

A Prospective, Randomized Comparison between Ultrasound versus Ultrasound with Nerve Stimulation Guidance for Multiple Injection Axillary Brachial Plexus Block

Mostafa Muhammed Sabra, Ali Fotouh Ali El Sayed, Abdalla Elsheikh and Sayed Ahmed Abd El Ali

Department of Anesthesiology and Intensive Care, Faculty of Medicine, Al-Azhar University, Egypt
icusayedgalal@gmail.com

Abstract: Background: The axillary brachial plexus block is one of the most commonly used regional anesthesia techniques. The axillary block is an excellent choice of anesthesia technique for elbow, forearm, and hand surgery. The axillary brachial plexus block is popular because of its ease, reliability, and safety. **Objective:** we sought to assess the efficacy, accuracy and liability of combined peripheral nerve stimulator with ultra-sonography guided peripheral nerve block versus ultrasound guided peripheral nerve block of upper limb using 0.5% bupivacaine with multiple injection technique and the impact of two methods in reducing the rate of conversion to general anesthesia. **Patient and methods:** this prospective randomized study was carried out on 30 ASA grade (I-II-III) adult patients classified into two groups (15 patients ultrasound US group and 15 patients ultrasound and nerve stimulator US&NS group), patients undergoing elective upper limb surgery, including forearm, wrist and hand procedures were prospectively enrolled. All blocks were performed with 20mm bupivacaine 0.5%. In US&NS group, the nerve location was performed with the aid of nerve stimulator using a 22-gauge, 5cm long, short beveled. The nerve stimulator was set with a pulse duration of 0.15ms, a current intensity of 1mA, a frequency of 2Hz. In US group, nerve location was performed using a linear probe, a 21-gauge, 10cm long, short beveled, was inserted and advanced along the longitudinal access of the ultrasound transducer. **Results:** showed that no statistically difference between the two groups as regard time of onset of sensory block, motor block, onset of analgesia, patient satisfaction, success rate, skin puncture, complications, supplementation of analgesia (fentanyl) and needle redirection. But this study showed that there is statistically significant difference as regard block execution time. **Conclusion:** this study demonstrates both US and US & NS techniques were effective in anesthesia of upper limb, patients are satisfied, no added benefits in using US & NS over US.

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Keywords: US ultrasound, NS nerve stimulator, Bupivacaine, Axillary block.

1. Introduction

The axillary block is an excellent choice of anesthesia technique for elbow, forearm, and hand surgery. The axillary brachial plexus block is popular because of its ease, reliability, and safety. Today, ultrasound (US) is one of the most widely used imaging technologies in medicine. It is portable, free of radiation risk, and relatively inexpensive when compared with other imaging modalities, such as magnetic resonance and computed tomography. Furthermore, US images are tomographic, i.e., offering a cross-sectional view of anatomical structures. The images can be acquired in—real time, thus providing instantaneous visual guidance for many interventional procedures including those for regional anesthesia and pain management. Modern medical US is performed primarily using a pulse-echo approach with a brightness- mode (B-mode) display (Fernando et al., 2011). The use of nerve stimulation became commonplace in clinical practice only in the mid- to late 1990s (Capdevila X, et al., 2004). Electrical nerve stimulation in regional anesthesia is a

method of using a low-intensity (up to 5 mA) and short-duration (0.05-1 ms) electrical stimulus (at 1-2 Hz repetition rate) to obtain a defined response (muscle twitch or sensation), to locate a peripheral nerve or nerve plexus with an (insulated) needle. The goal is to inject a certain amount of local anesthetic in close proximity to the nerve to block nerve conduction and provide a sensory and motor block for surgery and/or, eventually, analgesia for pain management. The use of nerve stimulation can also help to avoid an intraneural intrafascicular injection and, consequently, nerve injury (Chan et al., 2007). Nerve stimulation and ultrasound exhibit synergistic effects during most steps of PNB performance. Consequently, best practice may warrant combining the two modalities to truly improve important outcome parameters. It has been well described that one of the more challenging aspects of US is to maintain the needle position the same plane with the US beam when performing in-plane approaches (Adler, 2007). The fact that NS applies a three-dimensional search modality can alarm the operator of a needle approaching a nerve in cases

where the needle tip has left the two-dimensional plane provided by the US image. The same is applicable when performing out-of-plane techniques, a situation in which the operator is almost always uncertain as to whether the needle cross-section observed in the US image represents the needle tip. While US may have advantages for nerve localization purposes and in terms of needle guidance to the target, NS can be helpful in those cases where US visibility is poor due to technical or tissue related limitations and artifacts. The majority of nerves might be identifiable solely with US, especially once the structure in question is continuously scanned while following its course along an extremity in a distal direction. However, NS offers the option to quickly and definitively identify a nerve by providing a specific motor response. Finally, while US allows for observation of local anesthetic spread around the target structure, this modality can still result in inadequate intravascular local anesthetic application. NS can alarm the operator of inadequate local anesthetic delivery after as little as 1ml of the solution is injected and the motor response persists (failed Raj test) (Raj, 1980).

