

# Do the Concentration and Volume of Local Anesthetics Affect the Onset and Success of Infraclavicular Anesthesia?

Faramarz Mosaffa<sup>1</sup>; Babak Gharaei<sup>2</sup>; Mohammad Qoreishi<sup>3</sup>; Sajjad Razavi<sup>4</sup>; Farhad Safari<sup>5</sup>; Mohammad Fathi<sup>6</sup>; Gholamreza Mohseni<sup>1</sup>; Hedayatollah Elyasi<sup>7</sup>; Fahimeh Hosseini<sup>1,\*</sup>

<sup>1</sup>Anesthesiology and Critical Care Department, Akhtar Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

<sup>2</sup>Anesthesiology and Critical Care Department, Labbafinejad Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

<sup>3</sup>Orthopedic Department, Akhtar Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

<sup>4</sup>Anesthesiology and Critical Care Department, Mofid Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

<sup>5</sup>Anesthesiology and Critical Care Department, Loghmane Hakim Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

<sup>6</sup>Anesthesiology Research Center, Modarres Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

<sup>7</sup>Anesthesiology and Critical Care Department, Taleghani Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

\*Corresponding author: Fahimeh Hosseini, Anesthesiology and Critical Care Department, Akhtar Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Tel: +98-9155096022, Fax: +98-2144039870, E-mail: f.hosseini2009@gmail.com

Received: September 28, 2014; Revised: January 19, 2015; Accepted: February 2, 2015

**Background:** Although local anesthesia is a suitable method for upper limb surgeries, there is debate regarding the effects of appropriate dosing.

**Objectives:** In the current study, we investigated the effects of the concentration and volume of a local anesthetic on the beginning and quality of anesthesia during upper limb orthopedic surgeries.

**Patients and Methods:** This double-blinded, randomized, clinical trial was conducted on 60 patients aged between 18 and 85 years candidated for upper limb orthopedic operations. The patients were equally and randomly distributed into two groups (n = 30). Under ultrasound imaging guidance, the first group received 7 mL of 2% lidocaine and the second group 10 mL of 1.3% lidocaine into the brachial plexus cords. The onset of block and the level of sensory and motor block were documented for each nerve territory.

**Results:** The onset of sensory and motor block was significantly shorter in the 1.3% lidocaine group than in the 2% lidocaine group ( $P \leq 0.05$ ). The success rate of sensory and motor block was not different. The quality (completeness) of sensory block for the musculocutaneous nerve and that of motor block for the radial nerve were significantly better in the 1.3% lidocaine group than in the 2% lidocaine group.

**Conclusions:** The volume of the injected anesthetic accelerated the onset of sensory and motor block without affecting the rate of success in our patients.

**Keywords:** Anesthetics; Brachial Plexus; Lidocaine; Anesthesia, Local; Nerve Block

## 1. Background

The extensive advantages of local anesthesia, namely better airway management, more efficient postoperative pain control, definite patient alertness, modification of pathophysiologic response to surgical stress, and overall reduction in the mortality and morbidity, have helped this technique supersede general anesthesia in some orthopedic surgeries (1-3). Various factors such as the amplitude of the peripheral nerve excitation, type of elicited response, anesthesia technique, number of injections, use of complementary anesthetics, utilization of ultrasound in probing the exact location of the nerve for injection, and volume and concentration of the local anesthetic may influence the chance of a successful peripheral nerve block (4).

According to some studies, the concentration and volume of the local anesthetic agent are important factors with respect to the onset and rate of successful peripheral nerve block. The volume of the anesthetic substance in

large anatomic structures such as the epidural space and the axillary and popliteal fossae is very important in the success of the block. Meanwhile, using higher concentrations of the anesthetic agent for blocking peripheral nerves with larger perineurial diameters accelerates the onset of block and enhances its duration (4-10).

## 2. Objectives

We aimed at evaluating the effects of the concentration and volume of a local anesthetic on the features of local anesthesia. Thus, we designed the current study in order to compare the efficacy of 1.3% lidocaine and 2% lidocaine preparations on the onset and quality of anesthesia during surgical operations on the upper limb.

## 3. Patients and Methods

This double-blinded, randomized, clinical trial recruit-

ed 60 patients aged between 18 and 85 years with the American society of anesthesiologists (ASA) physical status classification systems I and II who were candidates for surgical operations on any of the forearm, wrist, and hand regions in Akhtar Hospital, Tehran, Iran. The study design was approved by the Clinical Research Ethics Committee in Shahid Beheshti University of Medical Sciences. All the participants were asked to sign an informed consent form after having been provided with details of the aim and proceedings of the study.

