Central Alveolar Hypoventilation Syndrome Due to Surgical Resection for Bulbar Hemangioblastoma

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Abstract

A 29-year-old man with a history of resected bulbar hemangioblastoma was admitted to hospital with nighttime breathing disturbance, but with apparently normal breathing while awake. After diagnostic work-up, including polysomnographic testing, he was diagnosed as having central alveolar hypoventilation syndrome due to surgical resection for bulbar hemangioblastoma. Non-invasive positive pressure ventilation (NIPPV) via oronasal facemask was given for nocturnal ventilatory support.

Two months after leaving our hospital, he was readmitted because of aspiration pneumonia. The pneumonia was successfully treated with antibiotics, but the desaturation during sleep worsened despite non-invasive ventilatory support. Higher bi-level positive pressure using a full facemask successfully alleviated sleep hypoventilation and apnea. To the best of our knowledge, this is the first case report of central alveolar hypoventilation syndrome due to surgical resection for bulbar hemangioblastoma.

Key words: central alveolar hypoventilation syndrome, non-invasive positive pressure ventilation, full face mask, polysomnography


Introduction

Central alveolar hypoventilation syndrome is a rare disorder that is characterized by lack of automatic control of ventilation during sleep because of dysfunction of the respiratory center in the brain stem (1-4). Affected patients can apparently breathe normally when they are awake, but they inevitably develop prolonged apnea after falling asleep. Central alveolar hypoventilation syndrome is usually congenital (4). This pathophysiological condition can also be caused by brainstem lesions, including surgical incisions into the second cervical segment of the spinal cord to relieve intractable pain, infarction in the respiratory center, encephalitis, and tumor in adults (5-8). However, central alveolar hypoventilation syndrome caused by impairment of the brain stem after surgery has not been previously reported.

This paper reports the first case of acquired central alveolar hypoventilation syndrome due to surgical resection for bulbar hemangioblastoma, which was diagnosed based on the criteria for congenital central alveolar hypoventilation syndrome. This case suggests that, in this syndrome, higher bi-level positive pressure using a full facemask may be needed to alleviate sleep hypoventilation and apnea.

Case Report

A 29-year-old man had been suffering from gait impairment, numbness of his left hand, and cervical pain since he was 13 years old. After he was diagnosed as having bulbar hemangioblastoma, cerebral decompression surgery and gamma knife radiotherapy were performed at the age of 19.

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years. The gait impairment persisted despite gamma knife radiotherapy, and resection of the bulbar hemangioblastoma was performed at the age of 28 years. Magnetic resonance imaging (MRI) findings before and after resection of the hemangioblastoma are shown in Fig. 1. Postoperatively, when he was 29 years old, the patient was hospitalized because of night-time breathing disturbance. Before the operation, the patient did not have sleep apnea; in fact, he had a pleasant sleep. On physical examination, the patient had left-sided cerebellar ataxia without significant motor paralysis or sensory abnormalities and no thoracic deformity. His body mass index was 21.7 kg/m². There were no abnormalities in echocardiography, electrocardiography, pulmonary function testing (VC 3.45 l, %VC 81.4%, FEV1.0 3.18 l, %FEV1.0 78.9%, FEV1.0% 90.1%), respiratory muscle strength testing (%MIP 70.7%, %MIP 76.6%), and chest computed tomography. A simple swallowing provocation test (9) showed no abnormal results. No evidence of chronic infection in the nasal sinuses, the nasal cavity, and the buccal cavity was observed. The laboratory findings showed no abnormalities. When he was awake, arterial blood gas analysis showed: pH 7.374, pCO2 56 mmHg, pO2 50.2 mmHg, HCO3 32 mmol/L, BE 5.1 mmol/L, and AaDO2 29.8 mmHg. However, one hour after sleep onset, arterial blood gas analysis showed: pH 7.323, pCO2 71.5 mmHg, pO2 53.6 mmHg, HCO3 36.3 mmol/L, BE 7.4 mmol/L, and AaDO2 7.02 mmHg. When he was forced to hyperventilate voluntarily, arterial blood gas analysis showed: pH 7.479, pCO2 27.2 mmHg, pO2 106.2 mmHg, HCO3 19.8 mmol/L, BE -2.4 mmol/L. Polysomnography showed central sleep apnea-hypopnea with an AHI of 51.8/hour and a minimum SpO2 of 51% during sleep (Table 1, Fig. 2).

