

World Journal of *Clinical Cases*

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Helmet-based noninvasive ventilation for acute exacerbation of chronic obstructive pulmonary disease: A case report

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Abstract

BACKGROUND

Noninvasive ventilation (NIV) reduces intubation rates, mortalities, and lengths of hospital and intensive care unit stays in patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD). Helmet-based NIV is better tolerated than oronasal mask-based ventilation, and thus, allows NIV to be conducted for prolonged periods at higher pressures with minimal air leaks.

CASE SUMMARY

A 73-year-old man with a previous diagnosis of COPD stage 4 was admitted to our medical intensive care unit with chief complaints of cough, sputum, and dyspnea of several days' duration. For 10 mo, he had been on oxygen at home by day and had used an oronasal mask-based NIV at night. At intensive care unit admission, he breathed using respiratory accessory muscles. Hypercapnia and signs of infection were detected, and infiltration was observed in the right lower lung field by chest radiography. Thus, we diagnosed AECOPD by community-acquired pneumonia. After admission, respiratory distress steadily deteriorated and invasive mechanical ventilation became necessary. However, the patient refused this option, and thus, we selected helmet-based NIV as a salvage treatment. After 3 d of helmet-based NIV, his consciousness level and hypercapnia recovered to his pre-hospitalization level.

CONCLUSION

Helmet-based NIV could be considered as a salvage treatment when AECOPD patients refuse invasive mechanical ventilation and oronasal mask-based NIV is ineffective.

Key words: Acute exacerbation of chronic obstructive pulmonary disease; Noninvasive ventilation; Helmet; Case report

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Core tip: We present a case of acute exacerbation of chronic obstructive pulmonary disease in a 73-year-old male. Despite oronasal mask-based noninvasive ventilation (NIV) and adjustment of positive end-expiratory pressure and inspiratory positive pressures, hypercapnia and conscious level were not improved. The patient refused invasive mechanical ventilation, and accordingly we opted for helmet-based NIV. Subsequently, hypercapnia and conscious level recovered to his pre-hospitalization level. Helmet-based NIV may be considered as a salvage treatment, when an acute exacerbation of chronic obstructive pulmonary disease patient refuses invasive mechanical ventilation and has failed to respond to oronasal mask-based NIV.

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INTRODUCTION

Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is defined as sustained worsening of condition from the stable state to beyond normal day-to-day variations possibly warranting additional treatment^[1]. AECOPD has negative impacts on quality of life, accelerates disease progression, and results in higher hospital admission and death rates than those associated with COPD without frequent exacerbations^[2-4]. The incidence of AECOPD per person per year has been estimated to range between 0.65 and 1.40^[3]. AECOPD therapy includes β -agonists, anticholinergics, corticosteroids, and antibiotics. Furthermore, noninvasive ventilation (NIV) may be preferred to invasive mechanical ventilation in patients with hypercapnic respiratory failure^[5,6].

NIV reduces the need for intubation, mortality rates, and lengths of hospital and intensive care unit (ICU) stays in cases of acute or acute-on-chronic hypercapnic respiratory failure^[4]. NIV has proven to be useful for breathing support, but complications such as air leaks, skin breakdown, and discomfort result in treatment failure^[7]. Helmet-based NIV is better tolerated than oronasal mask-based NIV, and thus, can be maintained for longer periods at higher pressure with fewer air leaks. Furthermore, in a previous study, the NIV failure rate was lower for AECOPD patients treated using an oronasal mask and a helmet sequentially than using an oronasal mask alone^[8].

Here, we report a case of AECOPD with hypercapnic respiratory failure in a 73-year-old male. In this case, the use of helmet-based NIV as a salvage treatment, which reduced hypercapnic respiratory failure, whereas high intensity oronasal mask-based NIV failed to do so.

CASE PRESENTATION

Chief complaints

A 73-year-old man was admitted to our medical ICU with chief complaints of cough, sputum, and dyspnea of several days' duration.

History of present illness

Initially, the patient visited our emergency room because of cough, sputum and breathing difficulties of 2 d duration. He refused admission and was discharged on antibiotics and systemic steroid, which improved his symptoms. Nonetheless, 2 d later, he was admitted to our medical ICU because of dyspnea and decreased consciousness.

History of past illness

In 2007, the patient was diagnosed to have pneumothorax and COPD stage 4, and in August 2017, he was admitted with recurrent pneumothorax. In April 2018, he was

admitted with AECOPD and treated by invasive mechanical ventilation with systemic steroid. After discharge, he was hardly able to perform anything alone because of dyspnea (modified medical research council dyspnea scale IV). He was maintained on oxygen at home by day and by oronasal mask-based NIV at night. He regularly used formoterol/budesonide and umeclidinium inhalers and salbutamol as needed. He had quit smoking for a year, but before that, he had smoked a pack per day for 50 years.

Personal and family history

There was no relevant personal or family history.

Physical examination upon admission

Initial physical examination showed he breathed with respiratory accessory muscles and lung sounds were diminished.

