Original Article

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Anaesthetic Effects of Ropivacaine and Bupivacaine on Onset, Duration of Block and Changes in Hemodynamic Parameters in Patients Undergoing Below Elbow Surgeries Under Ultrasound Guided Supraclavicular Brachial Plexus Block

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ABSTRACT

Background: Supraclavicular brachial plexus block is commonly used regional anesthetic technique for below elbow upper limb surgeries. Ultrasound and nerve stimulator are used for higher success rates and fewer complications. Ropivacaine has been used as an alternative to Bupivacaine for rapid onset and longer duration along with lesser or no cardiac and neurotoxicity.The study was conducted with objective of assessing sensory and motor block characteristics of Bupivacaine and Ropivacaine in terms of onset, duration and adverse effects.

Methods: A prospective observational study lasting three month duration from 15th February, 2022 to 14th May, 2022 was conducted among 60 patients divided by convenient sampling method into 30 in Group R (0.2% Ropivacaine 30 ml) and 30 in Group B (0.2% Bupivacaine 30 ml) undergoing below elbow orthopedic surgery under ultrasound and peripheral nerve stimulator guided supraclavicular brachial plexus block.

Results: Block using Ropivacaine as compared to Bupivacaine had faster sensory onset in minutes (7±3.37 vs. 10.17±3.34; P value 0.0005), faster motor onset in minutes (10.17±5 vs. 22.33±5.04), shorter duration of sensory block in minutes (437.16±55.54 vs. 633.38±58.33), shorter duration of motor block in minutes (411±57.15 vs. 698.16±47.89), shorter time required for rescue analgesia in minutes (78.66±25.56 vs. 73.83±21.11) and no complications.

Conclusions: 0.2% Ropivacaine can be used as an alternative to 0.2% Bupivacaine in below elbow upper limb orthopaedic surgeries under ultrasound and nerve stimulator guided supraclavicular brachial plexus block for rapid onset of sensory block and early regression of motor block.

Keywords: Brachial plexus block; nerve stimulator; supraclavicular; ultrasound

INTRODUCTION

Bupivacaine and Ropivacaine are commonly used local anaesthetics in supraclavicular block.The block provides surgical anaesthesia and analgesia to the upper limb surgeries below the shoulder covering mid- humerus, elbow, forearm and hand.[1]

The landmark technique[2] which was used earlier was associated with pneumothorax. Hence, it is replaced by the availability of ultrasound which is used to identify needle, plexus, vessels and pleura in real time.[3-5] The replacement of butyl radical in aromatic ring of Bupivacaine with propyl radical in Ropivacaine has made its faster dissociation from sodium channels resulting into lower cardiotoxicity than Bupivacaine. As compared to Bupivacaine, Ropivacaine is less lipophilic and is less likely to penetrate large myelinated motor fibers causing reduced motor blockade. Ropivacaine has more action on pain transmitting Aδ and C fibers as compared to motor fibers Aα resulting into less motor blockade and similar duration of sensory analgesia.[6-8]

Since Ropivacaine has been only introduced to Nepalese market recently and there are limited studies of

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Ropivacaine in brachial plexus block in our population, the study was conducted with aim of assessing block characteristics of Bupivacaine and Ropivacaine in ultrasound and nerve stimulator guided supraclavicular brachial plexus block for below elbow upper limb orthopedic surgeries. The objective was to study onset, duration of block (sensory, motor) and changes in hemodynamics between 0.2% Bupivacaine and 0.2% Ropivacaine.

METHODS

After ethical approval from Institutional review committee, a prospective observational single centre based study was conducted in operation theatre of military tertiary care hospital and followed in postoperative ward in 3 month duration from 15th February, 2022 to 14th May, 2022 . Patients belonging to 18-65 years of age of either sex, American Society of Anaesthesiologist (ASA) physical status classification class I and class II, scheduled for elective surgeries around elbow joint and forearm under brachial plexus block and weight>30 Kg were included in the study. Patient refusal, uncooperative patients, patients with history of hepatic/renal impairment, pregnant women, failed brachial plexus block, allergy to any of the study drug and patients with coagulopathy were excluded from the study.

Total 60 patients included in the study were divided into two groups by convenient sampling method. Group B where 30 ml of 0.2% Bupivacaine (12 ml of 0.5% Bupivacaine + 18 ml of water for injection= Total 30 ml) was used where as Group R where 30 ml of 0.2% Ropivacaine (no dilution) was used.

