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Original Research Article

Comparison of 0.5% Bupivacaine and 0.5% Ropivacaine in Axillary Brachial Plexus Block: A Prospective Randomized Study

Preeti Ray[1], Pravin Sidharth[2]

[1]Senior Resident, Department of Anaesthesia, Medini Rai Medical College and Hospital (MRMCH) Palamu, Jharkhand, India

[2]Assistant Professor, Department of Orthopaedics, Medini Rai Medical College and Hospital (MRMCH) Palamu, Jharkhand, India

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Corresponding Author: Dr. Pravin Sidharth

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Abstract:

Background: Axillary brachial plexus block is widely used for upper-limb surgeries. Selection of local anaesthetic influences onset, duration of block and safety. Bupivacaine provides prolonged blockade but has toxicity concerns, whereas ropivacaine offers improved safety and differential block.

Aim: To compare clinical efficacy and safety of 0.5% bupivacaine and 0.5% ropivacaine in axillary brachial plexus block.

Methodology: A prospective randomized study was conducted on 60 ASA I–II patients undergoing elective upper-limb surgery. Patients received either 30 ml 0.5% bupivacaine (Group B, n=30) or 30 ml 0.5% ropivacaine (Group R, n=30). Onset and duration of sensory and motor block, duration of analgesia, hemodynamics and adverse effects were assessed and statistically analyzed.

Results: Groups were demographically comparable. Sensory onset (7.9±1.9 vs 11.9±2.4 min) and motor onset (15.0±3.3 vs 23.8±4.1 min) were faster with ropivacaine ($p<0.001$). Bupivacaine produced longer sensory (452.2±48.3 vs 419.6±36.8 min) and motor block (410.6±52.1 vs 368.4±39.6 min) ($p<0.01$). Duration of analgesia was similar (~8.5 h). Hemodynamics and complications were comparable.

Conclusion: Both drugs are safe and effective. Ropivacaine provides faster onset and earlier motor recovery, while bupivacaine offers prolonged blockade.

Keywords: Axillary Brachial Plexus Block, Bupivacaine, Ropivacaine, Regional Anaesthesia, Postoperative Analgesia.

Introduction

Modern anaesthetic practice has incorporated regional anaesthesia due to its capacity to deliver useful intraoperative anaesthesia and long-term postoperative analgesia with minimal adverse effects in comparison to general anaesthesia. One of the most common processes, brachial plexus block, is still carried out as one of the regional blocks in the surgeries of the upper limbs. The history of brachial plexus block dates to the present providing surgical anaesthesia, and postoperative analgesia [1]. Some of its benefits include good working conditions, blood circulation stability, less stress reaction, early walking, shortened hospitalization, and patient satisfaction.

Various modifications to the brachial plexus block have been reported, with interscalene, supraclavicular, infraclavicular, and axillary being some of them. The axillary technique is especially a favored one in surgeries occurring below the mid-arm as it is technically easy, with a relatively lower incidence of complications such as pneumothorax and phrenic nerve palsy, and has a predictable success of blocking the radial, ulnar, median and musculocutaneous nerves. Proper localization and technique of the anatomy are not the only conditions in which the success of the block relies, and the pharmacological characteristics of the local anaesthetic. Thus, the choice of a proper local anaesthetic agent is very important to decide the time of onset, sensory and motor blockade duration, analgesia quality, and safety of the agent.

The optimal local anaesthetic to be used in the peripheral nerve block must have the following properties: fast onset, sufficient depth of anaesthesia, long-lasting postoperative analgesia, selective sensory-motor block and low systemic toxicity. Bupivacaine is one of the long acting amid local anaesthetics that have been in service over the last few decades as brachial plexus block. Bupivacaine is commonly employed as the local anaesthetic of the

brachial plexus anaesthesia due to the merit of having a prolonged action of activity and a positive sensory to motor neural block [2,3]. It especially helps in the postoperative control of pain since it has a longer analgesic effect and thus no systemic opioids are required and therefore no side effects.

