Ultrasound guidance versus nerve locator for infraclavicular brachial plexus block: a comparative clinical study

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Background The use of ultrasound (US) guidance for nerve blocks has dramatically increased over the past 20 years. The success rate of infraclavicular block is improved by US guidance compared with nerve locator (NL).

Aim In this study, we aimed to compare conventional block using NL and US-guided techniques in the infraclavicular approach to the brachial plexus for upper limb surgeries (forearm and hand surgeries, either elective or emergency).

Patients and methods The study was carried out on 40 adult patients of both sexes who were randomly classified using closed envelope method into two equal groups, with 20 patients each:
All patients undergoing either conventional block using NL or US-guided block were premedicated with 0.02 mg/kg of midazolam. The technique was done by identification and blocking the cords of brachial plexus by administration of 15-ml 0.5% bupivacaine and 15-ml of 2% lignocaine with adrenaline 1 : 200 000 in both groups.
Onset of the block, success rate, patient satisfaction, and the complications were recorded.

Results Sensory and motor block onset times were shorter in group B than in group A. The success rate and patient satisfaction were more in group B than in group A. Patients in group B had fewer complications than in group A.

Conclusion To conclude, our results showed less time to perform ICBPB in group B and the onset of complete block as well as high success rate, patient satisfaction, and fewer incidences of complications.
Sci J Al-Azhar Med Fac, Girls 2018 2:15–19

The Scientific Journal of Al-Azhar Medical Faculty, Girls 2018 2:15–19

Keywords: forearm and hand surgeries, infraclavicular, local anesthetics, nerve locator, ultrasound

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Received 8 March 2018 **Accepted** 29 March 2018

Introduction and aim

Regional anesthesia is the administration of local anesthetic (LA) agents to specific anatomic areas, resulting in a combination of sensory and motor block. It can be divided into central and peripheral nerve blocks based on the proximity of the infiltration site to the spinal cord [1].

The success of the classical infraclavicular approach to the brachial plexus block depends on a good understanding of anatomy and strong reliance on landmarks which may be obscured by obesity or anatomical variation. Because of the blind nature of this technique, unpredictable block failure and inadvertent puncture of adjacent structures (blood vessels, pleura, and nerves) may occur leading to complications, frustrating and time-consuming trial, and error attempts [2].

The nerve locator (NL) was considered the gold standard technique for nerve location. The multiple injection technique with nerve stimulation has been proved to provide more effective block than either double or single injection for axillary brachial plexus block [3].

Ultrasonography is a useful tool for regional anesthesia. By comparison with NL technique, ultrasound (US)-guided technique offers some advantages such as direct visualization of the anatomic structures, monitoring of the needle advancement and LA spread, and minimization of the vascular punctures by accurate needle position. So US-guided technique was reported for improving the quality of block, shortening the onset of block, and reducing the LA volume required for obtaining a successful block [4].

As a result, the popularity of US guidance for nerve blocks has dramatically increased over the past 20 years. The success rate of infraclavicular block was reported to be improved by US guidance compared with NL [5].

In this study, we aimed to compare conventional block using NL with US-guided techniques in the infraclavicular approach to the brachial plexus for upper limb surgeries (forearm and hand surgeries either elective or emergency) regarding onset time of sensory and motor blockade in minutes, success rate, patient satisfaction, and

incidence of complications such as hematoma formation, paresthesia, and pneumothorax.

Patients and methods

After approval of the local ethical committee at the Department of Anesthesiology, Intensive Care in Al-Azhar University and after obtaining the written informed consent, 40 patients of both sexes aged from 21 to 60 years with American Society of Anesthesiologists grade I–III physical status submitted for upper limb surgeries (forearm and hand surgeries either elective or emergency) were divided randomly with computer-generated and sealed envelope to two groups of 20 patients each. The study design was a prospective randomized clinical trial that began from February 2017 to October 2017 in Al-Azhar University hospitals.

Criteria for exclusion

The following were the exclusion criteria:

(1) Known hypersensitivity to used LAs.
(2) Pre-existing neurological deficits.
(3) Coagulation disorders.
(4) Skin lesions at the site of planned blocks or local sepsis.
(5) American Society of Anesthesiologists more than grade III.
(6) Refusal to the study.
(7) Hypertension, either controlled or not, and cardiac disease.

Patient groups

(1) Group A (NL; 20 patients): infraclavicular brachial plexus block using conventional method using NL for identification and block using MultiStim SENSOR NL (Pajunk; PAJUNK® USA Medical Systems) (Fig. 1).
(2) Group B (US; 20 patients): infraclavicular brachial plexus block guided by two-dimensional US image (Fig. 2).

Both groups were subjected to the following:

(1) Intravenous line and hydration with 10 ml/kg normal saline for both groups.
(2) All patients were premedicated with 0.02 mg/kg of midazolam.
(3) The technique will be done by identification and blocking the cords of brachial plexus by administration of 15-ml 0.5% bupivacaine and 15-ml of 2% lignocaine with adrenaline 1 : 200 000 in both groups.

