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Nasal High Flow Oxygen in Respiratory Failure

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ABBREVIATIONS:
BMI = body mass index
EELV = end-expiratory lung volume
FiO2 = fraction of inspired oxygen
FRC = functional residual capacity
HFNC = high flow nasal cannula
ICU = intensive care unit
nHFO = nasal high flow oxygen
PaCO2= partial pressure of carbon dioxide in the arterial blood
PaO2 = partial pressure of oxygen in the arterial blood
Paw = airway pressure
Vt = tidal volume

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ABSTRACT

High flow nasal cannula system or nasal high flow oxygen is an oxygen delivery device which administers heated, humidified high flow oxygen with concentrations from 21% to 100% and with a flow rate up to 60 L/min in adults. It generates many physiologic effects to respiratory system with a lot of clinical applications. Indeed, greater comfort and tolerance, more effective oxygenation, and improved breathing pattern with increased tidal volume and decreased respiratory rate and dyspnea have constantly been detected. Therefore, it can be used to improve cardiogenic pulmonary edema and hypoxemic respiratory failure of any cause, postoperatively, during post-extubation, as well as for palliative care.

INTRODUCTION

Oxygen in patients with hypoxemia is traditionally delivered either through low-flow devices (such as nasal cannula, non-rebreathing masks, and masks with reservoir bags) or through high-flow systems (such as Venturi masks). Low-flow devices deliver varying levels of fraction of inspired oxygen (FiO_2) depending on the patient's breathing pattern, peak inspiratory flow rate, delivery system and mask characteristics. High-flow devices provide a more constant FiO_2 but they are less well tolerated than nasal cannula and are dislodged more easily. Heating and humidifying of inspired oxygen is limited with both low- and high- flow devices, especially in maximal flow rates. Additionally, at high patient's inspiratory flow rates entrained room air dilutes the oxygen and lowers FiO_2.

An alternative to conventional oxygen therapy is the high flow nasal cannula (HFNC) system [or nasal high flow oxygen (nHFO) therapy], which delivers FiO_2 from 21% to 100% with a flow rate up to 60 L/min in adults. The device consists of an air/oxygen blender connected through an active heated humidifier to the nasal cannula of large diameter, through a single limb, heated, inspiratory circuit. It allows adjustment of the FiO_2 independently from the setting flow rate so that the patient is given a heated, humidified high flow oxygen, above its maximum inspiratory flow providing thus with confidence about the real FiO_2 being delivered to the patient. Several studies have shown that HFNC generates a low level of positive airway pressure, improves oxygenation, increases the end-inspiratory lung volume, reduces airway resistance, increases functional residual capacity (FRC) and flush nasopharyngeal dead space, thus helping to

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manage the acute respiratory failure from all causes. It is also better tolerated and more comfortable than conventional oxygen treatment. Finally, pulmonary defense mechanisms are restored. Herein, we review the literature for the physiologic effects of HFNC, its clinical applications in adults and the advantages or disadvantages of its use.

Nasal High Flow Oxygen (nHFO) Therapy is Associated with the Generation of Significant Positive Airway Pressure in Volunteers which is Flow Dependent and also Dependent on Whether the Patient is Breathing With Mouth Open or Closed

In a group of 10 healthy volunteers, a 10-French catheter was placed into the oropharynx and nHFO was initiated. Pharyngeal pressures were recorded during intranasal flows from 0 to 60 L/min with the mouth open and closed. As flow rates increased, expiratory pharyngeal pressure (EPP) increased also with both the mouth open and closed (P<0.001). EPPs were statistically higher (P<0.001) with the mouth closed compared with the mouth open. EPP tended to be higher among females than male subjects for both open (P<0.05) and closed (P<0.001) measurements. Female's facial features with smaller nares may have attributed to their higher EPPs because of less leak. Inspiratory pharyngeal pressures (IPP) increased with increasing flow rates with both the mouth open and closed (P<0.001) and although the IPP was significantly higher than no flow at 20, 40 and 60 L/min for both mouth open and closed measurements, values were not statistically different between open and closed mouth. IPPs were statistically different between genders with the mouth open (P<0.05) but not with the mouth closed. The authors concluded that nHFO generates significant expiratory positive pressure which appears to be flow dependent and influenced by whether the person is breathing with mouth open or closed. nHFO could be used as an alternative to non-invasive ventilation as it may be a comfortable, requires less patient cooperation, whilst still providing high inspired oxygen levels and positive pressure (Groves N et al, *Australian Critical Care* 2007;20**:**126-131).

