Section: Pulmonary Medicine

Original Research Article

UTILIZATION OF DIAPHRAGMATIC MOVEMENTS AND THICKNESS FOR SCREENING OF PLEURO-PULMONARY-MEDIASTINAL DISEASES IN PATIENTS VISITING THE RESPIRATORY MEDICINE OUTPATIENT OF TERTIARY CARE CENTRE, KANPUR

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ABSTRACT

Background: The diaphragm is the principal muscle of respiration, and alterations in its movement and thickness reflect underlying pleuro-pulmonary and mediastinal diseases. Early identification of diaphragmatic dysfunction can aid in prompt diagnosis and management of respiratory disorders. This study aimed to evaluate the utility of diaphragmatic movements and ultrasonographic assessment of diaphragmatic thickness as a screening tool for pleuropulmonary-mediastinal diseases in patients attending the Respiratory Medicine Outpatient Department (OPD) of Rama Medical College, Kanpur.
Materials and Methods: This prospective, observational study was conducted among 100 adult patients presenting with respiratory symptoms. All participants underwent clinical evaluation, chest radiography, spirometry (where feasible), and diaphragmatic ultrasonography. Diaphragmatic excursion was measured using M-mode ultrasonography, while diaphragm thickness and thickening fraction were assessed using B-mode ultrasonography at the zone of apposition. Ultrasonographic findings were compared with established normative reference values.
Results: The most common final diagnosis established was Chronic Obstructive Pulmonary Disease (COPD-40%), followed by Pleural Effusion (25%), Interstitial Lung Disease (ILD, 15%), and Mediastinal Masses (10%). Reduced diaphragmatic excursion, thinning of the diaphragm, and decreased thickening fraction were commonly observed, particularly in patients with chronic obstructive pulmonary disease and pleural effusion. The mean diaphragm thickness was below the lower limit of normal reference values, indicating prevalent diaphragmatic dysfunction. Diaphragmatic parameters showed a statistically significant positive correlation with spirometric indices, especially forced vital capacity and forced expiratory volume in one second.
Conclusion: Diaphragmatic ultrasonography is a reliable, non-invasive, and cost-effective screening tool for detecting pleuro-pulmonary-mediastinal diseases in the outpatient setting. Its routine use may facilitate early diagnosis, guide further evaluation, and improve respiratory disease management, particularly in resource-limited healthcare environments.
Keywords: Diaphragm, Ultrasonography, Diaphragmatic Excursion, Diaphragm Thickness, Respiratory Muscles, Pulmonary Function Tests, Chronic Obstructive Pulmonary Disease.

INTRODUCTION

The human respiratory system functions through a finely coordinated interaction of muscular, neural, and mechanical components that together ensure adequate ventilation, effective gas exchange, and maintenance of systemic homeostasis. Among the various muscles involved in respiration, the diaphragm plays a dominant and indispensable role, in contributing nearly 70% of tidal ventilation during quiet breathing.[1]

The clinical importance of the diaphragm becomes particularly evident in pathological conditions affecting the lungs, pleura, and mediastinum. Alterations in diaphragmatic movement, thickness, or contractility reflect early involvement of the respiratory system and often precede overt clinical symptoms or radiological abnormalities.[2] Consequently, assessment of diaphragmatic structure and function provides a valuable period for the early detection and monitoring of thoracic diseases. Structural thinning, mechanical weakness, or restricted movement of this dome-shaped musculotendinous partition indicates an underlying pleuro-pulmonary or mediastinal structural pathology.

Respiratory diseases represent a major global health burden and contribute substantially to morbidity, mortality, and healthcare utilisation worldwide. Chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), pleural effusions, and mediastinal pathologies account for a significant proportion of respiratory-related deaths and disability-adjusted life years lost. According to estimates by the World Health Organisation (WHO), respiratory diseases are responsible for approximately four million deaths annually, with COPD to be the third leading cause of death globally by the year 2030.[3]

Early detection and prompt management of respiratory diseases are therefore critical for improving clinical outcomes, slowing disease progression, and reducing healthcare costs. Traditional diagnostic pathways often rely on advanced imaging modalities or invasive investigations, which are not readily available or feasible in all clinical settings. In this context, there is a pressing need for accessible, non-invasive, and cost-effective diagnostic tools that could be deployed at the point of care, particularly in outpatient and resource-limited environments.[4]