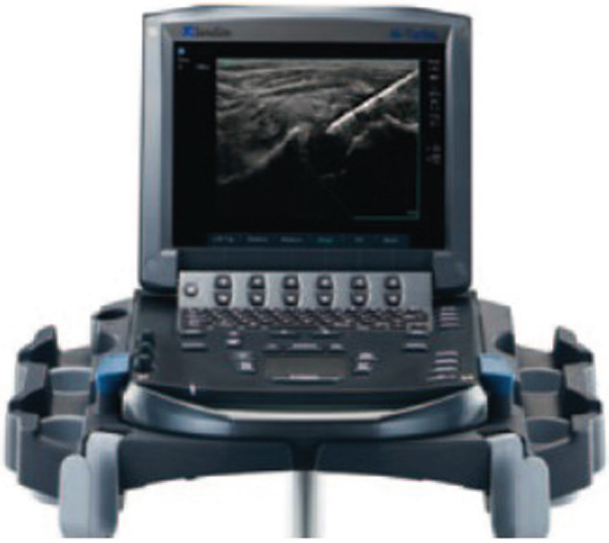
Primary outcome of the study: evaluation of these parameters

(1) Onset of action (minutes) was after LA administration till numbness occurred. The efficacy of the technique will be assessed every 5 min in the first 30 min for the following:
   (a) Sensory block: sensitivity will be tested with ice gel bag that will be applied to 5-cm diameter area for 3 s.
   (b) Intensity of motor block by modified Bromage scale.
      (i) Grade 0: normal motor function.

Figure 1

Nerve simulator PAJUNK® USA Medical Systems.

Figure 2



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(ii) Grade 1: ability to move only fingers.
(iii) Grade 2: complete motor block with inability to move elbow, wrist, and fingers [6].

Secondary outcome of the study

The secondaryoutcomes included thesuccess rate and patient satisfaction; moreover, complications such as hematoma formation, paresthesia, pneumothorax, and toxicity had been recorded.

Monitoring

Baseline respiratory rate, oxygen saturation%, mean arterial blood pressure, and heart rate were recorded before the injection of LA.

Respiratory rate, oxygen saturation%, mean arterial blood pressure, and heart rate were recorded every 5 min for 30 min and every 10 min till the end of operation.

Statistical methods

Data entry and statistical analyses were performed using SPSS (statistical package for the social sciences) version 21 (SPSS Inc., Chicago, Illinois, USA) [7]. Categorical data were expressed in number and percentage. Continuous normally distributed data were expressed in mean and SD. The quantitative data were examined by Kolmogrov–Smirnov test for normality of data.

χ^2-Test or fisher exact test (which is appreciate) was used to compare categorical data. Independent sample *t*-test (Student's *t*-test) was used to compare continuous normally distributed data between groups. One sample *t*-test was used to compare continuous normally distributed data in the same group. Statistical significance was considered when probability (*P*) value was less than or equal to 0.05.

Results

Demographic data

There was no significant difference in age, weight, and sex between patients in each group ($P>0.05$) as shown in Table 1.

Onset of the block

There was significant difference in the onset of sensory and motor block between both groups. Sensory block was faster in group B than in group A, with *P* value of 0.01, and also the onset of motor block was faster in group B than in group A, with *P* value of 0.001, as shown in Table 2.

Table 1 Comparison between the two groups regarding age, weight, and sex

Variables	Group A (*N*=20)	Group B (*N*=20)	*P* value
Age (years)			
Minimum	19	18	0.977
Maximum	59	60	
Mean	34.9	35.1	
SD	10.4	11.2	
Weight (kg)			
Minimum	65	93	0.858
Maximum	100	99	
Mean	80.3	80.8	
SD	9.2	9.9	
Sex [*n* (%)]			
Female	4 (20)	7 (35)	0.484
Male	16 (80)	13 (65)	

Table 2 Onset of sensory block (in minutes) in each group and onset of motor block

Variables	Group A (*N*=20)	Group B (*N*=20)	*P* value
Onset of sensory block in minutes			
Minimum	4.5	3.5	0.01*
Maximum	9	7.5	
Mean	**6.7**	5.4	
SD	1.3	0.9	
Onset to Bromage 3 time in minutes			
Minimum	16	13	0.001*
Maximum	22	19	
Mean	19.3	**15.3**	
SD	1.6	1.7	

Complications and satisfaction

Regarding the complications development, there was a significant difference between group A and group B regarding hematoma and paresthesia complications, being higher in group A (P value = 0.026 for both). While patients satisfaction shows significant difference between both groups, it was more in group B as show in Table 3.

