COPD: Tracing the Diagnosis
Session 2: COPD: Tracing the Diagnosis

Learning Objectives
1. Outline 3 clinical features that can be used to differentiate between asthma and COPD
2. Use spirometric data to definitively diagnose COPD

Faculty
Dennis E. Doherty, MD, FCCP
Professor of Medicine
Division of Pulmonary, Critical Care, and Sleep Medicine
University of Kentucky College of Medicine

Chairman of Medicine
Lexington Veterans Affairs Medical Center
Lexington, Kentucky

Dr Dennis E. Doherty, MD, FCCP, is chairman of medicine at the Lexington Veterans Affairs Medical Center and a professor of medicine in the Division of Pulmonary, Critical Care, and Sleep Medicine at the University of Kentucky College of Medicine and Chandler Medical Center. He completed his medical school training and internal medicine residency at The Ohio State College of Medicine and had a pulmonary and critical care fellowship at the University of Colorado Medical Center and National Jewish Medical and Research Center, where he continued as a faculty member for 11 years. He relocated in 1996 and served as chief of the Pulmonary and Critical Care Medicine Division at the University of Kentucky until 2007.

Dr Doherty has been the principal investigator on over 35 grants from the National Institutes of Health, Veterans Affairs, American Lung Association, and other granting organizations for basic science and clinical studies. He has published over 100 articles, abstracts, and chapters on the subjects of asthma, chronic obstructive pulmonary disease (COPD), acute and chronic lung inflammation, and pulmonary fibrosis.

Faculty Financial Disclosure Statement
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Drug List
There is no drug list for this session.
Suggested Reading List


Spirometry Basics

Pulmonary function tests (PFTs) are a series of different breathing tests led by a trained pulmonary function technologist, usually done at a hospital or clinic. To learn about your patient's lung health, you may want to have several pulmonary function tests done, including spirometry pre and post bronchodilator, lung volumes, diffusing capacity, airway resistance, and arterial blood gases.

What is Spirometry?
Spirometry measures how much air a patient can inhale and exhale as well as how fast they can exhale. It is an objective measurement for reversibility in asthma, a primary component in the diagnostic evaluation.

Key measurements obtained by spirometry are:
- (FVC) forced vital capacity: The largest amount of air that can be forcefully exhaled after a maximal inspiration. A decreased FVC may also indicate a restrictive pattern.
- (FEV\textsubscript{1}): The forced expiratory volume in one second. The degree of obstruction is determined by changes in the FEV\textsubscript{1}.\(\text{(1)}\)
- (FEV\textsubscript{1}/FVC%): The forced expiratory volume in one second as a percent of the FVC. When the FEV\textsubscript{1} and FEV\textsubscript{1}/FVC% are decreased, it is an indication of airway obstruction (80-85% is normal).

There may be other parameters measured during spirometry that are helpful in specific populations, such as pediatrics.

The National Heart, Lung, and Blood Institute (NHLBI) in the Expert Panel Report 2 “Guidelines for the Diagnosis and Management of Asthma” state that spirometry should be undertaken for patients in whom the diagnosis of asthma is being considered. The American Thoracic Society (ATS) and the American Association for Respiratory Care (AARC) have developed standards governing how to properly perform spirometry(2-4). These standards also provide guidelines on quality control measures and patient data acceptability (i.e., can you believe the results?). The NHLBI recommends following these standards when performing spirometry.

Who should be tested?
Spirometry is generally useful in individuals 4 years of age and older; although achievement of the ATS standards depends upon the stage of development of the individual. With a well-trained technologist, 95% of children 9 years or older are able to meet the adult criteria for spirometry as set forth in the ATS standards (5).

What should patients know about spirometry?
- Spirometry is a very common test to help you understand your patient’s asthma and to monitor control.
- Spirometry measures how fast they can exhale, as well as how much air they can inhale and exhale.
- Forced vital capacity (FVC) – During spirometry, the numeric and graphic results are measured and printed. The shape of the graph (flow-volume loop) is also helpful in the diagnostic evaluation.
- A decreased FEV\textsubscript{1}/FVC% and response to bronchodilator is consistent with a diagnosis of asthma.
- Peak Expiratory Flow (PEF) or Peak Flow (PF) is the maximum flow achieved at the beginning of the FVC maneuver, but can be very patient effort dependent.
- The results of spirometry are dependent on good patient effort. Patients must be coached well in order to achieve an optimal test.
- A normal spirometry does not exclude asthma. Other tests may be needed to confirm or exclude the diagnosis.

