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Medical Science

HIGH FLOW NASAL OXYGEN- ALL YOU SHOULD KNOW

KEY WORDS: HFNO, COVID 19, PEEP, Fio2

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INTRODUCTION:

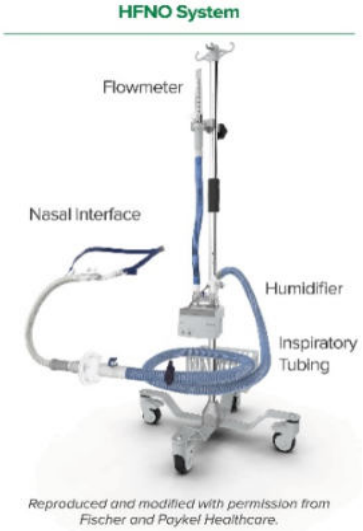
Respiratory support is applied to maintain adequate oxygenation and ventilation and hence supplemental oxygenation is the first line of treatment for hypoxemic respiratory failure. There are multiple conventional oxygen support devices. However, in majority of these, oxygen provided is not humidified and maximum flow rate is 15l/min. However, high flow nasal oxygen (HFNO) is an alternative to conventional oxygen therapy. It is a technique that delivers heated and humidified oxygen with a controlled fraction of inspired oxygen(FiO2) at a maximum flow rate of 60L/min via a specialized nasal cannula. [1]

Use of HFNO for acute respiratory failure has been considered for more than a decade now. Although it came into limelight for adults during the last two years when ICU beds and ventilators got occupied by the havoc of COVID-19 pandemic and it is during this time that HFNO came a lot handy.

Thus, the purpose of this article is to provide the clinicians recent information about HFNO and to discuss it's pros as well as cons.

COMPONENT PARTS OF HFNO: [2]

i. Electrically powered high pressure oxygen/air supplements(ideally with a blender to blend air into gas flow)
   It is set up between FiO2 21% to 100%
ii. Flowmeter at up to 60litre/min
iii. Humidifier
iv. Wide bore tubing to deliver the gas
v. Specialized wide bore nasal cannula: each cannula should snugly fit into the patient's nares.



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MECHANISM:

HFNO actually takes the gas and can heat it to 37 degrees Celsius with a 100% FiO2 at the flow rates of upto 60l/ min which can be independently titrated. [3]

HFNO improves the fraction of inspired oxygen and washes and reduces the dead space, generates PEEP and provides more comfort than cold and dry oxygen.

Through such an open circuit we cannot expect high end expiratory pressure but it reportedly creates PEEP and may increase the EELV (end expiratory lung volume). [4]

As an open system with constant flow HFNO is able to deliver a constant amount of vapour. Only when HFNO flow is more than patient's inspiratory flow with optimally positioned nasal prongs than only patient is inspiring well-conditioned gas. Thus, also there is little entrainment of room air. [5]

EFFECTS OF HFNO:

A. Humidification: Breathing in dry air causes excessive water loss by nasal mucosa which reduces the nasal mucociliary clearance rate. Also, occasionally high flow dry gas results in inspissated secretions which leads to life threatening airway obstruction.

HFNO deliver well-conditioned gas to the patients. It also usually incorporates a heated circuit to avoid losing vapor in condensation though some condensation is inevitable. [5]

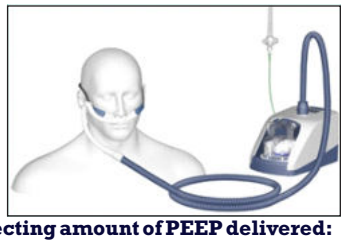
Proper conditioning minimizes airway constriction, decreases work of breathing, increases mucociliary clearance and facilitates clearance of secretions.

B. Physiological effect: HFNO neither pushes/pulls gas, consequently it does not facilitate Vt and minute ventilation. High flow in the form of positive airway pressure washes out carbon dioxide in the anatomical dead space and thus assists the process of O2 diffusion into the alveoli. Also, there is better thoraco-abdominal synchrony. Thus, there is decreased work of breathing (WOB) and hence decreased respiratory rates. [6]

C. Interface: Compared to other devices, HFNO has appropriate interface which offers a better balance between oxygenation and comfort. It is well tolerated by the subjects. Also, simple nasal prongs enable the patient to eat, speak and drink.

D. PEEP effect: HFNO generates a varying PEEP level. In healthy volunteers treated with HFNO with a closed mouth and flow rate of 60l/min the PEEP is approximately 7cm H2O. However, PEEP decreases with mouth opening. [7]

HFNO has been shown to deliver up to 1mmhg of PEEP for every 10litre/min if flow is delivered with closed mouth breathing. [4]



Factors affecting amount of PEEP delivered:

- Patient's size(obese, adult, child)
- Flow rate delivered
- Mouth opening/closed

Also, as PEEP increases; Intrathoracic pressure increases and thus preload decreases.

Roca et al demonstrated in a sequential interval study on 10 patients (NYHA III heart failure but not in an acute CHF exacerbation) that HFNO can cause inspiratory collapse of the inferior vena cava as compared from the previous echocardiogram.[8]

BENEFITS OVER NIV/OTHER CONVENTIONAL OXYGEN DELIVERY SYSTEMS:

- NIV interface increases the anatomical dead space. Whereas HFNO decreases the dead space.
- Decreases incidence of air leakage.
- Improves alveolar ventilation.
- Decreased incidence of skin lesions at nose, nasal trauma, pressure ulcers. It is more comfortable and results in extended tolerance.
- Effective delivered oxygen concentration is controlled as there is less entrainment of room air.
- Because of proper humidification it minimizes airway constriction, decreases the work of breathing and improves mucociliary function.