The bupivacaine action mechanism is the inhibition of sodium channels that open in the neuronal membranes through voltage-gated channels. Bupivacaine connects to the internal section of the sodium channels and obstructs the entry of sodium into nerve cells, which avoids depolarization [4] . This causes the inhibition of action potentials travelling along the nerve fibres affecting the loss of sensation and motor activity in the area supplied. The most common amide group local anaesthetics are bupivacaine, which is metabolized in the liver through conjugation with glucuronic acid. Although its pharmacodynamic profile is favourable, clinical experience showed that it has serious safety issues related to its use. But, in clinical use, it was observed that the application of racemic combination of bupivacaine led to cardiac and central nervous system poisoning in a few patients [5]. Cardiotoxicity that results due to the use of bupivacaine is especially severe as it may result in refractory ventricular arrhythmia and myocardial depression, and the central nervous system toxicity may be present as seizures or comas. These negative effects have to do with its lipid solubility and affinity to bind cardiac sodium channels [6] through its strong binding ability.

Due to these safety issues, there has been an ongoing effort to find other long-acting local anaesthetic agents which are effective but with a better safety profile. Ropivacaine proved to be an alternative. Ropivacaine is a long-acting amide local anaesthetic that has a possibly better safety profile compared to bupivacaine [7]. Rorpivacaine is the pure S-enantiomer, and bupivacaine is a racemic mixture, chemically. This cardiotoxic and neurotoxic potential is reduced by this stereoselective formulation.

Ropivacaine is not as lipophilic as bupivacaine and is less likely to enter large, myelinated motor fibres leading to a comparatively low motor blockade. It is due to this property that ropivacaine gives rise to differential blockade, whereby sensory fibres over motor fibres are more susceptible to the ropivacaine. The level of motor sensory differentiation is higher in ropivacaine. It is selective to the pain carrying Aδ and C fibres, but not Aβ fibers, that are motor ones. This selective blockade is also useful in the ambulatory and orthopaedic surgery wherein there is a good recovery of motor activity as early as possible, and analgesia is also preserved [8].

Many comparisons involving ropivacaine and bupivacaine have indicated that ropivacaine has lesser cardiac and central nervous system toxic effects, lesser motor block and equal duration of action of sensory pain as bupivacaine [9]. Lower affinity with myocardial sodium channels and accelerated dissociation kinetics is the reason why ropivacaine has a lower cardiotoxic potential. As a result, ropivacaine has larger margin of safety when there is accidental intravascular injection or system absorption [10].

Despite the similarity between the two drugs as they are long-acting local anaesthetics, there are slight variations in the onset effect, quality of block, analgesia duration and motor activity recovery. These differences could have a strong impact on the condition of surgeries in the upper limbs, postoperative pain, and rehabilitation of patients in the case of surgeries that are conducted under axillary brachial plexus block. An extended motor blockade can put physiotherapy and discharge in delay, with the opposite effect on postoperative pain and analgesic use. Hence, it will be required to compare these agents under the standard clinical environment to identify the most appropriate drug to use on regular basis.

The axillary brachial plexus block is an ideal example of such comparison since it can be used to test sensory and motor blockade in various terminal nerves separately. It is also typically applied in daycare orthopaedic and hand surgeries, where quick healing and good postoperative pain control are also of the essence. Although both bupivacaine and ropivacaine are widely used, there is still controversy on the relative efficacy and safety of using both in equal dosage.

Therefore, there is a clinical interest in a prospective randomized trial of 0.5% bupivacaine versus 0.5% ropivacaine in the axillary brachial plexus block. Such a study may be used to assess emergence and duration of sensory and motor blockades, quality of anaesthesia, postoperative analgesia, haemodynamic and adverse effects. The results can inform anaesthesiologists to choose the best local anaesthetic in upper limb surgeries between efficacy and patient safety.

Considering the mentioned factors, the current study aimed to compare the clinical properties of 0.5% bupivacaine and 0.5% ropivacaine in terms of axillary brachial plexus block in patients who underwent surgeries on upper limbs with a particular focus on block properties, postoperative analgesia, and safety profile.

Methodology

Study Design: This study was a prospective, randomized, comparative clinical study conducted to evaluate and compare the efficacy and safety of 0.5% Bupivacaine and 0.5% Ropivacaine in axillary brachial plexus block for upper limb surgeries.