How should patients prepare for their spirometry test?
- Wear loose clothing which will not restrict the ability to breathe deeply.
- Avoid large meals prior to the test time which will make it more comfortable for them to breathe deeply.
- Don’t use bronchodilators four to six hours before testing, if possible.

How is spirometry different from peak expiratory flows?
Spirometry is the diagnostic tool recommended by the NHLBI in the diagnosis and management of asthma.

A peak expiratory flow (PEF) meter is a device recommended for monitoring changes in moderate to severe asthma. Peak flow only measures a change in the large airways. Other significant changes in the airways may occur that are detected by spirometry but not a peak flow meter.

How is spirometry performed?
1. After an explanation and a demonstration of proper technique, the patient takes a maximal deep breath. The patient then exhales forcefully and completely without hesitation for a prolonged period of time into a properly calibrated measuring device (pneumotach).
2. The patient should then repeat this maneuver until three acceptable efforts are obtained. This typically requires the patient to repeat the maneuver four to eight times.
When should testing be done with a bronchodilator?

A bronchodilator is required to assess reversibility of airflow obstruction. The medication is usually delivered using a small volume nebulizer. Correct delivery of the medication is important in adequately evaluating the response to the bronchodilator. An alternative for delivering the bronchodilator is using a metered dose inhaler (MDI) and holding chamber. If this method is used, an adequate number of puffs must be delivered and delivery technique should be carefully monitored.

If the patient is already on pulmonary medications, if possible they should be withheld for a certain length of time. Short-acting inhaled bronchodilators should be withheld for four to six hours before the spirometry is performed. Long-acting bronchodilators should be withheld for 24 hours. Anticholinergics are withheld six hours.

After waiting a minimum of 15 minutes post-treatment, the spirometry is performed once again. According to ATS guidelines, a positive response is at least a 12% increase and an absolute volume increase of 200 ml in FVC and/or FEV₁. Not all patients will respond to a bronchodilator in the initial assessment, but reversibility may be measured after the patient has been on a course of therapy for a period of time.

How do I know if the tests are accurate?

It is important to assess the acceptability of each maneuver based on ATS guidelines.

- **Step 1 – Assess the “end of test”**
  To assess acceptability use the volume-time curve and the flow-volume loop (as illustrated below). The volume-time curve is used to assess “end of test”. On the X axis, the maneuver must last at least **six seconds** and there must also be an obvious plateau for **at least one second**. It may require more than six seconds to achieve the one second plateau. This plateau is characterized by a “flat” section at the end of the exhalation. The flat section signifies that the patient has no more air to exhale. Young children may achieve a plateau prior to six seconds and this is considered acceptable.

- **Step 2 – Assess the “start of test”**
  Look at the expiratory side of the flow-volume loop and ensure that the initial portion of the graph is parallel to the Y axis, and there is a peak at the top of the curve. If the patient does not exhale forcefully and rapidly at the beginning of the maneuver, most modern spirometers will give you a back extrapolation error. If this occurs, the results are not valid.

- **Step 3 – Assess reproducibility**
  - **FVC**: The two best acceptable FVC efforts must be within 200 ml.
  - **FEV₁**: The two best acceptable FEV₁ efforts must be within 200 ml.

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**Volume-Time Curve**

The volume-time curve shows the relationship between volume in liters (Y-axis) and time in seconds (X-axis). The expiratory time should be at least 6 seconds and the plateau at least one second.

The FVC is measured on the Y-axis of the graph in liters as shown on the graph.

The FEV₁ is also measured on the Y-axis in liters as shown on the graph.
How do I use a flow-volume loop in assessment?

Review the flow-volume loop below. The initial portion of the curve should be parallel to the Y axis and there should be a sharp peak the top of the curve. The sharp peak indicates good patient effort.

Next, assess the shape of the expiratory side of the curve. The greater the degree of concavity, the more significant the obstruction. Post bronchodilator, the concavity is changed to a more convex shape.

The inspiratory effort should be done with just as much force as the expiratory maneuver, as illustrated in the graph below. If the tracing appears to want to “go past” the point where the patient originally started, it likely indicates the original inspiration was not as deep as it could be.
What does actual patient data look like?

