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DIFFERENT EFFECTIVE VOLUMES OF LOCAL ANESTHETICS IN AXILLARY NERVE BLOCK: A COMPARATIVE RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: Ultrasound-guided together with the use of nerve stimulator in peripheral nerve block for correct needle placement and local anesthetic spread monitoring around the nerves helped to reduce the volume of local anesthetic (LA) required and achieve high success rate.

Objective: Determination of an effective volume of 2% xylocaine with epinephrine (1: 200,000) for ultrasound and nerve stimulator guided axillary brachial plexus block (ABPB).

Patients and Methods: Sixty patients who had plastic distal forearm and hand surgeries underwent a single-shot axillary brachial plexus block were enrolled in a prospective randomized clinical trial. Patients were randomly divided into three equal groups, according to the proposed injection volume of study medication LA; 2% xylocaine with epinephrine 1: 200,000 concentrations per nerve. Group I (received 5ml of study medication), group II (received 3 ml of study medication) and group III (received 1.5 ml of study medication).

Results: Sixty patients were blindly randomized into 3 groups, four patients did not complete the study and 56 patients were included in the analysis. The mean sensory and motor block duration respectively were 278.8 & 208.6±35.4 minutes in group I, 221&168.6±23.5 minutes in group II and 165.4&138.8±18 minutes in group III respectively with highly statistical significance between group III and both groups I and II. Statistical analysis did not show any significantly difference regarding sensory and motor onset block duration between and among the three groups. No adverse effects were reported during and after the block in all groups.

Conclusion: The current study showed highly statistically significance as regarding the total sensory & motor block durations when used volumes 5ml and 3ml VS 1.5ml per nerve of LA; 2% xylocaine with epinephrine 1: 200,000 in ABPB. Also, the present study showed that there was a higher success rate without statistical difference regarding the sensory and motor onset time in these different volumes of local anesthetics together without reported adverse effects when combination of ultrasound-guided and nerve stimulator used in axillary brachial plexus nerve block.

Key words: Ultrasound, nerve stimulator, axillary plexus block, effective volume, local anesthetics.

INTRODUCTION

Axillary brachial plexus block (ABPB) is one of the most popular and widely used techniques for brachial plexus blocks *(Nowakowski et al., 2013)* and the most commonly used techniques to achieve upper limb regional anesthesia and it is performed by blocking the terminal branches of the brachial plexus, which include the musculocutaneous, ulnar,

median, and radial nerves. It was believed that the failures or incomplete blockade due to this technique were the result of needle malposition or brachial plexus septa in the axillary region *(Ferraro et al., 2014).* Compared to general anesthesia technique, it has a superior recovery profile and allows early discharge *(Klein et al., 2005).*

ABPB approach is very universal and safe, and it allows analgesia for the distal arm, elbow, forearm and hand. Numerous upper limb procedures, in particular orthopedic ones, could be carried out under axillary block *(Nowakowski and Bierylo, 2015).* Its failures are typically attributed to improper needle placement or septation of the brachial plexus sheath in axillary region *(Nowakowski et al., 2013).* Traditional high-volume regional blocks such as the axillary brachial plexus block have relied on volumes of injectate of up to 40 ml to achieve surgical anesthesia. Much of this volume may diffuse into surrounding soft tissues or undergo vascular uptake and therefore did not contribute to anesthesia *(Harper et al., 2010).*

Using ultrasound guidance (US) has been used to guide catheter placement and needle insertion in only radiology area, but now it is used commonly in nerve block for regional anesthesia by anesthesiologists. Ultrasound helps identification of the target tissue, nerve, vessel and other structures so that needle placement can be made accurately and safely *(DUGER et al., 2013).* It provides good assessment of local anesthetic (LA) spread around the nerves, with the possibility of repositioning the needle in case of maldistribution, allowing for a reduction in LA dose without compromising the quality of PNB *(Marhofer et al., 2007).* Some publications indeed illustrate that the volume of LA can be significantly reduced when particular regional anesthetic techniques are performed with ultrasound guidance *(Casati et al., 2007 and O'Donnell & Ioham, 2009).*

