saturation were monitored preoperatively and postoperatively.

During the procedure, the patient was placed into supine position, the arm to be operated was placed at an angle of 90 degrees with the body, and the forearm was flexed to make an angle of 90 degrees with the arm. After ensuring antisepsis, probe of the high-frequency linear ultrasonography (Esaote, My LabFive-Genova, Italy) was placed. First, the axillary artery and vein and nerves around the artery (musculocutaneous nerve, median nerve, ulnar nerve, radial nerve) were detected. In all the patients, 22 gauge 50 mm insulated needles conducted the current (Stimuplex D.B. Braun Medical-Freiburg, Germany). A nerve stimulator that could be adjusted at 1.5 mA current to 1 Hz frequency and 0.1 ms velocity (Stimuplex HNS11, B Braun Medical-Melsungen, Germany) was used to investigate the motor response around the nerves. After finding the strongest responses, the current was first reduced to 1 mA, and then to 0.5 mA to obtain a motor response with the lowest current. Local anaesthetic was injected around the nerve upon seeing that no blood is drawn with aspiration, and the distribution of the local anaesthetic was observed with ultrasonography (Figure 1).

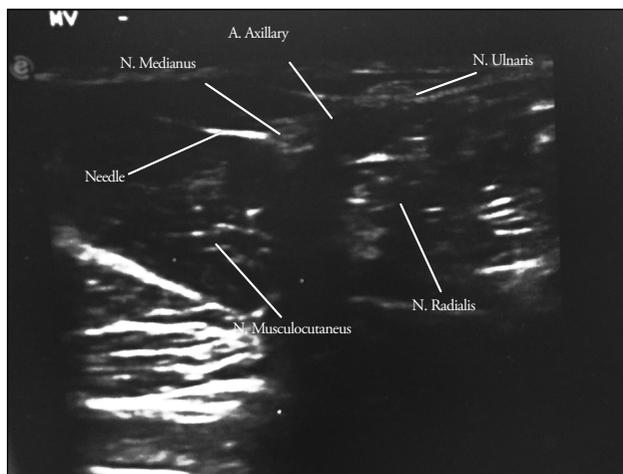


Figure 1. Axillary block ultrasound image

Articain 2% at 5 mg kg<sup>-1</sup> plus NaHCO<sub>3</sub> 8.4% were added in a concentration of 1 mL per 10 mL, and volume was adjusted to 30 mL with physiological saline. Patients were randomly divided into two groups. In both the groups, 6 mL of local anaesthetic were initially administered to the musculocutaneous nerve localization. In the first group (G1; n=30), 24 mL of local anaesthetic were applied to the median nerve localization in the two-injection method. In the second group (G2; n=30), 8 mL of local anaesthetic were administered to radial, median and ulnar nerve localizations.

The time period between the puncture of the skin with the needle and taking it out after the administration of the total dosage was determined and recorded as the application time. Patient's pain during the procedure was recorded using the VAS score (VAS 0=No pain, VAS 10=the most severe pain). Motor and sensorial blocks were evaluated at 3, 6, 9, 12, 15, 20, 25 and 30 minutes after the injection.

Flexion of the fingers was monitored for the median nerve; separation of fingers for ulnar nerve; extension of the forearm for radial nerve; and flexion of the forearm for the musculocutaneous nerve function. Motor block characteristics were evaluated based on a 3-point scale (0=normal strength; 1=decreased strength: paresis; 2=no function: paralysis). For sensory block, lateral side of the forearm was evaluated for the musculocutaneous nerve; the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> finger and palm were evaluated for the median nerve; dorsal sides of the hand and forearm were evaluated for the radial nerve; and the 5<sup>th</sup> finger was evaluated for the ulnar nerve function. Pin-prick test (with blunt-tip 27 G dental needle) was applied, and the results were evaluated on the 3-point scale (1=feels pain; 2=partial block: analgesia; 3=complete block: anesthesia). Based on the evaluation, 0 was accepted as clinically insufficient block, and 1 and 2 were accepted as clinically sufficient block, and operation was allowed. The moment when the pain started was accepted as the termination of sensory block, and the moment that the patient was able to bend his/her fingers into a fist and fully gained the arm strength back was accepted as the termination of motor block. The times when the patients felt pain for the first time and when they gained the hand and arm strength back were recorded for all the patients.

