Clinical Research Article

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Ultrasound does not shorten the duration of procedure but provides a faster sensory and motor block onset in comparison to nerve stimulator in infraclavicular brachial plexus block

Walid Trabelsi, Mondher Belhaj Amor, Mohamed Anis Lebbi, Chiheb Romdhani, Sami Dhahri, and Mustapha Ferjani

Department of Anesthesiology and Intensive Care, Tunisian Military Hospital, Tunis, Tunisia

Background: Infraclaviculr Brachial plexus (ICBP) block is useful for upper extremity surgery. The aim of this study was to compare the ultrasound (US) technique with the nerve stimulation (NS) technique in their success rates and times to perform ICBP block.

Methods: 60 patients undergoing surgery of the upper limb were randomly allocated into two groups (n = 30 per group). Group 1; US, and Group 2; NS. Procedure time (including time for initial ultrasound examination), the success rate and the onset time of sensory and motor blockade were assessed.

Results: The time needed to perform the ICBP block is similar in both groups (220 seconds ± 130 in US group versus 281 ± 134 seconds in NS group; P = 0.74). The success rate of all the nerve blocks in the US group was 100%. The success rate in the NS group was 73.3%, 76.7%, 76.7% and 100% for radial, ulnar, medial, and musculocutaneous nerve, respectively. A significantly faster onset of sensory block for the radial, ulnar, median, musculocutaneous, and the four nerves considered together were observed. The onset of motor block for the radial, ulnar, and medial nerves was faster in the US group. However, the onset of motor block for the musculocutaneous nerve and the four nerves considered together was comparable between the two groups.

Conclusions: The ultrasound-guided infraclavicular brachial plexus block is a significantly efficacious method with faster onset but similar procedure time compared to the nerve stimulation technique. (Korean J Anesthesiol 2013; 64: 327-333)

Key Words: Brachial plexus, Bupivacaine, Ultrasound.

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Corresponding author: Walid Trabelsi, M.D., Department of Anesthesiology and Intensive Care, Tunisian Military Hospital, Montfleury, 1002 Tunis, Tunisia. Tel: 216-2409-1983, Fax: 216-7139-1099, E-mail: walid_trabelsi2009@yahoo.fr

Introduction

For years, regional anesthesia has been performed mainly with the help of nerve stimulation (NS) [1]. Ultrasound (US) is now available in most centers practicing regional anesthesia and is a popular tool amongst trainees for performance of nerve blocks.

Many randomized controlled studies (RCS) have compared US-guided and NS-guided infraclavicular blocks in adults [2-4]. All studies reported a high success rate with either ultrasound- or with nerve stimulation-guidance, without being able to demonstrate a significant difference between the two modes of nerve identification.

We aimed to compare the overall success rate, procedure time and onset of sensory and motor block between the two techniques in infraclavicular brachial plexus (ICBP) block.

Materials and Methods

After local ethics committee approval and written informed consent, patients undergoing upper limb wrist/hand/elbow or distal arm surgery were recruited to this randomized, double-blind study. Inclusion criteria were age ≥ 18 and ≤ 80 years and American Society of Anesthesiologists Physical Status classification I−III. There were no exclusion criteria.

Patients were randomized by distributing sealed, opaque envelopes divided among two groups, each receiving an ICBP blok with bupivacaine 0.5%. No premedications were applied to the cases. An intravenous cannula was inserted into the contralateral arm, and continuous infusion (crystalloid solution) was started. For the whole procedure the patients were routinely monitored with electrocardiogram (ECG), non-invasive blood pressure (NIBP) measurement, and pulse oximetry (SpO2).

The patients were in supine position, with the head facing away from the side to be anesthetized, and the arm were adducted. The infraclavicular region was disinfected. All blocks were performed with 22 gauge needles and 15 ml bupivacaine 0.5%.

In the US Group-cases, a 10- to 12-MHz linear probe (Logiq 7 GE Health care, USA) covered with a sterile sheath with a liberal amount of sterile gel (Vygon, France) was placed in the deltopectoral groove. After subcutaneous infiltration, a 22 gauge insulated needle (Echoplex® D 50 mm, Vygon, France) was inserted and advanced using an in-plane needle-probe alignment. Injection of local anesthetic selectively surrounded each sonographically imaged brachial plexus cord with approximately 5 ml. The procedure time included the time required to perform an initial ultrasound exam and time puncture to block.

