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Retrospective Study

Predictive value of diaphragm ultrasound for mechanical ventilation outcome in patients with acute exacerbation of chronic obstructive pulmonary disease

Lei-Lei Qu, Wen-Ping Zhao, Ji-Ping Li, Wei Zhang

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Abstract

BACKGROUND
Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is often combined with respiratory failure, which increases the patient's morbidity and mortality. Diaphragm ultrasound (DUS) has developed rapidly in the field of critical care in recent years. Studies with DUS monitoring diaphragm-related rapid shallow breathing index have demonstrated important results in guiding intensive care unit patients out of the ventilator. Early prediction of the indications for withdrawal of non-invasive ventilator and early evaluation of patients to avoid or reduce disease progression are very important.

AIM
To explore the predictive value of DUS indexes for non-invasive ventilation outcome in patients with AECOPD.

METHODS
Ninety-four patients with AECOPD who received mechanical ventilation in our hospital from January 2022 to December 2023 were retrospectively analyzed, and they were divided into a successful ventilation group (68 cases) and a failed ventilation group (26 cases) according to the outcome of ventilation. The clinical data of patients with successful and failed noninvasive ventilation were compared, and the independent predictors of noninvasive ventilation outcomes in
AECOPD patients were identified by multivariate logistic regression analysis.

RESULTS
There were no significant differences in gender, age, body mass index, complications, systolic pressure, heart rate, mean arterial pressure, respiratory rate, oxygen saturation, partial pressure of oxygen, oxygenation index, or time of inspiration between patients with successful and failed mechanical ventilation ($P > 0.05$). The patients with successful noninvasive ventilation had shorter hospital stays and lower partial pressure of carbon dioxide ($\text{PaCO}_2$) than those with failed treatment, while potential of hydrogen ($\text{pH}$), diaphragm thickening fraction (DTF), diaphragm activity, and diaphragm movement time were significantly higher than those with failed treatment ($P < 0.05$). $\text{pH}$ (odds ratio (OR) = 0.005, $P < 0.05$), $\text{PaCO}_2$ (OR = 0.430, $P < 0.05$), and DTF (OR = 0.570, $P < 0.05$) were identified to be independent factors influencing the outcome of mechanical ventilation in AECOPD patients.

CONCLUSION
The DUS index DTF can better predict the outcome of non-invasive ventilation in AECOPD patients.

Key Words: Diaphragm ultrasound; Mechanical ventilation; Acute exacerbation of chronic obstructive pulmonary disease; Predictive value; Diaphragm thickening fraction; Diaphragm activity

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Core Tip: There are few relevant literature reports on the predictive value of diaphragm ultrasound (DUS) indexes for mechanical ventilation therapy, so we conducted a study in which the clinical data of patients with successful and failed noninvasive ventilation were compared, and the independent predictors of noninvasive ventilation outcomes in acute exacerbation of chronic obstructive pulmonary disease (AECOPD) patients were identified by multivariate logistic regression analysis. It was found that the DUS index DTF can better predict the outcome of non-invasive ventilation therapy in AECOPD patients.

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INTRODUCTION
Chronic obstructive pulmonary disease (COPD), a common chronic respiratory disease, has become the third leading cause of death and is one of the most serious public health problems worldwide[1,2]. The definition of COPD is constantly being updated, and according to the 2021 Global Initiative for Chronic Obstructive Lung Disease, COPD was defined as a common, preventable, and treatable disease characterized by breathing difficulties and restricted airflow due to abnormalities in the airways and alveoli, which is often associated with high exposure to toxic particulates and gases [3]. COPD patients often suffer from acute exacerbation under infection, stress, and other factors. When acute exacerbation of COPD (AECOPD) occurs, it is often combined with respiratory failure, which increases the patient's morbidity and mortality[4]. Current studies have shown that dynamic pulmonary hyperinflation and intrinsic positive end expiratory pressure are the most important respiratory mechanical changes in COPD patients with respiratory failure[5,6]. In patients with AECOPD, the above two respiratory mechanical functional abnormalities are further worsened, resulting in a significant increase in oxygen consumption and respiratory load of patients, exceeding the effective compensatory capacity of respiratory muscles such as the diaphragm, resulting in different degrees of hypoxemia and hypercapnia, and ultimately leading to type II respiratory failure[7,8]. If not rescued in time, respiratory failure can seriously endanger the patient's life. Currently, in addition to routine anti-infection, antispasmodic, reducing cough relieving, and removing phlegm, proper respiratory support is an important part of treatments for AECOPD[9,10].