To address these challenges, diaphragmatic ultrasonography (USG) has emerged as an objective, non-invasive, radiation-free alternative capable of direct dynamic visualisation at the bedside. In response to the limitations of conventional diagnostic techniques, ultrasonography has emerged as a promising modality for the evaluation of diaphragmatic structure and function. It is a non-invasive, radiation-free imaging technique that allows real-time visualisation of internal structures at the bedside. For diaphragmatic assessment, both B-mode (two-dimensional) and M-mode (motion) ultrasonography are used to measure diaphragm thickness and excursion, respectively.[5]

While the utility of diaphragmatic USG is well-documented in intensive care settings for predicting mechanical ventilation weaning success, its validation as a front-line screening mechanism in general ambulatory care remains sparse. Outpatient departments represent the first point of contact for most patients with early or mild respiratory symptoms, where timely diagnosis could significantly alter disease trajectory. Non-invasive, rapid, and easily deployable screening strategies are therefore essential in this setting.[6,7]

This clinical gap is particularly evident in developing countries, especially in India, where high smoking rates, biomass smoke exposure, and delayed diagnostic presentation contribute to a substantial respiratory disease burden. India bore a disproportionate share of the global burden of respiratory diseases. Accordingly, the present study is designed to evaluate diaphragmatic movements and thickness using ultrasonography in patients attending the Respiratory Medicine Outpatient Department of Rama Medical College, Kanpur, UP.

MATERIALS AND METHODS

Study Design and Setting: This prospective, cross-sectional, observational study was conducted over a continuous 12-month period within the Department of Respiratory Medicine, Rama Medical College Hospital and Research Centre, Kanpur, Uttar Pradesh. Patients were recruited from the Respiratory Medicine OPD, while ultrasonographic examinations were performed in the Radiology Department.

Study Population and Selection Criteria: A total of 100 adult patients presenting with prominent, non-specific respiratory signs or symptoms (such as dyspnea, chronic cough, or chest pain) suggestive of underlying pleuro-pulmonary or mediastinal pathology were consecutively enrolled.

Sample Size Calculation: The sample size was calculated based on available literature reporting the prevalence of diaphragmatic dysfunction in patients with respiratory diseases to be approximately **30%**. Using the standard formula for sample size estimation for prevalence studies

$$n = \frac{Z^2 \times p \times q}{d^2}$$

Where Z= 1.96 for 95% confidence level
p=0.30(estimated prevalence)
q=1-p=0.70
d=0.05 (allowable error). The minimum required sample was calculated to be approx. 100.

Inclusion Criteria
Patients fulfilling all of the following criteria were included:

- Age 18 years and above.
- Patients who visit the Respiratory medicine OPD of Rama Medical College, Kanpur.
- Willingness to undergo diaphragmatic ultrasonographic examination.
- Provision of written informed consent.

Exclusion Criteria
Patients with the following conditions were excluded to avoid confounding of diaphragmatic measurements:

- Known diaphragmatic paralysis or diaphragmatic eventration.
- History of thoraco-abdominal surgery or trauma affecting diaphragmatic structure or movement
- Diagnosed neuromuscular disorders involving the respiratory muscles
- Pregnancy
- Uncooperative patients or those unwilling to provide informed consent

Data Collection Protocol: In this study, all patients attending the Respiratory Medicine OPD who fulfilled the eligibility criteria were consecutively screened and enrolled after obtaining written informed consent. A standardised clinical proforma recorded patient baseline characteristics, including age, sex, BMI, smoking status, environmental biomass fuel exposures, and detailed respiratory clinical findings.

Ultrasonographic Assessment Technique: Diaphragmatic imaging was performed using a high-resolution ultrasound machine. Patients were placed in a comfortable supine or semi-recumbent posture. A curvilinear transducer (2–5 MHz) was used for assessment of diaphragmatic excursion, and a linear transducer (7–12 MHz) for measurement of diaphragm thickness at the zone of apposition.

Diaphragmatic Excursion (DE): M-mode ultrasound was used, and measurements (in cm) were taken during both quiet breathing and maximum deep inspiration

Diaphragm Thickness (DT) and Thickening Fraction (DTF): Diaphragm thickness was recorded using B-mode ultrasound at the zone of apposition and measured at end-expiration (T_{exp}) and peak-inspiration (T_{ins}) in millimetres.

