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Weaning from mechanical ventilation with high flow oxygen therapy via tracheal cannula

Odvajanje od mehaničnega predihavanja z visoko-pretočno terapijo s kisikom po trahealni kanili

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Abstract

Introduction: Application of oxygen at high flows via nasal cannula can be used in patients with hypoxemic respiratory failure and to prevent reintubation. It is well tolerated by the patients and has been associated with lower mortality. However, there is very little data on the use of oxygen at high flows connected to tracheal cannula (HFOTC).

Case presentation: We present two patients in whom weaning from mechanical ventilation was difficult and we decided to use HFOTC for weaning. Weaning from mechanical ventilation with HFOTC was successful in both patients and they tolerated long term (4 and 2 days, respectively) ventilatory support with HFOTC without adverse effects.

Conclusions: HFOTC might be used during weaning from mechanical ventilation, however, more data is needed to determine the optimal use of this treatment option.

Izvleček

Uvod: Visoko-pretočna terapija s kisikom preko nosne kanile se uporablja pri bolnikih s hipoksemično dihalno odpovedjo in tudi zato, da se prepreči potreba po ponovni intubaciji. Bolniki terapijo dobro prenašajo. Povezana je tudi z nižjo stopnjo umrljivosti. Kljub temu pa je v literaturi malo podatkov celo o uporabi visokopretočne terapije s kisikom s kanilo v sapniku (HFOTC).

Predstavitev primera: Prikazana sta dva primera težavnega odvajanja od mehaničnega predihavanja, pri katerih smo se za pomoč pri odvajanju zatekli k HFOTC. Odvajanje je bilo s pomočjo HFOTC v obeh primerih uspešno. Bolnika sta dobro prenašala dolgotrajno uporabo dihalne podpore s HFOTC (4 dni in 2 dneva) brez stranskih učinkov.

Zaključki: HFOTC se lahko uporabi za pomoč pri odvajanju od mehaničnega predihavanja, vendar so potrebne še študije, ki bodo natančno opredelile najprimernejši način uporabe te tehnike.

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1 Introduction

The gradual process of decreasing ventilator support is also known as weaning. We differentiate simple, difficult and prolonged weaning. Prolonged weaning (weaning > 7 days or > 3 attempts) from mechanical ventilation occurs in 20-30% of mechanically ventilated patients and is associated with increased mortality (1-4). As described by Heunks et al., weaning failure is defined as the failure to pass a spontaneous-breathing trial (SBT), during which the practitioner assesses the patient's ability to breath while receiving minimal or no ventilatory support, or the need for reintubation within 48 hours following extubation (1). A number of papers have been published in recent years describing the use of high flow nasal cannulas (HFNC), mainly in patients with hypoxemic respiratory failure (3,5-7). In a study by Frat et al., HFNC therapy was associated with lower intensive care unit (ICU) and 90-day mortality rates compared to oxygen via standard therapy and noninvasive ventilation, with decreased respiratory discomfort and improved dyspnoea in the HFNC arm (6). Application of oxygen at high-flow connected to a tracheal cannula (HFOTC) could potentially provide patients with ventilatory support without patient-ventilator asynchrony, provide humidified and heated gases and enable good control over the fraction of inspired oxygen (FiO_2). We report here on two patients in whom weaning from mechanical ventilation was difficult and in whom HFOTC was successfully used for weaning from mechanical ventilation. All the performed procedures involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.

2 Case reports

The first patient was a 76-year old male with preexistent right-sided spastic hemiplegia after stroke and was admitted to the ICU because of severe hospital-acquired pneumonia. Intubation and mechanical ventilation were required immediately upon admission, and inhalations of nitric oxide and prone positioning were needed to achieve adequate oxygenation. Noradrenaline infusion at around 0.4 mcg/kg/min was used to maintain his mean arterial pressure at around 80-85 mmHg. During the ICU stay he received treatment for a hospital acquired pneumonia (caused by *S. aureus, E. coli, K. variicola, C. freundii*) and a ventilator associated pneumonia (caused by *K. variicola*). Weaning from mechanical ventilation was started on day 5, after tracheotomy was performed, when he required positive end-expiratory pressure (PEEP) 6 cmH_2O, FiO_2 0.32 and a pressure support (PS) of 10 cmH_2O. Multiple SBTs were unsuccessful from day 5 to day 10. On day 10 he required a positive end-expiratory pressure of 8 cmH_2O, FiO_2 0.40 and was without additional pressure support.