Warm and Humidified Air through Nasal High Flow Oxygen (nHFO) System Improves Lung Mucociliary Clearance in Patients with Bronchiectasis

Patients with the diagnosis of idiopathic bronchiectasis underwent assessment of their mucociliary clearance from the retention of inhaled 99mTc-labelled polystyrene tracer particles, before (baseline) and after receiving warm and humidified air through nHFO system for 6 hours. Humidification resulted in significant and sustained enhancement of lung clearance (P=0.02 at 6 hours) compared with baseline assessment. After the end of the 6-hour treatment period with humidified air, the sputum wet weight was lesser, and after 7 days of treatment the number of coughs was slightly but non-significantly reduced. Although, differences were statistically non-significant, all lung function indices slightly improved following humidification compared with baseline assessment. The authors concluded that warm air humidification treatment improves lung mucociliary clearance in bronchiectatic patients (Hasani A et al, *Chronic Respiratory Disease* 2008; 5: 81–86).

In Cardiac Surgery Patients, the Mean Nasopharyngeal Pressure during Nasal High Flow Oxygen (nHFO) Increases as Flow Increases

In 15 cardiac surgery patients, a 10-French catheter was inserted via the nose to nasopharynx and nHFO was started after extubation. Nasopharyngeal airway pressure measurements were then performed with the patient's mouth open and closed, at flows of 30, 40, and50 L/min. Between mouth open and closed, there were statistically significant pressure differences at each flow. There was a positive linear relationship between flow and pressure, whilst the slope was lower with mouth open than with mouth closed. In the mouth-closed position, for every 10 L/min increase in gas flow, the mean pressure increased by 0.69 cmH_2O (P = 0.01). In the mouth-open position, for every 10 L/min increase in gas flow, the mean pressure increased by 0.35 cmH_2O (P=0.03). The resistance to expiration that is generated by the patient breathing out against the continuous incoming gas flow is the main mechanism for this positive airway pressure. The authors concluded that in cardiac surgery patients, there was a positive linear relationship between flow and airway pressure during nHFO which may extend the role of oxygen therapy by delivering low-level positive airway pressure (Parke RL et al, *Respir Care* 2011;56:1151-1155).

High Flow Nasal Cannulas (HFNCs) Reduce Respiratory Rate and Improve Oxygenation by Increasing Both End-Expiratory Lung Volume and Tidal Volume and are Most Beneficial in Patients With Higher Body Mass Indices (BMIs)

Post-cardiac surgery patients with respiratory distress and PaO_2/FiO_2 ratio <300 requiring oxygen therapy were recruited. When compared with a low-flow oxygen device, oxygen through HFNC increased mean airway pressure (Paw) by 3.0 cmH_2O (P<0.001), the end-expiratory lung volume (EELV) by 25.6% (P<0.001) and the tidal volume (Vt) by 10.5% (P<0.001). Patient's mouth, open or closed, did not affect EELV or Paw. A strong and significant correlation was found between Paw and EELV (r=0.7, P<0.001). The increased EELV and Vt resulted in improvement of $PaO_2/FiO_2$by 30.6% (P<0.001) even though 95% of patients were receiving an equal or lower FiO_2 while on HFNC than on low-flow oxygen. Additionally, with HFNC, respiratory rate was lowered by 3.4 bpm (P<0.001) and the Borg dyspnea score by 0.8 points (P=0.023) compared to low-flow oxygen. Body mass index (BMI) significantly influenced the positive effect of HFNC on EELV (P<0.001)

