I have no commercial, non-commercial, or institutional financial interests or personal financial relationships to disclose regarding the material presented in this lecture.
OBJECTIVES

• Describe indications for pulmonary function testing
• Develop a systematic approach to interpreting pulmonary function tests
• Recognize common patterns on pulmonary function tests
Routine PFTs are not indicated pre-operatively or in asymptomatic patients.

- Evaluate signs/symptoms
- Assess progression of lung disease
- Monitor effectiveness of therapy
- Screen at-risk populations (e.g., medications)
PFT Options

- Spirometry: Office or pulmonary diagnostics lab
- Lung Volumes: Only in pulmonary diagnostics lab
- Diffusion Capacity: Only in pulmonary diagnostics lab
Special Testing

Six minute walk test, arterial blood gas → Evaluate need for oxygen

Methacholine challenge testing → Rule out asthma

Maximal inspiratory/expiratory pressures → Evaluate for neuromuscular weakness
The Spirogram
Spirometry: Volume vs. Time

Normal $\text{FEV}_1/\text{FVC} \geq 0.7$
The Flow-Volume Loop

- Peak expiratory flow rate

FLOW (L/sec)

VOLUME (L)

Expiration

Inspiration

Vital Capacity

Predicted value based on population norms
What is Normal?

Compared to predicted value for someone of the same:

- Age
- Sex
- Race
- Height

80-120% predicted is “normal” for all volumes

Normal FEV$_1$/FVC is $\geq 0.7$
Approach to PFTs

1. Check spirometry (look for obstruction)
2. Check lung volumes (look for restriction)
3. Check diffusion capacity
**Case 1: A 52 Year-Old Man With Dyspnea**

<table>
<thead>
<tr>
<th>VALUE</th>
<th>PREDICTED</th>
<th>ACTUAL</th>
<th>% PREDICTED</th>
<th>POST BD*</th>
<th>% CHANGE WITH BD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC, L</td>
<td>4.22</td>
<td>3.19</td>
<td>76%</td>
<td>3.42</td>
<td>+7%</td>
</tr>
<tr>
<td>FEV₁, L</td>
<td>3.39</td>
<td>2.18</td>
<td>64%</td>
<td>2.38</td>
<td>+9%</td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>0.80</td>
<td>0.68</td>
<td>85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLC, L</td>
<td>6.82</td>
<td>8.35</td>
<td>122%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RV, L</td>
<td>2.59</td>
<td>3.20</td>
<td>124%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D⁺CO, mL/min/mm Hg</td>
<td>33.4</td>
<td>18.8</td>
<td>56%</td>
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BD: Bronchodilator
Question 1: What disease is most likely to account for the PFT findings?

1. Asthma
2. Pulmonary fibrosis
3. Emphysema
4. Pulmonary hypertension
5. Upper airway obstruction
Step 1: Look for Obstruction

Defined by:
- $\text{FEV}_1/\text{FVC} < 0.7$ (GOLD)
- $\text{FEV}_1/\text{FVC} < \text{LLN}$ (ATS/ERS)

Severity graded by:
- Degree of $\text{FEV}_1$ impairment

Bronchodilator response:
+12% and 200 mL increase in $\text{FEV}_1$ or FVC

LLN: Lower limit of normal
Flow-Volume Loop: Obstruction

Peak expiratory flow rate lower

Expiratory limb “scooped out”
Diffusion Capacity: $D_{LCO}$

Patient inhales a known [CO] and holds breath to allow for diffusion.

Exhaled [CO] measured and compared to inhaled amount.

$D_{LCO} \approx$ Surface area for gas exchange.

CO: carbon monoxide
Obstruction: Other Clues

Lung Volumes

- TLC > 120% (Hyperinflation)
- RV > 120% (Air trapping)

Diffusion capacity

- <80%:
  - Decreased SA for gas exchange; think emphysema
- Normal
  - Asthma
  - Upper airway obstruction

SA: surface area
Case 1: A 52 Year-Old Man With Dyspnea

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BD: Bronchodilator
Case 2: A 38 Year-Old Woman with Dyspnea on Exertion

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<td>1.11</td>
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<td>0.86</td>
<td>0.91</td>
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<tr>
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<td>4.73</td>
<td>2.49</td>
<td>53%</td>
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<tr>
<td>RV, L</td>
<td>1.40</td>
<td>1.61</td>
<td>115%</td>
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<td>DLCO, mL/min/mm Hg</td>
<td>26.6</td>
<td>22.0</td>
<td>83%</td>
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Question 2: What is the most appropriate next diagnostic step?