In the NS-Group cases, 15 ml of 0.5% bupivacaine was injected by using nerve-stimulator-specific, sterile, needles (22G insulated needle) in company with the available nerve stimulator (Stimuplex® Dig RC, B.Braun, Melsungen, Germany) . Initial stimulating current was 1−1.5 mA. Brachial plexus was reached at a level of 6−8 cm. The current was then gradually decreased until the sought response was still present at 0.3 mA or less. Twiches of triceps, forearm and hand muscles were observed and accepted for successful block.

Table 1. Sensory Test Sites and Motor Test

	Motor test	Sensory test site
Median	Flexion of the first three fingers	Thenar eminence
Ulnar	Abduction of fingers	Hypothenar eminence
Radial	Extension of wrist	Dorsum of hand
Musculocutaneous	Elbow flexion	Over the base of first metacarpal

Table 2. Modified Bromage Scale

Score	Definition
4	Full power in relevant muscle group
3	Reduced power but ability to move muscle group against resistance
2	Ability to move relevant muscle group against gravity but inability to move against resistance
1	Flicker of movement in relevant muscle group
0	No movement in relevant group

At the end of the ICBP block, an anesthetist blinded to the technique evaluated sensory and motor block every five minutes and for 30 minutes as follows. The innervated areas (each dermatome) was evaluated using a pinprick (Table 1). When the needles were no longer felt, cutaneous anesthesia was considered to be present. The motor block was evaluated by bromage modified scale at 10 , 20 and at the end of the 30 minutes (Table 2).

The succes of the block was defined by a complete sensory and motor block (bromage scale of 0) until 30 minutes after performing the block allowing for surgery, for all nerves.

All patients were awake during surgery, and a surgical tourniquet was used in all cases. Supplementary general anesthesia was at the discretion of the operating anesthesiologist and was based on sensory blockade of the intended operation area at 40 minutes. Anxious patients were administered additional midazolam. Subjects refusing awake surgery were administered a propofol infusion with supplemental oxygen as necessary.

Statistics

Prior to the study, a power analysis was performed to deter-

mine the necessary number of patients in each group. With a two-sided type I error of 5% and study power at 80%, it was estimated that 25 patients would be needed in each group in order to detect a difference of 10 mins at the onset of sensory and motor block between the two groups. Therefore 30 patients were included.

For statistical analysis, the program SPSS 13.0® for Windows (LEAD Technologies Inc, USA, 2004) was used. Categorical data was compared between the two groups using the Pearson Chi-2 test and described by count (percentages). The Kolmogorov-Smirnov test was used to evaluate the data distribution. We used the unpaired Student's t-test for normally distributed continuous variables and Mann-Whitney's U test for non-normally distributed continuous variables. Continuous variables were expressed as mean and standard deviation (SD) or median and interquartile range, depending on the normality distribution of the data. A P value of less than 0.05 was considered significant.

The primary end point in this study was onset time. The secondary end points were success rate and procedure time.

Table 3. Patients' Characteristics and Surgical Duration

	US group (n = 30)	NS group (n = 30)	P
Age (yr)	31 ± 10	37 ± 15	0.59
Sex			0.56
Male	23 (76.7%)	21 (70%)	
Female	7 (23.3%)	9 (30%)	
ASA			0.21
I	29 (96.7%)	25 (83.3%)	
II	1 (3.3%)	4 (13.3%)	
III	0 (0%)	1 (3.3%)	
Weight (kg)	72 ± 13	75 ± 10	0.31
Height (cm)	173 (163; 175)	174 (74; 177)	0.06
BMI (kg/m^2)	24.5 ± 4	25 ± 3	0.68
Surgical duration (min)	105 ± 55	87 ± 37	0.17

US: Ultrasound, NS: neurostimulation, ASA: American Society of Anesthesiologists's Physical Status classification system, BMI: body mass index; categorical data was described by count (percentages); continuous variables were expressed as mean and standard deviation (SD) or median and interquartile range, depending on the normality distribution of the data.

