PULMONARY FUNCTION TESTING WORKSHOP

Association of Physician Assistants in Allergy, Asthma, and Immunology

Presented by:
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OBJECTIVES

• Identification
  • Identify indications for performing in-office spirometry
  • Conditions that can be diagnosed with the aid of spirometry
  • Different forms of Pulmonary Function Testing
OBJECTIVES CONT’D

• Utilization
  • Terminology of PFT (FVC, FEV1, FEV1/FVC ratio, FEF25-75%)
  • Proper use of an MDI
  • Proper use of a spirometer
  • Factors that can affect reliability of your spirometry
OBJECTIVES CONT’D

• Interpretation
  • How to read a spirometry curve
    • Normal
    • Obstruction
    • Restriction
    • Mixed obstructive/restrictive curves
DISCLOSURES

We have no actual or potential conflict of interest in relation to the information provided in this presentation.
IDENTIFY INDICATIONS FOR PERFORMING IN-OFFICE SPIROMETRY: WHAT DOES IT DO?

- In-office spirometry is utilized in the evaluation of patients who have complaints of, or have risk factors for, respiratory symptoms and disease.
- The aim of in-office spirometry is primarily to evaluate and monitor obstructive pulmonary diseases, such as asthma and COPD.
- There is some diagnostic value for spirometry in restrictive disease, but it is not particularly useful in monitoring severity of disease as there is usually little variability in lung function with those with restrictive lung disease.
WHAT SPIROMETRY DOES NOT DO

• In-office spirometry can only provide information on lung air flow and lung volume. It CANNOT identify diffusion defects at the alveolar level (ie. unable to measure DLCO)

• DLCO can be measured with a formal pulmonary function test, which is not typically utilized in the office setting
TYPES OF PULMONARY FUNCTION TESTING

• Spirometry
  • Used for diagnosis of airflow obstruction (Asthma, COPD, Interstitial Lung Disease, Neuromuscular disease)
  • For asthma and COPD, we often do spirometry post bronchodilator use to assess reversibility
  • Spirometry will be our primary focus today

• Bronchoprovocation Challenges
  • Used to evaluate hyperresponsiveness in the airway which may not be apparent on spirometry alone
  • Use of methacholine is sometimes used to irritate the airways in asthmatics
  • This carries particular risk and is not commonplace in the outpatient setting
TYPES OF PULMONARY FUNCTION TESTING CONTINUED

• Formal Pulmonary Function Testing
  • A more comprehensive evaluation of lung function which can evaluate DLCO (diffusion capacity at the alveolar level).
  • This is done more frequently in hospital/academic institutions

• FeNo
  • Exhaled nitrous oxide
  • NO is thought to be involved in bronchial tone/bronchodilation, as well as ciliary movement in respiratory system
  • Asthmatics tend to have higher levels of FeNO, which can be useful for diagnosis and evaluation of asthma control
HOW TO OBTAIN GOOD SPIROMETRY

• Nose clips may be applied to patient to prevent air leakage before starting the test
• Patient should take a deep breath out, then a big breath in
• Patient should then place spirometer in mouth and breathe out as forcefully and quickly as possible for a minimum of six seconds
• Provider doing the spirometry should coach patient and encourage them to keep blowing out even if patient does not feel any air moving
• Three measurements should be collected to attain best effort if possible
  • Please note symptomatic asthmatics may experience worsening bronchospasm with repeated forced exhalations
• Spirometry may be repeated after use of an MDI to attain post-bronchodilator measurements
UTILIZATION: THINGS THAT CAN HAPPEN TO DECREASE RELIABILITY OF YOUR SPIROMETRY

• Patient Effort
  • Patient does not take deep inhalation prior to blowing into machine
  • Patient does not exhale for at least six seconds
  • Patient coughs
  • Patient removes device from mouth before complete inhalation
UTILIZATION: THINGS THAT CAN HAPPEN TO DECREASE RELIABILITY OF YOUR SPIROMETRY

