Case Report

Successful application of high-flow nasal cannula in a patient with postoperative respiratory disturbance after bilateral sagittal split ramus osteotomy surgery
- A case report -

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Bilateral sagittal split ramus osteotomy (BSSRO) is generally indicated for mandibular setback, to improve occlusion, masticatory function, and aesthetics by altering the mandibular position. However, BSSRO narrows the pharyngeal airway and increases airway resistance, resulting in postoperative respiratory disturbances during emergence from anesthesia. Oxygen delivery system via high-flow nasal cannula (HFNC) has been known to improve airway patency and oxygenation via low-level positive pressure as well as reduce the respiratory load. We report a case of postoperative respiratory disturbance, following a large mandibular setback, despite nasotracheal extubation in the fully awake patient. Respiratory disturbance was successfully controlled after oxygen delivery via HFNC until self-respiration was completely restored. Therefore, the use of HFNC may facilitate the control of postoperative respiratory disturbances induced by anatomical changes in upper airway after BSSRO surgery.

Key Words: Adult respiratory distress syndrome, Dyspnea, High-flow nasal cannula, Orthognathic surgical procedures, Oxygen inhalation therapy.

Bilateral sagittal split ramus osteotomy (BSSRO), a type of mandibular setback surgery, is generally indicated for mandibular setback, resulting in improved occlusion, masticatory function, and aesthetic outcomes by changing the mandibular position [1]. However, BSSRO surgery narrows the pharyngeal airway and increases airway resistance, which can induce respiratory disturbances such as obstructive sleep apnea syndrome (OSAS) [1,2]. Therefore, anesthesiologists, as well as surgeons, should consider the possibility of postoperative respiratory disturbance in patients diagnosed with a large mandibular setback [1]. The oxygen delivery system via high-flow nasal cannula (HFNC) has been introduced in many areas of anesthesia. The system improves airway pa-

tency and oxygenation through low-level positive pressure as well as reduces the respiratory load, in hypercapnic and hypoxemic respiratory failures, and obstructive sleep apnea [3,4]. Here, we report a case of successful use of HFNC in a patient diagnosed with respiratory disturbance during emergence from BSSRO surgery.

CASE REPORT

A 27-year-old male (height: 175 cm, weight: 92 kg) was scheduled for BSSRO surgery to rectify mandible prognathism (Fig. 1A). The patient was a non-smoke with any history of medical illness except obesity and snoring. However,
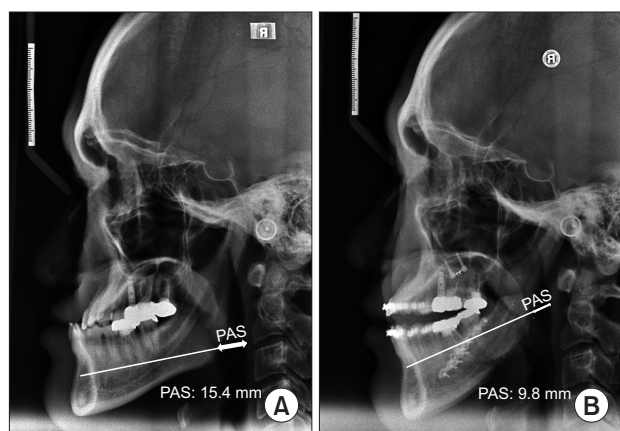
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Fig. 1. Dental X-ray shows anatomical changes in the upper airway before (A) and after (B) bilateral sagittal split ramus osteotomy surgery. Cephalometric analysis of the posterior airway space (PAS) in the mandibular plane shows a decreased diameter (9.8 mm) compared with the preoperative diameter (15.4 mm).

he was not evaluated for OSAS before surgery. Preoperative laboratory tests showed no abnormal results. Physical examination was unremarkable. Preoperative anesthetic airway evaluation yielded the following results: Mallampati class 3; thyromental distance, 6 cm; mouth opening, 4 cm; and posterior airway space (PAS) diameter in the mandibular plane, 15.4 mm.