Mechanical ventilation establishes a pressure difference between the airway opening and the alveoli to keep the airway open, thereby improving oxygenation and reversing hypoxia and carbon dioxide retention in the body[11]. Mechanical ventilation is clinically divided into two categories: Invasive ventilation and noninvasive ventilation[12]. Invasive ventilation involves the connection to the ventilator by invasive means such as tracheal intubation or tracheotomy, which is mostly used for critically ill patients. It can rapidly correct hypoxemia and hypercapnia, but it may also have unavoidable complications, such as ventilator-associated pneumonia and pneumatic injuries, and will bring a huge economic burden to the patient[13]. Noninvasive ventilation is a non-invasive way to connect a ventilator through a nasal mask or mask. It can provide patients with double-level pressure support and retain the natural defense function of the respiratory tract. Meanwhile, it can avoid lung injury and infection caused by invasive ventilation to the greatest extent. The value of noninvasive ventilation in the treatment of respiratory failure caused by AECOPD has been recognized, and the effective rate is more than 80% in patients with different degrees of carbon dioxide retention[14]. However, in clinical
The diaphragm is one of the main respiratory muscles in the human body, and it is responsible for nearly 60% to 80% of respiratory activities. Function decline or even dysfunction of the diaphragm is one of the important factors leading to dyspnea and even respiratory failure in patients with AECOPD\textsuperscript{[16]}. Therefore, the assessment of diaphragm function status becomes very important in the diagnosis and treatment of AECOPD\textsuperscript{[17]}. Recently, the development of ultrasound medicine has led to a wide range of clinical studies using ultrasound to evaluate the structure and function of the diaphragm. Ultrasonography can more directly observe the changes in the diaphragm and has the advantages of being safe, non-invasive, economical, portable, accurate, and reproducible. Therefore, it is increasingly widely used in clinical assessment of diaphragm structure and function\textsuperscript{[18]}. Diaphragm ultrasound (DUS) is rapidly developing in the field of critical care. Relevant studies have shown that the use of DUS to monitor the diaphragm-related rapid shallow breathing index to guide the weaning of ICU patients has achieved important research results. It can be used to early predict the indications for the withdrawal of non-invasive ventilators in AECOPD, and to assess the prognosis of patients in order to avoid or reduce the progression of the disease\textsuperscript{[19]}. However, there are few relevant literature reports on the predictive value of DUS indicators for mechanical ventilation therapy, so we conducted such a study and now reports the results as follows.

**MATERIALS AND METHODS**

**Patients**

Ninety-four patients with AECOPD who received mechanical ventilation in our hospital from January 2022 to December 2023 were retrospectively analyzed, and they were divided into either a successful ventilation group (successful withdrawal, 68 cases) or a failed ventilation group (unsuccessful withdrawal, 26 cases) according to the outcome of ventilation. All enrolled patients provided written informed consent.

**Inclusion and exclusion criteria**

The inclusion criteria were: (1) Patients with a definite diagnosis of AECOPD; (2) Patients meeting the indications for noninvasive ventilation, such as those with respiratory acidosis or severe dyspnea but without contraindications to mechanical ventilation; and (3) Patients with complete clinical follow-up data.

The exclusion criteria were: (1) Patients with other serious life-threatening diseases, such as cerebrovascular diseases, lung malignancies, and airway obstruction; (2) Patients with severe pneumothorax, atelectasis, pneumonia, or interstitial lung disease, or those who planned to undergo surgery recently; (3) Patients with altered mental state, being prone to aspiration and unable to cooperate with the treatment; (4) Patients who had received systemic treatment for COPD before admission; and (5) Patients who were intolerant to respiratory muscle masks or needed emergency tracheal intubation.

**Methods**

The clinical data such as gender, age, body mass index (BMI), comorbidities, length of stay, systolic blood pressure, blood oxygen saturation, mean arterial pressure, respiratory rate, heart rate, blood gas analysis results, and DUS indexes were collected.

