Spirometry and Beyond

PCCP MIDYEAR CONVENTION
2014
Objectives

1. Specify the indications for pulmonary function testing
   1. Spirometry
   2. Lung volume studies
   3. DLCO or Diffusing Capacity for CO

2. Describe how the following pulmonary function tests are performed

3. Understand interpretation and clinical implications of pulmonary function testing results, including differential diagnosis
Indications of PFT

- Evaluate respiratory symptoms, signs, and correlate with abnormal laboratory or radiographic findings
- Assist in diagnosing respiratory diseases
- Monitor respiratory disease activity and response to therapy
- Determine respiratory disease prognosis
- Evaluate the pulmonary effects of occupations, environmental and drug exposures
- Provide objective assessment of impairment or disability
- Evaluate risk prior to lung resection surgery

Murray and Nadel’s Textbook of Respiratory Medicine
Clinical goals of PFT:

- To categorize the physiological impairment from lung disease (obstructive vs restrictive)
- To quantify the degree of functional impairment

- Macintyre, Neil. 2006. PFT: Controversies and New Developments in Testing and Interpretation
Case #1

- 35 YEAR OLD FEMALE
- NON SMOKER
- EPISODIC SHORTNESS OF BREATH
- COUGH AT NIGHT
- RELIEVED BY SALBUTAMOL NEBULIZATION

<table>
<thead>
<tr>
<th></th>
<th>REF</th>
<th>PRE</th>
<th>%REF</th>
<th>POST</th>
<th>%REF</th>
<th>%CHANGE</th>
<th>ML CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1/FVC</td>
<td>75</td>
<td>61</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1</td>
<td>2.04</td>
<td>1.39</td>
<td>68</td>
<td>1.6</td>
<td>78</td>
<td>15</td>
<td>210</td>
</tr>
<tr>
<td>FVC</td>
<td>2.71</td>
<td>2.26</td>
<td>83</td>
<td>2.5</td>
<td>92</td>
<td>11</td>
<td>240</td>
</tr>
</tbody>
</table>
Obstructive vs Restrictive

- Reduction of maximal airflow in relation to maximal volume
- Airway narrowing during exhalation
- Reduced FEV1/VC ratio below 5th percentile
- Slowing in the terminal portion of the spirogram producing a concave shape

- Reduction in TLC below 5th percentile
- Often caused by submaximal inspiratory or expiratory efforts
- May be suspected when VC is reduced, the FEV1/VC is increased
- Flow volume curve shows a convex pattern
### Recommended Post Bronchodilator Study Protocol

1. Assess lung function at baseline
2. Administer salbutamol in **four separate doses of 100 mg through a spacer** (100 mcg/dose)
3. Re-assess lung function after 15 min. If you want to assess the potential benefits of a different bronchodilator, use the same dose and the same route as used in clinical practice. The wait time may be increased for some bronchodilators
(?) Reproducibility Criteria

(?) Loop Pattern

Verify with Numbers

Is FEV1/FVC $>$ LLN?

- Yes
  - Normal
  - Restrict.
- No
  - Obstruct.
  - Mixed

Is FVC $>$ LLN?

- Yes
  - Normal
  - Obstruct.
  - Mixed
- No
  - Probable Restrict.
  - Obstruct.

<table>
<thead>
<tr>
<th>REF</th>
<th>PRE</th>
<th>%REF</th>
<th>POST</th>
<th>%REF</th>
<th>%CHANGE</th>
<th>ML CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1/FVC</td>
<td>75</td>
<td>61</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1</td>
<td>2.04</td>
<td>1.39</td>
<td>68</td>
<td>1.6</td>
<td>78</td>
<td>15</td>
</tr>
<tr>
<td>FVC</td>
<td>2.71</td>
<td>2.26</td>
<td>83</td>
<td>2.5</td>
<td>92</td>
<td>11</td>
</tr>
</tbody>
</table>
Q1-1: What parameter is used as basis for the post bronchodilator response?

