

A Case of Acute Respiratory Failure with Hypercapnia Treated with Nasal High-Flow Therapy

Pierpaolo Prosperi¹, Francesca Guido², Angela D'Intino³, Antonella Spacone^{1*}

¹Respiratory Medicine Unit, Hospital "Santo Spirito" Pescara, Italy

²Radiology Unit, Hospital "Santo Spirito" Pescara, Italy

³Emergency Unit, Hospital "Santo Spirito" Pescara, Italy

*Corresponding Author: Antonella Spacone, Respiratory Medicine Unit, Hospital "Santo Spirito" Pescara, Italy.

Received: February 17, 2020; Published: February 25, 2020

Abstract

Introduction: Noninvasive ventilation (NIV) has always been considered as the firstline therapy for hypercapnic respiratory failure (HRF). Sometimes, patients are unsuited for this treatment, but there is no established alternative when they do not tolerate standard NIV. High-flow nasal cannula (HFNC) oxygen therapy has been gaining interest as an innovative respiratory support for critically ill patients, especially those with hypoxemic respiratory failure. We describe a case report of a patient with pneumonia and HRF that was treated successfully with HFNC.

Case Report: RA, a 78-years-old Caucasian, female, ex-smoker, with a history of chronic obstructive pulmonary disease and coronary heart disease, was admitted with a diagnosis of pneumonia and secondary respiratory acidosis. In addition to being administered steroid and antibiotic therapy, she began treatment with NIV and oxygen therapy for 3 days. Despite the correction in pH, the values of the capnia continued to remain high and NIV via a face mask was no longer tolerated. High-resolution computed tomography showed the presence of bronchiectasis. Thus, we decided to initiate HFNC and after beginning, the clinical condition of patient improved and she was transferred to a rehabilitation medicine unit in room air, without support oxygen and/or NIV.

Conclusion: This clinical case underscores the effectiveness of HFNC, through a dramatic decrease in arterial carbon dioxide in a patient with COPD and bronchiectasis, who experienced acute respiratory failure that was accompanied by hypercapnia, secondary to pneumonia.

Keywords: High-Flow Nasal Cannula; Hypercapnia; Respiratory Failure; Pneumonia

Introduction

High-flow nasal cannula (HFNC) oxygen delivery, sometimes referred to as humidified high-flow nasal cannula, is a relatively new noninvasive ventilation therapy [1]. Several previous studies have reported its effectiveness in the care of neonates and children with respiratory distress, particularly its ability to prevent the intubations [2-4]. Recently, HFNC was introduced into the acute setting in adults, too [5-7]. HFNC is an open nasal cannula system that delivers warm and humidified air or oxygen at high flow rates (of up to 60 L/min), assisting ventilation. Positive effects of HFNC include a reduction in anatomical dead space, improved end-expiratory pressure (PEEP; range, 3 - 5 cmH₂O), maintenance of a constant fraction of inspired oxygen (FiO₂) and good humidification [7-9]. Potential mechanisms of the clinical benefit of HFNC include humidification, increased water content of mucus, decreased metabolic cost of breathing, washout of upper airway dead space and PEEP – all of which reduce the work of breathing, facilitate secretion removal, improve the efficacy of ventilation, and enhance oxygen delivery [10]. The potential clinical applications of HFNC are hypoxemic respiratory failure, ARDS, pneu-

monia, idiopathic pulmonary fibrosis, cardiogenic pulmonary edema, postextubation and postoperative recovery (cardiothoracic, cardiac surgery, vascular) and palliative treatment of hypoxemia and respiratory distress in do-not-intubate patients [10]. However, compared with conventional noninvasive ventilation (NIV), much less experience with HFNC therapy has been reported by clinical studies. Further, the standard indications for NIV- acute and chronic hypercapnic respiratory failure - have not been examined sufficiently. Several studies have determined the effects of HFNC therapy on, for example, hypercapnia in patients with chronic obstructive pulmonary disease (COPD), but their sample sizes were limited [11-16]. Recent studies suggested that this therapy is effective in patients with hypercapnia, but who are stable and have demonstrated improvements in ventilatory parameters, such as the partial pressure of arterial carbon dioxide (PaCO₂) [12,13,17]. We describe a case of report of a patient with pneumonia and HRF, who was treated successfully with HFNC.