Also, nerve stimulation (NS) is an indirect technique of nerve identification, still one of the most popular techniques for peripheral nerve blocks and the success rate is 91% to 98%, depending on the trials *(Abrahms et al., 2009 and Marhofer & Chan, 2007).*

Although the incidence of systemic toxicity is less than 0.2% which is the major complication of regional anesthesia, the use of large amounts of local anesthetic increases the chance of systemic toxicity, that is difficult to treat and potentially fatal *(Mather et al., 2005).*

The volume and concentration of local anesthetics injected near a nerve is a factor determining the rate of successful nerve block *(Mather et al.,2005 and Casati et al., 2007).* Decreasing local anesthetic volumes and/or concentration for peripheral nerve blocks is a relevant solution to decrease the hospital stay time, improves the outcome and reduces the hospital service coast. Hence many of studies carried out to prove that consideration and this study came to give support for that newly rising concept.

The aim of this study was to evaluate and compare the effectiveness of different volumes of LA in ABPB by using US & NS to produce effective motor block and

sensory analgesia in patients scheduled for distal forearm and hand plastic surgeries.

PATIENTS AND METHODS

After ethical committee approval and written informed consent, sixty patients of physical status ASA (American Society of Anesthesiologists) I, II & III, aged 18 to 50 years old, scheduled for distal forearm and hand plastic surgeries were recruited for single shot axillary brachial plexus block (ABPB) using local anesthetic (LA); xylocaine 2% with epinephrine 1: 200,000.

Patients were randomized using a computer-generated randomization sequence using sealed, opaque envelopes to 3 groups (20 patients each) according to the proposed injection volume of LA; GI (5ml), GII (3ml), GIII (1.5ml) per nerve. Exclusion criteria include patients who did not cooperate and those who had psychological disorders or language barriers that might interfere with blockade assessment were excluded. Medical exclusion criteria were coagulopathies, known allergy to the study medications, infection at the puncture site, a body mass index 19 or 39 kg/m^2, known neuropathies, advanced cardiovascular diseases and advanced diabetes disease.

Study medication was prepared by an anesthesia technician not involved in the study in four separate 5 cc syringes and were disclosed to the anesthesiologist performing the block procedure.

After establishing intravenous access, connection to simple face mask oxygen 4-6 liters/minute, ASA routine monitoring; ECG, non-invasive blood pressure (NIBP) and peripheral oxygen saturation (SpO_2), single shot ABPB was performed under ultrasound guidance and nerve stimulator. Using a short axis, in-plane technique for ultrasound machine. All blocks were performed under aseptic conditions using chlorhexidine skin preparation, sterile ultrasound probe covers and by experienced anesthesiologists with the assistance of an anesthesia technician.

The patient was placed in the supine position with the head facing away from the arm to be blocked, the arm abducted and the elbow flexed in 90°. A 50-mm 22-gauge insulated short bevel needle (Sonoplex®; Pajunk, USA) connected to a nerve stimulator (Stimuplex® HNS 12; B. Braun, Germany) set to deliver electric current 0.2 to 0.5 mA, at 0.1 mS, in order to facilitate identification of the individual nerves, after localization of the desired nerve was performed using an ultrasound machine (Philips Healthcare®, Sqarq Release 1.0.1, USA). After analysis of different anatomical elements used the linear probe, it was positioned perpendicularly to the skin to obtain a cross-section of the humeral canal and the median, radial and ulnar were identified using ultrasound and the tip of the needle was brought in proximity of each individual nerve subsequently.