During the block application, throughout the operation and in the postoperative 120<sup>th</sup> minute, patients were observed for complications and adverse effects. They were informed about the neurologic complications (paresthesia, anesthesia and motor weakness), and they were called 24 hours after the block, when any neurologic complications and satisfaction of the patient with the procedure were questioned and recorded (0=Unsatisfied, 1=Less satisfied, 2=Satisfied, 3=Very satisfied).

### Statistical analysis

Power analysis was performed. In order to obtain 80% test strength and 90% safety interval, there should be 30 patients present in each group, which totals 60 patients.

MS-Excel 2003 and Statistical Package for the Social Sciences for Windows Ver. 15.0 (SPSS Inc.; Chicago, IL, USA) were used for statistical analyses and calculations. Data obtained from the study were analysed via Mann-Whitney U Test, which is a non-parametric test, regarding the differences of sensory and motor properties of all the nerves between the two groups. Dependence between the categorical variables was analysed by means of Chi-squared test. The value of  $p < 0.05$  was considered statistically significant.

### Results

There were no differences found between the groups regarding the demographic data of the patients (gender, ASA, age, body weight) and SpO<sub>2</sub> values, systolic and diastolic blood pressure values, and heart rate in all the time periods ( $p > 0.05$ ). It was observed that in Group 2, there were more women than men (Table 1).

It was found that there were no differences in the sensory and motor block characteristics for all the nerves included in the study between the 15<sup>th</sup> and 30<sup>th</sup> minute. For this reason, data from the first 20 minutes were taken into consideration in relation to the sensory and motor block characteristics.

When the sensory block characteristics of the musculocutaneous nerve were analysed for all the measurement times, it was found that a sufficient sensory block level was obtained at the 6<sup>th</sup> minute for the G1 group, and the 3<sup>rd</sup> minute for the G2 group. When comparing the groups, the sensory block characteristic values at minutes 3 and 6 were found significantly higher in the G2 group ( $p < 0.05$ ). 96.7% complete and 3.3% partial sensory block was obtained in the G1 group, whereas 93.3% complete and 6.7% partial sensory block in the G2 group was obtained at the 20<sup>th</sup> minute. 100% satisfactory sensory block was obtained with both the methods (Figure 2).

Considering the sensory block characteristics of radial nerve, it was seen that sufficient blockage levels were reached in the 9<sup>th</sup> minute in the G1 group and 6<sup>th</sup> minute in the G2 group. The sensory block level was found to be significantly higher in all the time periods in Group 2 ( $p < 0.05$ ). 23.3% partial and 73.4% complete sensory block occurred in the G1 group, whereas 3.3% partial and 96.7% complete block was found

Table 1. Demographic characteristics of groups ( $p < 0.05$ )

		Group 1	Group 2	p
Gender	Female	15 (50%)	19 (63.3%)	0.434
	Male	15 (50%)	11 (36.7%)	
ASA	ASA1	14 (46.7)	15 (50%)	1.000
	ASA2	16 (53.3)	15 (50%)	
Age		50.3±16	46.7±14.9	0.325
Body weight		73.6±16.4	73.7±12	0.756

in the G2 group at the 20<sup>th</sup> minute. Radial nerve could not be blocked in 1 patient from the G1 group (3.3%), whereas this was achieved in all the patients from the G2 group. Sensory block characteristics could not be fully achieved in 7 patients from the G1 group (23.3%) (Figure 3).

When the characteristics of the median nerve sensory block were analysed, it was found that a sufficient block level was obtained at the 6<sup>th</sup> minute for G1 group and 3<sup>rd</sup> minute for G2 group. When comparing the groups, the sensory block values at minutes 3 and 6 were found significantly higher in Group 2 ( $p<0.05$ ). There were no significant differences in the sensory block characteristic values between the groups in other time periods ( $p>0.05$ ). For median nerve, 100% complete sensory block was obtained in G1 group, while 3.3% partial and 96.7 complete sensory block in G2 group at the 20<sup>th</sup> minute. A 100% satisfactory block could be obtained with both the methods (Figure 4).

