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Review article

High flow nasal cannula versus conventional oxygen therapy and non-invasive ventilation in adults with acute hypoxemic respiratory failure: A systematic review

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A B S T R A C T

Introduction: Humidified oxygen via a high flow nasal cannula (HFNC) is a form of supplemental oxygen therapy that has significant theoretical advantages over conventional oxygen therapy (COT). However, the clinical role of HFNC in acute hypoxemic respiratory failure (AHRF) has not been well established. This review compares the efficacy of HFNC with COT and non-invasive ventilation (NIV) in patients with AHRF.

Methods: Studies reviewed were selected based on relevance from a systematic literature search conducted in Medline and EMBASE to include all published original research through May 2016. Twelve studies matched the inclusion criteria.

Results: In the majority of the studies, HFNC was associated with superior comfort and patient tolerance as compared to NIV or COT. HFNC was associated with reduced work of breathing in comparison with COT in some, but not all, studies in the review. COT and NIV were associated with a higher 90-day mortality rate compared to HFNC in only one multicenter randomized trial versus no mortality difference reported by others. Three out of four studies demonstrated a decreased need for escalation of oxygen therapy with HFNC. Six out of eight studies demonstrated improved oxygenation with HFNC as compared to COT. Two of three studies revealed worse oxygenation with HFNC as compared to NIV.

Conclusion: This review suggests that HFNC may be superior to COT in AHRF patients in terms of oxygenation, patient comfort, and work of breathing. It may be reasonable to consider HFNC as an intermediate level of oxygen therapy between COT and NIV.

Contents

Abbreviations: HFNC, High flow nasal cannula; ARF, Acute respiratory failure; AHRF, Acute hypoxemic respiratory failure; COT, Conventional oxygen therapy; NIV, Non-invasive ventilation; MV, Mechanical ventilation; NC, Nasal cannula; FM, Face mask; PEEP, Positive end expiratory pressure.

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1. Introduction

Acute respiratory failure (ARF) is a common and serious complication among hospitalized patients. It is the most frequent reason for admission to the intensive care unit (ICU) [1]. It carries an in-hospital mortality rate of 20.6% and cost 54.3 billion dollars nationwide in United States in 2009. Among those patients with ARF, 42.1% of patients require mechanical ventilation (MV), which is associated with a significant increase in both length of stay and medical expense [2].

ARF can be categorized into acute hypoxemic respiratory failure (AHRF) and acute hypercapneic respiratory failure. Supplemental oxygen and treatment of the underlying cause is the mainstay of therapy for AHRF. Options for oxygen therapy include conventional oxygen therapy delivered via nasal cannulae (NC) or face masks (FM) initially, followed by non-invasive ventilation (NIV), and finally intubation or mechanical ventilation (MV). Traditional NC and FM (collectively referred to as conventional oxygen therapy or COT) can achieve flow rates of up to 15 L/min. However, these flow rates may be significantly lower than patients' spontaneous inspiratory flow rates and the oxygen is diluted as it is mixed with room air. Consequently, the fraction of inspired oxygen (FiO2) delivered is variable and this is thought to explain why many patients require an escalation of oxygen therapy to NIV or MV.

By contrast, humidified high flow nasal cannula (HFNC) oxygen therapy utilizes an air oxygen blend allowing from 21% to 100% FiO2 delivery and generates up to 60 L/min flow rates [3,4]. The gas is heated and humidified through an active heated humidifier and delivered via a single limb heated inspiratory circuit (to avoid heat loss and condensation) to the patient through a large diameter nasal cannula [5]. Theoretically, HFNC offers significant advantages in oxygenation and ventilation over COT. Constant high flow oxygen delivery provides steady FiO2 and decreases oxygen dilution [6]. It also washes out physiologic dead space and generates positive end expiration pressure (PEEP) that augments ventilation [6–8]. The heated humidification facilitates secretion clearance, decreases bronchospasm, and maintains mucosal integrity [9].

HFNC has been well studied in the neonatal and pediatric settings [10–13]. However, in adults, the use of HFNC has primarily been studied in post-cardiac surgery [14,15], post-extubation [16–18], and bronchoscopy [19,20] patients. However, the utility of HFNC use in adults with AHRF in emergency and general inpatient practice is less clear [4]. Thus, the present review aims to collect and summarize published data on the performance of HFNC in comparison to COT and NIV in patients with AHRF.

2. Methods

A comprehensive and current search for relevant articles was conducted in Medline (via Ovid and PubMed) and EMBASE through May 2016. Searches of electronic databases were conducted both with controlled vocabulary (MeSH/EMTREE) terms and free text terms. Filters for human studies were employed.

The search strategy is detailed in Fig. 1. The search yielded 1222 citations in the PubMed database and 1267 citations in the EMBASE database. Articles were included if they were in English and were full text articles reporting original research. Editorials, case reports, letters, retrospective studies, and abstracts without full text publications were excluded. All citations were assessed by two reviewers (SR and CCL) and discrepancies were resolved in consultation with a third reviewer (SS) (Fig. 1). References of obtained articles and pertinent reviews were manually scanned for additional articles. Our exclusion criteria included studies in preprocedural or post-procedural settings (ex: surgery, bronchoscope), post-extubation, cancer or transplant patients, or those not performed in adults (Age < 18). Data extracted from the final studies included design, sample size, characteristics of patients and controls, and appropriate statistical analyses. Data are presented as mean ± standard deviation (SD) or median and range or interquartile range (IQR), as appropriate. The primary outcomes of interest in this review were oxygenation, work of breathing, need for escalation or mechanical ventilation, patient comfort (or tolerability), and mortality.

3. Results

A total of 12 [21–32] studies (n = 970) were included in the review (Table 1). Of these, 1 was a multicenter randomized trial, 4 were prospective randomized comparative studies, 1 was a prospective randomized sequential study, and 6 were prospective (sequential intervention or observational) studies.

3.1. Oxygenation

Eleven studies yielded data on oxygenation parameters (Table 2, Table 3). Oxygenation was assessed by the partial pressure of oxygen in arterial blood (PaO_2), the saturation of peripheral oxygen (SpO_2), or by the partial pressure of oxygen divided by the fraction of inspired oxygen (PaO_2/FiO_2). Six out of eleven studies demonstrated increased mean PaO_2 or PaO_2/FiO_2 levels in patients oxygenated with HFNC as compared to conventional oxygen therapy, while one (Itagaki et al.) reported no significant difference in oxygenation. In the largest included study, Frat et al. reported significantly lower PaO_2/FiO_2in HFNC compared to COT. Two studies (Rittayamai et al. and Jones et al.) only reported SpO_2, with no difference shown between HFNC and COT.

Parke et al. detected a significant difference of PaO_2 levels in patients receiving COT or NIV. However, they reported the number of desaturation events (defined as SpO_2<93% for more than 5 s). Events associated with signal loss or signal interference were not counted. HFNC was associated with a significantly lower rate of desaturation events (0.79 per patient) versus face-mask (1.86 per patient). Three studies (Table 3) compared oxygenation between NIV and HFNC. Two studies showed inferior oxygenation performance in patients receiving HFNC versus NIV. Vergas et al. reported no significant difference of PaO_2/FiO_2 in HFNC compared to COT.