High-Flow Nasal Cannula Oxygen in Adult Patients: A Narrative Review

David Sotello, MD, Marcella Rivas, MD, Zachary Mulkey, MD and Kenneth Nugent, MD

Abstract: High-flow nasal cannula oxygen (HFNC) is a relatively new therapeutic innovation being used in adults with severe respiratory disease. It delivers heated humidified oxygen through short nasal prongs and supplies much higher flow rates than traditional nasal cannula systems. These higher flows match patient flow demands better, reduce anatomic dead space and provide a slightly positive pressure in the upper airway. Randomized trials, nonrandomized prospective trials and case series using HFNC in adults were identified in the PubMed, Google Scholar and Cochrane databases for the period of June 1981 to December 2013. Fifteen studies meeting our inclusion criteria were analyzed; 5 were randomized controlled studies. These studies included 943 patients managed in intensive care units. Common clinical diagnoses included postoperative status, cancer and pneumonia. These studies demonstrated that HFNC provided better or comparable oxygenation when compared with conventional face masks and nasal cannulas. Side effects included epistaxis, nasal discomfort and dryness. No unexpected side effects were reported in the studies reviewed. Current studies demonstrate that HFNC can improve oxygenation adults with hypoxemic respiratory failure. In some patients, it is superior to traditional oxygen delivery systems and may obviate the need for positive pressure ventilation. More studies are needed to compare HFNC with noninvasive ventilation.

Key Indexing Terms: Oxygen therapy; High-flow; Nasal cannula; Acute respiratory failure. **[Am J Med Sci 2015;349(2):179–185.]**

High-flow nasal cannula oxygen (HFNC) is a relatively new therapeutic technology being used in adults with severe respiratory disease. These systems deliver heated humidified oxygen through short nasal prongs and provide much higher and more predictable gas flow rates and FiO_2s than traditional nasal cannulas and face masks.[1] For example, the Vapotherm Precision Flow device provides gas flow rates from 5 to 40 L per minute with FiO_2s from 21% to 100% at a relative humidity near 100% (Vapotherm Inc, Exeter, NH). These higher flow rates match the patient's inspiratory flow rates better than other O_2 delivery systems, may reduce the anatomic dead space and increase carbon dioxide (CO_2) wash out and create a positive pressure effect with nasal prongs that fit more firmly and allow less leak.[2,3] HFNC is more comfortable than continuous positive airway pressure (CPAP) and noninvasive positive pressure ventilation (NIV), and this reduces dyspnea in some patients.[2]

HFNC has been studied more extensively in the neonatal and pediatric patients.[1] The current literature on the use of HFNC in adults includes heterogeneous patient populations and clinical diagnoses and reports different outcomes.[1] Nevertheless, HFNC is now being used now in adult patients with hypoxemic respiratory failure with diverse etiologies without strong clinical data guiding its use. We need to know which patients are likely to benefit from this oxygen delivery system and which patients are unlikely to benefit. We have reviewed clinical studies and summarized them here as an up-to-date resource for clinicians who manage hospitalized patients.

From the Texas Tech University Health Sciences Center, Lubbock, Texas.

Submitted April 15, 2014; accepted in revised form August 5, 2014.

The authors have no financial or other conflicts of interest to disclose.

Correspondence: Kenneth Nugent, MD, 3601 4th Street, Lubbock, TX 79430 (E-mail: kenneth.nugent@ttuhsc.edu).

METHODS

Study Objectives

The goal of this review is to summarize the relevant medical literature on the use of HFNC in adults. Several reviews are available for the pediatric population, and these articles will not be included in our analysis.[1] We will try to answer the following key questions about the use of HFNC in adults.

1. What are the usual physiological changes seen in patients with the use of HFNC?
2. In which patients and clinical settings has HFNC been studied?
3. Does it help patients avoid the use of NIV or intubation and mechanical ventilation?
4. Is there any harm associated with HFNC use?

