A Successful Treatment of Obesity Hypoventilation Syndrome Using Bi-level Positive Airway Pressure in a Patient With Hypoxic Brain Damage

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We present the case of a 78-year-old female who experienced acute mental deterioration after vomiting. She showed severe hypercapnia without definite lung disease and hypoxic injury on brain image. After the acute period, she still had excessive daytime sleepiness, and the hypercapnia aggravated during the night. Polysomnography revealed severe obstructive sleep apnea, a sleep-related breathing disorder with a high apnea-hypopnea index of 60.2/h (mainly a hypopnea index of 59.0/h). She was diagnosed with combined obesity hypoventilation syndrome (OHS) and sleep-related breathing disorder, as the cause of daytime hypercapnia and excessive daytime sleepiness. Three months of successful bi-level positive airway pressure (BiPAP) therapy dramatically improved her daytime sleepiness and cognition. This case suggests that patients with OHS can be susceptible to hypoxic brain damage, and emphasizes the importance of the recognition and diagnosis of OHS and appropriate treatment with BiPAP therapy.

Keywords: Obesity hypoventilation syndrome; Bi-level positive airway pressure; Hypoxic brain damage.

INTRODUCTION

Obesity hypoventilation syndrome (OHS) is a sleep-related hypoventilation disorder defined as the presence of obesity (body mass index >30 kg/m²) with chronic daytime hypercapnia (PaCO₂ >45 mm Hg) in patients without any other causes to explain alveolar hypoventilation.1,2 The diagnosis of OHS is important, given the clinical aggravation leading to respiratory dysfunction along with the mortality rate in underdiagnosed patients.3 Also, OHS has been rising and is now a relatively common cause of chronic respiratory failure with hypercapnia, as obesity rates continue to increase. Therefore, an accurate diagnosis and therapeutic approach for OHS are necessary. We report a case of hypoxic brain damage in a patient with OHS who was treated with bi-level positive airway pressure (BiPAP) therapy.

CASE REPORT

An obese 78-year-old female was admitted to the neurologic-
encephalopathies.

Following mechanical ventilation, her hypercapnia improved within three hours of arrival at the hospital, and her mental state recovered within five hours. Diffusion-weighted brain magnetic resonance imaging (MRI) performed on the fifth day after admission showed acute restricted lesions in the bilateral basal ganglia, indicating hypoxic brain damage (Fig. 1). Although the patient was clearly alert, a mechanical ventilator was applied for 12 days, because CO₂ retention was not adequately resolved. There was no evidence of aspiration pneumonia on initial chest computed tomography (CT) with contrast, but prophylactic antibiotics were administered for 12 days, during ventilator application. The results of the arterial blood gas test after the ventilator removal still showed mild respiratory acidosis (a pH of 7.389, HCO₃ 29.9 mEq/L, PaCO₂ 49.2 mm Hg, PaO₂ 75.0 mm Hg, and SaO₂ 94.5%).

In the other exploration of respiratory failure, there were no anatomical explanations for hypoventilation or findings suggestive of heart failure, pulmonary hypertension, and pulmonary thromboembolism through various tests, such as echocardiography, pulmonary thromboembolism-CT, and bronchoscopy. However, the patient still showed hypercapnia upon waking in the morning (peak PaCO₂ 56.3 mm Hg), and this value was higher than that in her awakened state during the daytime (peak PaCO₂ 48 mm Hg). A pulmonary function test was performed two days after the removal of mechanical ventilation in a patient-cooperative state and showed a severe restrictive pattern: the forced expiratory volume in one second/forced vital capacity ratio (80%) was greater than normal, and the forced vital capacity (37%) was low, but there were no clear pulmonary diseases, such as chronic obstructive pulmonary disease (COPD) or asthma. Despite preserving her alertness, the patient showed excessive daytime sleepiness and snoring. She was usually very sleepy during the day and fell asleep while speaking. Cognitive impairment was confirmed through a mini-mental state examination score of nine. We suspected not only sleep breathing disorder, but also OHS as her diagnosis based on findings of hypercapnia, particularly during early morning and nighttime, along with a history of obesity. On day 19 following admission, a split-night polysomnography (PSG) study was performed. The PSG revealed severe obstructive sleep apnea (OSA), with a high apnea-hypopnea index (AHI) of 60.2/h (mainly a hypopnea index of 59.0/h). The PSG (Fig. 2) also showed sleep-aggravated hypercapnia and nocturnal hypoxemia during rapid eye movement sleep, with hypopnea events. In addition, the maximum end-tidal carbon dioxide values were 51 mm Hg during awakening and 61 mm Hg during sleep. The continuous positive airway pressure (CPAP) was adjusted by increasing the pressure from 4 to 15 cm H₂O, but hypoventilation and hypercapnia still occurred, leading to BiPAP titration, even during limited night hours. During titration, the optimal BiPAP pressure was determined, with an increased inspiratory pressure of 18 cm H₂O and expiratory pressure of 12 cm H₂O at a nadir AHI of 2/h. After three months of

