Nasal High Flow: Evidence & Application

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Member, AARC
Married to Kate with three sons Alex (15), Matthew (13) & Oliver (8 mo)
Crazy about the New Zealand All Blacks Rugby Team

Outline

1. What are the origins of HFNC?
2. What are the mechanisms of action?
3. How can high flow be used effectively in your ED? ▲ COVID-19
4. Q & A

Q1: Who routinely used HFNC in their ED before COVID-19?

Q2: Who routinely used HFNC in their ED during COVID-19?

Q3: Who understands the physics and physiology supporting HFNC?
History & background

c. 1920's

High flow fundamentals

Most of the problems of humidification could be solved by the use of water-vapour instead of aerosols. This would more nearly reproduce the physiological mechanism of humidification in the respiratory tract. Such a method became practicable when the author discovered that gas could be blown into one nostril at 20–30 litres per minute without discomfort, and even without perceptual, provided that the gas was at body-temperature and 100% saturated with water-vapour. (The highest tolerable flow of dry, cool gas is normally regarded as 6–8 litres per minute.)

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What is nasal high flow?

Nasal high flow therapy is the delivery of heated and humidified air (w/ or w/o supplemental oxygen), up to 60 L/min, to a patient using a high flow nasal cannula (HFNC).

Mechanisms of Action

- Airway hydration
- Patient comfort
- Supplemental oxygen
- Reduction of dead space
- Dynamic positive airway pressure

Reduction of dead space

- Spence 13, 14, 15, 16

Reduction of dead space: Spence
Reduction of dead space: Moller

Dynamic positive airway pressure

What changes are seen in patients using NHF?

Supplemental oxygen
Supplemental oxygen

Confidence in the delivery of blended humidified oxygen

- COT delivers dry, unheated gas to patient airways, which can damage cilia and increase thickened secretions (e.g., low flow O2 cannula, masks and unheated NIV)
- Optimal humidity (37°C, 44 mg/L H2O) improves mucociliary clearance, which promotes mobilization and thinning of these secretions
- This same mechanism is also crucial across the care continuum with NIV and invasive therapies
- Evidence has shown that COVID-19 patients develop dry cough and thick respiratory secretions

Airway hydration

Optimal humidity

- Prevents desiccation of the airway epithelium
- Improves mucociliary clearance

In vitro model of the effects of high flows of warm, humidified air on mucociliary transport

100% Humidity
99% Humidity for 10 minutes

How important is providing optimal humidity? COVID-19

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**Wide body of evidence supporting nasal high flow**

A recent systematic search of the PubMed database found 52 acute adult NHF controlled studies:

- 85% reported flow rates above 45 L/min
- 94% reported using F&P Optiflow systems

**What is the clinical evidence specific to the ED?**

Nasal high flow can decrease the need for intubation and might decrease the need for ventilation.

"Patients with HFNC were much more likely to recover from respiratory failure."
Evidence based guidelines for clinical mgmt. of COVID-19

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**Guideline**

**Nasal High Flow**

**WHO**
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**NIH**
- Recommended over NIV in patients with AHRF despite COT

**SSC**
- Suggest use over COT and NIV in patients with AHRF

**ANZICS**
- Considered for patients with hypoxemia

When a respiratory compromised patient presents in your ED

**If hypoxic:**
- Low levels of blood oxygen
  - \(\text{SpO}_2 < 92\%\), \(\text{PaO}_2 < 75\text{mm Hg}\)
  - Frat, EJIM, 2015.
  - 23 cr RCT, 710 pts AHRF; NHF vs COT vs NIV
  - NHF reduced mortality and need for intubation

**If hypercapnic:**
- High partial pressure of blood carbon dioxide
  - \(\text{PaCO}_2 > 45\text{mm Hg}\), \(\text{pH} < 7.35\)
  - 2 cr RCT, 100 pts with acute undifferentiated shortness of breath; NHF vs COT
  - NHF reduced mortality and need for intubation

**Clinical Practice Guidelines**
- ESICM, 2020 – recommend NHF over COT
- ACP, 2021 – use NHF over NIV
- SCCM, 2021 – suggest NHF over NIV

Can the early use of high flow reduce the rate of intubation?