The mean onset of sensory block in minutes in Ropivacaine group of the pilot study was 8 ± 2.73 and in Bupivacaine group was 12 ± 5.70. The mean standard deviation of the population being studied (s) was 4.21 and the real difference between the sensory onset times (δ) was 4. So calculation using above formula showed minimum of 21 patients required as shown below.

To compensate for the drop outs, we included 30 patients in each group which was decided by the formula: number of calculated sample size divided by 1 minus proportion of drop outs. The drop outs in our study came around 27. For uniformity and ease in statistics, we chose the number 30 instead of 27. After obtaining informed written consent from patients willing to participate in the study, patients were kept nil per oral for 6 hours for light meal, intravenous access was obtained with 18 G IV canula in non operative limb and slow infusion of Inj Ringers Lactate was done. Base line ASA standard monitoring like oxygen saturation, noninvasive blood pressure, electrocardiogram and heart rate was monitored and recorded. Inj Midazolam and Inj Sodium Thiopentone were kept ready to manage complications like seizure during or after block. The study medication was prepared by anaesthesia residents or anaesthesia technician not involved in the study as per convenience of anaesthesiologist (researcher) and was handed over to him.

Brachial plexus block technique.[8,9] After informing about the details of block procedure, patient was kept supine with 15° head up with head turned away from the limb to be operated and arm was held downward to depress the clavicle. Injection site was cleaned with Povidone iodine and covered with sterile eye towel. A high frequency (5-10 MHz) linear ultrasound probe of 4 cm length was kept inside sterile surgical glove lubricated with ultrasound jelly. Sterile povidone iodine solution was used as acoustic couplant between probe and skin. The brachial plexus was identified as hyperechoic structures like bunch of grapes in relation to the pulsating subclavian artery and the hyperechoic first rib. Local anaesthesia at the injection site was provided with 2ml 2% plain lignocaine. The plexus was then approached using an in-plane (IP) technique with a 5cm sterile nerve stimulating needle. The PNS was set to deliver 2 mA current at 1 Hz frequency and 0.1 ms of pulse duration. Once the needle tip reached the nerve sheath, visible twitch of fingers seen, the current amplitude was reduced to minimum of 0.5 mA at which such twitch were visible followed by negative aspiration for blood/air and injection of 30 ml of the study drug around the plexus under vision at the two locations mentioned in Figure 1, in boluses of 5ml with repeated aspirations in between. (Position 1: angle between subclavian artery and first rib. Position 2: outside the nerve sheath). Direct visualization of spread of drug was noticed.

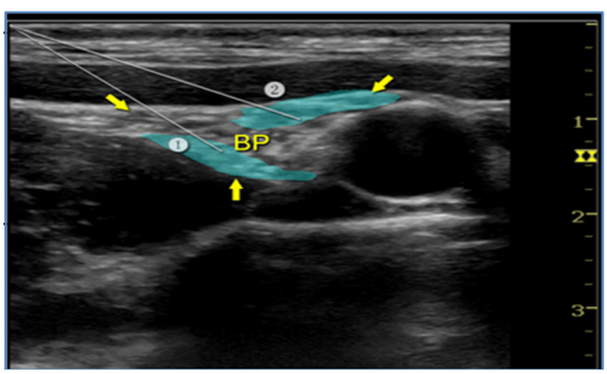

Figure 1. Ultrasound image of Brachial plexus showing two needle block positions[9]

Intercostal brachial block with 5 ml of 0.25% plain Bupivacane was injected with 24 G hypodermic needle at the site of tourniquet application to prevent postoperative tourniquet pain.

The onset of sensory blockade was defined as the time interval between injection of local anaesthetic and loss of prick sensation in radial (dorsum of thumb), median (palmar surface of index finger) and ulnar (palmar surface of little finger) dermatomes on the ipsilateral upper limb.[10] This was assessed by checking for prick sensation every 1 min till the onset of dull sensation and then every 5 min till there no sensation felt at all. Sensory block was divided into three grades.[11]

Grade 0: Sharp prick felt.

Grade 1: Analgesia, dull sensation felt.

Grade 2: Anaesthesia, no sensation felt.

The onset of motor blockade was defined as the time interval from administration of the drug to loss of movements of ipsilateral upper limb. This was assessed every 5 min till complete loss of movements of elbow, wrist and fingers. Motor block was graded using modified Bromage scale for upper extremities.[11]

Grade 0: Normal motor function.

