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Original Research Article

To study the relation of volume of local anaesthetic and diaphragmatic motility in ultrasound guided supraclavicular brachial plexus block

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ABSTRACT

Background: Supraclavicular brachial plexus block is a valuable technique for upper limb surgeries, but it carries the risk of hemi diaphragmatic paresis due to phrenic nerve involvement, which can limit its utility.
Materials and Methods: Thirty-six patients undergoing forearm and hand surgery received ultrasound-guided supraclavicular brachial plexus blocks with varying volumes of 0.5% ropivacaine, determined by Dixon and Massey's up-and-down approach starting at 25 ml. We assessed diaphragmatic paralysis/paresis incidence and spirometry parameters across different volumes to optimize clinical outcomes.
Results: Among the patients, 15 ml of 0.5% ropivacaine consistently provided effective surgical anesthesia without causing diaphragmatic paralysis or paresis. The study showed no significant changes in spirometry parameters such as FEV1 and FVC with lower volumes, while higher volumes correlated with increased diaphragmatic impairment.
Conclusion: Reducing the volume of 0.5% ropivacaine mitigates the risk of diaphragmatic paralysis associated with supraclavicular brachial plexus blocks, ensuring safe and effective anesthesia for upper limb surgeries.

1. Introduction

Regional anaesthesia and peripheral nerve blocks play an essential role and offer numerous benefits, making them the almost ideal anaesthetic approach for a variety of surgical procedures. The approach delivers site-specific surgical anaesthesia, prolongs postoperative analgesia, reduces the need for general anesthesia, and allows for early discharge. The peripheral nerve block technique saves opioids, makes the patient more comfortable, eliminates side effects like nausea and vomiting, and reduces the patient's fear, gagging on the endotracheal tube, surgical pain, remembrance, residual weakness, shivering, sore throat, and sleepiness. It fits the surgeon's and anaesthesiologist's needs while also providing greater patient comfort. A pleasant, symptom-free patient can be discharged from the post-anaesthesia care unit quickly, minimizing hospitalization time and expenditures.[1,2]

Ultrasound-guided supraclavicular brachial plexus block (US-SCBPB) helps us to locate structures around the brachial plexus more clearly. This technique allows more precise and effective deposition of local anaesthetic, thus reducing the risk of motor deficit and neurological complications.[3] It is safer, as the anatomy can be seen more clearly, and also it guides the proper placement of the needle, reduces the number of punctures required, and results in near-100% success with the least number of complications.[4]

A frequent complication of supraclavicular brachial plexus block is hemi-diaphragmatic paresis / paralysis,

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occurring in 67% of cases. The temporary reduction in ventilatory function can be compensated for by healthy patients and they typically experience only mild symptoms. Patients with cardiopulmonary comorbidity cannot tolerate a decline in respiratory function.[5] One of the causes behind phrenic nerve palsy is volume spread of the local anaesthetic drug near the phrenic nerve. The duration of phrenic nerve palsy is directly related to the type and volume of local anaesthetic used.[6] With use of US-SCBPB, incidence of complete hemi- diaphragmatic paralysis is reduced to approximately 34%.[7]

Diaphragmatic paralysis can be easily detected by pulmonary function test. For all patients with suspected diaphragmatic paralysis, both sitting and supine spirometry should be performed. Forced vital capacity decreased by 30% predicted in unilateral hemi-diaphragm, and further decreased to 75% predicted in bilateral paralysis.[8]

Ropivacaine is less cardiotoxic, more lipid-soluble, and has longer duration of action. Ropivacaine is a safe alternative for regional anaesthesia and post-operative pain relief due to improved effectiveness, decreased motor block propensity, decreased potential for toxicity of the central nervous system and cardio toxicity.[9] Studies have shown that the volume of local anaesthesia agent used in US-SCBPB to get successful effect is 15 ml.[10]

The current study was conducted on patients undergoing upper limb surgery and arterio-venous fistula procedures under US-SCBPB block using 0.5% ropivacaine, with the goal of determining the minimum volume of 0.5% ropivacaine at which the incidence of diaphragmatic paresis/paralysis is zero or minimal with effective supraclavicular brachial plexus block.

2. Materials and Methods

After obtaining approval from the institutional ethical committee, subjects were recruited from patients undergoing a procedure on upper limb. Written informed consent was obtained from all the subjects. This prospective experimental study was conducted in the Department of Anaesthesiology over a period of 1 year.

Patients of both sexes; age between 18–60 years; American Society of Anaesthesiology (ASA) physical status 1, 2, 3; body weight >50 kg were enrolled. Patient's refusal of supraclavicular block, active psychiatric condition, infection at the puncture site, bleeding diathesis, history of allergy to 0.5% ropivacaine, pregnancy, pre-existing lung diseases or hemi-diaphragmatic dysfunction, neuropathy, and chest and shoulder deformity were excluded. All patients underwent a thorough preoperative assessment, which included a history, examination, and investigations. No premedication was administered before to supraclavicular brachial plexus block (SBPB). All patients had an intravenous catheter placed in the vein of their non-operated arm, and crystalloid solution was supplied. Prior to performing the block, we measured pulse oximetry (SpO2), electrocardiogram (ECG), non-invasive blood pressure (NIBP), and respiratory rate (RR). Based on our institution's clinical experience, we began our trial with 25 ml of ropivacaine 0.5% as the starting volume.

Using a previously verified Dixon and Massey's up-and-down method,[11] the volume of LA for block in consecutive patients would be determined by the results of the prior one. In the event of a failed block, the injection volume was increased by 2ml. In the event of a successful block, the volume for the next patient was reduced by 2 mL. The patient was positioned supine with the head tilted to the non-operating side, a sterile ultrasound probe (Sonosite Machine linear probe of frequency 7-13 MHz) was prepared, and the skin was disinfected. An experienced anaesthesiologist performed brachial plexus block via the supraclavicular approach using ultrasound guidance.

The block was done by inserting a 50mm needle into the superior, posterior, and pocket produced by the first rib and subclavian arteries of the brachial plexus. A linear probe of frequency 7-13Mhz was placed in the supraclavicular fossa in the sagittal plane at midpoint of clavicle, and we tried to localise the subclavian artery. After visualisation of subclavian artery, first rib was localised and lung shadow seen and then we finally looked for hypoechoic round multiple shadows in a bunch near subclavian artery, then needle was advanced through in-plane technique from the lateral side to medial side. A 50 mm needle was inserted using US guidelines. When the needle tip was near the plexus, an aspiration test was performed to rule against intravascular insertion. Before injecting the medication solution, we supplied a saline bolus of 2-3 ml to test the correct position of the needle, and local anaesthetic was infiltrated superior, middle, and in pocket near the subclavian artery.[12] An assessor who was not informed of the volume injected assessed the presence of motor and sensory blockage in the radial, median, and ulnar nerve innervation zones. Block assessment was completed at 5-minute intervals for up to 30 minutes following the final dose. To compare each patient's sensory and motor functions, we tested the contralateral limb. A pinprick test was used to assess the amount of upper extremity sensory analgesia, as well as the distribution of each nerve using a 25 G hypodermic needle and a 3-point pain scale (2-sharp pain, 1-blunt pain, 0-no pain), and was compared to the same contralateral arm stimulation. Motor failure was assessed using a modified Bromage scale (grade 0, normal motor control with maximum flexion and extension of the elbow, wrist, and fingers; grade 1, decreased motor strength with the ability to move the fingers only; grade 2, complete motor block with inability to move the fingers). Thumb abduction (radial nerve), thumb adduction (ulnar nerve), and thumb opposition (median nerve) were measured to assess motor blocks. For patients with a failed block, a

supplemental peripheral nerve block, intravenous fentanyl intraoperatively or general anaesthesia was administrated as appropriate to achieve surgical analgesia. During and after surgery, all patients were monitored for any signs of dyspnea, desaturation, Horner syndrome, or pneumothorax. To rule out pneumothorax and diaphragm elevation, a chest radiograph was taken within 6 hours of the block being administered. All patients were monitored for up to 24 hours in the post-operative room. Baseline value was obtained by assessment of hemi- diaphragmatic movement before the procedure by Sonosite ultrasound machine with curvilinear probe of frequency 2–6 MHz using a subcostal approach as described by Gerscovich and colleagues[9]. In the supine position, patients were examined, and the hemi-diaphragm was established as a hyperechoic line with breathing-related motions using the liver as an acoustic window and the spleen. The hemi-diaphragmatic excursion for deep and quiet inspiration was calculated by real-time M-mode ultrasonography from the resting expiratory location. The measurements were performed in the supine position preop, after 30 min and 6 hours of block placement. Those patients with decrease in diaphragmatic motility >75% would be assumed to suffer from complete paralysis; a decrease between 25%–75% was referred to as partial paralysis and <25% as no paralysis. Patients were asked to recognize subjective signs of respiratory dysfunction.[13] Respiratory function was assessed before the regional procedure with a bedside handheld spirometer (company medical international research) After standard instructions, with subjects in a supine position, FVC, FEV1, and PEFR measurements was done. Spirometry was done at 4 points: before block placement, 30 minutes after the block, and in the post-anaesthesia care unit 6 hours and 24 hours after completion of surgery.

2.1. Statistical method

The SPSS statistical package was used for the analysis (version 17.0; SPSS Inc., Chicago, IL, USA). Continuous variables, including those within the groups, were analyzed using repeated measurements of analysis of variance (ANOVA), followed by Bonferroni's post hoc test. Nominal categorical data between groups will be compared using the chi-square test or Fisher's exact test, if needed. A P-value of less than 0.05 is used to indicate a significant difference in all statistical tests. The major goal was to investigate the occurrence of diaphragmatic paresis/paralysis in participants. With reference to previous studies[14], it was found the incidence of diaphragmatic paresis is about 33%. It was a time-bound study, patients meeting the eligibility criteria were enrolled during the study period.

Based on previous studies indicating a necessity for a minimum of 30 patients, we adopted Dixon and Massey's up-and-down approach[11] and included a total of 36 patients. We implemented two study-stopping criteria. The first criterion was met when the volume of 0.5% ropivacaine resulted in minimal or zero incidence of diaphragmatic paresis/paralysis across five consecutive cases, aligning with a previously observed incidence of 33%. The second criterion was fulfilled when the minimum volume of 0.5% ropivacaine consistently achieved a successful nerve block in five consecutive patients.

Dixon and Massey's up-and-down method is a sequential allocation procedure used in clinical studies to determine the optimal dosage or volume of a treatment. It involves adjusting the dosage based on the response of each patient in a sequential manner. When applied to studies on anesthesia or nerve blocks, this approach helps establish the minimum effective dose or volume that achieves the desired clinical outcome while minimizing adverse effects. This method is particularly useful for determining dosing in situations where precise control over the treatment's efficacy and safety profile is crucial.

3. Results

Eligibility criteria was met by 36 patients. We started with 25 ml of 0.5% ropivacaine according to our department protocol and administered this to 5 patients, then we decreased the volume of drug by 2 ml, according to Dixon and Massey's up-and-down method (Figure 1). Demographic data among different volume of drug were comparable regarding age, weight, and BMI of the patient (Table 1). We recorded the spirometry parameters FEV1, FVC, PEFR, and diaphragmatic motility pre-block, after 30 min of block, and 6 hours post-block. The hemodynamic variables (SBP, DBP, MBP, SpO2, RR) from baseline during observation period were comparable. Overall success rate was 97.2% (Table 2). Overall, out of 36 patients, 25% developed complete paralysis, 36.1% had no paralysis, and 38.9% had partial paralysis (Table 2).

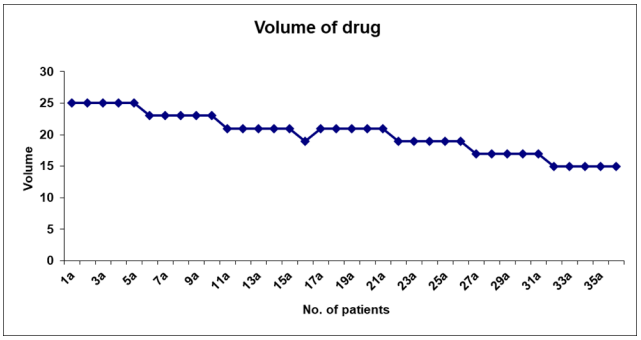

Figure 1: Volume of 0.5% Ropivacaine in consecutive patients

Diaphragmatic paralysis/paresis at pre-op, 30 min after block, and 6 hours after post-op with different volumes (25 ml, 23 ml, 21 ml, 19 ml, 17 ml, 15 ml) of 0.5% ropivacaine (Ropin) was observed; there was significant

Table 1: Demographic data among different volume of drug

	Dose						
	25	23	21	19	17	15	**P value**
	Mean±SD	Nean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Age in years	40.40 ±11.50	38.00 ±16.00	51.70 ±13.86	41.33 ±11.38	37.60 ±8.17	29.00 ± 9.43	0.08
Weight in Kg	57.60 ±10.50	51.60 ±9.10	57.00 ±10.42	64.00 ±9.19	68.00 ±11.60	66.40 ±17.10	0.086
BMI	23.00 ±2.38	21.45 ±3.40	21.88 ± 3.87	22.89 ±2.74	27.07 ±5.94	23.92 ±5.71	0.086

SD: Standard Deviation, Kg: Kilogram, BMI: Body Mass Index

Table 2: Incidence of diaphragmatic paralysis

Dose	**N**	**Complete Frequency (%)**	**No Frequency (%)**	**Partial Frequency (%)**	**p value**
25	5	1 (20.0%)	2 (40.0%)	2 (40.0%)	
23	5	2 (40.0%)	2 (40.0%)	1 (20.0%)	
21	10	2(20.0%)	2(20.0%)	6 (60.0%)	
19	5	2(40.0%)	1(20.0%)	2(40.0%)	0.426
17	5	0(0%)	2(40.0%)	3(60%)	
15	5	1 (20.0%)	4 (80.0%)	0(0%)	
Total	36	9(25%)	13(36.1%)	14(38.89%)	

N: Number of patients

diaphragmatic paralysis/paresis with higher volume of LA (Table 3). Spirometry parameters (FEV1, FVC, PEFR) at pre-op, 30 min after block, and 6 hours after post-op with different volumes (25 ml, 23 ml, 21 ml, 19 ml, 17 ml, 15 ml) of Ropin were observed; there was no significant change in FEV1 and FVC parameters (Tables 4 and 5). PEFR value decreased significantly with higher volumes (23 ml, 21 ml, 17 ml), but PEFR did not decrease significantly with lower volumes, i.e. 15 ml (Table 6).

Onset of sensory and motor block was comparable. There was no correlation found between the quality and onset of sensory and motor block with varying amounts of 0.5% ropivacaine (25 ml-15 ml). The mean times of involvement of ulnar, radial, and median nerves were also observed. The mean onset of ulnar nerve paralysis increased with the P-value of 0.041, which is statistically significant. Mean onset of radial nerve paralysis increases with P-value of 0.013, which is statistically significant. The mean time of onset of median nerve paralysis increases, but it is not statistically significant (P-value=0.080) (Table 7).

4. Discussion

Supraclavicular brachial plexus block (SCBPB) is a cornerstone in upper extremity surgical procedures. Incorporation of ultrasound in SCBPB further increases success, safety, and precise infiltration of local anaesthetic (LA), by which volume of LA can be reduced and thus incidence of complications due to the block and large volume of LA. Currently there are not convincing data showing minimum effective volume required for successful block with minimum complications (hemi-diaphragmatic paralysis).

Demographic data was comparable amongst the groups. Female preponderance was seen, this can be attributed to the fact that there were 10 female patients for AV fistula formation. Increased preponderance was seen in CKD.[15]

There are various techniques described for SBPB. We used the ultrasound-guided technique because it is safer, and onset, quality, and duration were superior as compared with other methods (classical, nerve stimulator).[16,17] We enrolled 36 patients in total, and one (2.8%) of them failed. This demonstrates the superiority of ultrasound-guided techniques. Liu S conducted this evidence-based study, which was a systematic assessment of the onset, quality, and length of a block for ultrasound guidance against alternative nerve visualization approaches.[18] The success rate in our study was 97.2%. Ratnawat A et al. compare the ultrasound-guided technique and the nerve-stimulator technique and found a success rate of 97.5% with ultrasound-guided technique and 90% with nerve-stimulator technique.[19]

In our work, we adopted the in-plane technique (needle around the longitudinal axis of the ultrasound probe) from lateral to medial because it improved structure visualization and allowed for clear needle visualization when the needle was introduced from the back of the probe. Kusre et al. and Song et al. explained this in-plane approach in US-SCBPB and strongly recommend it.[12,20] Gupta K explained that the needle visualisation is only possible when ultrasound is reflected from the needle back to the probe.[17]

Table 3: Comparison of diaphragmatic paralysis within groups

Dose (ml)	Diaphragm Movement	N	Mean ± SD	Mean Difference ± SD	p value
25	Pre op	5	2.37 ± 0.36	1.05 ± 0.32	0.012×
	After 30 min of block	5	1.32 ± 0.62		
	Pre op	5	2.37 ± 0.36	0.03 ± 0.22	0.891
	Post op	5	2.34 ± 0.35		
	After 30 min of block	5	1.32 ± 0.62	(-)1.02 ± 0.32	0.013×
	Post op	5	2.34 ± 0.35		
23	Pre op	5	2.19 ± 0.85	1.03 ± 0.63	0.139
	After 30 min of block	5	1.15 ± 1.12		
	Pre op	5	2.19 ± 0.85	(-)0.14 ± 0.52	0.793
	Post op	5	2.33 ± 0.80		
	After 30 min of block	5	1.15 ± 1.12	(-)1.18 ± 0.61	0.093
	Post op	5	2.33 ± 0.80		
21	Pre op	10	1.98 ± 0.52	0.97 ± 0.23	0.001×
	After 30 min of block	10	1.01 ± 0.53		
	Pre op	10	1.98 ± 0.52	0.01 ± 0.22	0.938
	Post op	10	2.00 ± 0.48		
	After 30 min of block	10	1.01 ± 0.53	(-)0.99 ± 0.22	0.001×
	Post op	10	2.00 ± 0.48		
19	Pre op	5	3.18 ± 1.28	0.77 ± 0.66	0.028×
	After 30 min of block	5	1.41 ± 0.72		
	Pre op	5	3.18 ± 1.28	(-)0.19 ± 0.76	0.809
	Post op	5	3.37 ± 1.11		
	After 30 min of block	5	1.41 ± 0.72	(-)1.96 ± 0.59	0.011×
	Post op	5	3.37 ± 1.11		
17	Pre op	5	2.21 ± 0.57	0.36 ± 0.38	0.366
	After 30 min of block	5	1.84 ± 0.62		
	Pre op	5	2.21 ± 0.57	0.01 ± 0.36	0.962
	Post op	5	2.19 ± 0.56		
	After 30 min of block	5	1.84 ± 0.62	(-)0.34 ± 0.37	0.384
	Post op	5	2.19 ± 0.56		
15	Pre op	5	3.13 ± 0.84	0.35 ± 0.77	0.657
	After 30 min of block	5	2.77 ± 1.51		
	Pre op	5	3.13 ± 0.84	(-)0.04 ± 0.67	0.947
	Post op	5	3.18 ± 1.25		
	After 30 min of block	5	2.77 ± 1.51	(-)0.40 ± 0.88	0.659
	Post op	5	3.18 ± 1.25		

ml: millilitre N: Number of patients, SD: Standard Deviation

The onset of sensory and motor block was equivalent across medication volumes. There was no relationship found between the quality and onset of sensory and motor block with varied amounts of 0.5% ropivacaine (25 ml-15 ml). Pushpender et al. and Chadha et al. found that time spent for achieving adequate motor block and sensory block did not vary significantly. [10,21]

We also measured the mean time of involvement of particular nerves such as the ulnar, radial, and median nerves in various volumes of 0.5% ropivacaine. We observed the minimum mean time of involvement of the ulnar nerve at 23 ml of LA was 17±2.74, as we decreased volume of LA, the average time increased to 24±2.24 at 15 ml. This shows that as volume of LA decreases mean time of involvement of UN increases, and it was statistically significant (P=0.041). Concerning radial nerve involvement, minimum mean time of involvement was 17±4.47 in 23 ml of LA and maximum mean time of involvement was 26±5.48 in 17 ml, showing that when decreasing volume of LA, mean time of involvement of the radial nerve

Table 4: Comparison of FEV1 within groups

Dose (ml)	FEV1	N	Mean ± SD	Mean Difference ± SD	p value
25	Pre op	5	1.50 ± 0.97	0.44 ± 0.43	0.083
	After 30 min of block	5	1.06 ± 0.65		
	Pre op	5	1.50 ± 0.97	0.11 ± 0.71	0.739
	Post op	5	1.396 ± 1.06		
	After 30 min of block	5	1.06 ± 0.65	(-)0.33 ± 0.58	0.271
	Post op	5	1.39 ± 1.06		
23	Pre op	5	1.86 ± 1.22	0.37 ± 0.32	0.060
	After 30 min of block	5	1.49 ± 1.02		
	Pre op	5	1.86 ± 1.22	(-)0.26 ± 1.41	0.697
	Post op	5	2.12 ± 1.61		
	After 30 min of block	5	1.49 ± 1.02	(-)0.64 ± 1.20	0.300
	Post op	5	2.12 ± 1.61		
21	Pre op	10	1.68 ± 0.92	0.54 ± 0.48	0.060
	After 30 min of block	10	1.14 ± 0.91		
	Pre op	10	1.68 ± 0.92	0.14 ± 0.74	0.553
	Post op	10	1.53 ± 0.81		
	After 30 min of block	10	1.14 ± 0.91	(-)0.40 ± 0.59	0.063
	Post op	10	1.53 ± 0.81		
19	Pre op	5	1.89 ± 0.84	0.25 ± 0.32	0.161
	After 30 min of block	5	1.65 ± 1.12		
	Pre op	5	1.89 ± 0.84	0.06 ± 0.16	0.454
	Post op	5	1.83 ± 0.97		
	After 30 min of block	5	1.65 ± 1.12	(-)0.19 ± 0.24	0.153
	Post op	5	1.83 ± 0.97		
17	Pre op	5	2.00 ± 0.56	0.61 ± 0.44	0.037×
	After 30 min of block	5	1.39 ± 0.27		
	Pre op	5	2.00 ± 0.56	(-)0.26 ± 0.53	0.328
	Post op	5	2.26 ± 0.54		
	After 30 min of block	5	1.39 ± 0.27	(-)0.88 ± 0.46	0.013×
	Post op	5	2.26 ± 0.54		
15	Pre op	5	2.22 ± 0.92	0.05 ± 0.22	0.646
	After 30 min of block	5	2.17 ± 1.00		
	Pre op	5	2.22 ± 0.92	0.19 ± 0.79	0.617
	Post op	5	2.03 ± 1.30		
	After 30 min of block	5	2.17 ± 1.00	0.14 ± 0.78	0.704
	Post op	5	2.03 ± 1.30		

ml: millilitre, FEV1: Forced Expiratory Volume in one second, N: Number of patients, SD: Standard Deviation

increased and it was statistically significant (P=0.013). While observed for involvement of median nerve which was statistically insignificant as P=0.080. Jeon DG et al. indicated that the ulnar and medial cutaneous nerves are generated from the inferior trunk of the brachial plexus, which is difficult to access using the in-plane technique, yet they accomplished a successful block with 30 ml.[22] We used the in-plane technique, but in combination with multiple directions technique.

Diaphragmatic paralysis was a significant problem in our investigation. This complication results from the cephalad spread of LA and involvement of the phrenic nerve. We measured diaphragmatic excursion with ultrasound in M-mode pre-operatively on both sides, after 30 minutes of block performance, and 6 hours later, and compared them at various amounts (25 ml, 23 ml, 21 ml, 19 ml, 17 ml, and 15 ml) of 0.5% ropivacaine.

We observed a significant decrease in diaphragmatic movement after 30 min of block with larger volumes (25

Table 5: Comparison of FVC within groups

Dose (ml)	FVC	N	Mean ± SD	Mean Difference ± SD	p value
25	Pre op	5	1.69 ± 1.12	0.39 ± 0.39	0.088
	After 30 min of block	5	1.30 ± 0.90		
	Pre op	5	1.69 ± 1.12	0.13 ± 0.69	0.705
	Post op	5	1.56 ± 1.20		
	After 30 min of block	5	1.30 ± 0.90	(-)0.27 ± 0.58	0.363
	Post op	5	1.56 ± 0.20		
23	Pre op	5	1.92 ± 1.28	0.38 ± 0.40	0.096
	After 30 min of block	5	1.53 ± 1.03		
	Pre op	5	1.92 ± 1.28	(-)0.34 ± 1.41	0.614
	Post op	5	2.26 ± 1.62		
	After 30 min of block	5	1.53 ± 1.03	(-)0.73 ± 1.11	0.218
	Post op	5	2.26 ± 1.62		
21	Pre op	10	1.75 ± 0.97	0.51 ± 0.55	0.017×
	After 30 min of block	10	1.24 ± 0.89		
	Pre op	10	1.75 ± 0.97	0.14 ± 0.86	0.625
	Post op	10	1.61 ± 0.86		
	After 30 min of block	10	1.24 ± 0.89	(-)0.38 ± 0.63	0.093
	Post op	10	1.61 ± 0.86		
19	Pre op	5	2.15 ± 0.97	0.23 ± 0.41	0.281
	After 30 min of block	5	1.93 ± 1.33		
	Pre op	5	2.15 ± 0.97	(-)0.10 ± 0.22	0.367
	Post op	5	2.26 ± 1.06		
	After 30 min of block	5	1.93 ± 1.33	(-)0.33 ± 0.42	0.157
	Post op	5	2.26 ± 1.06		
17	Pre op	5	2.22 ± 0.68	0.69 ± 0.60	0.063
	After 30 min of block	5	1.53 ± 0.22		
	Pre op	5	2.22 ± 0.68	(-)0.20 ± 0.54	0.448
	Post op	5	2.42 ± 0.59		
	After 30 min of block	5	1.53 ± 0.22	(-)0.89 ± 0.43	0.01×
	Post op	5	2.42 ± 0.59		
15	Pre op	5	2.44 ± 1.15	0.10 ± 0.26	0.448
	After 30 min of block	5	2.34 ± 1.15		
	Pre op	5	2.44 ± 1.15	0.18 ± 0.77	0.627
	Post op	5	2.26 ± 1.42		
	After 30 min of block	5	2.34 ± 1.15	0.09 ± 0.79	0.821
	Post op	5	2.26 ± 1.42		

ml, 21 ml, 19 ml). It was found to be safer to use 17 ml and 15 ml of 0.5% ropivacaine. Mak PHK et al. studied and observed complete diaphragmatic paralysis 50% and partial was 17%.[23] Renes et al. conducted a study on US-SCBPB and discovered that none of the patients suffered hemi-diaphragmatic paresis or a loss in lung functions FEV1, FVC, and PEFR.[24] Ferré et al. opposed the above study and concluded a high incidence of complete hemi-diaphragmatic paralysis. The presence of an accessory phrenic nerve or retrograde diffusion of the local anaesthetic could account for the incidence of this complication.[25]

In addition, we evaluated the diaphragmatic excursion by employing a small bedside spirometer. We conducted measurements of Forced Expiratory Volume in 1 second (FEV1), Forced Vital Capacity (FVC), and Peak Expiratory Flow Rate (PEFR) prior to the surgery as a baseline. These measurements were taken after 30 minutes of block and again 6 hours after the block. We then compared the pre-operative values with the measurements taken 30 minutes after the block, and the measurements taken 30 minutes after the block with those taken 6 hours after the block, within each group. In addition, we conducted

Table 6: Comparison of PEFR within group

Dose (ml)	PEFR	N	Mean ± SD	Mean Difference ± SD	p value
25	Pre op	5	220.60 ± 94.63	77.60 ± 92.97	0.135
	After 30 min of block	5	143.00 ± 25.89		
	Pre op	5	220.60 ± 94.63	41.40 ± 51.03	0.144
	Post op	5	179.20 ± 78.68		
	After 30 min of block	5	143.00 ± 25.89	(-)36.20 ± 79.62	0.367
	Post op	5	179.20 ± 78.68		
23	Pre op	5	260.00 ± 197.96	80.60 ± 0.44	0.034×
	After 30 min of block	5	179.40 ± 144.85		
	Pre op	5	260.00 ± 197.76	21.80 ± 56.45	0.437
	Post op	5	238.20 ± 173.34		
	After 30 min of block	5	179.40 ± 144.85	(-)58.80 ± 67.73	0.124
	Post op	5	238.20 ± 173.34		
21	Pre op	10	239.10 ± 99.87	67.40 ± 76.70	0.021×
	After 30 min of block	10	171.70 ± 97.37		
	Pre op	10	239.10 ± 99.87	41.20 ± 109.47	0.264
	Post op	10	197.90 ± 73.28		
	After 30 min of block	10	171.70 ± 97.37	(-)26.20 ± 89.72	0.380
	Post op	10	197.90 ± 73.28		
19	Pre op	5	229.60 ± 46.96	21.80 ± 54.28	0.420
	After 30 min of block	5	207.80 ± 78.54		
	Pre op	5	229.60 ± 46.96	20.40 ± 48.27	0.398
	Post op	5	209.20 ± 57.05		
	After 30 min of block	5	207.80 ± 78.54	(-)1.40 ± 94.49	0.975
	Post op	5	209.20 ± 57.05		
17	Pre op	5	229.40 ± 108.60	64.00 ± 66.09	0.096
	After 30 min of block	5	235.40 ± 111.74		
	Pre op	5	229.40 ± 108.60	(-)71.80 ± 85.48	0.134
	Post op	5	371.20 ± 89.83		
	After 30 min of block	5	235.40 ± 111.74	(-)135.80 ± 50.84	0.004×
	Post op	5	371.20 ± 89.83		
15	Pre op	5	309.40 ± 139.55	22.40 ± 35.59	0.232
	After 30 min of block	5	287.00 ± 134.89		
	Pre op	5	309.40 ± 139.55	71.80 ± 124.90	0.268
	Post op	5	237.60 ± 105.89		
	After 30 min of block	5	287.00 ± 134.89	49.40 ± 144.21	0.486
	Post op	5	237.60 ± 105.89		

ml: millilitre, PEFR: Peak Expiratory Flow Rate, N: Number of patients, SD: Standard Deviation

a comparison of findings using varying amounts of 0.5% ropivacaine. Our observations led us to the conclusion that there was a decline in pulmonary function after 30 minutes of block when the volume was increased. The observed disparity was more pronounced in larger volumes compared to smaller quantities. In the smaller volumes, it was observed that the pulmonary function tests during the post-operative period returned to normal. The mean difference was found to be significant at 17 ml. Typically, patients do not have difficulty in breathing until their Forced Vital Capacity (FVC) drops to a level that is equal to or less than 38% of the expected value. This is due to the body's natural compensatory mechanisms. Hence, none of our patients had any discomfort in respiration. We conclude that 17 ml and 15 ml of 0.5% ropivacaine were not associated with a significant decrease in hemi-diaphragmatic movement or pulmonary function. So, for patients with low cardiopulmonary reserves, 17 ml and 15 ml of 0.5% ropivacaine can be safely given. Mak PHK et al. observed substantial reduction in lung function, whereas