The definite criteria for the diagnosis of secondary central alveolar hypoventilation syndrome are not well established (10-12). Nattie et al proposed criteria for the diagnosis of congenital central alveolar hypoventilation syndrome (13). The criteria include: 1) existence of alveolar hypoventilation with hypoxia and hypercapnia; 2) no associated pulmonary diseases, neuromuscular diseases, or abnormalities of bone structure; and 3) improvement of arterial blood gas findings by voluntary effort. These criteria demonstrate the presence of a respiratory center disorder. In the present case, the patient had alveolar hypoventilation with hypoxemia and hypercapnia, the arterial gas abnormalities improved with voluntary hyperventilation, and there were no associated pulmonary diseases, neuromuscular diseases, or abnormalities of bone structure. Furthermore, nocturnal hypopnea and apnea accompanied by decreases in thoracic and abdominal movements were evident, especially during sleep, indicating a disorder of the respiratory center. In the present case, an organic lesion of the respiratory center appears to have become evident postoperatively, whereas preoperatively, the patient did not have alveolar hypoventilation or sleep apnea. Therefore, this case was diagnosed as secondary central alveolar hypoventilation syndrome due to surgical resection for bulbar hemangioblastoma, in accordance with the criteria for congenital central alveolar hypoventilation syndrome of Nattie et al (13).

This patient was also diagnosed as having sleep hypoventilation syndrome (SHVS) due to impairment of the brainstem or a high spinal cord lesion, since he showed hypercapnia during wakefulness (PaCO2 >45 mmHg) and an increase in PaCO2 during sleep (>10 mmHg from awake supine values) (14). The patient also showed severe desaturation during sleep (SpO2<85% for more than 50% of the sleep time).

Non-invasive positive pressure ventilation (NIPPV) by oronasal facemask was started because of severe night hypoxemia and daytime hypercapnia. The NIPPV setting was IPAP 14 cmH2O and EPAP 4 cmH2O with timed mode at a rate of 14 BPM during sleep. NIPPV therapy improved both night hypoxemia and AHI slightly (Table 1). Although the therapy was not completely effective, the patient was dis-
central alveolar hypoventilation syndrome is a very rare disease characterized by dysfunction of the respiratory center in the brain stem. While central alveolar hypoventilation syndrome is usually congenital, it can also be caused by organic brainstem lesions (5-8). To the best of our knowledge, this is the first case report of central alveolar hypoventilation syndrome due to surgical resection for bulbar hemangioblastoma.

The present patient presented with apnea and alveolar hypoventilation during sleep, but his ventilation was relatively normal during wakefulness. In fact, damage to part of the respiratory center, especially automatic respiratory drive, might have induced this syndrome, because voluntary respiratory drive, as well as automatic respiratory drive, did not work during sleep. On the other hand, his ventilation was relatively normal while awake because his voluntary respiratory drive, which is maintained by the cerebral cortex, remained intact.

Hemangioblastomas of the medulla are rare and seldom reported (15). Surgical resection of medullary hemangioblastomas is associated with high morbidity and mortality rates (15). Removal of large solid hemangioblastomas may result in severe postoperative edema and/or hemorrhage in the medulla affecting the respiratory and vagal centers (15). Therefore, preoperative embolization through the posterior inferior cerebellar artery (PICA) can be helpful in this situation (15). Preoperative embolization of hemangioblastomas is a useful and relatively safe procedure that reduces blood loss at the time of surgery and allows complete resection (16, 17). In the present patient, preoperative embolization through the posterior inferior cerebellar artery (PICA) and the vertebral artery (VA) was performed 24 hours before operation while he was intubated and mechanically ventilated. The patient was directly transferred to the operating room during intubated mechanical ventilation. Using an extended suboccipital craniectomy, the tumor was totally removed. Therefore, preoperative embolization and the operation itself may damage the part of the respiratory center involved in automatic respiratory drive.

The neuroanatomical pathways that control respiration likely originate in the pons and medulla, with descending connections into the upper segments of the cervical spinal cord (6, 8, 18). The two main collections of neurons that regulate respiration in the medulla are the dorsal respiratory group (DRG) near the solitary tract and the ventral respiratory group (VRG) near the nucleus ambiguus (19). There is also a collection of neurons in the dorsal pons that participate in the control of automatic respiration (20). Although all three of these groups of neurons are paired bilaterally, unilateral damage of the medullary tegmentum may be sufficient to cause the syndrome of central alveolar hypoventilation and apnea due to damage to crossing fibers connecting the paired medullary nuclei. Damage to the VRG may also

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**Table 1. Polysomnography Data during Spontaneous Breathing and Under NIPPV**

