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Original Research

A Comparative Study between Two Different Volumes of 0.5% Ropivacaine in Ultrasound Guided Supraclavicular Brachial Plexus Block for Upper Limb Surgeries: A Randomized Control Study

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ABSTRACT:

Background: The efficacy of regional anesthesia techniques continues to evolve with advancements in ultrasound guidance. This study investigated whether reducing the volume of local anesthetic in ultrasound-guided supraclavicular brachial plexus block could maintain clinical efficacy while potentially reducing complications. We compared two different volumes of 0.5% ropivacaine to determine the optimal volume for upper limb surgeries.
Methods: A prospective, randomized, double-blind study was conducted on seventy patients undergoing elective upper limb surgeries. Participants were randomly allocated into two groups: Group A (n=35) received 20 mL and Group B (n=35) received 30 mL of 0.5% ropivacaine. Primary outcomes included onset and duration of sensory and motor blockade. Secondary outcomes included hemodynamic stability, time to first analgesic requirement, and complications.
Results: The demographic characteristics were comparable between both groups. The onset of sensory block in Group A was 14.11 ± 3.279 mins and Group B was 13.46 ± 3.355 mins (P>0.05), while the onset of motor block in Group A was 18.29 ± 3.177 mins and Group B was 17.37 ± 3.473 mins (P>0.05), showing no significant difference in initial block characteristics. The duration of sensory block in Group A was 7.54 ± 1.400 hours and in Group B was 9.11 ± 1.762 hours (P<0.01), and the duration of motor block in Group A was 6.51 ± 1.422 hours and in Group B was 8.26 ± 1.804 hours (P<0.01), demonstrating significantly longer block duration with the larger volume. The mean time for first analgesic requirement in Group A was 10.69 hours and in Group B was 11.69 hours (P<0.05). Hemodynamic parameters remained stable in both groups, though Mean Arterial Pressure was consistently lower in Group B (P<0.05). Group A demonstrated a superior safety profile with fewer adverse effects (2.86% vs 14.3% overall complications, P<0.05). Pain assessment revealed slightly better control in Group B, though both groups maintained clinically acceptable analgesia levels.
Conclusion: While both volumes provided effective surgical anesthesia, 20 mL of 0.5% ropivacaine offered

adequate block characteristics with fewer side effects, making it suitable for shorter procedures. The reduced volume may be particularly advantageous in day-care surgery settings where faster recovery is desired.
Keywords: Ropivacaine, Supraclavicular block, Ultrasound-guided, Brachial plexus block, Local anesthetic volume, Regional anesthesia, Upper limb surgery.

INTRODUCTION:

Regional anesthesia has revolutionized the practice of upper limb surgery since Harvey Cushing first introduced the term in 1901. The technique operates on the fundamental principle that interrupting pain transmission at any point along nerve fiber pathways can provide effective anesthesia.[1] This approach has gained widespread acceptance due to its safety profile and ability to provide extended postoperative analgesia. The benefits of effective postoperative pain management extend beyond immediate comfort. It facilitates early mobilization, reduces cardiopulmonary complications, decreases the risk of deep vein thrombosis, accelerates recovery, and significantly improves patient satisfaction.[2,3] Peripheral nerve blocks, particularly supraclavicular brachial plexus blocks, have become instrumental in achieving these advantages in modern anesthetic practice.[4]
Among various approaches, the supraclavicular technique is considered optimal due to its straightforward nature and consistent anatomical relationship with the subclavian artery.[5,6] The integration of ultrasound technology has significantly enhanced the precision of nerve blocks by enabling real-time visualization of neural structures.[7] Modern local anesthetics like ropivacaine have been developed to provide extended duration of action with minimal cardiovascular effects. Ropivacaine's mechanism of action involves sodium channel inhibition, effectively reducing nerve impulse generation and conduction.[8] Traditional practice has often favored larger volumes of local anesthetic to ensure adequate spread and successful blocks. However, ultrasound guidance may allow for volume reduction while maintaining efficacy. This study aimed to investigate whether 20 mL of 0.5% ropivacaine could provide effective anesthesia compared to the conventional 30 mL volume in ultrasound-guided supraclavicular brachial plexus block for upper limb surgeries.