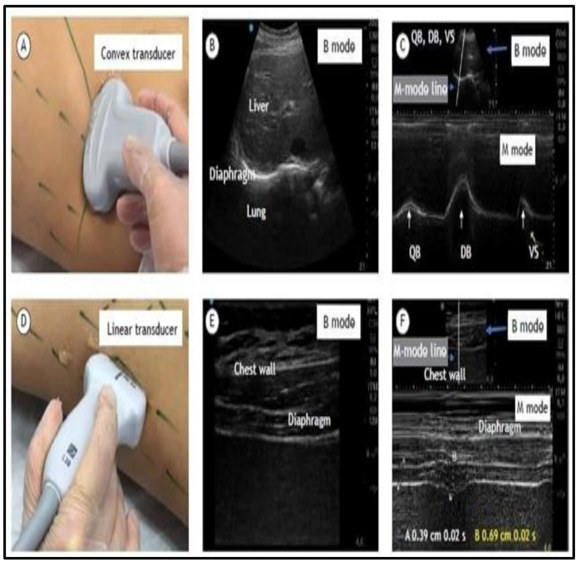

Figure 1: Surface anatomy and probe positioning for diaphragmatic ultrasonography using a linear transducer over the anterior/mid-axillary line at the 8th–9th intercostal space.

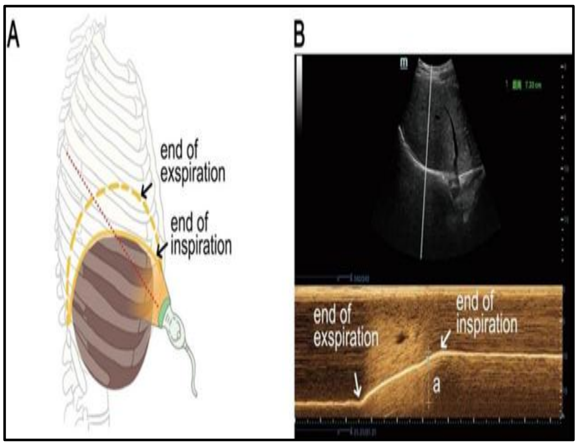

Figure 2: Ultrasonographic appearance of the diaphragm in B-mode showing external oblique muscle, intercostal muscles, diaphragmatic pleura, and peritoneum.

Pulmonary Function Testing: Spirometry was performed, where clinically feasible, using a calibrated standard spirometer in accordance with American Thoracic Society (ATS) guidelines. Recorded indices included Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), and the FEV_1 /FVC ratio.

Statistical Analysis
Data were analysed using SPSS Version 25.0. Categorical variables were expressed as frequencies and percentages. Continuous variables were expressed as mean ± standard deviation or median (interquartile range). Correlation between diaphragmatic ultrasonographic parameters and spirometric values was assessed using Pearson or Spearman correlation, as appropriate. Group comparisons were performed using an independent t-test or Mann-Whitney U test. A p-value < 0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Baseline Attributes

The study subjects (N=100) had a mean age of 48.5±12.3 years, with 65% of participants older than 45 years. The sample exhibited a male predominance (62% male vs. 38% female) and a high prevalence of smoking (55%).

Distribution of Respiratory Diseases

Based on clinical, radiological, and spirometric evaluation, patients were categorised into the following diagnostic groups. The most common final diagnosis established was Chronic Obstructive Pulmonary Disease (COPD-40%), followed by Pleural Effusion (25%), Interstitial Lung Disease (ILD, 15%), and Mediastinal Masses (10%). The remaining 10% comprised other non-specific conditions.

Table 1: Distribution of Respiratory Diseases

Disease Type	Number of Patients	Percentage (%)
COPD	40	40%
Pleural Effusion	25	25 %
Interstitial Lung Disease (ILD)	15	15%
Mediastinal Mass	10	10%
Others (Asthma, etc.)	10	10%

Ultrasonographic Assessment of the Diaphragm

All study patients underwent diaphragmatic ultrasonographic evaluation. The following parameters were assessed:

- Diaphragmatic excursion
- Diaphragm thickness at end-expiration
- Diaphragmatic thickening fraction (DTF)