Results

We included 60 patients into the study (30 patients in each group). Patient's demographics were similar in the two groups. The duration of surgery was comparable between the groups (Table 3).

There were no significant differences between groups in block procedure time (220 ± 130 sec in US group versus 281 ± 134 sec in NS group; P = 0.74).

The success rate of all the nerve blocks in the US group was 100%. The success rate in the NS group was 73.3%, 76.7%, 76.7% and 100% for radial, ulnar, median, and musculocutaneous nerve, respectively. The success rate was significantly higher in the US group for radial, ulnar, median, and the four nerves considered together (Table 4, Fig. 1 and 2).

We observed a significantly faster onset of sensory block for the radial, ulnar, median, musculocutaneous, and the

Table 4. Procedure Time, Success Rate and Onset Time

	US group (n = 30)	NS group (n = 30)	P
Regional block procedure time (sec)	220 ± 130	281 ± 134	0.74
Local anesthetic dose (ml)	15 ± 0	15 ± 0	1
Success of nerve block			
Radial nerve	30 (100%)	22 (73.3%)	0.005
Ulnar nerve	30 (100%)	23 (76.7%)	0.01
Median nerve	30 (100%)	23 (76.7%)	0.01
Musculocutaneous nerve	30 (100%)	30 (100%)	1
All the 4 nerves	30 (100%)	22 (73.3%)	0.005
Sensory block onset time (min)			
Radial nerve	10 (8; 13)	20 (10; 25)	0.01
Ulnar nerve	10 (10; 15)	18 (10; 25)	0.013
Median nerve	8 (6; 11)	13 (7; 25)	0.01
Musculocutaneous nerve	6 (6; 9)	11 (8; 21)	<0.001
All the 4 nerves	10 (10; 15)	14 (12; 25)	0.017
Motor block onset time (min)			
Radial nerve	19 (15; 22)	27 (16; 42)	0.014
Ulnar nerve	21 ± 10	27 ± 11	0.05
Median nerve	13 (10; 18)	20 (14; 33)	0.031
Musculocutaneous nerve	9 (8; 15)	10 (9; 23)	0.08
All the 4 nerves	20 (15; 26)	23 (16; 32)	0.1

Categorical data was described by count (percentages); continuous variables were expressed as mean and standard deviation (SD) or median and interquartile range, depending on the normality distribution of the data. US: Ultrasound, NS: Neurostimulation.