Anyone with pregnancy, neuromuscular disorders, coagulopathy, local interfering deformities, or infection was excluded from the study. The patients were equally and randomly distributed into a 1.3% lidocaine group and a 2% lidocaine group via randomization blocks. All the participants were premedicated with 0.1 mg/kg of intravenous midazolam and monitored routinely before attempting nerve block. The injection site was selected in the lower clavicular border and the coracoid process in a groove between the pectoralis major and the deltoid muscles. The skin was first sterilized and anesthetized with 1% lidocaine. The brachial plexus cords were probed via ultrasound (10 - 15 Hz), followed by the in-plane needle (gauge 22, 80 mm) progression towards the nerve bundles. Then, a nerve stimulator was applied (0.2 to 0.5 mA, 2 MHz) and the flexion response in the wrist, which corresponded to the stimulation of the medial cord, was observed (4).

The first group received 7 mL of 2% lidocaine and the second group received 10 mL of 1.3% lidocaine as an injection in the medial cord place. Under ultrasound guidance, the needle was pushed towards the posterior and lateral cords and the same dose of the same type of lidocaine was injected after observing wrist extension and elbow flexion on electrical nerve stimulation, which corresponded to the posterior and lateral cords, respectively. The block process was accomplished by an anesthesiologist, who was blind to the type of lidocaine. The level of sensory and motor block in the limb was also assessed and documented by a physician, blind to the groupings, every 5 minutes for 20 minutes. Sensory and

motor block were the primary clinical endpoints and were classified as complete, partial, and failed block. In cases with partial or failed anesthesia, the injection of fentanyl (1.5 µg/kg) and infusion of propofol (50 µg/kg/minute) was considered. If pain was reported by the patient during the operation, general anesthesia was attempted immediately. The number of patients requiring general anesthesia was the secondary clinical endpoint.

Sample size was calculated according to previous studies (11). All the data were gathered in a report sheet and analyzed using Statistical Package for the Social Sciences (SPSS) version 16. The descriptive statistics are reported as mean ± standard deviation (SD). The inferential statistics were done using the chi-square test, Fisher exact test, and independent t-test.

#### 4. Results

The anthropometric data on the total 57 participants (29 patients in the 1.3% lidocaine group and 28 patients in the 2% lidocaine group) are presented in Table 1. There were 21 male and 8 female patients in the 1.3% lidocaine group and 21 male and 7 female patients in the 2% lidocaine group. Both groups were similar in terms of the anthropometric data distribution.

The onset of sensory block was significantly shorter in the 1.3% lidocaine group than in the 2% lidocaine group ( $P < 0.05$ ) (Table 2). The rate of successful complete sensory and motor block was slightly higher in the 1.3% lidocaine group than in the 2% lidocaine group; however, it did not reach statistical significance (Table 2). On the other hand, the mean stimulation amplitude in the 2% lidocaine group was significantly above that in the 1.3% lidocaine group ( $P = 0.02$ ). In each group, 4 patients had stimulations above 0.5 mA.

In Table 3, the results for the quality of sensory and motor block are presented for each involved nerve separately. The only significant difference between the groups was detected for musculoskeletal sensory block ( $P = 0.04$ ) and radial motor block ( $P = 0.01$ ), with the other nerve blocks demonstrating insignificant differences.

**Table 1.** Anthropometric Data on the Study Population <sup>a</sup>

Demographic Data	1.3% Lidocaine (n = 29)	2% Lidocaine (n = 28)
Male gender	21 (72.4)	21 (75)
Age, y	40.7 ± 14.57	36.8 ± 16
Weight, kg	75.4 ± 12.114	70.3 ± 9.58
Height, cm	170.2 ± 10.52	169.8 ± 9.19
<b>Site of operation</b>		
Forearm	20 (69)	13 (46.4)
Wrist	5 (17.2)	8 (28.6)
Hand	4 (13.8)	7 (25)

<sup>a</sup> Values are presented as No. (%) or mean ± SD.

**Table 2.** Results of Sensory and Motor Anesthesia According to Each Nerve Territory<sup>a</sup>

Anesthesia Characteristics	1.3% Lidocaine (n = 29)	2% Lidocaine (n = 28)	P Value
Amplitude of stimulation	0.4 ± 0.092	0.4 ± 0.065	0.02
Successful complete block	25 (82.8)	24 (78.6)	0.7
<b>Onset of sensory block, min</b>			
Radial	7.93 ± 3.664	10.7 ± 4.852	0.01
Median	7.5 ± 3.438	10.5 ± 4.78	0.01
Ulnar	7.5 ± 3.438	10.7 ± 4.852	0.007
Musculocutaneous	6.5 ± 2.707	9.1 ± 4.524	0.01
<b>Onset of motor block, min</b>			
Radial	8.9 ± 4.508	13.3 ± 5.101	0.001
Median	8.9 ± 4.508	13.2 ± 4.756	0.001
Ulnar	9.1 ± 4.446	13.3 ± 5.101	0.001
Musculocutaneous	6.8 ± 3.385	10.1 ± 5.179	0.006

<sup>a</sup> Values are presented as No. (%) or mean ± SD.

