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Research Article

Comparative Study between Efficacies of Different Concentration of Ropivacaine (0.75% Vs 0.5%) In USG Guided Supraclavicular Brachial Plexus Block In Upper Limb Surgeries

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ABSTACT

Background: Regional anaesthesia using brachial plexus block is widely preferred for upper limb surgeries, with ultrasound guidance improving accuracy and safety. Ropivacaine, a long-acting amide local anaesthetic with reduced cardiotoxicity compared to bupivacaine, provides differential sensory and motor blockade depending on concentration. Determining the optimal concentration for effective block with minimal motor impairment and toxicity is clinically important. The aim of this study was to evaluate the efficacy of different concentrations of ropivacaine, (0.5% and 0.75%) in supraclavicular brachial plexus block in upper limb surgeries.

Material and Methods A prospective, blinded randomized study was conducted, enrolling 64 patients of either sex, American Society of Anesthesiologists (ASA) I and II, who were allocated into two groups in which supraclavicular brachial plexus block was performed using ropivacaine in concentrations of 0.5% and 0.75%, respectively. The onset and duration of sensory and motor blocks were recorded.

Results: The sensory and motor blockade onset and duration was longer in patients who received ropivacaine 0.75%, in comparison to patients who received ropivacaine 0.5%. The time to first rescue analgesia was longer with Ropivacaine 0.75% (12.27 ± 2.34 hours vs. 9.32 ± 1.17 hours; p = 0.001). Both the concentration of Ropivacaine maintained stable haemodynamics, with no major adverse effects reported.

Conclusion: The results suggest that 0.5% ropivacaine is optimal for most routine upper limb surgeries, reserving 0.75% for longer procedures or when extended analgesia is desired. Both concentrations were well-tolerated without any significant complications.

Keywords: Regional Anaesthesia, Monitored Anaesthesia Care, Ropivacaine, Sensory And Motor Blockade, Brachial Plexus Block, Postoperative Analgesia.

INTRODUCTION

Regional anaesthesia has become an integral component of modern anaesthetic practice, providing excellent intraoperative anaesthesia as well as postoperative analgesia. Among the various regional techniques, brachial plexus block is one of the most frequently performed procedures for upper limb surgeries, offering the advantage of dense anaesthesia, muscle relaxation, and prolonged postoperative pain relief while avoiding the systemic side effects and airway manipulation associated with general anaesthesia [1,2]. The supraclavicular brachial plexus block is favored for ambulatory upper extremity procedures (excluding shoulder surgeries) and is often described as the "spinal of the upper limb" due to its rapid onset, reliable anesthesia, and safety profile [3,4].

A successful peripheral nerve block, including a brachial plexus block for upper limb surgery, depends on the choice of local anesthetic (LA), drug concentration, and block techniques. The onset, duration, quality, and possibility of adverse effects of anesthesia are all greatly influenced by the type of LA used during the procedure [5]. Ropivacaine, a long-acting amide local anaesthetic structurally similar to bupivacaine, has gained popularity in peripheral nerve blocks due to its favourable safety profile and lower cardiotoxic potential. It produces differential blockade, causing greater sensory than motor block at lower concentrations, which can be advantageous in outpatient and postoperative settings where early motor recovery is desirable [6,7,8]. Nevertheless, the optimal concentration of ropivacaine for achieving effective anaesthesia while minimizing motor blockade and systemic toxicity remains an area of active research. Several studies have evaluated the efficacy of different concentrations of ropivacaine in peripheral nerve blocks, but data comparing 0.5% and 0.75% ropivacaine in ultrasound-guided supraclavicular brachial plexus block are limited and sometimes inconsistent.

The traditional landmark guided or nerve stimulator techniques are associated with variable success rates and potential complications such as pneumothorax or intravascular injection. The advent of ultrasound guidance (USG) has revolutionized regional anaesthesia by allowing real-time visualization of neural structures, local anaesthetic spread, and adjacent vascular anatomy. This has enhanced block success rates, reduced complications, and permitted the use of lower volumes and concentrations of local anaesthetics [9,10].

