ORIGINAL ARTICLE

Comparison of ultrasound and ultrasound plus nerve stimulator guidance axillary plexus block

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Abstract

Objective: To evaluate the characteristics of axillary plexus blockade applied using ultrasound only and using ultrasound together with nerve stimulator in patients undergoing planned forearm, wrist or hand surgery.

Methods: This randomised, prospective, double-blinded, single-centre study was conducted at Ankara Numune Training and Research Hospital, Ankara, Turkey, from November 2014 to August 2015, and comprised patients undergoing forearm, wrist or hand surgery. Participants were separated into 2 groups. In Group 1, the nerve roots required for the surgical site were located one by one and local anaesthetic was applied separately to each nerve for the block. In Group 2, the vascular nerve bundle was located under ultrasound guidance and a total block was achieved by administering all the local anaesthetic within the nerve sheath. In the operating room, standard monitorisation was applied. Following preparation of the skin, the axillary region nerve roots and branches and vascular structures were observed by examination with a high-frequency ultrasound probe. In both groups, a 22-gauge, 5cm block needle was entered to the axillary region with visualisation of the whole needle on ultrasound and 20ml local anaesthetic of 0.5% bupivacaine was injected. SPSS 19 was used for data analysis.

Results: Of the 60 participants, there were 30(50%) in each group. The mean age was 39.1±15 years in the group 1 which was the ultrasound nerve stimulation group, and 41.5±14.3 years in group 2. The duration of the procedure was longer in group I than in group 2 ($p<0.05$). Patient satisfaction values during the procedure were higher in group 2($p<0.05$). In the ulnar sensory examination, the values of the patients in group 1were higher at 10, 15, 20 and 25 minutes ($p<0.05$). In the median, radial and ulnar motor examination, the values of the patients in group 1were higher at 15 and 20 minutes ($p<0.05$).

Conclusion: Brachial plexus blockade via axillary approach guided by ultrasound offered excellent quality of sensory and motor block equivalent to that of the nerve stimulator-guided technique.

Keywords: Ultrasound, Nerve stimulation, Axillary plexus block. (JPMA 67: 508; 2017)

Introduction

Brachial plexus block via the axillary approach is a common technique to provide anaesthesia for surgery of the forearm, wrist and hand. Neurostimulation is the technique used more often in peripheral nerve blocks. There is increasingly widespread use of ultrasound (US) to guide regional blocks as it allows the anatomical evaluation of the region before the blockade to correctly identify the structures of the brachial plexus. Ultrasound imaging techniques enable anaesthesiologist to secure an accurate needle position and monitor the distribution of the local anaesthetic (LA) in real time, with the potential advantage of improving the quality of the nerve block, shortening the latency of the block, and reducing the minimum volume required to obtain a successful nerve block.[1-5]

Since vessels and nerves in the brachial plexus region are contained within the axillary sheath, the application of ultrasound with high-resolution imaging permits accurate real-time targeting of the plexus sheath and allows the spread of the local anaesthetics.

However, when applying axillary plexus block, the effects on the characteristics of the block used of the use of ultrasonography alone or together with peripheral nerve stimulator are not clear.

The current study was planned to compare the characteristics of axillary plexus blockage applied using ultrasound alone or with nerve stimulation to patients with planned forearm, wrist or hand surgery.

Materials and Methods

This randomised, prospective, double-blinded, single-centre study was conducted at the anaesthesiology, orthopaedic, hand surgery and plastic reconstructive surgery departments of Ankara Numune Training and Research Hospital, Ankara, Turkey, from November 2014 to August 2015. Approval for the study was granted by the institutional ethics committee. Adult patients classified as

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American Society of Anaesthesiologists (ASA) physical status I-II, who were to undergo elective, forearm, wrist or hand surgery were included. Written informed consent was obtained from each patient. Patients with coagulopathy, local anaesthetic allergy, local infection, any significant neurological, psychiatric or cognitive disorder, chronic analgesic use, known neuropathies, or infection in the injection site were excluded. After arrival in the operating room, an 18-gauge intravenous (IV) catheter was placed in the contra-lateral forearm. Standard monitoring was used throughout the procedure, including non-invasive arterial blood pressure, heart rate, and pulse oximetry. Using a computer-generated sequence of random numbers and a sealed envelope technique, patients were randomly allocated to receive axillary brachial plexus block using either ultrasound plus nerve stimulation (group USNS) or ultrasound (group US) guidance.

All the brachial plexus blocks were performed by the same anaesthesiologist.