When the characteristics of the sensory block of ulnar nerve were considered, it was found that the sufficient block level was reached at the 9<sup>th</sup> minute in the G1 group and 3<sup>rd</sup> minute in the G2 group. When comparing the groups, the sensory block characteristic values at minutes 3, 6, 9 and 12 were significantly higher in the G2 group ( $p<0.05$ ). In the other time periods however, there were no significant differences between the groups with regard to characteristics values of sensory block ( $p>0.05$ ). For ulnar nerve, 10% partial and 90% complete sensory block was achieved in the G1 group, whereas 6.7% partial and 93.3% complete block was achieved in the G2 group at the 20<sup>th</sup> minute. 100% complete block was achieved with both the methods (Figure 5).

Upon examining the sensory and motor block characteristics of all the nerves at the 20<sup>th</sup> minute (Table 2), statistically significant differences were found only in the sensory and motor

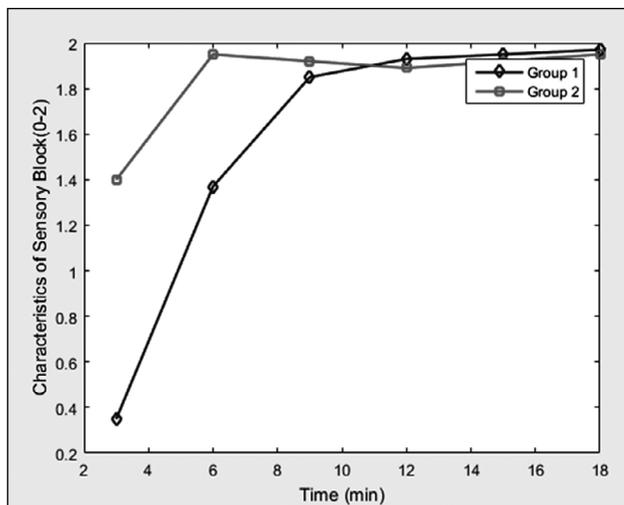


Figure 2. Sensory block characteristics for musculocutaneous nerve in all the measurement times of the groups (Mean±SD)

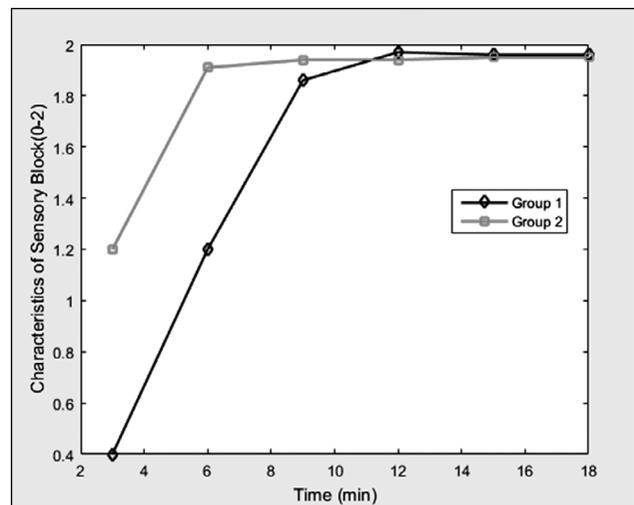


Figure 4. Sensory block characteristics of median nerve in all the measurement times in the groups (Mean±SD)