A. FEV1
B. FVC
C. FEV1/FVC
D. Either FEV1 or FVC
**ASTHMA**

**GINA 2014:**
Positive post bronchodilator response:
Increase in FEV1 of more than 12% AND 200 ml from baseline

**COPD**

**GOLD 2014:**
Postbronchodilator FEV1/FVC < 0.70
*The degree of reversibility of airflow limitation is no longer recommended

Consider COPD in a patient who is above 40 years old, with dyspnea, chronic cough or sputum production and history of exposure to risk factors

**ATS ERS 2005:**
Positive post bronchodilator response:
Increase in FEV1 and/or FVC of more than 12% AND 200 ml from baseline
Q1-2: Based on the given example, what would be the severity of the obstructive ventilatory defect?

A. Mild
B. Moderate
C. Severe
D. Very severe
Severity of Obstructive/Restrictive Ventilatory Defect
Use postbronchodilator FEV1 if available

<table>
<thead>
<tr>
<th>Degree of Severity</th>
<th>FEV1% Predicted (post bronchodilator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&gt; 70</td>
</tr>
<tr>
<td>Moderate</td>
<td>60-79</td>
</tr>
<tr>
<td>Moderately severe</td>
<td>50-59</td>
</tr>
<tr>
<td>Severe</td>
<td>35-49</td>
</tr>
<tr>
<td>Very severe</td>
<td>&lt; 35</td>
</tr>
</tbody>
</table>
Interpreter’s comments:

- The spirometry test is of good quality based on the standards set by the ATS ERS
- The FEV1/FVC is low (using the 5th percentile of the predicted as lower limit of normality)
- The FVC is normal (using the 5th percentile of the predicted as lower limit of normality)
- The severity of the obstructive ventilatory defect is mild based on post bronchodilator FEV1% predicted of 78
- There is significant response to bronchodilator.
- Normality of parameters is based on Morris Polgar Equation
Final Interpretation:

- Mild obstructive ventilatory defect with significant response to bronchodilator
- Please correlate results clinically
Case 2

- 50 year old male
- Chief complaint of dyspnea
- Progressive shortness of breath for 5 years accompanied by chronic cough
- Smoker 38 pack years, stopped 7 months ago
- History of PTB – 1982, treated for 6 months
- History of secondary spontaneous pneumothorax s/p CTT insertion - 1999
- PPE: decreased breath sounds, no wheezes, crackles over both bases
Case 2: Spirometry

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Pre</th>
<th>Pre%</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>4.13</td>
<td>2.44</td>
<td>59</td>
</tr>
<tr>
<td>FEV1</td>
<td>3.12</td>
<td>2.03</td>
<td>68</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>75</td>
<td></td>
<td>83</td>
</tr>
</tbody>
</table>

Q2-1: What is your interpretation?

A. Obstructive abnormality
B. Restrictive abnormality
C. Normal test
D. Combined restrictive and obstructive abnormalities
(?) Reproducibility Criteria

(?) Loop Pattern Verify with Numbers

Is FEV1/FVC > LLN?

<table>
<thead>
<tr>
<th>YES</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Restrict.</td>
</tr>
</tbody>
</table>

Is FVC > LLN?

<table>
<thead>
<tr>
<th>Yes</th>
<th>Probable Restrict.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Is TLC > LLN?

<table>
<thead>
<tr>
<th>Yes</th>
<th>Obstruct.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Restrict.</td>
</tr>
</tbody>
</table>

Ref | Pre | Pre%
---|-----|-----
FVC | 4.13 | 2.44 | 59
FEV1 | 3.12 | 2.03 | 68
FEV1/F VC | 75 | 83
Case 2: Post-bronchodilator response

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Pre</th>
<th>Pre%</th>
<th>Post</th>
<th>Post%</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>4.14</td>
<td>2.44</td>
<td>59</td>
<td>2.5</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>FEV1</td>
<td>3.12</td>
<td>2.03</td>
<td>68</td>
<td>2.1</td>
<td>70</td>
<td>2</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>75</td>
<td>83</td>
<td>84</td>
<td>84</td>
<td>84</td>
<td>84</td>
</tr>
</tbody>
</table>
Q2-2:
Which of the following would you least likely request for next?

