Introduction

- Types of Pulmonary Function Test
  - Spirometry
  - Lung Volumes
  - Diffusion Capacity
- Types of Ventilatory Defects
  - Obstructive Ventilatory Defect
  - Restrictive Ventilatory Defect
- Severity Classification
- Bronchodilator Response
- Interpretative Strategies

Spirometry

- Spirometry is a physiological test that measures how an individual inhales or exhales volume of air as a function of time.
- Primary measurement in spirometry is either volume or flow.
Indications for Spirometry

- Detecting & quantifying pulmonary impairment in cardiopulmonary diseases
- Following the evolution of diseases & monitoring response to therapy
- Monitoring the effects of environmental, occupational & drug exposures associated with lung injury
- Assess preoperative risk
- Assessing disability & impairment

Indications for Spirometry

- Spirometry is recommended as the “Gold Standard” for the diagnosis of obstructive lung disease by:
  - National Lung Health Education Program (NLHEP)
  - National Heart, Lung and Blood Institute (NHLBI)
  - World Health Organization (WHO)
  - Healthcare Effectiveness Data & Information Set (HEDIS)

HEDIS Measures for COPD

- Use of spirometry in the assessment and diagnosis of COPD
- Age 40 and older
- Adults with a new (within the measurement year) diagnosis or newly active COPD should receive spirometry to confirm the diagnosis
- Spirometric testing must occur 730 days prior to or 180 days after the diagnosing event
Spirometry

- Most common & useful of the lung function tests
- Three primary spirometric indices are:
  - Forced Vital Capacity (FVC)
  - Forced Expiratory volume in 1 sec (FEV1)
  - Ratio FEV1/FVC

**Spirometry**

- FVC test is performed by having patient inhale to TLC & make a maximally forced exhalation into a spirometer
- Exhaled volume is measured as a function of time
- Flow also measured & displayed as a function of exhaled volume

**Spirometry-Test Quality**

- Spirometry depends on achieving a maximal effort during the initial few seconds of exhalation & complete exhalation
- Complete exhalation is indicated by a plateau in the volume-time tracing with a minimum expiratory time of 6 sec
- Plateau is rarely reached:
  - Patients with airflow obstruction
  - Healthy older people who have reduced airflow at low lung volumes because of normal age-related loss of recoil
### Spirometry-Reproducibility Criteria
- At least 3 maneuvers
- “Best” are test with the highest FVC & FEV1
- Two Best test are within 150ml for FVC & FEV1
- Peak flows are within 12%
- No coughs are in the 1st second

### Spirometry-Test Quality
- Spirograms of acceptable quality but not reproducible, should have the patient repeat the test
- If both acceptability & reproducibility criteria are not met in 8 trials, it is unlikely that further test will be acceptable & test is terminated

### Normal Spirogram
Faulty Spirograms-False Start

Pathophysiologic Correlation with Spirometry

- Spirometry is used to classify patients as having one of three patterns:
  - Normal
  - Airflow obstruction
  - Restriction
- Specific diagnoses cannot be made with spirometry alone
- Spirometry patterns must be interpreted according to the clinical questions being asked

Types of Ventilatory Defects

- Obstructive Ventilatory Defects
- Restrictive Ventilatory Defects
Obstructive Ventilatory Defect

- Obstructive defect is characterized by a decreased expiratory flows compared with a healthy persons.
- Early airway obstruction begins in the small airways & tends to reduce flows at lower lung volumes.
- Progressive slowing of expiratory flow is reflected in the concave shape on flow-volume curve.

Obstructive Ventilatory Defect

- Primary marker for the presence of airway obstruction is the FEV1/FVC ratio.
  - FEV1/FVC < 70% predicted.
- Once airway obstruction has been diagnosed, severity is classified by using the FEV1%.

FVC vs FEV6

- Spirometry requires patient effort & cooperation.
- Make a diagnosis of obstruction need FEV1 & FVC.
- Measurement of FVC requires patient to empty lungs completely & can take up to 20 secs.
- Can be physically exhausting for older or impaired patients.
FEV6
- Shortens overall test time
- Reduces patient & technician fatigue
- Allows ATS EOT criterion to be meet
- FEV6 is more reproducible than FVC
- FEV1/FEV6 is as good as FEV1/FVC for diagnosing obstruction & predicting decline in smokers
- FEV1/FEV6 <73% is considered obstructive

FEF 25-75
- FEF 25-75 is an average forced expiratory flow rate over the mid 50% of FVC
- Can be helpful in diagnosing obstruction, but dependent on FVC
- In correct clinical situation, a reduced FEF 25-75 <60% & FEV1/FVC in low-normal range can confirm airflow obstruction

Severity of Obstructive Defect

<table>
<thead>
<tr>
<th>Degree of Severity</th>
<th>FEV1% pred</th>
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<tbody>
<tr>
<td>Mild</td>
<td>&gt;70%</td>
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<tr>
<td>Moderate</td>
<td>60-69%</td>
</tr>
<tr>
<td>Moderately Severe</td>
<td>50-59%</td>
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<tr>
<td>Severe</td>
<td>35-49%</td>
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<tr>
<td>Very Severe</td>
<td>&lt;35%</td>
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</table>
Mild Obstructive Defect

