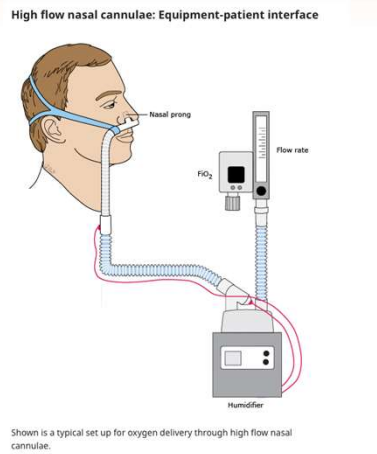
HIGH FLOW OXYGEN THERAPY

Stephen Tunnell



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DISCLOSURES

- Lungtreater CRO
  - Fluidics devices for Ventilation – Technical File creation/ FDA submission
  - Telesair Inc - Technical File Creation / FDA submission
  - eVent Medical Inc – founder and exiting CEO – Clinical Technical Files
- VentDx Ltd – Oxford University – Anesthesia and Neuro
  - Regulatory officer – Effective Lung Volume and Cardiac Output - Lung Injury monitor

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HIGH FLOW OXYGEN THERAPY - OBJECTIVES

- Introduction of High Flow O2 Therapy
- Definition or Indications for Use and Intended Use
- Ventilation vs Oxygenation
- Current Recommendations for use
  - Society for Critical Care Medicine
  - American Thoracic Society
  - European Respiratory Society
- Flow (match the inspiratory drive)
- Humidity (respiratory gases are dry – the standards)
- Thoughts from users

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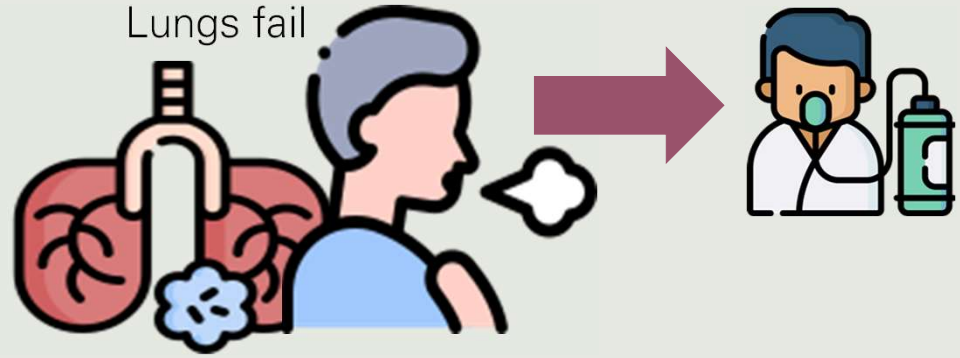
SUPPLEMENTAL OXYGEN SAVES LIVES

- When the heart or Lungs fail

Supplemental O2



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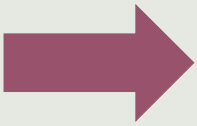
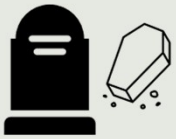
When Supplemental O2 fails



High Mortality



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MAJOR BENEFITS ARE REALIZED

The NEW ENGLAND JOURNAL of MEDICINE

JUNE 4, 2015

High-Flow Oxygen through Nasal Cannula in Acute Hypoxemic Respiratory Failure

ABSTRACT

In June 2015 A major article
By Frat et al., was published
In the NEJM.

In 310 patients – Improvement in the Hazard Ratio **Survival at 90 days** was found higher in HFNC patients than COT and NIV patients (death 12 vs 18 vs 27)

The number of **ventilator-free days** at day 28 was **significantly higher** in the high-flow–oxygen group. (**24**+-8 days, vs. **22**+-10 in COT and 19+-12 in the noninvasive-ventilation group).

HFNC was proclaimed as the preferred therapy for patients with Hypoxemic Respiratory Failure.