A. Methacholine bronchoprovocative test
B. Lung volume studies
C. Diffusion lung studies
D. High resolution CT of the chest
HRCT

- Patchy areas of emphysematous changes over both upper lobes
- Pleural fibrosis, right upper lobe
Restrictive Lung diseases

- **Spirometric Pattern**
  - FVC - decreased
  - FEV1 - normal/decreased
  - FEV1/FVC - normal/high
Patterns of Ventilatory Dysfunction

- Diseases: Thor. Pump*/Lungs
  - P: Pleura*
  - A: Alveoli
  - I: Interstitium
  - N: Neuromuscular*
  - T: Thoracic Cage*
- Inability to expand alveoli
- Restrictive Vent. Defect (RVD)
- ↓Lung Volume (TLC)

- Diseases: Airways
- Hindrance to passage of air
- Obstructive Vent. Defect (OVD)
- ↓Airflow (FEV1/FVC)***
Why perform lung volume studies?

• SPIROMETRY CAN NOT MEASURE TLC, FRC, AND RV

• TECHNIQUES:
  • HELIUM DILUTION
  • NITROGEN WASHOUT
  • RADIOGRAPHIC
  • BODY PLETHYSMOGRAPHY
Lung volumes: Indications

- Obstructive lung diseases
  - Distinguish asthma, chronic bronchitis, emphysema
  - Assess severity
  - Assess course and therapeutic response
  - Test for early airway disease
  - Measure non-communicating space
  - Determine presence of a combined defect

- Restrictive lung diseases
  - Confirm the presence based on patterns
  - Establish baseline level of impairment
  - Assess course and therapeutic response
  - Suggest physiologic type of disease based on patterns
Case 2: Lung Volume Studies

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Pre%</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC</td>
<td>3.17</td>
<td>76</td>
</tr>
<tr>
<td>TLC</td>
<td>5.75</td>
<td>102</td>
</tr>
<tr>
<td>RV</td>
<td>2.58</td>
<td>138</td>
</tr>
<tr>
<td>RV/TLC</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>FRC</td>
<td>3.83</td>
<td>120</td>
</tr>
<tr>
<td>IC</td>
<td>1.92</td>
<td>68</td>
</tr>
</tbody>
</table>

Lung Volumes

- TLC
- ERV
- RV

![Graph showing lung volumes: Ref and Meas](graph.png)
## Case 2: Lung Volume Studies

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Pre%</th>
<th>Post</th>
<th>Post%</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC</td>
<td>3.17</td>
<td>76</td>
<td>3.55</td>
<td>86</td>
<td>12</td>
</tr>
<tr>
<td>TLC</td>
<td>5.75</td>
<td>102</td>
<td>5.50</td>
<td>98</td>
<td>-4</td>
</tr>
<tr>
<td>RV</td>
<td>2.58</td>
<td>138</td>
<td>1.95</td>
<td>104</td>
<td>-24</td>
</tr>
<tr>
<td>RV/TLC</td>
<td>45</td>
<td></td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRC</td>
<td>3.83</td>
<td>120</td>
<td>3.22</td>
<td>101</td>
<td>-15</td>
</tr>
<tr>
<td>IC</td>
<td>1.92</td>
<td>68</td>
<td>2.28</td>
<td>81</td>
<td>18</td>
</tr>
</tbody>
</table>
Q 2-3: What is your interpretation?

A. Pure Restrictive defect is confirmed
B. Pure Obstructive defect is evident
C. Normal study
D. Combined defect is present
Vital capacity

- Reduced in lung disorders with loss of functioning lung parenchyma
- Used in assessing respiratory muscle involvement in NM disorders
- Mildly reduced in diffuse interstitial diseases
- May be reduced in obstructive airway defects
FRC

- End-expiratory lung volume
- Represents the mechanically neutral position of the respiratory system
- It is 50% of TLC in healthy young adults
FRC

- **Unaffected by**
  - Neuromuscular diseases

- **Reduced in**
  - Parenchymal diseases (alveolar filling or scarring, or atelectasis)
  - Thoracic cage abnormalities (Kyphoscoliosis)