Therefore, this study aims to compare the efficacy of 0.75% ropivacaine Vs 0.5% ropivacaine in ultrasound-guided supraclavicular brachial plexus block in patients undergoing upper limb surgeries. The primary outcomes assessed include the onset and duration of sensory and motor block, and the duration of postoperative analgesia. Secondary outcomes include haemodynamic stability and incidence of adverse effects. Through this evaluation, we seek to determine the optimal concentration of ropivacaine that provides effective anaesthesia and analgesia with minimal motor blockade and maximal safety in clinical practice.

MATERIALS AND METHODS

Study Design and Sample Size

This is a prospective, double-blind, randomized clinical study conducted in the Department of Anaesthesiology, VIMSAR, Burla, a tertiary medical center in Odisha, India, from October 2025 to May 2026, after ethical approval was obtained from the institute's Ethics Committee (VIREC No-001-2025/I/S/T/003/Dt.25.09.2025). Written informed consent was obtained from all participants.

The sample size was calculated based on a previous study by Ruban I et al. [11], Considering formula for repeated measures between factors using software G.*power 3.1, taking effect size of 0.3, α-error 0.05, β- error 0.2 (20%), no. of groups 2 & total no. of repeated measurements 8, the sample size calculated was 52, 26 in each group. Assuming of block failure of 20%, total sample size is 52+12= 64, 32 in each group.

Inclusion and Exclusion Criteria

Adult participants scheduled for upper limb surgeries under brachial plexus block were screened for eligibility. Participants aged between 18 and 60 years of any gender, and belonging to the American Society of Anesthesiologists (ASA) physical status I and II, were included in the study. Patients who refused consent, BMI≥30, had a known allergy to local anesthetics, infection at the block site, bleeding disorders, evidence of coagulopathy, H/o any neurologic or psychiatric disorders, Hemi-diaphragmatic paralysis contralateral to the site of surgery, Active liver, renal or chronic renal impairment, alcohol or drug abuse, pregnant or lactating mother, and chronic opioid use, were excluded.

Randomization and Allocation

Sixty-four patients who underwent elective forearm surgery under USG guided Supraclavicular brachial plexus block were randomly recruited and divided into two groups. Computer-generated random sequence was concealed in a sealed opaque envelope. (Figure-1).

Group A: Patients received 20ml of 0.5% Ropivacaine in USG guided Supraclavicular brachial plexus block.

Group B: Patients received 20ml of 0.75% Ropivacaine in USG guided Supraclavicular brachial plexus block.

The drugs were prepared by an anesthesiologist not involved in the study. Anesthesiologists who observed the patient and

surgeon were also made unaware of the study group until the end of the study.

