Interpretation of Common Lung Function Tests

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Lung (pulmonary) function tests (PFTs)

- Spirometry
  - Before and after bronchodilator
  - Sitting and supine
- Lung volumes
- Diffusion capacity (DLCO)
- Methacholine challenge
- Maximum voluntary ventilation (MVV)
- Maximum inspiratory and expiratory pressures (MIPS/MEPS)
- Pulse oximetry
- Arterial blood gases (ABGs)
- Six minute walk test
- Cardiopulmonary exercise test (CPET)
- Exhaled nitric oxide (FeNO)
Spirometry

Pulmonary function testing equipment
Lung Volumes (4) and Capacities (4)

- TLC
- IC
- VC
- IRV
- ERV
- VT
- FRC
- RV

Lung Volumes and Capacities

- Maximum possible inspiration
- Inspiratory reserve volume
- Total lung capacity
- Vital capacity
- Inspiratory capacity
- Tidal volume
- Maximum voluntary expiration
- Residual volume
- Functional residual capacity
- Expiratory reserve volume
Body Box

Flow Volume Loop
Flow-volume Characteristics of Acceptable and Unacceptable Spirometry

1. Instantaneous start of exhalation
2. Rapid rise in flow to peak flow
3. Sharp peak occurring early in exhalation
4. Smooth continuous fall in flow without interruptions
5. Gradual fall in low flow to IV
6. Smooth continuous inhalation to TLC
7. Reproducible shape

1. Slow start
2. Slow rise in flow
3. Broad late peak
4. Erratic flow (cough or vocal cord) dysfunction
5. Abrupt return to zero flow
6. Incomplete inhalation
7. Non-reproducible

PFT interpretation: Flow Volume loop

- Fixed Upper Airway Obstruction
- Variable Intra-thoracic Upper Airway Obstruction
- Variable Extrathoracic Upper Airway Obstruction
A 68 year old male for pre-op evaluation

Normal Spirometry

Normal Lung Volumes

Normal DLCO

Spirometry – Important Parameters

- **FVC:** maximum amount of air exhaled after a maximal inhalation
  - If normal:
    - Elasticity is fairly normal (normal lung tissue)
    - Thoracic cage (configuration of thoracic spine/ribs) is normal
    - Respiratory muscles aren’t too weak
  - If low, suggests one or more of the above is a problem (restrictive disorder)

- **FEV1:** amount of air exhaled in the first second as forcefully as possible from a full lung
  - Measuring the speed of the air being exhaled can provide a window to the airways
  - Volume exhaled in the first second is a measure of speed (liters/second) (FEV1)
  - Reduced speed indicates ‘obstructed’ or narrowed airways

- **FEV1/FVC ratio:** identification of airflow obstruction:
  - <70% of predicted
  - LLN
Lung Function, What’s Normal?

- Gender, Age, Height, Race
- Test data collected on a large number of ‘normal’ individuals
  - No history of lung disease
  - No symptoms
  - Normal chest X-ray
  - Normal EKG
- Pooled data used to relate lung function to characteristics most closely related to lung function
- Predicted value (% of predicted): Age and height are entered into an equation to calculate the **average predicted value** for an individual
  = middle of the normal range
- Lower limit of normal (LLN): Another equation is used to define the ‘**Lower Limit of Normal**’
  = lowest value considered normal for an individual
Racial Adjustment of Predicted Value

- Most studies for normal values in US looked at Caucasian populations of “normals”
- Not appropriate for other ethnic groups
- If used in African-American population, more likely to seem abnormal (12% higher)
  - Controversial: adjustment of predicted value downward reduces the sensitivity of the test for detecting abnormality
- NHANES predicted set for spirometry
- Comparing individual to him/herself increases sensitivity of the test to detect changes

PFT interpretation: step by step

- **Step 1: FEV1/FVC ratio**
  - FEV1/FVC <70% (or less than the LLN): Obstructive pattern (COPD, asthma)
  - ≥ 70%: Normal or Restrictive disease
- **Step 2:**
  - **Severity of obstruction (GOLD Criteria for COPD)**
    - FEV1 80 - 100% predicted: Mild (Stage I)
    - FEV1 50 - <80% predicted: Moderate (Stage II)
    - FEV1 30 -<50% predicted: Severe (Stage III)
    - FEV1 < 30% predicted: Very severe (Stage IV)
    - FEV1< 50% with right side heart failure: Very severe (Stage IV)
  - **Severity of obstruction (ATS General Criteria): keep it simple**
    - FEV1 over 70% predicted: MILD
    - FEV1 60-70% predicted: MODERATE
    - FEV1 50-60% predicted: MODERATELY SEVERE
    - FEV1 35-50% predicted: SEVERE
    - FEV1 < 35% predicted: VERY SEVERE
- **Step 3: Bronchodilator response:**
  - ≥ 12% increase AND an absolute improvement of at least 200 ml after inhaling a beta agonist
  - FEV1, OR FVC is considered a significant response
PFT interpretation: step by step