Table 2: Ultrasonographic Assessment of the Diaphragm

USG Variables	Excursion (cm)	No of Patients	Percentage %
Diaphragmatic Excursion During Quiet Breathing	< 1.8 (Reduced)	30	30 %
	1.8- 2.4 (Normal)	40	40 %
	>2.4	30	30 %
Mean+S.D.	2.2 ±0.6 cm		
	Excursion (cm)	No of Patients	Percentage %
Diaphragmatic Excursion During Deep Breathing	< 4.0 (Reduced)	35	35 %
	4.0-7.0 (Normal)	60	60 %
	>7.0	5	5 %
Mean+S.D.	4.3 ±1.1 cm		
	Thickness (mm)	No of Patients	Percentage %
Diaphragm Thickness at End Expiration	<1.5 (Thinned)	42	42%
	1.5-2.5 (Normal)	50	50%
	>2.5	8	8%
Mean+S.D.	1.4 ±0.3 mm		
	DTF (%)	No of Patients	Percentage %
Diaphragmatic Thickening Fraction (DTF)	<20(Reduced)	48	48 %
	≥20(Normal)	52	52 %
Mean+S.D.	18.5 ±6.2		

Based on established reference values, a high prevalence of diaphragmatic dysfunction was identified across the study population as follows;

- **Quiet Breathing Excursion:** Reduced (**<1.8 cm)** in 30% of patients.
- **Deep Breathing Excursion:** Reduced (**<4 cm)** in 35% of patients.
- **End-Expiratory Thickness (T_{exp}):** Pathologically thin (<1.5mm) in 42% of patients.
- **Diaphragmatic Thickening Fraction (DTF%):** Reduced (<20%) in 48% of patients.

No statistically significant gender-based differences were observed in diaphragmatic excursion, thickness, or thickening fraction (p > 0.05).

Table 3: Comparison of Diaphragmatic Excursion Across Diseases

Disease type	Mean Excursion (cm)	p-Value
COPD	**3.7±0.8**	**<0.001**
Pleural Effusion	3.5±0.9	<0.001
Interstitial Lung Disease (ILD)	4.2±0.7	0.03
Mediastinal Mass	4.0±0.6	0.08
Others (Asthma, etc.)	4.5±0.5	Reference

Statistically significant positive correlations were observed.

Correlation Analysis with Spirometric Indices:

Among patients who successfully performed spirometry, diaphragmatic parameters correlated strongly with classic pulmonary function metrics:

- **Diaphragmatic Excursion vs. FEV_1 :** Showed a strong positive correlation (r = +0.65, p < 0.001).
- **Diaphragmatic thickness vs. FEV_1 :** Showed a strong positive correlation (r = +0.45, p < 0.002).

- **Diaphragmatic thickness fraction vs. FEV_1 :** Showed a strong positive correlation ($r = +0.52$, $p < 0.001$).
- **Diaphragmatic Excursion vs. FVC:** Showed a significant positive correlation ($r = +0.58$, $p < 0.001$).

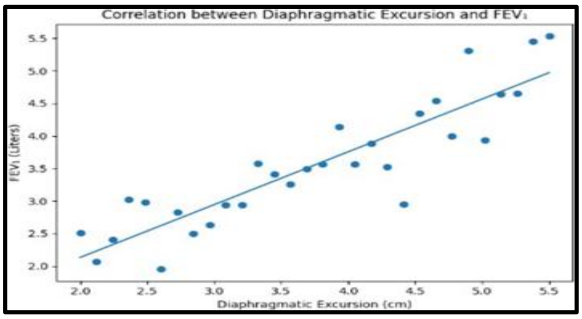

Figure 3: Scatter Plot – Correlation between Diaphragmatic Excursion and FEV1 (High Quality)

This shows significant correlations between diaphragmatic ultrasonographic parameters and spirometric indices, supporting the role of ultrasonography as an effective screening tool for pleuro-pulmonary-mediastinal diseases in outpatient settings.

Table 4: Correlation Analysis with Spirometric indices:

Parameter	Correlation Coefficient	p-Value
Diaphragmatic Excursion	+0.65	<0.001
Diaphragm Thickness	+0.43	0.002
Thickening Fraction	+0.52	0.001

DISCUSSION

The present prospective, cross-sectional, observational study was conducted to evaluate the role of diaphragmatic ultrasonography in assessing diaphragmatic movements and thickness as a screening tool for pleuro-pulmonary-mediastinal diseases. A total of 100 adult patients with respiratory complaints were evaluated using a combination of clinical assessment, spirometry, and ultrasonographic examination of the diaphragm. Nearly half (48%) of the symptomatic outpatient population demonstrated measurable diaphragmatic impairment, highlighting the systemic impact of common respiratory pathologies on the primary muscle of respiration.