Ultrasound anatomy

The patient is made comfortable in supine position with the arm abducted and the elbow flexed to 90 degrees. After skin and probe preparation, a linear 38-mm, high frequency 10-12 MHz transducer is placed in the transverse plane at the lateral border of pectoralis major muscle to obtain the best view of the brachial plexus. Image quality is optimized with selection of appropriate depth (within 1-2 cm), focus range (within 1cm) and gain. The structures of interest are very superficial with the pulsating axillary artery localized within 1 cm. Easing the pressure on the transducer often reveals one or more axillary veins which is often located medially to the artery. Surrounding the axillary artery, one will find the three out of four terminal branches of the brachial plexus: 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. They often have honey comb appearance with heterogeneous echogenicity. The fourth terminal branch, the musculocutaneous nerve is often seen as a hyperechoic flattened oval shape nerve in the plane between the biceps and coracobrachialis muscles. There is a considerable variation in the position of the nerves among individuals. The median nerve is most commonly seen at 11-12 o'clock position, the ulnar nerve at 2-3 o'clock, the radial nerve at 4-6 o'clock and the musculocutaneous commonly seen at 8-9 o'clock in relation to the artery (Christophe et al, 2009). Moving the transducer proximally towards the

axilla and distally towards the elbow allows appreciation of the course of each nerve. Of all the nerve, the radial nerve is often difficult to visualize and block. It is important to exclude the post cystic enhancement artefact beneath the artery. Identification of the confluence of the tendons of the latissimus dorsi and teres major with ultrasound may improve the chance of visualizing the radial nerve. It lies directly anterior to the humeral insertions of the tendons, with anatomic variation of this relation quite uncommon (Gray, 2009).

Using PNS for PNB

The equipment needs to be checked prior to starting and set to the desired initial current (1-2mA), pulse duration (0.1ms) and frequency (2Hz). The needle is connected to the cathode of the machine and the anode is connected to the patient via an ECG electrode which is placed on the patient. The local anaesthetic syringe is connected to the flexible tubing of the needle and the needle and tubing is flushed with local anaesthetic solution. The point of needle insertion is determined by anatomical landmarks. It is important to make sure the circuit is complete as soon as the needle is inserted. The machine may have a flashing light or audible bleep or some other mechanism to indicate that the circuit is complete. The needle is then advanced until the desired motor twitch is obtained. The current is then reduced until no motor response is seen. The displayed current on the nerve stimulator is noted. A current between 0.2-0.5 mA is accepted as an ideal threshold current. Below 0.5 has been shown to give a high success rate. Below 0.2mA may mean that the needle tip is IN the nerve and should be withdrawn before injection. Once the nerve has been located satisfactorily, aspirate the syringe to ensure that the needle is not intravascular, then local anaesthetic can be injected in increments of 5mls without moving the needle tip. The motor twitch should disappear as soon as 0.5 ml to 1 ml of local anaesthetic is injected. This is thought to be either due mechanical displacement of the nerve from the needle (Raj test) or due to change in the electrical conductivity around the nerve. Failure of the twitch to disappear, pain on injection of solution or high injection pressures suggests intraneural placement of the needle tip and warrants small withdrawal of the needle tip (0.5 -1mm) (ATOTW, 2009).

2. Patient and methods

This prospective randomized study was carried out on 30ASA grade (I-II-III) adult patients classified into two groups (15 patients US group and 15 patients US&NS group), patients undergoing elective upper limb surgery, including forearm, wrist and hand procedures were prospectively enrolled. All blocks

were performed with 20mm bupivacaine 0.5%. In US&NS group, the nerve location was performed with the aid of nerve stimulator using a 22-gauge, 5cm long, short beveled. The nerve stimulator was set with a pulse duration of 0.15ms, a current intensity of 1mA, a frequency of 2Hz. In US group, nerve location was performed using a linear probe, a 21-gauge, 10cm long, short beveled, was inserted and advanced along the longitudinal access of the ultrasound transducer.

3. Results

The present study included 30 patients of ASA physical status I, II & III, randomly allocated into two groups; the first group had received axillary plexus block using ultrasound and the second group had received axillary plexus block using dual guidance of ultrasound and nerve stimulator. Ultrasound group=group 1, while dual guidance group (US&NS) = group 2.

