



High-Flow Nasal Cannula, a Boon or a Bane for COVID-19 Patients? An Evidence-Based Review

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Abstract

Purpose of Review This review instantiates the efficacy and safety of HFNC in the context of COVID-19 pandemic.

Recent Findings Globally, the healthcare system is facing an unprecedented crisis of resources due to the 2019 novel coronavirus disease (COVID-19) pandemic. Fever, cough, dyspnea, myalgia, fatigue, and pneumonia are the most common symptoms associated with it. The incidence of invasive mechanical ventilation in ICU patients ranges from 29.1 to 89.9%. Supplemental oxygen therapy is the main stay treatment for managing hypoxemic respiratory failure. The high-flow nasal cannula (HFNC) is a novel non-invasive strategy for better oxygenation and ventilation in critically ill patients. In this grim scenario, a reduction in mechanical ventilation by means of HFNC is of prime interest

Summary HFNC is considered an aerosol-generating intervention with the risk of viral aerosolization with a concern of potential nosocomial transmission of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2). However, there is no consensus regarding the use of HFNC in novel coronavirus-infected pneumonia (NCIP). HFNC seems to be an effective and safe treatment modality in acute respiratory failure with optimal settings and selection of ideal patients.

Keywords COVID-19 · SARS-CoV-2 · HFNC

Introduction

The 2019 novel coronavirus disease (COVID-19), caused by severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), is the burning issue worldwide with an unprecedented crisis in healthcare systems. Fever, cough, dyspnea, myalgia, fatigue, and radiological corroboration of pneumonia are the most common symptoms associated with it. Acute respiratory infection due to COVID-19 is termed as novel coronavirus-infected pneumonia (NCIP) [1]. The initial

reports from China indicate severe clinical conditions in 14% of patients, and intensive care is required in 5% of patients [2]. The incidence of invasive mechanical ventilation in ICU patients ranges from 29.1 to 89.9% [3].

Supplemental oxygen is the cornerstone for managing hypoxemic respiratory failure. The use of a nasal cannula, bag valve masks, non-rebreathing masks, or any other low flow devices prompts entrainment of room air as the inspiratory flow rates in quiet breathing (30 L/min) surmounts the possible maximum supplemental oxygen flow of these devices (15 L/min), resulting in limiting the delivered FiO₂ during respiratory distress (>100 L/min) [4].

The high-flow nasal cannula (HFNC), delivering 60 L/min warm, humidified oxygen with precise titration of FiO₂ through nasal prongs, has emerged as a popular non-invasive strategy for better oxygenation and ventilation in critically ill patients by prevailing over the flow limitation of the low flow devices [5].

HFNC has been found to be beneficial for avoiding intubation in acute hypoxaemic respiratory failure patients in comparison with conventional oxygen devices. However, the majority of the studies are not in the context of COVID-19 pandemic, and bio-aerosol dispersion due to the high gas

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flow is a serious concern. Thus, the aim of this review is to address the efficacy and safety of HFNC in COVID-19.

Overview of Action

HFNC provides a flow-dependent FiO_2 by reducing room air entrainment through a greater flow than inspiratory demand (Fig. 1) [7]. An increase in flow from 15 to 45 L/min results into a subsequent rise in FiO_2 from 0.60 to 0.90 [8].

It reduces the work of breathing by washing out the carbon dioxide (CO_2) from the upper airways, thereby diminishing the anatomical dead space [9]. The anatomic dead space is found to be reduced significantly from 20 to 60 cc with a concomitant increase in flow from 15 to 45 L/min [10].

HFNC ensures better mucociliary clearance by providing heated and humidified oxygen. The optimally conditioned oxygen reduces the work of breathing also and provides better conductance and compliance in comparison with dry and cooler one. [11, 12]

It also provides low-level positive pressure. A flow of 50 L/min provides a mean airway pressure between 1.7 cm H_2O (mouth open) and 3.3 cm H_2O (mouth closed) [13]. The increase in end-expiratory lung volumes provides better alveolar recruitment and thereby reduces the risk of atelectasis and improves the oxygenation. However, as most of the patients in respiratory distress tend to breathe with an open mouth, the effect may not be evident [14].

In comparison with non-invasive ventilation (NIV), the oral intake, and toileting of secretions, communication is not hindered with HFNC [6].