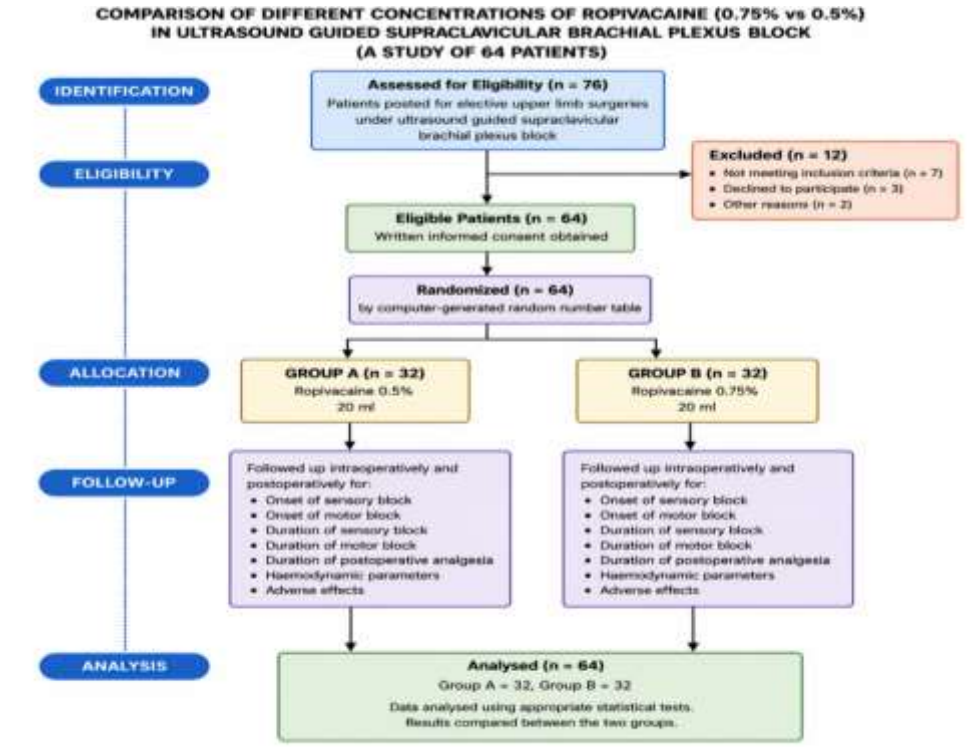

Figure-1. Consort Flow Diagram.

METHODOLOGY

A detailed preanesthetic check-up was performed a day before surgery. Details pertaining to the patient's clinical history, general physical and systemic examinations and basic routine investigations were obtained and patients were kept in NPO of solid food for 8 hours and of clear fluids up to 2 hours before the anaesthesia. Patients were explained in their own vernacular language about the brachial plexus block and linear visual analogue score using a 10centimeter line, where 0 denoted "no pain" while 10 "worst pain imaginable". All patients were given tablet alprazolam 0.5mg orally on the night before surgery and two hours prior to the surgery with sips of water.

In the operating room, intravenous line with 20 G cannula was secured and an infusion of ringer lactate was started. All the monitors (NIBP, ECG, SpO2) were attached and the readings were taken as baseline recordings. Patients were explained about the procedure. For supraclavicular approach, the patient was placed in supine position with the head turned 45 degrees to the contralateral side. The arm to be anaesthetized was adducted and extended along the side towards the ipsilateral knee as far as possible. A high-frequency linear ultrasound transducer (6–13 MHz) and a 22G, 50 mm sonographic block needle were used under strict aseptic precautions. The transducer is positioned in the transverse plane immediately proximal to the clavicle, slightly posterior to at its midpoint. The transducer is tilted caudally, as if to image the chest contents, to obtain a cross-sectional view of the subclavian artery (Figure 2). The brachial plexus is seen as a collection of hypoechoic oval structures posterior and superficial to the artery. Using a 25- to 27-gauge needle, 1–2 mL of local anaesthetic is injected into the skin 1 cm lateral to the transducer to decrease discomfort during needle insertion. The sonographic needle is then inserted in plane toward the brachial plexus under real-time ultrasound guidance, in a lateral-to-medial direction. When the needle reached the plexus, after negative aspiration, the assigned study drug was injected in 5-mL increments around the plexus sheath to ensure uniform spread.

Figure 2: Procedure of Ultrasound Guided Supraclavicular Brachial Plexus Block

Assessment Parameters: Assessment of sensory block was done by the 3-point Gormley and Hill scale of pain by pinprick with 23G needle (0= normal sensation, 1=Pin prick recognized as touch with blunt object, 2= complete loss of sensation) [12].

Onset of sensory block: The completion of injection of study drug to loss of pinprick sensation of Gormley and Hill scale of grade 1 in all dermatomes. Time to peak sensory effect was noted when complete loss of sensation (Gormley and Hill scale of grade 2)

Duration of sensory block: the time from the onset to the return of dull/blunt pain sensation (grade 1).

