Respiratory Failure
Shea Lambirth MD
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Objectives
- Identify noninvasive and invasive management options for acute hypercapnic and hypoxic respiratory failure.
- Discuss CO₂ monitoring and ABG results. Formulate a plan of action based on results.
- Discuss invasive ventilation weaning parameters and complications.

Purpose
Knowledgeable awareness and basic management of respiratory failure in adults on the floor and in the ICU

Objective #1
Identify noninvasive and invasive management options for acute hypercapnic and hypoxic respiratory failure

Hypoxia
- paO₂ <60 mmHg or saturation <90%
- Titrate down and monitor for 5 minutes after adjustment and at shift
- PaO₂ lower in supine position (Hardie et al. 2002)
- 10% of time at night oxygen sat below 92.8% in >60 years old
- PaO₂ misleading in CO poisoning

- AECOPD with PaO₂ <85% consider hospitalization
- PaO₂ >70 in AECOPD increased need for NIV and hospital LOS
- O'Driscoll et al. 2017: target 94-98% for acutely ill patients and 88-95% with risk of hypercapnic respiratory failure
- Risk of hypercapnic respiratory failure: morbid obesity, cystic fibrosis, chest wall deformity, neuromuscular disorders, bronchiectasis
- ICU mortality lowest with O₂ sat 93-96% (de Jonge et al. 2008)
Oxygen

- Flow meter with ball at the line marking desired oxygen level
- Oxygen is an intervention and should be prescribed with a target range
- Monitor at least 4 times daily and continuously in critically ill patients

Hypercapnia

- pCO₂ > 50 mmHg
- ERS/ATS 2016: Indicator for increased risk of death
- Symptoms: drowsiness, headache (vasodilation), flushed face
- pCO₂ > 5 during AECOPD associated with worse prognosis (Plant et al. 2003)
- Repeat ABG 30min–1h to make sure CO₂ level not rising

Dyspnea

- If not hypoxic, caution against using supplemental oxygen as may be harmful and does not help breathlessness
- Suspect COPD: >50 years old, long term smoker, chronic DOE without other cause

Carboxyhemoglobin

- >2% can affect oxygen saturation levels and common if obtain shortly after smoking cigarette
- Caution interpreting oxygen saturation with pulse oximetry if smoked within previous 10h
- Up to 15% in some individuals who smoke
- Up to 50% in carbon monoxide poisoning

Oxygenation

- Nasal cannula, venturi, NRB, HFNC, vent PEEP and FiO₂
- Too little, too much = BAD
- Siemieniuk et al. 2018: Strong recommendation for maintaining an oxygen saturation of no more than 96% with concerns for increased mortality
- Chu et al. 2017: Liberal oxygen strategy increased mortality in-hospital, at 30d, and long term follow up in 25 RCTs n=16037 with median oxygen saturation 96%
- MI, stroke – if there’s no hypoxia, avoid oxygen
- Suggestion of increased myocardial infarct size if receive (Nehme et al. 2020/O’Driscoll et al. 2017)
- Chu et al. 2017: Liberal oxygen strategy increased mortality in-hospital, at 30d, and long term follow up in 25 RCTs n=16037 with median oxygen saturation 96%
Noninvasive positive pressure ventilation (NIPPV)

- Lindseyauer et al. 2014
  - Noninvasive ventilation can reduce mortality when administered in select patients
  - Lower risk of hospital-acquired pneumonia
  - Shorter LOS
  - Lower cost compared to ventilated
  - Pneumonia — higher likelihood of failing NIV
- ERS/ATS 2016
  - AVOID use if not acidotic in setting of AECOPD with hypercapnia
  - Possible increased risk of MI — poor evidence
  - Quick return of hypoxia and work of breathing with removal

Be aware — don’t delay intubation if indicated

Predictors of NIV failure
- Older age
- ARDS or pneumonia
- Failure to improve after 6h
- ERS/ATS 2016: NIV failure independent risk factor for mortality
- Devlin et al. 2018: Abnormal sleep more likely to fail NIV and require intubation
- Increased ICU LOS
- Higher ICU and hospital mortality rate

