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Original Article

Anaesthesia Section

A Randomized Controlled Study of 0.5% Bupivacaine, 0.5% Ropivacaine and 0.75% Ropivacaine for Supraclavicular Brachial Plexus Block

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ABSTRACT

Introduction: For any surgery in the upper extremity that does not involve the shoulder, a supraclavicular block is preferred, as it is a safe procedure associated with rapid onset and reliable anaesthesia. Although ropivacaine has been extensively studied for epidural anaesthesia, very few reports exist on its use in supraclavicular brachial plexus block.

Aim: This study was conducted to investigate and compare the effectiveness of supraclavicular brachial plexus anaesthesia with two different concentrations of ropivacaine (0.5% and 0.75%) and to compare them with the standard 0.5% bupivacaine.

Materials and Methods: Ninety patients of age 18 to 60 years belonging to American Society of Anaesthesiologists (ASA) status 1 or 2, admitted to Pondicherry Institute of Medical Sciences were chosen for the study and were divided into three groups. Group A received 30 ml of 0.5% bupivacaine, group B received 30 ml of 0.5% ropivacaine and group C received 30 ml of 0.75% ropivacaine into the supraclavicular region, by a nerve-stimulator technique. Onset time of each of the drug was recorded both for the sensory and motor block. Duration of sensory and motor block was recorded along with peri-operative haemodynamic monitoring.

Results: The onset of complete sensory and motor block observed with both ropivacaine groups and bupivacaine was similar (16.85 ± 6.67 min in group A, 17.79 ± 5.03 min in group B and 18.48 ± 6.14 in group C, $p < 0.05$); onset of motor block (21.45 ± 4.45 min in group A, 22.23 ± 4.05 min in group B and 22.33 ± 5.17 in group C, $p < 0.05$). The duration of sensory block with 0.5% bupivacaine was 11.58 hours, with 0.5% ropivacaine was 9.02 hours with 0.75% ropivacaine was 8.87 hours ($p<0.001$). The duration of motor block with 0.5% bupivacaine was 12.94 hours, with 0.5% ropivacaine was 8.29 hours with 0.75% ropivacaine was 7.89 hours ($p<0.001$). Multiple comparison test with Bonferroni correction showed there was statistically significant difference in mean duration of sensory block between Group A (0.5% bupivacaine) and Group B (0.5% ropivacaine) and also between Group A (0.5% bupivacaine) and Group C (0.75% ropivacaine). However, there were no statistically significant difference in mean duration of sensory block between Group B (0.5% ropivacaine) and Group C (0.75% ropivacaine). The preoperative, intra operative and postoperative heart rate, systolic & diastolic blood pressure and oxygen saturation were comparable among the three study groups ($p>0.05$). No side effects were recorded in the study.

Conclusion: The onset of sensory and motor block was similar in all the three groups. However, when compared to bupivacaine group, recovery of motor functions was faster in both the ropivacaine groups. Patients in all the 3 groups did not experience any adverse effects.

Keywords: Motor block, Nerve stimulator, Sensory block

INTRODUCTION

Ever since William Stewart Halsted and Richard John Hall first reported the use of cocaine to block upper extremity nerves in 1884, brachial plexus regional anaesthesia has been used extensively by anaesthesiologists worldwide [1]. Supraclavicular block is preferred procedure for hand and fore-arm surgeries, as it is safe, has rapid onset and gives reliable anaesthesia. Success rates are better when a nerve stimulator is used as a clear response of the fingers is obtained at a seeking current which indicates a close proximity to the plexus [2].

Various local anaesthetic agents and adjuvants are used for this purpose. Among them, bupivacaine has been the most widely used long-acting local anaesthetic agent. However, bupivacaine is associated with various CNS and cardiac side effects and unintended intravascular injection of bupivacaine lead to cardiac arrest, prolonged resuscitation and a disproportionally high number of deaths [3,4]. In search of better alternative, ropivacaine has been proposed as a promising drug with fewer cardiovascular and central nervous system toxic effects compared with bupivacaine [5]. Researchers have demonstrated lesser cardiac depression and fewer CNS effects when ropivacaine is injected intravenously [6]. This study was conducted to compare the efficacy of 0.5% bupivacaine, 0.5% ropivacaine and 0.75% ropivacaine in supraclavicular brachial plexus block in terms of sensory and motor blockade.