He was pre-medicated with intramuscular midazolam 0.04 mg/kg 30 minutes before the induction of anesthesia and was transferred to the operating room (OR). He was monitored via an electrocardiogram, non-invasive blood pressure measurement, pulse oximetry, esophageal temperature, neuromuscular monitor, and bispectral index (BIS). Anesthesia was induced and maintained by total intravenous anesthesia using propofol and sufentanil to maintain the BIS score within 40 to 60. Manual mask ventilation with facemask was done before neuromuscular blockade, without any limitations. After adequate neuromuscular blockade by rocuronium bromide (0.6 mg/kg), nasotracheal intubation (internal diameter: 7.5 mm) was performed in the sniffing position. Mechanical ventilation (volume control mode) was used with 50% oxygen-air mixture, with a tidal volume (TV) of 8–10 ml/kg of ideal body weight and adjusted to maintain the peak inspiratory pressure (PIP) below 30 cmH$_2$O during anesthesia. After the nasotracheal intubation, the graph of end-tidal carbon dioxide (ETCO$_2$) showed an increased slope of phase III and a slight obstructive pattern was suspected. The TV was

maintained between 600–700 ml with respiratory rates 12 breaths per minute, and a PIP of 23 mmHg. No changes were detected after nasotracheal tube suction or administration of nebulized salbutamol. However, no challenges were detected with oxygenation and the levels of ETCO$_2$ were maintained below 45 mmHg throughout the surgery. Thus, we believed that the changes associated with ETCO$_2$ graph were physiological changes induced by obesity.

BSSRO for mandibular setback was performed followed by posterior repositioning of the mandible (right, 22.5 mm; left, 24.0 mm; transverse shift to right side 3.0 mm). The surgery ended after 150 minutes, and the patient's vital signs were maintained within normal limits. Administered fluid and estimated blood losses were 1,500 ml and 700 ml, respectively. The patient's mental state was clear after discontinuing propofol and sufentanil. Naloxone 0.15 mg was administered to stimulate respiration. The patient recovered from neuromuscular blockade (train-of-four > 99%) following treatment with 200 mg of sugammadex, and spontaneous respiration was maintained (TV > 500 ml). He was fully awake and responded well, and extubation was done.

However, the patient could not breathe well immediately after extubation. He exhibited difficulty during inhalation and stridor was heard. Nasal cannulation followed by manual mask ventilation with two-handed jaw-thrust maneuver was performed to maintain the airway without damaging the operated jaw. However, TV during mask ventilation was only 50–150 ml and ETCO$_2$ was increased more than 55 mmHg. The patient complained of choking and became irritable. Despite manual ventilation, sustained dyspnea was developed, and pulse oxygen saturation (SpO$_2$) decreased to 90%. Manual mask ventilation with 10 cmH$_2$O of positive airway pressure (PEEP) increased TV to more than 300 ml, but the effects were temporary, and dyspnea continued during spontaneous ventilation. Salbutamol nebulization had no effect. We suspected that anatomical changes of the upper airway triggered the respiratory disturbance. Re-intubation was performed with Glidescope® videolaryngoscope (Saturn Biomedical Systems Inc., Canada) under mild sedation with propofol because of the expected airway challenges. Videolaryngoscopy revealed small oral cavity, with mild laryngeal edema. After reintubation, ETCO$_2$ decreased to 45 mmHg and SpO$_2$ increased to 95%.

We discussed with the surgeon and confirmed the narrow

airway after surgery. Reoperation was needed for correct the posterior repositioning of the mandible. The patient complained deeply about the inconvenience of intubation and failed to cooperate well. Therefore, we delivered a humidified air-oxygen mixture via HFNC to provide PEEP and increase end-expiratory lung volume [4]. After advising the patient appropriately, we used HFNC (Airvo 2, Fisher & Paykel Healthcare, New Zealand). After careful extubation, the nasal cannula was used, and supplemental oxygen was initiated with an airflow rate of 10 L/min. The flow rate was increased according to the patient's breathing difficulty. An airflow rate of 15 to 20 L/min was comfortable and oxygen saturation was maintained above 99%. Respiratory disturbance was successfully controlled with HFNC, and the patient was transferred to the recovery room (RR). Arterial blood gas analysis at the RR yielded the following findings: pH, 7.364; $PaCO_2$, 47.5 mmHg; and PaO_2 233.2 mmHg. We suggested careful reoperation because HFNC was used to eliminate respiratory disturbance and maintain oxygenation of the patient very effectively.

He was transferred to the OR for emergent reoperation on the next day. He was in good condition under HFNC. Anesthesia was induced and maintained using the same maneuver. The correction of posterior repositioning of the mandible (right: 12.5 mm, left: 14.0 mm) reduced the anatomical changes of the upper airway (Fig. 1B). Surgery ended after 60 minutes, and emergence was smooth. Adequate recovery from neuromuscular blockade was followed by careful extubation without eliciting any complaints of respiratory disturbance. The TV was maintained more than 500 ml during manual mask ventilation. No dyspnea was detected, and the patient was sustained adequately with oxygen supplied via nasal cannula. No respiratory disturbance was detected and the patient was discharged after 6 days.

