

Sonographic assessment of hemi-diaphragmatic palsy post brachial plexus blocks

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ABSTRACT

Background and Aim: Brachial plexus blocks (BPB) are indispensable in providing surgical anaesthesia and postoperative analgesia. Although Hemi-diaphragmatic palsy (HDP) after BPB is clinically insignificant in the majority, it can cause significant physiological impairment in patients with reduced pulmonary function. Sonographic assessment of diaphragmatic function using the ABCDE approach provides accurate and quantitative information on HDP. This can be performed bedside before and after administration of the nerve block to quantify HDP. This was a prospective observational study comparing ultrasound-guided diaphragmatic thickness in two approaches of ultrasound-guided BPB. **Methodology:** Eighty participants receiving either interscalene/supraclavicular BPB were included in this observational study. Baseline vitals, NRS score for pain and ultrasound-guided diaphragm thickness at inspiration and expiration using the ABCDE approach were noted. After 20 minutes of BPB administration, the diaphragm thickness was remeasured. **Results:** Eighty participants completed the study, forty from either group. Average volume of the total local anaesthetic drug mixture used was noted to be 30ml.

The diaphragmatic thickness ratio in the supraclavicular group was found to decrease by 2.34% as compared to 2.39% in the interscalene group. (p-value 0.256 baseline values, 0.292 for post block values) The thickness fraction was found to decrease by 9.21% in Group A as compared to 9.04% in Group B (P value 0.248 baseline values and 0.292 post-block values). There was no statistically significant difference between the diaphragm thickness in both the group's pre- and post-block, irrespective of the approach used. **Conclusion:** The ABCDE approach to measure diaphragm thickness can be used as a simple bedside modality to quantify the amount of HDP occurring after ultrasound-guided BPB. It is easy to learn & a non-invasive modality which can be used to improve patient safety during BPB

Keywords

Hemidiaphragmatic palsy, ABCDE, Brachial plexus block

INTRODUCTION

Hemi-diaphragmatic palsy (HDP) is an established side effect after brachial plexus blockade (BPB). It occurs due to the spillage of local anaesthetic onto the phrenic nerve. The incidence of HDP ranges from nearly 92% in Interscalene blocks to 62% after supraclavicular blocks.^{1,2}

This transient unilateral diaphragmatic palsy is compensated by the opposite hemidiaphragmatic functions and is usually clinically insignificant in healthy subjects. However, HDP can be deleterious in high-risk populations with reduced respiratory reserve.³

Ultrasound-guided measurement of diaphragm

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thickness at the Zone of apposition (ZOA) the region where the diaphragm is directly opposed to the chest wall is a method used to detect HDP using the B-mode. Literature suggests a mean diaphragm thickness at the functional residual capacity to be 2.29 ± 0.4 mm.⁴ So, the paralyzed diaphragm does not thicken significantly or become thinner upon deep inspiration compared with the thickness on end-expiration.

A less than 20% increase in diaphragmatic thickness with inspiration suggests diaphragmatic weakness.⁵

Thus, ultrasound-guided assessment of HDP using the diaphragmatic thickness during inspiration and expiration provides an accurate and quantitative analysis. This can be performed by anaesthesiologists at the bedside in the perioperative period before and after the administration of BPB.⁶

Currently, there are limited studies quantifying the amount of HDP caused by different approaches to BPB.

METHODS

This prospective observational, single-centre study was done in a tertiary care hospital from April 2021 to September 2022. Institutional ethics committee approval was obtained (Reg.No EC/NEW/INST/2020/834) and written informed consent was taken from all of the participants. Patients above 18 years of age scheduled for elective and emergency upper limb surgeries under ultrasound-guided BPB as the sole anaesthesia were included.

Exclusion criteria included contraindications to peripheral nerve block (e.g., Patient refusal, allergy to local anaesthetics, coagulopathy, infection in the area), existing contralateral diaphragmatic palsy, moderate to severe pulmonary disease and chest deformities.

Using a computer-generated sequence of random numbers and a sealed envelope technique, patients were randomly assigned to receive either ultrasound-guided supraclavicular (Group A) or inter scalene (Group B) BPB.

A total of eighty participants were allocated into the 2 groups, each comprising 40 participants for the Supraclavicular BPB and Interscalene BPB.

For the scheduled anaesthetic procedure, patients were shifted to the block room where their baseline parameters were checked with standard ASA monitors.