Respiratory rate was around 25/min, tidal volume was around 350-400 ml and peripheral oxygen saturation was around 90-95%. We observed frequent double triggering efforts (2 consecutive triggers separated by an expiratory time 50% of the mean inspiratory time), attributed to the patients' agitation and respiratory discomfort. Therefore, to ease the weaning process and as a terminal option, we decided to use HFOTC (Veoflo High Flow Tracheostomy Interface, Flexicare Medical Ltd., UK). When weaning by means of HFOTC the gas flow was set to 30 l/min at FiO_2 0.41. He tolerated breathing at the above settings for 3

days, and FiO_2 was decreased to 0.31. Respiratory rate remained unchanged at around 25/min and peripheral oxygen saturation was around 95%. Gas flow was decreased to 20 l/min on day 12, and he was weaned to standard oxygen connected to the tracheal cannula at FiO_2 0.40 on day 13. Despite physiotherapy and adequate enteral feeding the patient remained dependent upon external assistance during the whole time. He died on day 25 in the ICU after the decision was made to withhold mechanical ventilation as well as vasoactive support due to poor prognosis and in agreement with the patient's relatives.

The second patient was a 65-year old female with a pre-existent Bence Jones lambda plasmacytoma, who was admitted to the haematology department one day before getting transferred to the ICU because of a community-acquired pneumonia that was refractory to treatment with amoxicillin/clavulanate. She developed respiratory and circulatory failure and required oxygen via a non-rebreather face mask on admission to the ICU and infusion of noradrenaline immediately thereafter. Her respiratory rate was 30/min, oxygen saturation was 90%, heart rate was 120/min and she required 0.3 mcg/kg/min of noradrenaline to maintain the mean arterial pressure at around 80 mmHg. Because of severe respiratory and circulatory failure, we decided against a non-invasive ventilation trial.

The analgesia/sedation strategy included using Fentanyl (60 mcg/h) and Propoven (50 mg/h) to achieve a target Richmond Agitation-Sedation Scale (RASS) score of -2. We intubated her and started mechanical ventilation immediately upon admission. The initial mode of mechanical ventilation was synchronized intermittent-mandatory ventilation (SIMV with 500 ml TV; 0.70 FiO_2; 10 cmH_20 PEEP, 6 cmH_20 PS), which we changed to volume assist-control ventilation (ACV) on day 2. Due to improvement on day 4 the mode was changed to CPAP.

She required noradrenaline at 0.2 mcg/kg/min to maintain her mean arterial blood pressure at around 80 mmHg. She was extubated on day 5 (pre-extubation settings: CPAP, 0.40 FiO_2, 8 cmH_2O PEEP, 6 cmH_2O PS), and HFNC (at 50 l/min gas flow rate at 0.70 FiO_2) was used for non-invasive ventilatory support after extubation. However, on day 7 respiratory parameters worsened (breathing rate 30/min; SpO_2 91 %), new pulmonary infiltrates on the chest X-ray appeared and she was reintubated. Because of difficult weaning from mechanical ventilation we performed tracheotomy on day 13, and restarted weaning from mechanical ventilation. Multiple attempts at spontaneous breathing were unsuccessful.

She required PEEP of 5 cmH_2O and FiO_2 of 0.40, with respiratory rate around 25-30/min and pressure support around 5 cmH_2O to achieve a tidal volume of around 300 ml (CPAP/PSV). Spontaneous breathing trials were performed by connecting the patient to the oxygen tube via a T-piece with around 5 l/min of oxygen flow. On day 18 we decided to use HFOTC (Veoflo High Flow Tracheostomy Interface, Flexicare Medical Ltd., UK). HFOTC was initially set to 30 l/min of gas flow rate and FiO_2 0.80. Respiratory rate decreased to around 20-25/min and peripheral oxygen saturation was around 95%. Over the following 2 days we reduced FiO_2 to 0.21 without changing the gas flow rate. On day 20 we reduced the gas flow from 30 l/min to 15 l/min, and on the same day we successfully connected her to standard oxygen at

3 l/min via a tracheotomy cannula. She was discharged from the ICU on day 22. The patient was transferred back to the haematology department. After 4 days, the patients' state worsened, most probably due to a reinfection. After consultation and in agreement with the patient's relatives, the decision was made not to readmit her to ICU. The decision was based on the patients multimorbidity and poor prognosis. A new antibiotic regime was introduced, after which the patient briefly recovered. However, due to the underlying disease the patient died during sleep on the fifth day.