• Coaching Effort/ User Error
  • Unfamiliarity with procedure or machine
  • Not obtaining 3 flow loops to choose best effort (ie. too few data points)
  • Not coaching patient to exhale for six seconds
  • Not coaching patient to exhale as forcefully as possible during testing
  • Improper administration of MDI for post-bronchodilatory response
  • Not waiting long enough after MDI administration before performing post-bronchodilatory spirometry
  • **Improper height/weight/age entered into the machine**
HOW TO PROPERLY USE AN MDI

• Shake inhaler device for ~5 seconds
• Exhale before using the inhaler
• Put inhaler to the lips
• Close lips around inhaler
• Push canister, and breathe in slowly and deeply
• Hold breath for 10 seconds
• Breathe out
KEY DEFINITIONS

- **FVC**: Forced Vital Capacity
  - The maximum amount of air that can be expelled during a forced exhale

- **FEV1**
  - The amount of air that can be expelled from the lungs in one second

- **FEV1/FVC ratio**
  - The amount of air that can be expelled in one second in relation to the total amount of air expelled with forceful exhale
KEY DEFINITIONS CONTINUED

• FEF25-75%
  • Mid flow ranges, sometimes used to evaluate small airways
  • Controversial ([https://erj.ersjournals.com/content/43/4/1051](https://erj.ersjournals.com/content/43/4/1051))
    • “Maximum mid-expiratory flow and flow towards the end of the forced expiratory manoeuvre do not contribute usefully to clinical decision making over and above information from FEV₁, FVC and FEV₁/FVC ratio.”
    • This is still often used by clinicians despite this

• Please note there are more in-depth values that can be evaluated on a PFT, but for the purpose of this course we will only focus on FEV₁, FVC, FEV₁/FVC, and FEF25-75%
FLOW-VOLUME LOOP
STEPWISE APPROACH TO INTERPRETATION

• Step 1: Get impression of curve BEFORE looking at the numbers
  • Obstructive? Restrictive? Flat?

• Step 2: Look at FVC

• Step 3: Look at FEV1

• Step 4: Look at FEV1/FVC Ratio

• Step 5: Evaluate bronchodilatory response (if applicable), check curve for good effort and reproducibility

• Step 6: Evaluate reliability of the curve and determine what kind of spirometry you have
NORMAL SPIROMETRY REPORTING WITH FLOW VOLUME LOOP
OBSTRUCTION

- Potential Dx: asthma, COPD, bronchiectasis, FEV1: Low, FVC: normal or low
- FEV1/FVC <70%
- ATS Guidelines for evaluating degree of obstruction:
  - FEV1 >70%, normal
  - FEV1 60-70%. Mild
  - FEV1 50-60% Moderate
  - FEV1 35-50% severe
  - FEV1 <35% very severe
- Bronchodilatory effect
  - If FEV1 improves >12% after AND improvement of 200ml after SABA use indicates bronchodilatory effect
RESTRICTION

- Potential Dx: Remodeled airway (untreated asthma/COPD over time), pulmonary fibrosis, pneumoconiosis, hypersensitivity pneumonitis, obesity, cystic fibrosis

- FVC: low
- FEV1: low
- FEV1/FVC Ratio **normal or elevated**

- Characterizing degree of restriction
  - FVC 60-80% - Mild
  - FVC 50-60% - Moderate
  - FVC <50% Severe
MIXED

- Potential Dx: chronic uncontrolled asthma, multifactorial health issues (ie. obese asthmatics)
- FVC: low
- FEV1: low
- FEV1/FVC: low
TYPES OF AIRWAY OBSTRUCTIVE PATTERNS

Schematic flow-volume loop configuration in a spectrum of airway lesions

(A) Normal.
(B) Variable extrathoracic upper airway obstruction.
(C) Variable intrathoracic upper airway lesions.
(D) Fixed upper airway obstruction.
(E) Lower airways obstruction.
# Diagnosing Obstructive Flow Patterns