Baseline ultrasound-guided diaphragm thickness was measured during inspiration and expiration in the B mode (Greyscale ultrasound) on the side scheduled to receive the BPB. The diaphragm thickness was measured in the ZOA using the linear probe (10-15MHz) of the LOGIQe ultrasound machine (GE Healthcare Technologies, Waukesha, Wisconsin) TM in all patients by a single assessor (Fig no -1).



Fig no- 1: A linear array transducer placed over anterior axillary line over the 8th and 9th ribs in the coronal plane.

The patient was asked to remain in the sniffing position and ABC Diaphragm Evaluation (ABCDE) approach was used to identify the diaphragm and the thickness was subsequently measured.⁷ This involved first placing the high-frequency, linear USG probe at the anterior (A) axillary line just below the level of the nipple. Lung sliding superficial to the diaphragm during (B) breathing was evident as a bright hyperechoic shadow entering the field of view from the cephalad aspect (Fig-2). As the transducer was moved (C) caudally, the (D) diaphragm thickened during inspiration and was (E) evaluated caudal to the pleural line (Fig-2)^{8,9}.



Fig 2: Depicting the diaphragm thickness between two hyperechoic lines namely the diaphragmatic pleura superiorly and the peritoneum inferiorly

Measurements were noted in centimetres using the following formulae to calculate the Thickness ratio (TR) and Thickness fraction (TF).

TR is Thickness at maximal inspiration/ Thickness at end-expiration, which is normally greater than 1.2(Fig-3A)

TF is the thickness at the end of Inspiration - thickness at end-expiration/thickness at end-expiration. (Fig- 3B)

The lower limit of normal TF is 0.21.

The patients received the allocated BPB - (Group A- Supraclavicular approach and Group B- Interscalene approach).

The local anaesthetic volume (0.5% Bupivacaine + 2% Lignocaine & Adrenaline and an adjuvant Dexmedetomidine or Fentanyl) was fixed at 30-32mL for both approaches.

20 minutes after the block placement, an assessment of sensory and motor blockade was done, if the blockade was satisfactory the TR and TF were reassessed via ultrasound and compared with baseline values. The patient was then shifted to the allotted operation theatre and surgery was initiated. Post- surgery, all patients were shifted to the PACU. None of the patients who participated in the study was noted to have any respiratory compromise in the perioperative period.

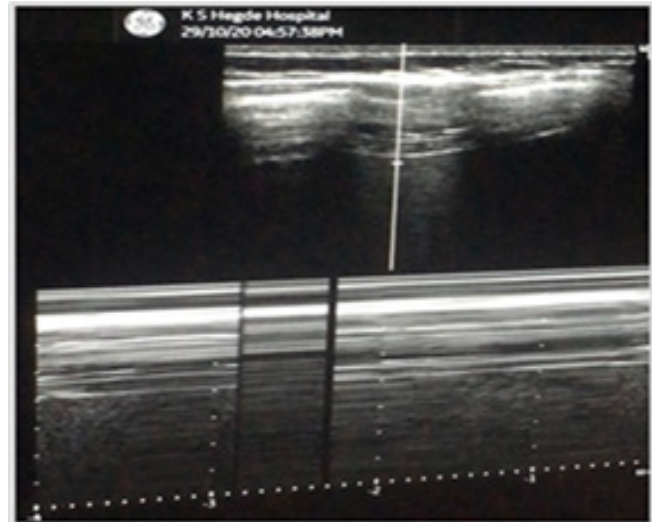


Fig-3A

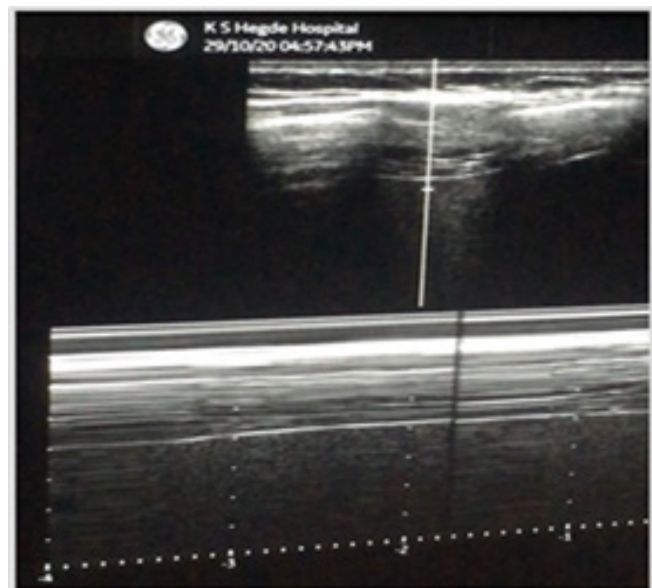


Fig-3B

Fig no 3: Diaphragm thickness noted on inspiration (A) and thinning on expiration (B).

