Heliox via High Flow Nasal Cannula to treat Coronavirus-related respiratory infection with airflow obstruction

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Background

Heliox, a helium-oxygen gas mixture, has been used for many decades to treat obstructive pulmonary disease. The lower density and higher viscosity of Heliox relative to nitrogen/oxygen mixtures can significantly reduce airway resistance (Raw) when airflow obstruction (UAO) is present and air flow is turbulent. Clinical uses of Heliox include stabilization of patients with upper airflow obstruction as well as reducing work of breathing and gas trapping in asthma and chronic obstructive pulmonary disease. Heliox may also enhance bronchodilating effects of beta agonists given by inhalation. Coronavirus infection in humans can present as severe acute bronchiolitis or pneumonia, and can produce airflow obstruction sufficient to cause respiratory failure. We describe a case of an infant with severe airflow obstruction due to Coronavirus OCA43 infection treated with Heliox to avoid intubation.

The Intervention

The primary gas source consisted of Heliox; 80% He and 20% O2 added to a secondary oxygen gas source through a gas sample tee (Figure 1)

The algorithm for setting HFNC gas flow-rates was as follows; First we calculated the estimated expired minute volume (EMV) = (VTE)*RR. In this patient, estimated VTE = 35mL and RR = 70, leading to an EMV = 2.4L. We then set the total gas flow rate (heliox +O2) at 3.5 to 4 times the estimated EMV. In this patient, 2.4 L x 3.5 = a target gas flow of at least 8 L/min.

Heliox gas from a cylinder containing 80% helium and 20% O2 was brought to the bedside. The inspired oxygen fraction (FiO2) was verified via O2 analyzer as the gases entered the humidifier chamber. The conventional O2 analyzer was not affected by the 80/20 Heliox gas mixture.

Case Report

A 10 month old Hispanic male was intubated in the field for seizures and transported to the Comer emergency department and then to the PICU for ventilator management. His respiratory swab was positive for Coronavirus OCA43. He improved sufficiently to be extubated three days later and was placed on High Flow Nasal Cannula (BC 3780) Pediatric Oxygen Therapy Nasal Cannula® [HFNC] (Fisher & Paykel Healthcare Ltd, Auckland, New Zealand) at 5 L/min and 100% FiO2.

Despite treatment with beta-2 agonists and chest physical therapy, he remained in respiratory distress after extubation with nasal flaring and +5 chest retractions. To forestall re-intubation and manage acute respiratory distress, Heliox was administered via HFNC.

Before Heliox initiation, the patient was breathing at 60 to 70 breaths/min with +5 chest retractions and nasal flaring. His SaO2 was 94% on 100% HFNC at 5 L/min, with intermittent desaturations to 84%. One minute after initiation, the patient’s RR had fallen to 31-36 breaths/min, and subcostal retractions had improved to +3. Breath sounds remained coarse but the patient appeared to be improved and was resting more comfortably. The patient SaO2 remained in the lower 90s. He was titrated gradually to Heliox 60/40.

Adjunct aerosolized Pulmicort® (0.25mg) was co-administered via an Aerogen® nebulizer (Galway Ireland) ANEB device with Heliox-augmented HFNC. to reduce bronchial inflammation. No respiratory deterioration was noted during Pulmicort administration. The patient remained on 60/40 Heliox overnight. He received one Racemic Epinephrine treatment (2.25%) via with no change in WOB. The next morning he appeared to be resting comfortably with no further episodes of SaO2 desaturation. On day 3, Heliox was discontinued and he was discharged from PICU, transferred to the floor for continued treatment and eventually discharged home.

Discussion

Heliox use to treat airway obstruction was first reported in 1934 by Alvin Barach, who observed that breathing Heliox appeared to relieve dyspnea in adults and children with asthma and upper airway obstruction. In many cases, improvement with Heliox manifested within several minutes and (as in our case) and the patient’s condition reversed when Heliox was discontinued even briefly. The proposed mechanism of Heliox is to decrease resistance to turbulent airflow, which normally occurs between the glottis and the 10th generation airways. During AFO, Raw can increase 30 to 50 cm H2O from baseline. We used the ANEB system to deliver inhaled agents. The ANEB is a micro pump nebulizer that operates without an additional jet flow. The efficacy of the ANEB in conjunction with Heliox has not been investigated.

In conclusion, we report a case of acute viral bronchiolitis with AFO treated with Heliox delivered by HFNC. Clinically, our patient improved after 48 hours of therapy. We believe that a trial of Heliox should be considered when caregivers are confronted with patients with severe acute bronchiolitis AFO.

Figure 1: HFNC configured to deliver a Heliox mixture. O2 is from the wall source and Heliox is "t’d in before the oxygen analyzer/humidifier

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