Assessment of High Flow Nasal Cannula Therapy use in the Emergency Department Setting: Observations of Practice Across Four Systems

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Abstract

Objectives: Recent evidence suggests that high flow nasal cannula (HFNC) may have a meaningful impact on care, workflow and economics in the Emergency Department (ED) setting. The goal of the current project was to better understand how utilization of HFNC as first line of respiratory support would impact workflow within the ED, and to define hypotheses for future research related to patient outcomes.

Methods: A multicenter study was designed to assess the utilization and value of HFNC in the ED setting using a real-time, case-by-case assessment of staff perceptions and decision-making around the application of HFNC. From May of 2013 through March of 2014, six hospitals in four systems across four states participated in the project. HFNC was initiated as a front line therapy in place of other oxygen therapy modalities, and used based on clinician discretion. For each individual use of HFNC, attending staff responded to questions regarding the decision to initiate HFNC, perceptions on how the therapy performed, and decisions on patient disposition. The respondents were instructed to record their answers at the time of therapeutic intervention.

Results: A total of 128 assessments were completed. Chronic obstructive pulmonary disease (COPD), general dyspnea and congestive heart failure (CHF) represented the majority of working diagnoses treated with HFNC (41%, 29% and 17%, respectively). Seventy-four percent of HFNC interventions involved patients with hypoxemia and 25% of them involved elevated arterial carbon dioxide levels. Respondents indicated excellent respiratory responses as well as high ease of use and patient tolerance. Disposition decisions were to admit 41% of cases to the ICU, 54% to the medical floor and 5% to discharge.

Conclusions: HFNC may be useful in the ED to rapidly stabilize patients in significant respiratory distress with an easily tolerated respiratory support modality. Clinical use guidelines were established that were effective and acceptable to clinical staff. The use of the therapy may have utility in reducing ICU admissions associated with the use of NIPPV as a primary respiratory modality.

Introduction

High Flow Nasal Cannula (HFNC) is a novel respiratory therapy delivered through a loose fitting nasal cannula that improves breathing efficiency by using high flow rates to flush the respiratory dead space of expired air and replace it with fresh respiratory gas\(^1,2\). Proper conditioning of respiratory gas to near 100% relative humidity and body temperature allows for the administration of high flow rates without damaging the nasal mucosa\(^3,5\). The high flow rates interact with the mechanisms of spontaneous breathing to improve ventilatory efficiency and therefore reduce work of breathing. Evidence suggests that the mechanisms of action for HFNC include purging nasopharyngeal dead space\(^6\), reducing inspiratory resistance, improving conductance and pulmonary compliance\(^7\), providing mild positive distending pressure\(^8,10\) and restoring mucociliary function through rehydration\(^11,12\).

HFNC is used on a widespread basis within the intensive care setting for ventilatory support to reduce the patient’s work of breathing and to alleviate dyspnea. It has consistently been used as a stopgap measure to treat patients in respiratory distress, and as an alternative to pressure based non-invasive ventilation that results in similar outcomes\(^11,14\). While both HFNC and supplemental oxygen are typically initiated as frontline therapies, clinical experience indicates that the numerous mechanisms of action for HFNC provide a higher level of support than simple oxygen therapy\(^15,16\).

Clinical experience with HFNC in multiple care settings shows it is easily tolerated, simple to administer and monitor, and rapidly stabilizes patients in distress. This experience suggests that HFNC may have meaningful impact on care, workflow and economics in the Emergency Department (ED) setting. Several recent articles have evaluated the performance of HFNC specifically in the ED including both pediatric\(^17,18\) and adult applications\(^11,16\), as well as three editorial comments\(^19,21\).

Although there is sufficient rationale for the adoption of HFNC in emergency care, the utilization within and impact on ED workflow has yet to be described. The goal of the current study was to ascertain ED staff opinions on the utility, practicality and value of HFNC in emergency care, and to help develop hypotheses for future research related to HFNC therapy and patient outcomes. The authors represent the clinical staff from six hospitals where HFNC was being introduced into the ED as a front line therapy. The hypothesis was that HFNC would have a positive impact on emergency care based on ED staff
perceptions of the effectiveness in providing respiratory support among various pulmonary pathologies, the practicality of use in the ED setting and the influence on patient disposition.