Data were computed on a Microsoft Excel spreadsheet (Microsoft office professional 2013, Microsoft Corporation, Redmond, WA, USA) and analysed by Statistical Package for Social Sciences (SPSS), (International Business Machines (IBM), Armonk, USA). The number of comparisons was done by one-way ANOVA, Bonferroni multiple comparison tests, and Kruskal Wallis/ Mann Whitney U test. The correlation was further found with Karl Pearson's coefficient

correlation test. P value of < 0.05 was considered significant.

Results

We assessed 89 patients for eligibility of which 80 patients were randomized, 40 in each group.

Fig. 4 shows the flow of the patients through the study.

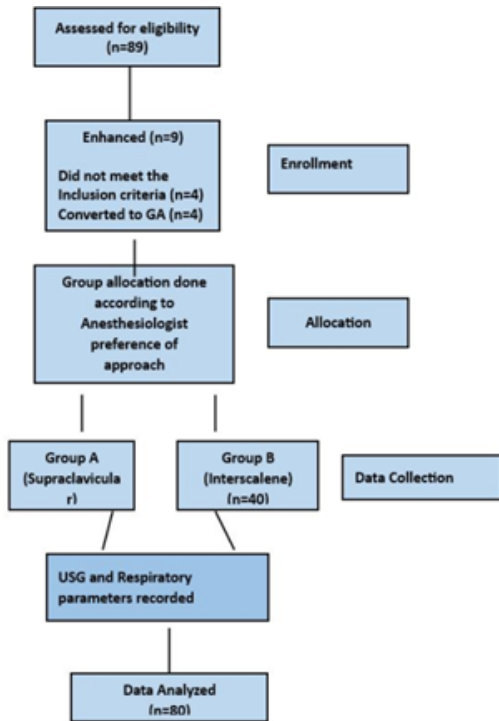


FIG-4 CONSORT DIAGRAM

Both groups were comparable based on demographical data and baseline hemodynamic parameters. Likewise, the distribution of ASA PS across the groups were also comparable. (Table -1).

All participants (100%) in both groups were noted to have a decrease in diaphragm thickening during inspiration post-administration of the BPB as noted by ultrasound parameters (Table 2). The TR post-administration was found to decrease by 2.34% in Group A as compared to 2.39% in Group B with no statistically significant difference between the two groups. (p-value 0.256 for baseline values and p-value 0.292 after block values).

DISCUSSION

The objective of this study was to estimate HDP by assessment of Diaphragmatic thickness using ultrasound

Table 1 – Demographic data

	Group A n = 40 Supraclavicular BPB	Group B n = 40 Interscalene BPB
Sex (M: F)	31:9	24:16
ASA PS 1	18	19
ASA PS 2	12	19
ASA PS 3	10	2
Age, mean (SD) yrs	46.27 (16.21)	41.53 (14.09)
Weight, mean (SD)	60.68 (9.95)	68.44 (10.99)
Height, mean (SD)	161.73 (6.66)	163.38 (6.58)
BMI, mean (SD) KG/m ²	23.15 (3.37)	25.60 (3.60)
TYPE OF SURGERY		
GENERAL SURGERY	24	27
UROLOGY	10	10
ORTHOPEDICS	6	3

Table 2- Comparison of TR and TF on ultrasound parameters.

ULTRASOUND PARAMETER (Mean +/- SD)	GROUP A SUPRACLAVICULAR	GROUP B INTERSCALENE	P-VALUE
TR (baseline)	1.391 +/- 0.071	1.409 +/- 0.074	0.256
TR (after block)	1.158 +/- 0.079	1.176 +/- 0.073	0.292
TF (baseline)	0.391 +/- 0.070	0.410 +/- 0.074	0.248
TF (after block)	0.158 +/- 0.079	0.176 +/- 0.073	0.292
No significant changes were noted in either group in terms of TR and TF			

after two approaches of BPB.