Laboratory examinations

Arterial blood gas analysis of a blood sample taken when he visited our emergency room showed; pH 7.20, PCO₂ 60.8 mmHg, PO₂ 60.6 mmHg, and O₂ saturation 86.1%. In addition, it revealed signs of infection, *i.e.*, white blood cell count ($10.39 \times 10^3/\mu\text{L}$), C-reactive protein (5.98 mg/dL), and procalcitonin (1.41 ng/mL). However, sputum gram staining and culture, blood culture, and urine antigens tests failed to identify any causative organism.

Imaging examinations

Chest radiography revealed infiltration of the right lower lung field.

FINAL DIAGNOSIS

The final diagnosis reached was AECOPD by community-acquired pneumonia.

TREATMENT

At admission, he was treated with intravenous methylprednisolone, antibiotics, short-acting inhaled beta₂-agonist, and an anticholinergic. However, dyspnea, consciousness level, and hypercapnia worsened. His Richmond Agitation-Sedation Scale score was -3, indicating movement response to voice but no eye contact. He was already using oronasal mask-based NIV for about 8 h/d. When we applied higher positive end-expiratory pressure (PEEP) and inspiratory positive pressure than ever applied, air leak increased, and the patient reported it was unbearable. The maximal peak pressure that the patient could withstand was 14 cmH₂O during oronasal mask-based NIV. At higher PEEP, respiratory failure was not improved. Although invasive mechanical ventilation was believed necessary, the patient had previously declined invasive mechanical ventilation and completed a "Do Not Resuscitate" form. Helmet-based NIV was applied at higher positive inspiratory pressure, PEEP than those used for oronasal mask-based NIV. After changing to helmet-based NIV, no air leak occurred and inspiratory positive pressure and PEEP were maintained at 12 and 10 cmH₂O, respectively, which the patient tolerated. After 5 h of helmet-based NIV, hypercapnia and level of consciousness were not improved. However, helmet-based NIV was maintained until the next morning, when hypercapnia and level of consciousness were improved. Thus, helmet-based NIV was applied for three consecutive days at 24 h/d (Table 1).

OUTCOME AND FOLLOW-UP

Three days after admission, consciousness level and arterial blood gas parameters recovered to pre-hospitalization level. Helmet-based NIV was switched to oronasal mask-based NIV. He was discharged to home on hospital day 14 and instructed to adopt the same oronasal mask-based NIV and the home oxygen procedure used prior to admission.

DISCUSSION

Some patients with AECOPD need invasive mechanical ventilation. However, our

Table 1 Physiological parameters during helmet-based noninvasive ventilation

Parameters	0 h	3 h	5 h	15 h	40 h	63 h
Heart rate (bpm)	60	96	94	72	68	77
Respiratory rate (bpm)	19	36	32	30	17	19
Blood pressure (mmHg)	74/47	166/85	159/80	91/57	99/59	115/69
ABG						
pH	7.19	7.14	7.18	7.25	7.33	7.36
PaCO ₂ (mmHg)	77.6	75.2	73.3	65.3	55.3	49.2
PaO ₂ (mmHg)	70.2	75.8	69.7	82.3	80.2	78.2
NIV mode						
FiO ₂	0.4	0.4	0.4	0.4	0.4	0.4
PEEP	8	10	10	10	10	10
PS	10	12	12	12	12	12

ER: Emergency room; ABG: Arterial blood gas; PaO₂: Arterial oxygen partial pressure; PaCO₂: Partial arterial carbon dioxide; NIV: Noninvasive ventilation; FiO₂: Fraction of inspired oxygen; PEEP: Positive end-expiratory pressure; PS: Pressure support.

patient refused invasive mechanical ventilation, and thus, other treatment options were considered. Because oronasal mask-based NIV had failed to address hypercapnia, we administered helmet-based NIV at higher intensity, which elicited recovery.

NIV reduces hospital stays and mortality by 50% in AECOPD patients^[9], and in a previous study, the treatment failure rate for the sequential use of an oronasal mask and a helmet was lower than that of an oronasal mask alone^[8]. Other studies have reported lower hospital mortalities and intubation complication rates for helmet-based NIV than for oronasal mask-based NIV in cases of acute respiratory failure^[7,10,11].

NIV treatment failures are caused by intolerance, uncontrolled air leaks, and lack of gas exchange improvement. Helmet-based NIV is better tolerated than oronasal mask-based NIV, and thus, allows longer treatment periods, maintains higher inspiratory positive pressures and PEEP with fewer air leak^[12]. Based on the patient's opinion and these previously reported results, we chose helmet-based NIV as a salvage treatment rather than invasive mechanical ventilation. In our patient, during the early phase, helmet-based NIV was ineffective at improving hypercapnic respiratory failure. Nevertheless, we persisted and hypercapnia and consciousness level began to improve after 15 h, and after 63 h of helmet-based NIV, these recovered to the pre-hospital level, when we switched to oronasal mask-based NIV and a high flow nasal cannula.

CONCLUSION

The helmet-based NIV can be applied continuously for a long time, because of less discomfort even under high pressure and because it can be continued during Levin tube feeding. Also, helmet-based NIV can deliver higher pressures without air leakage than oronasal mask-based NIV. In our opinion, these benefits and characteristics enable patient recovery from hypercapnic respiratory failure more effectively. We suggest helmet-based NIV be considered as a salvage treatment for AECOPD patients that have declined invasive mechanical ventilation.

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