Pulmonary Function Tests (PFTs)

Insights in ILD Pocket Guide
Pulmonary Function Tests

PFTs are noninvasive tests that can measure specific pulmonary parameters such as lung volumes, capacities, airflow, and diffusion\(^1\)

**Spirometry\(^1,2\)**
- Airflow measurement
- Most effective at identifying obstructive defects
- Bronchodilator test can be used to measure reversibility and help evaluate asthma and COPD
- Cannot measure RV, therefore the FRC and TLC also cannot be measured by spirometry

**Lung volume**
- Assessment techniques include body plethysmography, helium dilution, nitrogen washout, and radiographic imaging\(^3\)
- Most effective at confirming restrictive defects\(^4\)

**DL\(_{\text{CO}}\) (diffusing capacity of the lung for carbon monoxide)**
- Measures the diffusion capacity of carbon monoxide to assess how well O\(_2\) and CO\(_2\) diffuse across the alveolar-capillary membrane\(^5\)
- Low DL\(_{\text{CO}}\) can suggest restrictive, possible obstructive, and/or pulmonary vascular diseases\(^4\)

COPD, chronic obstructive pulmonary disease; FRC, functional residual capacity; RV, residual volume; TLC, total lung capacity.
Lung Volumes and Capacities

IRV: inspiratory reserve volume

VC: vital capacity

ERV: expiratory reserve volume

FRC: functional residual capacity

TLC: total lung capacity

VT: tidal volume

IC: inspiratory capacity

RV: residual volume

Lung volume

Lung capacity
## Lung Volumes and Capacities

### Volumes

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV</td>
<td>Volume of air remaining in the lungs after maximal expiration</td>
</tr>
<tr>
<td>ERV</td>
<td>Maximal volume of air expired after a normal resting expiration</td>
</tr>
<tr>
<td>VT</td>
<td>Volume of air inspired or expired with each resting breath</td>
</tr>
<tr>
<td>IRV</td>
<td>Maximal volume of air inspired after a normal resting inspiration</td>
</tr>
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</table>

### Capacities

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>IC</td>
<td>Maximal volume of air inspired after a normal exhalation</td>
</tr>
<tr>
<td>VC</td>
<td>Maximal volume of air expired after the maximal inspiration</td>
</tr>
<tr>
<td>FRC</td>
<td>Volume of air remaining in the lungs after a normal exhalation</td>
</tr>
<tr>
<td>TLC</td>
<td>Volume of air in the lungs after maximal inspiration</td>
</tr>
</tbody>
</table>

Volumes: gas-filled spaces in the lungs

Capacities: combination of two or more volumes
Obstructive defect is characterized by the reduced ability to expire air due to airway resistance.

Reduced FEV₁/FVC ratio
Normal or reduced FEV₁ and FVC
Normal or increased TLC

If obstructive pattern is seen, consider:
- Asthma
- Bronchiectasis
- Bronchiolitis obliterans
- COPD
- Cystic fibrosis
- Silicosis (early)

FEV₁, forced expiratory volume in the first second; FVC, forced vital capacity.
Restrictive defect is characterized by the reduced ability to fully expand lungs during inhalation.

Normal or increased FEV₁/FVC ratio
Reduced FVC
Normal or reduced FEV₁
Reduced TLC

If restrictive pattern is seen, consider:
- Interstitial lung disease
- Chest wall deformities
- Drug pneumotoxicity
- Neuromuscular disorders
**PFT – Mixed Defect**

**Mixed defect** is mixed features of obstructive and restrictive defects.

- Reduced FEV₁/FVC ratio
- Reduced TLC

If mixed pattern is seen, consider:
- A combination of obstructive and restrictive elements

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**Graph:**
- Inspiration
- Expiration
- Predicted flow-volume curves
- Observed flow-volume curves
Assess the gas diffusion from air in the lung to the red blood cells in the alveolar capillary in mL/min/mmHg

$DL_{co}$ Test\textsuperscript{5}

$DL_{co}$ can be affected by: thickness of the membrane, surface area for diffusion, or partial pressure. ILD and emphysema both reduce $DL_{co}$ by increasing the thickness of the membrane or decreasing the surface area, respectively.

Low $DL_{co}$ and normal spirometry and lung volumes may suggest pulmonary vascular disorders.\textsuperscript{6}

ILD, interstitial lung disease.

Boehringer Ingelheim
Interpreting PFTs requires comparing obtained values to reference values (GLI, NHANES III, LLN, fixed ratio), which are dependent on age, gender, race and ethnicity, and height.\(^7\)

Fixed ratio has the risk of underestimating obstruction in children and overestimating obstruction in elderly individuals.\(^7\)

<table>
<thead>
<tr>
<th></th>
<th>FVC</th>
<th>FEV(_1)/FVC</th>
<th>TLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>80-120%</td>
<td>≥70%</td>
<td>80-120%</td>
</tr>
<tr>
<td>Obstructive</td>
<td>80-120% or &lt;80%</td>
<td>&lt;70%</td>
<td>80-120% or &gt;120%</td>
</tr>
<tr>
<td>Restrictive</td>
<td>&lt;80%</td>
<td>≥70%</td>
<td>&lt;80%</td>
</tr>
<tr>
<td>Mixed</td>
<td>&lt;80%</td>
<td>&lt;70%</td>
<td>&lt;80%</td>
</tr>
</tbody>
</table>

\(DL_{CO}\) normal reference: 80-120\%
**Severity of Lung Function Impairment Using Z-Score***

- **Mild**  \(-1.65\) to \(-2.5\)
- **Moderate**  \(-2.51\) to \(-4.0\)
- **Severe**  \(< -4\)

*adapted from Stanojevic S et al. 2021\textsuperscript{8}

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**Key Recommendation Updates**

- Emphasis on role of PFT to classify physiology vs. making diagnosis
- Use of Global Lung Function Initiative (GLI) reference equations to define expected range
- Definition of normal range: LLN = 5\textsuperscript{th} percentile and ULN = 95\textsuperscript{th} percentile
- Positive bronchodilator response: >10\% change of predicted value in FEV\textsubscript{1} or FVC

ULN, upper limit of normal.
Assuring Spirometry Quality Is Important for Accurate Testing

A valid test has 3 or more good curves and repeatable FVC and FEV₁.

Any deviations from a “good curve” may require error correction.
References:


