

COMPARISON OF INCIDENCE OF HEMI DIAPHRAGMATIC PARALYSIS USING M MODE ULTRASOUND FOLLOWING SUPRACLAVICULAR VERSUS INFRACLAVICULAR APPROACH TO BRACHIAL PLEXUS BLOCKS : A RANDOMIZED CONTROLLED TRIAL

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Abstract

Background: The occurrence of hemi- diaphragmatic paralysis with supraclavicular block is one of the recognized complication even when performed under ultrasound guidance. Our study tested the hypothesis that the infraclavicular approach results in a lower incidence of hemi diaphragmatic paralysis compared with supraclavicular blockade when a standard local anesthetic volume and concentration are used. **Materials and Methods:** With institutional human ethics board approval, we enrolled 80 patients undergoing upper extremity surgery below mid humerus in a randomized, blinded, parallel-group trial. Patients were assigned to ultrasound-guided supraclavicular (group S) or infraclavicular blockade (group I) with 20 mL of 0.5% local anesthetic. The primary objective the occurrence of complete hemi diaphragmatic paralysis at 30 minutes, defined as a greater than 75% reduction in diaphragmatic excursion measured with the voluntary sniff test and deep breathing test using M-mode diaphragm ultrasonography. **Result:** 17.5% in group S and 7.5% in group I had significant and complete diaphragmatic paralysis. During VS test there was no notable HDP at post block and after 15 minutes in both group. But the p value for the 30th min is significant with a value 0.0083 showing lesser incidence in the group I. Similarly, there no remarkable change in deep breathing test in both groups following post block and at the end of 15 minutes. Whereas, 11 patients were involved in group S versus 2 in group I making a significant p value 0.0019. **Conclusion:** Infraclavicular block technique exhibits a superior safety margin in comparison to supraclavicular approach as evidenced by low incidence of hemi diaphragmatic paralysis assessed through M mode ultrasound.

INTRODUCTION

Brachial plexus block has been the cornerstone in anesthetizing patients for upper limb surgeries. Interscalene, supraclavicular and axillary were the various approaches brachial plexus block.^[1] Since the introduction of ultrasound into clinical practice, it has become a valuable tool for peripheral nerve blocks.^[2] Hemi diaphragmatic paralysis due to inadvertent phrenic nerve palsy (PNP) is a well-known complication of brachial plexus blockade, depending on the approach used to block brachial plexus block.^[3] Comprised of the anterior branches of the, Phrenic nerve with root value of C3-C5 spinal roots

usually seen on the surface of the anterior scalene muscle. Because of its anatomical association with brachial plexus, PNP resulting in ipsilateral hemi diaphragmatic paralysis can occur following brachial plexus blockade. Brief hemi diaphragmatic paralysis is usually well tolerated in healthy individuals, whereas in patients with compromised respiratory function PNP can be devastating.^[4-6]

Aim of the study

To assess incidence of diaphragmatic paralysis using M-mode ultrasonography after performing the block in both groups (supraclavicular versus infraclavicular) using ultrasound.

MATERIALS AND METHODS

The study was a prospective randomized controlled double-blinded clinical study. After obtaining patient consent and Institute Ethics Committee approval, eighty patients aged 18–60 years, weighing 55 and 85 kg with American Society of Anesthesiologists physical status Classes I and II undergoing surgeries for upper limb below mid humeral level were included in the study. Patients with local infection at the site of puncture, any neurologic deficit in the upper limb, severe chronic obstructive pulmonary disease, morbid obesity history were excluded from the study.

All patients were explained about the anesthetic technique and perioperative course in the preop assessment clinic. Patients were kept fasting for six hours before surgery. On the day of surgery patients all patients were started on IV access (18 G) venflon in the non-operative arm. Minimal mandatory monitoring devices were connected to all patients.

Eighty patients were randomized into two groups one for the Supraclavicular and infraclavicular group using computer-generated random numbers approach and a total of 20 ml of 0.5 % bupivacaine was given for each procedure using ultrasound guidance.

In both groups the blocks were performed in supine position with head turned opposite side. In group S, linear ultrasound probes (Sono site M turbo) were placed in the supraclavicular fossa in transverse orientation. After optimal visualization of the trunks and divisions was achieved, the skin was infiltrated with 2% lidocaine. Using an in-plane needling, a 22-gauge, 50-mm insulated peripheral nerve block needle was inserted from lateral to medial side targeting the “corner pocket. 20 ml of local anesthetic (10 ml of 2 % lignocaine with adrenaline and 10 ml of 0.5 bupivacaine) was injected in aliquots. Depending upon the spread in ultrasound the needle was redirected to cover the trunks and divisions^{7,8}. [Figure 1]

In group I, the linear probe was placed parasagittally medial to the coracoid process. All the three cords of the brachial plexus were identified deep to pectoralis major and minor. After giving puncture site analgesia a 22-gauge, 50-mm insulated peripheral nerve block needle gauge was inserted cephalad to caudad direction toward the posterior aspect of the axillary artery aiming for a perivascular injection targeting medial, posterior and lateral cords at the 3-o’clock 6-o’clock position 9-o’clock position ultrasound probe 20 mL of local anesthetic was injected in fractionated dose aiming to achieve U-shaped spread around the vessel.^[9,10] [Figure 1]

With the patient in a semi sitting position diaphragmatic function was assessed using M-mode ultrasonography with a curvilinear ultrasound probe placed subcostally between the right anterior axillary and midclavicular lines, using the liver as an acoustic window. [Figure 2] When optimal images were obtained, the ultrasound machine was set to M-mode,

displaying a single beam against time. In M-mode, the diaphragm appears as a crisp white, hyperechoic line slowly undulating through the respiratory cycle. Patients were then asked to perform 2 discrete breathing maneuvers.^[11,12]

“Voluntary sniff (VS) test, in which patients were asked to forcefully inhale through the nose in a sniffing fashion. Diaphragmatic excursion from baseline was measured using the digital calipers on the ultrasound machine interface. A normal upward movement (toward the probe) was designated positive. A paradoxical downward movement was designated negative. Two measurements were made, and the average taken.

Second, patients were asked to perform a “deep breathing” (DB) maneuver, inhaling deeply through the mouth up to vital capacity and then slowly exhaling. Similar to the VS test, each patient performed 2 DB maneuvers. The above measurements were performed immediately preceding brachial plexus blockade, and then at 15 and 30 minutes after block.

The primary objective was complete hemi diaphragmatic paralysis at 30 minutes, defined as a greater than 75% reduction in diaphragmatic excursion in the VS test. Partial paralysis was defined as a 25% to 75% reduction in the VS test. [Figure 3A&3B]

Sample size: The sample size calculation was based on the master article reference, Hong, B., Lee, S., Oh, C. et al.^[13] The incidence of HDP above and below clavicle (34% vs 3%). For a power of 90% and a risk of 5% for type I errors we arrived a sample size of 35 patients in each group. Considering the drop outs we planned to recruit 80 subjects.

Statistical analysis

- The collected data was entered in Microsoft Excel and transferred to SPSS software for analysis (version 22). Quantitative variables will be represented as mean and standard deviation analyzed by Fischer exact test. Significant Fischer exact t test will be further analyzed by post hoc test to determine the significant group.
- Qualitative variables will be presented as numbers and percentages and will be analyzed by Chi-square test. $P < 0.05$ was considered significant and <0.01 was considered highly significant.

RESULTS



Figure 1: Sonoimage of brachial plexus block



Figure 2: M mode-Diaphragm ultrasound

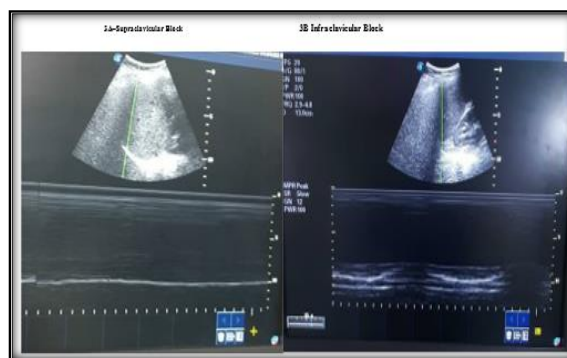


Figure 3: M mode Ultrasound of diaphragm

Table 1: Demographic and clinical characteristics.