Relevance in COVID-19

The SARS-CoV-2 virus is mediated by angiotensin-converting enzyme 2 (ACE2) receptor, which is abundantly expressed in the alveolar epithelial cells [15, 16]. Initially, the virus replicates in the epithelium of the upper airways. With further multiplication, it infiltrates the pulmonary parenchyma, causing an inflammatory response by means of vasodilation, increased endothelial permeability, and leukocyte recruitment, resulting in focal pneumonia and thereby hypoxemia [17].

At present, two types of NCIP are recognized. The L type presents with a lower lung elastance along with normal lung compliance. On the contrary, The H type manifests as classic ARDS with, low compliance, increased extravascular lung water, and high elasticity [18, 19].

The HFNC has a potential role for reducing the requirement of intubation in both the phenotypes, preferentially in L type as it is capable to meet the higher oxygen demand by means of providing heated and humidified oxygen 21 to 100% up to 60 L/min [6].

The Evidence So Far

HFNC undoubtedly has better patient compliance [20]. In comparison with NIV for providing a tidal volume of 7 to 10 mL/kg, the use of HFNC (50 L/min; FiO_2 , 100%) in patients with $\text{PaO}_2/\text{FIO}_2 < 200$ results has been associated with lower intubation rate (50%, 38%, respectively) and mortality rate (49%, 30%, respectively) [21].

Fig. 1 Schematic diagram of high-flow nasal cannula (HFNC) [6]

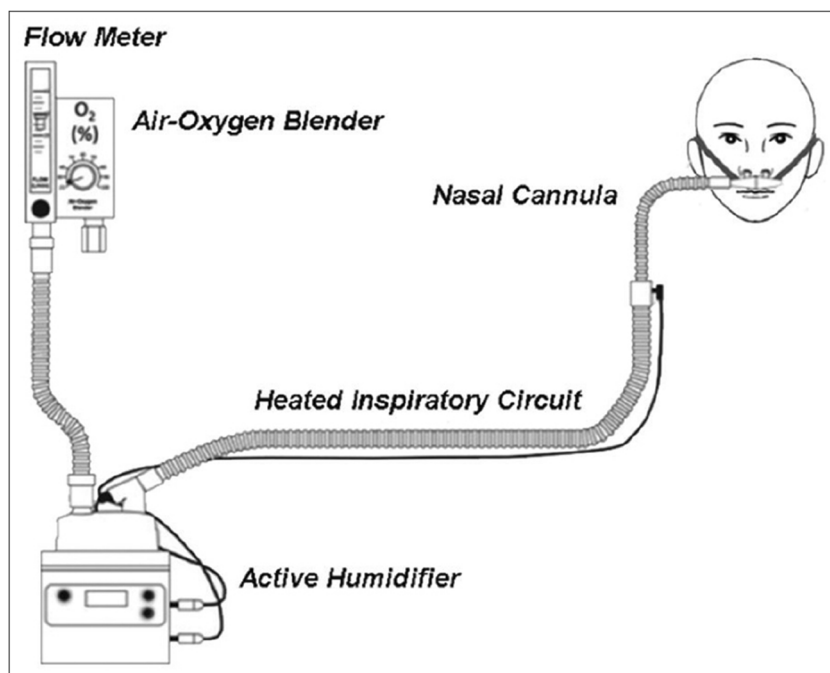


Table 1 Efficacy of high-flow nasal cannula (HFNC) in COVID-19 patients

Author/year	Type of study	HFNC (n)	Success	NIV/IV	Death
Ke Wang et al., 2020 [25•]	Retrospective Observational study	17	10	7	
Ming Hu et al. [26•]	Retrospective Observational study	105	65	9/15	16
Wang Y et al., 2020 [27]	Retrospective Observational study	35	7	-	28
S. Geng et al., 2020 [28]	Case series	8	8	-	-
Yang X et al., 2020 [29]	Retrospective Observational study	33	17	-	16
Zhou F et al.2020 [30]	Retrospective cohort study	41	8	-	33
Liao X et al., 2020 [31]	Retrospective Observational study	31	25	-	6
Luo X et al., 2020 [32]	Retrospective Observational study	106	32	-	74

HFNC High-flow nasal cannula, NIV non-invasive ventilation, IV invasive ventilation

HFNC is found to be non-inferior to NIV for reintubation in patients after cardiac surgery [22] as well as extubation after acute respiratory failure [23].

A recent systematic review has reported that HFNC may reduce the requirement of mechanical ventilation in comparison with conventional oxygen therapy (RR, 0.71; 95% CI 0.51 to 0.98; $I^2 = 52%$) with a potential risk of airborne transmission. However, the included studies are not providing direct evidence regarding COVID-19 [24•].

Wang et al. reported that HFNC was the most common ventilation support for patients with NCIP in China.

