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Review Article

# High-Flow Nasal Cannula (HFNC): An Advanced Respiratory Support System

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## Abstract

High-Flow Nasal Cannula (HFNC) therapy has revolutionized oxygen delivery by providing heated, humidified oxygen at high flow rates, offering significant advantages over conventional oxygen therapy (COT) and non-invasive ventilation (NIV). Originally developed for neonates, HFNC is now widely used in adult respiratory care, particularly in managing acute respiratory failure and post-COVID-19 complications. It improves oxygenation, reduces work of breathing, and enhances patient comfort. Despite its higher cost and some limitations, HFNC has proven to be an effective and well-tolerated modality in various clinical scenarios, with ongoing research exploring its full potential.

**Keywords:** HFNO, hypoxemic failure, ARDS.

## Introduction

The administration of supplemental oxygen through a nasal cannula is a fundamental aspect of conventional oxygen therapy (COT). Traditional nasal cannulas are commonly used, but they come with significant limitations, particularly in high-flow oxygen delivery. The inability to provide adequate heating and humidification, along with insufficient inspiratory flow, often results in patient discomfort and reduced treatment efficacy. To address these shortcomings, the high-flow nasal cannula (HFNC) was developed as an advanced oxygen delivery system capable of providing heated and humidified oxygen at high flow rates.

Initially designed for neonates to minimize pressure sores while maintaining effective oxygenation, HFNC has since gained widespread use in adult patients across various clinical settings. This article explores the physiological effects, benefits, limitations, and clinical applications of HFNC, particularly in the post-COVID-19 era.

## HFNC Setup and Components

HFNC is a user-friendly device designed to provide a consistent oxygen flow while ensuring patient comfort. Its key components include:

### *Oxygen and air source*

Supplies gas for the system.

### *Flow meter*

Regulates the flow of oxygen up to 60 L/min.

### *Air-oxygen blender*

Adjusts the FiO2 from 21% to 100%, irrespective of flow rates.

### *Heated humidifier*

Provides 100% body humidity to maintain airway moisture.

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### *Single-limb heated tubing*

Prevents condensation and heat loss.

### *Soft, wide-bore nasal cannula*

Enhances comfort and reduces the risk of pressure sores.

Setting up HFNC involves selecting the appropriate nasal cannula and circuit based on patient size, ensuring a free-flowing sterile water supply, and securely fitting the nasal cannula in the patient's nares. The FiO2 and flow rate are adjusted as per the patient's requirements.

## Physiological Benefits of HFNC

HFNC offers several physiological advantages over conventional oxygen therapy and non-invasive ventilation (NIV). These include:

### *Consistent FiO2 Delivery*

Unlike standard nasal cannulas, HFNC delivers a stable and controlled oxygen concentration without dilution from ambient air.

### *Positive End-Expiratory Pressure (PEEP) Generation*

The high flow of gas creates PEEP, preventing alveolar collapse and enhancing oxygen exchange. The effectiveness of PEEP depends on whether the patient breathes with an open or closed mouth.

### *Reduction of Anatomical Dead Space*

HFNC helps clear expired CO2 from the airways, reducing the work of breathing.

### *Enhanced Mucociliary Clearance*

Heated and humidified gas maintains mucosal integrity, reducing dryness and irritation.

### *Reduced Work of Breathing*

Studies have shown HFNC decreases respiratory effort and improves lung mechanics compared to conventional oxygen therapy.