Assessment of motor block was done by Modified Lovett rating scale ranging from 6 to 0. (6 = normal muscular force, 5 = slightly reduced muscular force, 4 = pronounced reduction of muscular force, 3 = slightly impaired mobility, 2 = pronounced mobility impairment, 1 = almost complete paralysis, 0 = complete paralysis) [13].

Onset of motor block: The completion of injection of study drug to loss of motor power of Modified Lovett rating scale (MLRS) grade 4. A motor block of scale 2 was considered as endpoint for the start of surgery.

Duration of motor block: Time from onset to recovery of motor power (MLRS) grade 5.

Intensity of pain: assessed by 0-10 linear visual Analogue Scale (VAS) at 0,1,2,4,6,12 and 24 hours interval.

Time to first rescue analgesia: Interval between completion of block and first request for analgesic (VAS ≥ 4). Rescue analgesia was provided with intravenous diclofenac 75 mg when VAS ≥ 4. Total analgesic consumption in the first 24 hours was recorded.

Hemodynamic parameters: Heart rate, systolic and diastolic blood pressure, and oxygen saturation were recorded at baseline and every 10 min intraoperatively.

Adverse effects: Incidence of vascular puncture, local anesthetic systemic toxicity (LAST), Horner's syndrome, or neurological deficits were noted. Every patient was monitored for any adverse reactions like bradycardia (HR <50), hypotension (Decrease MAP>20% of baseline, PONV and respiratory

distress. If there was any adverse effect managed accordingly.

Block failure was defined as failure to achieve both a sensory block of 2 (complete loss of touch sensation) and a motor block score of 2 within 30 minutes of block performance in the distribution of the targeted peripheral nerve. Any requirement of additional rescue blocks also classified as block failure.

Statistical Analysis: Data were analyzed using SPSS version 25.0 [Illinois, Chicago: SPSS Inc., 2017]. Continuous variables were expressed as mean ± standard deviation (SD) and analyzed using the unpaired Student's t-test. Categorical variables were compared using the Chi-square test or Fisher's exact test as appropriate. A *p*-value < 0.05 was considered statistically significant.

RESULT

A total of 76 patients undergoing elective upper-limb surgeries under ultrasound-guided supraclavicular brachial plexus block were enrolled. Twelve patients were excluded from the study, leaving 64 participants for analysis, with 32 in each group. The CONSORT flow diagram of recruitment, allocation, follow-up, patient analysis, and causes of exclusion is shown Figure-1.

Both groups were comparable in baseline demographic and clinical characteristics, including age, sex distribution, body mass index (BMI), ASA physical status, and mean duration of surgery ($p > 0.05$), as shown in Table 1. This indicates adequate randomization and homogeneity between the groups prior to intervention.

Table 1. Baseline Demographic and Clinical Characteristics between Two Groups

Variables	Group A (n=32)	Group B (n=32)	p-value
Sex (M: F)	12:22	15:19	0.78
Age (Years)	38.01 ± 15.103	35.28 ± 12.337	0.43
Body Weight (Kg)	61.12 ± 9.431	65.96 ± 10.97	0.062
Height(cm)	155.03 ± 11.04	161.68 ± 8.543	0.09
ASA-PS (I: II)	18:14	15:17	0.84
Durationof 74±20 0.63 surgery(mins)	85 ± 39.58	91 ± 29.43	0.63

The onset of sensory and motor block was significantly faster in Group B (ropivacaine 0.75%) (9.04 ± 2.13 min and 11.13 ± 3.21 min, respectively) compared to Group A (ropivacaine 0.5%) (12.23 ± 3.56 min and 15.36 ± 4.34 min, respectively). The duration of sensory block and motor block were also significantly longer with Group B (10.16 ± 1.04 hours and 9.61±1.7 hours, respectively) compared with Group A (8.32 ± 1.2 hours and 7.40±1.23 hours, respectively) ($p = 0.003$ and $p = 0.027$). Similarly, the time to first rescue analgesic requirement was markedly prolonged in Group B (12.27 ±2.34 hours) compared with the Group A (9.32±1.17 hours), demonstrating a statistically significant difference ($p = 0.006$). [Table 2, 3,4]. Additionally, the mean number of analgesic doses required was lower in Group B (1.37±0.49 doses) compared to Group A (1.15±0.36 doses). The total amount of diclofenac required was also significantly less in Group B (165 ± 15.53 mg) than in Group A (186 ± 32.45 mg), with a p-value of < 0.001.