METHODOLOGY

This prospective, randomized, double-blind controlled study was conducted in the Department of Anesthesiology and Critical Care at Pacific Medical College and Hospital over a two-year period from 2022 to 2024. Following approval from the Institutional Ethics Committee, the study enrolled seventy adult patients scheduled for elective upper limb surgeries. The sample size was calculated using Kraemer and Thiemann formula, with Zα at 95% confidence level (1.96), Z1-β at 80% power of study (0.8413), P as 0.5 margin of error, and desired precision of 3, yielding a minimum requirement of 35 patients per group. Patient selection followed strict criteria. Included patients were adults aged 18-60 years with ASA Physical Status I and II, weighing between 50-80 kg. Exclusion criteria encompassed patients with ASA grades III-V, anticipated difficult intubation (Mallampati Grade 3 and 4), comorbidities (COPD, Ischemic Heart Disease, Hypertension, Diabetes Mellitus, Renal & Hepatic Dysfunction), allergies to local anesthetics, coagulation disorders, pregnancy, and those scheduled for emergency surgeries. All participants provided written informed consent before enrollment.
Using sealed envelope technique, patients were randomly allocated into two groups. Group A (n=35) received 20 mL of 0.5% ropivacaine, while Group B (n=35) received 30 mL of 0.5% ropivacaine. In the preoperative room, standard monitoring was established including pulse rate, oxygen saturation, and noninvasive blood pressure measurements. Baseline parameters were recorded, and the procedure was explained to patients in their preferred language. The supraclavicular block was performed under strict aseptic conditions by an experienced anesthesiologist. A linear ultrasound probe of 11-13 Hz frequency was used along with a 22-gauge Stimuplex needle employing in-plane technique. After confirming proper needle positioning through ultrasound visualization, the local anesthetic was administered using multisite injection technique following negative aspiration for blood. To maintain study blinding, both the subjects and the observer assessing the block were unaware of the volume used.
Block assessment was conducted systematically. Sensory block was evaluated using pinprick method and scored as 0 (absent block), 1 (<50% decrease in sensation compared to contralateral side), and 2 (complete block). Assessment sites included the lateral side of the forearm for musculocutaneous nerve, first dorsal webspace for radial nerve, distal phalanx of index finger for median nerve, and distal phalanx of little finger for ulnar nerve. Motor block was assessed through flexion of elbow and hand against gravity, graded from 1 to 4, where Grade 1 indicated complete flexion and extension of forearm, wrist, and fingers, and Grade 4 represented no motion. Pain assessment utilized the Numerical Rating Scale (NRS), with patients rating their pain between 0 (no pain) and 10 (worst pain imaginable). Scores above 3 indicated inadequate analgesia, while scores exceeding 7 defined severe pain.

Hemodynamic parameters were monitored at regular intervals, including heart rate, blood pressure, and mean arterial pressure. All adverse events were documented throughout the study period.

Statistical Analysis

Statistical analysis was performed using IBM-SPSS statistics software version 23.0. Descriptive statistics included frequency analysis and percentage analysis for categorical variables, while means and standard deviations were calculated for continuous variables. Quantitative measures were analyzed using t-test, and qualitative measures through Chi-square tests. Results were presented as means ± standard deviation (SD), with p-values ≤ 0.05 considered significant and <0.01 highly significant. The study maintained rigorous documentation and followed standardized protocols throughout the data collection and analysis process.

RESULTS

The analysis of data from 70 patients undergoing upper limb surgeries revealed significant patterns in anesthetic efficacy and associated outcomes. The comprehensive evaluation encompassed demographic characteristics, block parameters, hemodynamic stability, and adverse effects, providing insights into the comparative efficacy of two different volumes of 0.5% ropivacaine. The analysis of demographic characteristics revealed comparable patterns across both groups, with no statistically significant differences. The mean age distribution showed remarkable similarity (35.23 ± 12.596 years in Group A versus 35.97 ± 12.693 years in Group B, P=0.809), ensuring age-related physiological responses would not confound the results. Male predominance was observed in both groups (82.9% in Group A, 74.3% in Group B, P=0.382), reflecting the typical gender distribution in upper limb surgical cases. Weight distribution demonstrated clinical comparability (61.51 ± 8.143 kg in Group A versus 66.54 ± 8.219 kg in Group B, P=0.513), ensuring that body mass variations would not significantly impact drug distribution and efficacy. ASA status distribution was also similar between groups, with a balanced representation of ASA I and II patients, confirming comparable baseline physical status (Table 1).

Table 1: Demographic Profile of Study Participants

Characteristic	Group A (20 mL)	Group B (30 mL)	P-value
Age (years)	35.23 ± 12.596	35.97 ± 12.693	0.809
Gender (M/F)	29/6 (82.9%/17.1%)	26/9 (74.3%/25.7%)	0.382
Weight (kg)	61.51 ± 8.143	66.54 ± 8.219	0.513
ASA Status (I/II)	22/13	20/15	0.624

Table 2: Sensory and Motor Block Parameters

Parameter	Group A (20 mL)	Group B (30 mL)	P-value
Onset of sensory block (min)	14.11 ± 3.279	13.46 ± 3.355	0.410
Duration of sensory block (hrs)	7.54 ± 1.400	9.11 ± 1.762	<0.01
Onset of motor block (min)	18.29 ± 3.177	17.37 ± 3.473	0.255
Duration of motor block (hrs)	6.51 ± 1.422	8.26 ± 1.804	<0.01
Time to first analgesic (hrs)	10.69 ± 1.811	11.69 ± 1.843	0.025