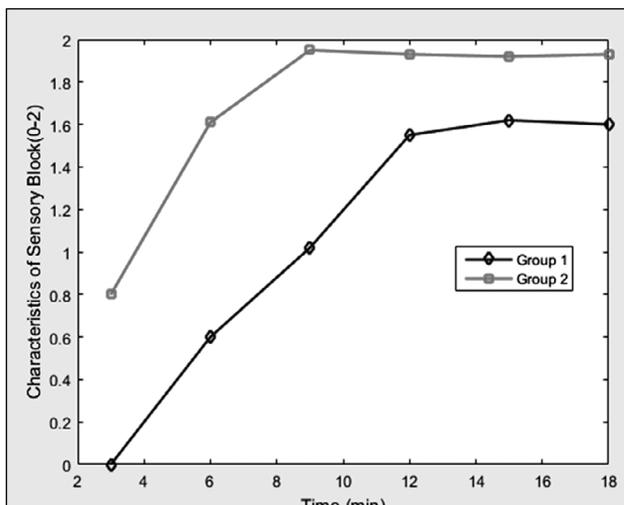


Figure 3. The sensory block characteristics for radial nerve in all the measurement times of the groups (Mean±SD)

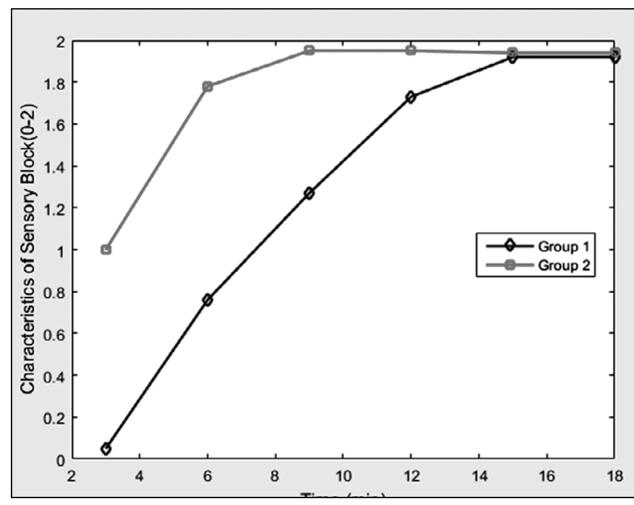


Figure 5. Sensory block characteristics for ulnar nerve in all the measurement times for the groups (Mean±SD)

Table 2. Sensory and motor block characteristics of all nerves at the 20<sup>th</sup> minute (n, %, Mean±SD)

Group		Block Characteristics (0–2)						Mean±SD	p
		0		1		2			
		n	%	n	%	n	%		
Musculocutaneous nerve (sensory)	Group 1	0	0.0	1	3.3	29	96.7	1.96±0.18	0.557
	Group 2	0	0.0	2	6.7	28	93.3	1.93±0.25	
Musculocutaneous nerve (motor)	Group 1	0	0.0	2	6.7	28	93.3	1.93±0.25	0.643
	Group 2	0	0.0	3	10.0	27	90.0	1.9±0.31	
Radial nerve (sensory)	Group 1	1	3.3	7	23.3	22	73.4	1.7±0.53	0.012*
	Group 2	0	0.0	1	3.3	29	96.7	1.96±0.18	
Radial nerve (motor)	Group 1	1	3.3	9	30.0	20	66.7	1.63±0.56	0.028*
	Group 2	0	0.0	3	10.0	27	90.0	1.9±0.31	
Median nerve (sensory)	Group 1	0	0.0	0	0.0	30	100.0	2±0	0.317
	Group 2	0	0.0	1	3.3	29	96.7	1.96±0.18	
Median nerve (motor)	Group 1	0	0.0	0	0.0	30	100.0	2±0	0.317
	Group 2	0	0.0	1	3.3	29	96.7	1.96±0.18	
Ulnar nerve (sensory)	Group 1	0	0.0	3	10.0	27	90.0	1.9±0.31	0.643
	Group 2	0	0.0	2	6.7	28	93.3	1.93±0.25	
Ulnar nerve (motor)	Group 1	0	0.0	4	13.3	26	86.7	1.87±0.35	0.690
	Group 2	0	0.0	3	10.0	27	90.0	1.9±0.31	