## Causes of Wheezing Based on Anatomic Site of Obstruction

<table>
<thead>
<tr>
<th>Extrathoracic Upper Airway Obstruction</th>
<th>Intrathoracic Upper Airway Obstruction</th>
<th>Lower Airway Obstruction</th>
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<tbody>
<tr>
<td>Postnasal drip syndrome</td>
<td>Tracheal stenosis</td>
<td>Asthma</td>
</tr>
<tr>
<td>Paroxysmal vocal cord motion</td>
<td>Foreign body aspiration</td>
<td>Chronic obstructive pulmonary disease</td>
</tr>
<tr>
<td>Hyperinflated tonsils</td>
<td>Benign airway tumors</td>
<td>Pulmonary edema</td>
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<tr>
<td>Supraglottitis</td>
<td>Malignancies</td>
<td>Aspiration</td>
</tr>
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<td>Laryngeal edema</td>
<td>Intrathoracic goiter</td>
<td>Pulmonary embolism</td>
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<td>Tracheobronchomegaly</td>
<td>Bronchiolitis</td>
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<tr>
<td>Postextubation granuloma</td>
<td>Acquired tracheomalacia</td>
<td>Cystic fibrosis</td>
</tr>
<tr>
<td>Retropharyngeal abscess</td>
<td>Herpetic tracheobronchitis</td>
<td>Carcinoid syndrome</td>
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<tr>
<td>Benign airway tumors</td>
<td>Right-sided aortic arch</td>
<td>Bronchiectasis</td>
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<tr>
<td>Anaphylaxis</td>
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<td>Lymphangitic carcinomatosis</td>
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<td>Malignancy</td>
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<td>Parasitic infections</td>
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<tr>
<td>Obesity</td>
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<td>Keilaniella rhinoscleroma</td>
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</tr>
<tr>
<td>Mobile supraglottic soft tissue</td>
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<td></td>
</tr>
<tr>
<td>Relapsing polychondritis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laryngeal</td>
<td></td>
<td></td>
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<tr>
<td>Abnormal anhydroid movement</td>
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<tr>
<td>Vocal cord hematoma</td>
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<td></td>
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<tr>
<td>Bilateral vocal cord paralysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laryngomalacia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granulomatosis with polyangiitis (Wegener’s)</td>
<td></td>
<td></td>
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</tbody>
</table>

Source: UptoDate
EXTRATHROACIC UPPER AIRWAY OBSTRUCTION

- Flattening on inspiratory curve indicates upper airway obstruction (extrathroacic)
- DDx is extensive, but vocal cord dysfunction should be high on the list
FIXED OBSTRUCTION

- Can be difficult to evaluate if large or small airway
- When the fixed obstruction is more “boxed-shaped,” the more likely it is a large airway obstruction
COUGH
QUESTIONS?
PRACTICE WITH PFTS
STEPS TO READING A PFT

• 1: LOOK at the graph!
• 2: What is the FVC?
• 3: What is the FEV1?
• 4: What is the FEV1/FVC ratio?
• 5: Was there bronchodilatory effect?
• 6: Ask: Is this a good effort?
NOTE

• These are real PFTs performed by real patients
• These are not textbook examples of every condition, as there is no such thing as a textbook patient!
• Remember, clinical history is more important than a lab test
EXAMPLE #1

- 1) Curve LOOKS obstructive
- 2) FVC: 93%
- 3) FEV1: 83%
- 4) FEV1/FVC: 68%
- 5) Bronchodilatory effect? – 12%, yes
- 6) Useable PFT? Not perfect, but usable
  - Not as reproducible as I would like
- Verdict?: Borderline obstructive
EXAMPLE #2

1) Curve LOOKS restrictive
   - Smaller than I would expect

2) FVC: 52%

3) FEV1: 55%

4) FEV1/FVC: 91%

5) Bronchodilatory effect? – 33%
   - FEF25-75% improvement of 56% which would indicate defect in the small airways