with higher BMI resulting in greater improvements of EELV. The authors concluded that HFNC may be a useful treatment option for post-cardiac surgery patients experiencing respiratory dysfunction, generating clinically relevant increases in Paw, EELV and Vt, particularly in patients with higher BMIs. These changes are associated with reduced respiratory rate, less dyspnea, and improved oxygenation (Corley A et al, *Br J Anaesth*2011;107:998-1004).

High Flow Nasal Cannula (HFNC) has a Beneficial Effect on Respiratory Rate, Heart Rate, Dyspnea Score and Oxygenation Indices in ICU Patients With Acute Respiratory Failure Without Any Significant Side Effects

Efficiency, safety and outcome of oxygen therapy with HFNC were evaluated in ICU patients with acute respiratory failure and signs of respiratory distress who were previously treated with oxygen through a non-rebreathing mask. Use of HFNC was associated with a significant reduction in respiratory rate, heart rate, dyspnea score, supraclavicular retraction and thoraco-abdominal asynchrony (both being signs of respiratory distress), and a significant improvement in pulse oximetry. These improvements were seen within the first 30 minutes after the beginning of HFNC (except for the heart rate which improved within the first 6 hours) and lasted throughout the study period. The PaO_2/FiO_2 ratio was significantly improved at 1 and 24 h when compared with the value observed before use of HFNC (P =0.036) without any significant increase in pH (P =0.87) and $PaCO_2$ (P =0.77) on arterial blood gases throughout the study period. No unexpected side effect was reported and intolerance was never a cause of HFNC cessation. Average duration of HFNC use was 2.8 ± 1.8 days (maximum 7 days). A total of 24% of patients required intubation and invasive mechanical ventilation while on HFNC. After HFNC beginning, predictors of HFNC failure were a higher respiratory rate at 30 min (29.1±3.8 vs. 24.6±5.8; P =0.05), lower SpO_2 at 15 and 30 min (92.7±10.1 vs. 98.4±2.2, P =0.007 and 94.2±7.8vs. 97.8±2.6, P =0.0035, respectively), a lower PaO_2/FiO_2 ratio at 1 h (90.7±33.1 vs. 200.6±111.7; P =0.008) and a greater proportion of thoraco-abdominal asynchrony at 15 min. The authors concluded that HFNC shows a favorable effect on clinical signs and oxygenation in critical care patients with acute respiratory failure. An early lack of decrease in respiratory rate and persistence of thoraco-abdominal asynchrony are early and simple indicators of HFNC failure (Sztrymf B et al, *Intensive Care Med* 2011;37:1780–1786).

Nasal High Flow Oxygen (nHFO) May be More Effective Than Standard Oxygen Through Unhumidified High-Flow Face Mask in Treating Mild to Moderate Hypoxemic Respiratory Failure Reducing the Need for Non-Invasive Ventilation

Patients with mild to moderate hypoxemic respiratory failure were randomly allocated to receive humidified high-flow oxygen via either nHFO system or unhumidified high flow face mask (standard face mask). More nHFO than standard face mask patients succeeded on their allocated therapy (P=0.006). The rate of noninvasive ventilation in the nHFO group was 10%, compared with 30% in the standard face mask group (P=0.10). Although baseline SpO_2 was similar between the two treatment groups, the nHFO group had significantly fewer desaturations compared to the standard face mask group (42% vs 71%, respectively; P=0.009).PaO_2/FiO_2 ratio, ICU and hospital stay did not differed significantly between the two groups. The authors concluded that the nHFO system was more successful than the standard face mask in the treatment of mild to moderate hypoxemic respiratory failure. They attributed the difference in the use of noninvasive ventilation to the positive pressure delivered by the nHFO system (Parke RL et al, *Respir Care* 2011;56:265–270).