Grade 1: Ability to move wrist and fingers.

Grade 2: Ability to move fingers only.

Grade 3: Complete motor block with inability to move elbow, wrist and fingers.

Duration of sensory block was defined as time interval between losses of prick sensations to its reappearance. For this, the prick sensation during intraoperative period was assessed by operating surgeon in operating limb at the start of surgery then every 30 min till end of the surgery and by trained registered nurse in postoperative period every hourly till the reappearance of prick sensation. Duration of motor block was defined as time interval between losses of movements of ipsilateral upper limb to reappearance of movements. For this, the movement of operating limb was assessed by operating surgeon during intraoperative period at the start of incision, then every 30 min till the end of surgery and thereafter by trained registered nurse in postoperative ward every hourly till the reappearance of movement of elbow, wrist and fingers.

Time to first analgesic request was defined as the time interval from onset of sensory blockade to first request for analgesia by patient once block has worn off. Incomplete or patchy block was defined as presence of Grade 1 sensory or motor block. Failed block was defined as Grade 0 sensory or motor block.[11] In either case of incomplete or failed block, general anaesthesia was given and the case was excluded from the study.

Postoperative pain was assessed and recorded by trained registered nurse with 10 point Visual Analaogue scale (VAS) every hourly till first 12 hour then 4 hourly till 24 hrs post surgery with 0 as no pain and 10 as worst imaginable pain[12] Inj Ketorolac 30 mg IV was given as first rescue analgesic with VAS score ≥ 6 and Inj Pethidine 50 mg IM and Inj Promethazine 25 mg IM was given as alternative second rescue analgesic if required. Side effects like Bradycardia, hypotension, arrhythmias, headache, convulsion, urticaria etc were noted every 5 min during intraoperative period by recording hemodynamic parameters like heart rate, non invasive blood pressure, electrocardiogram and asking patient whether he was having any symptoms like pain at operative site, pain at tourniquet application, headache, shortness of breath, itching etc.

Data collected were statistically analyzed using Graph Pad Prism version 8. Onset and duration of sensory & motor block and time interval for first rescue analgesic was expressed as mean ± SD. The data were compared in two groups and differences were analyzed by two tailed unpaired 't' test.

RESULTS

The study was carried out in 60 consented patients in the age group of 18-65 years of either sex. There was 66.66 % male and 33.34% female population in Ropivacaine group as compared to 70% male and 30% female in Bupivacaine group. Similarly, ASA I and ASA II populations in Ropivacaine group were 80% and 20 % respectively as compared to the Bupivacaine group where they were 83.33% and 16.67% respectively. The demographic profiles (age and weight) and duration of surgery between two groups were comparable and almost similar as shown in Table 1.

Table1. Demographic data and duration of surgery.

Variables	Group R (n=30)		Group B (n=30)		
	Mean	SD	Mean	SD	P value
Age (years)	36.73	14.88	36.37	12.46	0.80
Weight (kg)	60.10	8.85	62.67	7.77	0.23
Duration of surgery (min)	78.66	25.56	73.83	21.11	0.42

The mean onset time of sensory block was found to be

faster in Ropivacaine group than in Bupivacaine group which was statistically significant (P value 0.0005). However, the sensory block in Ropivacaine group though lasted for lesser duration than in Bupivacaine group was statistically not significant as shown in Table 2.

Table 2. Mean time for onset and duration of sensory block in min.

Variables	Group R (n=30)		Group B (n=30)		
	Mean	SD	Mean	SD	P value
Onset (min)	7	3.37	10.17	3.34	0.0005
Duration of block (min)	437.16	55.54	633.38	58.33	2.27

The mean onset time of motor block was faster and motor block lasted for lesser duration in Ropivacaine group than that in Bupivacaine group which were statistically not significant as shown in Table 3.

Table 3. Mean time for onset and duration of motor block in min.

Variables	Group R (n=30)		Group B (n=30)		
	Mean	SD	Mean	SD	P value
Onset (min)	10.17	5	22.33	5.04	3.04
Duration of block (min)	411	57.15	698.16	47.89	2.54

The mean time taken for rescue analgesia between the two groups were statistically insignificant as shown in Table 4 with patients in Ropivacaine group requiring rescue analgesics earlier in postoperative period than those in Bupivacaine group.

Table 4. Mean time for rescue analgesia in min.