1. Maximal respiratory pressures
2. High resolution chest CT
3. Echocardiogram
4. Methacholine challenge test
5. Cardiopulmonary exercise test
Step 2: Look for Restriction

Defined by:

TLC < 80%

Severity graded by:
Degree of TLC impairment
Flow-Volume Loop: Restriction

The vital capacity is smaller.
Causes of Restriction

Intrapulmonary
Diffuse parenchymal lung diseases

Extrapulmonary
- Chest wall diseases
- Pleural diseases
- Abdominal distension
- Neuromuscular weakness
### Case 2: A 38 Year-Old Woman with Dyspnea on Exertion

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Case 3: A 32 Year-Old Woman with Dyspnea on Exertion

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<td>TLC, L</td>
<td>5.36</td>
<td>5.25</td>
<td>98%</td>
</tr>
<tr>
<td>RV, L</td>
<td>2.04</td>
<td>2.08</td>
<td>102%</td>
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<tr>
<td>$D_LCO$, mL/min/mm Hg</td>
<td>24.2</td>
<td>9.9</td>
<td>41%</td>
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</tbody>
</table>
Question 3: What is the most appropriate next step?

1. Bronchodilator testing
2. Chest radiograph
3. Cardiopulmonary exercise testing
4. Echocardiogram
5. Maximal respiratory pressures
Step 3: Look for Diffusion Impairment

Defined by:

$D_LCO < 80\%$

Severity graded by:
Degree of $D_LCO$ impairment

Decreased $D_LCO = \text{Decreased surface area for gas exchange}$
If the $D_LCO$ is Low...

**With Obstruction**
- Emphysema

**With Restriction**
- Parenchymal disease (e.g., interstitial lung disease)

**Isolated Low $D_LCO$**
- Anemia
- Early diffuse parenchymal lung disease
- Pulmonary vascular disease
Case 3: A 32 Year-Old Woman with Dyspnea on Exertion

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Case 4: A 67 Year-Old Man with Dyspnea and Dry Cough

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<tr>
<td>FEV$_1$, L</td>
<td>3.65</td>
<td>1.57</td>
<td>43%</td>
</tr>
<tr>
<td>FEV$_1$/FVC</td>
<td>0.84</td>
<td>0.91</td>
<td></td>
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<tr>
<td>TLC, L</td>
<td>6.12</td>
<td>2.68</td>
<td>44%</td>
</tr>
<tr>
<td>RV, L</td>
<td>1.98</td>
<td>1.01</td>
<td>51%</td>
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<td>$D_LCO$, mL/min/mm Hg</td>
<td>32.2</td>
<td>5.1</td>
<td>16%</td>
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</table>
Question 4: What is the most appropriate next step?

1. Bronchodilator testing
2. Methacholine challenge test
3. Cardiopulmonary exercise test
4. Echocardiogram
5. High resolution chest CT
### Case 4: A 67 Year-Old Man with Dyspnea and Dry Cough

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All lung volumes are decreased with parenchymal causes of restriction.
Parenchymal Restriction

Diffuse Parenchymal Lung Diseases
- Occupational
- Drug related
- Granulomatous
- Idiopathic interstitial pneumonias

Evaluate further with high-resolution chest CT
More on Grading Severity

- Obstruction
  - FEV$_1$

- Restriction
  - TLC

- Mixed obstruction and restriction
  - FEV$_1$
### Case 5: A 42 Year-Old Man with Dyspnea

<table>
<thead>
<tr>
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<td>FVC, L</td>
<td>4.35</td>
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<td>102%</td>
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<tr>
<td>FEV₁, L</td>
<td>3.69</td>
<td>2.56</td>
<td>69%</td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>0.85</td>
<td>0.58</td>
<td></td>
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</table>
Question 5: Which of the following is most likely to account for the PFT findings?

1. Asthma
2. Thyroid mass
3. Vocal cord dysfunction
4. Tumor in mainstem bronchus
5. Tracheal stenosis
Simplified Flow-Volume Loop

...but you should understand why this happens!
Variable Intrathoracic Obstruction

FLOW (L/sec)

VOLUME (L)

Expiration

Inspiration
More Flow-Volume Loops

Variable extrathoracic obstruction, e.g., thyroid mass

Variable intrathoracic obstruction, e.g., mainstem tumor

Fixed airway obstruction, e.g., tracheal stenosis
Bronchoprovocation Testing

- Identify specific triggers
- Diagnose asthma
- Assess response to therapy

- Typical symptoms with normal spirometry
- Not responding to empiric therapy
- Atypical symptoms
Methacholine Challenge Test

Administration of increasing concentrations of methacholine, followed by spirometry looking for ≥ 20% reduction in FEV$_1$

PC20 < 8 mg/mL = Positive test
PC20 > 16 mg/mL = Negative test
High negative predictive value
Approach to PFTs

- Look for obstruction: $\text{FEV}_1/\text{FVC} < \text{LLN}$
  - Severity: $\text{FEV}_1$

- Look for restriction:
  - TLC < 80%
  - Severity: TLC

- Look for diffusion impairment:
  - $D_L\text{CO} < 80$
  - Severity: $D_L\text{CO}$

…and don’t forget to look at the flow-volume loop!
PFTs can evaluate symptoms, disease progression, and response to treatment.

Use a systematic approach to determining presence of obstruction, restriction, and diffusion impairment.

Identifying common patterns on PFTs can provide clues to the diagnosis.