Hypoxic respiratory failure

- J96.01 Acute respiratory failure with hypoxia
- J96.11 Chronic respiratory failure with hypoxia
- J96.21 Acute and chronic respiratory failure with hypoxia

Hypercapnic respiratory failure

- J96.02 Acute respiratory failure with hypercapnia
- J96.12 Chronic respiratory failure with hypercapnia
- J96.22 Acute and chronic respiratory failure with hypercapnia

Special situations

- Periop
  - Sleep-disordered breathing should bring CPAP
  - PaO2 <88% post op with diagnosis OSA/HHS should prompt NIPPV use
  - NIPPV reduces reintubation (Squadrone et al. 2005)
- DHI
  - HIV on the floor — good outcomes (Wilson et al. 2010)
- Palliative/hospice
  - If comfortable oxygen levels irrelevant
  - Manage with opiates and fan
- AMS

Objective #2

Hypoxemic COPD exacerbation and AMS results: Formulate a plan of action based on results.
CO₂ monitoring

- Capnography – continuous monitoring of concentration or partial pressure CO₂ in respiratory gases
- End tidal CO₂ is max concentration or partial pressure CO₂ in respiratory gases at end of exhaled breath
- Does not correlate well with PaCO₂ in patients with COPD (O’Driscoll et al. 2017)
- Assess CPR quality

End tidal CO₂

ABG indications

- Gold standard evaluating respiratory failure
- Unexplained agitation or confusion may be presenting symptom of hypoxia or hypercapnia
- Consider arterial line if anticipate repeat measurements
- Pulse oximeters less reliable <88% but 100% sensitive and 86% specific for excluding hypoxia (PaO₂ <60 mmHg) if >/=92% (Kelly et al. 2002/O’Driscoll et al. 2017)

ABG Interpretation

- #1 pH < 7.35 or >7.45
- #2 CO₂ increased or decreased from 40
- #3 Compensation

Objective #3

Objective: Describe invasive ventilation weaning parameters and complications
Light sedation and/or daily sedation interruption

- Devlin et al. 2018
- RASS greater than or equal to -2
- Sedation interruption useful to reduce total opioid consumption
- Observational trials reduced risk of death at 90 days and time to extubation

Spontaneous breathing trial (SBT)

- ATS/CHEST 2016: >24h ventilation perform SBT with inspiratory pressure augmentation (5-8 cmH2O)
- Usually 30 minutes to 2 hours

Weaning

- ATS/CHEST 2016: ventilator liberation protocol spent 25 fewer hours on mechanical ventilation
- Reading for weaning?
  - Mental status
  - Cause of respiratory failure addressed
  - P02 <10.5
  - Secretions
  - Hemodynamically stable
- Failed weaning: RR>35, HR>120, SBP>180 or <90

Complications

- VALI
- Auto-PEEP
- Hemodynamic
- Musculoskeletal
- Infectious
- Mechanical
- Neuropsychiatric

Extubate to HFNC or NIPPV?

- ATS/CHEST 2016: >24h ventilation and high risk for extubation failure but passed SBT recommend extubate to NIV
- Risk factors: older age, COPD or CHF, hypercapnia during SBT
- ERS/ATS 2016: high risk patients lower rate of respiratory failure after extubation with NIV, no difference in hospital mortality, 90 day survival better
- Nava et al. 2005: hypercapnia, CHF, ineffective cough/excessive secretions, age weaning trial failure, coma, obesity, upper airway obstruction
- Ferrer et al. 2008: age >60, cardiac failure as reason for respiratory failure, APACHE II >12 day of extubation
- Ferrer et al. 2009: chronic respiratory disorder with hypercapnia during SBT

Extubate to HFNC or NIPPV?

- Ni et al. 2007: Post hoc analysis no difference between extubating to HFNC or NIPPV
- Hernandez et al. 2016: HFNC reduced reintubation in 72h in low risk
- Frat et al. 2015: HFNC increased ventilator free days and decreased 90 day mortality but did not reduce reintubation rate
Post-Extubation Respiratory Failure

- Expect ~10% to fail and require reintubation
- ERS/ATS 2016: Recommend not using NIV as treatment with higher ICU mortality
- ERS/ATS 2016: Re-intubated worse prognosis

References

- Google images