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High Flow Nasal Oxygen Therapy Utilization: 7-year Experience at a Community Teaching Hospital

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Abstract

Objective—To examine the use of high flow nasal cannula oxygen therapy (HFNC) between 2008 and 2014 in patients 18 years or older at a community teaching hospital.

Methods—Yearly utilization rates of HFNC, noninvasive ventilation (NIV) and invasive mechanical ventilation (IMV) were calculated among admissions with a set of cardiopulmonary diagnoses (heart failure, COPD, asthma or pneumonia).

Results—Among the 41,711 admissions with at least one of the above cardiopulmonary condition, HFNC was utilized in 1,128 or 27.0/1000; NIV was used in an average of 169/1000 and IMV in 231/1000. HFNC was accompanied by IMV or NIV 71.3% of the time. From 2008 to 2014 HFNC utilization increased an average of 17.5% annually; NIV increased by 10.2% annually while IMV's utilization increased by 1.6% annually. The highest rate of change in HFNC use was among admissions with pneumonia and those with COPD.

Conclusion—HFNC utilization increased steadily over a 7-year period at our hospital. Frequently, HFNC therapy was used in combination with other ventilatory modes to support patients' respiration. Similar with other technologies in healthcare, the uptake of HFNC has preceded the evidence from robust clinical trials.

Keywords

High flow nasal cannula oxygen; mechanical ventilation; respiratory failure

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Background

Within the last decade there has been increasing interest on using high flow nasal cannula oxygen (HFNC) as an alternative to standard oxygen and noninvasive positive pressure ventilation (NIV).(1, 2) HFNC delivers constant oxygen and provides low levels of continuous positive end-expiratory pressure; it heats and moistens the inspired air which results in improved comfort and compliance.(3, 4)

Randomized controlled trials support the efficacy of HFNC in preventing endotracheal intubation in patients with acute respiratory failure (ARF)(5) and in decreasing the risk of postextubation failure(2, 6–8) however, the majority of these studies were published after 2014. The evidence for efficacy of HFNC in patients with COPD, asthma or acute cardiogenic pulmonary edema is limited.

We conducted a ‘natural history’ study of noninvasive respiratory support use at our institution with a particular emphasis on HFNC delivery. We were interested in how providers adopted this relatively new technology before the publication of the major clinical trials supporting its effectiveness. We hypothesized that HFNC therapy use increased significantly during the study period, and that its utilization would vary by underlying patient diagnosis.

Methods

Study design, Settings and Population

We performed a retrospective, single center, serial cross-sectional analysis of all adult admissions to a 716-bed tertiary care medical center in Western Massachusetts between January 2008 and December 2014. We began the reporting from 2008 because this was the first time when we identified a charge for HFNC. In our hospital high flow nasal cannula oxygen can be ordered by any physician, in emergency room or on the regular medical floor. When a patient is placed on high flow oxygen the only requirement is to have oxygen saturation monitored continuously, but the patient does not need to be transferred to a higher level of care. The respiratory therapists can start a patient on high flow, but a physician needs to place an order thereafter.

We obtained principal and secondary ICD-9 codes to identify cardiorespiratory disease subgroups which represented most of the indications for the HFNC use (COPD/asthma, congestive heart failure, pneumonia and acute myocardial infarction). We also obtained procedure billing codes to identify all forms of respiratory support ordered during the hospitalization.

Outcomes

The primary outcome was the proportion of all admissions with any HFNC utilization yearly, and among the above acute cardiopulmonary conditions. The secondary outcomes were the proportion on NIV and IMV use yearly. Due to the lack of granularity of the administrative data, we were not able to report the sequence of ventilation methods;

consequently, we report each method of respiratory support at any time during hospitalization.

Statistical Analysis

Utilization of HFNC, IMV and NIV per 1000 admissions (all admissions and those with cardiopulmonary conditions) were calculated and presented with 95% confidence intervals, both overall and by study year. Trends in utilization over time were confirmed using the χ^2 test for linear trend of the log-odds. Variability in utilization by year and cardiopulmonary condition was explored using generalized linear models (binomial family, logit link) with a random patient effect and exchangeable correlation structure to account for multiple admissions within patient.

