Clinical Investigation

Comparison of peripheral nerve stimulator versus ultrasonography guided axillary block using multiple injection technique

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ABSTRACT

Background: The established methods of nerve location were based on either proper motor response on nerve stimulation (NS) or ultrasound guidance. In this prospective, randomised, observer-blinded study, we compared ultrasound guidance with NS for axillary brachial plexus block using 0.5% bupivacaine with the multiple injection techniques. **Methods**: A total of 120 patients receiving axillary brachial plexus block with 0.5% bupivacaine, using a multiple injection technique, were randomly allocated to receive either NS (group NS, n = 60), or ultrasound guidance (group US, n = 60) for nerve location. A blinded observer recorded the onset of sensory and motor blocks, skin punctures, needle redirections, procedure-related pain and patient satisfaction. **Results:** The median (range) number of skin punctures were 2 (2–4) in group US and 3 (2–5) in group NS ($P < 0.001$). No differences were observed in the onset of sensory block in group NS (6.17 ± 1.22 min) and in group US (6.33 ± 0.48 min) ($P = 0.16$), and in onset of motor block (23.33 ± 1.26 min) in group US and (23.17 ± 1.79 min) in group NS; $P > =0.27$). Insufficient block was observed in three patient (5%) of group US and four patients (6.67%) of group NS ($P > =0.35$). Patient acceptance was similarly good in the two groups. **Conclusion:** Multiple injection axillary blocks with ultrasound guidance provided similar success rates and comparable incidence of complications as compared with NS guidance with 20 ml 0.5% bupivacaine.

Key words: Axillary block, multiple injection techniques, peripheral nerve stimulator

INTRODUCTION

Axillary brachial plexus anaesthesia is widely used for upper extremity surgery. Nerve stimulation (NS) was considered the gold standard technique for nerve location, and the multiple injection technique with NS has been demonstrated to provide more effective anaesthesia than either double or single injection for axillary brachial plexus block.[1,2] Ultrasound imaging techniques however enable the anaesthesiologist to secure an accurate needle position and monitor the distribution of the local anaesthetic in real time, with the advantage of improving the quality of nerve block, shortening the latency of the block, and reducing the minimum volume required to obtain a successful nerve block.[3-6] Evaluating ultrasound guidance for interscalene and axillary brachial plexus blocks, it is reported that using ultrasonography (USG) significantly improved the onset and completeness of sensory and motor blocks as compared with an immobile needle single injection technique with NS.[7] Significant improvement is seen in the overall success rate of axillary block with ultrasound guidance as compared with a transarterial technique.[8] However, no studies have compared nerve block performance with ultrasound guidance or NS when the most effective technique for nerve blockade is used; the multiple injection techniques using 0.5% bupivacaine.[1,9]

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Therefore, we conducted this prospective, randomized, observer-blinded study to test the hypothesis that ultrasound guidance can shorten the onset of axillary brachial plexus block using 0.5% bupivacaine as compared with NS guidance for nerve location when using a multiple injection technique.

Our objective was to assess the efficacy, accuracy and reliability of peripheral nerve stimulator guided peripheral nerve block versus USG guided peripheral nerve block of upper limb using 0.5% bupivacaine with multiple injection technique and the impact of the two methods in reducing the rate of conversion to general anaesthesia.

METHODS

The study was carried out in 2010–2011 over a period of 18 months. The clearance from Institutional Ethical Committee of the institute was taken for this prospective randomized study. After obtaining written informed consent, ASA physical status I patients undergoing elective upper limb surgeries were prospectively enrolled. Patients with clinically significant coagulopathy, infection at the injection site, history of allergy to local anaesthetics, severe cardiopulmonary disease, body mass index >35 kg/m^2, diabetes mellitus, or known neuropathies, as well as patients receiving opioid for chronic analgesia were excluded.