Variable	Group R (n=30)		Group B (n=30)		
	Mean	SD	Mean	SD	P value
Time taken for rescue analgesia	444	55.93	692	30.44	3.65

The mean systolic blood pressure, mean diastolic blood pressure and the mean heart rate among the patients between two groups during first 24 hour of the study were comparable and almost similar as shown in Table 5.

Table 5. Mean hemodynamic during first 24 hour.

Variables	Group R (n=30)		Group B (n=30)		
	Mean	SD	Mean	SD	P value
Mean Systolic blood pressure (mm of Hg)	126.53	11.91	123.40	10.01	0.27
Mean Diastolic blood pressure (mm of Hg)	77.53	9.01	74.40	9.53	0.19
Mean Heart rate (beats per min)	79.07	10.62	71.40	11.19	0.008

The complications like failed or partial block, hypotension, bradycardia, nausea, vomiting, arrhythmias, seizure, Horner syndrome etc were not found in the patients of both the study groups.

DISCUSSION

Supraclavicular Brachial plexus block has been one of the preferred peripheral nerve block procedures for hand and fore arm surgeries due to its safety, rapidity and reliability.[1] The safety and success rates can be increased reducing complications if the block is performed under ultrasound guidance[2-4] and peripheral nerve stimulator.[11] Bupivacaine has been commonly used as a local anaesthetic for supraclavicular block in patients undergoing upper limb below elbow surgeries. However, due to its cardiac and neurotoxicity, Ropivacaine has been used as a safer alternative.[6] Although Ropivacaine is less potent than Bupivacaine and has shorter duration of action along with motor sparing property, it has been widely used in lumbar epidural for labor analgesia (0.2% 10-20 ml bolus followed by 6-10 ml/hr), intrathecally for cesarean section (0.5% 2-4 ml) and in various concentrations mainly 0.5% and 0.75% in supraclavicular, interscalene, axillary and subclavian block.[7,8] However, effects and role of 0.2% Ropivacaine in brachial plexus block has been lacking in studies.

The effectiveness of low concentration of Ropivacaine as comapred to Bupivacaine in postoperative analgesia in brachial plexus block was supported by the study done by Iwata T[14-16] who used low dose Ropivacaine (10 ml of 0.375%) in fluoroscopy guided supraclavicular block after induction of general anaesthesia for successful postoperative analgesia in surgery of upper extremities. Similarly, Thornton KL et al[17]also compared 0.2% ropivacaine with 0.25% Bupivacaine for axillary brachial plexus block in paediatric hand surgery and found that 0.2% Ropivacaine as effective as 0.25% Bupivacaine. Our study is similar to above mentioned two studies as we also found that 0.2% Ropivacaine was effective as compared to 0.2% Bupivacaine in equal volume of 30 ml in supraclavicular brachial plexus block under ultrasound guidance with use of peripheral nerve stimulator.

The results of our study suggested that 0.2% Ropivacaine had significantly faster sensory onset and faster motor onset both in minutes than 0.2% Bupivacaine. The

findings were similar to Kaur et al[18] where sensory onset with use of 30 ml of 0.5% Ropivacaine was 8.88 ± 1.74 faster than 30 ml of 0.5% Bupivacaine (12.04 ± 2.57) and motor onset was also faster in Ropivacaine (14.88 ± 3.35) than in Bupivacaine group (22.92 ± 3.79) although the later study was conducted under axillary brachial plexus block. However both the sensory and motor onset was earlier in our study. This might be due to use of lower concentration of local anaesthetic effectively blocking the pain sensitive Aδ and C fibers along with direct visualization of needle in nerve plexus area along with the spread of drug.

The findings of onset of sensory and motor block in the Ropivacaine group of our study was different than that of Venkatesh et al[19] where sensory onset with use of 30 ml of 0.5% Ropivacaine was 17.79 ± 5.03 and with 30 ml of 0.75% of Ropivacaine was 18.48 ± 6.14 both longer than in the group where 30 ml of 0.5% Bupivacaine was used (16.85 ± 6.67). Similarly, the motor onset in the study done by Venkatesh et al was longer both with 0.5% Ropivacaine (22.23 ± 4.05) and with 0.75% Ropivacaine (22.33 ± 5.17) as compared to 0.5% Bupivacaine (21.45 ± 4.45). This might be due to use of higher concentration of Ropivacaine and use of peripheral nerve stimulator only in supraclavicular brachial plexus block.

