Acute Respiratory Failure: What’s New in the Literature?

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Overview

Last Five Years’ Literature on Acute Respiratory Failure
1. Early Acute Respiratory Failure
   - Noninvasive Positive Pressure Ventilation
   - High Flow Nasal Cannula
2. Late Acute Respiratory Failure
   - ECMO
   - Timing of tracheostomy

Noninvasive Positive Pressure Ventilation (NPPV)

- NPPV has been routine in the ICU for many years, particularly for our patients with severe COPD
- Cochrane Meta-analysis (2004) of 14 RCTs of acute hypercarbic respiratory failure in COPD showed mortality RR 0.52 (95% CI 0.35-0.76)
- Some areas of recent evidence:
  - ALI
  - Heart Failure
  - Asthma
  - Post-extubation
No trials exist for ARDS
- For ALI, one non-blinded RCT enrolled 40 patients <70 yo and with $200 < \text{PaO}_2/\text{FiO}_2 < 300$
- Patients were intubated for $P:F < 200$, or 2 of the following: somnolence; $pH < 7.30$; work of breathing assessment; $RR \geq 35$

**NPPV in ALI**

Is there a mortality benefit?
- Several studies and meta-analyses suggest benefit
- Most recent and comprehensive was Cochrane 2013 systematic review of clinical trials of cardiogenic pulmonary edema comparing NPPV (CPAP or BPAP) versus standard medical care (31 studies, 2916 participants)
  - Mortality RR 0.66, 95% CI 0.48 to 0.89
  - Endotracheal Intubation RR 0.52, 95% CI 0.36 to 0.75

**NPPV in Acute Heart Failure**

Commonly used in clinical practice
- However, data remains scarce:
  - Most recently, a 2012 Cochrane systematic review of 5 trials (206 patients) could not reach firm conclusions about whether intubation can be avoided with use of NPPV given low intubation rate in the populations studied

**NPPV in Asthma**

Smaller trials and meta-analysis have suggested benefit in compensated chronic hypercapnea
- Multicenter RCT (2011) patients with history of chronic hypercapnea, mostly COPD, intubated for at least 48 hours, who exhibited intolerance after 5 minutes on T-piece by RR, pH, HR, or oxygenation, randomized to:
  - Extubation to BPAP
  - Extubation to supplemental O2
  - Weaning of pressure support followed by extubation

**NPPV in Post-extubation**


Vital et al. Noninvasive positive pressure ventilation (CPAP or bilevel NPPV) for cardiogenic pulmonary oedema. Cochrane Database Systematic Review 2013 May.

Lim et al. Noninvasive positive pressure ventilation for treatment of respiratory failure due to severe acute exacerbations of asthma. Cochrane Database Systematic Review 2012 Dec.

How about Nasal Cannula?

- Existed since the 1940’s
- Flow rates limited by humidity (or lack thereof)
- Since 2000’s, some consistent findings about high flow nasal cannula:
  - Decreased RR
  - Increased SpO2
  - Comfort levels
  - Mild CPAP effect

HFNC - Comfort

Increase humidity and warmth
- LFNC systems and rates >6L/min = discomfort
- With HFNC and various types of humidification systems, can achieve relative humidity of between 75-100%.
  - Simple bubble technology vs membrane technology
  - Heated wire circuits to prevent condensation in the tubing

Makowskii T, Lamberti J. Oxygen concentrations via nasal cannula at high flow rates (abstract). Respir Care 2002;47(9):1039.

HFNC - Comfort

20 patients with ARF (SpO2 <96% on facemask) treated with facemask plus LFNC for 30 mins followed by HFNC at 20-30 L/min for 30 mins


High Flow: Physiology

- Oxygenation: Higher FiO2; Positive Pressure
- Ventilation: Reduce anatomic dead space

HFNC - CPAP effect

Upper airway pressure versus time scalar of a subject using a high flow nasal cannula. A nasopharyngeal cannula measured a mean pressure of approximately 2.7 cm H2O (bold line). The cannula was set at 35 L/min and the subject breathed with mouth closed. The gray line shows the pressure with an aerosol type face mask.