Success rate

The block was successful in 90% of patients in US group B and 65% of patients in group A (NL). Of the remaining patients, partial block requiring additional sedation/analgesia was 10% in US group and 35% in group A. There was a statistically significant difference, as shown in Table 4.

Discussion

In the present study, successful block was defined as anesthesia that was sufficient for a pain-free surgery without the need for supplemental anesthetics or analgesics. Block success rate was 65% for NL group and 90% for US group (*P*=0.0682).

Table 3 Complications and patient satisfaction in both groups

	Paresthesia [*n* (%)]	Pneumothorax [*n* (%)]	Hematoma [*n* (%)]	Toxicity [*n* (%)]	Patient satisfaction [*n* (%)]
Group A	4 (20)	0 (0)	5 (25)	0 (0)	13 (65)
Group B	1 (5)	0 (0)	1 (5)	0 (0)	18 (90)
P value	0.026	0.026	0.026	0.026	0.026

Table 4 Success rate in both groups

	Group B (US) [*n* (%)]	Group A (C) [*n* (%)]	*P* value
Totally effective	18 (90)	13 (65)	0.026
Partially effective	2 (10)	7 (35)	
Failure	0	0	
Total	20	20	

The failure to show the superiority of NL over US in present study and other studies could be related to training and learning curve of the performer as shown by a study of Luyet and Cédric [8] in which the rate of successful axillary block by US (87.8%) was lower than that by NL (93.2%), during a transition period when performed by trainees. This is likely the result of mistaken nerve identity and misinterpretation of LAs; however, Schwemmer [9] reported a significantly higher success rates in US group compared with NL group (96 vs. 80%, respectively; *P*=0.014). Moreover, a high failure rate of the NL infraclavicular block and no failures in the US-guided technique are reported. This is most probably because in adequately trained hands ultrasonography allows visual confirmation of the infraclavicular structures and accurate localization of the needle, all of which promote the effective infiltration of the LA, so it increases the efficacy and enhances the block success rate [10].

This result was supported by Marhofer *et al.* [11], in a study of an infraclavicular block in children with upper extremity trauma, who found that US guidance reduces visual analog scale-measured block discomfort significantly compared with the NL guidance. Similarly, Luyet and Cédric [8] found that the number of patients who reported discomfort or pain at axillary block placement were significantly fewer in US group (3.1%) than in NS group (20.6%) (*P*=0.002).

The same results were observed by Casati [12], who found a significantly shorter onset of sensory block in US group (14 min) than in NS group (18 min) (*P*=0.01). This may be attributed to the enhancement of speed of block onset by US assistance which enables the LA to be deposited in close proximity around the nerves under direct vision [12].

However, Dean [13] found that onset times of sensory and motor block were similar in patients undergoing interscalene blocks whether performed using US or NL guidance. This may be attributed to the fact that they used a different and lower concentration of LA drug (20 ml of 1% ropivacaine) than that in the present study (15 ml 0.5% bupivacaine and 15 ml of 2% lignocaine with adrenaline 1 : 200 000 in both groups), which could have affected the onset and quality of the block. This reason was confirmed by Thomas and Bendtsen [14] who found the US group achieved a significantly faster onset of sensory and motor block than NL group using 20 ml of 1.5% mepivacaine and 20 ml of 0.75% ropivacaine for interscalene blocks.

The current study showed that the incidence of hematoma secondary to vessels puncture was significantly lower in US group (5%) compared with NL group (25%) (*P*0.026), and also paresthesia during procedure was lower in US group (5%) than in NL group (20%), without statistically significant differences (*P*=0.026).

The same result was confirmed by Luyet and Cédric [8], who reported that the incidence of axillary vessels puncture was significantly lower in the sonographically guided blocks (11.8%) compared with the nerve stimulator-guided blocks (32.4%) (*P*<0.001), and paresthesia during puncture was not different significantly between US group (1.3%) and NL group (2.7%). Moreover, Liu and Spencer [10], in a randomized study of axillary block, showed that no complaints were received from patients in the US-guided group. The incidence of adverse events such as paresthesia (10%), vessels puncture (10%), and subcutaneous hematoma (1%) was significantly higher in NS group (20%) as compared with US group (0%) (*P*=0.03).

In current study, patient satisfaction was similarly good in both groups: 90% of patients in group US and 65% patients in group NL would accept the same anesthesia technique if needed in the future (*P*=0.062).

A similar result of patient satisfaction was obtained by Casati [12] who reported patient's acceptance of the block was similar between both groups. Similarly Luyet and Cédric [8] reported that the overall patient satisfaction was high in both groups (95% for US group vs. 90% for NS group; *P*=0.893).

In conclusion, the current study reported that sonographically guided and nerve stimulation-guided infraclavicular blocks have more success rates, and US guidance offers faster onset and better quality of sensory and motor block, shorter time to perform the block, lower incidence of complication and patient discomfort, and more patient satisfaction.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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