The following is actual patient data from the above flow volume loop and volume time curve. The patient is a 38 year-old female asthmatic with a good response to a bronchodilator.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Bronch</th>
<th>Post-Bronch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Pred</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>2.37</td>
<td>3.23</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>1.66</td>
<td>2.65</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>70</td>
<td>82</td>
</tr>
<tr>
<td>FEF 25% (L/sec)</td>
<td>3.28</td>
<td></td>
</tr>
<tr>
<td>FEF 75% (L/sec)</td>
<td>0.38</td>
<td>1.40</td>
</tr>
<tr>
<td>FEF 25-75% (L/sec)</td>
<td>1.03</td>
<td>2.94</td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>5.26</td>
<td>6.03</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>2.39</td>
<td></td>
</tr>
<tr>
<td>FIF Max (L/sec)</td>
<td>3.74</td>
<td></td>
</tr>
</tbody>
</table>

Other Pulmonary Function Tests (PFTs)

**Lung Volumes**

To differentiate between obstructing and restrictive patterns, lung volumes must be measured. The three most commonly used methods for measuring lung volumes are:

- **Body Box** – also known as plethysmography, is done while sitting in an enclosed clear chamber while asked to perform a series of very small panting breaths. This is the most accurate way to measure lung volumes.

- **Helium dilution** – done by normal breathing of gas mixture of helium and oxygen (may underestimate trapped gas in asthma).

- **Nitrogen Washout** – done by normal breathing of pure oxygen while exhaled gas is collected and analyzed (may underestimate trapped gas in asthma).

People with asthma may show changes in their lung volumes. This may help in the diagnosis and treatment of asthma.

**Diffusing Capacity (DLCO)**

Diffusing capacity of the lungs measures how well gases such as oxygen move from the lungs into the blood. The ATS accepted method is the single-breath technique. DLCO is generally normal or increased in asthma.

**Airway Mechanics**

This is an effort-independent test (spirometry is effort-dependent) that measures resistance to airflow in the airways between the mouth and the alveoli. Gentle panting breaths remove the bronchospastic component found in forced expiratory maneuvers. Changes in box pressure (plethysmograph) are proportional to alveolar volume changes. Airway mechanics are a more sensitive measure of changes in airway resistance caused by asthma, so therefore may detect airway disease earlier than spirometry and responses to therapeutic interventions.

**Arterial Blood Gases (ABGs)**

This is a blood test that can be done in order to show how well lungs are getting oxygen into the blood and carbon dioxide out of the blood. For this test, a sample of blood is drawn from the radial or brachial artery. Changes in arterial blood gases occur very late in an asthma exacerbation. When the PO2 decreases and the PCO2 increases it indicates impending respiratory failure.

**REFERENCES**

Chronic Obstructive Pulmonary Disease

Tracing the Diagnosis

Learning Objectives

After learning from this CME session, you should be able to

• Outline 3 clinical features that can be used to differentiate between asthma and COPD
• Use spirometric data to definitively diagnose COPD

COPD Is Common and Often Underdiagnosed

• NIH estimates that approximately 24 million American adults have COPD
  – 12 million diagnosed
  – 12 million undiagnosed

Which of the following most hinders your ability to diagnose COPD?

1. Patients lack specific symptoms
2. Patients fail to recognize and report dyspnea
3. Patients have multiple chronic conditions
4. I need more knowledge/training
5. I lack access to spirometry
6. I have no effective treatment to offer

Why Is COPD Underdiagnosed?
Clinicians Tell All

According to a survey of 278 clinicians, the most common perceived barriers to diagnosing COPD include:

1. Lack of effective treatment (64%)
2. Lacks access to spirometry (48%)
3. Patient lacks specific symptoms (45%)
4. Inadequate knowledge and training (43%)
5. Patient fails to report/receive dyspnea (33%)
6. Patient has multiple chronic conditions (29%)
7. Needs more knowledge/training (21%)

Survey of 278 Clinicians

Perceived Barrier (%)
Key Barriers to COPD Diagnosis

- Failure of patients to notice and report symptoms
- Misdiagnosis of COPD as asthma or bronchitis by clinicians
- Underuse of spirometry by clinicians

Patients Fail to Note and Report Symptoms

- Early symptoms are not particularly unusual or alarming to patients
- Patients are unaware of COPD signs
- Early symptoms often do not interfere with completing activities of daily living
- Symptom severity increases very slowly

Clinicians Fail to Distinguish COPD From Other Respiratory Diseases

*Shared Symptoms*

Chronic Progressive

Allergy
Rhinitis
Eczema (atopy)

