Combination therapy of continuous nebulization and high-flow nasal cannula for severe congenital tracheal stenosis

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Abstract

We submit this manuscript without an abstract because it is a Letter to the Editor.

Title Page

Title

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Continuous nebulization under HFNC for CTS

Main Text

To the Editor,

Children with congenital tracheal stenosis (CTS) easily develop refractory respiratory failure[1] and are frequently treated with nebulized epinephrine. This type of non-invasive respiratory support is a better therapy for CTS than tracheal intubation, since it reduces potential harm to the stenotic airway through direct mechanical stress and loss of spontaneous respiration. One such treatment is high-flow nasal cannula (HFNC), which has been used for various types of respiratory failure in children. While combined therapy of epinephrine nebulization under HFNC would theoretically be useful for dyspnea in patients with CTS, little information about the therapy is available. Here, we describe the successful management of acute respiratory failure with continuous epinephrine nebulization under HFNC in a child with CTS.

The patient was a 1-year-and-7-month-old boy with Goldenhar syndrome and congenital tracheal malformation, which was usually managed by oxygen therapy at home (0.25–0.5 L/min). He also had a surgical history of congenital esophageal atresia (Gross type C) and a small, untreated atrial septum defect. He presented at the emergency department of our hospital with fever, increased respiratory secretions, and increased oxygen demand. He received conventional oxygen therapy (maximum of 4 L/min), albuterol nebulization under a common nebulizer, and antibiotics at the general ward. Despite nine hours of treatment, his respiratory symptoms deteriorated, and he was transferred to the pediatric intensive care unit (PICU) for advanced respiratory support.

The patient had severe respiratory effort, stridor, and paradoxically slow respiratory rate with prolonged expiration and inspiration. Arterial blood gas analysis showed severe hypercarbia ($PaCO_2$ 82.4 mmHg) and mild oxygenation disorder (PaO_2 163 mmHg, $F_IO_20.6$). A chest radiograph showed infiltration of the right upper lung field. His previous chest computed tomography image had demonstrated a bridging bronchus: a tracheal bronchus and a narrowed trachea between the inlet of the tracheal bronchus and the carina (Figure 1).

Immediately after the PICU admission, continuous epinephrine nebulization using a vibrating-mesh nebulizer under HFNC was begun (nebulizer: Aerogen solo, Aerogen Ltd., Galway, Ireland, HFNC: Optiflow Jr, Fisher & Paykel Healthcare, Auckland, New Zealand). The nebulizer was installed directly downstream of the humidifier in the HFNC circuit (3 L/kg/min), and two mL of epinephrine (1 mg/mL) diluted with 50 mL of saline were dripped into the nebulizer chamber at a rate of 25 mL/h (corresponding to 0.1 mg/kg/h). As an adjunct therapy, intravenous dexamethasone (0.15 mg/kg/dose every six hours) was also administered, and the patient was sedated with dexmedetomidine, phenobarbital, and chloral hydrate. Immediately after the initiation of the combined respiratory therapy, the patient's respiratory effort decreased, and his hypercarbia improved to approximately 60 mmHg within three hours. His heart rate and blood pressure normalized, and neither hypokalemia nor hyperglycemia was observed after the therapy. HFNC and continuous epinephrine nebulization continued for three days, after which they were replaced with conventional nasal cannula oxygen and intermittent epinephrine nebulization. As a result, tracheal intubation was avoided, and the patient returned to the general ward on the fourth day in the PICU.

Respiratory management for CTS is a challenging task because, even in mild cases, the disease can cause refractory respiratory distress. Typical invasive mechanical ventilation, such as tracheal intubation, carries an additional risk of injuring the stenotic lesion and causing further stenosis, especially when the tracheal tube must pass through the lesion to maintain sufficient ventilation. This can cause prolonged intubation, which is related to poor prognosis, since surgical techniques for CTS are difficult[1]. Similarly, conventional non-invasive positive pressure ventilation, which is widely used in adults, is often unsuitable for severe dyspnea in children, because it requires an uncomfortable mask. The mask often causes additional agitation or respiratory efforts, resulting in further stenosis due to the Venturi effect. In contrast, HFNC could provide effective gas fractions in the lung by purging the dead space of the upper airway more comfortably. Thus, HFNC could be an ideal respiratory support for patients with CTS.

Epinephrine nebulization is difficult to perform on children with respiratory distress, since the effect of

nebulization greatly depends on breathing pattern and compliance for the treatment. For a conventional nebulization with a mouthpiece or a mask, the reported dose varies from 0.5–5.0 mg of epinephrine regardless of body weight[2], which suggests insufficient reliability of conventional nebulization in our case. HFNC could provide more reliable nebulization though the cannula without stopping the respiratory support. This is true even in case of continuous nebulization, although a larger dose is required because of the lower concentration of nebulized epinephrine by the high purging flow of HFNC, which would result in an insufficient therapeutic range for treatment[3].

Continuous nebulization of large doses of bronchodilators or epinephrine is occasionally used in cases of severe respiratory failure[4,5]. Because of its short biological half-life (approximately 2 min), epinephrine levels in the blood will peak soon after continuous nebulization begins. At this point, side effects of epinephrine may appear, including tachycardia, hypertension, hypokalemia, and/or hyperglycemia. Our patient, however, experienced no side effects and demonstrated consistent improvement of severe dyspnea and tachycardia with continuous nebulization of epinephrine by HFNC (1.0 mg/hour: 0.1 mg/kg/hour). Therefore, a large dose of epinephrine, along with close observation for side effects, may be effective for treating severe respiratory failure in refractory cases of intermittent nebulization.

In conclusion, continuous epinephrine nebulization under HFNC has significant potential for the treatment of acute respiratory failure in a child with CTS. Further studies are required to establish a correct method and dosage.

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Disclosure

The authors declare no conflict of interest.

Author contribution

HT clinically performed patient's treatment, designed the report, and wrote the manuscript. KU and KH clinically performed patient's treatment and made significant comments on the manuscript. SK and MM made significant comments on the manuscript. HM (correspondence) supervised writing the report and finally approved the manuscript for the submission. All authors have read and approved the final manuscript.

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