The patient was made comfortable in the supine position with the arm abducted and the elbow flexed to 90°. After skin and probe preparation, a linear 38-mm, high frequency 6-13 MHz transducer (Logiq e, General Electric, United States) was placed in the transverse plane at the lateral border of the pectoralis major muscle to obtain the best view of the brachial plexus. Image quality was optimised with the selection of the appropriate depth (within 2-3cm), focus range (within 1cm) and gain. Three out of the four terminal branches of the brachial plexus were found surrounding the axillary artery, together with the median (superficial and lateral to the artery), the ulnar (superficial and medial to the artery) and the radial (posterior and lateral or medial to the artery) nerves. A 22-gauge, 5-cm-long, short-bevelled, Teflon-coated needle (Locoplex; Vygon) was inserted parallel to the long axis of the transducer from the lateral side. As the needle was in the same plane as the ultrasound beam, the path of the advancement couldbe visualised in real time as the needle approaches the target nerves. The musculocutaneous nerve was blocked separately outside the neurovascular bundle with 3 ml 0.5% bupivacaine in all of the patients. Firstly, the radial nerve should be targeted, as it lies posterior to the artery, in order to prevent obscuring the median and ulnar nerves or deeper displacement of the structures of interest. Then, the ulnar, radial, and median nerves were blocked separately with 5ml local anaesthetic for each nerve.

In group USNS, the nerve location was performed with the aid of a nerve stimulator (Plexygon; Vygon, Ecouen, France) using a 22-gauge, 5-cm-long, short-bevelled, Teflon-coated needle (Locoplex; Vygon) and ultrasound guidance. The nerve stimulator was set with a pulse duration of 0.15 ms, a current intensity of 1 mA, and a frequency of 2 Hz. The needle was further adjusted as needed to evoke a distal motor response at 0.5 mA or less. Each nerve was located and blocked separately with 0.5% 6 ml bupivacaine. Nerves were located according to the specific twitches elicited by their stimulation. For the radial nerve: arm and finger extension, supination; for the median nerve: wrist, second and third finger flexion, pronation; and for the ulnar nerve: fourth and fifth finger flexion, thumb adduction.

An independent observer recorded the block procedure time, defined as the time from the start of the needle insertion to the end of the local anaesthetic injection. Then, a blinded observer, who was not present during the block placement, recorded the onset of sensory and motor blocks and monitored the blocks at 5-minute intervals in the four nerves under consideration. Sensory block was assessed as the loss of pinprick sensation in the central sensory region of each nerve with the same stimulus delivered to the contra-lateral side, and scored as follows: normal sensation=no block; touch sensation but no pain= partial block; total loss of sensation = complete block. Motor block was evaluated using forearm and wrist flexion/extension, thumb and second digit pinch, and thumb and fifth digit pinch, and scored as follows: no loss of force=no block; reduced force compared with the contra-lateral arm = partial block; incapacity to overcome gravity= complete motor block. The zero time for onset of sensory and motor blocks was the completion of the local anaesthetic injection. Readiness for surgery was defined as the presence of complete sensory block in the three territories and complete motor block in at least two of the three nerves, with partial motor blocks in the three remaining nerves. If any potential surgical territory was not completely anaesthetised before surgery, the block was supplemented at the elbow or wrist and was considered to have failed. Pain during rest before and after surgery at 2,4,6,8,10,12,18 and 24 hours were assessed by visual analogue scale (VAS). VAS determination was performed with a scale of numbers between 0 and 10 cm. Besides, 1mg/kg tramadol and 15 mg/kg paracetamol IV infusion were administered to patients with a requirement for additional analgesia (VAS $\geq$ 4). The number of patients who required additional analgesic drugs was noted. Patient's satisfaction was evaluated as poor (1), moderate (2), good (3) or very good (4) during the initial procedures, during the operation and post-operatively.

SPSS 19 was used for statistical analysis. In the evaluation

of the study data, descriptive statistical methods (frequency, percentage, mean, standard deviation) were used. In the comparison of qualitative data, Pearson's chi-squared test, Fisher's exact test or Yates's tests were used. Conformity of the data to normal distribution was evaluated with the Kolmogorov-Smirnov test. In the evaluation of quantitative data showing normal distribution, the independent samples t-test was used, and for non-parametric data the Mann-Whitney U-test was used. P<0.05 was considered statistically significant.

Results

Of the 60 participants, there were 30(50%) in each group. The mean age was 39.1±15 years in the USNS group and 41.5±14.3 years in US group. There were 10(33.3%) females and 20(66.7%) males in group USNS compared to 11(36.7%) females and 19(63.3%) males in group US (Table-1).

The mean procedure time of group USNS (237.0±59.8 seconds) was found to be higher than that of group US (123.9±20.2 seconds) (p<0.05).

In the sensory examination (median, radial, ulnar), a statistically significant difference was determined between the groups in respect of the total block duration and in the block onset times (p<0.05 for both). The time to onset of the block in the patients in Group US was found to be higher.