Literature Searches

Randomized and nonrandomized trials and case series using HFNC in adults were identified in the PubMed, Google Scholar and Cochrane databases for the period of June 1981 to December 2013. The Medical Subject Headings (MeSH) terms included oxygen inhalation therapy and positive end–expiratory pressure. Text terms included oxygen therapy, oxygen delivery devices, high flow, nasal cannula, positive pressure respiration and humidified. These terms were then combined using Boolean operators to refine the search. All studies published in English or Spanish were included. All titles and abstracts were reviewed, and duplicates and irrelevant returns were removed (Figure 1). The reference lists of included studies were also reviewed for additional eligible studies. Data regarding design, diagnostic and treatment variables and outcomes were extracted and tabulated by 2 authors.

The Cochrane Collaboration's tool for assessing risk of bias was used to evaluate the randomized controlled trials recovered from the search. All 5 studies were considered to have high-risk elements for bias (see Appendix).

RESULTS

Fifteen studies met our inclusion criteria and were analyzed. Five studies were randomized studies (Table 1), 5 were nonrandomized prospective studies (Table 2) and 5 were retrospective cohort studies. These studies included 943 patients managed in intensive care units (ICUs) (9 studies), emergency departments (1 study), postoperative units (4 studies) and inpatient hospital services (1 study also with some ICU patients). Frequent diagnoses included postoperative patients (410 patients), cancer (183 patients), pneumonia (154 patients),

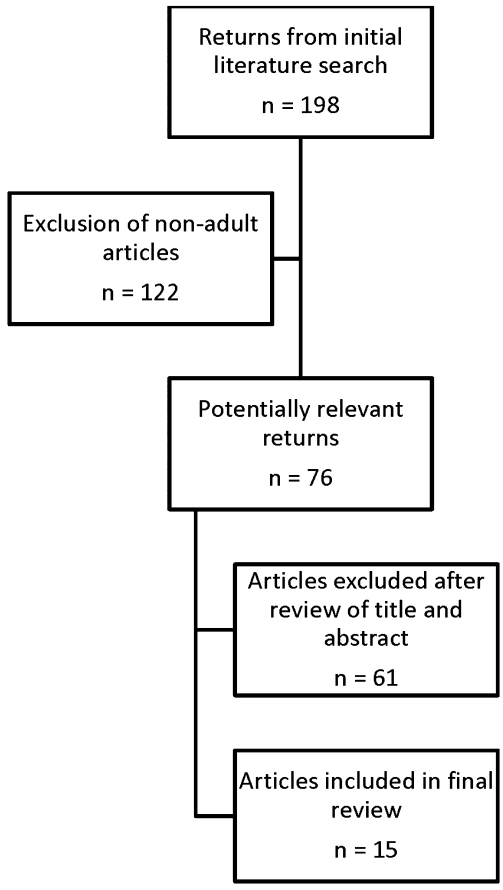

FIGURE 1. Medical literature search results.

postextubation (67 patients), pulmonary edema (18 patients), pulmonary fibrosis (15 patients), COPD (12 patients) and other (84 patients, miscellaneous diagnoses and not reported).