**Methods**

**Study Design**

A multicenter study was designed to assess staff perceptions on the utility and value of HFNC in the ED setting. This study was conducted during a period in which HFNC was being introduced into the ED at the participating centers. The study was part of a quality assessment in each institution as to the early impact of HFNC in the ED. The data was collected by having attending staff respond to a set of assessment questions each time they administered HFNC in the care of an ED patient. The respondents were instructed to complete the assessment document as close to the time of HFNC initiation as appropriate in order to improve recall of their perceptions. The form used for data collection was designed for rapid completion, where staff perception information was collected using a Likert-type scale, and judgments were reported by circling choices.

From May of 2013 through March of 2014, six hospitals in four systems across four states (Georgia, Texas, Tennessee, and North Carolina, USA) participated in the project. Each center already used HFNC in the Intensive Care Units and respiratory staff was trained and competent in its delivery. Application of HFNC was by clinician discretion on a case-by-case basis; there were no defined inclusion criteria for this project. All data represent staff self-reported perceptions related to device utility, including presumed diagnoses at the time of HFNC initiation and perceptions regarding disposition options; no actual patient information was used in this study.

**Application of HFNC**

Participating centers used the Precision Flow® HFNC system (Vapotherm, Exeter, NH, USA), and prior to initiation of the project agreed upon HFNC application guidelines for use in the ED. The application guidelines, shown in Figure 1, provided a set of decision trees for determining starting cannula flow rates and inspiratory oxygen fractions, as well as recommendations for increasing these parameters. The two decision trees were differentiated by early indications of whether hypoxia or work of breathing was the primary symptomology, and initial application differed by the starting oxygen fraction. Starting inspiratory oxygen fraction was set at 100% for hypoxia and 50% for increased work of breathing. HFNC was always initiated as a front line respiratory support modality, and pressure-based...
therapies were recommended for patients failing to respond to HFNC. Real-time decision-making was always at the discretion of attending staff.

Recording Assessment and Clinical Perceptions
To classify the clinical perceptions across the various conditions warranting HFNC use, respondents were asked to choose responses related to:

- If they had followed or deviated from the HFNC application guidelines (e.g., by using a higher or lower initial flow or oxygen fraction).
- The presentation symptomology that lead to the choice to use HFNC for the patient: hypercapnia, hypoxemia and/or increased work of breathing (WOB).
- The working ED diagnosis as presumed at the time HFNC was initiated (not necessarily the patient’s confirmed diagnosis): Chronic Obstructive Pulmonary Disease (COPD), Congestive Heart Failure (CHF), Chronic Respiratory Failure (CRF), Drug Over Dose (OD), Asthma or General Dyspnea.

To assess attending staff’s perceptions of HFNC performance and utility for each patient application, the following questions were asked. The responses were given in the format of a Likert-like scale between 1 and 5, where 5 represented ideal and 1 represented disappointment.

- Patient respiratory response to therapy, ranging from Excellent (5) to Insufficient (1).
- Frequency of rain-out, interface slippage or other technical/clinical difficulties applying therapy, ranging from Never (5) to Frequent (1).
- Patient comfort and tolerance of therapy, ranging from Excellent (5) to Insufficient (1).
- Simplicity of set-up and use, ranging from Simple (5) to Complex (1).
- Monitoring and support of therapy required (adjustments, refilling fluids, adjusting interface), ranging from Minimal (5) to Frequent (1).

To assess the impact of HFNC on workflow and disposition, staff were asked to report the decisions on patient disposition from the ED. Responses included patients’ post ED assignment to either the intensive care unit (ICU), be released to a medical floor (Floor), discharged from the hospital (Discharge) or some other arrangement (Other).

Data Analysis
Data were compiled in a single database to represent overall staff perceptions across all centers. Data on working diagnosis and decisions on disposition are presented as incidence and percentage of total cases, while categorical data on staff feedback are presented as median ± 95% Confidence Interval (CI), mode and range. Data were analyzed using MedCalc statistical software, v 13.3.0.0 (MedCalc Software bvba, Belgium).

Results
A total of 128 assessments were completed across the six participating centers as shown in Table 1. Seventy-two (56%) respondents reported the adopted application guidelines were followed, 8 (6%) reported they deviated from the application guidelines were followed, 8 (6%) reported they deviated from the application guidelines were followed, and 48 (38%) did not report on this question.

Table 1: Responses by center

<table>
<thead>
<tr>
<th>Center</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens Regional Medical Center</td>
<td>68</td>
</tr>
<tr>
<td>Memorial Herman Texas Medical Center</td>
<td>16</td>
</tr>
<tr>
<td>Baroness Erlanger</td>
<td>16</td>
</tr>
<tr>
<td>Memorial Herman Northeast</td>
<td>11</td>
</tr>
<tr>
<td>Mission Hospital</td>
<td>9</td>
</tr>
<tr>
<td>Memorial Herman The Woodlands</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2: Presentation Symptomology

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxemia</td>
<td>94</td>
<td>74</td>
</tr>
<tr>
<td>Hypercapnia</td>
<td>32</td>
<td>25</td>
</tr>
<tr>
<td>Combined Failure</td>
<td>28</td>
<td>22</td>
</tr>
<tr>
<td>Increased WOB</td>
<td>108</td>
<td>84</td>
</tr>
</tbody>
</table>

n = total number of cases for each condition, where the n > 128 HFNC uses because of cases who had multiple presentations; % relative to the n per the total 128.

Table 3: Subjective Performance Ranking per Staff Response

<table>
<thead>
<tr>
<th>Category</th>
<th>n</th>
<th>Range</th>
<th>Mode</th>
<th>Median</th>
<th>95% CI</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient respiratory response</td>
<td>127</td>
<td>1 - 5</td>
<td>5</td>
<td>4.0</td>
<td>4.0 to 5.0</td>
<td></td>
</tr>
<tr>
<td>Technical difficulties</td>
<td>123</td>
<td>1 - 5</td>
<td>5</td>
<td>5.0</td>
<td>5.0 to 5.0</td>
<td></td>
</tr>
<tr>
<td>Comfort and tolerance</td>
<td>118</td>
<td>1 - 5</td>
<td>5</td>
<td>5.0</td>
<td>4.1 to 5.0</td>
<td></td>
</tr>
<tr>
<td>Simplicity</td>
<td>123</td>
<td>1 - 5</td>
<td>5</td>
<td>5.0</td>
<td>5.0 to 5.0</td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td>122</td>
<td>1 - 5</td>
<td>5</td>
<td>5.0</td>
<td>4.0 to 5.0</td>
<td></td>
</tr>
</tbody>
</table>

Scores represent the perception responses on a Likert scale where 5 was the ideal situation and 1 was least desirable. n = total number of reports with a response to the question.
Respiratory Therapy

against medical advice (5%). This trend for a majority of Medical small number of patients who were discharged to home or left all diagnoses, the majority of cases resulted in a discharge to where HFNC was administered in the ED (Figure 3). Across Staff reported the post ED disposition decisions for 94 cases (95% CI of the median 4 to 5, range 1 to 5). 

Decisions on Disposition

requirement for monitoring during therapy, with a median of 5.0 (95% CI of the median 5 to 5, range 1 to 5). Anecdotal instances was confounded with CHF in 21 cases (40% of all COPD) and CHF was confounded with pneumonia in 1 case (6% of all CHF).

Perception of HFNC Performance

Table 3 shows the range, median and mode subjective staff rating given for each of the five performance categories related to HFNC use. Patient respiratory response was perceived to be more than adequate, with a modal score of 5 and a median score of 4 (95% CI 4.0 to 5.0, range 1 to 5). There were minimal technical difficulties reported, with only four instances reporting average or below with respect to perceived technical challenges. Median rating for perceived technical competence was 5.0 (95% CI 4.3 to 4.6, range 1 to 5), with a mode of 5.

Comfort and tolerance of the therapy by the patient were rated very highly across the group with a median 5 out of 5 (95% CI of the median 5.0 to 5.0, range 1 to 5). Anecdotal instances (assessed via the free-text comment section of the collection tool) of mechanical ventilation avoidance were reported in patients who may have been intubated secondary to being intolerant of a full-face non-invasive ventilation mask. Simplicity of use was rated highly, with a median of 5.0 (95% CI of the median 5 to 5, range 1 to 5), as was the perception of a minimal requirement for monitoring during therapy, with a median of 5.0 (95% CI of the median 4 to 5, range 1 to 5).