Nasal High Flow Oxygen (nHFO) Can Improve Arterial Blood Gases and Dyspnea in Patients With Refractory Hypoxemia Due to Acute Pulmonary Edema Secondary to Heart Failure

Patients with respiratory failure due to acute pulmonary edema who were initially treated with non-invasive ventilation or developed refractory hypoxemia to conventional oxygenation methods, received oxygen through high flow nasal cannula (HFNC) at high flow rates (60L/min). After 24 h of treatment with the HFNC system PaO_2, SaO_2, heart rate and respiratory rate showed significant improvement (P<0.001, P=0.42, P=0.024, and P=0.002, respectively) without any deterioration in $PaCO_2$values. In patients with moderate or severe dyspnea, the intensity of the condition improved significantly, becoming mild in 80% of the patients. The HFNC system was well tolerated with only 2 patients feeling tracheal discomfort, which was self-limited. The mean duration of treatment with HFNC was 62.4±21.4 hours. The authors concluded that the use of HFNC system is a good alternative to traditional oxygenation systems for the treatment of patients with refractory hypoxemia due to acute pulmonary edema secondary to acute heart failure. The system is well tolerated and produces significant clinical arterial blood gases improvements (Carratala Perales JM et al, *Rev Esp Cardiol* 2011;64:723–725).

During Bronchoscopy, Both the Venturi Mask and HFNC at Flow Rate of 40 L/Min Behave in a Similar Way, but HFNC at 60 L/min Flow Produce Better Oxygenation and Could be Used in Patients With Mild Respiratory Dysfunction

Patients without respiratory failure ($SpO_2 \geq 90\%$) undergoing fiberoptic bronchoscopy and bronchoalveolar lavage (BAL) fluid collection as a diagnostic tool for pulmonary disease, were randomly assigned to 3 groups of oxygen administration

during the procedure: Venturi mask at 40L/min (V40), HFNC at 40L/min (N40) and HFNC at 60L/min (N60). FiO_2 was set to 50% in all 3 groups. At the end of bronchoscopy, in the N60 group, $PaO_2/FiO_2$and SpO_2 were larger than those in V40 and N40 groups, while in V40 and N40 they did not differ. No differences in pH, $PaCO_2$, heart rate and mean arterial pressure values were found among the 3 groups. Ten minutes after the end of bronchoscopy, SpO_2 between N60 andV40 was the only detected significant difference. There was no difference in the level of comfort among the three groups (P =0.569). In an extra group of normal volunteers, end-expiratory airway pressure amounted to 3.6 (2.4–4.0) cmH_2O using HFNC at flow rates of 60 L/min while no measurable end-expiratory pressure was detected with HFNC at 40L/min and Venturi mask at 40L/min. The authors concluded that during bronchoscopy, where hypoxemia is commonly found, HFNC at flow rates of 60 L/min could protect patients to a larger extent, especially those with mild respiratory dysfunction (Lucangelo U et al, *Crit Care Res Pract* 2012;20:365-382).

The Use of nHFO is Associated With a Lower Respiratory Rate, Higher Oxygen Saturation, and Improved Comfort Scales Compared to Conventional Oxygen Therapy in a Group of Patients With Hypoxemia in the Emergency Department