DISCUSSION

Complications post-BSSRO surgery including hemorrhage, airway obstruction, mechanical problems, nerve injury, infection, and foreign body presence are well known. Life-threatening complications such as airway obstruction may require reoperation even though most of the respiratory distress was reduced after the early release of mandibular fixation. Prevention of potential postoperative complications requires evaluation of possible risks of complication, and

awareness of significant reduction in the pharyngeal airway space after mandibular setback surgery resulting in respiratory complications [5]. Anteroposterior and cross-sectional area dimensions of the pharyngeal airway space are significantly decreased at the level of the soft palate and tongue base in computerized tomography images after mandibular setback surgery [6]. Yajima et al. [1] reported that mandibular setback surgery is associated with a significant decrease in the minimum cross-sectional area as well as pressure in the pharyngeal airway space. The pressure in pharyngeal airway space decreased greatly when its minimum sectional area was less than 1 cm^2. This decrease leads to further narrowing of pharyngeal airway space, and results ultimately in iatrogenic obstructive sleep apnea [7]. Postoperative OSAS occurs in patients experiencing mandibular setback greater than 5 mm [2,8]. Therefore, only a small amount of mandibular setback is recommended for BSSRO in patients with high preoperative Mallampati scores [9]. If patients express risk factors such as obesity, sleep-disordered breathing, and undergo a large mandibular setback of more than 5 mm, a combination surgery for mandibular setback and maxillary advancement is recommended to prevent the development of OSAS [8].

In the current case, the patient was diagnosed with obesity, preoperative snoring, and a large mandibular setback. Especially, the PAS diameter at the mandibular plane was 15.4 mm (normal range: 12.54 ± 2.78, Fig. 1A) based on the dental X-ray, which showed significant clinical correlation with anatomic parameters of patients with OSAS [10]. However, the PAS diameter significantly decreased to 9.8 mm after the second operation (Fig. 1B), suggesting that PAS diameter after the first operation was similar to the average PAS diameter of the patient with OSAS (7.16 ± 4.01). Although we failed to obtain a dental X-ray after the first surgery, it was expected that the PAS diameter after the first surgery was significantly smaller, especially in the supine position. Consequently, anatomical changes of the upper airway were suspected as the cause of respiratory disturbance after the extubation.

To control postoperative respiratory disturbance, manual mask ventilation with PEEP may be used during emergence from anesthesia. Continuous positive airway pressure (CPAP), or oxygen delivery system via HFNC is recommended to relieve upper airway obstruction by stabilizing the hypotonic upper airway dilators, by monitoring the respiratory rate and capnography [11]. Especially, the oxygen delivery

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system via HFNC improves the overall performance of the anesthesiologist in a difficult scenario because it improves airway patency via low-level positive pressure, improves oxygenation, and reduces the respiratory load [3]. In addition, HFNC facilitates emergency airway management of the patient with difficult airway, for instance, in patients with a history of or indications for maxillofiacial surgery as it delivers continuous high-flow humidified oxygen during intubation [12].

In this case, the patient suffered from sustained respiratory distress after nasotracheal extubation in fully awake state after obtaining Train-of-four ratio of above 0.9. First, we applied manual mask ventilation with PEEP 10 cmH$_2$O, without successful resolution. We hypothesized that the upper airway anatomical changes in patients exposed to BSSRO during emergence from anesthesia may be similar to those of patients with OSAS undergoing surgery under sedation. Wong et al. [13] suggested that high-flow nasal oxygen therapy led to satisfactory oxygenation, maintained the partial carbon dioxide pressure within a reasonable range in a patient with moderate OSAS treated with surgery under deep sedation. Moreover, the present case was morbidly obese, with a reduced functional residual capacity and increased risk of atelectasis, and ventilation-perfusion mismatch leading to hypoxia [14]. Thus, HFNC application facilitates effective correction or prevention of hypoxemia. Therefore, HFNC was used successfully to control the respiratory disturbances until full recovery of self-respiration.