- **Increased in**
  - Other thoracic cage abnormalities like ankylosing spondylitis and
  - Obstructive airway diseases
Total Lung Capacity (TLC)

- The greater the lung volume, the shorter the inspiratory muscle fibers.
- This diminishes the effectiveness of the inspiratory muscle contraction.
TLC

• Emphysema
  • Greater lung compliance, lower elastance
  • Lungs can be inflated to large TLC while lung recoil pressure is less than normal

• Pulmonary Fibrosis
  • Reduced lung compliance, greater elastance
  • Inspiratory muscles are at a mechanical advantage and lung recoil pressure is greater than normal
CAUSES OF REDUCED TOTAL LUNG CAPACITY

• EXTRAPULMONARY
• PLEURAL DISEASE
  • EFFUSION
  • THICKENING
  • PNEUMOTHORAX
• RIB CAGE DEFORMITY
  • SCOLIOSIS
  • THORACOPLASTY
• RESPIRATORY MUSCLE WEAKNESS
• GROSS ABDOMINAL ENLARGEMENT
• OBESITY
Residual volume

Increased in
- Expiratory muscle weakness
- Aging
- Diffuse airway narrowing

Reduced in
- Space occupying lesions
- Lung resection
Obstructive Lung diseases

- Increased RV
  - Due to dynamic airway closure and narrowing important during expiration below FRC leading to air trapping and hyperinflation

- Increased FRC and TLC
  - Increased inspiratory muscle tone
  - Decreased lung elastic recoil
Indications of lung volume studies for Obstructive lung diseases

• Assess severity
• Assess response to therapy or bronchodilator challenge
• Detect mild airway disease
Assess severity

• Relationship between RV or TLC and surgical morbidity and mortality
• The general conclusion is that the simpler FEV1 is more useful
• IC/TLC was an independent predictor of respiratory and all-cause mortality in COPD patients

Casanova et al. AM J Respir Crit Care Med 2005; 171:591-597
Assess response to therapy or bronchodilator challenge

• Measurements of lung volumes before and after bronchodilators add sensitivity when examining for bronchodilator response
  • TLC, FRC and RV decreases
  • IC and VC increases

Newton et al. CHEST 2002; 121:1042-1050
Detect Mild airway disease

• Isolated RV elevation in the presence of a normal FEV1/FVC, were found in patients with airway disease

Vulterini et al. THORAX 35:461-466, 1980

• Increased RV in obstruction is a marker of airway closure.

Pride NB. Handbook of Physiology, 1986
Case 2: Lung Volume Studies

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Pre%</th>
<th>Post</th>
<th>Post%</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC</td>
<td>3.17</td>
<td>76</td>
<td>3.55</td>
<td>↑86</td>
<td>12</td>
</tr>
<tr>
<td>TLC</td>
<td>5.75</td>
<td>102</td>
<td>5.50</td>
<td>↓98</td>
<td>-4</td>
</tr>
<tr>
<td>RV</td>
<td>2.58</td>
<td>138</td>
<td>1.95</td>
<td>↓104</td>
<td>-24</td>
</tr>
<tr>
<td>RV/TLC</td>
<td>45</td>
<td></td>
<td></td>
<td>↓35</td>
<td></td>
</tr>
<tr>
<td>FRC</td>
<td>3.83</td>
<td>120</td>
<td>3.22</td>
<td>↑101</td>
<td>-15</td>
</tr>
<tr>
<td>IC</td>
<td>1.92</td>
<td>68</td>
<td>2.28</td>
<td>↑81</td>
<td>18</td>
</tr>
</tbody>
</table>
Patterns of LV Abnormalities
# LUNG VOLUME STUDIES

<table>
<thead>
<tr>
<th></th>
<th>OBSTRUCTIVE</th>
<th>RESTRICTIVE PARENCHYMAL</th>
<th>RESTRICTIVE EXTRAPARENCHYMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TLC</strong></td>
<td>NORMAL/INC.</td>
<td>DECREASED</td>
<td>DECREASED</td>
</tr>
<tr>
<td><strong>RV</strong></td>
<td>INCREASED</td>
<td>DECREASED</td>
<td>INCREASED</td>
</tr>
<tr>
<td><strong>RV/TL C</strong></td>
<td>INCREASED</td>
<td>NORMAL/INC.</td>
<td>INCREASED</td>
</tr>
</tbody>
</table>
Diffusing Capacity