6) Useable PFT?
   - Debatable; short exhalation, but curves are similar in shape
   - Would not expect to see such a bronchodilatory effect on a restrictive curve like this

7) Verdict?
   - Moderately Restrictive PFT, likely mixed due to underlying bronchodilatory effect
NOTE: This is a PFT obtained on a child

1) Curve LOOKS normal for a child
2) FVC: 101%
3) FEV1: 106%
4) FEV1/FVC: 94%
5) Bronchodilatory effect? No
6) Useable PFT?
   • Yes, good reproducibility
   • This PFT was done on a CHILD and thus curve is smaller in appearance and an exhalation of 3 seconds is usually adequate
7) Verdict?
   • Normal PFT

### EXAMPLE #3

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Units</th>
<th>Predicted</th>
<th>Pre-Bronchodilator</th>
<th>Post-Bronchodilator</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Actual</td>
<td>% Pred.</td>
<td>Actual</td>
<td>% Pred.</td>
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<tr>
<td>FVC</td>
<td>L</td>
<td>1.63</td>
<td>1.65</td>
<td>1.59</td>
<td>-3 %</td>
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<tr>
<td>FEV1</td>
<td>L</td>
<td>1.46</td>
<td>1.54</td>
<td>1.48</td>
<td>-4 %</td>
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<tr>
<td>FEV1/FVC</td>
<td>%</td>
<td>89 %</td>
<td>94 %</td>
<td>93 %</td>
<td>0 %</td>
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<tr>
<td>FEF25%</td>
<td>L/S</td>
<td>2.36</td>
<td>3.59</td>
<td>3.01</td>
<td>-16 %</td>
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<tr>
<td>FEF50%</td>
<td>L/S</td>
<td>2.06</td>
<td>3.00</td>
<td>2.85</td>
<td>-5 %</td>
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<tr>
<td>FEF75%</td>
<td>L/S</td>
<td>1.07</td>
<td>1.25</td>
<td>1.86</td>
<td>49 %</td>
</tr>
<tr>
<td>FEF25-75%</td>
<td>L/S</td>
<td>1.87</td>
<td>2.53</td>
<td>2.56</td>
<td>1 %</td>
</tr>
<tr>
<td>PEF</td>
<td>L/S</td>
<td>3.56</td>
<td>3.50</td>
<td>2.96</td>
<td>-15 %</td>
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<tr>
<td>Exp. Time</td>
<td>Sec.</td>
<td>2.22</td>
<td>98 %</td>
<td>83 %</td>
<td>13 %</td>
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<tr>
<td>V ext.</td>
<td>L</td>
<td>0.05</td>
<td>0.08</td>
<td></td>
<td>46 %</td>
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</tbody>
</table>

Pre-BD FVC: 3 attempted, 3 accepted, 2 matches.
Post BD FVC: 1 attempted, 1 accepted, 0 matches.
### EXAMPLE #4

#### Measurement Results:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Units</th>
<th>Predicted</th>
<th>Pre-Bronchodilator</th>
<th>Post-Bronchodilator</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>L</td>
<td>2.81</td>
<td>2.25</td>
<td>80 %</td>
<td>21 %</td>
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<tr>
<td>FEV1</td>
<td>L</td>
<td>2.30</td>
<td>1.33</td>
<td>58 %</td>
<td>20 %</td>
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<tr>
<td>FEV1/FVC</td>
<td>%</td>
<td>81 %</td>
<td>59 %</td>
<td>73 %</td>
<td>0 %</td>
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<tr>
<td>FEF25%</td>
<td>L/S</td>
<td>5.61</td>
<td>1.71</td>
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<td>32 %</td>
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<td>FEF50%</td>
<td>L/S</td>
<td>3.58</td>
<td>0.92</td>
<td>26 %</td>
<td>1 %</td>
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<tr>
<td>FEF75%</td>
<td>L/S</td>
<td>1.38</td>
<td>0.24</td>
<td>17 %</td>
<td>12 %</td>
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<tr>
<td>FEF25-75%</td>
<td>L/S</td>
<td>2.89</td>
<td>0.70</td>
<td>24 %</td>
<td>7 %</td>
</tr>
<tr>
<td>PEF</td>
<td>L/S</td>
<td>5.98</td>
<td>2.88</td>
<td>48 %</td>
<td>34 %</td>
</tr>
<tr>
<td>Exp. Time</td>
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<td>6.93</td>
<td>8.12</td>
<td>65 %</td>
<td>17 %</td>
</tr>
<tr>
<td>V. ext.</td>
<td></td>
<td>0.01</td>
<td>0.02</td>
<td>51 %</td>
<td></td>
</tr>
</tbody>
</table>

