Respiratory Disorders 2
(or Pulmonary Potpourri)

Thomas Lahiri MD
Professor of Pediatrics
Larner College of Medicine
University of Vermont
Disclosure

- I have no relevant financial relationships with the manufacturers(s) of any commercial products(s) and/or provider of commercial services discussed in this CME activity.

- I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.
Objectives

- Develop a differential for exertional dyspnea
- Recognize signs of respiratory failure
- Know the evaluation and management of sleep disordered breathing
- Understand key components of pulmonary function testing
Lecture Content

- Exercise Induced Dyspnea
- Obstructive Sleep Apnea
- Aspiration
- Pleural Fluid
- Pulmonary Function Testing
Dyspnea with Exertion

- May be the earliest sign of respiratory conditions
- Asthma
- Vocal cord dysfunction (usually with stridor)
- Airway narrowing/collapse (e.g. severe malacia)
- Cardiac etiologies
- Pulmonary hypertension
- Neuromuscular weakness
- Deconditioning
Exertional Dyspnea

- Young children
  - Labored breathing
  - Inability to keep up with peers
- School aged/adolescent
  - Chest tightness
  - Throat closure
  - Fatigue
Exertional Dyspnea

- Chest tightness, cough, wheeze: think of a pulmonary etiology
  - Most common: Exercise induced bronchoconstriction (asthma)
  - Airway issues, interstitial lung disease
- Chest pain, syncope: r/o cardiac disease
Exertional Dyspnea

- Rapid onset & resolution with stridor: VCD
- Evaluation may include (after thorough history):
  - Spirometry
  - Radiography
  - EKG
  - Exercise challenge
Differential Diagnosis

- Vocal cord dysfunction (often with stridor)
- Dynamic airway collapse (severe malacia)
- Bronchial stenosis/tracheal compression
- Pulmonary hypertension
- Neuromuscular disease
- Deconditioning
Bronchiolitis

- Viral etiology: RSV, influenza, parainfluenza, metapneumovirus

- Presentation:
  - Apnea (especially under 4 months of age)
  - Copious rhinorrhea
  - Cough/wheeze
  - Exam findings include +/- fever, nasal secretions/flaring, wheeze, crackles, retractions, prolonged expiratory phase
Radiologic Findings
Do You Need an X-Ray?

Chronic Aspiration
Do You Need an X-Ray?

Cystic Fibrosis
Management of Bronchiolitis

- Supportive care
- Nasal suctioning, hydration, supplemental $O_2$
- **Trial** of $\beta_2$ agonist or racemic epinephrine
- 3% hypertonic saline
- Inhaled corticosteroids have no role acutely
- No clear benefit from systemic corticosteroids or chest percussion
- Why screen for RSV?
  - Avoid unnecessary use of antibiotics
  - Cohort hospitalized infants
Sequeleae of Bronchiolitis

- Obstruction of upper and lower airways may lead to respiratory failure in infants
  - Highest risk in premature and younger infants
  - Pre-existing airway or lung disease
  - Can be mitigated with monthly palizumab in selected infants
Sequelae of Bronchiolitis

- Hospitalization may be required
  - If presenting with apnea
  - Unable to maintain adequate oral intake
  - Hypoxemia (SaO2 <90%)
  - Concern for impending respiratory failure
Impending Respiratory Failure in Infants

- Scenarios:
  - Upper airway obstruction
  - Lower respiratory involvement
  - Sepsis
  - Hypotonia
Impending Respiratory Failure in Infants

- Increased accessory muscle use
- Inability to coordinate feeding
- Decreased arousability
- Hypoxemia/hypercarbia
  - normal PCO₂ with marked tachypnea
Severe Airway Obstruction

- Signs include:
  - Nasal flaring
  - Grunting
  - Retractions
  - Accessory muscle use
  - Cyanosis
  - Decreased responsiveness
Aspiration

■ From Below:
  ■ Related to gastroesophageal reflux

■ From Above:
  ■ Functional: swallowing abnormalities, vocal cord paresis, neurologic (Chiari 2)
  ■ Structural: laryngeal cleft, craniofacial
  ■ Even children with tracheostomies may continue to aspirate
Chronic Aspiration- Evaluation

- Radiographs may show chronic airway inflammation (non-specific)
- Videofluoroscopic evaluation with feeding team is the gold standard
- Bronchoscopy to look for indirect evidence of aspiration or structural etiologies
Aspiration
Laryngeal Cleft
Vocal Cord Paresis
Sleep Apnea

- **Obstructive**
  - Most common
  - Decreased airflow with chest wall movement

- **Central**
  - Lack of respiratory drive, no effort
  - Congenital central hypoventilation syndrome

