Improving Long Term Outcomes of Hypercapnic Respiratory Failure
Disclosures

• Grant funding from the American Lung Association and National Institutes of Health
Objectives

• Discuss causes of acute hypercapnic respiratory failure
• Discuss outcomes of patients hospitalized with hypercapnic respiratory failure
• Discuss strategies to improve outcomes of patients hospitalized with acute hypercapnic respiratory failure.
Hypercapnic Respiratory Failure

• A case
• How common is hypercapnic respiratory failure?
• Who gets it?
• What are the outcomes for hypercapnic respiratory failure at UVMMC?
• What is the appropriate management after acute presentation?
Case Presentation

• 68 year old woman
• 2 days cough (yellow sputum), shortness of breath, no fevers
• 25 pack year smoking history, quit 1986 -- “COPD”, on 5 liters oxygen at home
• Obesity hypoventilation (BMI 52 kg/m^2) – on CPAP at home
• Heart failure with preserved ejection fraction, hypertension, hyperlipidemia
• Osteoarthritis
• Possible pulmonary hypertension
• Presented to Copley “dusky” with (SaO$_2$ in 70’s)

• Diffuse wheezing

• Started on CPAP, and transferred to UVMMC MICU
• Flu swab positive for influenza A

• Treated with BIPAP, Tamiflu, systemic steroids

• Transferred to floor after 1 day
Nocturnal Oximetry: Hospital Day 4

Oxygen saturation
Nocturnal Oximetry:

Data Summary:

Oximetry was recorded for 7 hours and 39 minutes, from 20:40 to 04:20, with the patient on 5L BIPAP.

The average oxygen saturation was 87.4 %.
The lowest oxygen saturation was 76 %.
The oxygen desaturation index (ODI) was 8 events per hour.

The time spent equal to or below 89% saturation was 334 minutes.
The time spent equal to or below 88% saturation was 208 minutes.

Oxygen saturations abruptly decreased and increased in a periodic fashion suggestive of obstructive or central sleep apnea.

Oxygen saturations ramped down progressively for intervals during the recording suggestive of underlying cardiac or pulmonary disease or hypoventilation during sleep.
ABG Results:

- ABG: 7.52/54/59 -- hospital day 4
- “Back to baseline” - total LOS 7 days
“She will require BiPAP as she was noted to have respiratory failure with CPAP and an overnight oximetry study was performed (on bipap) and VBG was drawn.............At time of discharge, she was very anxious to leave and frustrated that it had been taking so long to have her BiPAP approved. There was great difficulty in having her approved for BiPAP and great lengths were taken to have her approved as she requires BiPAP to prevent significant desaturations with CPAP. Dr. Antikowiak, with pulmonary, also called the vendor to support pt's needs for Bipap. At the time of discharge, approval was pending. Family and patient were explained the reason and importance for Bipap in pt's chronic respiratory failure/OSA/pulmonary HTN. They understood this and they wanted to go home and await Bipap approval.”
Follow Up

• No further notes in EPIC
• Died June 2017 in Copley hospital (per online obituary)
What Causes Hypercapnic Respiratory Failure?

• Obesity hypoventilation (OSA + hypoventilation)
• Chronic lung disease
• Neuromuscular disease (e.g. ALS)
What Are the Major Pulmonary Causes of Acute Hypercapnic Respiratory Failure?

1. COPD
2. Overlap of obesity and obstructive sleep apnea
3. Obesity hypoventilation

- 67% had COPD by spirometry (only 24% previously diagnosed)
  - Prevalence of moderate or severe OSA in patients with COPD: 66%
- OSA
  - Prevalence of moderate or severe OSA in patients without COPD: 94%
What is Obesity Hypoventilation?
Response to increased CO$_2$ in obese mice
Obesity state of leptin resistance, leptin regulates ventilation

O’Donnell AJRCCM 1999
Lean research participant: FRC, FRC with PEEP 10
Healthy, BMI 48, FRC and FRC with PEEP 10
What is Obesity Hypoventilation?