Case Report

R.A, a 78-year-old Caucasian female, ex-smoker, was admitted with a diagnosis of pneumonia and secondary respiratory acidosis. Her medical history revealed a 10 years of severe COPD (frequent exacerbations on treatment with ICS/LABA/LAMA), a 5-year history of arterial hypertension, dyslipidemia syndrome, and coronary artery disease. She had had a fever, productive cough and dyspnea for 5 days before. On clinical examination, she had a high fever and a BMI (body mass index) of 24 kg/m². Her cardiovascular examination detected tachyarrhythmia (cardiac frequency 140 b/min), but without murmurs, rubs or gallops. Pulse oximetry revealed a saturation of 87% breathing room air. The neurological examination showed Kelly 2. A respiratory examination revealed mild tachypnea with dullness to percussion over the right basal lung. Auscultation showed decreased breath sounds in the same area, with crackles and diffuse wheezing. The electrocardiogram showed atrial fibrillation. The remainder of the physical examination was normal. There was no jugular venous distention or pedal edema. The laboratory tests revealed leukocytosis at 14.900/μL (4000 - 10000), C-reactive protein of 141 mg/dL (0 - 5), and erythrocyte sedimentation rate of 56/h (0 - 15); procalcitonin was normal. Serum electrolytes and renal and liver function tests were normal. The chest-x-ray, showed an infiltrate in the basal right lung (Figure 1). The arterial blood gas analysis showed: PaO₂ 58 mmHg, PaCO₂ 68 mmHg, pH 7.28, serum bicarbonate concentration was 29 mmoli/L. Consequently, NIV treatment with bilevel positive airway pressure (BiPAP) at FiO₂ 28% was started: PS 12 cmH₂O, PEEP 5 cmH₂O, with tidal volume of 420 mL (predicted body weight 56 Kg). The patient began antibiotics, steroids and anti-arrhythmics. After 3 days of NIV and oxygen treatment, despite the correction in pH, the values of the capnia value remained high (PaO₂ 70 mmHg, PaCO₂ 70 mmHg, pH 7.43, HCO₃ 47 mmoli/l) and NIV via a face mask was no longer tolerated (tolerance NIV scale 3). High-resolution computed axial tomography (HRCT) detected the presence of severe thickening of bronchial wall in right basal and medium lobes, with a small subpleural consolidation area, bronchiectasis and centrolobular opacities (Figure 2). Thus, HFNC was started (40 L/min FiO₂ 28%) and after 3 days after beginning, the clinical condition of patient improved and she was transferred to a rehabilitative medicine unit in room air (PaO₂ 68 mmHg PaCO₂ 43 mmHg pH 7.43), without oxygen support or NIV. In figure 3 X ray to discharge is reported.



Figure 1: Chest-x-ray.

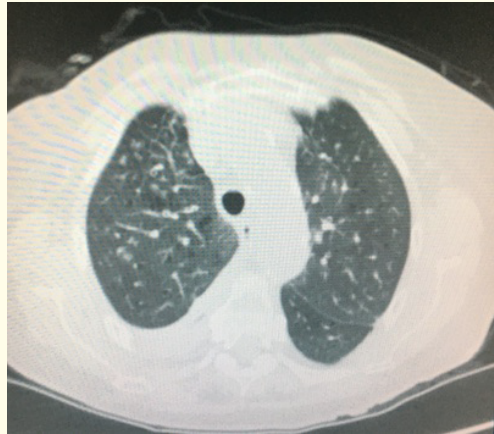


Figure 2a



Figure 2b



Figure 2c



Figure 2d

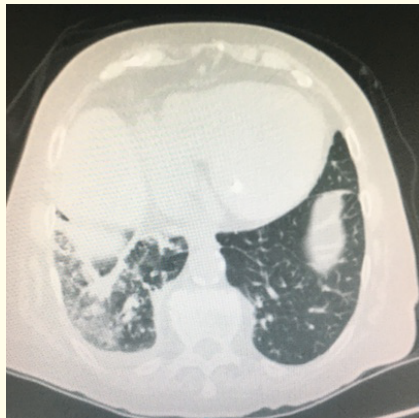


Figure 2e

Figure 2: HRCT images.