Study Area: The study was conducted in the Department of Anaesthesia, Medini Rai Medical

College and Hospital (MRMCH), Palamu, Jharkhand, India.

Study Duration: The study was carried out over a period of 8 months.

Sample Size: A total of 60 patients were included in the study.

Patients were randomly divided into two equal groups:

- **Group B (n = 30):** Received 30 ml of 0.5% Bupivacaine
- **Group R (n = 30):** Received 30 ml of 0.5% Ropivacaine

Randomization was done using a computer-generated randomization table and allocation concealment by sealed opaque envelopes.

Study Population: Patients scheduled for elective upper limb surgery under axillary brachial plexus block in the Department of Orthopaedics and General Surgery were considered for inclusion.

Inclusion Criteria

- Adult patients aged 18–60 years
- ASA Physical Status Grade I and II
- Patients posted for elective upper limb surgeries under brachial plexus block
- Patients willing to participate and giving written informed consent
- No known allergy to amide local anaesthetics

Exclusion Criteria

- Patient refusal
- ASA Grade III or IV
- Local infection at injection site
- Coagulation disorders or anticoagulant therapy
- Peripheral neuropathy or neuromuscular disease
- Significant cardiac, renal, hepatic or respiratory disease
- Pregnancy
- Morbid obesity
- Uncooperative or psychiatric patients
- Known hypersensitivity to study drugs

Data Collection: All patients underwent detailed pre-anaesthetic evaluation including history, general physical examination, airway assessment and routine laboratory investigations. Patients were kept nil per oral for 6–8 hours prior to surgery. Baseline vital parameters including heart rate, blood pressure, respiratory rate and oxygen saturation were recorded before the block and monitored throughout the procedure and postoperative period.

Procedure: After shifting the patient to the operation theatre, an intravenous line was secured, and baseline vital parameters were recorded. Patients were premedicated with intravenous midazolam 1–2 mg. The patient was positioned supine with the operative arm abducted to 90 degrees. Under strict aseptic precautions, the axillary brachial plexus block was performed using the paresthesia technique. The skin was infiltrated with 1 ml of 1% lignocaine. After locating the brachial plexus sheath and confirming negative aspiration, the study drug was injected in 5 ml increments with repeated aspiration to avoid intravascular injection. Group B received 30 ml of 0.5% bupivacaine while Group R received 30 ml of 0.5% ropivacaine. Patients were observed for onset of block and intraoperative comfort.

Sensory block was assessed using pinprick method over the distribution of median, radial, ulnar and musculocutaneous nerves at 5-minute intervals for 30 minutes and then hourly. Motor block was assessed using the modified Bromage scale for upper limb. Block failure was defined as absence of surgical anesthesia within 30 minutes and such patients were converted to general anesthesia and excluded from analysis.

Postoperative pain was assessed using the Visual Analogue Scale (VAS) at regular intervals. Rescue analgesia in the form of intramuscular diclofenac sodium (1.5 mg/kg) was administered when VAS score reached 6. Duration of sensory block, motor block and analgesia were recorded. Hemodynamic parameters were monitored and any complications such as hypotension, bradycardia, nausea, vomiting, vascular puncture or signs of local anesthetic toxicity were noted.

Statistical Analysis: All collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software. Quantitative data were expressed as mean and standard deviation while qualitative data were presented as frequency and percentage. Comparison between the two groups was performed using unpaired Student's t-test for continuous variables and chi-square test for categorical variables. Repeated measures were analyzed using analysis of variance (ANOVA). A p-value of less than 0.05 was considered statistically significant."

Result

Table 1 compares demographic variables between Group B and Group R (n=30 each) and shows no significant differences. The mean age was 36.84 ± 10.92 years in Group B vs 35.71 ± 11.36 years in Group R (t=0.398, p=0.692). Gender distribution was similar with male:female ratio 19:11 vs 18:12 (χ^2=0.069, p=0.793). Mean body weight was also comparable (59.08 ± 8.94 kg vs 57.96 ± 9.21 kg; t=0.477, p=0.635). Since all p-values were >0.05, the two groups were demographically comparable at baseline.