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MAJOR BENEFITS ARE REALIZED

FOCUSED REVIEW

High-Flow Nasal Cannula Oxygen in Adults: An Evidence-based Assessment

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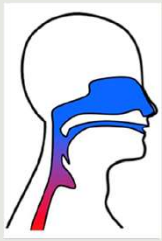
Abstract

High-flow nasal cannula oxygenation has distinct advantages over other oxygen devices because of its unique effects on respiratory physiology. In particular, adjustable oxygen delivery and flow-dependent carbon dioxide clearance reduce work of breathing and better match inspiratory demand during respiratory distress. Historically, few studies had evaluated whether the physiologic effects of these devices translated into clinical benefit. However, recent publications have begun to address this knowledge gap. High-flow nasal cannula oxygenation has been shown to have similar, and in some cases superior clinical efficacy compared with conventional low-flow oxygen supplementation and noninvasive positive pressure ventilation in acute hypoxemic respiratory failure. High-flow nasal cannula oxygenation also prevents reintubations in medical and postoperative surgical populations, provides preoxygenation for laryngoscopy, and supports oxygenation during bronchoscopy. This review examines the evidence for high-flow nasal cannula oxygenation use in adults, including a focus on the unique effects of high flow on respiratory physiology and keys for tailoring flow for specific clinical scenarios.

Keywords: respiratory failure; hypoxia; high-flow nasal cannula; noninvasive ventilation

Table 1. Physiologic benefits of high-flow nasal cannula compared with conventional low-flow oxygenation

Improved oxygenation
Decreased anatomic dead space owing to washout of upper airway
Decreased metabolic cost of breathing/reduced carbon dioxide generation
Generation of positive nasopharyngeal and tracheal airway pressure
Improved work of breathing
Preconditioning of inspired gas (heated and humidified)
Better secretion clearance
Superior comfort
Reduced room air entrainment



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INDICATIONS & INTENDED USE

- Indication for use
  - Indicated to augment the breathing of spontaneously breathing patients suffering from respiratory distress and/or hypoxemia.[FDA]
  - Clinically to treat hypoxemic respiratory failure where conventional Oxygen Therapy has failed.
- Intended use
  - intended to add moisture and to warm breathing gases for administration to a patient. [FDA]
  - Intended to provide higher inspiratory flows of precise oxygen concentrations while humidifying and warming inspired gas.
- Expert panel – Ventilation Matters

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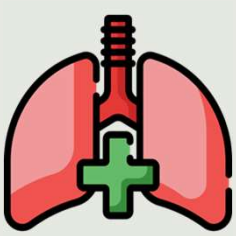
VENTILATION VS OXYGENATION

- Oxygenation
  - Oxygen Drivers :
    - O2 Concentration
    - Mean Airway Pressure
- Ventilation
  - CO2 removal:
    - Convection
    - Stroke volume [Vt]
- Work (work rate)
  - Force (hPa or cmH2O) x Distance (volume)
  - Respiratory Frequency (Frequency Rate)



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OXYGENATION

- O2 Concentration ≠ FiO2
  - In non-invasive modes for O2 concentration to equal FiO2 the device operator must provide flows that exceed the peak flow of the patient.
  - If peak flow is not exceeded, then entrainment of room air will dilute the inspired gas.
  - Peak flows of respiratory distress patients often meet or exceed 100 lpm.
- Drivers of Oxygenation
  - O2 Concentration
  - Mean Airway Pressure (MAP)

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VENTILATION & WORK

- Ventilation of the lung
  - Purpose: Removal of CO2
  - The stroke volume of the lungs – Tidal Volume (Vt) facilitates CO2 removal.
- Work = Force x Distance
  - High Flow Eliminates dead space by removal of the nasopharyngeal space thus reducing the travel distance of CO2.
  - Entrainment of expired gas (bernoulli) from the tracheal space as high flow gas.
- Expiratory resistance
  - Associated with elongation of the expiratory time constant – leading to longer respiratory cycle times and a reduction in Respiratory Frequency.
  - Reduced frequency means the work rate of breathing is reduced.