Stata 14.1 (College Station, TX) was used for all analyses.

The Institutional Review Board of Baystate Medical Center approved this project.

Results

Among the 41,711 admissions with at least one diagnosis of a cardiopulmonary condition, HFNC was used in 1,128 or 27.0 per 1000 (95% CI 25.5 to 28.8). During the same time period, NIV was used in an average of 169 per 1000 (95% CI 165, 173) and IMV in 231 per 1000 (95% CI 227, 236). Among those admissions treated with HFNC, the median age of the subjects was 67 years, 75.4% were white and the median Charlson comorbidity score was 2. The most common cardiopulmonary diagnosis were pneumonia and COPD/asthma. The median length of stay was 10.6 days (IQR: 6, 17) and 28.2% of patients died during hospitalization. Admissions with HFNC utilization frequently had concurrent NIV (55.9%) or IMV (42.6%) use; HFNC was the only form of respiratory support in 296 of the 1128 cases (26.2%). (Figure 1)

Trends in HFNC therapy use 2008-2014

HFNC utilization increased in an approximately linear fashion over the study period, from 3.3 (95% CI 2.7 to 4.0) per 1000 inpatient admissions in 2008, to 8.9 (95% CI 7.8, 9.9) per 1000 admissions in 2014. From 2008 to 2014 HFNC utilization increased an average of 17.5% yearly (95% CI: 13.8%, 21.3%); NIV increased by 10.2% yearly (95% CI 8.8%, 11.7%) while IMV's utilization increased 1.6% yearly, (95% CI 0.4%, 2.8%).

Among patients with a set of cardiopulmonary conditions there was a similar trend of HFNC increasing utilization over time (an increase of 164% from 2008 to 2014). (Figure 2) The annual rate of change was highest among patients with COPD and pneumonia (18% annual increase for each condition vs 14% in CHF). In all cardiopulmonary conditions NIV increased modestly (8-13%), and IMV remained flat.

Comparing respiratory support as number of orders per 1000 admissions in patients with pneumonia, CHF and COPD, the largest change in HFNC use was in patients with pneumonia (230% increase; from 21/1000 to 69/1000). In all three conditions NIV use increased, with the largest changes in patients with COPD (66% from 194/1000 to

321/1000). There was a trend for decrease in use for IMV but not statistically significant. (Table 1)

Discussion

We found that over a 7-year period HFNC utilization more than doubled, while NIV and IMV use had a more modest increase. In patients with CHF, COPD or pneumonia the use of IMV decreased slightly although not statistically significant. HFNC utilization increased most rapidly in admissions related to COPD or asthma. More than 70% of patients treated with HFNC received NIV and/or IMV during the same hospitalization.

Prior to 2014 only few studies have analyzed the effectiveness of HFNC in adults and most were either observational studies, investigations to study physiological mechanisms of HFNC, or pilot controlled trials.(1, 3, 4, 9) Starting in 2014 several randomized controlled trials have examined the role of HFNC in preventing endotracheal intubation in patients with hypoxic ARF secondary to pneumonia(5) or have evaluated its role to prevent or treat extubation failure.(2, 7, 8),(10) In this study, we were interested in how health care provider adopted HFNC prior to the publication of these landmark studies.

There is relatively limited epidemiological data on the use of HFNC in the general inpatient setting and no large observational studies have been published reporting on the HFNC use in hospitals in US. This may be due to the lack of ICD-9 or 10 procedure codes which are needed to assess its utilization. One study in an academic institution in Texas, found that in 2014, one hundred six patients received HFNC and the usual indication was hypoxic ARF. (11) Messika et al evaluated prospectively over one year the respiratory management of 560 patients with ARF in a medical ICU; they found that HFNC was used in 15% of these patients and more than half had hypoxic ARF.(12) Similar with these results, we showed that most common diagnoses for HFNC use in our hospital were pneumonia and CHF which are main causes of hypoxic respiratory failure. Nevertheless, in 20% of all admissions where HFNC was used, patients had a diagnosis of COPD or asthma exacerbation despite very limited evidence. Further studies should determine if HFNC has a role in treating patients with acute exacerbation of COPD for which the use of NIV is supported by strong evidence and the possible financial implications due to lower cost and easier use.