The strong positive correlation between diaphragmatic excursion and FEV_1 ($r = +0.65$, $p < 0.001$) supports previous physiological models establishing that diaphragmatic mobility directly affects structural lung displacement and volume velocity profiles. This alignment with data from Paulin et al. [8] and Baria et al [9] confirms that ultrasound metrics reliably mirror standard spirometric indices. Consequently, in clinical settings where patients cannot perform spirometry due to acute dyspnea, cognitive impairment, or physical weakness, diaphragmatic ultrasound can serve as an objective surrogate for assessing respiratory mechanical function.

Chronic Obstructive Pulmonary Disease (COPD) emerged as the most common diagnosis (40%), followed by pleural effusion (25%), interstitial lung disease (15%), mediastinal masses (10%), and other respiratory conditions such as asthma (10%). This distribution is consistent with epidemiological data from India, which highlight COPD as a leading cause of respiratory morbidity and mortality. The Global Burden of Disease (GBD) Study has reported that India contributes to more than 30% of global COPD cases, underscoring the public health relevance of early detection strategies.[10]

This study was conducted on the high prevalence of diaphragmatic dysfunction, as detected by ultrasonography. These findings suggest that diaphragmatic dysfunction is common among patients with respiratory diseases, even in outpatient settings. Similar observations have been reported by Boussuges et al., who documented altered diaphragmatic motion in patients with respiratory pathology, and by Sarwal et al., who demonstrated reduced diaphragmatic thickness and contractility in patients with respiratory muscle impairment.[11]

One of the most significant findings of the present study was the strong positive correlation between diaphragmatic excursion and FEV_1 ($r = +0.65$, $p < 0.001$). Moderate positive correlations were also observed between FEV_1 and diaphragm thickness as well as thickening fraction. The pathology-specific patterns observed in this study highlight different underlying mechanisms of diaphragmatic dysfunction. In the COPD cohort, significant reductions in end-expiratory thickness and thickening fraction reflect the mechanical consequences of pulmonary hyperinflation. Chronic air trapping flattens the diaphragm dome, shortening its muscle fibres and reducing its contractile efficiency according to the length-tension relationship. Over time, this mechanical disadvantage can lead to adaptive structural thinning and disuse atrophy, consistent with findings by Kim WY et al. & Similowski et al [12,13] regarding chronic hyperinflation states.

In contrast, the restriction observed in pleural effusion cases is primarily driven by hydrostatic and mechanical loading. The accumulation of pleural fluid exerts upward pressure on the ipsilateral hemidiaphragm, reducing its mobile excursion cycle. This finding is consistent with Cassart et al [14] has noted that pleural effusions induce an architectural configuration change that limits normal caudal movement during inspiration. The resolution of this mechanical restriction following therapeutic thoracentesis further demonstrates the utility of ultrasound for monitoring therapeutic response over time. Kabil A study [15] concluded that diaphragmatic excursion is the most accurate, sensitive, and excellent discriminator for the prediction of successful weaning among diaphragmatic parameters. Diaphragmatic kinetics measured at total lung capacity and thickening fraction have good correlations with degree of dyspnea, forced vital capacity and exercise tolerance.[16,17] The combination of RSBI with DTf >26% was a more accurate predictor of successful weaning from mechanical ventilation than RSBI alone in another study.[18, 19] In a study by Kaur [20], DTf in patients with SBT failure was 19.26% ± 3.49% compared to 36.57% ± 8.22% in patients with successful extubation. In a study done by Alam et al. [21] in extubation-ready ICU patients, it was observed that DUS (DE and DTf) was a better tool to predict successful extubation compared to RSBI.

This finding suggests that diaphragmatic USG could serve as an early physiological marker of smoking-induced muscle injury, even before structural emphysema is fully visible on conventional chest imaging. This study has several limitations. First, it was conducted at a single centre with a modest sample size (N=100), which may limit the generalizability of the findings to broader populations. Second, ultrasonography is inherently operator-dependent, requiring standardised training to achieve reproducible results across diverse clinical settings. Third, advanced techniques such as speckle-tracking strain imaging or shear-wave elastography were not used. Finally, the study lacked a longitudinal follow-up component to track changes in diaphragmatic parameters over time or in response to specific therapeutic interventions.

CONCLUSION

The present study demonstrates that diaphragmatic ultrasonography is a valuable, non-invasive screening tool for detecting diaphragmatic dysfunction in patients with pleuro-pulmonary-mediastinal diseases. Significant associations with pulmonary function and smoking reinforce its clinical relevance. Despite limitations, the study supports the integration of diaphragmatic assessment into routine respiratory practice, particularly in resource-constrained settings.