CLINICAL SIGNIFICANCE:

HFNO has many clinical applications**:**

A. AHRF(Acute Hypoxemic Respiratory Failure):

In hypoxemic respiratory failure HFNO may produce a lower intubation rate than standard oxygen and non-invasive ventilation in most patients.

In a study conducted by Frat et al. which was a randomized control trial. Conducted on patients of AHRF, who were assigned to receive HFNO, standard oxygen or NIV. almost similar percentage in each of these were intubated, however similar and lower rates in the subgroup of patients with PaO2/FiO2 <200mmhg of intubation were seen in those with HFNO.

Also, HFNO group had significant lower mortality.[9]
According to Messika et al. subjects with ARDS when primarily applied HFNO, 40% were subsequently intubated.[10]

Based on many previous studies, it was found that HFNO application decreases breathing frequency, heart rate, dyspnea score and supraclavicular retraction with improved thoraco-abdominal synchrony and SpO2.[5]

Thus, we can conclude that HFNO can be promising for early treatment in AHRF but as the intubation rates are high, we will need more evidence to guide further choices.

B. PRE-INTUBATION OXYGENATION:

Pre-oxygenation before intubation is essential and HFNO can be provided for this in an alert awake patient thus increasing the pO2. This ensures pO2 maintenance during intubation and elongates the time span for intubating especially in difficult intubation.

Besnier, Emmanuel et al. 2016 suggested that HFNO is superior to both NIV and NRM in pre-intubation period.[11]

Miguel-Montanes et al. conducted a study on 101 patients of ICU comparing spO2 during intubation on bag reservoir mask and HFNO where high saturation during intubation was achieved by HFNO.[12]

Thus, HFNO can be used successfully during the apneic period of tracheal intubation as nasal cannulas do not interfere with laryngoscopy.

C. POST-EXTUBATION:

HFNO provides good oxygen support for stepping down, that is post-extubation.

Maggiore et al. conducted a trial comparing Venturi mask and HFNO post-extubation in 105 ICU patients and concluded that post extubationPaO2/FiO2 ratio was higher in those on HFNO.[13]

Also, previous studies concluded that the risk of re-intubation decreased with HFNO.

D. POST SURGERY SETTING:

Hypoxemia frequently occurs after major surgery and expiratory complications are second most common complications after surgery.

HFNO is a valuable alternative to Non-invasive ventilation to prevent acute respiratory failure in post-surgical setting as evidenced by previous studies.[12]

E. HYPERCAPNIC RESPIRATORY FAILURE:

This is a very common problem found in the ICU's and for such patients the primary modality of support turns out to be NIV.HFNO can turn out to be a good alternative modality in the patients who are unable to tolerate the conventional modes of NIV.

Although, some previous studies suggested that when applying HFNO on patients with hypercapnic respiratory failure – it led to improvement of pCO2 in some whereas resolved tachypnea in some but these need further evaluation by proper RCT's. In stable COPD patients it has been observed to increase the exercise capacity.[5]

F. OBSTRUCTIVE SLEEP APNEA(OSA):

CPAP is the most effective treatment for OSA. However, McGinley et al. found that HFNO can alleviate upper airway obstruction in children whereas it decreases the arousals and AHI (Apnea Hypopnea Index) in children as well as adults.[14]

G. ACUTE HEART FAILURE / PULMONARY EDEMA:

Moriyama et al. has reported a case of life-threatening reperfusion pulmonary edema who has successfully maintained his saturation on HFNO.[15]

H. HFNO and COVID-19:

HFNO may be effective for treating COVID-19 disease with mild to moderate acute hypoxemic respiratory failure.

According to a study conducted by Jingen Xia et.al[16] on 43 patients, they demonstrated that 20 patients experienced HFNO failure of which 13 patients required endotracheal intubation, 6 later received NPPV and 1 died. HFNO failure was defined as upgrading respiratory support to NPPV or IPPV or death after HFNO treatment. In cases of HFNO success, they showed higher oxygenation levels on admission. Thus, concluding that HFNO may be an effective respiratory support for covid-19 patients with mild to moderate Acute hypoxemic respiratory failure and also that the failure of HFNO indicates poor prognosis. HFNO use may reduce the need for tracheal intubation.

At a study conducted at Sodersjukuset,[17]Stockholm on 41

patients treated on HFNO concluded that HFNO treatment would be useful outside the ICU mostly as a stepping down oxygen support as the patients are stabilized which is very important for offloading the ICU's.

PROBLEMS ASSOCIATED WITH HFNO:

- Expensive than the conventional oxygen support systems.
- Complex mechanism and needs trained persons.
- Cannot monitor the Vt delivered and as well as the pressures.
- Identifying patients who are going to benefit with HFNO is a challenge.
- Could delay intubation and thus delay critical lifesaving decisions.
- As the high pressures cannot be monitored and there are no safety valves in adult machines – cases of pneumothorax/ pneumomediastinum have been observed.[5]

CONTRAINDICATIONS:

- Intra-cranial space communications like Skull based fractures or CSF leak.
- Pneumothorax which has been treated with a chest tube
- Nasal obstruction (complete)
- Recent FESS
- Disrupted airways like laryngeal fracture or tracheal rupture.[2]

CONCLUSION:

HFNO is a novel respiratory support as it has a number of clinical applications.it can be used in children as well as adults.it has proven its worth in COVID -19 scenario and has gained a lot of attention. Although, some further studies are implicated for its application in hypercapnic respiratory failure and acute heart failure.

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