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Case Report

Severely obese 14-year-old boy with central sleep apnea several years after head trauma

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Highlights

- Obesity may be associated with central sleep apnea.
- Obesity leads to respiratory center suppression and oxygen reserve reduction.
- Cautious interpretation of central apnea is warranted for patients with obesity.

Abstract. Central sleep apnea (CSA) is rare in older children. Although CSA mostly arises from neurological diseases such as Chiari malformation, the frequency of CSA is significantly higher in obese children. Herein, we describe the case of a 14-yr-old boy who presented with CSA secondary to severe obesity and a history of traumatic lateral medullary syndrome at 8 yr of age. Polysomnography revealed severe sleep apnea syndrome with apnea-hypopnea index of 41.4 per hour and central apnea index of 8.9 per hour. Magnetic resonance imaging of the head showed no new brainstem or cerebellar infarcts; however, old changes in the cerebellar infarction persisted. Obesity is primarily associated with obstructive sleep apnea. However, obesity can result in CSA through pharyngeal collapse and the reduction of oxygen reserves caused by reduced thoracic volume, which suppresses respiratory center stimulation. Because the respiratory center disorder owing to head injury sequelae improved after the acute stage, obesity was deemed the cause of CSA in this case. Hence, children with severe obesity may require CSA monitoring.

Key words: central sleep apnea, obesity, sleep-disordered breathing, polysomnography, childhood

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Introduction

Central sleep apnea (CSA) is a sleep-related disorder characterized by airflow cessation because of a lack of effort in ventilatory function during sleep. CSA is defined as the absence of chest and abdominal movements associated with the cessation of airflow for more than 20 sec or lasting for more than two baseline respiratory cycles, with arousal or oxygen desaturation of at least 3% in children (1). CSA is often observed in preterm infants, newborns, and other infants. In healthy children, central apneas for short durations within 20 sec are considered physiological, followed by a sigh, movement, and rapid eye movement sleep, which gradually decrease with the maturation of the central nervous system (2). The frequency of CSA in children is approximately 5.4–14.9% (3). Neurological disorders are the most common causes of CSA in non-preterm infants. Arnold–Chiari malformation has been reported to account for 22% of all cases (4). Other known causes of CSA include Prader–Willi syndrome, upper respiratory tract malformations, gastroesophageal reflux, and hypothyroidism (2).

Obesity is associated with obstructive sleep apnea (OSA). Moreover, obese children had a significantly higher frequency of CSA than nonobese children (3). Herein, we present the case of a child with CSA and severe obesity. Prior to the diagnosis of CSA, the patient had a history of cerebrovascular disease caused by sumo training. The relationship between cerebrovascular disease and CSA was also examined. There are few reports of CSA associated with obesity, and this case is unique in that it provides grounds for denying the influence of cerebrovascular disease.

Patients and Methods

Case presentation

A Japanese boy aged 8 yr and 6 mo complained of headaches after sumo training. One week later, the patient visited a primary clinic with headache, nausea, and vomiting and was treated symptomatically. Two weeks later, the patient was taken to the emergency department because of an inability to sit and stand, accompanied by a tilt to the right side of the body. Computed tomography (CT) and magnetic resonance (MR) imaging (MRI) (**Fig. 1A**) revealed a right cerebellar infarction, and edaravone was administered. Upon admission, there were no coagulation abnormalities, arrhythmias on electrocardiography, or thromboses on echocardiography. Anticoagulation therapy with heparin was also administered because no infarction expansion or bleeding was observed in the follow-up CT.

Sixteen days after onset, the patient was transferred to our hospital to investigate the cause of cerebellar infarction. Upon admission, the patient was 134 cm tall and weighed 66 kg, resulting in a body mass index (BMI) of 36.8 kg/m^2, which fell within the 99.7 percentile. The patient presented with right eyelid ptosis, myosis, and facial sensory disturbances. The finger-to-nose, pronation, supination, and heel-to-knee test results were poor on the right side. There was no evidence of motor paralysis. Enhanced cranial CT and MR angiography (**Fig. 1B**) revealed a defect in the visualization of the right vertebral artery. Although the artery dissection was unclear, the patient was diagnosed with traumatic vertebral artery dissection, cerebellar infarction, and lateral medullary syndrome based on the medical history. The symptoms gradually improved with rehabilitation, and the patient was discharged without any sequelae after 16 days of hospitalization.

