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EDITORIAL

Role of diaphragmatic ultrasound in patients with acute exacerbation of chronic obstructive pulmonary disease

Prakash Banjade, Yasoda Rijal, Munish Sharma, Salim Surani

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Abstract

Assessing diaphragm function status is vital for diagnosing and treating acute exacerbation of chronic obstructive pulmonary disease (AECOPD). Diaphragmatic ultrasound has become increasingly important due to its non-invasive nature, absence of radiation exposure, widespread availability, prompt results, high accuracy, and repeatability at the bedside. The diaphragm is a crucial respiratory muscle. Decline or dysfunction of the diaphragm can lead to dyspnea and even respiratory failure in AECOPD patients. In this editorial, we comment on an article, retrospectively analyzed ninety-four acute exacerbations of chronic obstructive pulmonary disease patients who received mechanical ventilation from January 2022 to December 2023. The study found that the diaphragm thickening fraction, an index from diaphragm ultrasound, can better predict the outcome of non-invasive ventilation in patients with AECOPD. The value of non-invasive ventilation in treating respiratory failure caused by AECOPD has been widely acknowledged. Diaphragmatic dysfunction diagnosed with ultrasound is associated with prolonged mechanical ventilation and weaning times and higher mortality.

Key Words: Diaphragm ultrasound; Chronic obstructive pulmonary disease; Diaphragm; Ultrasound; Obstructive lung disease; Nivalenol; Respiratory failure; mechanical ventilation

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Core Tip: Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) could lead to respiratory failure, increasing the patient's morbidity and mortality. Diaphragmatic ultrasound could be an important tool to predict better the outcome of noninvasive ventilation in patients with AECOPD. Diaphragmatic indices such as diaphragm activity, diaphragm movement time index, and diaphragm thickening fraction can be assessed with ultrasonography, which could predict the mechanical ventilation outcomes in AECOPD patients.

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INTRODUCTION

Global initiative for chronic obstructive lung disease 2023 defines chronic obstructive pulmonary disease (COPD) as a "heterogeneous lung condition characterized by chronic respiratory symptoms (dyspnea, cough, expectoration, and exacerbations) due to abnormalities of the airways (bronchitis, bronchiolitis) and/or alveoli (emphysema) that cause persistent, often progressive, airflow obstruction"[1,2]. Acute exacerbation of COPD (AECOPD) may lead to respiratory failure that increases morbidity and mortality. The key respiratory changes in COPD-related failure are intrinsic positive end-expiratory pressure and dynamic hyperinflation[3,4]. These respiratory mechanical abnormalities worsen in AECOPD, significantly increasing oxygen consumption and respiratory demand. This overwhelms the compensatory ability of respiratory muscles, including the diaphragm, leading to hypoxemia, hypercapnia, and type II respiratory failure[5,6]. Proper respiratory support is crucial in treating AECOPD alongside routine standard treatments[7]. As the primary respiratory muscle in the human body, the diaphragm is responsible for approximately 60% to 80% of respiratory activity. In patients with AECOPD, a decline in diaphragm function, or even dysfunction, is a significant factor contributing to dyspnea and potentially leading to respiratory failure. Consequently, assessing the status of diaphragm function is crucial in diagnosing and treating AECOPD[8,9].

Ultrasonography (US) is a safe, non-invasive, and accurate technique widely used in intensive care for bedside assessment of diaphragmatic function. Studies have described its feasibility and high reproducibility in identifying diaphragm dysfunction in severely ill patients[10]. A prospective study by Boon *et al*[11] found that ultrasound has a sensitivity of 93% and a specificity of 100% for diagnosing neuromuscular diaphragm dysfunction. Diaphragmatic excursion and thickening measurements have been used to predict extubation success or failure during weaning from mechanical ventilation and spontaneous breathing trials. Patients with severe hypoxia requiring non-invasive ventilation (NIV) are at risk of diaphragmatic impairment, which can negatively impact outcomes, potentially leading to the need for invasive mechanical ventilation. US has been widely used in various studies to assess the functionality of the diaphragm and assist in predicting outcomes for patients with NIV[12].

STUDY FINDINGS

The retrospective study by Qu *et al*[13] analyzed 94 patients with AECOPD on mechanical ventilation, dividing them into successful or failed ventilation groups. Patients with a confirmed AECOPD diagnosis, those in need of NIV, and those with complete clinical follow-up data fulfilled the inclusion criteria. Patients with life-threatening severe conditions like cerebrovascular diseases, lung cancer, airway obstruction, pneumothorax, atelectasis, pneumonia, or interstitial lung disease, as well as those with altered mental states or risk of aspiration, those who had received COPD treatment before admission, or those intolerant to respiratory muscle masks or requiring emergency tracheal intubation, were excluded from the study. Diaphragm movement time index, diaphragm activity and diaphragm thickening fraction (DTF) were evaluated with diaphragm ultrasound (DUS).

The study found that compared to those with failed NIV, patients who successfully underwent NIV had shorter hospital stays and lower $PaCO_2$. In patients with successful NIV, the diaphragmatic tension-time index, diaphragmatic excursion (DE), pH, and Ewart index were significantly higher ($P < 0.05$)[13].