- Altered respiratory drive to breathe
- De-recruitment, airway closure, air-trapping
How Common is Hypercapnic Respiratory Failure at UVMMC?
Patient hospitalized with hypercapnic respiratory failure at UVMMC last 4 years.
What are the Outcomes of Hospitalization for Hypercapnic Respiratory Failure?
Methods

- Identified patients ≥ 18 years admitted in 2016
- ICD10 code of hypercapnic respiratory failure
  - Acute hypercapnic RF
  - Acute and chronic hypercapnic respiratory failure
  - Chronic respiratory failure with hypercapnia
  - Morbid obesity with hypoventilation
- Electronic records of individual patients reviewed by 3 investigators
- Excluded: advanced cancer, trauma, acute stroke/seizure, cardiac arrest prior to admission, advanced neurologic disorder, other disease that would limit life expectancy
Patients Admitted With HRF 2016 to UVMMC

12 month mortality = 41%
30 day readmission rate = 23%

Excluded those with neuromuscular disease, advanced cancer, admitted with cardiac arrest
## Mortality During Index Admission

<table>
<thead>
<tr>
<th></th>
<th>All (n = 202)</th>
<th>Living (n = 119)</th>
<th>Dead (n = 15)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td>113 (56%)</td>
<td>104 (56%)</td>
<td>9 (60%)</td>
<td>0.79</td>
</tr>
<tr>
<td><strong>Age (M ± SD) (years)</strong></td>
<td>63.4 ± 15.3</td>
<td>62.4 ± 15.3</td>
<td>75.7 ± 9.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>ICU admission</strong></td>
<td>119 (59%)</td>
<td>105 (56%)</td>
<td>14 (93%)</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Blood pressure MAP&lt; 70</strong></td>
<td>52 (27%)</td>
<td>43 (23%)</td>
<td>9 (60%)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
What About 30 Day Readmission?

• Medicare penalizes hospitals with higher than expected 30 day readmissions for certain diagnoses (MI, heart failure, COPD, pneumonia)
• Admission within 30 days is considered related to the initial admission
• How high are 30 day readmission rates for patients with HRF?
Patients Admitted With HRF 2016 to UVMMC

30 day readmission rate = 23%

Prior published data
MI: 15%
Heart failure 23%
Pneumonia 16.7%
COPD exacerbation (7-20%)
What Predicts Risk of 30 Day Readmission?

- Diagnosis of peripheral vascular disease
  - 4.8 fold risk of readmission compared to patients without peripheral vascular disease

- Rapid heart rate in first 24 hours of admission
  - > 119 associated with a 3-fold increased risk of admission compared to those with normal heart rate
Why Peripheral Vascular Disease??

• Increases risk of readmission from heart failure, after cardiac procedures
• Risk factor for hospitalization in older adults
• Could patients with peripheral vascular disease have more severe pulmonary disease??
Why Rapid Heart Rate?

• A marker of chronic cardiac dysfunction too?
How Many Patients Die in the Year Following Hospitalization?

37% of patients who survive the initial hospitalization die within approximately 2 years.
What Predicts Risk of Death?

- **Age**
  - Risk increases 1.33 fold for every 5 years of age

- **Home oxygen**
  - Risk increases 4-fold for those who use home oxygen

- **Peripheral vascular disease**
  - Risk increases 12.6 fold for those with PVD

- **Charlson comorbidity index**
  - A validated instrument that predicts risk of death, measures chronic diseases

- **Being readmitted**
  - 3-fold increased risk of death
Why Home Oxygen Use?

• Only 19% of patients discharged on CPAP or BiPAP
• Most patients on home oxygen were on home oxygen alone
• Worsen ventilation: perfusion matching?
Hyperoxia Minimally Affects Minute Ventilation
Hyperoxia Can Worsen Hypoxic Vasoconstriction

Normal

Poor ventilation, reduced oxygen
Could oxygen by itself worsen long term outcomes related to hypercapnic respiratory failure?
What are the Treatment Options?
Chronic Hypercapnic Resp Failure

Mortality data

Kohnlein 2914
NIV for COPD Persistent Hypercapnia After D/C

Risk of readmission or death

Murphy, JAMA 2017
NIV Started Prior to D/C in Patients with COPD and Hypercapnic Respiratory Failure

Struik, 2014
NIV for COPD Persistent Hypercapnia After D/C

Graph showing the comparison between Home oxygen plus home NIV and Home oxygen alone over time (mo) with admission-free survival rates. The graph includes hazard ratios:

- Unadjusted hazard ratio: 0.54 (0.34–0.84); P = .007
- Adjusted hazard ratio: 0.49 (0.31–0.77); P = .002

Data points for Home NIV:
- 57
- 37
- 28
- 26
- 25
- 24
- 16

Data points for Home oxygen alone:
- 59
- 23
- 11
- 10
- 8
- 8
- 6

Reference: Murphy, JAMA 2017
When Do We Start NIV in COPD Patients?