REFERENCES

1. De Troyer A, Kirkwood PA, Wilson TA. Respiratory action of the diaphragm. *Physiol Rev*. 2005;85(2):385–422.
2. McCool FD, Tzelepis GE. Dysfunction of the diaphragm. N Engl J Med. 2012; 366 (10): 932–942
3. Laghi F, Tobin MJ. Disorders of the respiratory muscles. Am J Respir Crit Care Med. 2003;168(1):10–48.
4. Ottenheijm CAC, Heunks LMA, Sieck GC, et al. Diaphragm dysfunction in chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2005;172(2):200–205.
5. Wait JL, Nahormek PA, Yost WT, Rochester DP. Diaphragmatic thickness–lung volume relationship in vivo. J Appl Physiol. 1989;67(4):1560–156
6. Kharbanda PS, Prasad KT, et al. Role of diaphragm ultrasound in respiratory disease.Indian J Chest Dis Allied Sci. 2019;61(2):87–92.
7. Samanta S, Singh RK, Baronia AK, et al. Diaphragm ultrasound predicts weaning outcome. Indian J Crit Care Med. 2017;21(12):768–774
8. Paulin GA, et al. Diaphragmatic mobility and its correlation with lung volumes in chronic obstructive pulmonary disease. Respiratory Medicine. 2016;112:45-52.
9. Baria MR, et al. Ultrasound evaluation of the diaphragm: Correlation with pulmonary function tests in an outpatient population. Journal of Ultrasound in Medicine. 2014;33(5):795-802.
10. Global Burden of Disease Study 2018 Collaborators. Global, regional, and national burden of chronic respiratory diseases, 1990–2018. Lancet Respir Med. 2020;8(6):585–596.
11. Sarwal A, Walker FO, Cartwright MS. Neuromuscular ultrasound for evaluation of the diaphragm. Muscle Nerve. 2013;47(3):319–329.
12. Kim WY, Suh HJ, Hong SB, Koh Y, Lim CM. Diaphragm dysfunction assessed by ultrasonography: Influence on weaning outcomes. Crit Care Med. 2011;39(12):2627–2630.
13. Similowski T, et al. Diaphragmatic dysfunction: Clinical manifestations, etiologies, and diagnostic evaluation. European Respiratory Journal. 2011;37(5):1214-1222.
14. Cassart M, et al. Effects of pleural effusion on diaphragmatic kinetics and shape: An ultrasonographic study. American Journal of Respiratory and Critical Care Medicine. 2000;162(4):1291-1295.
15. Kabil A, Abdelrahman H, Ali A. Ultrasonographic assessment of diaphragmatic excursion in healthy adults. Egypt J Chest Dis Tuberc. 2022;71(1):35–41.
16. El-Shahat, H., Mahfouz, T., Elfeqy, M., Shehata, S. Chest Ultrasonographic Assessment of Diaphragmatic Excursion and Thickness as a New Weaning Parameter in Mechanically Ventilated Chronic Obstructive Pulmonary Disease Patients. Zagazig University Medical Journal, 2023; 1282-1293
17. Ali AA; Elnaby, Hassanin A HE ; and Yousef GA; Assessment of Diaphragmatic Mobility by Transthoracic Ultrasound in Patients with Interstitial Lung Diseases; Al-Azhar International Medical Journal, 2023,4(2),16. 98-103.
18. Weber MD, Lim JKB, Glau C, Conlon T, James R, Lee JH. A narrative review of diaphragmatic ultrasound in pediatric critical care. Pediatr Pulmonol 2021;56:2471-83.
19. Gupta S.; Ultrasonographic assessment of diaphragmatic parameters for predicting weaning outcome in patients on mechanical ventilation in the intensive care unit setting. Indian J Anaesth 2022;66(Suppl 1):S72–3.
20. Kaur A, Sharma S, Singh VP, Krishna MR, Gautam PL, Singh G. Sonographic assessment of diaphragmatic thickening and excursion as predictors of weaning success in the intensive care unit: A prospective observational study. Indian J Anaesth 2022;66:776-82
21. Alam MJ, Roy S, Iktidar MA, Padma FK, Nipun KI, Chowdhury S, *et al*. Diaphragm ultrasound as a better predictor of successful extubation from mechanical ventilation than rapid shallow breathing index. Acute Crit Care 2022;37:94-100.