The needle was inserted at the lateral end of the probe to keep it in the plane of the sonogram. The needle bevel and shaft were viewed throughout the approach to the selected nerve. The predefined local anesthetic volume was injected after negative aspiration test which repeated between each bolus of 1/3 of desired volume. The injection was slow and at low pressure by an anesthesia technician. The absence of intra neural injection was avoided by adjusted lower electrical

current stimulation not below than 0.2 mA and ultrasound-guidance. After a unique needle puncture, needle repositioning was allowed to optimize the distribution of local anesthetic around each nerve. A circumferential spread was required without exceeding the defined volume. Each patient had two skin puncture after local infiltration with xylocaine 1%, one for median, redial and ulnar nerves blockade.

The other skin puncture done for musculocutaneous nerve blockade outside the axilla within its course with coracobrachialis muscle. All blocks done under ultrasound and nerve stimulator guidance to approach the nerves individually. Adverse events (i.e., paresthesia, pain during injection, intravascular injection, and cardiovascular and neurologic events) were noted during the procedure and extended until the end of the sensory block. The Blockade considered to be successful if the patient did not require supplemented intervention. If the block was ineffective (incomplete block), the surgeon performed local or a rescue wrist infiltration with 5 mL of 2% xylocaine without adrenaline and in complete block failure, the patient was received general anesthesia. The sensory and motor blockade onset times were tested periodically every 5 minutes, *(O'Donnell BD and Iohom G,2009)* till the surgical anesthesia achieved or up to 25 minutes by a blinded observer (attending surgeon). The sensory block was assessed by the patient's ability to differentiate cold sensation by ice and to discriminate a light touch in the center of the skin area innervated by each nerve. A successful blockade was considered when there was motor function ≤2 according to the modified Bromage scale.

A variety of surgical procedures included in the study e.g. cut wrist wound exploration and repair, k-wire of metacarpal bones fractures, individualized cut tendons repair and open reduction internal fixations of hand bones fractures that necessitated Tourniquet application at the blocked arm.

By the end of surgery, the patients were transferred to the post anesthesia care unit (PACU) and monitored by ECG, NIBP and SpO_2 till patient mete PACU discharge criteria. Postoperative block duration and analgesia was assessed in the PACU using a visual analog scale at 0min., 30mins., 60 mins. and continued assessment in the ward at 120mins, 180mins, 240mins. Sensory blockade time duration considered when patient had complete sensory loss (onset of sensory blockade) at all nerve examined fields till the time when patient called for analgesia. Also the motor blockade time duration determined when patient obtained failure of movement at fingers, wrist and elbow joints (onset of motor blockade) till patient regained partial power to do these movements.

STATSTICAL ANALYSIS: The findings of the groups were statistically compared using SPSS version 20 (SPSS Inc., Chicago, IL). Data were expressed as mean±SD, number and percentage. Nominal non-parametric data were analyzed using Chi-Square test (cross-tabs) and Pos-hoc test. Parametric data between the study groups were compared using One-Way ANOVA test. P-values < 0.05 were considered statistically significant.

RESULTS

Between November 2014 - September 2015, sixty patients were randomized and 56 patients completed the study. Only 4 patients (1 in GII, 1 in GII & 2 in GIII), block was labelled as failed because of inadequate block and needed supplemented rescue interventions. Overall the block procedures done without noted adverse events.

Patients demographics and baseline clinical characteristics showed that there was no statistically significant difference between and among the three groups in relation to age, weight, height, gender, ASA and the types of surgical procedures performed (Table 1). There was a prevalence of male patients in all groups as most of the study patients are labors and the injuries are occupation-related. Only 4 female patients enrolled in the study due to kitchen-related hand injuries.