All patients were given basic treatment, including intravenous infusion of methylprednisolone. During hospitalization, the use and dosage of antibiotics were adjusted according to clinical symptoms and signs, sputum culture test, and the results of inflammatory marker detection. Meanwhile, treatments such as reducing phlegm and relieving asthma and maintaining internal environment were given. Noninvasive ventilator was used to give non-invasive ventilation treatment (oral and nasal mask ventilation). The ventilation mode was self-dominant touch/time-switching mode. The oxygen concentration fraction (FiO\textsubscript{2}) in inhaled air was 30% to 60%, the inspiratory pressure was 8 to 14 cmH\textsubscript{2}O, the expiratory pressure was 4 to 8 cmH\textsubscript{2}O, the ratio of inhalation to exhalation was (1.5 to 2.0):1, and the respiratory rate was 10-14 times /min. When the pressure rose, the parameters would be adjusted at any time to make the blood oxygen saturation > 90%. Real-time attention was paid to the sputum excretion capacity of patients, and sputum drainage was performed regularly.

**Evaluation of diaphragm ultrasound indicators**

A doctor skilled in ultrasound operation performed ultrasound examination under the guidance of a superior doctor to evaluate diaphragm activity (DE), diaphragm movement time (E-T) index, and diaphragm thickening fraction (DTF). The patient was placed in the supine region with the head of the bed elevated by 20° to 40°, and the wide-frequency line array probe was placed at the junction of the anterior axillary line and the lower edge of the costal arch. The liver or spleen was used as the diaphragm transducer window. The DE was measured by M-mode ultrasound, and the average value was obtained by repeating the measurement three times. DE was calculated as the distance of the diaphragm from baseline at the end of inhalation - distance of the diaphragm from baseline at the end of expiration. E-T index was calculated as DE × time of inspiration (TI). For the measurement and evaluation of DTF, the ultrasound probe was placed at the 8th to 10th intercostal spaces in the right axillary midline for continuous observation, the patient was instructed to take 10-15 deep breaths, the changes in the thickness of the right diaphragm were captured during the respiration process, and the thicknesses of the diaphragm at the end of inhalation and expiration were measured on the images. After measuring five respiratory cycles, the average DTF was calculated. DTF was calculated as (end-inspiratory diaphragm thickness - end-
expiratory diaphragm thickness)/end-expiratory diaphragm thickness × 100%.

**Statistical analysis**

SPSS 27.0 software was applied for statistical analyses. Measurement data, expressed as the mean ± SD, were compared by the t-test. Count data, described as percentages, were compared between groups using the χ² test. Parameters with statistically significant differences in univariate analysis were included in the multivariate logistic regression model for analysis. The receiver operating characteristic (ROC) curve was drawn to analyze the predictive efficacy of each index for the treatment effect of non-invasive ventilation in AECOPD patients. The area under the ROC curve (AUC) was calculated. P < 0.05 was considered statistically significant.

**RESULTS**

**General clinical information**

Table 1 shows that there were no significant differences in gender, BMI, age, complications, systolic pressure, heart rate, mean arterial pressure, respiratory rate, oxygen saturation, partial pressure of oxygen, oxygenation index (PaO₂/FiO₂), or TI between patients with successful and failed mechanical ventilation (P > 0.05). Patients with successful noninvasive ventilation had lower hospital stays and partial pressure of carbon dioxide (PaCO₂) than those with failed treatment, while potential of hydrogen (pH), DTF, DE, and E-T index were significantly higher in patients with successful noninvasive ventilation than in those with failed treatment (P < 0.05).

**Multivariate logistic regression analysis**

Using the ventilation outcome as the dependent variable, and hospital stays, pH, PaCO₂, DTF, DE, and E-T index as independent variables, the multivariate logistic regression analysis indicated that pH [odds ratio (OR) = 0.005, P < 0.05], PaCO₂ (OR = 0.430, P < 0.05), and DTF (OR = 0.570, P < 0.05) were independent factors influencing the outcome of mechanical ventilation in AECOPD patients (Table 2).

**Predictive efficacy for noninvasive ventilation**

As shown in Table 3 and Figure 1, the AUC values of pH, PaCO₂, and DTF in predicting the outcome of non-invasive ventilation in AECOPD patients were 0.690, 0.833, and 0.876, respectively, suggesting good predictive efficacy (P < 0.05). The optimal cut-off values of pH, PaCO₂ and DTF were 7.33, 63.50 mmHg, and 21.35%, respectively.

