Journal of Clinical and Nursing Research, 2024, Volume 8, Issue 11
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Analysis of Factors Affecting Non-Invasive Ventilation Failure in AECOPD Patients with Type II Respiratory Failure

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Abstract: *Objective:* To analyze key factors associated with the failure of non-invasive ventilation (NIV) in patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD) complicated by type II respiratory failure. *Methods:* A total of 122 patients with AECOPD and type II respiratory failure admitted to Gaoyou People's Hospital between January 2020 and June 2023 were selected for the study. Upon admission, all patients received ECG monitoring and NIV, along with comprehensive therapies such as anti-infective treatment, antispasmodics, bronchodilators, and expectorants. NIV was provided using the S/T mode, with ventilator parameters adjusted based on the patient's respiratory status and blood gas analysis results. Clinical data were retrospectively analyzed from electronic medical records. *Results:* Out of the 122 patients, 30 experienced NIV failure, accounting for 24.59%. Significant differences were observed in C-reactive protein (CRP), pH, and partial pressure of arterial carbon dioxide ($PaCO_2$) between patients with successful and failed NIV outcomes ($P < 0.05$). There were no statistically significant differences in gender, age, arterial oxygen partial pressure (PaO_2), neutrophil count (NEUT), procalcitonin (PCT), albumin (ALB), or tidal volume between the two groups ($P > 0.05$). Logistic regression analysis confirmed that CRP, pH, and $PaCO_2$ were significant risk factors for NIV failure ($P < 0.05$). *Conclusion:* CRP, pH, and $PaCO_2$ are independent risk factors influencing NIV failure.

Keywords: Type II respiratory failure; Acute exacerbations of chronic obstructive pulmonary disease; Non-invasive ventilation; Influencing factors

Online publication: November 28, 2024

1. Introduction

Chronic obstructive pulmonary disease (COPD) is characterized primarily by progressive and irreversible airflow limitation, posing a significant threat to the health of middle-aged and elderly individuals [1]. During

acute exacerbations of COPD (AECOPD), airway narrowing, respiratory infections, and respiratory muscle fatigue can lead to type II respiratory failure, which, if inadequately controlled, may become life-threatening [2]. Current clinical treatment prioritizes non-invasive ventilation (NIV) for its ease of operation, reduced trauma, and lower risk of complications, providing rapid relief from hypercapnia and hypoxemia while restoring respiratory function [3]. Studies indicate that approximately 26%–74% of patients with acute exacerbation of COPD complicated by type II respiratory failure require intubation combined with mechanical ventilation to ensure adequate oxygen supply, improve gas exchange, and stabilize blood oxygen levels, thus reducing respiratory workload. However, in practical treatment settings, some patients continue to exhibit suboptimal outcomes and poor prognosis [4]. A thorough investigation into potential risk factors contributing to NIV failure in AECOPD patients with type II respiratory failure, along with the implementation of targeted interventions, is crucial for improving patient prognosis. This study aims to analyze clinical data from AECOPD patients with type II respiratory failure admitted to Gaoyou People's Hospital between January 2020 and June 2023 to identify potential risk factors for NIV failure.

2. Materials and methods

2.1. General information

A total of 122 AECOPD patients with Type II respiratory failure admitted to Gaoyou People's Hospital between January 2020 and June 2023 were selected. All patients received immediate ECG monitoring and non-invasive ventilatory support upon admission, along with comprehensive treatments including anti-infective therapy, antispasmodics, bronchodilators, and expectorants. The cohort included 86 male and 36 female patients, aged between 55 and 95 years, with a mean age of 74.00 ± 7.89 years. All patients and their families were informed of the study and signed consent forms. This study was approved by the hospital's ethics committee.

Inclusion criteria were as follows: (1) patients met the criteria for AECOPD as defined by the Chinese Medical Association's Respiratory Disease Committee's "Guidelines for the Diagnosis and Treatment of Chronic Obstructive Pulmonary Disease" (2013 revised version); (2) history of a previous diagnosis of COPD; (3) confirmation of condition through pulmonary function testing, chest X-ray, and laboratory tests; (4) recent onset of symptoms such as shortness of breath, worsening cough, and production of thick, purulent sputum; (5) complete medical records; (6) age of 55 years or older.

Exclusion criteria included: (1) patients with oral or pharyngeal deformities or cervical spine injuries preventing intubation; (2) those with respiratory diseases other than AECOPD; (3) patients with severe infections such as sepsis; and (4) cases with incomplete medical record data, precluding detailed statistical analysis.

2.2. Methods

All patients underwent standard treatments, including non-invasive mechanical ventilation, anti-infective therapy, expectorants, cough suppressants, antispasmodics, and bronchodilators. Cardiac pacemakers were placed, and non-invasive ventilatory support was provided. A tracheal catheter was inserted in advance, enabling positive pressure mechanical ventilation. Basic patient information was collected, including gender, age, pH, arterial oxygen partial pressure (PaO_2), arterial carbon dioxide partial pressure ($PaCO_2$), neutrophil count (NEUT), C-reactive protein (CRP), procalcitonin (PCT), albumin (ALB), and tidal volume. The rate of

weaning failure was recorded, and these factors were analyzed for their impact on the weaning process.

2.3. Statistical analysis

Data analysis was performed using SPSS 23.0 statistical software. Measurement data with a normal distribution were expressed as mean ± standard deviation (SD), with between-group comparisons performed using the *t*-test. Data not conforming to a normal distribution were expressed as a median and interquartile range, with between-group comparisons conducted using the Mann-Whitney test. Categorical data were presented as relative numbers, with comparisons made using the χ^2 test. Multivariate logistic regression analysis was used to identify factors influencing non-invasive ventilation failure. A significance level of $P < 0.05$ indicated statistical significance.