The use of HFNC in patients with postoperative respiratory disturbance after BSSRO surgery results in the following physiological advantages [4,13,15]:
- It reduces airway collapse by PEEP and leads to improved oxygenation and ventilation. Application of PEEP effectively reduces airway collapse and atelectasis, and increases end-expiratory lung volume (EELV). Moreover, HFNC is more effective in increasing airway pressure facemask. Thus, the current use of HFNC improves airway patency by reducing upper airway resistance and preventing airway collapse due to anatomical changes induced by BSSRO surgery.
- HFNC increases EELV due to the CPAP effect resulting in a decreased respiratory workload. It is also effective for carbon dioxide washout of anatomical dead space. Thus, minute alveolar ventilation remains unchanged despite a

decrease in respiratory rate during HFNC, which reduces the respiratory workload.
- HFNC provides heat and humidification to reduce mucosal drying and triggers bronchoconstriction. Dry cold gas induces mucosal drying, mucociliary impairment, and atelectasis. It also triggers bronchoconstriction and reduces respiratory compliance. Thus, the application of HFNC may facilitate respiratory compliance, at least partially.
- HFNC may provide greater patient comfort than nasotracheal intubation or CPAP, leading to better compliance and outcomes.

In conclusion, anesthesiologists should expect respiratory disturbances after mandibular setback surgery exceeding 5 mm. Preoperative determination of the degree of setback using radiological tools during surgical planning is important to prevent postoperative respiratory disturbance during emergence from anesthesia. Furthermore, the application of HFNC may aid in the control of postoperative respiratory disturbance triggered by anatomical changes of upper airway after BSSRO surgery.

REFERENCES

1. Yajima Y, Oshima M, Iwai T, Kitajima H, Omura S, Tohnai I. Computational fluid dynamics study of the pharyngeal airway space before and after mandibular setback surgery in patients with mandibular prognathism. Int J Oral Maxillofac Surg 2017; 46: 839-44.
2. Riley RW, Powell NB, Guilleminault C, Ware W. Obstructive sleep apnea syndrome following surgery for mandibular prognathism. J Oral Maxillofac Surg 1987; 45: 450-2.
3. Keshishyan S, Harris K, Mohan A, Patil M. Bronchoscopic management of central airway obstruction secondary to rheumatoid arthritis. J Bronchology Interv Pulmonol 2018; 25: e9-11.
4. Nishimura M. High-flow nasal cannula oxygen therapy in adults: physiological benefits, indication, clinical benefits, and adverse effects. Respir care 2016; 61: 529-41.
5. Mattos CT, Vilani GN, Sant'Anna EF, Ruellas AC, Maia LC. Effects of orthognathic surgery on oropharyngeal airway: a meta-analysis. Int J Oral Maxillofac Surg 2011; 40: 1347-56.
6. Degerliyurt K, Ueki K, Hashiba Y, Marukawa K, Simsek B, Okabe K, et al. The effect of mandibular setback or two-jaws surgery on pharyngeal airway among different genders. Int J Oral Maxillofac Surg 2009; 38: 647-52.
7. Degerliyurt K, Ueki K, Hashiba Y, Marukawa K, Nakagawa K,

Yamamoto E. A comparative CT evaluation of pharyngeal airway changes in class III patients receiving bimaxillary surgery or mandibular setback surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 105: 495-502.

8. Demetriades N, Chang DJ, Laskarides C, Papageorge M. Effects of mandibular retropositioning, with or without maxillary advancement, on the oro-naso-pharyngeal airway and development of sleep-related breathing disorders. J Oral Maxillofac Surg 2010; 68: 2431-6.

9. Choi SK, Yoon JE, Cho JW, Kim JW, Kim SJ, Kim MR. Changes of the airway space and the position of hyoid bone after mandibular set back surgery using bilateral sagittal split ramus osteotomy technique. Maxillofac Plast Reconstr Surg 2014; 36: 185-91.

10. Barrera JE, Pau CY, Forest VI, Holbrook AB, Popelka GR. Anatomic measures of upper airway structures in obstructive sleep apnea. World J Otorhinolaryngol Head Neck Surg 2017; 3: 85-91.

11. Subramani Y, Singh M, Wong J, Kushida CA, Malhotra A, Chung F. Understanding phenotypes of obstructive sleep apnea: applications in anesthesia, surgery, and perioperative medicine. Anesth Analg 2017; 124: 179-91.

12. Patel A, Nouraei SA. Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways. Anaesthesia 2015; 70: 323-9.

13. Wong JW, Kong AH, Lam SY, Woo PY. High-flow nasal oxygen in patient with obstructive sleep apnea undergoing awake craniotomy: a case report. A A Case Rep 2017; 9: 353-6.

14. Domi R, Laho H. Anesthetic challenges in the obese patient. J Anesth 2012; 26: 758-65.

15. Onodera Y, Akimoto R, Suzuki H, Masaki N, Kawamae K. A high-flow nasal cannula system set at relatively low flow effectively washes out CO_2 from the anatomical dead space of a respiratory-system model. Korean J Anesthesiol 2017; 70: 105-6.

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