<table>
<thead>
<tr>
<th></th>
<th>On admission</th>
<th>NIPPV by oronasal facemask (I/E=14/4)</th>
<th>NIPPV by full facemask (I/E=22/8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHI</strong></td>
<td>51.8 /h</td>
<td>21.1 /h</td>
<td>0.1 /h</td>
</tr>
<tr>
<td><strong>Minimum SpO₂</strong></td>
<td>51 %</td>
<td>60 %</td>
<td>85 %</td>
</tr>
<tr>
<td><strong>Duration of SpO₂ &lt;90%</strong></td>
<td>214 min</td>
<td>102 min</td>
<td>0.5 min</td>
</tr>
</tbody>
</table>

The optimal therapy in the patient was high pressure NIPPV by full facemask. NIPPV: non-invasive positive pressure ventilation, AHI: apnea-hypopnea index, I: inspiratory positive airway pressure, E: expiratory positive airway pressure.

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Figure 2. A: A polysomnographic recording shows nocturnal desaturation due to hypopnea and apnea with a decrease in thoracic and abdominal movement on admission. B: A polysomnographic recording shows no nocturnal desaturation after high pressure NIPPV therapy using a full facemask.

be sufficient to result in loss of automatic respiration (8). In the present patient, small right dorsolateral scar formation that developed following surgical resection for bulbar hemangioblastoma could have damaged the ventral respiratory group (VRG).

The aspiration pneumonia in the present case may have been associated with sleep apnea-related gastroesophageal reflux (GER) (21). Relaxation of the lower esophageal sphincter (LES), which is induced by no contraction of the diaphragm during apnea, is thought to be one explanation for GER (21), though this association could not be established by clinical examination in the present case. In addition, increased AaDO2 during wakefulness may be caused by ventilation-perfusion imbalance induced by microaspiration-related bronchiolitis.

The severe respiratory failure secondary to aspiration pneumonia in the present case may have been associated with impairment in the patient’s perception of the symptoms of pneumonia. In fact, poor perception of the severity of an asthma attack, due to reduced chemosensitivity to hypoxia and blunted perception of dyspnea, has been proposed as a mechanism underlying treatment delay (22). Sustained hy-

Figure 3. A: Chest CT on first admission. B: Chest CT at the time of diagnosis of aspiration pneumonia.

Hypoxia has a depressant effect on dyspnea and ventilation through depression of the central nervous system and impaired cognitive function (23, 24). The ventilatory response to hypoxia and hypercapnia could not be assessed in the present case because the patient did not consent to the test. However, sustained hypoxia due to central alveolar hypoventilation may have led to depression of the central nervous system, especially the cerebral cortex that maintained the patient’s voluntary respiratory drive. Therefore, impairment in the patient’s perception of the symptoms of aspiration pneumonia may have resulted in the severe respiratory failure requiring intubation.

The present case recovered from ventilatory failure following the use of higher pressure NIPPV therapy. There are several therapies for central hypoventilation syndrome, such as administration of the respiratory stimulants, methylxanthine and medroxyprogesterone, and noninvasive ventilation (10). Mechanical ventilation may be clearly required for patients with severe or end-stage central hypoventilation syndrome (10-12). NIPPV is superior to non-invasive negative-pressure ventilation (e.g. extrathoracic biphasic cuirass ventilator) or diaphragm pacing, with diaphragm pacing reserved for patients who cannot tolerate positive-pressure techniques (25). Since both non-invasive negative-pressure ventilation and diaphragm pacing may induce upper airway obstruction in some patients, tracheotomy often needs to be performed (26). Therefore, due to its lack of airway obstruction risk, NIPPV has been thought to be more appropriate. A case series also suggests that a combination of expiratory muscle-assist equipment and NIPPV is more effective in reducing hospital admissions than tracheostomy ventilation (27). However, the appropriate settings for NIPPV are not well-established in this syndrome.

A full facemask is usually used if patients are unable to tolerate NIPPV due to air leaks around the mask, facial discomfort, and claustrophobia (28). In the present case, a much higher pressure NIPPV (IPAP/EPAP; 22/8) therapy was required to overcome the elastic resistance load of the lung and chest wall during sleep hypoventilation and apnea. Although higher pressure IPAP may cause lung hyperinflation, abdominal distension, excessive load on the expiratory muscles, altered ventilatory synchronization, and increased gas leakage, no complications were observed in the present patient. The full facemask may also improve ventilation and gas exchange by reducing gas leakage around the mouth due to increased tightness between the mask and face.

This is the first reported case of acquired central alveolar hypoventilation syndrome due to surgical resection for bulbar hemangioblastoma. Polysomnography is essential to diagnose this pathophysiological entity because, in this syndrome, severe ventilatory failure may be present during sleep but not during the day.

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References


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