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MATCHING INSPIRATORY DEMAND

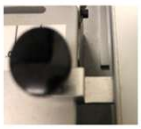
Matching Inspiratory Demand with Higher Flows has several benefits:

- Oxygenation (MAP/FiO2)
- Work of Breathing / Cost of Breathing
- Patient Comfort (debatable)

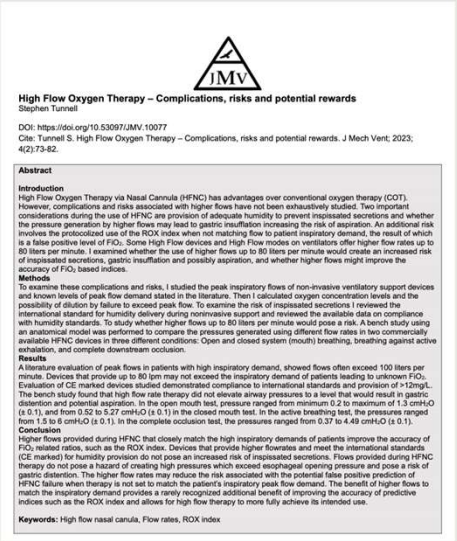
- Improves diagnosis and accuracy of predictive indices.
  - If the care staff is using O2 concentration as FiO2 and not considering the effects of dilution.
    Then Indices that use FiO2 as a denominator are falsely positive or inaccurate.


cannula in place


cannula in place


Spontaneous test model


T-piece check valve



JMV

High Flow Oxygen Therapy – Complications, risks and potential rewards

Stephen Tunnell

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Abstract

Introduction
High Flow Oxygen Therapy via Nasal Cannula (HFNC) has advantages over conventional oxygen therapy (COT). However, complications and risks associated with higher flows have not been exhaustively studied. Two important considerations during the use of HFNC are provision of adequate humidity to prevent inspissated secretions and whether the pressure generation by higher flows may lead to gastric insufflation increasing the risk of aspiration. An additional risk involves the protocolized use of the ROX index when not matching flow to patient inspiratory demand, the result of which is a false positive level of FiO_2. Some High Flow devices and High Flow modes on ventilators offer higher flow rates up to 80 liters per minute. I examined whether the use of higher flows up to 80 liters per minute would create an increased risk of inspissated secretions, gastric insufflation and possibly aspiration, and whether higher flows might improve the accuracy of FiO_2 based indices.
Methods
To examine these complications and risks, I studied the peak inspiratory flows of non-invasive ventilatory support devices and known levels of peak flow demand stated in the literature. Then I calculated oxygen concentration levels and the possibility of dilution by failure to exceed peak flow. To examine the risk of inspissated secretions I reviewed the international standard for humidity delivery during noninvasive support and reviewed the available data on compliance with humidity standards. To study whether higher flows up to 80 liters per minute would pose a risk. A bench study using an anatomical model was performed to compare the pressures generated using different flow rates in two commercially available HFNC devices in three different conditions: Open and closed system (mouth) breathing, breathing against active exhalation, and complete downstream occlusion.
Results
A literature evaluation of peak flows in patients with high inspiratory demand, showed flows often exceed 100 liters per minute. Devices that provide up to 80 lpm may not exceed the inspiratory demand of patients leading to unknown FiO_2. Evaluation of CE marked devices studied demonstrated compliance to international standards and provision of +12mgL. The bench study found that high flow rate therapy did not elevate airway pressures to a level that would result in gastric distention and potential aspiration. In the open mouth test, pressure ranged from minimum 0.2 to maximum of 1.3 cmH_2O (± 0.1), and from 0.52 to 5.27 cmH_2O (± 0.1) in the closed mouth test. In the active breathing test, the pressures ranged from 1.5 to 6 cmH_2O (± 0.1). In the complete occlusion test, the pressures ranged from 0.37 to 4.49 cmH_2O (± 0.1).
Conclusion
Higher flows provided during HFNC that closely match the high inspiratory demands of patients improve the accuracy of FiO_2 related ratios, such as the ROX index. Devices that provide higher flowrates and meet the international standards (CE marked) for humidity provision do not pose an increased risk of inspissated secretions. Flows provided during HFNC therapy do not pose a hazard of creating high pressures which exceed esophageal opening pressure and pose a risk of gastric distention. The higher flow rates may reduce the risk associated with the potential false positive prediction of HFNC failure when therapy is not set to match the patient's inspiratory peak flow demand. The benefit of higher flows to match the inspiratory demand provides a rarely recognized additional benefit of improving the accuracy of predictive indices such as the ROX index and allows for high flow therapy to more fully achieve its intended use.