**DISCUSSION**

AECOPD occurs often due to pneumothorax and pulmonary embolism caused by upper respiratory tract infection. Moreover, AECOPD can further aggravate the lung function damage and greatly increase the morbidity and mortality, seriously threatening the physical and mental health and life of the patients[20]. Non-invasive ventilation increases the minute ventilation of the lungs by giving constant volume or pressure, thus preventing alveolar collapse, reducing intrapulmonary shunts, improving the ventilation and blood flow ratio, promoting gas exchange, preserving spontaneous respiration in patients with AECOPD, and effectively decreasing the rate of endotracheal intubation[21]. The diaphragm is the most important respiratory muscle that performs 70% of the respiratory muscle functions, belongs to the muscle-fiber structure, and is located between the thoracic cavity and the abdominal cavity. In mechanical ventilation, ventilation failure is frequently seen, which is mainly due to diaphragm dysfunction[22]. Therefore, clinicians must objectively assess the function of the patient’s diaphragm, so as to provide a reference basis for the successful withdrawal of the machine. In clinical practice, DUS is widely used for the assessment of diaphragm function due to its advantages of safety, feasibility, and reproducibility[23,24]. Our study results indicated that the PaCO₂ of patients with successful noninvasive ventilation was lower than that of patients with treatment failure, and the pH, DTF, DE, and E-T index were markedly higher than those of patients with treatment failure.

In patients with AECOPD, the decrease in inspiratory time and restriction of expiratory flow along with the increase in respiratory rate lead to lung hyperinflation and expiratory restriction. If the mechanical load on the diaphragm is resistive, DE and TI will increase accordingly, resulting in an increase in the E-T index[25]. When the mechanical load is elastic, the diaphragm can counteract the pressure, and although TI decreases, DE may increase, resulting in a constant E-T index. However, if the diaphragm’s contractile force decreases and is insufficient to overcome the excessive increase in mechanical load, mechanical injury will eventually occur as the diaphragm quickly depletes its functional reserve, resulting in a decrease in the E-T index[26]. Previous studies have demonstrated that DE and DTF are significantly reduced in patients with AECOPD, and diaphragmatic activity in COPD is closely related to endotracheal intubation, lung hyperinflation, ventilatory capacity, and dyspnea[27,28]. In a study of 30 mechanically ventilated COPD patients, Saeed et al[29] found that a DE of 11 mm had a sensitivity of 0.864, specificity of 0.875, and accuracy of 0.895 for predicting off-exit outcomes during a spontaneous respiration test. Since DE is related to inspiratory volume and creates pressure by increasing the patient’s respiration, DE indicators are clinically significant only in the absence of ventilation support. In addition, since diaphragm movement is not only the result of diaphragm contraction and relaxation, DE may be affected by the position, which is more obvious when the patient is supine or sitting. And when the abdominal or chest pressure changes (ascites and atelectasis), the patient’s diaphragm movement is significantly reduced, but it has nothing to do with
### Table 1 Comparison of clinical data between two groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Successful ventilation group (n = 68)</th>
<th>Failed ventilation group (n = 26)</th>
<th>t/χ²</th>
<th>P value</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male [n (%)]</td>
<td>35 (51.47)</td>
<td>16 (61.54)</td>
<td>0.768</td>
<td>0.381</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>64.74 ± 4.25</td>
<td>65.77 ± 4.48</td>
<td>1.040</td>
<td>0.301</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.41 ± 2.12</td>
<td>23.62 ± 2.15</td>
<td>0.428</td>
<td>0.669</td>
<td></td>
</tr>
<tr>
<td>Hypertension [n (%)]</td>
<td>39 (57.35)</td>
<td>16 (61.54)</td>
<td>0.136</td>
<td>0.713</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>26 (38.24)</td>
<td>12 (46.15)</td>
<td>0.490</td>
<td>0.484</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>22 (32.35)</td>
<td>11 (42.31)</td>
<td>0.818</td>
<td>0.366</td>
<td></td>
</tr>
<tr>
<td>Systolic pressure (mmHg)</td>
<td>109.85 ± 21.09</td>
<td>107.77 ± 13.19</td>
<td>0.469</td>
<td>0.640</td>
<td></td>
</tr>
<tr>
<td>Mean arterial pressure (mmHg)</td>
<td>91.98 ± 9.79</td>
<td>90.85 ± 10.43</td>
<td>0.496</td>
<td>0.621</td>
<td></td>
</tr>
<tr>
<td>Heart rate (times/min)</td>
<td>83.79 ± 12.37</td>
<td>88.92 ± 12.56</td>
<td>1.790</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td>Oxygen saturation (%)</td>
<td>87.93 ± 4.01</td>
<td>88.73 ± 5.39</td>
<td>0.788</td>
<td>0.433</td>
<td></td>
</tr>
<tr>
<td>Respiratory rate (times/min)</td>
<td>21.85 ± 3.24</td>
<td>23.04 ± 3.36</td>
<td>1.569</td>
<td>0.120</td>
<td></td>
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<tr>
<td>Hospital stays (d)</td>
<td>8.89 ± 3.14</td>
<td>11.46 ± 4.34</td>
<td>3.172</td>
<td>&lt; 0.001</td>
<td></td>
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<tr>
<td>Blood gas analysis results</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.32 ± 0.16</td>
<td>7.21 ± 0.15</td>
<td>2.936</td>
<td>0.004</td>
<td></td>
</tr>
<tr>
<td>PaO₂ (mmHg)</td>
<td>47.69 ± 5.41</td>
<td>46.69 ± 5.66</td>
<td>0.790</td>
<td>0.432</td>
<td></td>
</tr>
<tr>
<td>PaCO₂ (mmHg)</td>
<td>62.21 ± 3.69</td>
<td>66.54 ± 3.02</td>
<td>5.334</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>PaO₂/FiO₂</td>
<td>98.35 ± 5.24</td>
<td>96.32 ± 5.16</td>
<td>1.687</td>
<td>0.095</td>
<td></td>
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<tr>
<td>Diaphragm ultrasound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>DTF (%)</td>
<td>24.18 ± 3.02</td>
<td>19.12 ± 3.18</td>
<td>7.172</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>DE (mm)</td>
<td>21.02 ± 2.26</td>
<td>17.42 ± 2.14</td>
<td>7.010</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>TI (s)</td>
<td>1.14 ± 0.19</td>
<td>1.06 ± 0.14</td>
<td>1.920</td>
<td>0.058</td>
<td></td>
</tr>
<tr>
<td>E-T index</td>
<td>2.39 ± 0.47</td>
<td>1.84 ± 0.33</td>
<td>5.411</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
</tbody>
</table>

