Pulmonary Function Testing

The Basics of Interpretation

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Objectives

- Identify the components of PFTs
- Describe the indications
- Develop a stepwise approach to interpretation
- Recognize common patterns
- Apply this information to patient care
Which of the following is used to follow disease severity in COPD patients?

a. Total lung capacity (TLC)
b. Degree of responsiveness to bronchodilators
c. Forced vital capacity (FVC)
d. Forced expiratory volume in 1 second
e. Diffusing capacity (DLCO)
A 36yo WF, non-smoker, presents to your office for follow-up of ‘recurrent bronchitis.’ You suspect asthma and decide to order spirometry. Which of the following would you include in your prescription for testing?

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d. Flow volume loop
e. b and c
A 68yo HM is admitted to the ICU with acute respiratory distress. A CXR obtained in the ED demonstrates bilateral pulmonary infiltrates, and his DLCO is elevated. What is the most likely diagnosis?

a. Pulmonary edema
b. Aspiration pneumonitis
c. Pulmonary emboli
d. Alveolar hemorrhage
e. Interstitial lung disease
The Purpose

Provide quantifiable, reproducible measurement of lung function
Description

- Spirometry
- Flow Volume Loop
- Bronchodilator response
- Lung volumes
- Diffusion capacity (DLCO)
- Bronchoprovocation testing
- Maximum respiratory pressures
- Simple and complex cardiopulmonary exercise testing
Indications — Diagnosis

- Evaluation of signs and symptoms
  - SOB, exertional dyspnea, chronic cough
- Screening at-risk populations
- Monitoring pulmonary drug toxicity
- Abnormal study
  - CXR, EKG, ABG, hemoglobin
- Preoperative assessment
Indications — Diagnosis

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Smokers > 45yo (former & current)
Indications — Diagnosis

- Evaluation of signs and symptoms
  - SOB, exertional dyspnea, chronic cough
- Screening at-risk populations
- Evaluation of occupational symptoms
- Monitoring pulmonary drug toxicity
- Abnormal study
  - CXR, EKG, ABG, hemoglobin
- Preoperative assessment
**Indications — Prognostic**

- Assess severity
- Follow response to therapy
- Determine further treatment goals
- Referral for surgery
- Disability
Spirometry

- Simple, office-based
- Measures flow, volumes
- Volume vs. Time
- Can determine:
  - Forced expiratory volume in one second (FEV$_1$)
  - Forced vital capacity (FVC)
  - FEV$_1$/FVC
  - Forced expiratory flow 25%-75% (FEF$_{25-75}$)
Lung Volumes

- Inspiratory Capacity (IC)
- Vital Capacity (VC)
- Inspiratory Reserve Volume (IRV)
- Tidal Volume (TV)
- Total Lung Capacity (TLC)
- Expiratory Reserve Volume (ERV)
- Functional Residual Capacity (FRC)
- Residual Volume (RV)
- Residual Volume (RV)
Spirometry
Normal Spirometry
Obstructive Pattern

- Decreased FEV$_1$
- Decreased FVC
- Decreased FEV$_1$/FVC
  - <70% predicted

FEV$_1$ used to follow severity in COPD
Obstructive Lung Disease — Differential Diagnosis

- Asthma
- COPD
  - chronic bronchitis
  - emphysema
- Bronchiectasis
- Bronchiolitis
- Upper airway obstruction
Restrictive Pattern

- Decreased FEV$_1$
- Decreased FVC
- FEV$_1$/FVC normal or increased
Restrictive Lung Disease — Differential Diagnosis

- Pleural
- Parenchymal
- Chest wall
- Neuromuscular
Spirometry Patterns

Diagram showing flow rate vs. lung volume for normal, restrictive, and obstructive patterns.
Bronchodilator Response

- Degree to which FEV₁ improves with inhaled bronchodilator
- Documents *reversible* airflow obstruction
- Significant response if:
  - FEV₁ increases by 12% and >200ml
- Request if obstructive pattern on spirometry
Flow Volume Loop