**Table 1:** Comparison of HFNC, Conventional Oxygen Therapy (COT), and Non-Invasive Ventilation (NIV)

| *Feature* | *COT* | *HFNC* | *NIV* |
|---|---|---|---|
| FiO2 Range | 21–40% | 21–100% | 21–100% |
| Comfort | Good | High | Lower |
| Flow Rate | 1–15 L/min | 1–60 L/min | 1–180 L/min |
| Humidification | No | Yes | Yes |
| Effect on Dead Space | None | Reduced | Increased |
| PEEP Generation | No | Flow-dependent | Independent of flow |
| Eating and Speaking | Possible | Possible | Not possible |
| Risk of Pressure Sores | Low | Low | High |
| CO2 Washout | Minimal | Moderate | High |
| Risk of Lung Injury | Low | Low | Higher |

## The ROX Index: Predicting HFNC Success

The respiratory rate-oxygenation (ROX) Index is a useful tool for determining the need for intubation in patients receiving HFNC. It is calculated as the ratio of SpO2/FiO2 to respiratory rate. A ROX index between 4.2 and 5.4 is associated with a favorable response to HFNC. Studies indicate that this index has good predictive power in COVID-19 patients, aiding clinicians in early decision-making.

## Clinical Applications of HFNC

HFNC has diverse applications in both emergency and critical care settings. Some of its key uses include:

## Acute Respiratory Failure (Type I and II)

HFNC is an effective first-line therapy for Type I respiratory failure, offering superior comfort and oxygenation compared to COT. Although studies like the FLORALI trial did not show a reduced intubation rate with HFNC, they did demonstrate improved survival in patients with acute hypoxemic respiratory failure. Its role in Type II respiratory failure, particularly in COPD patients, is still under investigation, with some evidence suggesting it may improve PaCO2 levels and hospital stay duration.

## Pre-Oxygenation for Intubation

HFNC has been used to optimize oxygenation before intubation, reducing desaturation risks. Studies suggest that while HFNC improves oxygenation compared to non-rebreather masks, its effectiveness over bag-mask ventilation remains inconclusive.

## Post-Extubation Respiratory Support

HFNC is an excellent alternative to NIV for post-extubation support in high-risk ICU patients. Research has shown that HFNC is non-inferior to NIV in preventing reintubation and is better tolerated by patients.

## Apneic Oxygenation During Airway Management

HFNC can provide continuous oxygenation during airway procedures, reducing the risk of desaturation. However, its superiority over NIV remains a subject of debate.

## Use in Immunocompromised Patients

The efficacy of HFNC in immunocompromised patients is controversial. While some studies indicate no significant survival benefit over COT, others suggest a reduction in mortality and intubation rates.

## End-of-Life Care

HFNC is a viable option for palliative care patients, providing comfort and reducing respiratory distress. Retrospective studies indicate that HFNC can improve oxygenation in do-not-intubate patients, though mortality rates remain high.

## HFNC in COVID-19 Pneumonia

HFNC played a crucial role in managing COVID-19 pneumonia, offering an effective balance between oxygenation and patient comfort. Concerns about aerosol generation

were later addressed, revealing that HFNC posed no greater risk than standard oxygen therapy. The SOHO-COVID trial found that while HFNC reduced intubation rates, it did not significantly impact 28-day mortality.

## Limitations and Contraindications of HFNC

### *Contraindications*

- Skull base fractures
- Recent nasal or upper airway surgery
- Severe nasal obstruction
- Hemodynamic instability
- Upper airway obstruction

### *Limitations*

- Higher cost compared to standard nasal cannula
- Potential for delayed intubation in critically ill patients
- This may lead to inappropriate delays in end-of-life decisions

### *Complications*

- Epistaxis
- Discomfort
- Pneumothorax (neonates)
- Gastric distension
- Secretion blockage in nasal cannula

## Cost-Effectiveness and Patient Comfort

Studies suggest that HFNC is a cost-effective alternative to high-flow face masks. It is also better tolerated than NIV, leading to improved patient compliance. Research indicates that HFNC reduces device-related costs while enhancing patient outcomes and comfort levels.

# Conclusion

HFNC has emerged as a valuable respiratory support system, offering numerous physiological benefits and improved patient tolerance. While it has shown promise in acute respiratory failure, post-extubation care, and COVID-19 pneumonia, its efficacy in certain populations, such as immunocompromised patients, remains debated. Future studies with larger sample sizes are needed to refine its clinical applications further. Despite some limitations, HFNC continues to gain traction as an effective alternative to both COT and NIV in modern respiratory care.

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