Because sumo training was prohibited owing to the risk of recurrence, exercise frequency decreased leading to worsening of obesity. Therefore, lifestyle and nutritional guidances were provided, and the patient was followed up at the Department of Endocrinology and Metabolism at the age of 10 yr and 2 mo. Family history revealed that the patients' older brother and mother were obese, with mother having hypertension, hyperuricemia, impaired glucose tolerance, and hip osteoarthritis. Hypothyroidism and Cushing's syndrome were ruled out, and lifestyle-related diseases, such as hyperuricemia, hypertriglyceridemia, hypertension, fatty liver, and severe insulin resistance, were observed. However, the obesity of the patient did not improve, and the patient had to be hospitalized for obesity management at the age of 14 yr and 6 mo. At the time of admission, the patient was 166.3 cm tall, weighed 96.1 kg, had a body mass index of 34.7 kg/m^2, and a waist circumference of 100 cm. A diet of 1,800 kcal/d and exercise therapy were administered, resulting in a weight loss of 5.5 kg over 4 weeks.

Ethical considerations

Written informed consent was obtained from the patient's parent to protect their personal information and privacy.

Results

Polysomnography recorded by the Alice 6 LDx Diagnostic Sleep System (Royal Philips, Amsterdam, Netherlands) during hospitalization revealed severe sleep apnea syndrome with an apnea-hypopnea index of 41.4 per hour and a central apnea index (CAI) of 8.9 per hour (obstructive apnea index 1.0, mixed apnea index 0.6, and hypopnea index 31.0) (**Fig. 2**). Head MRI was performed again. Although old changes in the cerebellar infarction persisted, no new brainstem or cerebellar infarcts were observed (**Figs. 1C, 1D**). Continuous positive airway pressure (CPAP) therapy was considered; however, consent was not obtained. We continued to monitor the patient's weight on an outpatient basis as part of a weight control program.

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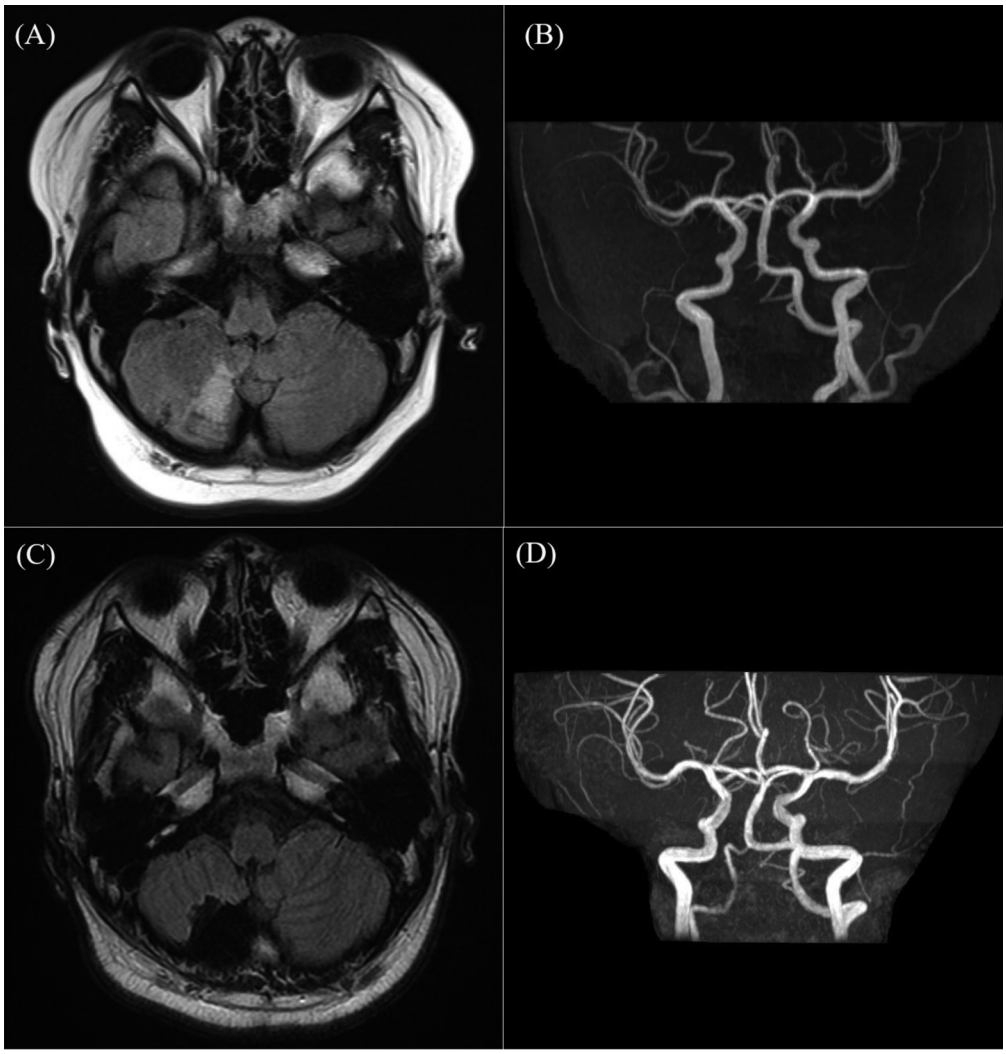