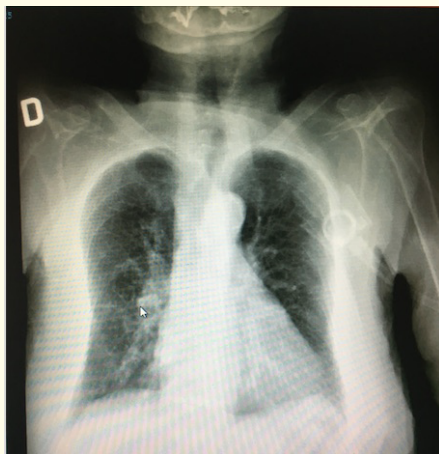


Figure 3: Chest-x-ray to discharge.

Discussion

HFNC is a new method of supporting breathing. Several studies have reported benefits after extubation or cardiothoracic surgery in hypoxemic patients compared with the Venturi mask or NIV [18-20]. It might be an alternative treatment device in stable hypercapnic COPD patients [12,21]. Our case report with COPD, bronchiectasis and pneumonia presented with HRF that was unresolved with NIV; she had increased airway secretions and expended considerable effort expelling them - a common phenomenon in respiratory distress [22]. This effort can contribute to respiratory muscle fatigue and the progression of respiratory failure, especially when secretions become thick and difficult to mobilize. Thus, humidification is needed to preserve and optimize mucosal functions, including facilitating gas exchange, reducing the cost of breathing, and maintaining host defenses. To this end, HFNC is useful for these conditions: it was first envisioned as a modality to facilitate secretion removal in patients with bronchiectasis [23]. Warming inspired gas to the level of 37°C and humidifying it to saturation helps patients maintain adequate mucosal function and preserves the rheology and volume of secretions, optimizing mucociliary clearance without the risk of thermal injury or overhumidification. Also, HFNC increases ventilatory efficiency, reducing the work of breathing by providing a small amount of inspiratory assistance and counterbalancing auto-PEEP, especially in patients with COPD, and alters breathing patterns through an increase in tidal volume and a reduction in respiratory rate [10]. Moreover, in our case report, the patient presented with discomfort on NIV treatment, intolerant of the tight interfacial contact for which HFNC was a viable alternative. Her clinical condition and HRF were resolved with HFNC and pharmacological treatment.

Conclusion

In recent years, HFNC has been receiving greater attention, and physicians have been applying it for a variety of diseases and conditions. In the present case, HFNC therapy significantly improved gas exchange and the clinical condition in a COPD/bronchiectasis patient with pneumonia and acute hypercapnic failure. Randomized controlled studies are needed to confirm the clinical advantages of HFNC over NIV in specific adult populations, to determine its longer-term effects.

Conflict of Interests

All authors declare that they have no competing interests.