Frat et al. 2015 NEJM

**FLORAL Study**
- 39% fewer intubations between NIV and NHF

**Evidence based guidelines for clinical mgmt. of COVID-19**

**Systematic Reviews w/ Meta Analyses**

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82% of studies required flows > 45 L/min

**COVID-19**

**Evidence based guidelines for clinical mgmt. of COVID-19**

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**Guidance**
- Pantazopoulos, COPD, 2020.
  - Literature review (99 papers) and treatment algorithm
  - NHF recommended for patients with
    - \(\text{pH} < 7.25\)
    - Escalate to NIV

**REFERENCES**
- Zhao et al. 2017
- Ou et al. 2017
- Ni et al. 2018
- Rochwerg et al. 2019
- Agaranal et al. 2020

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RCT of NHF vs NIV vs COT in AHRF

Frat JP et al, NEJM 2015

Bell et al. 2015 Emergency Medicine Australasia

STUDY
A comparison of NHF with noninvasive ventilation (NIV) therapy (COT) in patients with acute hypercapnia and respiratory failure in the ED

• Noninvasive treatments resulted in lower mortality
• NHF resulted in higher survival rates

RESULTS
• Lower rates of intubation
• Lower rates of death

When a respiratory compromised patient presents in your ED

If hypoxemic:

- Low levels of blood oxygen
  - \( \text{SpO}_2 < 92\% \), ABG: \( \text{PaO}_2 < 75\text{mm Hg} \)

Frat. NEJM. 2015.

- 23-cnt RCT, 310 pts AHRF, NHF vs COT vs NIV
  - NHF reduced mortality and need for intubation
  - 2-cnt RCT, 105 ED pts with acute hypercapnia
    - NHF reduced mortality and need for intubation


- Literature review (99 papers) and treatment algorithm

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  - ESICM, 2020 – recommend HFNC over COT
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If hypercapnic:

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- Retrospective ABG analysis of 81 ED pts with ARF
  - Reduced \( \text{PaCO}_2 \) and RR in hypercapnic group
  - Increased \( \text{PaO}_2 \) and \( \text{SpO}_2 \) for hypercapnic and non-hypercapnic groups


- 9-cnt RCT, 78 pts ACCORD, NHF vs NIV
  - NHF non-inferior to NIV vs initial ventilatory support
  - 30% of pts receiving NHF required NIV by 72

Clinical Practice Guidelines for hypoxemic patients


- Literature review (99 papers) and treatment algorithm

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Jeong et al. 2015 American Journal of Emergency Medicine

Study
A retrospective analysis of clinical trials shows that 32% of patients required NIV by 6 h.

Results
- Significant reduction in PaCO2 in the hypercapnic group
- No difference in PaCO2 and PaO2 between hypercapnic and non-hypercapnic patients
- No significant difference in respiratory rate for patients with hypercapnia

graphic courtesy of Dr. Nicholas Hill and Wendolyn Hill (Certified Medical Illustrator)

Pantazopoulos et al. 2020 COPD: Journal of Chronic Obstructive Pulmonary Disease

Design
- Literature review

Aim
Discuss suitability of NHF therapy for COPD patients who cannot tolerate NIV and propose a therapy algorithm for patients with AECOPD based on current literature.

Search result
- AECOPD (9 studies)

Conclusions
- NHF may be used in place of NIV in least tolerate and compliant patients, or in association with NIV to reduce mask-related side effects.

Takeaway
- NHF recommended as initial ventilatory support for patients with:
  - pH between 7.25 – 7.35
  - PaCO2 ≥ 45 mmHg
  - Escalate to NIV for pH < 7.25

graphic courtesy of Dr. Nicholas Hill and Wendolyn Hill (Certified Medical Illustrator)
When a respiratory compromised patient presents in your ED

If hypoxemic:
Low levels of blood oxygen

- SpO2 ≤ 90% (ABG: PaO2 < 75 mmHg)

Frat. NEJM. 2015.
- 22 RCT, 310 pts ARF: NHF vs COT vs IV
- NHF reduced mortality and need for intubation

- 2 RCT, 100 ED pts with acute unilateral dyspnea: NHF vs COT
- NHF reduced escalation in ventilatory support

- Literature review (99 papers) and treatment algorithm

Clinical Practice Guidelines
- ESMIC. 2020 – recommend HFNC over COT
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Literature review (99 papers) and treatment algorithm
NHF recommended for patients with
- pH between 7.25 – 7.35
- escalate to IV for pH < 7.25

What flow rates and ranges are used?

Pressure increases approximately 0.5 – 1 cmH2O per 10 L/min of flow.

For example, flows of 50 L/min generate 2.5 – 5.0 cmH2O.

When are the effects of nasal high flow observed?

How much pressure is generated?

How do we know if nasal high flow will be successful?

First look at the ROX index: defined by three common noninvasive measurements:

\[
\text{ROX index} = \frac{\text{SpO2} / \text{FiO2}}{\text{RR}}
\]

Roca & colleagues conducted derivation (2016) and validation (2019) studies of the ROX index to predict the success of HFNC in pneumonia patients with ARF.

Oxygen saturation measured by SpO2 / FiO2 had a greater weight than RR.

Using the ROX index to predict the outcome of Nasal High Flow

The authors confirmed that a ROX value of 4.88 predicted the success of NHF.
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EPIC flowsheet

Review

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Any volunteers to experience nasal high flow?

Thank you from Fisher & Paykel Healthcare
Open for any questions