pH: Potential of hydrogen; PaO₂: Partial pressure of oxygen; PaCO₂: Partial pressure of carbon dioxide; PaO₂/FiO₂: Oxygenation index; DTF: Diaphragm thickening fraction; DE: Diaphragm activity; E-T: Diaphragm movement time; TI: Time of inspiration.

### Table 2 Multivariate logistic regression analysis of predictive indicators for non-invasive ventilation outcome in acute exacerbation of chronic obstructive pulmonary disease patients

<table>
<thead>
<tr>
<th>Index</th>
<th>β</th>
<th>SE</th>
<th>Wald</th>
<th>P value</th>
<th>OR</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital stays</td>
<td>0.221</td>
<td>0.156</td>
<td>1.999</td>
<td>0.157</td>
<td>1.247</td>
<td>0.918-1.694</td>
</tr>
<tr>
<td>pH</td>
<td>5.367</td>
<td>2.731</td>
<td>3.861</td>
<td>0.049</td>
<td>0.005</td>
<td>0.000-0.986</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>0.845</td>
<td>0.350</td>
<td>5.841</td>
<td>0.016</td>
<td>0.430</td>
<td>0.216-0.852</td>
</tr>
<tr>
<td>DTF</td>
<td>0.562</td>
<td>0.219</td>
<td>6.613</td>
<td>0.010</td>
<td>0.570</td>
<td>0.371-0.875</td>
</tr>
<tr>
<td>DE</td>
<td>0.190</td>
<td>0.219</td>
<td>0.758</td>
<td>0.384</td>
<td>1.210</td>
<td>0.788-1.857</td>
</tr>
<tr>
<td>E-T index</td>
<td>2.401</td>
<td>2.020</td>
<td>1.413</td>
<td>0.234</td>
<td>0.091</td>
<td>0.002-4.747</td>
</tr>
</tbody>
</table>