Decisions on Disposition

Staff reported the post ED disposition decisions for 94 cases where HFNC was administered in the ED (Figure 3). Across all diagnoses, the majority of cases resulted in a discharge to the Medical Floor (54%) compared to the ICU (41%), with a small number of patients who were discharged to home or left against medical advice (5%). This trend for a majority of Medical Floor admissions held through each presumed diagnosis and presentation category, where COPD was associated with 65% floor admission, CHF with 50%, a hypercarbia presentation with 57% and hypoxemia with 55%. The ratio of Floor to ICU admissions was 1.43:1 across all responses, 2.2:1 for COPD, 1.28:1 for CHF, 1.45:1 for hypercarbia and 1.33:1 for hypoxemia.

Discussion

The goal of this project was to identify the impact of introducing HFNC to the ED department based on ED staff perceptions and resultant patient disposition following treatment with HFNC in the ED. The focus was on application, staff acceptance and patient disposition. A secondary objective was to define a hypothesis for a prospective clinical trial of patient outcomes and value using HFNC as a ventilatory support modality in the ED. The situations in which the staff felt HFNC should be used as a treatment modality represented a typical spread of clinical presentations for this geographical region (South and South Eastern United States), and no one set of respiratory symptomologies emerged as particularly responsive or unresponsive to HFNC. However, HFNC does appear to be contraindicated for patients under the influence of a drug overdose, and thus depression of respiratory drive. This is in line with the primary indication for HFNC that the patient is able to breathe spontaneously and protect his/her airway.

Overall, staff perceived excellent success with HFNC to affect respiratory response and to achieve patients’ satisfaction and compliance. Few instances occurred where staff felt that patients were unable to be supported by HFNC, and in no circumstances did staff perceive that patients were unable to tolerate the therapy. In the majority of cases, staff made decisions to admit HFNC patients to the general care floors, as opposed to the ICU. Guidelines for non-invasive ventilation, and the common practice in all participating centers, recommend ICU admission for patients on NIV.22,23 It is likely that any avoidance of NIV resulted in a meaningful change to workflow and total cost of care based on patients being admitted to lower acuity care areas instead of the ICU.

A number of case reports were generated for presentation from the current project (abstracts). One instance involved a complex 60 year-old COPD patient with lung cancer, chronic renal failure and CHF, presenting in combined failure, and who was intubated with similar presentations on prior visits. The medical team was anticipating intubation when HFNC was trialed; however, moments after initiation of HFNC the patient began to return toward normal respiratory values with a markedly reduced work of breathing. The medical team concluded that this patient avoided intubation and her exacerbation was successfully mitigated through use of HFNC, despite failing non-invasive ventilation. A second patient presenting with orthopnea and acute onset of severe respiratory distress, have a respiratory rate near 50 breaths/min, was initially treated with non-invasive ventilation via full facemask. She was started on HFNC in an effort to oxygenate prior to intubation; however, rapidly following HFNC initiation her respiratory rate dropped to 12 breaths/min. The effort to intubate was successfully aborted.

The responses reported in this paper demonstrate that the use of HFNC within the ED setting is not only feasible, but has the potential to dramatically improve patient experience during acute exacerbations of respiratory disease. Nonetheless, Esquinas and Martin point out that while HFNC as a first
line intervention in the ED is practicable, there are no good randomized controlled trial data to indicate that HFNC is effective in the applications where non-invasive ventilation is normally used. A defined goal of this project was to support the development of a sound hypothesis for a prospective randomized controlled trial. The data here indicate that a comparison of HFNC to non-invasive ventilation in the ED may be warranted, as opposed to a comparison with front line oxygen therapies.

Limitations of this project are that the data are purely observational and not directed by a protocol for application in any specific conditions or patient population. There was no control group for a comparison to conventional standard of care, and historical data from each center proved difficult to abstract given that care and disposition would need to be inferred from billing codes. Additionally, not every case treated by HFNC during the assessment period was represented in the data set, and thus the possibility exists that complicated cases were not included.

In conclusion, this project resulted in an understanding that HFNC is perceived to be valuable in the ED setting and perhaps more analogical to non-invasive ventilation versus oxygen therapies. Moreover, the clinical use guidelines established and presented herein were generally effective and acceptable to clinical staff. The authors recommend these use guidelines as a starting point for the establishment of uniform clinical practice guidelines. Lastly, these observations led to a hypothesis to evaluate HFNC against non-invasive ventilation in the ED setting for patients in respiratory distress.

References