Both supraclavicular and inter-scalene approaches were found to cause post-block HDP. The thickness ratio (TR) and thickness fraction (TF) values measured using the ABCDE technique confirmed the findings. Sonographic assessment of diaphragm function relies on visualising the diaphragm and quantifying the magnitude and direction of its movement with respiration.

In this study, diaphragmatic TR and TF values were noted before and after the two approaches. There was no significant difference between both groups which consisted of healthy patients devoid of pulmonary dysfunction.

Our TR values were similar to those found in a study done by Lopez et al, who compared diaphragmatic TR values after an interscalene block. Their index of inspiratory/expiratory diaphragmatic thickness at cut-off <1.2 proved useful in the diagnosis of phrenic paresis associated with interscalene block. This index does not require a baseline pre-assessment.¹⁰

Cohn et al, in their study, were able to demonstrate that 2-D ultrasonography was accurate in measuring diaphragm thickness in the lateral region of the ZOA. They found that during inspiration, the diaphragm thickens as it shortens.¹¹ Tsui et al¹² noted the change in the diaphragm TR reflected muscle effort and contractility.

The lack of statistically significant difference in quantifiable HDP between the two approaches of BPB in our study is presumed to be due to the total volume of LA used for the plexus blockade. The available literature suggests modifying the LA dose (volume and concentration) and the site of the blockade as strategies which help in minimizing the occurrence of HDP. There is no standardized volume of LA for ultrasound-guided supraclavicular and visualised. Regardless of the site of injection, volumes of 20mL or greater around C5-C6 nerve roots inevitably doses due to its increased accuracy of LA deposition as the plexus is directly

produce HDP which probably explains our findings.^{13,14}

The HDP caused might be transient or persistent phenomena with the transient palsy being caused by LA spreading directly to the phrenic nerve and the accessory phrenic nerve. The volume and dosage of LA used for the plexus blockade determine the duration of transient HDP. This is found to be 100% after inter

scalene approach of BPB which uses volumes greater than 20mL.¹⁴ Due to the lack of both objective and subjective respiratory signs and symptoms, transient nerve palsy has no clinical significance in the vast majority of healthy individuals. Unfortunately, data on high-risk populations such as patients with pulmonary disease, obesity or Obstructive sleep apnoea who are more likely to develop symptoms due to transient nerve palsy is limited.

According to the literature, there are no exclusive clinical predictors for phrenic nerve palsy, except in patients who have a BMI $\geq 30\text{kg/m}^2$.⁷

The quantifiable bedside methods available for assessment of the severity of HDP include pulse oximetry, PFTs and ultrasound-guided evaluation of the diaphragm. The PFTs and oxygen saturation assess bilateral pulmonary function simultaneously including the use of contralateral diaphragmatic activity and the accessory respiratory muscles. Hence, we used the more sensitive sonographic method to quantitatively assess unilateral diaphragmatic dysfunction which occurs post-BPB administration.

The limitations of this study include that it is a single-centre study; hence our dosing and choice of the local anaesthetic mixture were according to institutional protocol. Further research should be conducted in multiple centres. The volume of the local anaesthetic mixture used for the BPB administration was large which led to inevitable HDP in both approaches which were quantified on USG.

Another limitation was that by studying various volumes of LA mixture, an attempt to estimate the minimum volume required for HDP could have been measured.

CONCLUSION

Sonographic assessment effectively identifies hemidiaphragmatic palsy following brachial plexus blocks, offering a non-invasive diagnostic approach. This method can aid in prompt detection and management of diaphragmatic dysfunction, improving patient outcomes. Further research is warranted to validate the reliability and reproducibility of sonography in clinical practice for timely intervention in patients undergoing brachial plexus blocks.

However, the ABCDE technique used in this study was fast, non-invasive, easily reproducible and highly

accurate. It could be used for bilateral sonographic assessment of the diaphragm perioperatively to demonstrate evidence of diaphragmatic dysfunction. If patients have abnormal diaphragmatic thickening on the contralateral side of the surgical site, it may necessitate alternate anaesthetic techniques.

Scope for future research in this area could include studies which can correlate sonographic evidence of

HDP associated with pulmonary function tests, oxygen saturation and subjective symptoms of respiratory compromise.

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