**Table 3.** Assessment of the Quality of the Sensory and Motor Block in Each Nerve Territory<sup>a</sup>

Quality of Block	1.3% Lidocaine Group (n = 29)			2% Lidocaine Group (n = 28)			P Value
	Complete	Partial	Failed	Complete	Partial	Failed	
<b>Sensory block</b>							
Radial	27 (93.1)	2 (6.9)	0	23 (82.1)	3 (10.7)	1 (3.6)	0.4
Median	27 (93.1)	2 (6.9)	0	23 (82.1)	4 (14.3)	1 (3.6)	0.3
Ulnar	28 (96.6)	1 (3.4)	0	25 (89.3)	3 (10.7)	0	0.2
Musculocutaneous	28 (96.6)	1 (3.4)	0	22 (78.6)	5 (17.9)	1 (3.6)	0.04
<b>Motor block</b>							
Radial	28 (96.6)	1 (3.4)	0	19 (67.9)	8 (28.6)	1 (3.6)	0.01
Median	25 (86.2)	4 (13.8)	0	21 (75)	6 (21.4)	1 (3.6)	0.4
Ulnar	27 (92.3)	2 (6.9)	0	23 (82.1)	4 (14.3)	1 (3.6)	0.3
Musculocutaneous	28 (96.6)	1 (3.4)	0	23 (82.1)	4 (14.3)	1 (3.6)	0.1

<sup>a</sup> Values are presented as No. (%).

## 5. Discussion

We performed this study to compare the efficacy of 10 mL of 1.3% lidocaine with 7 mL of 2% lidocaine and found that the former was more effective in shortening the onset of complete sensory and motor block. Although the rate of successful complete block was clinically higher in the 1.3% lidocaine group than in the 2% lidocaine group, there was no significant statistical difference between the two groups. As the study protocol was strictly adhered to, we believe that the shorter onset of block was the result of a larger anesthetic volume.

Local infiltration anesthesia is a surgeon-controlled analgesic technique, which can be used to enhance patient satisfaction and reduce the pain in the very early postoperative period by the surgeon independently (12). Local anesthesia, especially in shoulder and upper limb procedures, has experienced significant advances in terms of providing appropriate analgesia during and after surgery

and reducing the need for opioid drugs, which has led many researchers to concentrate on this field of practice (13, 14). Ilfeld et al. (15) reported that the total dose of anesthetic was the main factor affecting the clinical results in hip arthroplasty among their study population. On the other hand, Yang et al. (16) considered three different volumes and concentrations of ropivacaine in vertical infraclavicular anesthesia on 110 patients and found that despite improved motor block with an increased dose, the onset of anesthesia, the rate of successful block, and the rate of sensory block were not significantly different and that the increased dose, in terms of either increased volume or increased concentration, not only did not yield a better outcome but also was likely to cause systemic toxicity. Casati et al. (17) found that an increased dose of the anesthetic agent by an increased concentration with the same volume resulted in faster sensory and motor block,

without affecting the success of the block. Bertini et al. (18) also found that different volumes of 400 mg of bupivacaine caused no difference in the onset and success of sensory and motor block but affected postoperative analgesia. Amiri et al. (19) showed that the duration of analgesia with peripheral nerve block was longer than that with spinal anesthesia. Although our results point to the efficacy of a higher volume of lidocaine, our study is limited by the absence of a control group for each arm, which precludes the conclusion that the anesthetic volume is superior to its concentration.

Overall, we believe that the volume of the injected anesthetic agent affects a faster onset of the sensory and motor block without affecting the success rate of the block. Thus, it seems that the volume of the local anesthetic drug is an important factor insofar as it affects the clinical results in upper limb surgeries and, as such, should be considered when attempting local anesthesia.

## Acknowledgements

The authors appreciate the staff of the Department of Anesthesia in Akhtar Hospital and the Clinical Sublimity Center in Taleghani Hospital for their sincere cooperation. We also thank the Farzan Institute of Technology and Clinical Research for their advice on the study conduct and report.

## Authors' Contributions

Faramarz Mosaffa designed the study, conducted the study, wrote the manuscript, and performed final review. Babak Gharaei conducted the study and conducted final review. Mohammad Qoreishi conducted the study and reviewed the final paper. Sajjad Razavi conducted the study and performed final review. Farhad Safari conducted the study and performed final review. Mohammad Fathi conducted the study and reviewed the manuscript. Gholamreza Mohseni conducted the study and performed final review. Hedayatollah Elyasi designed the study. Fahimeh Hosseini saw the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.

## Funding/Support

This study was supported by a teaching and research scholarship from Shahid Beheshti University of Medical Sciences, Tehran, Iran.

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