Table (1): Distribution of the studied patients regarding their demographic data, site of surgery, block execution time, onset of motor and sensory blocks, onset of analgesia, success of block, patient satisfaction, number of skin punctures, complications, needle redirection and supplementation of analgesia (Mean \pm SD)

Groups		Group 1 (n=15)	Group 2 (n=15)	P value
Parameters				
Age (years)		37 \pm 4.47	40.27 \pm 4.83	0.065
Gender	Male	46.7%	53.3%	0.726
	Female	53.3%	46.7%	
Site of surgery	Ulna	26.7%	20%	0.702
	Fingers	33.3%	33.3%	
	Radius	25.7%	13.3%	
	Forearm	13.3%	13.3%	
	Wrist	0%	6.7%	
	Olecranon	0%	6.7%	
	Hand	0%	6.7%	
Block execution time (minute)		8.43 \pm 1.66	9.64 \pm 1.51	0.046*
Onset of sensory blockade (minute)		12.46 \pm 1.36	11.76 \pm 1.27	0.202
Onset of motor blockade (minute)		22.01 \pm 1.67	20.89 \pm 1.44	0.061
Onset of analgesia (minute)		6.22 \pm 0.86	6.34 \pm 1.44	0.797
Success of block	Complete	80%	93.3%	0.475
	Partial	6.7%	0%	
	Failed	13.3%	6.7%	
Patient satisfaction	Good	86.7%	93.3%	0.543
	Bad	13.3%	6.7%	
Number of skin punctures	Two punctures	73.3%	83.3%	0.142
	Three punctures	26.7%	6.7%	
Complications	Tachycardia (<100 bpm.)	13.3%	0%	0.189
	Hematoma	6.7%	0%	
	No complications	80%	100%	
Number of needle redirection	Once	73.3%	86.7%	0.361
	Twice	26.7%	13.3%	
Supplementation of analgesia (fentanyl, 50mcg iv.)		20%	6.7%	0.283

Significance < 0.05

4. Discussion

Surgeries of the hand, forearm and elbow are indications for axillary block which is performed at the level of the terminal nerves around the axillary vessels. The axillary plexus block provides consistent anesthesia of the axillary and musculocutaneous

nerves. The axillary plexus block is popular because of its ease, reliability and safety. This block is ideally suited for outpatients and is easily adapted to the pediatric populations. However, axillary block is unsuitable for surgical procedures on the upper arm or shoulder and the patient must be able to abduct the

arm to perform block. When using a PNS, a multiple injection technique increases success as compared with single injection technique (**Block, 2007**), while ultrasound can provide visual information regarding nerve and needle localization and spread of local anesthetic, NS allows the operator to gain information regarding nerve physiology and can reliably confirm structure identity. In addition, if US visibility is inadequate, NS may still be utilized to confirm needle position prior to injection as well as to avoid inadequate local anesthetic delivery (**Sandu, 2002**). The aim of dual guidance is to achieve optimal nerve location and injection pattern while avoiding peri-neural structures and untargeted nerves, maximizing success and minimizing complications (**Ralf et al., 2008**). The current study was designed to compare between the block execution time, onset of block, patient satisfaction, success rate, number of skin punctures, needle redirection, complications, intravascular placement and poster dose analgesia; the primary goal of this study is to pick up the best tool which help the anesthetist to do axillary block with better outcomes and less complications in short time and with minimal patient discomfort. The current study showed no statistically significant difference between the two groups of patient as regards age and gender. Also no statistically significant differences as regards different surgical sites (ulna, radius, finger, etc.). In this study, the block execution time was 8.43 ± 1.66 min for US group and 9.64 ± 1.51 min for dual guidance group as there is less significant differences between the two groups that supported by studies of **GU" RKAN et al. (2008)** and **Dingemans (2007)** in their studies concluded that dual guidance consume more time than US alone. This study disagrees with **Satuer and colleagues (2008)** who had found similar time of both groups of study. Increased procedure time in group (US&NS) reflect the extra technical effort require to obtain adequate neurostimulation. In addition, despite US group, adequate neurostimulation is occasionally difficult to obtain when appropriate neurostimulation was achieved, the stimulating needle was kept immobile during local anesthetic injection which is another challenge for early practitioners. As regards onset of the block, the study found that no statistical differences between the two groups but disagree with the study of **Satuer et al. (2008)** that found significant difference between the US group and (US&NS) group and agree with the study of **Dingemans et al. (2007)**. As regards success of block, no statistically difference between US group (80% complete, 6.7% partial, 13.3% failed) and (US&NS) group (93.3% complete, 0% partial, 6.7% failed) and this agree with **Gunkan et al. (2010)** (block success rate was 94.5% in both