Table 1: Comparison of Demographic Variables between the Two Groups			
Characteristic	**Group B (n=30)**	**Group R (n=30)**	**Significance of difference**
Mean Age ± SD (years)	36.84 ± 10.92	35.71 ± 11.36	t = 0.398; p = 0.692
Male : Female	19:11	18:12	χ^2 = 0.069; p = 0.793
Body weight (kg) Mean ± SD	59.08 ± 8.94	57.96 ± 9.21	t = 0.477; p = 0.635

Table 2 demonstrates significant differences in sensory block characteristics between Group B and Group R. The onset of sensory block was significantly faster in Group R (7.90 ± 1.90 min) compared to Group B (11.90 ± 2.40 min) with t = 7.22, p < 0.001. However, the duration of sensory block was significantly longer in Group B (452.20 ± 48.30 min) than in Group R (419.60 ± 36.80 min) with t = 2.94, p = 0.005. Therefore, Group R provided quicker onset, whereas Group B produced a more prolonged sensory blockade.

Table 2: Comparison of Sensory Block Characteristics				
Variable	**Group B (n=30) Mean ± SD**	**Group R (n=30) Mean ± SD**	**t value**	**p value**
Onset of sensory block (min)	11.90 ± 2.40	7.90 ± 1.90	7.22	<0.001 (S)
Duration of sensory block (min)	452.20 ± 48.30	419.60 ± 36.80	2.94	0.005 (S)

Table 3 shows a significant difference in motor block characteristics between Group B and Group R. The onset of motor block was significantly faster in Group R (15.00 ± 3.30 min) compared to Group B (23.80 ± 4.10 min) with t = 9.21, p < 0.001. However, the duration of motor block was significantly longer in Group B (410.60 ± 52.10 min) than in Group R (368.40 ± 39.60 min) with t = 3.54, p = 0.001. Thus, Group R produced quicker onset whereas Group B produced more prolonged motor blockade.

Table 3: Comparison of Motor Block Characteristics				
Variable	**Group B (n=30) Mean ± SD**	**Group R (n=30) Mean ± SD**	**t value**	**p value**
Onset of motor block (min)	23.80 ± 4.10	15.00 ± 3.30	9.21	<0.001 (S)
Duration of motor block (min)	410.60 ± 52.10	368.40 ± 39.60	3.54	0.001 (S)

Table 4 compares the duration of analgesia between Group B and Group R. The mean duration was 8.40 ± 0.96 hours in Group B and 8.62 ± 0.72 hours in Group R, with a t value of −1 and p = 0.321, which is not statistically significant. This indicates that both groups provided a similar duration of postoperative analgesia.

Table 4: Duration of Analgesia				
Variable	**Group B (n=30)**	**Group R (n=30)**	**t value**	**p value**
Duration of analgesia (hours) Mean ± SD	8.40 ± 0.96	8.62 ± 0.72	-1	0.321 (NS)

Table 5 presents heart rate changes between Group B and Group R over time and shows comparable values throughout the observation period. At baseline, heart rate was 82.6 ± 6.8 vs 84.1 ± 7.2 beats/min (p=0.401); at 5 min 81.3 ± 6.4 vs 83.7 ± 6.9 (p=0.213); at 10 min 80.9 ± 6.2 vs 83.0 ± 6.7 (p=0.228); at 20 min 79.6 ± 5.8 vs 82.4 ± 6.3 (p=0.091); and at 30 min 80.1 ± 5.7 vs 82.0 ± 6.0 (p=0.184) respectively. As all p-values were greater than 0.05, there was no statistically significant difference in heart rate between the two groups at any time interval, indicating similar cardiovascular response in both groups.