• **Step 4: Total Lung Capacity (TLC) (Normal range: 80 - 120% of predicted)**
  - TLC > 120 = Hyperinflation
  - TLC < 80% = Restrictive disease (ATS criteria for severity): **keep it simple**
    - 70-80 % predicted: mild
    - 60-70% predicted: moderate
    - 50-60% predicted: moderately severe
    - < 50% predicted: severe

• **Step 5: RV/TLC ratio (Normal range: < 35% or < predicted)**
  - RV/TLC > 35% or > predicted indicates Air trapping

• **Step 6: DLCO (Normal range: 80- 120% of predicted)**
  - **In obstructive disease:**
    - Decreased in Emphysema
    - Normal in chronic bronchitis
    - Normal or increased in Asthma
  - **In restrictive disease:**
    - Decreased in parenchymal disease
    - Normal in non-parenchymal (e.g. chest wall) restriction
DLCO

- **Diffusing Capacity of the Lung for Carbon Monoxide (CO)**
- Measures the efficiency of the gas transfer characteristics of the lungs
A 39-yr-old male: pre-op evaluation

- Normal FEV1/FVC ratio
- Normal FVC
- Normal FEV1
- Normal Spirometry

A 21-yr-old female with cough and wheezing

- Reduced FEV1/FVC ratio = obstruction
- Reduced FEV1
- Normal FVC = pure obstruction
- Significant Bronchodilator response
- Reversible airway obstruction: asthma
A 69-yr-old male with chronic cough and progressive SOB

| Date | FEV1 | FVC | FVC% | FEV1/FVC | TLC | FRC | TLC% | DLCO | DLCO% |
|------|------|-----|------|----------|-----|-----|------|------|-------|-------|
| 1/12 | 2.50 | 2.90 | 90.3  | 0.86     | 50  | 190 | 45.7 | 1.90 | 39.5  | 39.5  |

Normal FEV1/FVC ratio
Reduced FVC, Reduced FEV1
Reduced TLC
Reduced DLCO

A 58-yr-old female with chest pain

| Date | FEV1 | FVC | FVC% | FEV1/FVC | TLC | FRC | TLC% | DLCO | DLCO% |
|------|------|-----|------|----------|-----|-----|------|------|-------|-------|
| 1/24 | 2.00 | 2.05 | 90.6  | 0.97     | 50  | 150 | 45.6 | 1.50 | 50.0  | 50.0  |

Normal FEV1/FVC ratio
Normal FVC
Normal FEV1
Normal Spirometry
A 65-yr-old female with shortness of breath

Normal Spirometry
Normal Lung Volumes
Reduced DCLO: isolated

Common Spirometry Patterns

- Normal:
  - normal spirometry (normal FVC, FEV1/FVC ratio)
- Obstruction to airflow:
  - normal FVC + low FEV1 = low FEV1/FVC%; assess BD response
- Restrictive changes:
  - low FVC + Low FEV1 =normal FEV1/FVC%; consider get lung volumes and DLCO
- Combined obstructive and restrictive:
  - low FVC, low FEV1, and low FEV1/FVC%; consider lung volumes and DLCO
PFTs: Methacholine Challenge

Key take home points

• The term pulmonary function test (PFT) can mean many different things
• Spirometry is the most commonly performed PFT
• Focus on 3 parameters: FVC, FEV1 and FEV1/FVC ratio
• Following a simple preset algorithm, and common spirometry patterns, one can determine the presence of:
  – Obstruction: COPD, Asthma, etc
  – Restriction: ILD (IPF and others), chest wall disease, etc
  – Mixed disorders: sarcoidosis, cystic fibrosis, COPD+ILD, etc

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Reference

eMedicine Specialties > Pulmonology > Pulmonary Functions

Pulmonary Function Testing

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