Table 2: Comparison of Onset & Duration of Sensory Block between Two Groups

Sensory Block	Group A (R 0.05%)	Group B (R 0.75%)	P Value
Time To Achieve Gr.1 (Mins) (Onset Of Sensory Block)	12.23±3.56	9.04±2.13	0.016
Time To Achieve Gr.2 (Mins)	16.61±3.42	11.17±2.37	0.002
Duration Of Block (Hours)	8.32±1.21	10.16±1.04	0.003

Table 3: Comparison of Onset & Duration of Motor Block between Two Groups

Motor Block	Group A (R 0.05%)	Group B (R 0.75%)	P Value
Time To Achieve MLRS Gr.4 (Mins) (Onset Of Motor Block)	15.36±4.34	11.13±3.21	0.020
Time To Achieve MLRS Gr.0 (Mins)	20.56±4.02	16.15±3.36	0.017
Duration (Hours)	7.40±1.23	9.61±1.7	0.027

Table 4: Comparison of Rescue Analgesia between Two Groups

	Group A	Group B	P-Value
Time To First Rescue Analgesia (Hrs.)	9.32±1.17	12.27±2.34	0.006
Mean Numbers Of Rescue Analgesia Requirements	1.37±0.49	1.15±0.36	0.002
The Total Amount Of Diclofenac Required (Mg)	196 ± 32.45	165 ± 15.53	< 0.001

Heart rate, systolic and diastolic blood pressure, mean arterial pressure, and peripheral oxygen saturation in percentage (SpO2) were all normal in both groups during the procedure and after the block and the differences between the two groups were not statistically significant (Figure 2, 3).