To all patients with hypoxemic respiratory failure who presented at the emergency department and remained dyspneic despite aggressive conventional treatment in parallel with administration of supplemental oxygen through face mask, oxygen through HFNC was initiated. Compared to the variables at hour zero, while receiving oxygen therapy through face mask, HFNC was associated with a significant decrease in dyspnea intensity in both the Borg score [6 (5-7) vs 4 (3-4); P<0.05] and the Visual Analog Scale [7 (5-8) vs 5 (2-6); P<0.05] as early as 15 min. After 15 min, respiratory rate decreased significantly (P<0.05) and SpO_2 increased significantly (P<0.01). These beneficial effects were maintained throughout the next hour with fewer subjects on HFNC exhibiting clinical signs of respiratory distress (P<0.03). All patients but one stated greater comfort with HFNC than with the face mask and only two of them declared having been disturbed by the noise. Objective sound level measurement indicated that HFNC generated the same noise as face mask (55 dB vs 50 dB respectively). The great majority of caregivers (76%) declared preferring HFNC as it seems more efficient than conventional oxygen therapy through the face mask and because patients feel more comfortable with this device. The authors concluded that HFNC could constitute a first line therapy for selected patients presenting to the emergency department with acute respiratory failure with rapid and sustained alleviation of dyspnea and improvement in oxygenation while it seems to be well tolerated and more comfortable to use than conventional oxygen therapy via a face mask (Lenglet H et al, *Respir Care* 2012;57:1873–1878).

HFNC Can Provide Adequate Oxygenation for Do-Not-Resuscitate (DNR) Patients With Hypoxemic Respiratory Failure and May be an Alternative to Non-Invasive Ventilation

Patients with do-not-resuscitate (DNR) resuscitation status who develop respiratory failure are commonly treated with noninvasive ventilation. In this study, nHFO was initiated to those patients instead of noninvasive ventilation and it was found that breathing frequency decreased from 30.6 breaths/min to 24.7 breaths/min (P <0.001) and mean oxygen saturation improved from 89.1% to 94.7% (P <0.001), without significant difference on $PaCO_2$ values. 18% of subjects escalated to noninvasive ventilation, while 82% were maintained on nHFO until improvement or withdrawal of support. Among the 18% who progressed to noninvasive ventilation, 67% died, versus 58% among those who did not receive noninvasive ventilation (P=0.72). nHFO was well tolerated, with no episodes of nasal bleeding or facial skin breakdown. The authors concluded that nHFO can provide adequate oxygenation for many patients with hypoxemic respiratory failure, and may be an alternative to noninvasive ventilation for DNR patients or patients who decline intubation (Peters SG et al, *Respir Care* 2013;58:597–600).

Nasal High Flow Oxygen (nHFO) Increases Functional Residual Capacity, Regardless of Body Position. With nHFO Administration, Regional Ventilation is More Homogenous in Prone Position, While in Supine Position Ventilation was Higher in the Ventral Lung Regions

Oxygen through HFNC at a constant flow of 40 L/min was applied to 20 healthy volunteers and regional ventilation was estimated through electrical impedance tomography (EIT). Good correlations have been found between changes in end-expiratory lung impedance (EELI) and changes in EELV. In supine position, global EELI increased by 1.26 units (P<0.001) when HFNC was applied, compared to ambient air breathing and decreased by 1.30 (P<0.001) when the subject breathed ambient air again. In prone position, similar changes in global EELI with HFNC were observed. EELI increased by 0.87 units (P<0.001) during the HFNC application and decreased by 1.03 units (P<0.001) when it stopped. In supine position, higher values of regional EELI were observed in the ventral versus dorsal lung regions while on HFNC compared to ambient air breathing (P<0.001). In prone position, a more homogeneous pattern of regional EELI variation was observed, with a non-significant increase in EELI in the ventral regions versus dorsal regions. Breathing frequency decreased while on HFNC by a mean of 2.73 breaths/min (P=0.02) in supine position and by a mean of 7.89 breaths/min (P<0.001) in prone position. The authors concluded that administration of nHFO therapy may help to develop new management strategies for hypoxemic respiratory failure through significant increment of EELI, a

fact that suggests an increment of functional residual capacity in both supine and prone positions with simultaneous decrement of the breathing frequency in both positions (Riera J et al, *Respir Care* 2013;58:589-596).