MATERIALS AND METHODS

This study was a prospective study done in Pondicherry Institute of Medical Sciences, Puducherry from November 2010 to June 2012. After obtaining ethical and institutional committee approval, 90 patients of the age group of 18 to 60 years, belonging to ASA physical status I or II scheduled to undergo elective arm, forearm and hand surgery under regional anaesthesia in this Institution were included in this study. Patients with history of allergy or any form of reaction to local anaesthetic drug, infection at the site of block placement, coagulopathy, history of neurologic or psychiatric disease, hemi diaphragmatic paralysis contra lateral to the side of surgery, history of active liver, renal disease or chronic renal impairment and patients undergoing day care surgeries were excluded from the study for obvious reasons. Totally 90 patients

were recruited into the study. Sample size was calculated using difference between the overall duration of sensory block of 50 minutes. The sample size required to have a 90% probability of detecting a decrease in duration of 50 min (level of significance 0.05) was 26 patients per group using following formula,n=2 ($Z\alpha$ + Z {1-β})^2× SD2/d^2. Compensating for dropout, we chose to include 30 patients per group. Informed written consent was obtained after explaining the procedure to the patients in the language they understood. Block randomization was done according to the computer generated random numbers generated using Microsoft Excel Program. The random numbers were kept concealed in opaque sealed envelopes and were opened after obtaining informed consent from the patient. The envelope was opened by an anaesthesiologist not involved in the study and the study medication was prepared and handed over to the researcher. Neither the researcher nor the patient was aware of the study medication. In Group A, supraclavicular block was given with 0.5% Bupivacaine, Group B with 0.5% Ropivacaine and Group C with 0.75% Ropivacaine. Intravenous access was established with 18 gauge cannula and the slow infusion of crystalloid was started. Injection Midazolam 2mg intravenous was administered before proceeding to give the supraclavicular block, to relieve anxiety. Following this supraclavicular brachial plexus block was given with 30ml of three different solutions, i.e., Group A received 0.5% Bupivacaine, Group B received 0.5% Ropivacaine and Group C received 0.75% Ropivacaine.

Brachial Plexus Block Technique: Patients were placed in the supine position with the head turned slightly away from the side to be blocked and the arm placed alongside the body. A 22-gauge, 50-mm, insulated, blunt needle and a nerve stimulator was used to identify the brachial plexus. The site that triggered muscular response to a stimulus equal to or lower than 0.4 mA was identified, and 30mL of the local anaesthetic was administered. Immediately after the block placement, patients were evaluated every 4min, by an operator unaware of the injected solution, by asking the patient to elevate the arm while keeping the elbow straight and at the hand by grip strength to determine loss of shoulder abduction (deltoid sign) as evidence of a successful motor blockade. In addition, sensory block was also assessed by pinprick every 4 min in the C5-T2 dermatomes. Failure to lose shoulder abduction after 30 min was considered as block failure. All episodes of local anaesthetic toxicity or haemodynamic changes requiring anaesthesiologist intervention (increased IV fluids or inotropes) were recorded as adverse events. At the conclusion of surgery, all patients were transferred to the Post-Anaesthesia Care Unit (PACU) and reassessed to confirm sensory and motor blockade. Patients and nursing staff was asked to document the time of first oral narcotic/analgesic drug, the time when incisional discomfort begins, and the time when full sensation returns to the shoulder.

Sensory block was assessed in the C5-T2 dermatomes and was graded as

Grade
0 - If no loss of sensation to pinprick.
1 - Analgesia (Patient feels touch but no pain).
2 - Anaesthesia (Patient does not feel touch/pain).

Motor block was assessed

1) At shoulder – By asking the patient to elevate arm by keeping the elbow straight (to assess superior trunk).
2) At hand – By the grip strength (to assess middle and lower trunk).

And the motor block was graded as

Grade
0 - No weakness
1 - Paresis
2 - Paralysis

In addition, patients were monitored constantly for any signs of CNS or CVS toxicity for two hours in PACU (Change in blood pressure, heart rate or rhythm, and signs and symptoms CNS stimulation). Heart rate and blood pressure were recorded before pre-medication and administration of the block and at 2, 5, 10, 15, 20, 25, 30, 45 and 60 minutes and thereafter every 30 minutes for 2 hours post-operative in the PACU.

STATISTICAL ANALYSIS

Statistical analysis was done by using SPSS-17.0. The statistical tests used were student t-test, paired t-test, chi-square test and Anova test with multiple comparison. The p-value of <0.05 was considered statistically significant.