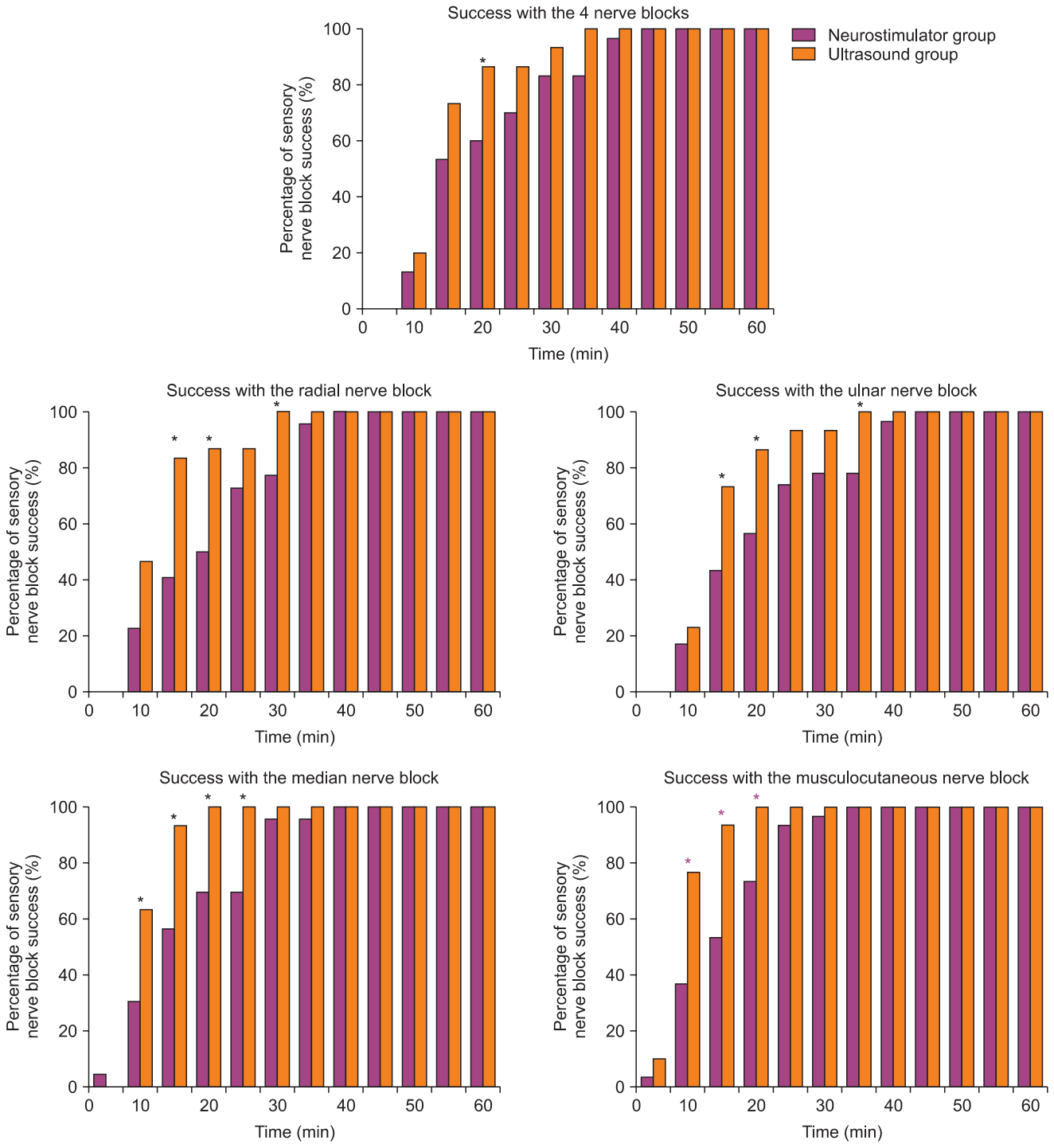

Fig. 1. Percentage of patients with sensory block success over time for each nerve and for the four nerves considered together. *P < 0.05.

four nerves considered together (Table 4, Fig. 3). The onset of motor block for the radial, ulnar, and medial nerves was faster in the US group. However, the onset of motor block for the musculocutaneous nerve and the four nerves considered together was comparable between the two groups (Table 4, Fig. 4).

Discussion

We found that the success rate of all the nerve blocks in the US group was 100%. The success rate in the NS group was 73.3%, 76.7%, 76.7% and 100% for radial, ulnar, medial, and