However, patients with $PaO_2/FiO_2 < 200$ were associated with HFNC failure. [25•]

Another retrospective study from China reported HFNC as an effective therapeutic modality in 61.9% of severe COVID-19 patients. The respiratory rate-oxygenation index (ROX index $SpO_2/FiO_2 \times RR > 6.10$ at 24 h after starting HFNC was a good predictor for positive outcome [26•].

Globally, the COVID-19-related respiratory failure is constraining the ICU resources and mechanical ventilators. In this grim scenario, a reduction in mechanical ventilation by means of HFNC is of prime interest with a potential risk

Table 2 Recommendations of different International Societies for High-Flow Nasal Cannula (HFNC) in COVID-19 patients [33, 34]

Organization/country	Recommendation	Comment
AAMR, Argentina [33]	HFNC	Pro
ANZICS (Australia/New Zealand) [35]	HFNC	Suggest
AIPO (Italy) [36]	Helmet CPAP	-
CTS (China) [37]	HFNC	Pro
ESICM/SCCM (EU/US) [38]	HFNC	Pro
German recommendations for critically ill patients with COVID-19 (Germany) [39]	Helmet NIV	Restricted
Irish Thoracic Society, (Ireland) [33]	HFNC	Pro
National Healthcare System Guidelines, (UK) [40]	CPAP	HFNC contra indicated, no benefit but risk
SEPAR (Spain) [41]	HFNC	Maintain > 2-m distance
SPP (Portugal) [42]	HFNC	Pro
US Department of Defense COVID management guidelines [33]	HFNC	Pro
US Surviving Sepsis Campaign/SCCM [33]	HFNC	HFNC next modality for patient's not tolerating supplemental O ₂
WHO [43••]	HFNC	Not for: COPD, cardiopulmonary edema, hemodynamic instability

AAMR Asociación Argentina de Medicina Respiratoria, AIPO Associazione Italiana Pneumologi Ospedalieri, ANZICS Australian and New Zealand Intensive Care Society, CTS Chinese Thoracic Society, ESICM European Society of Intensive Care Medicine, SCCM Society of Critical Care Medicine, SPP Sociedade Portuguesa de Pneumologia, SEPAR Sociedad Española de Patología Respiratoria

of nosocomial transmission of SARS-CoV-2. The clinical evidence in this regard is still evolving (Table 1) [27–32].

Controversy

At present, there is no consensus regarding the use of HFNC in NCIP across the eminent organizations (Table 2). In view of potential aerosol-generating modality, some guidelines are skeptical about it. Some institutions strongly favor early intubation in view of the suspected high failure rate of non-invasive approaches in COVID-19 that often lands in to crash intubation, resulting in an increased risk of contracting SARS-CoV-2 in caregivers. The alternative opinion is the use of adequate personal protective equipment (PPE), high-energy particulate accumulator (HEPA) filters, negative-pressure rooms are sufficient for protection. Additionally, the non-invasive approaches help in avoiding unnecessary intubations and well-known aerosol generators thereby protecting the staff and ensuring optimal utilization of resources [33, 34].

The WHO guidelines advocate for HFNC prior to intubation in the overall plan of management [43••]. Similarly, the surviving sepsis guidelines of SCCM also recommend for HFNC over non-invasive ventilation during conventional oxygen therapy failure [38].

HFNC is considered an aerosol-generating intervention with the risk of viral aerosolization. The dispersion is maximum at 60 L/min; however, the smoke dispersion distance from the manikin is similar to a simple oxygen mask at 15 L/min [44].

The use of a proper fitting nasal cannula, along with a droplet mask placed over the nasal interface with a high limit of 30–40 L/min, preferably in a negative-pressure room is beneficial for reducing the risk of dispersion of aerosol [6, 45••].

HFNC Failure

The application of HFNC demands vigilant monitoring as unanticipated intubation bears an increased risk of aerosol exposure. Tachypnoea, tachycardia, inadequate oxygenation despite a high-flow rate, altered sensorium, and hypercarbia are the signs of impending failure. Roca et al. [46••] suggested that a high specificity for ROX score < 3.85 at 12 h is associated with failure.

Conclusion

HFNC is an easy and safe treatment modality in acute respiratory failure with multiple physiological benefits. However,

further studies regarding optimal settings, initiation, selection of patients, and duration of therapy are the need of the hour.

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Compliance with Ethical Standards

Conflict of Interest None of the authors has any potential conflicts of interest to disclose.

Permissions NA

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- Of importance
- Of major importance

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