Table (1): Demographic data of patients (mean ±SD)**.**

Groups / **Data**	GI(5ml)		GII(3ml)		GIII(1.5ml)		P-value
Age, years	33.8±8.2		30.6±6.5		32±5.5		0.356
Gender, M: F	18:1		17:2		17:1		NS
Weight, kg	68.5±11		71±12		73.±5		0.26
Height, cm	168±5.4		167±3.2		166±6		0.52
ASA Grade	n	%	n	%	n	%	
Grade I	9	45%	13	65%	11	55%	0.38
Grade II	9	45%	5	25%	7	35%	
Grade III	1	5	1	5%	0	0%	

ASA = American Society of Anesthesiologists; M = male; F = female, n = number of patients,
% = percentage. GI:5ml volume of the study medication, GII:3ml volume of the study medication, GIII:1.5ml volume of the study medication.

A complete sensory block five minutes after block placement, was confirmed only in one patient in Group I and other one in Group III. All patients included in the study groups achieved both sensory and motor block within twenty minutes after the block without statistical significance. The mean time for onset of sensory block in group I was 13.5±4.3 min, group II was 14±2.2 min and group III was 14.5±3.2 min, and the mean time for onset of motor block in group I was 14.7±3.4 min, group II was 15±3.6 min and group III was 16.2±3.6 min that didn't show significant statistical differences between and among the study groups (Table 2).

The mean duration of sensory block in group I was 278.8±60 min, group II was 221±44.8 min and group III was 165.4±32 min, showed statistical significance between Group I versus Group III, also between Group II versus Group III with highly significant P-value (P <0.001), as

shorter sensory block duration in Group III, with no significance statistical difference between Group I and Group II (P >0.05). Also, the mean duration of motor block in group I was 208.6±35.4 min, group II was 168.6±23.5 min and group III was 138.8±18 min that demonstrated significant statistical difference with highly significant P- value (p = 0.005) in total motor block duration time between groups I versus group III, groups II versus group III and non-significant statistical difference between group I versus group II (P >0.05 - Table 2).

None of the studied patients showed adverse events during the block procedure and all the patients enrolled in the study didn't express any sign of nerve damage when screened for postoperative nerve damage in the first clinic visit, one week after surgery.

Table (2): Block characteristics (mean ±SD).

Groups / Variable	GI(5ml)		GII(3ml)		GIII(1.5ml)		P-value
	n	%	n	%	n	%	
Onset of the sensory block, min.							
At; 5 min	1	5%	0	0%	1	5%	0.6
10 min	2	10%	3	15%	2	10%	0.85
15 min	15	75%	15	75%	13	76%	0.73
20 min	1	5%	1	5%	2	10%	0.77
Sensory onset time (mean), min.	13.5±4.3		14±2.2		14.5±3.2		0.65
Onset of the motor block, min.	n	%	n	%	n	%	
At; 5 min	0	0%	0	0%	0	0%	1
10 min	1	5%	1	5%	1	5%	1
15 min	13	65%	12	60%	11	55%	0.8
20 min	5	25%	6	30%	6	30%	0.92
Motor onset time (mean), min.	14.7±3.4		15±3.6		16.2±3.6		0.39
Block success rate, %	(n)19	95%	(n)19	95%	(n)18	90%	0.77
Duration of the sensory block, min.	278.8±60		221±44.8		165.4±32*		<0.001
Duration of the motor block, min.	208.6±35.4		168.6±23.5		138.8±18*		0.005
Tourniquet duration, min.	52.0±15.7		47.5±21.2		54.2±18		0.6
Total surgical duration, min.	64.4±17		59±23.7		67.2±18.5		0.39

min = minutes, n = number of patients, % = percentage.

★ means p-value < 0.05. GI:5ml volume of the study medication,

GII:3ml volume of the study medication, GIII:1.5ml volume of the study medication.

DISCUSSION

Occupational hand injuries encountered the most common leading cause of plastic hand surgeries in developing countries and considered as an emergency situation that needs rapid interference to save neurovascular and musculoskeletal structures of the hand. A large scale of patients need proper pain control and quick discharge from the hospital which cannot be achieved by the used standard multimodal analgesia regimens.