RESULTS

The study population consisted of 90 patients posted for elective forehand surgery. They were divided into three groups of 30 each. Group (A) received 30ml of 0.5% Bupivacaine, group (B) received 30ml of 0.5% Ropivacaine, and group (C) received 30ml of 0.75% Ropivacaine. There were five cases of block failure and according to our protocol they were converted to GA (3 patients from Group A and one each from Group B and Group C).

Significant differences in anthropometric data and physical status were not observed between both groups demonstrating that the study groups were comparable [Table/Fig-1].

There was no statistically significant difference in mean heart rate, systolic blood pressure, diastolic blood pressure and SpO_2 between the three study groups A, B and C during peri-operative period (p-value is > 0.05). The outcome variables such as mean onset/initiation time of grade 3 sensory block and mean onset/ initiation time of grade 3 motor block were comparable in three study groups A, B and C [Table/Fig-2].

Variable	Study Group						Test of Significance*	
	0.5% Bupivacaine		0.5% Ropivacaine		0.75% Ropivacaine		F statistic	p-value
	Mean	SD	Mean	SD	Mean	SD		
Age (yrs)	30.57	9.09	34.45	10.94	29.66	8.82	2.001	0.142
Weight	66.79	10.08	62.28	6.34	63.07	8.38	2.335	0.103

[Table/Fig-1]: Mean demographic data in group A, group B and group C.
*Anova test used.

Variable	Study Group						Test of Significance*	
	0.5% Bupivacaine		0.5% Ropivacaine		0.75% Ropivacaine		F statistic	p-value
	Mean	SD	Mean	SD	Mean	SD		
Onset of sensory block (min)	16.85	6.67	17.79	5.03	18.48	6.14	0.524	0.594
Onset of motor block(min)	21.45	4.45	22.23	4.05	22.33	5.17	0.514	0.565

[Table/Fig-2]: Comparison of mean onset/ initiation of grade 3 sensory block of patients in group A, group B and group C.
*Anova test used

Variable	Study Group						Test of Significance*	
	0.5% Bupivacaine		0.5% Ropivacaine		0.75% Ropivacaine		F statistic	p-value
	Mean	SD	Mean	SD	Mean	SD		
Duration of sensory block(hour)	11.58	3.03	9.02	0.98	8.87	2.65	11.561	<0.001
Duration of motor block(hour)	12.94	3.09	8.29	0.92	7.89	2.74	37.755	<0.001

[Table/Fig-3]: Duration of effective sensory and motor block.
*Anova test used.

Dependent Variable	Study group	Study group	Mean Difference	p-value
Duration of sensory block (in min)	0.5% Bupivacaine group	0.5% Ropivaciane group	2.50	<0.001
	0.75% Ropivaciane group	0.5% Bupivacaine group	-2.70198	<0.001
	0.5% Ropivaciane group	0.75% Ropivaciane group	.14069	1.00
Duration of motor block (in min)	0.5% Bupivacaine group	0.5% Ropivaciane group	4.65139	<0.001
	0.75% Ropivaciane group	0.5% Bupivacaine group	-5.05312	<0.001
	0.5% Ropivaciane group	0.75% Ropivaciane group	.40172	1.00

[Table/Fig-4]: Multiple comparison test with Bonferroni correction for duration of effective sensory and motor block.

The total duration of effective sensory block with 0.5% bupivacaine was 11.58 ± 3.03 hrs, with 0.5% ropivacaine 9.02 ± 0.98 hrs and with 0.75% ropivacaine was 8.87 ± 2.65 hrs. This difference was statistically significant (p-value <0.001) [Table/Fig-3].

Multiple comparison test with Bonferroni correction showed there was statistically significant difference in mean duration of sensory and motor block between Group A (0.5% Bupivacaine) and Group B (0.5% Ropivacaine) and also between Group A (0.5% Bupivacaine) and Group C (0.75% ropivacaine). However, there were no statistically significant difference in mean duration of sensory and motor block between Group B (0.5% Ropivacaine) and Group C (0.75% Ropivacaine) [Table/Fig-4].