THE ROLE OF DUS IN COPD

Numerous studies assessed diaphragm thickness (DT) or the variation of diaphragmatic thickness fraction (DTF) between end-inspiration and end-expiration. These studies have explored various ultrasonographic methods to predict outcomes for NIV. However, due to the variability of each technique and the different areas of interest for bedside ultrasound,

understanding the clinical significance and achieving widespread acceptance of specific ultrasound methods can be challenging[12]. Diaphragmatic thickening is an accurate index of respiratory muscle workload during assisted mechanical ventilation. An observation study by Zambon *et al*[10] indicates that DUS is a reliable method for evaluating diaphragm atrophy in patients undergoing mechanical ventilation.

Most assisted ventilation modes have been evaluated for their effectiveness in reducing the work of breathing, particularly during the weaning process from mechanical or NIV[14]. Several methods, such as gastric and pleural pressure measurement, diaphragm electromyography, and work of breathing, have been used to evaluate diaphragmatic function in clinical research involving critically ill patients[15]. This underscores the need for simple and accurate tools to evaluate diaphragmatic performance in the intensive care unit. US to measure diaphragm excursions could aid in identifying patients with diaphragmatic dysfunction during the weaning process from mechanical ventilation[16]. Additionally, the thickness of the diaphragm in its area of apposition can be directly seen *via* US[14]. A prospective observational study by Elsayed *et al*[17] showed that DTF was higher in successful NIV group than NIV failure group. Another study by Kheir *et al*[12] demonstrated that DTF < 20% predicted NIV failure more accurately than baseline pH value < 7.25.

Indications of diaphragmatic dysfunction (DD) may include diminished, absent, or paradoxical diaphragmatic motion. Diaphragmatic excursion < 10 mm is the most often used criteria to diagnose DD in critically ill patients. DD diagnosed with ultrasound is associated with prolonged mechanical ventilation and weaning times, and higher mortality. Among patients on MV for prolonged periods, Santana *et al*[18] found the prevalence of DD to be 34%. Lerolle *et al*[19] reported that diaphragmatic excursion < 25 mm during the best excursion maneuver accurately detected DD in patients on multinodular and vacuolating (MV) for extended periods following cardiac surgery. Different studies showed that DUS (DE and DTF) better predicted successful extubation than rapid shallow breathing index. Furthermore, DE was found to be a more accurate predictor of successful extubation than DTF[20,21].

DE during the inspiratory phase is related to lung volume but doesn't correlate with the inspiratory muscular effort in patients undergoing assisted mechanical ventilation, and several factors influence it. The value of DE is best assessed during spontaneous breathing as it results from the combined patient's inspiratory activity and mechanical ventilatory support. One study found that mechanical pressure support significantly increased DE during NIV (P = 0.001)[22]. Cammarota *et al*[23] found that assessing diaphragmatic excursion two hours after starting NIV was a more accurate predictor of NIV failure than pH, PaCO2, and left expiratory diaphragmatic thickness. They observed that diaphragmatic excursion was greater in patients who succeeded with NIV than in those who failed at the beginning of NIV.

STRENGTH AND LIMITATIONS OF THE STUDY CONDUCTED BY QU LL ET AL

Strength

The study addresses a critical clinical issue using DUS, a safe and non-invasive method, to evaluate diaphragm function. Identifying DUS indexes like DTF as predictors of NIV outcomes offers valuable insights for improving patient care. Multivariate logistic regression to identify independent predictors strengthens the study's findings by accounting for multiple variables and reducing potential confounding effects. The study effectively compares patients with successful and failed NIV, providing a clear contrast that helps highlight the significance of the identified predictors.

Limitations

The study is retrospective and single-centric, with a sample size of only 94 patients. Therefore, it may need more power to detect smaller effects, so the results may not be generalizable. Patients with severe comorbidities or those requiring emergency interventions were excluded, which could skew the results and limit the applicability to a more diverse patient population. Although multivariate logistic regression was used, unmeasured confounding factors may still influence the outcomes of NIV in AECOPD patients. Moreover, the study did not assess diaphragmatic strength in relation to sonographic findings using magnetic phrenic nerve stimulation, which is regarded as the gold standard. Diaphragmatic ultrasound assessment depends on the user's skill level, which may affect the study's generalizability. Understanding the clinical significance and generalized acceptance of specific ultrasound techniques is difficult due to the variability of each method and the numerous areas of interest for bedside ultrasound. The study mainly addresses the short-term outcomes of mechanical ventilation and does not evaluate long-term patient outcomes, such as survival rates or quality of life post-treatment.

CONCLUSION

Several studies have shown that diaphragmatic ultrasound is a reliable tool for assessing diaphragmatic indices, which in turn predict the outcomes of NIV in patients with acute exacerbation of COPD. The study by Qu *et al*[13] demonstrated that DTF, a DUS index, can more effectively predict the outcome of NIV in AECOPD patients. The study addresses an important and practical clinical problem-predicting the outcome of NIV in patients with AECOPD-which is critical for improving patient management and outcomes. However, more multicentric research with a larger sample size is needed to evaluate further the role of DUS in the acute exacerbation of COPD patients.

FOOTNOTES

Author contributions: Bandaje P, Yasoda R and Sharma M were involved in review of literature and writeup; Surani S was involved in originator, supervision, review and revision of the manuscript; all of the authors read and approved the final version of the manuscript to be published.

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