In the operating room, after premedication (midazolam 0.03 mg/kg intravenous), standard monitoring was used throughout the procedure, including non-invasive arterial blood pressure, heart rate, and pulse oximetry. Patients were randomly allocated to either NS group (*n* - 60) or ultrasound (US) group (*n* - 60) using a computer generated sequence of random numbers. All blocks were placed by one of the same two investigators, who had substantial expertise in regional anaesthesia techniques. The patients were placed in the supine position with the arm abducted to approximately 90° with the hand resting on a pillow next to the head [Figure 1]; all blocks were performed with 20 ml bupivacaine, 0.5%. In NS group, nerve location was performed with a nerve stimulator (Plexygon®; Vygon, Italy) using a 22-gauge, 5-cm-long, short-bevelled, Teflon-coated needle (Locoplex®; Vygon, UK). The nerve stimulator was set with a pulse duration of 0.15 ms, the current intensity of 1 mA, and a frequency of 2 Hz. All four main branches of the brachial plexus (ulnar, radial, median and musculocutaneous nerves) were located according to the specific twitches elicited by their stimulation: Musculocutaneous nerve: Arm flexion; radial nerve: Arm and finger extension, supination; median nerve: Wrist, second and third finger flexion, pronation; ulnar nerve: Fourth and fifth finger flexion, thumb adduction. After the proper twitch was elicited, the stimulating intensity was progressively reduced to <0.5 mA maintaining the proper twitch; then, 1 ml local anaesthetic was injected. After this injection stopped the twitch, the location was considered adequate, and the remaining 4 ml was injected. Then, the needle was redirected looking for the other respective twitches [Figure 1]. In group US, nerve location was performed using a 5-cm, 10-MHz linear probe (LOGIQ Book XP®; GE Healthcare, Milan, Italy) by the radiologist. After examination of the anatomy of the neurovascular bundle, a 21-gauge, 5-cm-long, short-bevelled, Teflon-coated needle (Locoplex; Vygon, UK) was inserted either in-plane or out-of-plane relative to the probe and both needle shaft and tip could be visualized. NS was not used. Based on the anatomy, the needle insertion was performed from the lateral or medial aspects of the arm to make the access to the target nerves easier in each individual case. Then, the ulnar, radial, median, and musculocutaneous nerves were blocked separately with 5 ml local anaesthetic for each nerve. The proper spread of the local anaesthetic around the considered nerves was continuously evaluated under sonographic vision, and needle tip position was continuously adjusted with minimum movements during injection under sonographic vision to optimize the impregnation of nerve structures [Figures 1-2]. We performed infiltration of 3 ml of local anaesthetic subcutaneously on the medial border of the axilla to block the intercostobrachial nerve in both the groups.

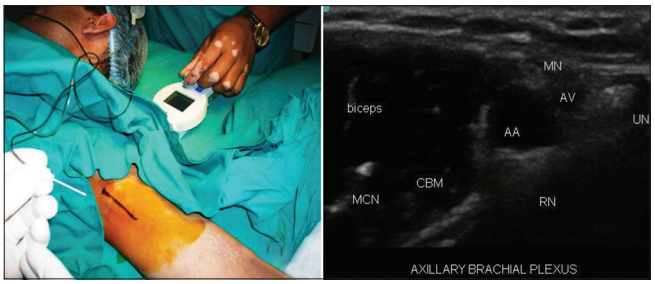

Figure 1: Axillary block and the anatomical localisation of nerves around axillary artery. AA – Axillary artery; AV – Axillary vein; MN – Median nerve; UN – Ulnar nerve; RN – Radial nerve; CBM – Coracobrachialis; MCN – Musculocutaneous nerve

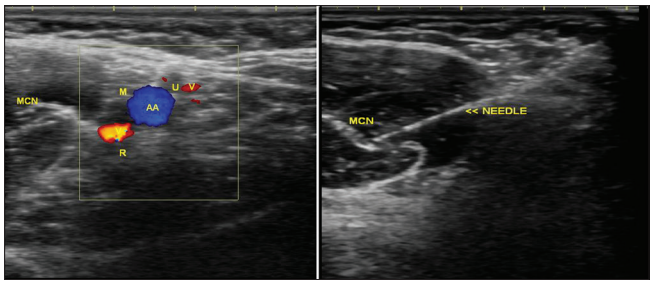

Figure 2: Colour Doppler with visualisation of axillary artery, vein and the location of nerves around the vessel. Also visualised is musculocutaneous nerve in the plane between biceps and coracobrachialis muscle. AA – -Axillary artery;, AV – -Axillary vein;, M-Median nerve; U – -Ulnar nerve; R-Radial nerve; MCN – -Musculocutaneous nerve

Number of skin punctures, needle redirections and occurrence of intravascular needle placements were noted by the investigator who performed the block. The initial needle insertion counted as first 'skin puncture'. After location of nerve and injection of local anaesthetic another nerve was located by adjustment of the needle. Any subsequent forward movements of the needle that were preceded by retractions of the needle of at least 10 mm were counted as needle redirections.