- **1)** Curve REALLY obstructive
- **2)** FVC: 80%
- **3)** FEV1: 58%
- **4)** FEV1/FVC: 59%
- **5)** Bronchodilatory effect? 20%
- **6)** Useable PFT?
  - Yes, good reproducibility and exhalation time
- **7)** Verdict?
  - Moderately Obstructive PFT, Mild Restriction (mixed defect)
**EXAMPLE #5**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Units</th>
<th>Predicted</th>
<th>Pre-Bronchodilator</th>
<th>Post-Bronchodilator</th>
<th>% Change</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>% Pred.</td>
<td>Actual</td>
<td>% Pred.</td>
</tr>
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<td>FVC</td>
<td>L</td>
<td>3.47</td>
<td>2.96</td>
<td>85 %</td>
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<td>FEV1</td>
<td>L</td>
<td>3.02</td>
<td>2.19</td>
<td>73 %</td>
<td>3.09</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>%</td>
<td>87 %</td>
<td>74 %</td>
<td>85 %</td>
<td>88 %</td>
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<tr>
<td>FEF25%</td>
<td>L/S</td>
<td>5.86</td>
<td>3.57</td>
<td>61 %</td>
<td>5.83</td>
</tr>
<tr>
<td>FEF50%</td>
<td>L/S</td>
<td>3.87</td>
<td>2.46</td>
<td>64 %</td>
<td>4.57</td>
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<tr>
<td>FEF75%</td>
<td>L/S</td>
<td>1.77</td>
<td>1.07</td>
<td>60 %</td>
<td>2.09</td>
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<tr>
<td>FEF25-75%</td>
<td>L/S</td>
<td>3.68</td>
<td>1.81</td>
<td>49 %</td>
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<tr>
<td>PEF</td>
<td>L/S</td>
<td>6.21</td>
<td>3.75</td>
<td>60 %</td>
<td>5.72</td>
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<tr>
<td>Exp. Time</td>
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<td>3.90</td>
<td>0.07</td>
<td>2.77</td>
<td>0.13</td>
</tr>
<tr>
<td>V ext.</td>
<td>L</td>
<td>0.07</td>
<td>101%</td>
<td>86 %</td>
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</tbody>
</table>

- 1) Curve LOOKS normal-ish
- 2) FVC: 85%
- 3) FEV1: 73%
- 4) FEV1/FVC: 74%
- 5) Bronchodilatory effect? – 41%...waaaait a minute!
- 6) Usable PFT?
  - No, patient coughed!
- 7) We have a cougher! This needs to be repeated
EXAMPLE #6