\*p&lt;0.05

block characteristics of radial nerve ( $p<0.05$ ). There were no statistically significant differences for the musculocutaneous nerve, median nerve and ulnar nerve. While sensory and motor block could not be achieved in 1 patient in the G1 group, complete block could not be achieved in 9 patients from the G1 group, whereas it was achieved in all the patients from the G2 group. Sufficient sensory and motor blockage was detected in both the groups. In the G2 group, satisfactory sensory and motor block was observed in 100% of the cases and for all nerves. Although no significant dependency was observed between the groups in the number of patients with a complete sensory and motor block of all the four nerves ( $p>0.05$ ), the number of complete sensory and motor block for all the four nerves was greater in the G2 group. In the G2 group, a complete sensory block was recorded in 25 (83.3%) patients, and complete motor block in 22 (73.3) patients. In the G1 group, a complete sensory block was achieved in 20 (66.7%) patients and complete motor block in 17 (56.7%) patients (Table 3).

When the patient satisfaction and additional sedation needs were evaluated (Table 4), there were no statistically significant differences found between the two groups ( $p>0.05$ ). Sufficient anaesthesia level was obtained in both the groups without any need for additional local anaesthetics. Axillary block application times and VAS values in the G2 group were

Table 3. Complete sensory and motor block

		Group 1		Group 2		p
		n	%	n	%	
Complete sensory block	No	10	33.3	5	16.7	0.233
	Yes	20	66.7	25	83.3	
Complete motor block	No	13	43.3	8	26.7	0.279
	Yes	17	56.7	22	73.3	

significantly higher than those in the G1 group ( $p<0.05$ ) (Table 5). Statistical difference was found between the groups in the onset times of the sensory and motor blocks ( $p<0.05$ ). The onset time of the sensory and motor block in the G1 group was longer than in the G2 group (Table 5). Total period of motor blocks (min) were  $232.9\pm 26.3$  in Group 1,  $235.8\pm 33.9$  in Group 2, and p value was 0.941. This difference was not statistically significant (Table 5).

There were no adverse effects or complications including hematoma, vascular puncture, intravascular injection, convulsions, tinnitus, nausea, vomiting, paraesthesia, and hemodynamic changes observed in patients from both the groups who were monitored during the block application, during the

Table 4. Additional need for sedation and satisfaction in groups

		Group 1		Group 2		p
		n	%	n	%	
Additional sedation need	No	21	70.0	22	73.3	0.77
	Yes	9	30.0	8	26.7	
Satisfaction	Not satisfied	0	0.0	1	3.3	0.053
	Low satisfaction	1	3.3	4	13.3	
	Satisfied	24	80.0	23	76.7	
	Very satisfied	5	16.7	2	6.7	

Table 5. Block application times, VAS values in groups, sensory and motor block times

	Group 1 (n=30)	Group 2 (n=30)	p
Application time (min)	6.27±1.26	9.8±1.32	0.000*
VAS (0–10)	1.03±0.72	1.5±0.78	0.018*
Sensory block onset time (min)	4.5±1.5	3±0	0.000*
Total period of sensory block (min)	242.2±29.5	249.6±36.5	0.459
Motor block onset time (min)	4.6±1.5	3±0	0.000*
Total period of motor block (min)	232.9±26.3	235.8±33.9	0.941
*p<0.5			

operation, and in the postoperative period, 1 month after the procedure.

### Discussion

Ambulatory surgery is becoming widespread all over the world. General anaesthesia and brachial plexus blockage have been studied in ambulatory surgery, and it was found that brachial plexus blockage provided earlier discharge (9). When it comes to axillary blockage, different success rates are reported in the literature. Successful Vester-Andersen block criteria include the effective block in the areas innervated by at least two musculocutaneous nerves, median nerve, ulnar nerve and radial nerve (10). Baranowski and Pither (11), however, as a successful block define a complete block of three major nerves. In our study, success was evaluated based on the mean block characteristics of each nerve. At the same time, the rates of complete block have been reported as 66.7% and 83.3%, respectively, for the four nerves. No additional local anaesthetic application was required.