A blinded observer who was unaware of the type of block technique, recorded the onset of sensory and motor blocks every 1 min. Sensory block was assessed as loss of pinprick sensation in the central sensory region of each nerve with the same stimulus delivered to the contralateral 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 as compared with contralateral arm - partial block; incapacity to overcome gravity - complete motor block. The 0 time for the onset of sensory and motor blocks was the completion of local anaesthetic injection. Time to readiness for surgery (complete sensory block and complete motor block in at least three of the four nerves, with partial motor block in the fourth remaining nerve) was recorded. In case of pain, supplementary analgesia with 1 mcg/kg boluses of intravenous fentanyl was given. The need for more than 100 mcg fentanyl to complete surgery was considered as an insufficient block. If fentanyl supplementation (maximum dose 200 mcg) was not sufficient for surgery, general anaesthesia was administered with placement of laryngeal mask airway and the block was considered as failed. Post-operative analgesia was provided with injection diclofenac 75 mg IM 8 h in all patients.

After the end of surgery, patient satisfaction was assessed using a two-point scale. Post-operative recovery was checked, and the occurrence of untoward events (paraesthesia, dysaesthesia or motor deficits) were recorded. The main outcome variable was the time to achieve readiness for surgery.

Statistical analysis was performed using the *Z*-test. Discrete variables like gender and patient satisfaction were analysed using Chi-square test. Variables were presented as mean ± standard deviation (SD) categorical data (patient satisfaction, insufficient block and gender) are presented as number (%) while number of skin punctures and needle redirections as median (range). A $P < 0.001$ was considered as significant. Power calculations were based on the SD reported in previous investigations with multiple injection techniques for axillary brachial plexus. To appreciate the difference of 10% in onset of block between two groups accepting a β error of 10%, a sample size of 120 was achieved. Data were analysed using the software package SPSS version 11, SPSS Inc., Chicago, IL 60606-6412.

RESULTS

There were no differences in age of the patients between the two groups. The patients in Group US weighed more ($P < 0.001$). Group US had more number of male patients whereas Group NS had more female patients ($P < 0.001$). Duration of surgery was significantly more in Group US ($P < 0.001$). The median number of skin punctures was less in group US than in group NS ($P < 0.001$). Group US required fewer needle redirections than group NS ($P < 0.001$). No differences were observed in the onset of sensory and motor block or readiness to surgery ($P > 0.001$). Failed block requiring general anaesthesia was nil in either group. Insufficient block (more than 100 mcg fentanyl required to complete surgery) was reported in three patients of group US (5%) and four patients of group NS (6.67%) ($P > 0.001$). Patient satisfaction was similar in both the groups ($P > 0.001$) [Table 1].

Patients in Group NS consisted of Excision of Head of Radius ($n = 30$), Open reduction and Internal fixation (ORIF) of forearm bones ($n = 20$) and removal of Implants from forearm ($n = 10$) while patients in Group US consisted of Closed reduction ($n = 20$),

Table 1: Comparison of the study groups

Parameters	Group NS (*n*=60)	Group US (*n*=60)	*Z*/Chi-square*	*P*
Age (years)	28.33±8.53	27±5.01	1.04	>0.001 (0.15)
Weight (kg)	68.33±6.18	74.7±10.6	4	<0.001
Gender				
Male	52 (86.67)	57 (95)	10.91*	<0.001
Female	8 (13.33)	3 (5)		
Duration of surgery (min)	36±10.3	91.7±12.6	26.56	<0.001
Number of skin punctures median	3 (2-5)	2 (2-4)	8.57	<0.001
Needle redirections median	4 (2-5)	2 (2-3)	13.41	<0.001
Onset sensory (min)	6.17±1.22	6.33±0.48	0.98	>0.001 (0.16)
Onset motor (min)	23.17±1.79	23.33±0.26	0.59	>0.001 (0.27)
Patients satisfaction				
Good	53 (44.17)	54 (45)	0.09*	>0.001 (0.76)
Not good	7 (5.83)	6 (5)		
Insufficient block	4 (6.67)	3 (5)	0.39	>0.001 (0.35)

Group NS: Nerve stimulator, Group US: Ultrasonography, SD: Standard deviation. Values are mean±SD; median (range); or number of patients (%)

ORIF (n = 20) and ORIF + Bone Grafts (n = 20) of forearm bones.