The 5 randomized trials compared HFNC with standard oxygen therapy by face mask or conventional nasal cannula and included 493 patients (Table 1). Parke et al[5] randomized 60 patients (56 analyzed in study) with mild to moderate hypoxemia to either a high-flow face mask or HFNC. Twelve patients (30%) on high-flow face masks were switched to NIV (7 patients) or HFNC (5 patients). Three patients (10%) in the HFNC were switched to NIV. Arterial blood gases, respiratory rates, heart rates and O_2 saturations were similar in the 2 groups. Patients on HFNC had fewer episodes of desaturation. Cuquemelle et al[6] compared the effects of standard oxygen therapy without humidification and HFNC on the upper airway in 30 patients with acute hypoxemic respiratory failure. This study used a crossover of therapies after 24 hours. There were no differences in nasal airway dimensions measured by acoustic rhinometry, but dryness (based on direct assessment) increased in the nose, mouth and throat on standard therapy. Patients tolerated HFNC better. Parke et al[7] evaluated HFNC oxygenation in 340 postcardiac surgery patients. This study did not identify any significant benefit with HFNC except for a reduction in the escalation of respiratory support (increased O_2 delivery, NIV or reintroduction of oxygen therapy) during the postoperative period. Two studies compared HFNC and face masks postextubation and used a crossover after 30 minutes. Tiruvoipati et al[4] studied 50 patients who had just been extubated. These patients were put on either HFNC at 30 L per minute or a face mask at 30 L per minute and then crossed over to the other treatment arm after 30 minutes. There were no significant differences in respiratory rates, heart rates or oxygen saturations between the 2 groups. Patients on HFNC had higher comfort scores. Rittayamai et al[8] reported similar results in 17 patients randomized to HFNC or face mask after extubation. Patients in this study had less dyspnea and lower respiratory rates on the HFNC. Therefore, the outcomes varied significantly among these 5 trials. All 5 randomized trials reported that HFNC had better overall tolerance or better comfort scores. No study directly compared HFNC with NIV.

The nonrandomized prospective studies included 115 patients in acute respiratory failure in whom conventional oxygen delivery with face masks or nasal cannulas was replaced by HFNC (Table 2).[9–13] The definitions of respiratory failure were similar but not identical in the studies. Pneumonia was the most common diagnosis. All studies reported significant improvements in clinical indices relevant to respiratory distress (respiratory rate and oxygen saturation) and symptom/comfort scores. The PCO_2 did not change. The rate of secondary intubation was considered similar to other methods of respiratory support by the authors of 1 study.[11]

The 5 retrospective studies included 25 patients with confirmed H1N1 influenza, 183 cancer patients with dyspnea, 5 patients with heart failure and pulmonary edema, 50 patients with a "do-not-intubate" status and respiratory distress and 72 patients in a high-dependency surgical unit.[14–18] The study with H1N1 infections reported a 45% success rate defined as avoiding mechanical ventilation.[14] In this study, the patients requiring intubation were sicker overall as reflected by significantly lower PaO_2/FiO_2 ratios and were more likely to need vasopressors. HFNC was used in cancer patients with hypoxemia; 85% of the patients stabilized or improved on treatment.[15] The median time was 3 days; 55% of the patients died, usually in the hospital. The patients with pulmonary edema were switched from CPAP or BiPAP to HFNC.[16] They had improved PaO_2s and pHs and reduced dyspnea after 24 hours of treatment with HFNC and did well. The patients with acute respiratory failure and a "do-not-intubate" status had significant increases in O_2 saturation and reductions in breathing frequency.[17] Nine of these patients required NIV; the other 41 stayed on HFNC until they improved or had care withdrawn. The overall mortality was 60%. The patients in the high-dependency surgical unit tolerated HFNC well and had an increase on PaO_2 and a decrease in respiratory rate.[18] They had no change in $PaCO_2$ or pH. Eighty percent of these patients survived and were discharged.

DISCUSSION

HFNC provides higher gas flow rates with higher FiO_2s than conventional O_2 supplementation with nasal cannulas, face masks, Venturi masks and non–rebreathing masks. Therefore, these devices increase O_2 delivery and improve PaO_2 in hypoxemic patients and potentially obviate the need for positive pressure ventilation. In addition, the high flow rates can create a slightly positive pressure in the upper airway similar to nasal CPAP.[2,3] This technique has been widely studied in pediatric patients with beneficial effects.[1]

Physiological Effects in Respiratory Failure

Several factors explain the improvement in respiratory parameters using HFNC. The addition of sufficient warmth and high levels of humidification to inspired gas increases comfort and allows higher gas flow rates with higher FiO_2s to patients