Keywords: High flow nasal canula, Flow rates, ROX index

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RISKS OF HIGHER FLOWS

- Desiccated Secretions / Humidity Standards
- Greater consumption of water may result in water chamber exhaustion / Alarms
- Flows are associated directly with higher airway pressures
  - Does higher airway pressures result in gastric insufflation/ Esophageal opening pressures
  - Increasing the risk for Aspiration and Vomiting.

80 lpm	Pressure (cmH2O)
Open mouth	1.30
Closed mouth	5.27
Active Exhalation	6.00
Occlusion	4.49

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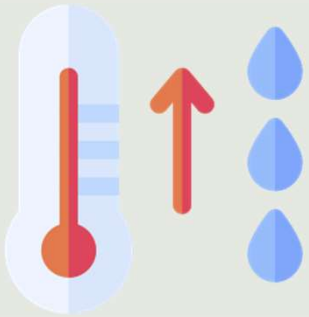
HUMIDIFICATION REQUIREMENTS

Standards of Care

Technology Standards of Care

- ISO (International Standards Organization)
  - Humidification Standard 80601-2-74
    - Non Invasive = >12 mg/L
    - Airways Bypassed => 33 mg/L



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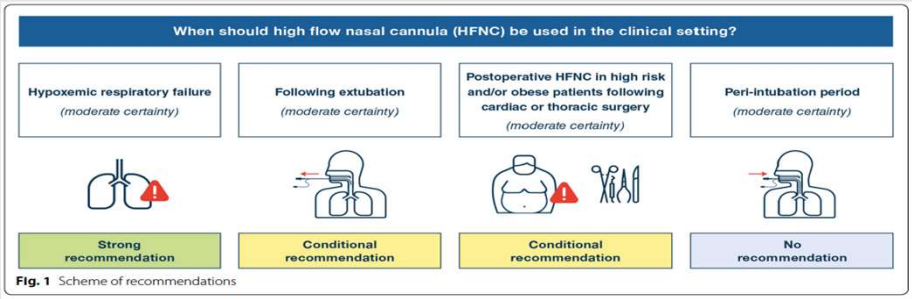
SOCIETY RECOMMENDATIONS FOR USE

- American Thoracic Society
- European Respiratory Society
- Society for Critical Care Medicine



Rochwerg etal Expert Panel 2020 SCCM Practice Guideline: Role for High Flow Nasal Cannula

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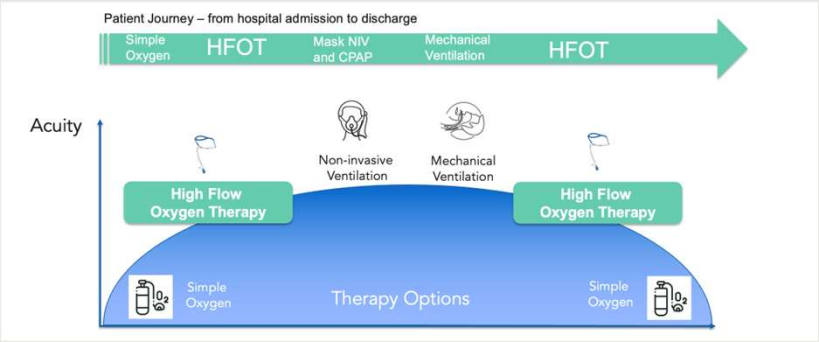
SUMMARY

High Flow Oxygen Therapy is an accepted therapy in the treatment of hypoxemic patients.

Clinical applications continue to evolve including the use of high flow oxygen therapy HFOT

- Peri-Intubation
- COPD – Hypercapnic Respiratory Failure
- Pulmonary rehab – Walking Therapy



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