groups). But disagree with **Satuer et al. (2008)**, compared US and (US&NS) concluded that dual guidance does not improve the success rate 85% (US&NS) and 95% in US alone and **Dingemans et al. (2007)** 92% US vs. 74% (US&NS). In this study failed block was in US group and can be explained also by operator experience. Patient satisfaction was assessed using a two-point scale: 1= good: if ever operated on again in the future, I want the same anesthetic procedure; 2= bad, in this study (86.7% were good and 13.3% were bad) in US group and (93.3% were good while 6.7% were bad) in (US&NS) group and no statistical difference, there is less needle paths less current as it is less than 0.9 mA with less muscle contraction. As regards the number of skin punctures and needle redirections, no statistical difference between the two groups, the patient was punctured more in US group and needle was redirected during placement mostly due to lack of experience. Regarding complications, no statistical significant difference between the two groups and no recorded complications except for three patients in US group (tachycardia for two and hematoma for one in normal coagulation profile) and no cases recorded in (US&NS) group. Heart rate, perhaps the most commonly measured vital sign in clinical practice, is a key determinant of myocardial metabolism and cardiac output. Tachycardia, conventionally defined as an atrial and/or ventricular rate of >100 beats per minute (bpm) has an arbitrary and debated definition. Nevertheless, tachycardia can be of importance, since it can cause myocardial ischemia, hypotension, low cardiac output, peripheral hypoperfusion, severe symptoms (chest pain, weakness, syncope, lightheadedness), cardiomyopathy, cardiac arrest and death (**Gopinathannair R. et al, 2008**). and tachycardia during the operation was managed by sedation (midazolam 0.03mg/kg). And finally, regarding poster dose analgesia (fentanyl), no statistical difference between the two groups as in US group, 20% only needed 100 mcg fentanyl and 6.7% of (US&NS) group needed also.

Summary

The axillary brachial plexus block (ABPB) provides surgical anaesthesia at and below the elbow. The technique is relatively simple to perform because of superficial location and relatively lower risk of complications as compared to interscalene (e.g., phrenic nerve block, spinal cord or vertebral artery puncture) or supraclavicular (e.g., pneumothorax) approaches. Inadvertent intraneural and intravascular injections are the only significant risks. Various methods of ABPB have been described such as paraesthesia-seeking, nerve-stimulating, perivascular,

trans-arterial and ultrasound-guided techniques (**Anil et al, 2014**). There is several positive significant impact of the USGRA technique including reduction in block-related complications, decreasing the incidence of systemic local anesthetic toxicity, increasing patient satisfaction during anesthesia due to the relatively painless procedure, especially when compared to other techniques. (**Jeng et al., 2010**). Dual guidance refers to the use of the two modalities, peripheral NS and US guidance, in combination to act synergistically. The aim of dual guidance is to achieve optimal nerve location and injection pattern while avoiding perineural structures and untargeted nerves, maximizing success and minimizing complications(**Bloc et al, 2007**). The present study included 30 patients of ASA physical status I, II and III, randomly allocated into 2 groups; the 1st group had received axillary plexus block using ultrasound, the 2nd group had received the block using dual guidance of ultrasound with the nerve stimulation. The demographic data of patients as regard age, gender and ASA class showed no statistically significant changes between the two groups of patients and there was no statistically significant difference between different groups as regard site of operation. Regarding the block performance time there is significant difference between the two groups. As regards onset of the block, the study found that no statistical differences between the two groups. As regards success of block, no statistically difference between US group (80% complete, 6.7% partial, 13.3% failed) and (US&NS) group (93.3% complete, 0% partial, 6.7% failed). In this study, no statistical difference between the two groups regarding patient satisfaction. As regards the number of skin punctures and needle redirections, no statistical difference between the two groups, the patient was punctured more in US group and needle was redirected during placement mostly due to lack of experience. Regarding complications, no statistical significant difference between the two groups and no recorded complications except for three patients in US group (tachycardia for two and hematoma for one in normal coagulation profile) and no cases recorded in (US&NS) group.

Conclusion

Axillary brachial plexus block is effective and widely used technique for providing surgical anesthesia at and below the elbow. It is relatively simple and safe among the four approaches to brachial plexus. With the advent of ultrasound technology, there is a marked improvement in the success rate, shorter onset time and reduction in the volume required for successful block. Paramount

importance should be given to continuous visualisation of the needle advancement, tip position and spread of injectate in order to minimise intravascular and intraneural injection and no significant difference between the use of dual guidance over the use of US.

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Weblinks

<http://totw.anaesthesiologists.org/2009/05/18/peripheral-nerve-blocks-getting-started-134/>

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