DISCUSSION

Brachial plexus block has long been considered a safe method when proper technique is followed, which includes monitoring and patient selection. However, being a very vascular area, brachial plexus blockade can set a potential place for absorption of local anaesthetics and the development of systemic toxicity. Worldwide, long acting bupivacaine has been the most popular local anaesthetic for supraclavicular block in patients undergoing elective upper limb surgeries. But the CNS and CVS side effects are its limitations. Ropivacaine is the product of an intensive search for a safer alternative to bupivacaine [7]. Although safe, ropivacaine is found to be less potent than bupivacaine and has a slightly shorter duration of action along with some motor sparing qualities [8]. Ropivacaine has been extensively studied as an effective drug for labor analgesia and it has proved that it is comparable to bupivacaine in its efficacy with least side effect [9,10]. However, evidence regarding the role of ropivacaine in other peripheral nerve blocks is lacking. Several researchers have tried to address this issue by utilizing different drugs in different combinations in supraclavicular brachial plexus block in an attempt to reduce the dose requirements and consequently the incidence of complications. We have tried to study ropivacaine as a safer alternative to bupivacaine and also tried to find out the most effective concentration of Ropivacaine for the supraclavicular brachial plexus block.

The results of our study suggest that 0.5% bupivacaine, 0.5% ropivacaine, and 0.75% ropivacaine have a fast onset time of 16.85 min, 17.79 min and 18.84 min respectively. Klein et al., compared 0.5% bupivacaine, 0.5% ropivacaine, and 0.75% ropivacaine for inter-scalene brachial plexus block and observed mean onset time of sensory block to be <6min [11]. This onset time is faster than what we observed in our study. The reason could be the difference in the anatomical level of the nerves to be blocked: in supraclavicular brachial plexus block, local anaesthetic is injected at the level of the nerve trunks, whereas in inter-scalene brachial plexus block drug is injected at the level of the nerve roots. Kaur et al., compared ropivacaine with bupivacaine for axillary brachial plexus block and found that ropivacaine showed a better quality of analgesia with a shorter onset (5 min vs 20 min for 0.5% ropivacaine compared to 0.5% bupivacaine) and recovery time for both sensory and motor blockade in comparison to bupivacaine [12].

Regarding motor blockade, our study suggests that 0.5% Bupivacaine, 0.5% ropivacaine, and 0.75% ropivacaine provide a fast onset time of 16.48 min, 19.21 min and 20.31min respectively. Time of onset for motor blockade is less in our study when compared to a similar study done by Hickey et al., which compared bupivacaine 0.5% with ropivacaine 0.5% for sub-clavian perivascular block [13]. They documented a mean onset of motor blockade of 48 min (28-58 min) at the hand (at the C5 and C6 dermatomes) which was substantially longer compared to our findings. The difference in observation may be because of difference in the technique of block, and accurate localization of the nerves to be blocked by eliciting motor response by a nerve stimulator in our study compared to elicitation of parasthesias, as used by Hickey et al., [13] Data from our study in terms of duration of blockade shows that there is no difference in duration of motor blockade which is consistent with the findings of Hickey et al. In our study, we observed that 0.5% bupivacaine is faster in duration of motor blockade than 0.5% Ropivacaine and 0.75% Ropivacaine. There were no adverse effects observed in patients in the perioperative period, neither CNS nor CVS adverse effects, and were comparable among the three study groups which was again consistent with the study done by Hickey et al., and Klein et al., Chatrath et al., compared 0.75% ropivacaine with clonidine and 0.5% bupivacaine with clonidine for infraclavicular block and reported that addition of clonidine to bupivacaine lead to early onset and prolonged duration of sensory and motor block with prolonged analgesia as compared to the addition of clonidine to ropivacaine. Sensory onset time was time approximately 5 minutes and motor was approximately 10 minutes in both the group which is much faster compared to our group and it can be explained that addition of clonidine as an adjuvant potentiated the onset in their group compared to ours [14].

The clinical results of ropivacaine in brachial plexus blocks, both in the present study and in the literature, indicate that onset, duration, and quality of the blockade is similar to that of bupivacaine. However, we found that increasing the concentration of Ropivacaine from 0.5% to 0.75% failed to improve onset as well as duration. Considering the greater toxicity potential and the cardiovascular effects of the bupivacaine, ropivacaine seems a good alternative for brachial plexus blocks at a concentration of 0.5%.

LIMITATION

The dose of ropivacaine used in the study was not based on patient's body weight; rather it was a fixed dose which would have altered the above mentioned results.

CONCLUSION

On the basis of our study, conclusions were drawn that onset of action of sensory, motor block was similar in all the groups. However, recovery of motor functions was faster in ropivacaine groups as compared to bupivacaine group. No adverse effects were noted in either groups. Increasing the concentration of ropivacaine from 0.5% to 0.75% failed to improve onset as well as duration of sensory/motor block. Considering the greater toxicity potential and the cardiovascular effects of the bupivacaine, ropivacaine seems a good alternative for brachial plexus blocks at a concentration of 0.5%.

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