No neurologic complications were reported at the 24-h follow-up, and complete recovery of sensory and motor function was observed in all studied patients.

DISCUSSION

The success of a peripheral nerve block is based on the ability to correctly identify nerves involved in the surgery, and place an adequate dose of local anaesthetic around them, to achieve a complete impregnation of all nerves involved in the surgery. The established methods of nerve location were based on either elicitation of paraesthesia or identification of the proper motor response on NS. The paraesthesia and perivascular techniques for axillary approach of brachial plexus block are not free from complications and failure. In past few years, there have been a shift in established methods of nerve location from elicitation of paraesthesia to identification of the proper motor response on NS. Each of these two techniques has been reported to have a low sensitivity for detection of needle to nerve contact.[10] US guidance introduced into clinical practice to identify peripheral nerves offers the potential advantage of optimizing the spread of the local anaesthetic solution around the nerves under sonographic vision.[3-7] US imaging technique not only enables to secure an accurate needle position but one can also monitor the distribution of the local anaesthetic in real time, with the potential advantage of improving the quality of nerve block, shortening the latency of the block, and reducing the minimum volume required to obtain a successful nerve block.[11-14] The use of USG improves the onset and completeness of sensory and motor blocks,[6,12] and has better overall success rate for axillary brachial plexus block as compared with the transarterial technique.[8] There have been studies comparing US guidance with electrical NS for peripheral nerve blocks, and US guidance has been shown to provide better quality of block.[11-15]

Studies have used conventionally either 20 ml of 0.75% of bupivacaine/ropivacaine or more than 20 ml of 0.5% bupivacaine. Our results showed that USG and neurostimulation guidance provide similar success rates with as little as 20 ml 0.5% bupivacaine.[1,9,15-17] Musculocutaneous nerve usually leaves the plexus sheath before the brachial plexus enters the axilla and therefore it is often spared when axillary approach is used for blocking brachial plexus. When musculocutaneous nerve is excluded, the success rate of the effective axillary block using US and nerve stimulator for all the nerves is 90% and 70% respectively.[15] With double injection technique wherein the musculocutaneous nerve is blocked separately, the success rate is 85–95%.[18] Although multiple injection technique requires more number of skin punctures and needle redirections as compared to single and double injection technique, the multiple injection technique has been demonstrated to be the most effective NS technique.[1]

In this prospective, randomized, observer-blinded study, we compared US guidance for axillary brachial plexus block using 0.5% bupivacaine with the most effective technique of NS, the multiple injection techniques.

Our results showed that USG and neurostimulation guidance provide similar success rates and a comparable incidence of complication after multiple injection axillary brachial plexus block. No differences were reported in the onset time of sensory or motor block, patient satisfaction and overall success rate of the block.

Looking for all terminal nerves of axillary brachial plexus, with multiple injection NS technique, all patients were expected to have a minimum of four needle passes. The withdrawal and redirection of the stimulating needle can reduce patient acceptance, requiring implementation of deeper sedation/analgesia

to improve acceptance of the anaesthesia technique. However, this study revealed fewer number of skin punctures in both the groups. Moreover, needle redirections were significantly less in US guided block allowing for vision guidance of the needle tip. Our study was not powered to detect a difference in patient acceptance of the anaesthesia procedure. It was noticed that the number of needle passes required to complete the block was less with US guidance, which could reduce the proportion of patients reporting procedure-related pain when compared with NS. However, in our study patient satisfaction was similarly good with both the techniques.

The success rate of nerve block obtained in either group with small volumes of local anaesthetic obtained with multiple injection technique are consistent with the conclusions of previous investigations and suggests that multiple injection technique may allow reduction of the minimum volume of local anaesthetic required to produce a successful nerve block.[19-22]

CONCLUSION

Multiple injection axillary blocks using 0.5% bupivacaine with US guidance provided similar success rates and incidence of complication as compared with NS guidance. The use of 20 ml of 0.5% bupivacaine is sufficient to block brachial plexus in the axilla if individual nerves are identified correctly and blocked separately.

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