- Addresses the gas-transfer function of the lungs
- Reflects the amount of functioning capillary bed in contact with ventilated alveoli
- $\text{DLCO} \equiv$
- $= (\text{Pressure diff.}) \cdot \text{Area} \cdot \text{Solubility} \cdot \text{Thickness of the membrane. MW}
- $\text{DLCO} = \text{ml/min/mmHg}$
DIFFUSING CAPACITY

• DECREASED DLCO
  1. DISORDERS OF THE PULMONARY PARENCHYMA
     Increased thickness of the alveolar-capillary membrane
  2. VASCULAR ABNORMALITIES
     Destruction of capillary bed through scarring and capillary obliteration
  3. REDUCED EFFECTIVE ALVEOLAR UNITS (i.e. LUNG RESECTION, EMPHYSEMA)
     Loss of membrane surface area
  4. ANEMIA
  5. HEAVY CIGARETTE SMOKING
DIFFUSING CAPACITY

- INCREASED DLCO
  1. INCREASED PULMONARY BLOOD VOLUME
  2. ASTHMA
  3. OBESITY
  4. L-R SHUNT
  5. POLYCYTHEMIA
  6. POST-EXERCISE
ALTERATIONS IN DL/VA

• Low DL with normal or increased VA (Low DL/VA)
  1. Anemia
  2. Emphysema
  3. Pulmonary embolism
  4. Pulmonary vasculitis
  5. Early ILD
ALTERATIONS IN DL/VA

• Low DL and Low VA (low, normal or high DL/VA)
  1. Lung resection (DL/VA near normal)
  2. Pulmonary interstitial disease
### Degree of Severity of Decrease in DLCO

<table>
<thead>
<tr>
<th>Degree of Severity</th>
<th>DLCO% pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&gt; 60% and &lt; LLN</td>
</tr>
<tr>
<td>Moderate</td>
<td>40-60 %</td>
</tr>
<tr>
<td>Severe</td>
<td>&lt;40%</td>
</tr>
</tbody>
</table>
Case 2: Diffusing Capacity (DLCO)

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Pre Meas</th>
<th>Pre % Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLCO</td>
<td>21.6</td>
<td>12.96</td>
<td>60</td>
</tr>
<tr>
<td>VA</td>
<td>6.18</td>
<td>5.01</td>
<td>81</td>
</tr>
<tr>
<td>DLCO/VA</td>
<td>4.14</td>
<td>2.58</td>
<td>62</td>
</tr>
</tbody>
</table>
FEV/VC > LLN

Yes

VC > LLN

Yes

Normal

No

TLC > LLN

Yes

TLC > LLN

Yes

Normal

No

Restriction

No

Obstruction

Mixed Defect

No

DLCO > LLN

Yes

Normal

PV Disorders

No

CW and NM disorders

ILD

Pneumonitis

Asthma

CB

Yes

Emphysema

ATS/ERS TASK FORCE, ERJ 2005;26:948-968
Interpreters
comments:

- The spirometry test is of good quality based on standards set by the ATS-ERS
- The FEV1/FVC is normal (using the 5th percentile of the predicted as lower limit of normality)
- The FVC is low (using the 5th percentile of the predicted as lower limit of normality)
- There is no significant response to bronchodilator
- Normality of parameters is based on Morris Polgar equation
### Lung Volume Studies and DLCO

- **Lung volume studies** based on body plethysmograph showed normal results.
- **DLCO** is mildly reduced.

#### Final Interpretation

- Mild obstructive ventilatory defect with no significant response to bronchodilator.
- Please correlate clinically.