Compared with the Venturi Mask, nHFO Results in Better Oxygenation for the Same Set FiO_2 After Extubation, Better Patient Comfort, Fewer Desaturations and a Lower Reintubation Rate

A total of 105 patients mechanically ventilated for more than 24 hours were randomized after their extubation to Venturi mask or nHFO if the PaO_2/FiO_2 ratio was <300 at the end of spontaneous breathing trial. The PaO_2/FIO_2ratio was significantly higher with nHFO compared to Venturi mask at 24 hours (287.2± 74.3mm Hg vs 247.4± 80.6 mm Hg; P =0.03) and at 48 hours (313.3±83.8 mm Hg vs 250.2±110.1 mm Hg; P =0.01).Respiratory rate was always significantly lower with the nHFO, with a mean difference of 4±1 breaths/min. Vital signs (heart rate and mean arterial blood pressure) did not differ between groups. Using a 10-point numerical rating scale (0=no discomfort to 10=maximum discomfort), nHFO compared to Venturi mask was associated with a lower discomfort related to mouth dryness (3.6±2.5 vs 5±3.1; P =0.016), throat dryness (2.7±2.4 vs 4.5±3.3; P =0.002), difficulty to swallow (2.5±2.6 vs 4.1±3.4; P =0.007) and throat pain (1.7±2.1 vs 3.1±3.4; P =0.008) during the 48-h study period. Fewer patients in the nHFO group had episodes of oxygen desaturation, detected electronically (39.6% vs 75%; P<0.001) and by nurses (18.9% vs 51.9%; P<0.001). 7.5% of the patients on nHFO group developed post extubation respiratory failure requiring any form of ventilator support versus 34.6% in the control group (P <0.001). Specifically, fewer patients received non-invasive ventilation (P=0.04) and required endotracheal intubation (P <0.01) with the nHFO than with the Venturi mask. The authors concluded that as compared with the Venturi mask, the use of the nHFO system in the post-extubation period results in better oxygenation for the same set FIO_2. In addition, nHFO decreases respiratory rate, while improving patient comfort and reducing episodes of oxygen desaturation. Also nHFO in the post-extubation period is associated with less need for any kind of ventilator support (Maggiore S et al, *Am J Respir Crit Care Med* 2014;190:282-288).

Nasal High Flow Oxygen (nHFO) Improves Survival in Patients With Acute Hypoxemic Respiratory Failure But it Does not Improve Intubation Rates

A total of 310 patients with acute hypoxemic respiratory failure were randomized to receive oxygen therapy either through a non-rebreathing face mask, nHFO or they received non-invasive mechanical ventilation. The intubation rate at day 28 was 38% in the nHFO group, 47% in the non-rebreathing mask group, and 50% in the non-invasive ventilation group (P = 0.18).The intervals between enrollment and intubation, as well as the reasons for intubation, did not also differ significantly among the 3 groups. In the subgroup of patients with a PaO_2/FiO_2 of 200 mmHg or less, the intubation rate was significantly lower in the nHFO group than in the other 2 groups. The hazard ratio for death at 90 days was 2.01 in the non-rebreathing mask group as compared with the nHFO group (P=0.046) and 2.50 in the non-invasive ventilation group as compared with the nHFO group (P=0.006).The number of ventilator-free days at day 28 was significantly higher in the nHFO group than in the other two groups(24±8 days, vs 22±10 in the standard oxygen group and 19±12 in the non-invasive ventilation group; P=0.02 for all comparisons).The authors concluded that treatment with nHFO improved the survival rate among patients with acute hypoxemic respiratory failure, even though no difference in the intubation rate was observed with nHFO therapy, as compared with standard oxygen therapy through a non-rebreather mask or non-invasive ventilation (Frat JP et al, *N Engl J Med* 2015;372:2185-2196).