- “Spirogram”
- Measures forced inspiratory and expiratory flow rate
- Augments spirometry results
- Indications: evaluation of upper airway obstruction (stridor, unexplained dyspnea)
Flow Volume Loop
Upper Airway Obstruction

- Variable intrathoracic obstruction
- Variable extrathoracic obstruction
- Fixed obstruction
Upper Airway Obstruction

- Fixed Obstruction
- Variable Extrathoracic
- Variable Intrathoracic
Lung Volumes

- **Measurement:**
  - helium
  - nitrogen washout
  - body plethsmography

- **Indications:**
  - Diagnose restrictive component
  - Differentiate chronic bronchitis from emphysema
Lung Volumes – Patterns

- Obstructive
  - TLC > 120% predicted
  - RV > 120% predicted

- Restrictive
  - TLC < 80% predicted
  - RV < 80% predicted
Diffusing Capacity

- 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
Diffusing Capacity

- **Decreased DLCO**
  - (<80% predicted)
  - Obstructive lung disease
  - Parenchymal disease
  - Pulmonary vascular disease
  - Anemia

- **Increased DLCO**
  - (>120-140% predicted)
  - Asthma (or normal)
  - Pulmonary hemorrhage
  - Polycythemia
  - Left to right shunt
DLCO — Indications

- Differentiate asthma from emphysema
- Evaluation and severity of restrictive lung disease
- Early stages of pulmonary hypertension
- Expensive!
Case 1

CC/HPI: A 36yo WM, nonsmoker, presents to your clinic with c/o episodic cough for 6mo. Also reports occasional wheezing and dyspnea with exertion during softball practice.

Exam: Heart RRR, no murmurs; Lungs CTAB, no labored breathing

Based on your exam and a thorough review of systems, you suspect asthma and decide to order spirometry for further evaluation.
Continued…

PFTs:  \( \text{FEV}_1 \) 86% predicted  \( \text{FEV}_1/\text{FVC} \) 82% predicted

Flow Volume Loop: normal inspiratory and expiratory pattern

You still suspect asthma. What is your next step in the workup of this patient?
Bronchoprovocation

- Useful for diagnosis of asthma in the setting of *normal* pulmonary function tests

- Common agents:
  - Methacholine, Histamine, others

- Diagnostic if: $\geq 20\%$ decrease in $\text{FEV}_1$
Continued…

SYMPTOMS

↓

PFTs

↓

OBSTRUCTION?

↓

YES

TREAT

↓

NO

BRONCHOPROVOCATION

↓

Obstruction?

TREAT

↓

No Obstruction?

Other Diagnosis
PFT Interpretation Strategy

- What is the clinical question?
- What is “normal”?
- Did the test meet American Thoracic Society (ATS) criteria?
- Don’t forget (or ignore) the flow volume loop!
Obstructive Pattern — Evaluation

- **Spirometry**
  - FEV$_1$, FVC: decreased
  - FEV$_1$/FVC: decreased ($<70\%$ predicted)

- **FV Loop**
  - “scooped”

- **Lung Volumes**
  - TLC, RV: increased

- Bronchodilator responsiveness
Restrictive Pattern – Evaluation

- **Spirometry**
  - FVC, FEV$_1$: decreased
  - FEV$_1$/FVC: normal or increased

- **FV Loop**
  - “witch’s hat”

- **DLCO**
  - decreased

- **Lung Volumes**
  - TLC, RV: decreased

- Muscle pressures may be important
PFT Patterns

- **Emphysema**
  - FEV$_1$/FVC $<$70%
  - “Scooped” FV curve
  - TLC *increased*
  - Increased compliance
  - DLCO *decreased*

- **Chronic Bronchitis**
  - FEV$_1$/FVC $<$70%
  - “Scooped” FV curve
  - TLC *normal*
  - Normal compliance
  - DLCO usually *normal*
PFT Patterns

- **Asthma**
  - FEV$_1$/FVC: normal or decreased
  - DLCO: normal or increased

*But PFTs may be normal → bronchoprovocation*
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Questions?