Fig. 1. Magnetic resonance (MR) imaging (MRI) of the head of the patient. (A) and (B) are MRIs at first admission to our hospital at 8 years of age. (A) Fluid-attenuated inversion recovery image of axial section at the cerebellar level reveals right cerebellar infarction due to traumatic right vertebral artery dissection. (B) The right vertebral artery is not visualized on MR angiography. (C) and (D) are MRIs at 14 yr old.

Discussion

Here, we report a case of CSA associated with severe obesity. This finding highlights the importance of considering CSA and not just OSA in patients with severe obesity. The main sleep-disordered breathing pattern in this patient was hypopnea, with a hypopnea index of 31.0 per hour. These respiratory patterns exhibited a CSA-like pattern, characterized by a lack of thoracic and abdominal movements during hypopnea. Additionally, the frequency of apneas meeting the CSA criteria was higher, with a CAI of 8.9 per hour, compared with an obstructive apnea index (OAI) of 1.0. Based on these findings, we concluded that CSA was more significant than OSA in our patient.

Although obesity is more commonly associated with OSA, its link with CSA has also been deduced (3, 5). Mechanistically, obesity may lead to suppression of the respiratory center through upper airway mechanoreceptor stimulation due to pharyngeal collapse and reduction of the oxygen reserve due to reduced thoracic volume (5). However, conflicting results have been reported, with the mean CAI being significantly lower in obese children than in non-obese children. Obesity is associated with increased leptin levels, which have been implicated in preventing respiratory depression by increasing CO2 chemosensitivity during sleep in obese children (6). We had no data on the leptin levels in this patient; therefore, we could not discuss the relationship between leptin levels and CSA. However, it is assumed that the leptin level in this patient was high, which is inconsistent with the increased CAI, given that leptin acts to prevent respiratory depression. Thus, the effects of leptin on the respiratory center require further investigation, and the effects of obesity on the CSA remain unclear.

Thoracic and abdominal movements during polysomnography are prone to artifacts in patients with obesity; thus, central apnea in such patients must be interpreted cautiously. Increased abdominal fat,