#### Lung Volume Studies

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Pre%</th>
<th>Post</th>
<th>Post%</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>4.14</td>
<td>2.44</td>
<td>59</td>
<td>2.5</td>
<td>60</td>
</tr>
<tr>
<td>FEV1</td>
<td>3.12</td>
<td>2.03</td>
<td>68</td>
<td>2.1</td>
<td>70</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>75</td>
<td>83</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VC</td>
<td>3.17</td>
<td>76</td>
<td>3.55</td>
<td>86</td>
<td>12</td>
</tr>
<tr>
<td>TLC</td>
<td>5.75</td>
<td>102</td>
<td>5.50</td>
<td>98</td>
<td>-4</td>
</tr>
<tr>
<td>RV</td>
<td>2.58</td>
<td>138</td>
<td>1.95</td>
<td>104</td>
<td>-24</td>
</tr>
<tr>
<td>RV/TLC</td>
<td>45</td>
<td></td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRC</td>
<td>3.83</td>
<td>120</td>
<td>3.22</td>
<td>101</td>
<td>-15</td>
</tr>
<tr>
<td>IC</td>
<td>1.92</td>
<td>68</td>
<td>2.28</td>
<td>81</td>
<td>18</td>
</tr>
<tr>
<td>DLCO</td>
<td>21.6</td>
<td>12.96</td>
<td></td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>VA</td>
<td>6.18</td>
<td>5.01</td>
<td></td>
<td></td>
<td>81</td>
</tr>
<tr>
<td>DLCO/VA</td>
<td>4.14</td>
<td>2.58</td>
<td></td>
<td></td>
<td>62</td>
</tr>
</tbody>
</table>
Case 3

- 75 M with COPD diagnosed with RLL Stage II a NSCLCA
- Evaluated for curative resection with a right lower lobectomy.
- PMHx: HPN and GERD
- Current medications:
  - Tiotropium bromide 2.5 mcg/puff 2 puffs once a day
  - Salmeterol+ Fluticasone 25/250 2 puffs BID
  - Ipatropium bromide + Salbutamol MDI as needed
  - Telmisartan 40 mg tab Once a day
  - Esomeprazole 20 mg daily

PPE: decreased breath sounds both lung fields
Case 3

Pre BD spirometry:

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>4.25</td>
<td>3.1</td>
<td>73%</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.04</td>
<td>1.40</td>
<td>46%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td></td>
<td>0.45</td>
<td></td>
</tr>
</tbody>
</table>
Q 3-1: What is your interpretation of the spirometric study?

A. Obstructive abnormality
B. Restrictive abnormality
C. Normal test
D. Combined restrictive and obstructive abnormalities

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>4.25</td>
<td>3.1</td>
<td>73%</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.04</td>
<td>1.40</td>
<td>46%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>0.45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interpreters comments:

- The spirometry test is of good quality based on standards set by the ATS-ERS
- The FEV1/FVC is low (using the 5th percentile of the predicted as lower limit of normality)
- The FVC is low (using the 5th percentile of the predicted as lower limit of normality) which is probably due to a restrictive ventilatory defect or obstructive ventilatory defect (with residual volume hyperinflation)
- The severity of the obstructive ventilatory defect is severe based on the postbronchodilator FEV1 % predicted of 46
- Post bronchodilator testing was not done
- Normality of parameters is based on Morris Polgar equation

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>4.25</td>
<td>3.1</td>
<td>73%</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.04</td>
<td>1.40</td>
<td>46%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td></td>
<td>0.45</td>
<td></td>
</tr>
</tbody>
</table>

Final Interpretation:

Severe obstructive ventilatory defect. We suggest to proceed to post bronchodilator testing. We suggest requesting for a lung volume study to confirm presence of restrictive ventilatory defect and rule out obstructive ventilatory defect. Please correlate clinically.
Q3-2: What is the next step in your evaluation of the patient prior to surgical resection?