Table 5: Heart Rate Changes (beats/min)			
Time Interval	**Group B Mean ± SD**	**Group R Mean ± SD**	**p value**
Baseline	82.6 ± 6.8	84.1 ± 7.2	0.401
5 min	81.3 ± 6.4	83.7 ± 6.9	0.213
10 min	80.9 ± 6.2	83.0 ± 6.7	0.228
20 min	79.6 ± 5.8	82.4 ± 6.3	0.091
30 min	80.1 ± 5.7	82.0 ± 6.0	0.184

Table 6 compares mean arterial pressure (MAP) between Group B and Group R over time, showing similar hemodynamic stability in both groups. At baseline, MAP was 93.4 ± 5.6 mmHg vs 94.7 ± 6.1 mmHg (p=0.389), at 5 min 92.1 ± 5.4 vs 93.8 ± 5.7 (p=0.267), at 10 min 91.5 ± 5.2 vs 93.3 ± 5.8 (p=0.203), at 20 min 90.8 ± 5.0 vs 92.9 ± 5.6 (p=0.154), and at 30 min 90.2 ± 4.9 vs 92.1 ± 5.2 (p=0.17) respectively. Since all p-values were greater than 0.05, no statistically significant difference in MAP was observed at any time interval, indicating comparable cardiovascular stability between the two groups.

Table 6: Mean Arterial Pressure (mmHg)

Time Interval	Group B Mean ± SD	Group R Mean ± SD	p value
Baseline	93.4 ± 5.6	94.7 ± 6.1	0.389
5 min	92.1 ± 5.4	93.8 ± 5.7	0.267
10 min	91.5 ± 5.2	93.3 ± 5.8	0.203
20 min	90.8 ± 5.0	92.9 ± 5.6	0.154
30 min	90.2 ± 4.9	92.1 ± 5.2	0.17

Table 7 presents the adverse effects observed in Group B and Group R (n=30 each), showing a low and comparable complication rate between the groups. Nausea occurred in 2 (6.7%) patients in Group B vs 1 (3.3%) in Group R (p=0.554), bradycardia in 1 (3.3%) vs 0 (p=0.313), and hypotension in 1 (3.3%) vs 1 (3.3%) (p=1.0) respectively. No cases of CNS toxicity were reported in either group. As all p-values were >0.05, there was no statistically significant difference in adverse effects between the two groups, indicating both interventions had similar safety profiles.

Table 7: Adverse Effects

Complication	Group B (n=30)	Group R (n=30)	p value
Nausea	2 (6.7%)	1 (3.3%)	0.554
Bradycardia	1 (3.3%)	0	0.313
Hypotension	1 (3.3%)	1 (3.3%)	1
CNS toxicity	0	0	—

Discussion

The current prospective randomized trial showed that the two groups were demographically matched such that differences in results could be due to the nature of drugs as opposed to differences in patients. It has been found that similar baseline comparability has been observed in previous regional anesthesia trials comparing brachial plexus block agents and this confirms the reliability of comparative pharmacodynamic assessment (Klein et al., 1998) [11]. We thus have a valid platform to use which can directly compare the onset, duration and safety of 0.5% bupivacaine and 0.5% ropivacaine, in axillary brachial plexus block."

An important observation in our study was that sensory block was formed much faster when ropivacaine was used (7.90 +1.90 min) in comparison with bupivacaine (11.90 +2.40 min). This is in line with the findings of Bertini et al. (1999) [1] who stated previously total sensory blockage with ropivacaine 10-20 minutes after injection than with bupivacaine. Equally, the results on the onset of sensations related to our study are closely similar to the prior discussion study (8.88 ± 1.74 min vs 12.04 ± 2.57 min), which once again confirms that ropivacaine has a greater diffusion rate in neural tissue. Nevertheless, the opposite outcomes were encountered by Klein et al. (1998) [11] who found the onset of the two drugs to take less than 6 minutes under interscalene block. This variation is probably explained by differences in anatomical approach since interscalene blocks are more oriented to nerve roots, and thus they have a faster onset when compared to axillary approaches. Mageswaran and Choy (2010) [12] sensory onset was 13.5 ± 2.9 min with ropivacaine as compared to our findings, which could also be due to the intraclavical procedure and heterogeneous surgical population.

