Practice Point

High Flow Nasal Cannula Oxygenation

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The current pandemic of COVID-19 caused by novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) tested the healthcare infrastructure throughout the globe at all possible levels. Early reports suggest about 20% of patients infected with SARS-CoV-2 require hospitalization and 5-8% require admission to intensive care unit (ICU) due to severe disease.^{1,2} Supplementation of oxygen provided by various conventional oxygen therapy (COT) devices (like nasal prongs, face mask, venture mask or non-rebreather mask) may not be sufficient in cases of worsening respiratory failure. One form of escalating respiratory support in such patients is a high flow nasal oxygenation device. High flow nasal cannula oxygenation (HFNC) is a form of non-invasive respiratory support^{3,4}. It acts as a bridge between low flow devices and non-invasive ventilation and may reduce the need for intubation.

Limitations of conventional oxygen supplementation devices^{3,4}

- Due to flow limitation COT devices are not able to provide higher flow required by patients in respiratory failure, resulting in entrainment of room air and reduction in delivered FiO_2 .
- Due to lack of adequate humidification, COT devices provide dry and cool oxygen that can lead to airway inflammation and impaired mucocilliary function which can increase airway resistance and reduced secretion clearance.

High flow nasal cannula (HFNC) oxygenation

HFNC oxygenation device provides high flow oxygenated

gas that is heated and humidified to body condition and is delivered via a special nasal cannula at higher flow rates (10-60 l/min).

Mechanisms of Clinical benefit with HFNO³

- **Heated and humidified air**

In contrast to COT devices, HFNC provides heated and humidified air which helps in maintaining airway hydration, prevents airway desiccation and epithelial injury thereby preserving mucocilliary function.

- **Higher flow rates**

HFNC by virtue of its higher flow rate (~60 L/min) prevents entrainment of room air and therefore provides higher and more reliable FiO_2 . Besides, higher flow rate is also associated with reduction in inspiratory effort, work of breathing and upper airway dead space due to continuous flushing of CO_2 from nasopharynx.

- **Positive end expiratory pressure (PEEP) effect**

HFNC delivers a PEEP of upto 1cm of H_2O for every 10L/min of flow delivered with closed mouth breathing. This PEEP effect can potentially counteract the auto-PEEP, thereby, increasing alveolar recruitment and improving oxygenation.

Advantages of HFNO

HFNC as compared to COT devices and NIV is more comfortable and better tolerated. NIV requires a properly fit

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interface (mask) which in turn hinders clearance of secretions, oral intake, communication as well as proper positioning during awake self-proning.

Uses of HFNO^{5,6,7}

Oxygenation with HFNC has been shown to have similar and in some cases superior clinical efficacy as compared to COT and NIV. Various clinical scenarios where HFNO has been used include.

- **Management of acute hypoxemic respiratory failure in immunocompromised patients:** Immunocompromised patients with hypoxemic respiratory failure that require intubation have higher mortality. Use of HFNC was associated with significant reduction in rate of intubation and mortality as compared to COT and NIV.
- **Preventing reintubation:** Oxygenation with HFNC reduces the rate of reintubation as compared to COT in low risk medical patients, where as in high risk patients HFNC was non inferior to NIV.
- **Post operative respiratory failure:** HFNC is a reasonable alternative to NIV and COT for treating postoperative respiratory failure and preventing reintubation especially after cardiothoracic, abdominal and lung resection surgeries.
- **Pre-oxygenation:** HFNC has also been used in providing pre-oxygenation to prevent desaturation during endo-tracheal intubation.
- **To facilitate interventions like bronchoscopy:** Patients with hypoxemic respiratory failure are prone to significant desaturation during the bronchoscopy. HFNC can provide respiratory support and reduce the duration and severity of hypoxemia during the procedure.
- **Adult respiratory distress syndrome (ARDS):** Few studies have demonstrated the successful use of HFNC in patients with moderate to severe ARDS.

Precautions

Use of HFNC is considered to be associated with aerosol generation and therefore has potential to spread the infection among health care workers. However use of negative pressure rooms, high energy particulate

accumulator (HEPA) filters, adequate personal protective equipment (PPE) and surgical mask or an N-95 mask over HFN cannula are sufficient to reduce the transmission of infection.⁸

Components of HFNC device and how to set it up^{4,9}

The HFNC apparatus comprises of following components (Fig.1)

- **Humidifier:** Provides heated and humidified gas to the patient through heated inspiratory circuit.
- **Air-Oxygen blender:** At air /oxygen blender, the inspiratory fraction of oxygen (FiO₂) can be adjusted from 21% to 100%.
- **Flow meter:** Allows adjustment of oxygen flow rate upto 60 L/min.
- **Nasal cannula**

Inspiratory circuit: Connects the humidifier with the nasal cannula.

Fig.1: Various components of HFNC device (Source: Wikipedia)

Fig.2: Various adjustable parameters on device (temperature, flow rate and FiO₂).

Setting up of a device

- **Choosing appropriate size cannula:** Nasal cannula should fit well into the nares; however prongs should not totally occlude the nostrils and should allow ample egress of expired gas. A tight fitting nasal cannula can lead to uncomfortably higher distending pressure in nasopharynx.
- **Setting Flow rate:** Maximum physiological benefit of HFNO is achieved at higher flow rates. Although there is no standard way to set the flow rate, an approach that is frequently used in clinical practice is to initiate the flow of 30L/min. Lower flow is preferred in case of COVID-19 to reduce aerosol generation unless higher flows are required to treat respiratory failure.
- **FiO₂:** FiO₂ is set next to achieve a desired peripheral oxygen concentration. **(88-92% in patients underlying COPD, 92-96% for others)**
- **Temperature:** For optimum humidification of air the temperature is set at 37°C. However if there is rain out in the humidifier circuit tubing it may be necessary to reduce the set temperature to 34-35°C.

Patient's respiratory rate (RR), peripheral oxygen saturation (SPO₂) and breathing pattern is monitored continuously. In case there is no improvement in oxygen saturation, reduction in respiratory rate or respiratory distress, flow rate is increased at an increment of 10L/min till desired oxygenation target is achieved. If maximum tolerable flow rate fails to improve oxygenation, FiO₂ is adjusted to achieve same.

Predictors of failure of HFNO

Patients requiring HFNO are at risk of severe respiratory failure, therefore it should be preferably used in areas with facility for close monitoring and intubation if need arises. Indicators of failure include.

- Increasing respiratory rate and heart rate.
- Failure to achieve a target oxygenation despite a high flow rate and FiO₂
- Rising PaCO₂ level.
- Dys-synchronous breathing
- Alteration in mental status and

- Hemodynamic instability.

Use of ROX index (defined as ratio of oxygen saturation as measured by pulse oximetry/FiO₂ to respiratory rate) has been suggested to predict success or failure of HFNC. ROX index more than 4.88 at 12 hours after HFNO predicts success and less likely-hood of intubation where as score less than equal to 3.85 at 12 hour predict failure with 100% specificity.¹⁰

Weaning from HFNO

HFNO is well tolerated and can be used for prolonged periods. Shifting of patient from HFNO to COT can be considered once the flow rate reaches to < 20L/min and FiO₂ of < 50%.

CONCLUSION

HFNO is better tolerated and more comfortable than COT and NIV. Its use may reduce the need of intubation or escalation of respiratory support as compared to COT. Therefore HFNO should be considered in patients with persistent respiratory failure despite COT.

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