Block characteristics analysis revealed nuanced differences between the two volume regimens. The onset times for both sensory and motor blocks showed no statistically significant difference between groups, suggesting that reducing the volume does not compromise the initial effectiveness of the block. The sensory block onset (14.11 ± 3.279 mins in Group A versus 13.46 ± 3.355 mins in Group B, P=0.410) and motor block onset (18.29 ± 3.177 mins versus 17.37 ± 3.473 mins, P=0.255) were clinically comparable, indicating that both volumes achieve adequate initial neural blockade. However, significant differences emerged in block duration. The larger volume in Group B produced substantially longer durations of both sensory (9.11 ± 1.762 versus 7.54 ± 1.400 hours, P<0.01) and motor blocks (8.26 ± 1.804 versus 6.51 ± 1.422 hours, P<0.01). This approximately 1.5-hour difference in block duration could have clinical implications for procedure planning and post-operative care protocols. The time to first analgesic requirement also showed a statistically significant difference (11.69 versus 10.69 hours, P=0.025), though the clinical significance of this one-hour difference may vary depending on the specific surgical procedure and patient factors (Table 2).

Mean heart rates were consistently higher in Group B (30 mL) compared to Group A (20 mL) but without statistical significance (P>0.05). Both groups showed similar heart rate reductions over time, converging at 20 minutes (76.54 vs 76.51 bpm) demonstrating comparable hemodynamic stability regardless of volume used. Both groups showed gradual SBP reductions without statistically significant differences (P>0.05). Group B demonstrated a marginally greater decrease (126.03 to 118.89 mmHg) compared to Group A (124.23 to 120.43 mmHg), but all values remained clinically stable, indicating that both volumes maintained safe systolic pressure profiles. Group A maintained slightly lower DBP values throughout the observation period, but differences were not statistically significant (P>0.05). Both groups showed minimal DBP reductions (Group A: 76.11 to 72.43 mmHg; Group B: 77.89 to 75.97 mmHg), with values remaining within clinically acceptable ranges. MAP showed statistically significant differences between groups (P<0.05), with consistently lower values in Group B. Despite Group B showing more pronounced MAP reduction (85.29 to 84.34 mmHg vs 92.63 to 88.66 mmHg in Group A), all values remained clinically acceptable suggesting adequate tissue perfusion with both volumes.

Table 3: Incidence of Complications

Adverse Effect	Group A (n=35)	Group B (n=35)	P-value
Hypotension	1 (2.86%)	2 (5.7%)	0.038
Vomiting	0 (0%)	3 (8.6%)	0.038
No complications	34 (97.14%)	30 (85.7%)	0.038

The adverse effects profile demonstrated meaningful differences between the two volume regimens. Group A showed a markedly lower overall incidence of complications, with 97.14% of patients experiencing no adverse effects compared to 85.7% in Group B (P=0.038). The specific complications observed were primarily hemodynamic (hypotension) and gastrointestinal (vomiting) in nature. Hypotension occurred in 2.86% of Group A patients versus 5.7% in Group B, while vomiting was exclusively observed in Group B (8.6%). These findings suggest a dose-dependent relationship between local anesthetic volume and adverse effects. The absence of vomiting in Group A is particularly noteworthy, as post-operative nausea and vomiting can significantly impact patient comfort and recovery time. The overall safety profile favors the lower volume regimen, though all complications were successfully managed without long-term sequelae (Table 3).

Table 4: Numerical Rating Scale (NRS) Scores

Parameter	Group A (20 mL)	Group B (30 mL)	P-value
Mean NRS Score	6.14 ± 0.772	5.69 ± 0.832	0.020

Pain assessment using the Numerical Rating Scale revealed statistically significant differences between the groups (P=0.020). Group B demonstrated superior pain control with a mean NRS score of 5.69 ± 0.832 compared to 6.14 ± 0.772 in Group A. While this difference is statistically significant, the clinical relevance requires careful consideration. Both scores fall within the moderate pain range (4-6 on NRS), suggesting that both volumes provide acceptable analgesia. The difference of 0.45 points on the NRS, while statistically significant, is below the commonly accepted minimal clinically important difference (MCID) of 1.3 points for acute pain. This suggests that while the larger volume provides marginally better pain control, both volumes achieve clinically acceptable analgesic efficacy. The slightly higher pain scores in Group A should be considered alongside the lower incidence of adverse effects when making clinical decisions about volume selection (Table 4).