In the motor examination (median, radial, ulnar) of the comparison between the groups, no statistically significant difference was determined between the groups in respect of the block onset time (p>0.05) but a statistically significant difference was determined in the total block duration (p<0.05). The total block duration in the patients in Group US was found to be higher (Table-2).

No statistically significant difference was determined between the groups in respect of block success rates (p>0.05). Of all, 2(3.3%) patients required ulnar nerve block in the wrist because of an incomplete block at 30 minutes. There were no conversions to general anaesthesia.

No statistically significant difference was determined between the groups in respect of the VAS values (p>0.05) (Figure).

No statistically significant difference was determined between the groups in respect of the VAS values at all the measured times (p>0.05).

No statistically significant difference was determined between the groups in respect of the time of additional analgesia (p>0.05). The mean value of the need for additional analgesia was 19.6±4.1 hours in group USNS

Table-1: Demographic data.

		Group USNS (n=30)		Group US (n=30)
Age, year		39.1 ± 15.0		41.5 ± 14.3
Height, cm		166.9 ± 9.7		169.8 ± 10.1
Weight, kg		72.9 ± 13.9		79.8 ± 13.3
BMI		26.0 ± 3.8		27.8 ± 4.9
Sex	**N**	**%**	**n**	**%**
female	10	33.3	11	36.7
Male	20	66.7	19	63.3
ASA				
I	13	43.3	10	33.3
II	17	56.7	20	66.7

USNS: Ultrasound and nerve stimulation
US: Ultrasound
BMI: Body mass index.
ASA: American Society of Anaesthesiologists.

Table-2: Characteristics of the Axillary Brachial Plexus Block.

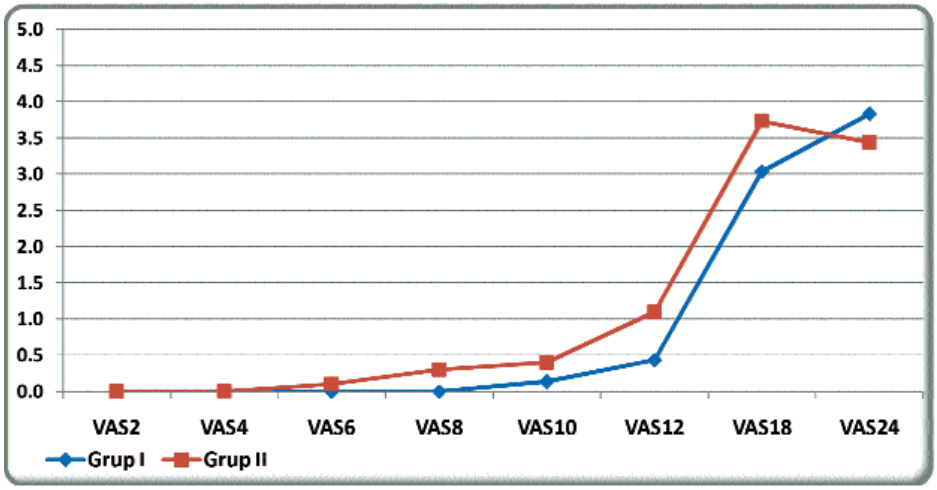
		Group USNS (n=30)	Group US (n=30)	P
Sensory	Median[1]	7.5 (5 - 10)	10 (5 - 15)	0.031
	Median[2]	20 (15 - 30)	25 (15 - 35)	0.338
	Radial[1]	7.5 (5 - 10)	10 (5 - 15)	0.031
	Radial[2]	20 (15 - 35)	25 (15 - 35)	0.441
	Ulnar[1]	7.5 (5 - 10)	10 (5 - 20)	0.009
	Ulnar[2]	20 (15 - 30)	25 (15 - 40)	0.051
Motor	Median[1]	10 (5 - 15)	10 (5 - 15)	0.195
	Median[2]	22.5 (15 - 40)	30 (20 - 40)	0.018
	Radial[1]	10 (5 - 15)	10 (5 - 15)	0.391
	Radial[2]	22.5 (15 - 40)	27.5 (20 - 40)	0.029
	Ulnar[1]	10 (5 - 15)	10 (5 - 20)	0.121
	Ulnar[2]	22.5 (15 - 40)	30 (20 - 40)	0.015

Median (min - max)
USNS: Ultrasound and nerve stimulation
US: Ultrasound
[1]Onset times of sensory and motor blocks
[2]Completion times of sensory and motor blocks.

Table-3: Comparison of patient satisfaction.

Patient satisfaction	Group I * (n=30)	Group II ** (n=30)	P
During procedure	2.8 ± 0.8	3.4 ± 0.7	0.001
Operation	3.8 ± 0.4	3.9 ± 0.4	0.220
Postoperative	3.9 ± 0.3	4.0 ± 0.0	0.078

* Ultrasound and nerve stimulation
** Ultrasound.



VAS: Visual analogue scale.