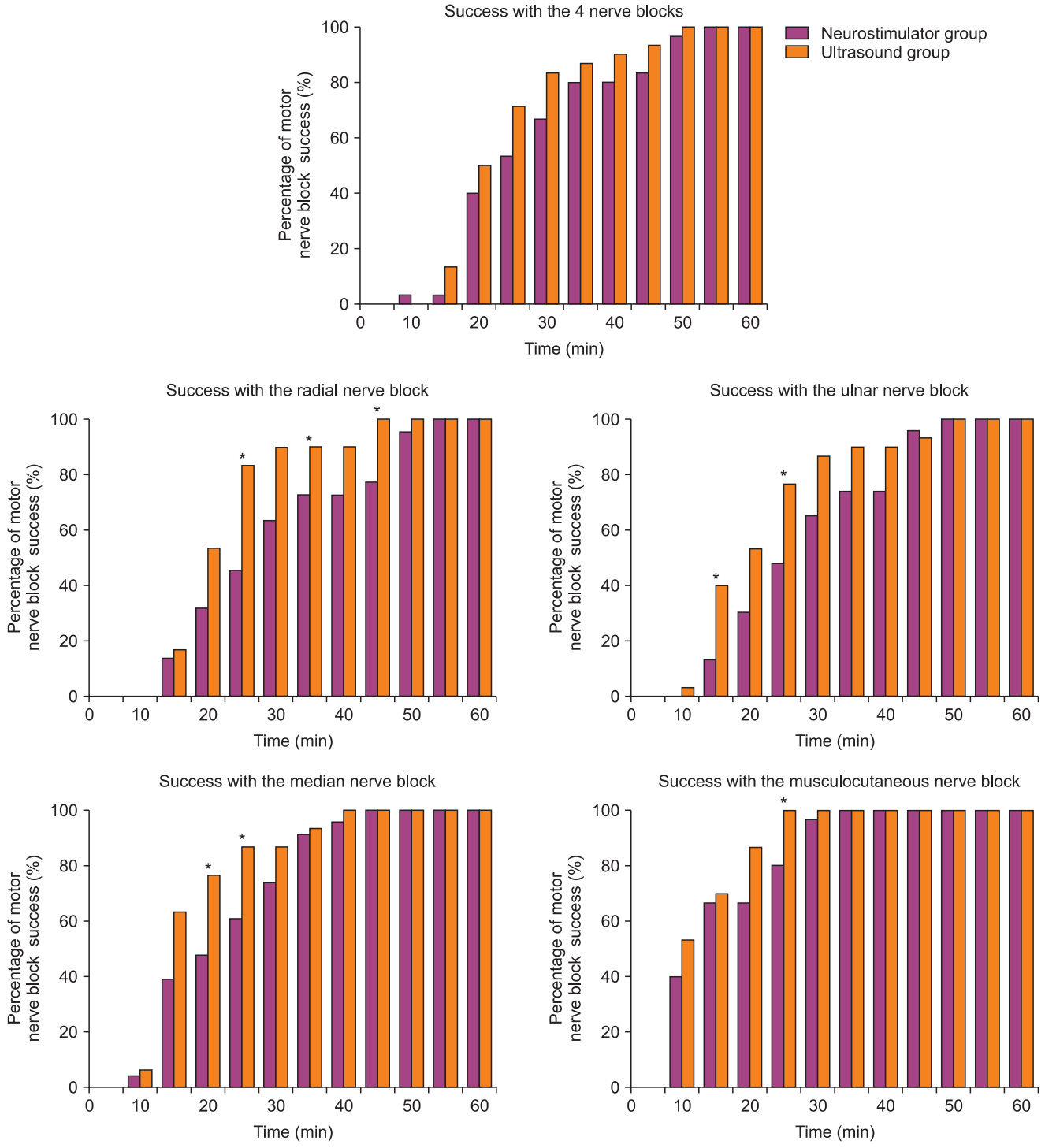

Fig. 2. Percentage of patients with motor block success over time for each nerve and for the four nerves considered together. *P < 0.05.

musculocutaneous nerve, respectively. This success rate was significantly higher in the US group. We also found a significant faster onset of sensory and motor block in favor of US. However, US does not shorten procedure time.

Wu et al. [5], in one of the first studies, reported eight successful blocks in nine patients. We can infer that their weaknesses in perfoming the study included not identifying the cords and for depositing the LA at the lateral border of the subclavian artery. In addition, the use of a thin (23-gauge) spinal needle can compromise the success and the safety of the procedure. So, the

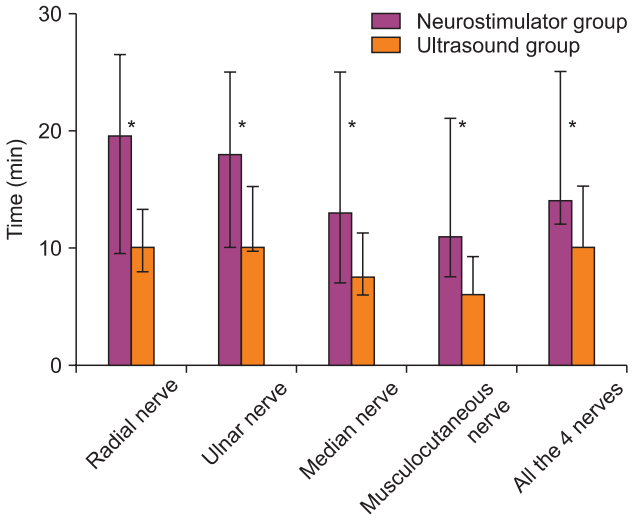

Fig. 3. Median onset of sensory block for each nerve and for the four nerves considered together. Error bars show interquartile range. *P < 0.05.