DISCUSSION

This randomized controlled trial provides comprehensive insights into optimizing local anesthetic volumes in ultrasound-guided supraclavicular brachial plexus block, with findings that both support and extend current literature in the field. The comparable demographic distributions between our study groups established a reliable foundation for outcome analysis, similar to the methodology employed by Sirigeri S et al.[9] who compared 0.5% bupivacaine with 0.75% ropivacaine. Our study design aligns with recent methodological trends, as demonstrated by Chadha M et al.[10] and Wang S et al.[11], who emphasized the importance of standardized protocols in volume comparison studies.

Our findings regarding block onset times revealed no significant differences between the 20 mL and 30 mL groups (14.11 ± 3.279 vs 13.46 ± 3.355 mins for sensory block; 18.29 ± 3.177 vs 17.37 ± 3.473 mins for motor block). This aligns closely with research by Chadha M et al.[10], who reported comparable sensory and motor block onset times (18.06 ± 3.04 vs 17 ± 2.01 minutes). Dae Geun Jeon et al.[12] further supported these findings, demonstrating no

statistically significant difference in block onset times across various volumes. Interestingly, our results contrast with those of Mosaffa et al.[13], who found shorter onset times with larger volumes of lidocaine. However, this difference might be attributed to the different pharmacological properties of ropivacaine versus lidocaine, as suggested by Kumar S et al.[14] and Bafna U et al.[15]

The duration of analgesia showed significant differences between groups, with the 20 mL group experiencing shorter duration. This finding corresponds with results from Khanna S et al.[16], who reported longer sensory block duration (599.9 ± 110.4 vs 530.2 ± 83.5 min) with higher volumes. However, this contrasts with findings by Pushpender et al.[17], who found no significant difference in analgesia duration with different volumes. Zhai W et al.[18] provided additional insight by demonstrating that while volume differences affect block duration, concentration plays an equally important role. This was further supported by Wang S et al.[11], who found that 0.375% ropivacaine could be as effective as 0.5% when proper volumes are used.

Our hemodynamic observations align closely with findings by Prasad JN et al.[19], who reported similar hemodynamic profiles between different volume groups. The lower MAP values in our 30 mL group, while statistically significant, remained clinically acceptable, supporting observations by Zhang L et al.[20] regarding cardiovascular stability with varying volumes. Jain K et al.[21] and Singh N et al.[22] provided additional context by demonstrating that adjuvant addition might influence hemodynamic stability more than volume variations. This suggests that volume reduction might be safely achieved without compromising cardiovascular stability.

The reduced incidence of adverse effects in our lower volume group strongly correlates with findings by Bao X et al.[23], who reported decreased complications with 20 mL compared to 30 mL of 0.375% ropivacaine. Particularly noteworthy was their observation of reduced phrenic nerve palsy and pulmonary function impairment with lower volumes. Dharmarao PS et al.[24] and Mathew S et al.[25] further supported the safety profile of reduced volumes, especially when combined with ultrasound guidance. Their studies demonstrated that precise visualization allowed for volume reduction without compromising block quality.

Recent literature has increasingly supported the use of lower volumes under ultrasound guidance. Gautier P et al.[26] demonstrated successful surgical anesthesia with volumes as low as 5 mL for certain approaches, while Duggan et al.[27] identified 23 mL as the minimum effective volume for supraclavicular blocks Venkatraman R et al.[28] emphasized the importance of balancing analgesic efficacy with adverse effects, while Ahmed SA et al.[29] demonstrated adequate pain control with reduced volumes, though with slightly shorter duration of action. These findings align with our observations of acceptable analgesia despite volume reduction.

The study's results support the growing body of evidence suggesting that ultrasound guidance allows for reduction in local anesthetic volume while maintaining clinical efficacy. This has important implications for regional anesthesia practice, particularly in ambulatory surgery settings. The ability to achieve adequate surgical anesthesia with lower volumes could potentially reduce the risk of local anesthetic systemic toxicity while maintaining satisfactory block characteristics.

Limitations of our study include the single-center design and the inability to blind the anesthesiologist performing the block to the volume used. Additionally, the study focused on immediate and short-term outcomes; future research could investigate longer-term outcomes and specific patient subgroups who might particularly benefit from the lower volume approach.

CONCLUSION

This study demonstrates that a reduced volume of 0.5% ropivacaine can provide effective surgical anesthesia in ultrasound-guided supraclavicular brachial plexus block, with onset times comparable to the conventional larger volume. While the duration of analgesia was shorter with the lower volume, it showed a superior safety profile with fewer adverse effects. The reduced volume maintained hemodynamic stability while providing adequate surgical anesthesia and postoperative pain relief, making it particularly suitable for shorter procedures and day-care surgeries. This finding supports the current trend toward using lower volumes of local anesthetics when guided by ultrasound visualization, potentially reducing the risk of complications while maintaining clinical efficacy. The study suggests that the choice of volume should be tailored to the expected duration of surgery and patient characteristics, with the lower volume being a viable option for procedures of shorter duration where rapid recovery is desired.

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