OR: Odds ratio; CI: Confidence interval; pH: Potential of hydrogen; PaCO₂: Partial pressure of carbon dioxide; DTF: Diaphragm thickening fraction; DE: Diaphragm activity; E-T: Diaphragm movement time.
Table 3 Predictive efficacy of potential of hydrogen, partial pressure of carbon dioxide, and diaphragm thickening fraction for non-invasive ventilation outcomes in patients with acute exacerbation of chronic obstructive pulmonary disease

<table>
<thead>
<tr>
<th>Index</th>
<th>AUC</th>
<th>95%CI</th>
<th>P value</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>0.690</td>
<td>0.576-0.804</td>
<td>0.005</td>
<td>0.885</td>
<td>0.500</td>
</tr>
<tr>
<td>PaCO(_2)</td>
<td>0.833</td>
<td>0.745-0.920</td>
<td>&lt; 0.001</td>
<td>0.923</td>
<td>0.691</td>
</tr>
<tr>
<td>DTF</td>
<td>0.873</td>
<td>0.793-0.953</td>
<td>&lt; 0.001</td>
<td>0.808</td>
<td>0.809</td>
</tr>
</tbody>
</table>

pH: Potential of hydrogen; PaCO\(_2\): Partial pressure of carbon dioxide; DTF: Diaphragm thickening fraction; AUC: Area under curve; CI: Confidence interval.

Figure 1 Receiver operating characteristic curves of potential of hydrogen, partial pressure of carbon dioxide, and diaphragm thickening fraction to predict outcome of non-invasive ventilation in acute exacerbation of chronic obstructive pulmonary disease patients. TPR: True positive rate; FPR: False positive rate; AUC: Area under curve; pH: Potential of hydrogen; PaCO\(_2\): Partial pressure of carbon dioxide; DTF: Diaphragm thickening fraction.

The results of multivariate analysis in our study showed that pH, PaCO\(_2\), and DTF were independent predictors of the therapeutic effect of noninvasive ventilation. Previous studies have consistently shown that the severity of hypercapnia and acidosis is related to the therapeutic effect of early non-invasive ventilation in AECOPD patients\[^{30}\]. ROC curve analysis in our study displayed that the AUC of pH in predicting the therapeutic effect of noninvasive ventilation was 0.690, and when the optimal cut-off value was 7.33, the sensitivity and specificity were 0.885 and 0.500, respectively. PaCO\(_2\) had an AUC of 0.833, with a sensitivity of 0.923 and specificity of 0.691 at the optimal cut-off value of 63.50 mmHg. In most patients with AECOPD, non-invasive ventilation should be given early when pH < 7.35 and PaCO\(_2\) > 48.75 mmHg (6.5 kPa)\[^{31}\]. Marchioni et al\[^{32}\] showed that diaphragmatic dysfunction (DTF < 20%) on admission to the hospital in patients with AECOPD was an early predictor of failure of noninvasive ventilation, and was more accurate than baseline pH and PaCO\(_2\). DTF is a good indicator of active diaphragm contraction compared with DE. In our study, the DTF of the failed group was significantly lower than that of the successful group, which was related to the decrease of diaphragm contraction function in the failed group. The optimal cut-off value of DTF was determined to be 21.35%, which is similar to the results of Antenora et al\[^{33}\] (DTF < 20% is closely associated with failure of noninvasive ventilation in AECOPD patients). The study by Dres and Demoule\[^{34}\] has shown that DTF is the gold standard for assessing diaphragm dysfunction. However, this study also had some limitations, such as single-center study, small sample size, no lung volume assessment, and no dynamic assessment of diaphragm function.

CONCLUSION

The DUS index DTF can better predict the outcome of non-invasive ventilation in AECOPD patients.

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FOOTNOTES

Author contributions: Qu LL and Zhao WP performed the research; Li JP and Zhang W contributed new reagents and analytic tools; Qu LL, Zhao WP, Li JP, and Zhang W designed the research study, analyzed the data, and wrote the manuscript; all authors have read and approved the final manuscript.

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DUS for prediction of ventilation outcome


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