- **Mixed: Apnea of prematurity**
Sleep Disordered Breathing

- Obstructive sleep apnea syndrome (OSAS)
  - Craniofacial anomalies
  - Adenotonsillar hypertrophy
  - Laryngomalacia
  - Metabolic disorders
  - Obesity

- Hypoventilation
  - Neuromuscular disorders
  - Central apnea
Obstructive Sleep Apnea

- Snoring is common, but <50% have OSA
- Children may present with:
  - Witnessed apneic/gasping episodes
  - Difficult to arouse from sleep
  - Excessive daytime somnolence
  - Deteriorating school performance
  - Attention deficit hyperactivity
  - Morning headaches
OSAS

- Witnessed apneic events with snoring, abnormal physical exam findings → adenotonsillectomy

- Polysomnography (sleep study)
  - Different definitions for children vs. adults
  - Apnea/hypopnea index (# total events/hour)
  - AHI >1 is **abnormal** in children
  - AHI <5 is **normal** in adults
Pleural Fluid

- Infectious and non-infectious causes
- Evaluation of effusion?
  - Plain films—including decubitus
    - Blunting of costophrenic angles
  - Ultrasound—look for striations vs.
    free flowing collection
  - CT—may not identify features of a complicated effusion
Pleural Fluid

- Increased hydrostatic pressure
  - Cardiogenic
  - Responsive to diuretics, positive pressure
- Decreased oncotic pressure
  - Hypoalbuminemia
  - Address with colloid, nutritional repletion
- Capillary leak
  - Seen in sepsis, SIRS/ARDS
Pleural Fluid

- Complicated parapneumonic effusion
  - Increased protein, low pH, high LDH
- Chylous effusion
  - Alkaline pH, milky, lymphocytes, chylomicrons
- Transudate
  - Plasma pH, straw colored, low protein/LDH
Parapneumonic Effusion
Pleural Effusions
Role of Ultrasound

- Locate fluid & estimate size
- Distinguish loculated from free flowing collections
- Visualize pleural thickening
- CT cannot detect septations or detect empyema
Empyema

- Presence of pus in the pleural space
- Pleural fluid with positive Gram stain or culture
- Tube drainage (usually ultrasound guided) with parenteral antibiotics
- Adjunct treatment includes fibrinolytics
PFTs

- Spirometry
- Lung volume measurement
  - Plethysmography
  - Gas dilution
- Diffusion capacity
Spirometry

- Flow volume loop
- Examine shape of the curve
- Inspiratory and expiratory limbs
Spirometry Parameters

- FVC = Forced vital capacity
- FEV1 = Forced expiratory volume in 1 sec
- FEF25-75 = Forced expiratory flow at 25-75% of vital capacity (small airways)
- Decreased FEV1 = airflow limitation/obstruction
- Decreased FVC = restrictive process
Spirometry

- Response to bronchodilator
- Significant response (ATS standards) = 12% following albuterol
- Normal FEV1/FVC >80-85%
- Airflow limitation based on FEV1 % predicted and FEV1/FVC
- Severe airflow limitation may also limit FVC
### Spirometry

<table>
<thead>
<tr>
<th></th>
<th>Pre-Med</th>
<th></th>
<th></th>
<th></th>
<th>Post-Med</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>%Pred</td>
<td>Pred</td>
<td>LLN</td>
<td>Actual</td>
<td>%Pred</td>
<td>%Chng</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>3.19</td>
<td>64</td>
<td>4.92</td>
<td>4.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>1.62</td>
<td>38</td>
<td>4.17</td>
<td>3.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1/FVC (%)</td>
<td>51</td>
<td>60</td>
<td>84</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEF 25-75% (L/sec)</td>
<td>0.52</td>
<td>11</td>
<td>4.53</td>
<td>3.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>5.69</td>
<td>63</td>
<td>8.93</td>
<td>6.75</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Graphs:**
- **Left:** Plot of FVC vs. Flow (L/sec) showing data points and lines for Pred and Pre.
- **Right:** Plot of FVC vs. Volume (L) over time (sec) showing data points and a line for Post.
Post Test Comments: pt. gave good effort, gave 2 puffs of albuterol. reviewed spacer technique.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Med</th>
<th></th>
<th>Post-Med</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>%Pred</td>
<td>Pred</td>
<td>LLN</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>2.97</td>
<td>119</td>
<td>2.49</td>
<td></td>
</tr>
<tr>
<td>FEV₁ (L)</td>
<td>2.01</td>
<td>94</td>
<td>2.12</td>
<td></td>
</tr>
<tr>
<td>FEV₁/FVC (%)</td>
<td>68</td>
<td>79</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>FEF 25-75% (L/sec)</td>
<td>1.39</td>
<td>58</td>
<td>2.36</td>
<td></td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>4.01</td>
<td>72</td>
<td>5.51</td>
<td></td>
</tr>
</tbody>
</table>