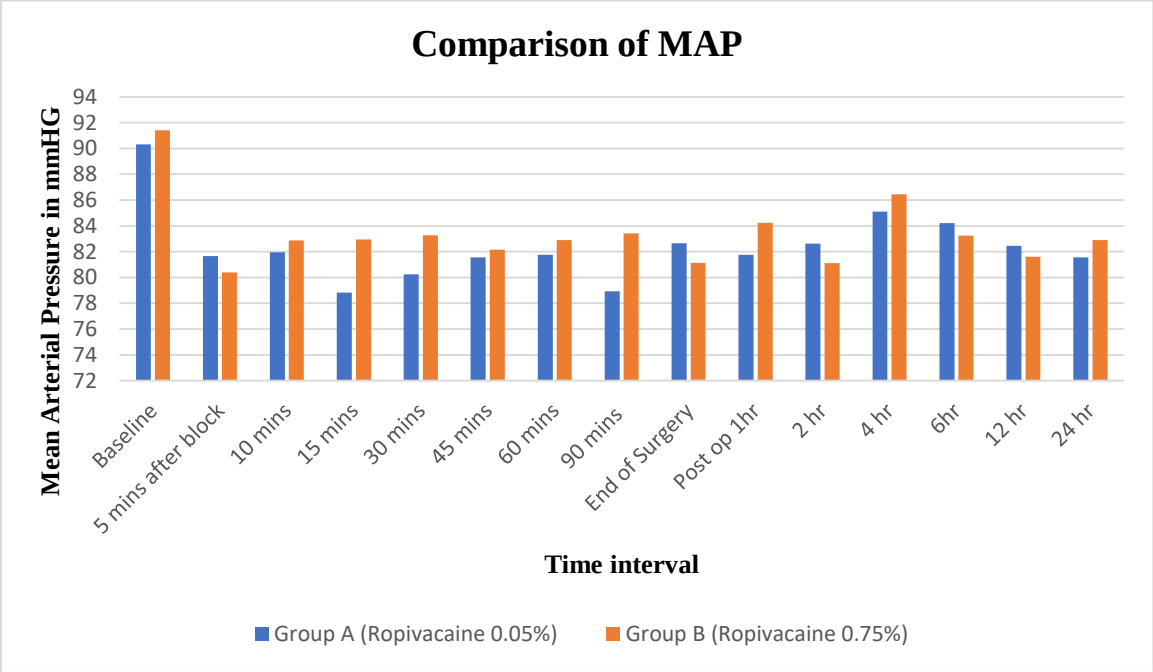

Figure 2: Comparison of Mean Arterial Pressure between Two Groups

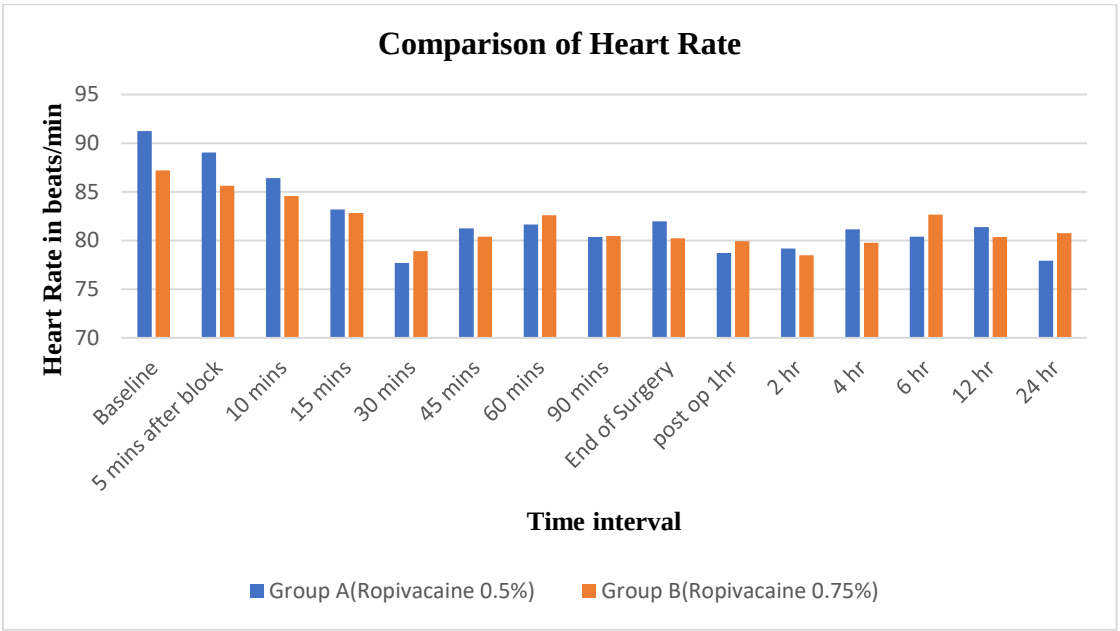

Figure 3: Comparison of Heart Rate between Two Groups

DISCUSSION

Regional anaesthesia is now an important aspect of upper limb surgery due to its capability to provide dense surgical anaesthesia, decrease opioid consumption, and provide residual analgesia postoperatively. The supraclavicular approach achieves rapid and complete blockade of the upper limb below the shoulder. 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 [6]. 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 [7]. 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 [14,15]. With development of ultrasound, the ability to image the plexus, rib, pleura, subclavian artery and real time needle tracking with ultrasound probe improves the safety and quality of block. In the present study, we evaluated two concentrations of ropivacaine—0.75% and 0.5% in ultrasound-guided supraclavicular brachial plexus block.