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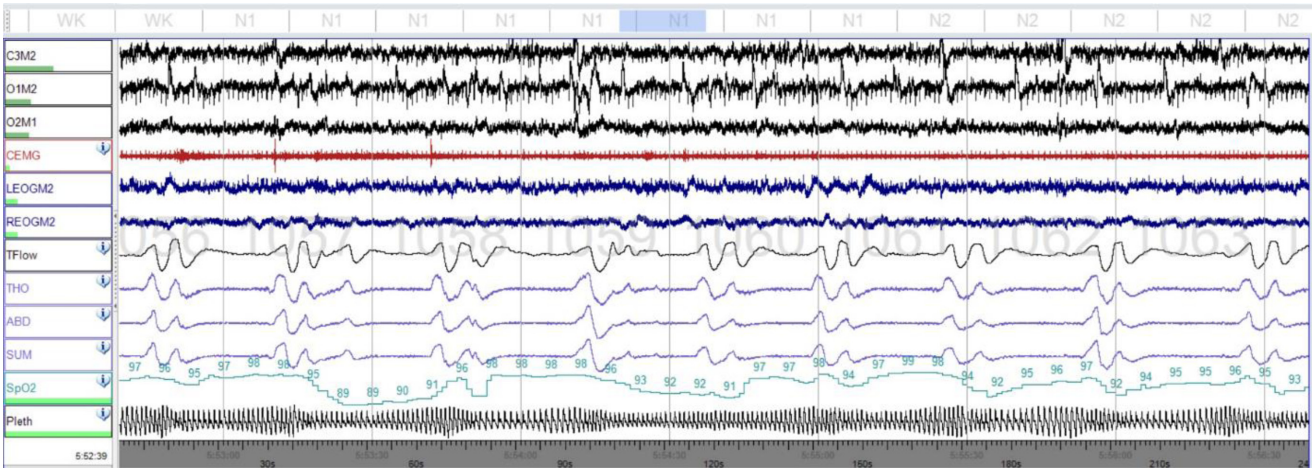

Fig. 2. Central sleep apnea pattern on polysomnography. A central sleep apnea pattern can be observed, with a periodic cessation of the thoracic and abdominal movements lasting approximately 20 sec with an SpO_2 drop of 3% or more from baseline.

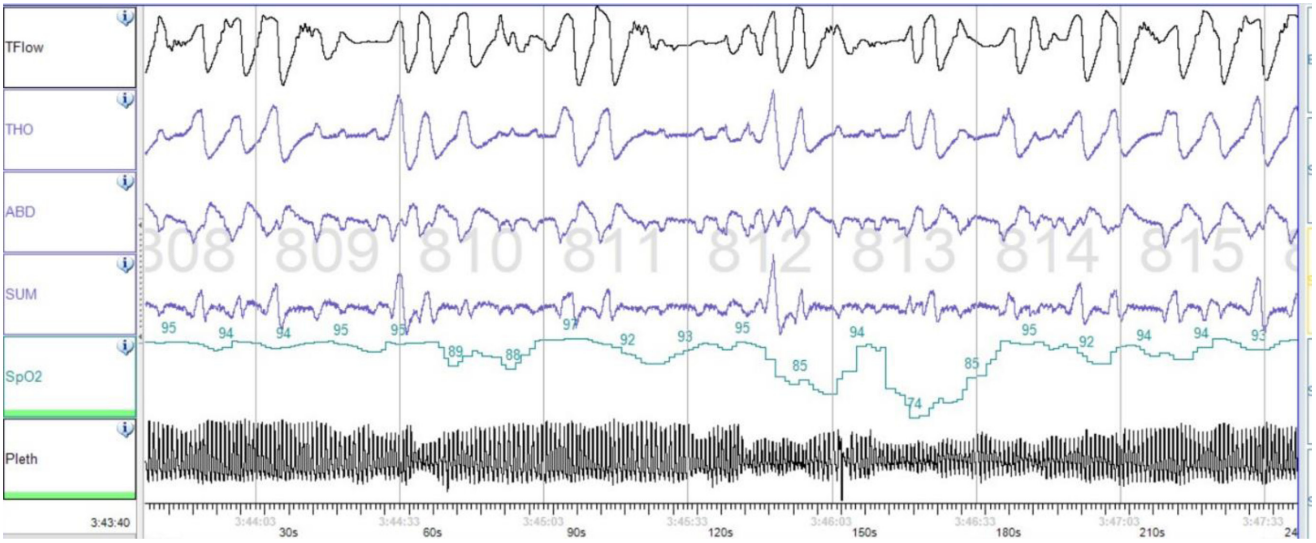

Fig. 3. Obstructive sleep apnea pattern on PSG. An obstructive sleep apnea pattern with the attenuation of thoracic and abdomen movement signals can be observed. This pattern fits the criteria for obstructive apnea as per the AASM Manual for Scoring Sleep, 2020.