Bibliography

1. Campbell EJ, et al. "Subjective effects of humidification of oxygen for delivery by nasal cannula. A prospective study". *Chest* 93.2 (1988): 289-293.
2. Dani C., et al. "High flow nasal cannula therapy as respiratory support in the preterm infant". *Pediatric Pulmonology* 44.7 (2009): 629-634.
3. Myers TR and American Association for Respiratory C. "AARC Clinical Practice Guideline: selection of an oxygen delivery device for neonatal and pediatric patients-2002 revision & update". *Respiratory Care* 47.6 (2002): 707-716.
4. Ojha S., et al. "Use of heated humidified high-flow nasal cannula oxygen in neonates: a UK wide survey". *Acta Paediatrica* 102.3 (2013): 249-253.
5. Sztrymf B., et al. "Impact of high-flow nasal cannula oxygen therapy on intensive care unit patients with acute respiratory failure: a prospective observational study". *Journal of Critical Care* 27.3 (2012): e9-e13.
6. Roca O., et al. "High-flow oxygen therapy in acute respiratory failure". *Respiratory Care* 55.4 (2010): 408-413.
7. Nishimura M. "High-flow nasal cannula oxygen therapy in adults". *Journal of Intensive Care* 3.1 (2015): 15.
8. Parke RL., et al. "A preliminary randomized controlled trial to assess effectiveness of nasal high-flow oxygen in intensive care patients". *Respiratory Care* 56.3 (2011): 265-270.

9. Dewan NA, *et al.* "Effect of low flow and high flow oxygen delivery on exercise tolerance and sensation of dyspnea. A study comparing the transtracheal catheter and nasal prongs". *Chest* 105.4 (1994): 1061-1065.
10. Spoletini G, *et al.* "Heated humidified high-flow nasal oxygen in adults mechanisms of action and clinical implications". *Chest* 148.1 (2015): 253-261.
11. Bräunlich J, *et al.* "Effects of nasal high flow on ventilation in volunteers, COPD and idiopathic pulmonary fibrosis patients". *Respiration* 85.4 (2013): 319-325.
12. Bräunlich J, *et al.* "Nasal high-flow versus non-invasive ventilation in stable hypercapnic COPD: a preliminary report". *Multidisciplinary Respiratory Medicine* 10.1 (2015): 27.
13. Bräunlich J, *et al.* "Nasal high flow improves ventilation in patients with COPD". *COPD* 11 (2016): 1077-1085.
14. Jeong JH, *et al.* "Changes in arterial blood gases after use of high-flow nasal cannula therapy in the ED". *American Journal of Emergency Medicine* 33.10 (2015): 1344-1349.
15. Fraser JF, *et al.* "Nasal high flow oxygen therapy in patients with COPD reduces respiratory rate and tissue carbon dioxide while increasing tidal and end-expiratory lung volumes: a randomised crossover trial". *Thorax* 71.8 (2016): 759-761.
16. Pisani L, *et al.* "Change in pulmonary mechanics and the effect on breathing pattern of high flow oxygen therapy in stable hypercapnic COPD". *Thorax* 72.4 (2017): 373-375.
17. Fricke K, *et al.* "Nasal high flow reduces hypercapnia by clearance of anatomical dead space in a COPD patient". *Respiratory Medicine Case Report* 19 (2016): 115-117.
18. Maggiore SM, *et al.* "Nasal high-flow versus Venturi mask oxygen therapy after extubation. Effects on oxygenation, comfort, and clinical outcome". *American Journal of Respiratory Critical Care Medicine* 190.3 (2014): 282-288.
19. Stéphan F, *et al.* "High-Flow Nasal Oxygen vs Noninvasive Positive Airway Pressure in Hypoxemic Patients After Cardiothoracic Surgery: A Randomized Clinical Trial". *Journal of American Medical Association* 313.23 (2015): 2331-2339.
20. Frat JP, *et al.* "High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure". *New England Journal of Medicine* 372.32 (2015): 2185-2196.
21. Bräunlich, *et al.* "Effectiveness of nasal high flow in hypercapnic COPD patients is flow and leakage dependent". *BMC Pulmonary Medicine* 18 (2018): 14.
22. Wood KE, *et al.* "Inspissated secretions: a life-threatening complication of prolonged noninvasive ventilation". *Respiratory Care* 45.5 (2000): 491-493.
23. Hasani A, *et al.* "Domiciliary humidification improves lung mucociliary clearance in patients with bronchiectasis". *Chronic Respiratory Disease* 5.2 (2008): 81-86.

Volume 3 Issue 3 March 2020

©All rights reserved by Antonella Spacone, *et al.*