Axillary brachial plexus block is considered to be a regional anesthesia technique of a choice to provide intraoperative anesthesia, postoperative analgesia, subsequently early ambulation and quick hospital discharge. The use of ultrasonography (US) enables all steps of a regional block to be controlled, such as determination of the anatomical structure of the anaesthetized region via real time control, operational correction of the needle position and verification of the injection site and pathway of local anesthetic agent dispersion *(Nowakowski et al., 2013).*

In this prospective, randomized study, comparison between three different local anesthetic volumes of same concentration of lidocaine 2% with epinephrine 1: 200,000 had done in US&NS-ABPB. There were no significant differences in patients' characteristics among and between the three groups. The hypothesis of This study was that the utility of combination of ultrasound & nerve stimulator guidance in upper limb distal forearm and hand plastic surgery resulted in reduction of injected local anesthetic volume without negative impact on the onset of sensory and motor time, success rate and the quality of the block. In the present study, we found that there were no differences regarding the onset of both sensory and motor block among and between the three groups. These findings are in line with the findings of McNaught et al. *(2010)* who Provided data supported that, the use of ultrasound in regional nerve block had reduced the number of attempts, local anesthetic volume and postoperative pain.

Also, the onset time and quality of the blocks depend on the nerve itself and approach technique *(Taboada et al.,2008).* This study showed the advantages of using ultrasound guidance together with peripheral nerve stimulator to improve the block technique and subsequently achieving highly successful a single shot axillary brachial plexus block with less volumes of local anesthetic in plastic distal forearm and hand surgeries as shorter duration of sensory and motor block duration showed in group III (1.5 ml/nerve) didn't affect negatively on the onset and quality of the block.

This study demonstrated that the onset of sensory and motor block did not differ significantly between and among the study groups, which was proved by the study done by Latzke and his Colleges *(2009)* as in their study there was no effect on sensory onset time 20 volunteers enrolled and scheduled for sciatic nerve block with ultrasound guidance used local anesthetic volume of 0.10 mL/mm cross-sectional nerve area.

This current study results agreed with the conclusion came from the study done by O'Donnell and Iohom, *(2009)* by minimizing the volume of injected local anesthetics and achieved block success

with LA volume of 1 ml per nerve of 2% lidocaine with epinephrine 1: 200,000, but their study design didn't consist of large scale of patient groups for compression which were in the current presented study, that showed large number of patients in different groups with different LA volumes, that allowed for more precise results and higher success rate.

Regarding the duration of the sensory and motor block, this study showed shorter duration in group III (1.5 ml) as compared with the other study groups I (5 ml) and II (3 ml) with highly statistically significate value, which came in line with the study done by Fenten et al., *(2015)* and showed that a higher dose and concentration administration resulted in a longer duration of sensory and motor block.

In the later study, *Fenten et al., (2015)* they compared the groups with equal concentrations, there was no difference found in block duration, despite the difference in dose and volume, suggesting a role for concentration and not for dose in determining block duration. When compared the groups with equal dose, there is a tendency for a longer duration for sensory and motor block in the group with higher concentration and smaller volume, which met the current presented study.

Also, the current study came with the agreement of the study done by De Morais et al. *(2012)* that concluded the use of 5 mL of 1% ropivacaine promoted analgesic efficacy similar to 10 mL or 20 mL of 0.5% ropivacaine in the posterior brachial plexus block using neuro-stimulator and without the help of ultrasonography.

On the other hand, Ponrouch et al., (*2010)* demonstrated the ultrasound guided median and ulnar nerve block, selectively provided a 50% reduction in the MEAV of mepivacaine 1.5% for median nerve sensory blockade in comparison with neurostimulation and decreased the local anesthetic volume which decreased sensory block duration but not onset time, which met the results proved by the current study.

CONCLUSION

The effectiveness between different three effective volumes of LA; 2% xylocaine with epinephrine 1: 200,000 LA in single shot axillary brachial plexus block in upper limb distal forearm and hand surgeries did not affect the onset time of sensory and motor block but negatively decreased the total sensory duration as the LA volume decreased.