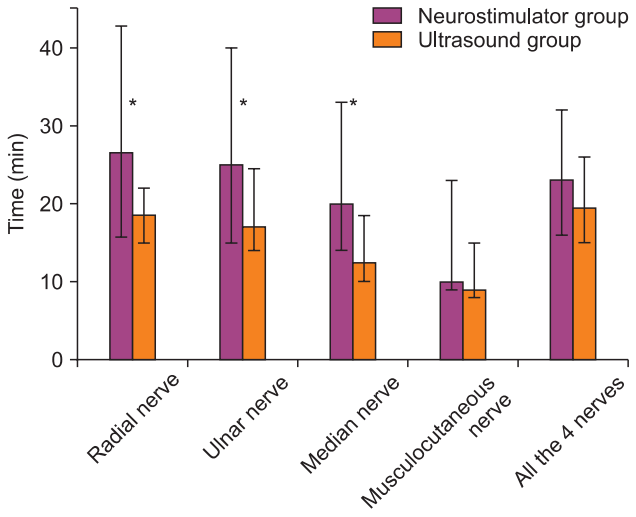

Fig. 4. Median onset of motor block for each nerve and for the four nerves considered together. Error bars show interquartile range. *P < 0.05.

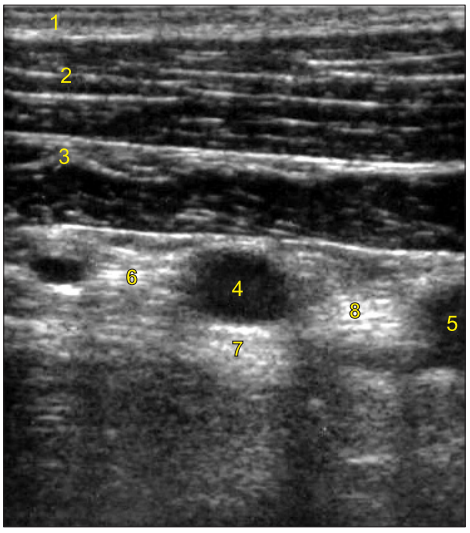

Fig. 5. Ultrasonography of infraclavicular region. 1: skin, 2: pectoralis major, 3: pectoralis minor, 4: axillary artery, 5: axillary vein, 6: lateral cord, 7: posterior cord, 8: medial cord.

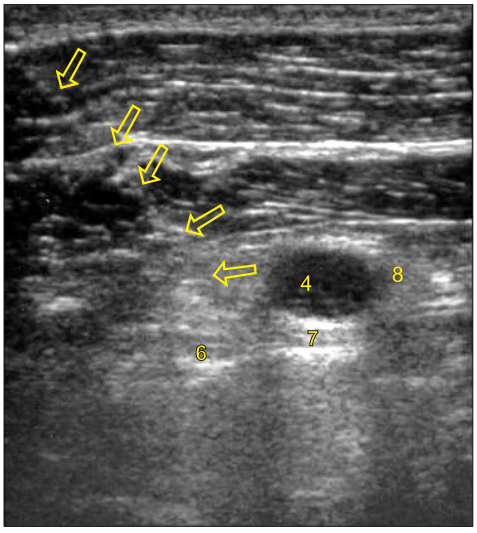

Fig. 6. Needle (arrows) trajectory during ultrasound guided infraclavicular brachial plexus block. 4: axillary artery, 6: lateral cord, 7: posterior cord, 8: medial cord.

needle was directed to each of the cords individually. The entire length of the needle (bevel up) was seen at all times. In addition, the echogenicity of our needles (specially manufectured to this goal) provides better visibility and better control of its tip during manipulations This simple measure was probably a major factor in obtaining the higher success rate in our study (Fig. 5 and 6).