Ultrasonography is becoming an essential and indispensable tool in the local anaesthesia. USG application leads to less

axillary pain and nerve injury (3, 12). In our study, USG and neurostimulator were used together to block all the nerves. Chan and colleagues evaluated the success of axillary block in 188 patients divided into 3 groups where USG, neurostimulator, and USG plus neurostimulator were additionally used. Higher success rates were observed in the two USG groups compared to the group in which only a neurostimulator was used (12).

Sensory block is required in operations planned under regional anaesthesia for a successful operational area. While some studies found that a satisfactory sensory nerve blockade could be obtained with a local anaesthetic in low concentrations, motor blockade was low or was not found at all (13). We have applied in our study as regards the sensory block characteristics in the first place. In our study, sufficient sensory block was accomplished by axillary plexus block using articaine in all the patients.

In a retrospective study, Fanelli et al. (14) reported a success rate of 93% using a local anaesthetic with volumes less than 30 mL in the upper extremity they applied with multiple injections. The investigators advocated that the high pressure created by the high volume of the local anaesthetic solution would cause tears in the septa thought to present within the sheath, which would enable an easier drug distribution between the nerves (1). In other studies on this subject, volumes of 40, 50, and 60 mL have been used, and no differences were found in the sensory and motor blockage success between the groups (10). The volume of the local anaesthetic used in our study was 30 mL, and satisfactory sensory block was obtained in 96.7%–100% of cases when using the two-injection method, and in 100% of cases when using the four-injection method for the axillary block.

In their study, Coventry et al. (2) blocked the musculocutaneous and median nerves in one group, and the musculocutaneous, median and radial nerves in the other group, and determined the ratios of patients in who a complete block was obtained for all the nerves, which was 53% and 97%, respectively. Likewise, our study has shown that the percentage of cases with a complete sensory block was higher with the multiple injection method (66.7% and 83.3%) for all the four nerves. The percentage of complete motor block was also higher in the four-injection group (56.7% and 73.3%). As the success rate in our study for radial nerve blockade was lower in the two-injection group, multiple-injection technique must be preferred in the surgical procedures to be performed on the areas innervated by the radial nerve. If the smaller number of injections is preferred, the radial nerve must be blocked separately (15).

Patient satisfaction also plays an important role in regional anaesthesia. Sia et al. (16) applied axillary block in patients who were to undergo hand surgery, and blocked only 1 or 2 nerves that innervated the operation area, and blocked the

musculocutaneous nerve, median nerve and radial nerve in the other group. They found similar patient satisfaction rates in both the groups, and an additional drug requirement for sedation was less in the multiple injection group. The patient satisfaction rates and the additional sedation requirements during the operation were found to be similar in both the groups in our study. During the blockage procedure, VAS values were statistically higher in the four-injection technique. These results were found to be consistent with the other studies (17-19).

Malke et al. (20) applied an axillary brachial plexus block using 1% articaine hydrochloride and 1% mepivacaine in 40 patients who were to undergo hand and forearm surgeries. The authors suggested that articaine hydrochloride is a safe and reliable agent with rapid onset and a longer sensory and motor block period than mepivacaine. Our study also showed that articaine hydrochloride is a rapid-onset agent that provides the sensory and motor block required for surgery.

NaHCO<sub>3</sub> is commonly used to decrease the onset time of the brachial plexus block. Various studies have explored the effect of this additional drug. Contreras-Dominguez et al. (21) applied the brachial plexus block by adding clonidine to mepivacaine sodium bicarbonate (NaHCO<sub>3</sub>). They reported that adding sodium bicarbonate to mepivacaine delayed the onset of blockage time. Armstrong et al. (22) found that alkalization shortened the onset time of the sensory and motor block and slowed down the fading of sensory block.

## Conclusion

Whereas axillary block application takes longer when using the four-injection technique during the procedure, we found in our study that with this technique, a complete block was obtained for all the four nerves more rapidly and in a greater number of patients.

In this study, we have used and compared the two- and four-injection technique for the axillary block with alkalized articaine. In our opinion, sufficient analgesia and anaesthesia levels can be obtained with both the techniques without requiring additional local anaesthetics in selected patients, including those with carpal tunnel syndrome.

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