--- SPIROMETRY ---
Post Test Comments: Pt. with good efforts, reproducible tests. 2p Albuterol was given via spacer, good technique. The attending was not physically present during testing.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Med</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>%Pred</td>
<td>Pred</td>
<td>LLN</td>
<td>Actual</td>
<td>%Pred</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>0.79</td>
<td>47</td>
<td>1.67</td>
<td>1.27</td>
<td>0.73</td>
<td>43</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>0.74</td>
<td>43</td>
<td>1.72</td>
<td>1.37</td>
<td>0.68</td>
<td>39</td>
</tr>
<tr>
<td>FEV1/FVC (%)</td>
<td>94</td>
<td>110</td>
<td>85</td>
<td>75</td>
<td>93</td>
<td>109</td>
</tr>
<tr>
<td>FEF 25-75% (L/sec)</td>
<td>1.23</td>
<td>75</td>
<td>1.62</td>
<td></td>
<td>1.04</td>
<td>64</td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>1.65</td>
<td>37</td>
<td>4.36</td>
<td>3.37</td>
<td>1.88</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

--- SPIROMETRY ---

![Graphs showing spirometry results before and after medication.](image)
Post Test Comments: Good patient effort & cooperation. The results of this test meet the ATS standards for acceptability and repeatability. 2 puffs albuterol given for test

--- SPIROMETRY ---

<table>
<thead>
<tr>
<th></th>
<th>Pre-Med</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>%Chng</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>%Pred</td>
<td>Pred</td>
<td>LLN</td>
<td>Actual</td>
<td>%Pred</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>5.17</td>
<td>117</td>
<td>4.39</td>
<td>3.57</td>
<td>5.27</td>
<td>120</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.74</td>
<td>99</td>
<td>3.77</td>
<td>3.06</td>
<td>3.93</td>
<td>104</td>
</tr>
<tr>
<td>FEV1/FVC (%)</td>
<td>72</td>
<td>82</td>
<td>88</td>
<td>78</td>
<td>75</td>
<td>84</td>
</tr>
<tr>
<td>FEF 25-75% (L/sec)</td>
<td>3.01</td>
<td>72</td>
<td>4.13</td>
<td>2.65</td>
<td>3.32</td>
<td>80</td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>6.02</td>
<td>78</td>
<td>7.62</td>
<td>5.56</td>
<td>6.01</td>
<td>78</td>
</tr>
</tbody>
</table>
Post Test Comments: gave good reproducible efforts, gave 2 puffs of albuterol

<table>
<thead>
<tr>
<th></th>
<th>Pre-Med</th>
<th></th>
<th>Pred</th>
<th>LLN</th>
<th></th>
<th>Post-Med</th>
<th>%Pred</th>
<th>%Chng</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>Actual</td>
<td>%Pred</td>
<td>Pred</td>
<td>LLN</td>
<td></td>
<td>Actual</td>
<td>%Pred</td>
<td>%Chng</td>
</tr>
<tr>
<td></td>
<td>4.53</td>
<td>101</td>
<td>4.48</td>
<td>3.64</td>
<td></td>
<td>4.86</td>
<td>108</td>
<td>+7</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.28</td>
<td>85</td>
<td>3.85</td>
<td>3.14</td>
<td></td>
<td>3.88</td>
<td>100</td>
<td>+18</td>
</tr>
<tr>
<td>FEV1/FVC (%)</td>
<td>72</td>
<td>83</td>
<td>87</td>
<td>77</td>
<td></td>
<td>80</td>
<td>91</td>
<td>+10</td>
</tr>
<tr>
<td>FEF 25-75% (L/sec)</td>
<td>2.84</td>
<td>68</td>
<td>4.18</td>
<td>2.66</td>
<td></td>
<td>3.57</td>
<td>85</td>
<td>+25</td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>5.21</td>
<td>67</td>
<td>7.74</td>
<td>5.64</td>
<td></td>
<td>5.46</td>
<td>70</td>
<td>+4</td>
</tr>
</tbody>
</table>
Lung Volume Parameters

- TLC = total lung capacity
- RV = residual volume
- FRC = functional residual capacity
- RV/TLC = marker of air trapping, weakness or poor effort
- Normal RV/TLC is usually < 25%
Lung Volumes

- Helium diffusion/ Nitrogen washout
  - May underestimate lung volume if there is a non- or poorly communicating region of trapped air

- Plethysmography ($\Delta PV$)
  - More sensitive
Diffusion Capacity

- Diffusing capacity of the lung for carbon monoxide = DLCO
- Single breath technique
- Should be corrected for unit alveolar volume (VA) and hemoglobin
- > 80% predicted is normal