Several studies have reported the importance of depositing LA around each nerve in the brachial plexus as a factor in improving the success rate [6,7].

Ootaki et al. [8] reported no failed ultrasound-guided infraclavicular block in 60 patients performed by a unique person. Of them, 57 did not require any additional local anaesthetic or opioid supplementation. Two patients were given additional LA infiltration and one received analgesia with fentanyl. However the time to perform the block was not mentioned. While they claimed an overall success rate of 100%, the ulnar, radial and median nerves were spared in 10%, 6.7% and 3.3% of patients, respectively, 30 min after injection. In addition, the onset in their study [8] was 30 min; it was 10 min (for sensory) and 20 min (for motor) in our series despite our

Table 5. Randomized Controlled Studies Comparing US and NS in Infraclavicular Brachial Plexus Block

Study	No. patients	Onset of block time (min)	Time for procedure completion (min)	Success rate (%)	Local anesthetic volume
Sauter et al. [2]	80	13.9 (US) versus 13.7 (US&NS)	4.1 (US) versus 4.3 (US&NS)	95% (US) versus 85% (US&NS)	20 ml lidocaine 0.5% + 20 ml Bupivacaine
Brull et al. [3]	103	5 (US) versus 10.5 (NS)	5 (US) versus 10.5 (NS)	85% (US) versus 65% (US&NS)	Lidocaine 2% 15 ml and 15 ml Bupivacaine 0.5% with epinephrine
Taboada et al. [4]	70	17 (US) versus 19 (NS)	3 (US) versus 6 (NS)	89% (US) versus 91% (NS)	*
Dingemans et al. [10]	72	*	3.1 (US) versus 5.2 (US&NS)	92% (US) versus 74% (US&NS)	Lidocaine 1.5% and bupivacaine 0.125% with epi 0.5 ml/kg
Dhir and Ganapathy [11]	66	28 (NS) versus 24 (SC) versus 21(US&NS)	6 (NS) versus 8 (SC) versus 6 (US&NS)	59% (NS) versus 58% (SC) versus 96% (US&NS)	30 ml of ropivacaine 5 mg/ml with epi 2.5 μg/ml
Our study	60	10 (US) 14 (NS)†	3.5 (US) 5 (NS)	100% (US) 73.3% (NS)†	15 ml bupivacaine 0.5%

US: ultrasound, US&NS: ultrasound and peripheral nerve stimulation, SC: stimulating catheter. *Not defined, †$P < 0.05$.

using bupivacaine which is known to have a delayed action. This delay can be attributed to making no attempt to see the nerve cords. Consequently, the anaesthetic was deposited on all sides of the subclavian artery with the expectation that it would spread around the nerves. Sandhu and colleagues [9], using the same technique that we used, found that sensory onset (6.7 ± 3.2 min) was shorter than ours probably because they used lidocaine as LA.

We believe that the rapid onset of the block depends on perineural rather than perivascular spread. Another reason for the slow onset in the study of Ootaki et al. [8] may be related to the use of a slightly lower concentration of lidocaine (1.5%; 7.3 mg/kg) without adjuvants. The rapid onset in the study of Sandhu and Capan [9] can be explained by the use of lidocaine 1.5% with sodium bicarbonate and by the larger volume (9.3 mg/kg) compared to what we used (approximately 1 mg/kg). However our study would be theoretically safer than that of Sandhu and Capan by decreasing the dosage of anesthetic resulting in lowering systemic and local neurologic toxicity.

In medical literature, five randomized controlled trials compared US-guided and NS-guided ICB in adult patients [2-4,10,11]. All of them showed a high success rate with either US- or with NS-guidance (Table 5).

The vast majority of studies [3,4] suggest that the time required to perform peripheral nerve blocks is shortened with the use of ultrasound (which we did not find), however the time required to perform an initial ultrasound exam is not included in the total time reported in any of these investigations.

In summary, the significance of ultrasound guidance in the armamentarium of regional anesthesia is indisputable in terms of its success rate, speed of onset and duration of action.

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