![Figure 1](https://www.e-jsm.org)

**Figure 1.** Diffusion-weighted magnetic resonance imaging of brain shows high signal intensity on bilateral basal ganglia (white arrows) but low signal intensity on apparent diffusion coefficient map.
BiPAP use, the arterial CO₂ retention in the morning was lowered, from 55.4 mm Hg to 38 mm Hg, and the residual AHI was 4.1/h. She adhered to BiPAP therapy for an average of 7 hours and 17 minutes, with 99% usage during the prescribed days. The patient is being followed-up on an outpatient basis, with no clinical signs of dyspnea, edema, nor neurological symptoms, including daytime sleepiness and cognitive impairment. Her family members subjectively believe that communication with the patient is smoother than before, and her cognitive decline improved, despite the lack of objective cognition or sleepiness measures. In summary, we report a case of OHS combined with OSA that presented with acute exacerbation of chronic respiratory failure and hypoxic brain damage. Furthermore, the patient's condition improved after the BiPAP treatment. The patient provided written informed consent.

**DISCUSSION**

OHS is characterized by obesity and daytime hypercapnia that occurs in the absence of an explanation for hypoventilation.⁴ Previous studies have shown significant health impairments in these patients. They often endure prolonged periods of hospitalization and draw heavily on healthcare resources, with worsening comorbidities and high mortality.³-⁵

Patients with OHS suffer from OSA and exhibit severe and prolonged oxygen desaturation during sleep, which results from reduced lung volumes and increased airway resistance.⁶ Therefore, hypoxia in OHS is sustained, and notably worsens during sleep.

Prior studies have reported that patients with chronic respiratory insufficiency, such as COPD, are susceptible to hypoxic brain damage and cognitive dysfunction, including increased inflammation and oxidative and physiological stress.⁷ Congenital central hypoventilation syndrome is a disorder that affects hypoventilation during sleep, resulting in a shortage of oxygen and a buildup of carbon dioxide in the blood. This potentially leads to absent or reduced ventilatory and arousal responses to sustained hypercapnia and, to a lesser extent, sustained hypoxia.⁸ Some studies have revealed that several brain regions in patients with congenital central hypoventilation syndrome respond inappropriately to problems with ventilation or blood pressure. In prior study results, the brain lesions typically appeared in the forebrain diencephalon, midbrain, and cerebellar areas.⁹ MRI findings of hypoxic brain damage preferentially indicate lesions in areas such as the cerebellar hemispheres, basal ganglia, or cerebral cortex.¹⁰ The patient in our presenting case exhibited hypoxia by asphyxiation from vomiting, following accelerated aggravated hypercapnia on OHS. Given the clinical history and circumstances of the present case, hypoxic injury may be a convincing explanation for the pathophysiology of brain injury in the patient rather than other infectious, vascular, epileptic, genetic/congenital, metabolic, or toxic causes.

Chronic hypoventilation in patients with OHS exposes them to chronic hypoxia and daytime hypercapnia, which leads to an accumulated hypoxic burden and susceptibility to even minimal levels of hypoxic insult. OHS often remains underdiagnosed in clinical practice and presents with a lack of specific symptoms or tools, such as in-lab PSG and carbon dioxide measurement.¹¹ It is important for clinicians to be aware of and suspect the possibility of OHS, given that early detection and proper management are critical for improving patient quality of life and even averting mortality. Therefore, physicians must consider early ventilatory management to provide neuroprotec-
tion against delayed hypoxic brain damage during the acute phase in patients with OHS who have experienced a hypoxic event, and even in those without definite respiratory failure.

Patients with OHS combined with severe OSA should be treated with CPAP or BiPAP to manage sleep-disordered breathing and improve nocturnal gas exchange. However, high CPAP was insufficient for resolving the hypercapnia and hypopnea in this patient. Therefore, we adjusted the BiPAP to provide pressure support and improve hypoventilation. This case study suggests that patients with OHS may be susceptible to anoxic damage. Notably, we would like to highlight the importance of concerns surrounding OHS in obese patients and introduce successful treatment with non-invasive ventilation in order to prevent chronic respiratory failure.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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