How can we explain this growing use of HFNC? First, there is a rationale for application of HFNC for patients with hypoxia and several studies have found an improvement in oxygenation. Second, although NIV has proven efficacy in COPD and acute pulmonary edema, patient intolerance is frequently an issue. HFNC is very well tolerated and there is no risk for face ulcerations. In addition, HFNC is easy to apply and less time intensive for the respiratory therapists and nurses; there is no air leak thorough the mask and no risk of aspiration. Like other new or updated interventions, the adoption of HFNC in our institution preceded extensive testing and clinical trials. However, we recommend caution in using HFNC before is further tested in clinical trials and guidelines recommend it, especially for patients with COPD. Most hospitals, including ours, do not have any policy regarding the HFNC therapy and the ease of use made it spread very rapidly despite the lack of strong evidence. Based on the results of these study which showed a significant use of HFNC, we

convened a hospital committee tasked with developing guidelines for the use of HFNC and NIV.

Although one may expect a decrease in the use of IMV with the increased implementation of noninvasive therapies, IMV utilization remained flat. These findings suggest that HFNC or NIV are not used instead of IMV but rather in patients with less severe respiratory distress.

Our study has several strengths: it is one of the largest clinical series of HFNC use published to date. We present the natural history of HFNC utilization at our institution from its inception to the current time and we compared its use with NIV and IMV utilization in various clinical conditions. The study has also several limitations. First, the results reflect the experience from one single hospital and the utilization of HFNC could be different in other institutions. Second, we did not assess the sequence of the ventilation therapies or the 'success' of each modality. HFNC may be applied with various objectives at different times during the course of an episode of respiratory distress. Third, we counted HFNC, NIV and IMV at any time during hospitalization and not only as the initial method of ventilation and more than one ventilatory method could have been used during same admission. Fourth, we used ICD-9 diagnostic codes to identify the cardiopulmonary conditions and this practice carries an acknowledged risk of disease misclassification.

In conclusion, HFNC utilization increased steadily over a 7-year period at our hospital. Frequently, HFNC therapy was used in combination with other ventilatory modes to support patients' respiration. Similar with other technologies in healthcare, the uptake of HFNC has preceded the evidence from robust clinical trials.

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Figure 1.
Venn diagram demonstrating Overlap of Respiratory Support Modes

Figure 2.
HFNC utilization per 1000 Admissions by Year among All Admissions and
Cardiopulmonary Conditions

Table 1

Respiratory support per 1000 hospitalizations for selected cardiopulmonary conditions, 2008 vs. 2014 (expressed as counts per thousand with the percent change 2014 vs. 2008)

	COPD n=6213			CHF n=9550			Pneumonia n=8084		
	2008	2014	Percent Change, 2014 vs. 2008 (95% CI)	2008	2014	Percent Change, 2014 vs. 2008 (95% CI)	2008	2014	Percent Change, 2014 vs. 2008 (95% CI)
	Orders per 1000			Orders per 1000			Orders per 1000		
HFNC	12.4	37.6	+202% (+53,+497)	8.3	18.7	+124% (+10, +353)	21.0	69.2	+230% (+108, +424)
NPPV	193.5	321.4	+66% (+41, +96)	230.9	319.6	+38% (+22,+57)	163.9	219.2	+34% (+13,+59)
IMV	124.1	115.4	-7% (-27, +19)	91.1	84.0	-8% (-28, +18)	191.3	166.0	-13 (-27, +3)

COPD: chronic obstructive pulmonary disease); **CHF**: congestive heart failure; **IMV**: invasive mechanical ventilation; **NPPV**: non-invasive mechanical ventilation; **HFNC**: high flow nasal cannula