During Intubation, nHFO Significantly Improves Preoxygenation and Reduces the Prevalence of Severe Hypoxemia Compared With Non-Rebreathing Bag Reservoir Facemask, Thus Potentially Improving Patient Safety

A total of 101 adult patients requiring endotracheal intubation in an ICU were divided to receive preoxygenation for 3 minutes either through a non-rebreathing face mask or through nHFO cannula. The decrease in SpO_2 during intubation was greater in the face mask group as evidenced by the lowest values of SpO_2 reached in each group (94% vs 100%; P<0.0001). These lowest values were received at the end of preoxygenation period. After adjustment for significant baseline covariates, such as reason for intubation or difficulty of intubation, the difference remained significant (94% vs 99%; P=0.007). The prevalence of severe hypoxemia, defined by a SpO_2 less than 80% during the procedure, was significantly lower in the nHFO group (2% vs 14%; P=0.03). In multivariate analysis, preoxygenation with nHFO was an independent protective factor of the occurrence of severe hypoxemia (P=0.037). The authors concluded that use of nHFO for preoxygenation significantly reduced the prevalence of severe hypoxemia during intubation compared with face mask in ICU patients (Miguel-Montanes R et al, *Crit Care Med* 2015;43:574-583).

HFNC was not Shown to Reduce the Need for Non-Invasive or Invasive Mechanical Ventilation in Emergency Department Subjects With Acute Respiratory Distress Compared With Standard Oxygen Therapy Although it Reduced the Need for Escalation of Oxygen Therapy Within the First 24 h of Admission

Patients presenting at the emergency department with respiratory failure (SpO_2 ≤92% on air or ≤90% on air if there is a

known history of CO_2 retention) were randomized to receive oxygen through HFNC or through standard methods (Venturi mask, Hudson mask, nasal prongs). There was no difference between the groups in the proportion of subjects requiring non-invasive ventilation or invasive positive-pressure ventilation in the emergency department: 3.6% in the HFNC group vs 7.3% in the standard O_2 group (P=0.16).There was also no difference in the emergency department or hospital length of stay, with a median of 4.5 hours in the HFNC group vs 4.9 hours in the standard O_2 group (P=0.32) and 5.0 days in the HFNC group vs 5.6 days in the standard oxygen therapy (P=0.43), respectively. Mortality at 90 days was similar between the 2 study groups: 21.2% in the HFNC group compared to 17.4% in the standard oxygen delivery group (P=0.40). Nose or mouth dryness was significantly lesser in HFNC group (29.8% vs 45.3%; P=0.046). The authors concluded that HFNC was not shown to reduce the need for mechanical ventilation in the emergency department for subjects with acute respiratory distress compared with standard oxygen therapy. However, HFNC may reduce the need for escalation of oxygen therapy within the first 24 h of admission (Jones PG et al, *Respir Care*2015 Nov 17. pii: respcare.04252. [Epub ahead of print]).

Other articles

Nasal high flow oxygen (nHFO) has also been investigated or reviewed in the following articles: 1) Diaz-Lobato S et al, *Respir Care* 2013;58:e164-e167; 2) Chatila W et al, *Chest* 2004; 126:1108–1115; 3) Spoletini G et al, *Chest* 2015; 148: 253-261; and 4) Gotera C et al, *Rev Port Pneumol* 2013;19:217-227.

CONCLUSION

Benefits of nasal high flow oxygen (nHFO) over conventional oxygen therapy have been reported in almost all studies. Indeed, greater comfort and tolerance, more effective oxygenation, and improved breathing pattern with increased tidal volume and decreased respiratory rate and dyspnea have constantly been documented. Therefore, nHFO can be used as an intermediate therapy to improve cardiogenic pulmonary edema and hypoxemic respiratory failure of any cause, postoperatively, during post extubation, as well as for palliative care. However, in order to make recommendations, there is a great need for further research with physiologic and randomized controlled studies to determine its clinical use in relation to traditional methods of oxygenation and mechanical ventilation.