In this study, the onset of both sensory and motor block was significantly faster in the group B (ropivacaine 0.75%) compared to the group A (ropivacaine 0.5%). This finding correlates with the pharmacodynamic principle that higher concentration of local anaesthetic produces a steeper diffusion gradient across the nerve membrane, facilitating quicker penetration of the drug into the axoplasm and faster blockade of sodium channels [16]. 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 [17]. 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. Jain et al., also reported similar results in supraclavicular blocks, with faster onset in the higher concentration group [18]. The results of the current study thus reinforce that increasing concentration accelerates block onset.

The duration of sensory and motor blockade was significantly prolonged in the group B (0.75%). A higher concentration maintains a greater perineural concentration gradient, resulting in sustained sodium channel inhibition and prolonged anaesthetic effect. These findings are consistent with those of Gupta et al. [19] who observed longer duration of sensory block with 0.75% ropivacaine, and motor recovery was delayed compared with 0.5% ropivacaine in spinal anaesthesia. The clinical implication is that although 0.75% ropivacaine provides longer analgesia, it may be less desirable when early motor recovery is advantageous—such as in day-care or hand surgeries where early limb function is preferred.

In the present study, postoperative analgesia was significantly prolonged with 0.75% ropivacaine (12.27±2.34 hours) compared to 0.5% ropivacaine (9.32±1.17 hours). The superior analgesic duration can be attributed to the extended sensory blockade achieved by the higher concentration. Kuthiala G et al., highlighted this concentration- dependent differential block property of ropivacaine, which is particularly beneficial when lower concentrations can maintain sensory block with limited motor impairment (6). The present study supports these observations, suggesting that 0.5% ropivacaine may be a suitable alternative when postoperative mobility and safety are priorities.

Both concentrations of ropivacaine were associated with stable haemodynamics throughout the intra- and postoperative periods. This is in keeping with the known favourable safety profile of ropivacaine compared to bupivacaine, owing to its lower lipid solubility and decreased cardiotoxic potential. No episodes of local anaesthetic systemic toxicity, pneumothorax, or significant adverse effects were observed in either group, demonstrating the safety of both concentrations under ultrasound guidance. These results are comparable with the findings of Karmakar et al., who reported a low incidence of complications with ultrasound-guided blocks, even with reduced volumes and concentrations of local anaesthetics [20].

The findings in the current study suggest that the higher dose leads to a longer duration of block, potentially reducing the need for repeated interventions during longer

procedures and improving overall patient comfort. The reduced need for rescue analgesia and lower overall analgesic consumption associated with the higher concentration (Ropivacaine 0.75%) imply better postoperative pain control. Better patient outcomes, a speedier recovery, and possibly fewer adverse effects linked to the overuse of analgesics could result from this. Optimizing resource utilization in healthcare settings may be possible with an understanding of how various doses affect analgesic requirements. Using doses that lead to lower analgesic consumption may have cost-saving implications and reduce the workload on healthcare providers.

For prolonged surgeries or when extended postoperative analgesia is desired, 0.75% ropivacaine may be preferable. Conversely, for ambulatory or shorter procedures, 0.5% ropivacaine can be considered sufficient and safer. Both medications were well tolerated with stable hemodynamics and no significant non-expected complications, indicating that either medication can be chosen regardless of the patient's clinical presentation.

Limitations

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 mentioned results. The study population was limited to ASA I–II patients aged 18–50 years-old, limiting the applicability to elderly patients with higher comorbidity.

CONCLUSION

Both 0.75% and 0.5% ropivacaine provide effective and safe anaesthesia for ultrasound-guided supraclavicular brachial plexus block. Both concentrations maintained stable haemodynamics and had no significant complications under ultrasound guidance. The results suggest that 0.5% ropivacaine may be optimal for most routine upper limb surgeries, reserving 0.75% for longer procedures or when extended analgesia is desired. Thus, the choice of concentration should be tailored to the surgical duration and postoperative requirements.

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Conflicts of Interest:

There are no conflicts of interest.

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