A. No further testing  
B. Exercise Echocardiogram  
C. Cardiopulmonary exercise testing  
D. Perfusion Lung scan
Estimation of Postoperative FEV1

Predicted postoperative FEV1 = Preoperative FEV1 (L) x 
(1 – y/z)

Y – no. of functional units to be removed
Z – total no. of lung units

Same formula applies to DLCO.
Postoperative FEV1

Postoperative FEV1 = (1.40) x (1-5/18)
= 0.92 L (33%)

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>4.25</td>
<td>3.1</td>
<td>73%</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.04</td>
<td>1.40</td>
<td>46%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td></td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>DLCO (ml/min/mmHg)</td>
<td>33</td>
<td>18.15</td>
<td>55 %</td>
</tr>
</tbody>
</table>
Postoperative DLCO

Postoperative DLCO = (18.15) x (1 - 5/18)
  = 13.10 (48%)

Postoperative FEV1 X Postoperative DLCO
  = 0.92 x 13.10
  = 12.052

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>4.25</td>
<td>3.1</td>
<td>73%</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.04</td>
<td>1.40</td>
<td>46%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td></td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>DLCO (ml/min/mmHg)</td>
<td>33</td>
<td>18.15</td>
<td>55%</td>
</tr>
</tbody>
</table>

A PRODUCT < 16.5% RENDERS THE PATIENT HIGH RISK
ACCP evidence based guidelines on % PPO For Lung Cancer being Considered for Resectional Surgery

Chest 2007 Colice GL, Shafzand S, Griffin
Case No. 4

- 40 year old male
- BMI of 40
- 10 pack year smoker
- Complaint of shortness of breath and easy fatigability
- Non hypertensive, normal ecg findings
- Chest x-ray: normal
Question 4-1:
What could be the most probable cause of the shortness of breath of this patient based on the PFT?

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>5.00</td>
<td>2.30</td>
<td>46</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>4.00</td>
<td>2.00</td>
<td>50</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>0.87</td>
<td>0.80</td>
<td></td>
</tr>
</tbody>
</table>

A. Obstructive ventilatory defect (secondary to smoking history)
B. Restrictive ventilatory defect (secondary to obesity)
C. Both obstructive and restrictive
D. Upper airway obstruction
<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>5.00</td>
<td>2.30</td>
<td>46</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>4.00</td>
<td>2.00</td>
<td>50</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>0.87</td>
<td>0.80</td>
<td></td>
</tr>
</tbody>
</table>

(?) Reproducibility Criteria
(?) Loop Pattern
Verify with Numbers

Is FEV1/FVC > LLN?
- Yes
  - Normal
  - Restrict.

Is FVC > LLN?
- Yes
  - Normal
- No
  - Probable Restrict.

Is TLC > LLN?
- Yes
  - Obstruct.
- No
  - Restrict.
<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>Actual</th>
<th>% Pred</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>5.00</td>
<td>2.30</td>
<td>46</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>4.00</td>
<td>2.00</td>
<td>50</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>0.87</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>RV (L)</td>
<td>1.00</td>
<td>0.80</td>
<td>80</td>
</tr>
<tr>
<td>TLC (L)</td>
<td>6.00</td>
<td>3.1</td>
<td>52</td>
</tr>
<tr>
<td>DLCO</td>
<td>24.00</td>
<td>13.00</td>
<td>54</td>
</tr>
<tr>
<td>DLCO/TLC</td>
<td>4.00</td>
<td>4.20</td>
<td>105</td>
</tr>
<tr>
<td>ERV (L)</td>
<td>0.010</td>
<td>0.200</td>
<td>5</td>
</tr>
<tr>
<td>NIF (cm H20)</td>
<td>120</td>
<td>110</td>
<td>92</td>
</tr>
</tbody>
</table>

Interpreter’s comments:
1. The spirometry test is of good quality based on standards set by the ATS ERS.
2. FEV1/FVC is normal (using the 5th percentile of the predicted as the lower limit of normality)
3. The FVC is low (using the 5th percentile of the predicted as the lower limit of normality).
4. Post bronchodilator testing was not done
5. Lung volume studies via body pletysmograph shows a moderately severe restrictive ventilatory defect
6. DLCO is moderately reduced
7. Normality of parameters is based on Morris Polgar.

**Final Interpretation:**
Moderately severe restrictive ventilatory defect.
Suggest to proceed with postbronchodilator testing.
Please correlate results clinically.