Heavy Sputum
Production

Episodic Variable

Cough
Dyspnea
Chest Tightness
Wheezing

Asthma

COPD

Misdiagnosis of COPD as Asthma Is More Common in Women Than in Men


42% 31%

Hypothetical male patient with COPD symptoms

Hypothetical female patient with COPD symptoms

Characteristics That Help Distinguish COPD From Asthma

<table>
<thead>
<tr>
<th>Feature</th>
<th>COPD</th>
<th>Asthma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset</td>
<td>Often in midlife</td>
<td>Often in childhood</td>
</tr>
<tr>
<td>Family history</td>
<td>Variable</td>
<td>Often</td>
</tr>
<tr>
<td>Medical or social history</td>
<td>Smoking (often ≥20 pack-years)</td>
<td>Atopy (ie, allergy and/or eczema)</td>
</tr>
<tr>
<td>Patients report symptoms as . .</td>
<td>Most notable during exercise</td>
<td>Most notable at night or early morning</td>
</tr>
<tr>
<td></td>
<td>“Mostly bad days”</td>
<td>“Mostly good days”</td>
</tr>
<tr>
<td>Airflow obstruction</td>
<td>Can be partially reversed with bronchodilation</td>
<td>Largely reversible with bronchodilation</td>
</tr>
</tbody>
</table>

Beeh et al Questionnaire to Differentiate Asthma and COPD

- A short questionnaire asking about age at onset, smoking history, atopy status, and cough quality was developed for clinical use
- High scores on the questionnaire were associated with a diagnosis of COPD

Spirometry Underuse

- Survey of 29 primary care offices
  - Two thirds of offices owned a spirometer
  - Spirometry performed on 50% of patients with COPD, asthma, or respiratory symptoms

### Main Reasons Cited for Not Performing Spirometry

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Unsure of impact on care</td>
<td>41%</td>
</tr>
<tr>
<td>Unfamiliar with test</td>
<td>38%</td>
</tr>
<tr>
<td>Lack of training</td>
<td>34%</td>
</tr>
<tr>
<td>Concern about reimbursement</td>
<td>28%</td>
</tr>
<tr>
<td>Equipment too costly</td>
<td>28%</td>
</tr>
<tr>
<td>Concern about quality control</td>
<td>28%</td>
</tr>
</tbody>
</table>


Rates of Spirometry Use Vary by Region

How Does Use in Your Region Compare?

COPD Mortality in the United States: Not What You Would Suspect

- Between 1980 and 2000, the number of deaths per year more than tripled for women
- In 2000, the number of deaths in women surpassed that in men

Why Do Spirometry?

Spirometry Helps Differentiate COPD From Asthma

Spirometry-Based Diagnosis Dictates How to Implement Evidence-Based Therapy

<table>
<thead>
<tr>
<th>GOLD Stage</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Severe</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- Active reduction of risk factors: influenza vaccine. Add short-acting bronchodilators when needed.
- Add regular Rx with ≥1 long-acting bronchodilator. Add rehabilitation.

Long-acting bronchodilators and corticosteroids are also used for asthma, but in the reverse order.

Add inhaled corticosteroids (ICS) if repeated exacerbations.

Consider O₂ and surgery.

Active reduction of risk factors: influenza vaccine. Add short-acting bronchodilators when needed.

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Spirometry Is Useful for Monitoring Disease Progression

Changes Can Be Seen Earlier in Spirometry Than in Many Other Respiratory Parameters

- Spirometry
- Symptoms
- Arterial blood gas
- Chest X-ray

Time

Interpreting Spirometry

The Basic Spirometry Technique

1. Enter patient data—including birth date, height, weight, sex, and ethnic origin—into the machine.
2. Explain and demonstrate the procedure:
   - Instruct patient to stand or sit straight up in the chair.
   - Apply nose clip.
   - Instruct patient to take a deep breath.
   - Instruct patient to form a tight seal around the mouthpiece.
   - Instruct patient to exhale forcefully into the mouthpiece and continue to exhale for at least 6 seconds.
3. Coach the patient, assisting verbally, to give a successful effort.
4. Repeat steps 2 and 3 until 3 similar readings are obtained.

Spirometry Ameliorates Gender Bias

Remember This Image?