• Should be considered 2-4 weeks after discharge.
• Started an NIV clinic in Pulmonary
  • Not for patients with obstructive sleep apnea or obesity hypoventilation syndrome
Coverage for BiPAP in COPD

PaCO2 ≥ 52 mm Hg

and

Sleep oximetry SAO2 ≤ 88% for ≥ 5 mins while breathing oxygen at 2 LPM or prescribed FIO2 (whichever is higher);

and

OSA has been considered and ruled out (Note: Formal sleep testing is not required if there is sufficient information in the medical record to demonstrate that the beneficiary does not suffer from some form of sleep apnea (Obstructive Sleep Apnea (OSA), CSA and/or Comp SA) as the predominant cause of awake hypercapnia or nocturnal arterial oxygen desaturation).
COPD OSA Overlap
COPD Patients with OSA Treated and Not Treated with CPAP

↓ exacerbations with CPAP treatment
Marin, AJRCCM 2010
When Do We Start NIV in COPD-OSA Overlap Patients?

• Screen for symptoms of OSA in COPD patients
• Refer for outpatient sleep study
• If BMI > 35, consider obesity hypoventilation
When do we start NIV in Obesity Hypoventilation?

- Prior to discharge...
Coverage for BIPAP for OHS

BIPAP without backup covered if 1, 2, and either 3 or 4 are met:

1. Awake $\text{PaCO}_2 \geq 45 \text{ mm Hg}$.
2. FEV1/FVC $\geq 70\%$
3. During sleep/immediately upon awaking (breathing prescribed $\text{FiO}_2$), $\text{PaCO}_2 \geq 7\text{ mm Hg}$ above #1
4. PSG demonstrates oxygen saturation $\leq 88\%$ for at least 5 minutes (minimum recording time of two hours) not caused by obstructive upper airway events.
COPD with Acute Hypercapnic Respiratory Failure ($\text{PCO}_2 > 52$)

- COPD w/ BMI $\geq 30$ or high likelihood of OSA
  - PSAT
  - Positive
    - FEV$_1 > 50\%$
    - OSA- desaturations
      - Expedited PSG
  - Negative
    - FEV$_1 < 50\%$
    - Non-OSA desaturations

- COPD w/ BMI $< 30$
  - Refer to NIV Clinic

Evaluation:
- History +/- OSA
- Spirometry
- ABG
- HCO$_3$ $> 30$
Obesity Hypoventilation with Hypercapnic Respiratory Failure

- OHS (BMI > 40, metabolic syndrome)
- Respiratory failure (PCO$_2$ >52)
- High likelihood of chronic respiratory failure (i.e. HCO$_3$ >30, etc.)

\[ \text{ABG spirometry} \]

- PSAT (before leaving MICU)

- Positive OSA
  - CPAP titration with ETCO$_2$ in MICU
    - improves

- Negative OSA
  - BiPAP titration with ETCO$_2$ in MICU
    - Doesn’t improve

- sleep clinic
Summary

• Hypercapnic respiratory failure is a “silent” epidemic
  • High mortality
  • High readmission rate

• Major respiratory disease causes
  • COPD
  • COPD/OSA overlap
  • Obesity hypoventilation

• Treatment of HRF in COPD (and chronic “lungers”)
  • Outpatient assessment and initiation of NIV

• Treatment of COPD-OSA overlap
  • Consider inpatient PSAT, follow up in sleep clinic

• Treatment of OHS
  • Inpatient assessment and start on CPAP or BiPAP prior to discharge
Thank you!

• Janet DesLauriers
• Elizabeth Denton
• Emily Parent
• Susan Dunning
• Prema Menon
• Charlotte Teneback
• MaryEllen Antkowiak
• Amber Meservey
• Michael Burton