impaired muscle function, and respiratory drive may impair the ability of the chest wall to move in response to upper airway obstruction. Therefore, obstructive sleep events may be misdiagnosed as CSA (7). In our patient, we observed OSA patterns (**Fig. 3**), and although thoracic and abdominal movements were not flat, they were attenuated. Careful observation was warranted, as the pattern was clearly different from the CSA pattern (**Fig. 2**). Owing to these differences in the findings, we could distinguish between CSA and OSA in this patient. However, it may not be possible to distinguish all OSA from CSA events. Moreover, differentiating OSA from CSA using the current polysomnography monitoring in patients with obesity and with attenuated thoracic and abdominal belt signals is challenging, which is a limitation of the present study. Polysomnography results of patients with obesity must be interpreted with caution.

The patient had developed lateral medullary syndrome due to head trauma at 8 years of age. As the respiratory center is located in the medulla oblongata, CSA may be a sequela of lateral medullary syndrome or a new intracranial lesion. MRI of the head was negative for new lesions. In addition, sleep apnea syndrome, especially CSA, after cerebrovascular disease, including lateral medullary syndrome, is frequent in the acute phase (2–6% in lateral medullary syndrome), and CSA decreases in the subacute and stable phases (8, 9). Further, CSA induced by cerebrovascular diseases increases in the acute phase but decreases in 3–6 mo (10, 11, 12). Nevertheless, conclusive reports are lacking, and it remains unclear whether CSA is caused by a sequela of cerebrovascular diseases in the chronic phase. However, there was no record of significant desaturation during sleep in the acute phase of lateral medullary syndrome

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at the time of initial admission at 8 yr of age. Subsequent MRI at 14 yr of age revealed no new lesions, and there was no evidence of sleep apnea syndrome during the acute phase of the lateral medullary syndrome. Based on these findings, we concluded that the patient had CSA secondary to obesity.

The weight of the patient had increased significantly compared to that at 8 yr old, while the BMI remained almost the same. Hypopituitarism and hypothalamic dysfunction may occur after several years following head trauma, potentially leading to obesity. However, the lesion was localized only in the blood supply area of the vertebrobasilar artery, and no lesions were found in the pituitary gland or hypothalamus on head MRI performed either at 8 or 14 yr of age. Thyroid function was tested at 13 yr of age and indicated euthyroidism. Additionally, no rapid decline in growth rate, suppressed progression of puberty, electrolyte abnormalities, or hypoglycemia was observed during the course. Thus, we concluded that obesity caused by hypopituitarism or hypothalamic dysfunction was unlikely. We would like to retrospectively confirm that CAI reduces after obesity improved. However, improving obesity was challenging because the patient's elder brother and mother, who shared the same dietary habits, were also obese. Nevertheless, the patients' weight decreased by 4 kg within five months of entering high school. This change could be attributed to the patients' steady school attendance, which was problematic during junior high school, and the family's decision to refrain from eating out. We believe that adjusting to the living environment and administering dietary therapy are effective in improving obesity. Nevertheless, the patient's BMI remained above 30 kg/m^2, and polysomnography was not performed because of insufficient weight loss. Therefore, assessing whether obesity is the cause of central apnea is difficult. In addition, consent for CPAP therapy was not obtained, and only follow-up observations continued. If polysomnography can be performed during CPAP therapy, the mechanism of central apnea syndrome onset due to obesity may be examined; however, this could not be evaluated.

Conclusion

Attention should be paid to both CSA and OSA in children with severe obesity. Because sufficient time has passed since the cerebrovascular accident in this case, it was considered to have little role in the development of apnea. Several studies have suggested a correlation between obesity and CSA. However, the mechanisms by which obesity causes CSA remain unclear, and further studies are required.

Conflict of interests: The authors declare no conflicts of interest.

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