Severe Obstructive Ventilatory Defect

Bronchodilator Response

- Performing spirometry before & after inhaling SABA can be beneficial in patients with an obstructive defect
- Test is performed by:
  - obtaining baseline spirometry
  - administering SABA, waiting 15 mins
  - then repeat the spirometry
Bronchodilator Response

- No consensus about the drug, dose or mode of administering the SABA
- MDI should be administered in 4 separate doses using a spacer
- An improvement in FEV1 and/or FVC of 12% & 200ml from baseline is considered a positive response
- Lack of response does not preclude a clinical response

Restrictive Ventilatory Defect

- Restrictive pattern are characterized by a reduced FVC
- Flows taken from spiromgrams are typically reduced because of the smaller absolute lung volumes
- If airway obstruction is present & FVC is low, a restrictive defect maybe present
- Would recommend obtaining lung volumes to confirm the restrictive defect

Examples of Flow Volume Loops

- Examples of different flow-volume loops for normal, restrictive, obstructive, and combined patterns.
Interpretation of Change in Lung Function

- Evaluating an individual’s change in lung function over time is extremely valuable
- Not easy to determine whether a measured change reflects a true change in pulmonary status or is only a result of test variability

Interpretation of Change in Lung Function

- All lung function measurements tend to be more variable when made weeks to months apart when compared at the same test session or even daily

<table>
<thead>
<tr>
<th></th>
<th>FVC</th>
<th>FEV1</th>
<th>FEF 25-75</th>
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<tbody>
<tr>
<td><strong>Within a day</strong></td>
<td></td>
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<tr>
<td>Normal subjects</td>
<td>&gt;5%</td>
<td>&gt;5%</td>
<td>&gt;13%</td>
</tr>
<tr>
<td>COPD patients</td>
<td>&gt;11%</td>
<td>&gt;13%</td>
<td>&gt;23%</td>
</tr>
<tr>
<td><strong>Week to Week</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
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<tr>
<td><strong>Year to Year</strong></td>
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Lung Volumes Testing

- The term "lung volumes" usually refers to the volume of gas within the lungs as measured by body plethysmography, gas dilution or washout.

Indications for Lung Volume Testing

- Major indication for Lung Volume Testing is to diagnose a restrictive lung disease & to determine the severity of the impairment.
- Restrictive lung disease is defined as reduced lung volumes, particularly VC & TLC.
- Help to clarify whether a decrease in FVC is due to restriction or a consequence of air trapping due to airflow obstruction.
Typical Patterns in Lung Volumes
- TLC Normal Range is 80-120% predicted
- Restrictive Defect
  - TLC < 80% predicted
- Obstructive Defect
  - TLC > 120% predicted

Diffusion Capacity (DLCO)
- Diffusing capacity of lungs for CO
- Measures ability of lungs to transport inhaled gas from alveoli to pulmonary capillaries
- Depends on:
  - alveolar—capillary membrane
  - hemoglobin concentration
  - cardiac output

Diffusion Pathway-Schematic

Diffusion

Alveolar—capillary membrane

Plasma

RBC membrane

RBC interior

Chemical reaction

O2 + Hb

CO + Hb

RBC
**Histology 101**

- Normal Alveolar-capillary membrane
- End Stage COPD
- Normal Lung Parenchyma
- Idiopathic Pulmonary Fibrosis

**Indications for Diffusion Capacity**

- Evaluation & follow-up of parenchymal lung disease
- Evaluation & follow-up of emphysema & differentiate between asthma
- Quantification of impairment & disability
- Evaluation of cardiovascular diseases (e.g. acute/chronic PE, pulmonary hypertension)
- Evaluation of pulmonary involvement in systemic diseases (e.g. RA, SLE)
- Evaluation of effects of chemotherapy or other drugs known to induce pulmonary dysfunction
- Evaluation of pulmonary hemorrhage

**Diffusion Capacity**

- Decrease DLCO (<80% Predicted)
  - Obstructive Lung Disease
  - Parenchymal Lung Disease
  - Pulmonary Vascular Disease
  - Anemia
- Increase DLCO (>120% predicted)
  - Asthma (maybe also normal)
  - Pulmonary Hemorrhage
  - Polycythemia
  - Left to Right Shunt
Pulmonary Function Tests: Systematic Way to Interpretation

- Look at the Force Vital Capacity (FVC) to see if it's within normal limits
- Look at the FEV1 & determine if it is within normal limits
- If both FVC & FEV1 are normal, then you do not have to go any further

- If the FEV1/FVC is <70%, you probably have an obstructive defect
  - Severity can be determined by the FEV1
- If FEV1/FVC is >88% and/or FVC <80%, you probably have a restrictive defect & would consider obtaining lung volumes and/or diffusion capacity

- If the TLC < 80% predicted, then there is a restrictive ventilatory defect
- If the TLC >80% predicted, but the FVC <80%, the patient does not have a restrictive defect
- If the TLC >120% predicted, then there is an obstructive ventilatory defect
Pulmonary Function Tests: Systematic Way to Interpretation

- Would recommend ordering DLCO:
  - To help differentiate asthma from emphysema
  - To help in the evaluation & determine, the severity of interstitial lung disease or restrictive lung disease
  - Evaluate cardiovascular disease

Questions