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Units</th>
<th>Predicted</th>
<th>Pre-Bronchodilator</th>
<th>Post-Bronchodilator</th>
<th>% Change</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Actual</td>
<td>% Pred.</td>
<td>Actual</td>
</tr>
<tr>
<td>FVC</td>
<td>L</td>
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<td>2.48</td>
<td>84 %</td>
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<td>L</td>
<td>2.37</td>
<td>1.32</td>
<td>55 %</td>
<td>1.53</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>%</td>
<td>80 %</td>
<td>53 %</td>
<td>66 %</td>
<td>56 %</td>
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<td>FEF25%</td>
<td>L/S</td>
<td>5.24</td>
<td>1.93</td>
<td>37 %</td>
<td>2.08</td>
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<tr>
<td>FEF50%</td>
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<td>3.27</td>
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<td>24 %</td>
<td>0.88</td>
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<td>FEF75%</td>
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<td>0.70</td>
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<td>PEF</td>
<td>L/S</td>
<td>5.99</td>
<td>2.01</td>
<td>36 %</td>
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<td>0.05</td>
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<tr>
<td>V exp.</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 1) Curve LOOKS obstructive
- 2) FVC: 84%
- 3) FEV1: 55%
- 4) FEV1/FVC: 53%
- 5) Bronchodilatory effect? 16%
- 6) Usable PFT?
  - Yes. Good reproducibility
- Verdict: Moderate Obstruction
EXAMPLE #7

1) Curve LOOKS normal on exhalation
   • Marked flattening on inspiratory curve

2) FVC: 114%

3) FEV1: 101%

4) FEV1/FVC: 85%

5) Post-Bronchodilator effect was not measured in this PFT

6) Usable PFT?
   • Yes, very reproducible, good curves

7) Normal PFT, flattening on inspiration suggests upper airway abnormality (ex. Possible Vocal Cord Dysfunction)

<table>
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<tr>
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<th>Predicted</th>
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<th>3</th>
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<td>% Pred.</td>
<td>Actual</td>
<td>% Pred.</td>
</tr>
<tr>
<td>FEV1</td>
<td>L</td>
<td>2.85</td>
<td>3.33</td>
<td>111%</td>
<td>3.41</td>
<td>114%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>%</td>
<td>95 %</td>
<td>2.79</td>
<td>98 %</td>
<td>2.88*</td>
<td>101%</td>
</tr>
<tr>
<td>FEF25%</td>
<td>L/S</td>
<td>6.04</td>
<td>84 %</td>
<td>88 %</td>
<td>85 %</td>
<td>89 %</td>
</tr>
<tr>
<td>FEF50%</td>
<td>L/S</td>
<td>4.16</td>
<td>80 %</td>
<td>92 %</td>
<td>85 %</td>
<td>91 %</td>
</tr>
<tr>
<td>FEF75%</td>
<td>L/S</td>
<td>2.20</td>
<td>1.48</td>
<td>67 %</td>
<td>1.55</td>
<td>71 %</td>
</tr>
<tr>
<td>FEF25-75%</td>
<td>L/S</td>
<td>3.31</td>
<td>3.15</td>
<td>95 %</td>
<td>3.15</td>
<td>95 %</td>
</tr>
<tr>
<td>PEF</td>
<td>L/S</td>
<td>6.45</td>
<td>4.82</td>
<td>75 %</td>
<td>5.35</td>
<td>83 %</td>
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<td>Exp. Time</td>
<td>Sec.</td>
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<td>2.55</td>
<td>2.02</td>
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<td>V_ext.</td>
<td>L</td>
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<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>
EXAMPLE #8

1) Curve LOOKS fairly normal, maybe a little obstructive

2) FVC: 96%

3) FEV1: 86%

4) FEV1/FVC: 82%

5) Bronchodilatory effect? No

6) Usable PFT?
   - Yes, very reproducible, good curves

7) Normal by ATS guidelines. Possibly some slight obstruction.
EXAMPLE #9

• 1) Curve LOOKS obstructive
• 2) FVC: 90%
• 3) FEV1: 70%
• 4) FEV1/FVC: 71%
• 5) Post Bronchodilatory Effect? 20%, yes
  - Note FEF25-75% had 55% improvement
• 6) Usable PFT?
  - Yes, reproducible, good curves
• 7) Mildly obstructive PFT, more so notable in FEF25-75% which I personally would consider to be valuable information based on pt history
EXAMPLE #10