Figure: Comparison between the groups of the VAS values.

and 17.7±4.4 hours in group US.

No statistically significant difference was determined between the groups in respect of patient satisfaction during the operation and post-operatively ($p>0.05$), while a statistically significant difference was determined between the groups during the procedure ($p<0.05$). The patient satisfaction values of the patients in group US were found to be higher (Table-3).

Discussion

Current techniques available for nerve localisation mark anatomical indicators for the estimated location of the brachial plexus. In the nerve stimulator technique, it is ensured that the needle is correctly placed without causing paraesthesia. Rather than defining the nerve localisation using nerve stimulator alone, intervention with the use of ultrasonography has been reported to increase success rates and reduce complications.

Ultrasonography allows visualisation of the brachial plexus at a higher quality and helps nerve localisation, and these factors then increase the quality of the nerve block. Through ultrasonography, peripheral nerves, needle localisation and local anaesthetic distribution, all of which are required for a successful conduction block, can be directly displayed.[6,7] However, the use of more than one assistive method may cause technical problems. Therefore, the use of ultrasonography alone is seen as an alternative technique.

The variables which have been identified as relevant when comparing ultrasound and ultrasound and neurostimulation in peripheral nerve blocks include block procedure time, readiness for surgery, success rate, VAS values of post-operative pain, requirement for additional analgesia and patient satisfaction.

Casati and Conceicão[8,9] compared ultrasound-guided with neurostimulation-guided axillary brachial plexus block and found similar success rates for both techniques. Chan et al.[10] compared ultrasound-guided to neurostimulation-guided axillary brachial plexus block in hand surgery and the ultrasound group was found to have a higher success rate and a shorter time to perform the technique. In the current study, the success rate of an effective block for all nerves was 100% in the USNS group and 93.3% in the US group. Additional LA infiltration was required by 2 patients in the US group. A lower success rate of the block was seen in the US group due to poor spread of the local anaesthetic around the ulnar nerve in 2 patients. The increased anaesthetic efficacy of the USNS group is thought to trigger a longer block performance time. In the current study, the time needed to perform the block in both applications was extremely short, with the US group taking a statistically significantly shorter time at 123.9±20.2 seconds than the ultrasound plus neurostimulation guidance group at 237±59.8 seconds.

In respect of patient satisfaction, a study reported similarly good results with both techniques.[8] There is some evidence suggesting an equal risk of complications and less satisfactory anaesthesia with methods using the US plus neurostimulation rather than US.

The use of low currents (0.5 mA) during nerve stimulation for neural blockade has been applied in many ultrasound-guided neural blockade techniques. Nerve stimulator-guided blocks performed by trainees can be considered to cause more patient discomfort compared to blocks performed by experts due to the prolonged time taken for block placement with unpleasant muscle contractions. The elicitation of paraesthesia or muscle twitch response was not welcome for most patients. Interestingly, patient discomfort was reduced by sonographic guidance compared to the nerve stimulator technique, even though sonographically-guided blocks were performed predominantly by trainees and nerve stimulator-guided blocks by experts. The anatomic landmark for the axillary

artery was sought under ultrasonographic guidance that offered accurate placement of the injection needle while avoiding puncture of nerve structures during the injection. Several studies have demonstrated that ultrasound- guided axillary brachial plexus blocks allow significant reductions in the use of supplementary analgesics and provide better quality of blocks compared with the nerve stimulator-guided technique.[11]

Soeding et al. compared conventional "landmark-based" and ultrasound-guided brachial plexus anaesthesia using both interscalene and axillary approaches, and reported that the use of ultrasonography improved the onset and completeness of sensory and motor blocks.[12] Soeding et al.[12] reported that the onset of sensory block was 5 minutes faster with ultrasound guidance than with nerve stimulation. Furthermore, there were no differences in the onset time of motor block, readiness for surgery and the overall success rate of the block.

Chin et al. reported that multiple-injection techniques using neurostimulation for axillary plexus block provided more effective anaesthesia than either double or single-injection techniques.[13]

In the current study, the higher time to onset of the sensory block in the US group was considered to be due to the local anaesthetic having been administered further from the nerve in comparison with other combined techniques, but this was not considered important as there was no statistically significant difference in the total sensory block duration. On the other hand, the longer motor block duration in the US group was considered a disadvantage. Effective analgesia was achieved in both groups in the post-operative period and the times of the requirement of the first analgesia were similar.

A limitation of the current study was that in addition to the patient satisfaction values, patient anxiety before and after the procedure could have been evaluated.

Conclusion

The brachial plexus blockade via the axillary approach guided by ultrasound offered excellent quality of sensory and motor block equivalent to that of the nerve stimulator-guided technique and significantly improved patient comfort compared to the established ultrasound plus nerve stimulator technique.

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Conflict of Interest: None.

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