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كميات مختلفة فعالة من التخدير الموضعي في إحصار العصب الإبطي: دراسة مقارنة ومُوجَّهة باستخدام عينات عشوائية

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خلفية البحث: استخدام الموجات فوق الصوتية والمحفز الكهربائي للأعصاب في إحصار "تخدير" العصب الطرفي من أجل إيجاد المكان الصحيح لوضع الإبرة ومتابعة انتشار المخدر الموضعي حول الأعصاب يساعد في تقليص كمية المخدر الموضعي اللازمة لتحقيق معدل عالٍ من النجاح.

الهدف من البحث: تحديد فعالية كمية من المخدر الموضعي (تركيز ٢٪ من عقار الزيلوكائين مع الإبينيفرين "الأدرينالين" بنسبة ١: ٢٠٠٠٠٠) لإحصار العصب الإبطي في الكتلة "الضفيرة" العضدية باستخدام الموجات فوق الصوتية والمحفز الكهربائي للأعصاب.

المرضى وطرق البحث: شملت الدراسة ستين مريضاً أجريت لهم جراحات تجميلية في الجزء الأعلى من الساعد واليد، أعطيت لهم حقنة واحدة لإحصار الضفيرة العضدية في دراسة سريرية استطلاعية عشوائية. وقد تم تقسيم المرضى بطريقة عشوائية إلى ثلاث مجموعات متساوية وذلك حسب كمية المخدر الموضعي (تركيز ٢٪ من عقار الزيلوكائين مع الإبينيفرين "الأدرينالين" بنسبة ١: ٢٠٠٠٠٠ لكل عصب). وفي المجموعة الأولي إستخدم حجم ٥ مل ليتر من المخدر الموضعي موضوع الدراسة، أما المجموعة الثانية فقد إستخدم فيها كمية مقدارها ٣ مل ليتر، في حين إستخدم 1,5 مل ليتر من المخدر الموضعي في المجموعة الثالثة.

النتائج: تم تقسيم المرضى عينة الدراسة بطريقة عشوائية إلى 3 مجموعات، ولم يكمل أربعة مرضى الدراسة؛ وبذلك شمل التحليل ٥٦ مريضاً. وبلغ متوسط فترة الإحساس والإحصار الحركي على التوالي 8,278 و208,6 ± 35,4 دقيقة في المجموعة الأولى، و١٢٢ و168,6 ± 23,5 دقيقة في المجموعة الثانية، و165,4 و138,8 ± ١٨ دقيقة في المجموعة الثالثة مع وجود دلالة إحصائية كبيرة بين المجموعة الثالثة وكلتا المجموعتين الأولى والثانية. ولم يظهر التحليل الإحصائي أي فرق ذي دلالة إحصائية فيما يتعلق بفترة الإحساس وبداية الإحصار الحركي فيما بين المجموعات الثلاثة.

الخلاصة: أظهرت هذه الدراسة أن هناك دلالة إحصائية كبيرة فيما يتعلق بإجمالي فترات الإحساس والإحصار الحركي عند استخدام كميات ٥ مل ليتر و٣ مل ليتر و1,5 مل ليتر من المخدر الموضعي لكل عصب؛ و٢% من الزيلوكائين مع الإبينيفرين ١: ٢٠٠٠٠٠ في إحصار الضفيرة العضدية الإبطية. كما أظهرت الدراسة كذلك معدل نجاح أعلى دون فرق إحصائي فيما يتعلق بوقت بداية الإحساس والإحصار الحركي عند إستخدام هذه الكميات المختلفة من المخدر الموضعي معاً دون الإبلاغ عن آثار عكسية عند الجمع بين إستخدام الموجات فوق الصوتية الموجهة والمحفز الكهربائي للأعصاب قي إحصار عصب الضفيرة العضدية الإبطية.