In our study, Ropivacaine group had lesser duration (in minutes) of both the sensory block and motor block as compared to Bupivacaine group (437.16 ± 55.54 vs. 633.38 ± 58.33 and 411 ± 57.15 and 698.16 ± 58.33 respectively). However, in the above findings of our study, the duration of sensory block was more than duration of motor block in Ropivacaine group (437.16 ± 55.54 vs. 411 ± 57.15) as compared to Bupivacaine group where duration of sensory block was less than that of duration of motor block (633.38 ± 58.33 vs. 698.16 ± 58.3). The findings were similar to the Kaur et al[18] where both the sensory block and motor block duration in 0.5% Ropivacaine group was lesser than that of 0.5% Bupivacaine group (421.20 ± 38.33 vs. 450.40 ± 54.20 and 365.60 ± 34.29 vs. 408.40 ± 50.39 respectively) in axillary brachial plexus block.

The findings of our study were different to Modak S[20] where both the duration of sensory block and motor block were more in 0.5% Ropivacaine group than that of 0.5% Bupivacaine group (9.03 ± 1.38 vs. 7.18 ± 1.08 and 7.53 ± 41.22 vs. 6.62 ± 1.01 respectively). Later study was done using higher concentration of both Ropivacaine and Bupivacaine under paraesthesia technique combined with use of nerve stimulator. In our study, the onset of sensory and motor block was earlier with 0.2% Ropivacaine as compared to 0.2% Bupivacaine however the duration of both senosry and motor block were lesser with Ropivacaine group. This might be due to use of lower concentration of Ropivacaine.

The time at which first rescue analgesic required in hour in our study was earlier in Ropivacaine group (7.4 ± 0.93) than Bupivacaine group (11.53 ± 0.50) which were different and less than that in Kaur et al[18] (8.44 ± 0.65 vs. 8.32 ± 0.99) and Modak S[20] (14.40 ± 2.13 vs. 11.60 ± 1.81). Shorter time required for rescue analgesic or duration of analgesia in our study might be due to lower concentration of both the Ropivacaine (0.2%) and Bupvacaine (0.2%). Similarly, the mean duration of surgery (in hour) in our study was 1.31±0.41 in Ropivacaine group and 1.23±0.35 in Bupivacaine group which was almost similar to Mathew S et al[21] (1.19±0.48 and 1.18 ± 0.42 respectively) but less than that in Modak S et al[20] (3.23±0.82 and 3.07±0.74 respectively. There were no procedure related (arterial puncture, bleeding, hematoma, infection, pneumothorax) and local anaesthesia related (tinnitus, headache, seizure, arrhythmias, asystole, death) side effects or complications seen in both the groups of our study during intraoperative period and 24 hour postoperative period which was similar to the study done by Mathew S et al.[21] The reasons for not finding procedure related side effects might be due to use of ultrasound to visualize the nerve plexus and to see the spread of study drugs. Also nerve stimulator was used to observe the twitch of muscle contraction on stimulation and disappearance of those twitches on injecting drugs. Similarly we also used low concentration of study drugs that might have contributed to no drug related side effects.

Firstly, this study was single centre based prospective cross-sectional observation study. It was neither randomized nor blinded. So there is observer bias. Secondly, the study had shorter duration of analgesia requiring early request for post operative analgesia due to use of lower 0.2% concentration of Ropivacaine. Similar study using higher concentration of 0.5 % or 0.75% Ropivacaine might have to be done in future to know and compare the effects of those concentration on onset and duration of sensory and motor block. Finally, as our study used lower concentration of 0.2% Ropivacaine,although the onset time of sensory and motor block were earlier, the duration of both were shorter requiring early post operative analgesia, we think that 0.2% Ropivacaine might not be suitable in below elbow surgeries lasting more than 2 hours.

CONCLUSIONS

Ropivacaine at a concentration of 0.2% can be used as an alternative to similar concentration of Bupivacaine in below elbow upper limb orthopaedic surgeries under ultrasound and nerve stimulator guided supraclavicular brachial plexus block for rapid onset of sensory block and early regression of motor block in postoperative period without any complications. Since Ropivacaine is very popular in other countries for peripheral nerve block and evidence for its indication in our populations were missing, this study can be taken as an evidence for its use. However, randomized control studies using larger samples and involving multiple center might be required for final recommendation of use of 0.2% Ropivacaine in such kind of blocks.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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