HFNC - Acute Heart Failure

- N = 10 patients with decreased EF <40%
- Placed on HFNC at 20 L/min and 40 L/min – did TTEs and measured IVC diameter as outcome measure (clinical significance if changed > 20%)


Post-op Patients


Respiratory Failure – RCT

- ARF patients n=60 (more than 4-6L NC or facemask for multiple hours) were randomized to either HFNC vs high flow facemask.
- Kept SpO2 >97% in both groups by adjusting flows
- Results:
  - More patients were able to stay or come off HFNC (26/29) when compare to HFFM (15/27) p<0.05. Failed patients had to switch groups or move to BPAP
  - Overall less desaturations per hour in the HFNC when compared to HFFM

Post-extubation – RCT

- 105 patients with low P:F (<300) extubated either to High Flow or Venturi mask.
- Results:


- High Flow is a powerful tool in our arsenal of therapies for patients with respiratory failure with clear benefit over other forms of supplemental oxygen
- Patient comfort
- Physiologic rationale
- Clinical efficacy compared with nasal cannula
- Key question to be addressed by future RCT: how does High Flow compare with BPAP?

High Flow Nasal Cannula: Summary

Extracorporeal Membrane Oxygenation

Indications:
- Severe hypoxemia
- Uncontrolled lung compliance
- Severe hypercapnia/acidosis

Note: Patients must be anticoagulated

Respiratory ECMO – Pandemic Flu

- 2009 H1N1: several reports published showing benefit in younger patients (30’s); peripartum patients.
Respiratory ECMO – RCT

Conventional Ventilation or ECMO for Severe Adult Respiratory Failure (CESAR)

- UK trial conducted between 2001-2006
- 180 patients randomized either to conventional rx or ECMO center referral.
- Only 70% of conventional rx got lung protective ventilation
- 37% death with ECMO versus 53% with conventional (RR=0.69, 95% CI 0.05-0.97)

Peek et al. Lancet 2011 379(9810):1299

ECMO: Volume-Outcome

- Analysis of registry data from 1989-2013


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Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome (EOLIA)

- France, 2011-2016, targeting ~300 patients

ARDS defined according to the following criteria:

- Intubation and mechanical ventilation for ≤ 6 days, bilateral radiological pulmonary infiltrates consistent with edema, PaO2/FiO2 ratio < 200 mm Hg
- Severity will be high:
  - i. PaO2/FiO2 < 50 mm Hg with FiO2 ≥ 80% for > 3 hours, despite optimization of mechanical ventilation (Vt set at 6 ml/kg and trial of PEEP ≥ 10 cm H2O) and despite possible recourse to usual adjunctive therapies (NO, recruitment maneuvers, prone position, HFO ventilation, almitrine infusion) OR
  - ii. PaO2/FiO2 < 80 mm Hg with FiO2 ≥ 80% for > 6 hours, despite optimization of mechanical ventilation (Vt set at 6 ml/kg and trial of PEEP ≥ 10 cm H2O) and despite possible recourse to usual adjunctive therapies (NO, recruitment maneuvers, prone position, HFO ventilation, almitrine infusion) OR
  - iii. pH < 7.25 for > 6 hours (with respiratory rate increased to 35/min) resulting from MV settings adjusted to keep plat ≤ 32 cm H2O (first, tidal volume reduction by steps of 1 ml/kg to 4 ml/kg then PEEP reduction to a minimum of 8 cm H2O).

Limited high quality RCT data prior to 2013, when a UK multicenter RCT of 1032 patients randomized to early (within 4 days) or late (>10 days) tracheostomy

- 79% medical patients
- 60% respiratory, GI 19%, cardiovascular 12%

No difference in mortality out to 2 years
Timing of Tracheostomy: An Update

- Modest difference in sedative use favoring early trach

Take Home Points

- NPPV remains best supported by data for use in severe COPD exacerbations and heart failure
- Potential benefit in ALI and asthma
- High flow nasal cannula is a promising therapy for respiratory failure with multiple physiologic benefits
- Comparative data for ECMO in ARDS will soon be available
- Data are still not available to justify early tracheostomy