1) Curve LOOKS small, possibly mildly obstructive
2) FVC: 76%
3) FEV1: 73%
4) FEV1/FVC: 81%
5) Post Bronchodilatory Effect? 7%, no.
   • Again, FEF25-75% Shows bronchodilatory effect of 29%
6) Usable PFT?
   • Yes, reproducible, good curves
7) Mildly restrictive, borderline obstructive. Personally, concern for small airway involvement based on FEF25-75%

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Units</th>
<th>Predicted</th>
<th>Pre-Bronchodilator</th>
<th>Post-Bronchodilator</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Actual</td>
<td>% Pred.</td>
<td>Actual</td>
<td>% Pred.</td>
</tr>
<tr>
<td>FVC</td>
<td>L</td>
<td>5.10</td>
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<td>3.89</td>
<td>76 %</td>
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<tr>
<td>FEV1</td>
<td>L</td>
<td>4.26</td>
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<td>3.13</td>
<td>73 %</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>%</td>
<td>84 %</td>
<td></td>
<td>81 %</td>
<td>95 %</td>
</tr>
<tr>
<td>FEF25%</td>
<td>L/S</td>
<td>7.95</td>
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<td>7.12</td>
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<td>FEF50%</td>
<td>L/S</td>
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<td>3.49</td>
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<td>FEF75%</td>
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<td>1.38</td>
<td>47 %</td>
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<tr>
<td>FEF25-75%</td>
<td>L/S</td>
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<td>PEF</td>
<td>L/S</td>
<td>8.69</td>
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<td>7.98</td>
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<td>Exp. Time</td>
<td>Sec.</td>
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<td>V. ext.</td>
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<td>0.11</td>
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<td>0.06</td>
<td>-50 %</td>
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</tbody>
</table>
**EXAMPLE #11**

1) Curve LOOKS Wrong
   - Curves do not MATCH or look anything ALIKE
2) We can stop here. This is not a useful PFT and needs to be repeated

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Units</th>
<th>Predicted</th>
<th>Pre-Bronchodilator</th>
<th>Post-Bronchodilator</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Actual</td>
<td>% Pred.</td>
<td>Actual</td>
<td>% Pred.</td>
</tr>
<tr>
<td>FVC</td>
<td>L</td>
<td>3.100</td>
<td>2.981</td>
<td>96 %</td>
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<tr>
<td>FEV1</td>
<td>L</td>
<td>2.868</td>
<td>2.527</td>
<td>88 %</td>
<td>1.345</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>%</td>
<td>93 %</td>
<td>85 %</td>
<td>92 %</td>
<td>58 %</td>
</tr>
<tr>
<td>FEF25%</td>
<td>L/S</td>
<td>5.795</td>
<td>4.910</td>
<td>85 %</td>
<td>1.558</td>
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<td>FEF50%</td>
<td>L/S</td>
<td>3.599</td>
<td>3.057</td>
<td>85 %</td>
<td>0.927</td>
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<tr>
<td>FEF75%</td>
<td>L/S</td>
<td>1.765</td>
<td>1.050</td>
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<td>FEF25-75%</td>
<td>L/S</td>
<td>3.642</td>
<td>2.710</td>
<td>74 %</td>
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<td>PEF</td>
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<td>7.112</td>
<td>5.365</td>
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<td>Sec.</td>
<td>5.200</td>
<td>0.087</td>
<td>0.037</td>
<td>-58 %</td>
</tr>
</tbody>
</table>

- Pre-BD FVC: 3 attempted, 2 accepted, 2 matches.
- Post BD FVC: 3 attempted, 3 accepted, 0 matches.
HANDS ON: FUN WITH SPIROMETERS

• We will now practice with our in office spirometers
• Please ask questions! We are here to help!
REFERENCES

- https://www.uptodate.com/contents/flow-volume-loops?search=flow%20volume%20loop&source=search_result&selectedTitle=1~55&usage_type=default&display_rank=1