In our case, motor block was also achieved much earlier with ropivacaine (15.00 ± 3.30 min) than with bupivacaine (23.80 ± 4.10 min). These results once again are in line with Bertini et al. (1999) [1] who showed increased levels of complete motor block earlier on in the ropivacaine group. The previous discussion section has also observed that motor block starts at 5 minutes with ropivacaine compared to 20 minutes with bupivacaine. The increased rate of onset using ropivacaine could be attributed to the lower pKa and increased percentage of unionized drug to penetrate nerves. Nonetheless, Klein et al. (1998) [11] did not find any difference in the onset between the drugs, as drug concentration and block site played an important role in determining the onset kinetics.

Although, bupivacaine had slower onset, the sensory (452.20 ± 48.30 min vs 419.60 ± 36.80 min) and motor blockade (410.60 ± 52.10 min vs 368.40 ± 39.60 min) were significantly longer. Such results are in

line with the findings of McGlade et al. (1998) [9], who had shown a shorter blockade period using ropivacaine in axillary brachial plexus block. The same discussion had attributed more time of stay in the bupivacaine group. Bupivacaine is more lipid soluble and protein binding with resultant long neural retention and hence longer block (Arthur et al., 1988) [8]. Similar results were observed by Junca et al. (2001) [13], when ropivacaine was reported to be less time consuming in cervical plexus block as compared to bupivacaine. Therefore, ropivacaine works fast whereas bupivacaine is persistent.

Interestingly, the duration of analgesia in our study did not differ between groups (8.40 +0.96 h vs 8.62 + 0.72 h; p = 0.321). Similar results were observed by Thornton et al. (2003) [10] during the use of the two drugs; no significant difference was found in the postoperative analgesia between the two drugs in pediatric axillary block. Similar analgesic effectiveness between long-acting amide anesthetics was also reported by Mageswaran and Choy (2010) [12]. This is to imply that bupivacaine extends the sense block, but the analgesia duration may be affected by the central pain modulation and surgical conditions and not by the pure duration of sensory block.

The hemodynamic stability between the two groups was similar during our period of observation. Mean arterial pressure and heart rate did not exhibit statistically significant intergroup differences to argue that cardiovascular safety of the two agents is safe. As it was shown in the study by Scott et al. (1989) [7], the cardiotoxic potential of ropivacaine is lower than that of bupivacaine, but at clinical doses, both drugs are hemodynamically stable. This is also in line with the previous observations in discussions as well as other clinical trials which have provided minimal cardiovascular disturbances during peripheral nerve blocks (Crews et al., 2002) [14].

The adverse effects were low in both groups, nausea was present in 6.7-3.3, bradycardia in one patient of bupivacaine, and hypotension in one patient on each side. No CNS toxicity occurred. Such findings are in line with comparative toxicity investigations that have shown that there is low systemic toxicity of ropivacaine but general good toxicity of the two agents in peripheral blocks (Scott et al., 1989) [7]. As described by Clarkson and Hondeghem (1985) [4], the sodium channel binding of bupivacaine is one of the causes of cardiotoxic risk at high plasma levels, yet peripheral nerve block doses are safe, which is also evident in our study.

On the whole, we find that there is a pharmacodynamic trade-off: ropivacaine has a shorter time to onset of sensory and motor blockade, but bupivacaine has a longer blockade duration. Ropivacaine can prove beneficial in cases where the clinician wants fast surgical readiness, and the patient recovers quicker and bupivacaine can be useful where the patient needs an extended period of anesthesia. The two agents showed comparable analgesia time duration and a high level of hemodynamic safety; hence they are reliable in the use of axillary brachial plexus block.

Conclusion

This is a prospective randomized trial that illustrates that 0.5 percent bupivacaine and 0.5 percent ropivacaine are effective and safe axillary brachial plexus block predictors with similar demographic backgrounds and hemodynamic stability of both groups. Ropivacaine had a much faster sensory and motor block onset reaction whereas bupivacaine had a longer sensory and motor blockade duration. The two drugs were similar in terms of the postoperative analgesia time. There were few negative effects in both test groups, and no severe complications were identified in any of them. On the whole, ropivacaine can be considered a choice in the case of the need to achieve early onset and high speed of motor recovery, whereas bupivacaine can be an advantage in the case of the necessity to have a longer block of action which is clinically favorable.

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