3. Results

3.1. Non-invasive ventilation failure in patients

Of the 122 AECOPD patients with Type II respiratory failure who received non-invasive ventilatory support, 30 experienced failure of non-invasive mechanical ventilation, accounting for 24.59%.

3.2. Univariate analysis of factors influencing non-invasive ventilation

There were statistically significant differences in CRP, pH, and $PaCO_2$ between patients with successful non-invasive ventilation and those with failed non-invasive ventilation ($P < 0.05$). However, no statistically significant differences were found in gender, age, PaO_2, NEUT, PCT, ALB, or tidal volume between the two groups ($P > 0.05$). See **Table 1**.

Table 1. Univariate analysis of factors influencing non-invasive ventilation [*n* (%)]

Factors		Ventilation failure group (*n* = 30)	Ventilation success group (*n* = 92)	*t* / Z / χ^2	*P*
Gender (cases)	Male	18 (60.00)	68 (73.91)	2.105	0.147
	Female	12 (40.00)	24 (26.09)		
Age (years)	< 65	4 (13.33)	9 (9.79)	0.300	0.584
	≥ 65	26 (86.67)	83 (90.22)		
pH		7.33 ± 0.08	7.38 ± 0.08	-3.105	0.002
PO_2 (mmHg)		81.83 ± 34.06	88.19 ± 33.38	-0.89	0.375
PCO_2 (mmHg)		82.50 ± 20.09	66.14 ± 15.34	4.634	0.000
NEUT ($\times 10^9$/L)		6.01 ± 3.37	5.71 ± 2.62	0.508	0.612
CRP (mg/L)		24.10 (4.3, 47.4)	6.48 (1.4, 23.7)	-2.008	0.045
PCT (ng/mL)		0.04 (0.0, 0.1)	0.04 (0.0, 0.1)	-0.175	0.861
ALB (g/L)		37.27 ± 5.31	38.08 ± 4.15	-0.84	0.403
Tidal volume (mL/kg)	6–8	16 (53.33)	42 (45.65)	0.535	0.464
	8–10	14 (46.67)	50 (54.35)		

3.3. Multivariate analysis of factors influencing non-invasive ventilation

Non-invasive ventilation failure was included as the dependent variable, and the factors with statistically significant differences in the univariate analysis were included as independent variables. See **Table 2** for variable assignments.

Table 2. Variable assignments

Factors	Assignment
pH	pH < 7.35 = 1; pH ≥ 7.35 = 0
$PaCO_2$ (mmHg)	$PaCO_2 \geq 70 = 1$; $PaCO_2 < 70 = 0$
CRP (mg/L)	CRP ≥ 7 = 1; CRP < 7 = 0

Based on logistic regression analysis, CRP, pH, and $PaCO_2$ were identified as independent risk factors for non-invasive ventilation failure ($P < 0.05$). See **Table 3**.

Table 3. Multivariate analysis factors influencing non-invasive ventilation failure

Factor	β	SE	Wald	*P*	OR	95% CI
pH	0.237	0.341	0.481	0.488	1.267	0.624–2.473
$PaCO_2$ (mmHg)	0.290	0.186	2.430	0.119	1.337	0.928–1.926
CRP (mg/L)	0.443	0.205	4.669	0.031	1.557	1.042–2.327

4. Discussion

Chronic obstructive pulmonary disease is a serious public health concern that significantly reduces quality of life and increases mortality rates, imposing a considerable economic burden on individuals, families, and society. According to the 2018 China Pulmonary Health Study, the prevalence of COPD among adults aged 20 and over in China reached 8.6%, rising to 13.7% in those aged 40 and above. Characterized by persistent airflow limitation and associated lung symptoms, COPD involves pathological changes primarily affecting bronchial and alveolar function, often triggered by exposure to harmful particles or gases [5]. Additionally, genetic susceptibility, immune dysregulation, and poor lung development contribute to COPD pathogenesis. Acute exacerbations of COPD represent severe episodes marked by respiratory distress, intense coughing, and excessive purulent sputum production, requiring adjustments in medication therapy [6]. Non-invasive mechanical ventilation has become a widely adopted intervention for AECOPD with type II respiratory failure, aiming to alleviate respiratory acidosis, reduce $PaCO_2$ levels, breathing frequency, and perceived respiratory effort, thereby decreasing hospitalization duration, mortality risk, and the need for endotracheal intubation. NIV also helps mitigate airway damage, lowers the incidence of ventilator-associated pneumonia, and reduces sedative dependency, minimizing patient discomfort [7].

While ventilation is essential in managing AECOPD with type II respiratory failure, the efficacy of NIV varies. In some cases, ventilation does not significantly improve the patient's condition post-intubation, leading to recurrence after extubation. Therefore, it is clinically important to investigate the factors contributing to NIV failure to enhance patient stability and improve weaning success rates.

This study found significant differences in CRP, pH, and $PaCO_2$ levels between patients who succeeded with NIV and those who failed ($P < 0.05$). Further analysis revealed that $PaCO_2$ and pH are indicative of lung ventilation capacity and hypoxia severity in AECOPD patients with respiratory failure. However, impaired baseline pulmonary ventilation in these patients can hinder responsiveness to NIV, affecting treatment outcomes. Elevated CRP levels directly reflect the severity of inflammation, necrosis, and both acute and chronic conditions, all of which influence the effectiveness of non-invasive mechanical ventilation.

5. Conclusion

In conclusion, CRP, pH, and $PaCO_2$ are independent risk factors for NIV failure. Identifying these risk factors promptly and implementing timely medical interventions can reduce the rate of NIV treatment failure.

Disclosure statement

The authors declare no conflict of interest.

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