Table 7: Mean time of involvement of nerves at different volumes of LA

	Dose						
	25	**23**	**21**	**19**	**17**	**15**	**p value**
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Absent thumb adduction (ulnar nerve)	22 ± 4.47	17 ± 2.74	17.78 ± 4.41	20.83 ± 3.76	21 ± 4.18	24 ± 2.24	0.041*
Absent thumb abduction time (radial nerve)	20 ± 3.54	17 ± 4.47	18.33 ± 3.54	21.67 ± 4.08		25 ± 6.12	0.013*
Absent thumb opposition time (median nerve)	22 ± 4.47	20.00 ± 5.00	16.11 ± 6.97	21.67 ± 6.06	24 ± 4.18	25.00 ± 5.00	0.080

SD: Standard Deviation

those with decreased or normal movement had minor changes.[23] Bao X et al. observed significant decreases in hemi-diaphragmatic movement and pulmonary function in patients with higher volumes of LA.[26]

Another factor we took into account in our investigation was the volume of the LA. We conducted an investigation to determine the smallest amount of 0.5% ropivacaine needed to achieve surgical anesthesia. The minimum effective volume estimated was 15 ml of 0.5% ropivacaine. Pushpender et al. determined that by using 15 ml of 0.5% ropivacaine, successful surgical anesthesia using US-SCBPB could be attained without any noticeable negative effects on the block onset, duration, and patient's breathing.[10] Saric et al. determined that the lowest effective volume for the elderly population was 16.49 ml, while for middle-aged individuals it was 44.52 ml.[27]

Song et al. concluded that with the use of 1.5% mepivacaine, effective doses were 9 ml, 15 ml, and 17 ml.[12] Despite utilizing the corner pocket approach, Duggan et al. and Tran et al. were unable to decrease the volume of local anaesthetic. It was deduced that at the supraclavicular level, the connective tissue intertwines around the brachial plexus. They observed that the neuronal structures in the supraclavicular area, which are surrounded by connective tissue, may not be able to decrease in volume any further due to their already compact nature.[28,29]

Incidence of complications like pneumothorax and vessel injury was nil with the use of ultrasound-guided technique in our study. Zhai et al. found none of their patients suffered from respiratory distress, hypoxia, post-block hoarseness, hematoma, or LA toxicity.[30] The hemodynamic parameters, including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), respiratory rate (RR), and oxygen saturation (SpO2), did not show any statistically significant differences across the various volumes of 0.5% ropivacaine. Therefore, these parameters were considered comparable. Pushpender et al. and Gupta et al. also monitored the above parameters and did not find any significant variations.[10,26]

5. Study Limitations

It was a time-bound study over 12 months, so the sample size was of least power. We used the Dixon and Massey's up-and-down method, which calculates only over a limited number of patients. For accuracy, the authors suggest more than 20 patients. We took a total 36 patients. We did not follow up with the patient for the duration of the block. We could not calculate the minimum effective volume in 95% (MEV95) of patients and 50% (MEV50), because our stopping rule was reached, and also, the sample size was small. We did not follow up for neurological complications in patients receiving US-SCBPB since the study was time-bound. We did not do continuous assessments of diaphragm movement throughout the intraoperative period. The partial paralysis may have extended to complete paralysis, which we have not assessed.

6. Conclusion

In conclusion, our findings demonstrate that reducing the volume of 0.5% ropivacaine led to a substantial decrease in the incidence of diaphragmatic paralysis. Importantly, this reduction did not compromise the effectiveness of the nerve block nor did it adversely affect pulmonary function. Our study identified an optimal volume range of 17-15 ml of 0.5% ropivacaine, which consistently provided effective nerve blockade without any reported cases of diaphragmatic paralysis. These results suggest that minimizing the volume of ropivacaine can offer significant clinical benefits by reducing adverse effects while maintaining therapeutic efficacy.

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None.

8. Conflict of Interest

None.

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