3 Discussion

We presented two cases in which HFOTC was used to wean the patients from mechanical ventilation. A number of studies support the use of HFNC in patients with hypoxemic respiratory failure and to prevent reintubation (5,8). HFNC reduces the work of breathing by reducing dead space ventilation (consequently also reducing the respiratory rate), enables excellent control of FiO_2, provides at least some positive end-expiratory pressure (estimated at 1 cm-H_2O for every 10 l/min of gas flow with the mouth closed) (9,10) and provides warmed, humidified gases to aid mucociliary clearance (11).

We believe that the most important beneficial effects of HFOTC in our patients were decreased patient discomfort related to ventilatory support (especially in the first patient), better humidification (as passive humidification is used for invasive mechanical ventilation in our ICU), along with limited PEEP-effect and excellent control over FiO_2. This can be seen from the quick drop in oxygen dependency, flow rates as well as successful weaning. Also, another proposed mechanism is the washout effect of CO_2 that reduces dead space by a decrease of rebreathing. Weaning from mechanical ventilation includes assisted modes of mechanical ventilation using pressure support and spontaneous breathing trials via endotracheal tube. Assisted ventilation is associated with ventilator-patient asynchrony in up to 50-80 % of patients on invasive mechanical ventilation and in up to 40 % in patients receiving non-invasive ventilation (12). It has been reported that 20-40% of patients experience discomfort associated with assisted, controlled as well as spontaneous breathing on the ventilator (13,14). Also, even when ventilator tubing is optimized (i.e. equipment such as nebulizers and heat-moisture exchange filters is used appropriately), it may be difficult to remove the excessive dead-space volume. The possible importance and relevance of this subject can be seen from several recent studies which compared HFNC with HFOTC and/or standard oxygen therapy (16). The study from Natalini et al. on 26 tracheostomised patients showed that HFOTC generates a small flow-dependent improvement in oxygenation and increases in tracheal expiratory pressure. They concluded that compared to standard oxygen, 50 l/min of HFOTC are needed to improve oxygenation, reduce respiratory rate and provide a small degree of positive airway expiratory pressure, which, however, is significantly lower than the one produced by HFNC (16).

Similarly, improved oxygenation parameters were observed in a study by Corley (17). Their results suggested that HFOTC at 50 l/min could be useful in augmenting oxygenation during weaning from prolonged mechanical ventilation, compared to standard oxygen therapy via T-piece at 15 l/min. The study

was performed on 20 tracheotomised patients, and after a 15 min treatment period they observed higher mean airway pressures, improved oxygen saturation to FiO_2 ratio, and lower tidal volumes in the HFOTC group. However, bypassing of the larynx and the upper airway appeared to negate some of the beneficial effects of HFNC (17). Furthermore, a recent study by Stripoli et al. compared the effects of HFOTC or conventional low-flow oxygen therapy (conventional O_2) on neuro-ventilatory drive, work of breathing, RR and gas exchange, in a mixed population of tracheostomised patients at high risk of weaning failure. The authors reported that HFOTC in comparison with conventional oxygen therapy did not improve neuro-ventilatory drive, work of breathing, respiratory rate and gas exchange. Their findings suggest that physiological effects of HFOTC might substantially differ from nasal high flow (18).

High-flow oxygen therapy is becoming more frequent; however, its use should not be taken too lightly (15). The consideration of when to choose this type of therapy before other modalities does not so much depend on its possible few contraindications (surgery of the face, nose, or airway) and its rare complications (possible abdominal distension, aspiration, and rarely barotrauma) but should be individualized and depend upon clinician preference, institutional availability, patient preference, severity of hypoxemia, need for ventilation, and PEEP. It must be stressed that any type of high-flow oxygen therapy should not delay mechanical ventilation in those with severe respiratory failure and worsening respiratory distress. To conclude, we presented two patients who were successfully weaned from mechanical ventilation using HFOTC, despite their multimorbidity. Recently published larger studies underline the importance of the said therapeutic modality, the importance of studies on the said subject and the need for further elucidation of the physiological benefits of HFOTC in comparison with different approaches as well as the use in distinct pathological states.

Patients consent: All patients gave their informed consent to being included in the manuscript.

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