	Group S (n = 40)	Group I (n = 40)	SMD
Female, n (%)	17 (48.6%)	19 (47.5%)	0.021
Age (year), median [IQR]	44.0 [41.0 to 60.5]	43.5 [35.5 to 58.0]	0.269
Height (cm), mean (SD)	164.8 (7.9)	165.8 (8.7)	0.118
Weight (kg), median [IQR]	62.0 [55.0 to 76.5]	63.8 [56.0 to 71.1]	0.110
BMI (kg/m ²), median [IQR]	23.1 [21.5 to 26.3]	22.9 [20.8 to 25.4]	0.198
Operation side (Lt./Rt.)	22/28	18/22	0.093
Surgical site (elbow/forearm/hand/wrist)	4/3/18/15	8/18/10/4	0.590
Operation time (min), median [IQR]	54.0 [43.5;78.5]	56.5 [45.5;75.0]	0.026

BMI body mass index, SMD standardized mean difference

Table 2: Percentage of patients with hemi diaphragmatic paralysis

	Group S (n = 40)	Group I (n = 40)	Effect size (95% CI)	p-value
HDP, n (%)	18 (45%)	5(12.5%)	- 36 (- 54 to - 16)	0.002**
Complete , n (%)	11 (27.5%)	2 (5%)		
Partial, n (%)	7 (17.5%)	3 (7.5%)		
No paralysis, n (%)	22 (55%)	35 (87.5%)		

Table 3: Patients showing positive Voluntary sniff test & deep breathing sonographically (Fisher's exact test)

Voluntary sniff test	Group S		Group I		P value
	Positive	Negative	Positive	Negative	
Baseline	0	0	0	0	1
5 mins	3	37	1	39	.0823
15 mins	6	34	4	36	.0614
30 mins	18	22	5	35	.0083
Deep breathing					
Baseline	0	0	0	0	1
5 mins	3		0		0.2347
15 mins	6		1		0.0983
30 mins	11		2		.0019

DISCUSSION

Onset of HDP following various approaches to brachial plexus block depends on injection site, type, volume and dose of the local anesthetic used as well as anatomical variations of subjects. The most important factor of these is limiting local anesthetic dose and injection volume and performing the injection further away from the C5–C6 nerve roots.

HDP is one of the recognized side effect secondary to ISB is due to cephalic propagation of the local anesthetic towards nerve roots C3---C5 and/or its anterior diffusion towards the phrenic nerve.^[14-16]

In this study, we assessed the incidence of HDP during ultrasound-guided distal approaches to brachial plexus supraclavicular versus infraclavicular block following standard volume of injection of local anesthetic. Both groups were comparable in clinical

and demographic profile.[Table 1] Throughout the study , the heart rate and systolic and diastolic BP were comparable and were stable.

Eighteen patients in group S and five patients in group I had HDP, [Table 2] our results were in contrast to those of Renes et al, who found that ultrasound- guided supraclavicular brachial no hemi diaphragmatic paralysis 16. Siva Shanmugam et al,^[17,18] reported an incidence of HDP in 1 of 20 patients receiving costoclavicular block.

The hemi diaphragmatic paralysis was determined by the voluntary sniff test and deep breathing test at 15 and 30 minutes with diaphragm ultrasound before and after the block. VS test in the group S, 3 patients had hemidiaphragm paralysis immediately after block and one patient in the group I. In the 15th min 6 patient in group S and 4 patient in group II had paralysis. At 30 min,18 patients in group S and 5

patients in group I had paralysis. The p value for the immediate and 15th min were insignificant. [Table 3] But the p value for the 30th min is significant with a value 0.0083 showing lesser incidence in the group I. our results were concordant with Koscielniak-Nielsen et al,^[18] that infraclavicular block produced lesser number of hemi diaphragmatic paralysis than supraclavicular block.

Three patients reacted for deep breathing test in group S immediately after the block is none in group I. At 15th min it is positive for 6 patients in group S and 1 patient in group I. (p value 0.0983.) Only at the 30th min ,11 patients were involved in group S versus two in group I making a p value 0.0019. supporting infraclavicular approach as the safest comparatively. Regarding ultrasound-guided infraclavicular blockade, the present finding of a 3% incidence of complete hemi diaphragmatic paralysis generally is consistent with previous reports on conventional techniques showing a minimal risk. It is important to note though that while the incidence was low, it was not zero, in contrast to recent suggestion in the review literature by Dullenkopf A et al.^[19,20]

The following were the limitations of our study. We didn't incorporate the diaphragmatic thickness, excursion and pulmonary function test and fluoroscopic assessment of diaphragm to validate study. Patients with respiratory compromise were excluded from the study.

CONCLUSION

Incidence of hemi diaphragmatic paralysis as assessed by the M mode ultrasound is lesser with infraclavicular than supraclavicular block substantiating the better safety margin. Anesthesiologist should weigh the risk benefits of each approach and tailor the choices based on patients' respiratory function and nature of the surgery.

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