Hypothetical male patient with COPD symptoms

Hypothetical female patient with COPD symptoms

COPD suspected on the basis of symptoms

42% COPD accurately diagnosed on the basis of spirometry

74% COPD accurately diagnosed on the basis of spirometry

Interpreting Spirometry

Coaching the Forced Expiration Maneuver

<table>
<thead>
<tr>
<th>Spirometry</th>
<th>Normal</th>
<th>Moderate</th>
<th>Severe</th>
<th>Acute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms</td>
<td>Cough, sputum</td>
<td>Exercise intolerance</td>
<td>Breathlessness</td>
<td></td>
</tr>
<tr>
<td>Arterial blood gas</td>
<td>Normal</td>
<td>Hypoxemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest X-ray</td>
<td>Normal</td>
<td>Hypoxemia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Flow-Volume Curve

Normal

Volume-Time Curve

Normal

Problems Commonly Experienced in Performing Spirometry

- Inadequate or incomplete inhalation
- Lack of blast effort during exhalation (ie, submaximal effort)
- Delayed onset of maximal effort
  - Underestimates FEV₁
- Incomplete emptying of lungs
- Additional breath during maneuver
- Lips not tight around mouthpiece (ie, leak)
  - Underestimates FEV₁ and FVC
- A slow start to the blow
  - Underestimates FEV₁


Sample Tracing 1 – Slow Start

Sample Tracing 2 – Early Stop

Sample Tracing 3 – Extra Breath
Prebronchodilator and Postbronchodilator Testing

- Bronchodilator reversibility testing can rule out asthma diagnosis and guide initial treatment decisions
  - If >12% and 200-mL improvement occurs in FEV₁, patient has reversible component
  - Complete or very nearly complete reversibility suggests asthma, whereas partial reversibility (not to normal) suggests COPD
  - Basic Protocol
    - Give 1 puff, wait 1 minute, then administer the second dose
    - Wait 20 minutes for the inhaler to take effect
    - Repeat the pulmonary function study
    - Compare post results to pre results

Lung Age

GOLD COPD Diagnosis and Stage

<table>
<thead>
<tr>
<th>GOLD Stage</th>
<th>FEV₁/FVC</th>
<th>FEV₁ (% of predicted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Mild</td>
<td>&lt;.70</td>
<td>≥80%</td>
</tr>
<tr>
<td>II: Moderate</td>
<td>&lt;.70</td>
<td>≥50%, &lt;80%</td>
</tr>
<tr>
<td>III: Severe</td>
<td>&lt;.70</td>
<td>≥30%, &lt;50%</td>
</tr>
<tr>
<td>IV: Very severe</td>
<td>&lt;.70</td>
<td>&lt;30%</td>
</tr>
</tbody>
</table>

*Or <30% plus chronic respiratory failure.*

Sample Tracing 5 – Obstruction

Algorithm for Interpreting Spirometry Results

Sample Tracing 4 – Coughing

Practice Tracing 1

What is your interpretation?
1. Poor effort
2. COPD
3. Asthma
4. Restrictive pattern
5. I don’t know

Practice Tracing 2

What is your interpretation?
1. Poor effort
2. COPD
3. Asthma
4. Restrictive pattern
5. I don’t know
Avoid Interpretation Pitfalls

Common Interpretation Errors Among Family Physicians (N = 12) New to Interpreting Spirometry

- Interpreting a normal result as an obstructive pattern
- Interpreting a poor effort as a restrictive pattern
- Diagnosing COPD in the absence of an FEV1/FVC ratio <70%

The Practicality of Performing Spirometry in Your Office

NLHEP Recommendations for Office-Based Spirometers

- The National Lung Health Education Program (NLHEP) has developed an official review process for spirometers
  - Must be developed for use in a primary care practice setting
  - Is preferred to come from the factory in primary care practice mode; if it does not, must come with easy instructions to put spirometer in this mode
  - Should allow for FEV1 as a substitute for FVC


Available at http://www.nlhep.org/spirom1.html or go to NLHEP home page and click on Spirometry

National Lung Health Education Program (NLHEP)

Spirometry Workshop Today

- To learn more about spirometry, attend one of the Making a Good Effort workshops
- Topics:
  - Proper demonstration of spirometry maneuver
  - Importance of proper coaching
  - Resources for using spirometry in your daily practice

Summary

- COPD is a common respiratory disorder with increasing mortality rates, especially in women
- COPD is underdiagnosed
- COPD and asthma can be challenging to differentiate
- Spirometry is the gold standard for definitively diagnosing and staging COPD
- Spirometry-based COPD staging dictates what evidence-based care should be given