Performing & Interpreting Spirometry: Understanding & Implementing the ATS/ERS Guidelines

Seminar # 2502

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Disclosures

• None

• The opinions expressed in this presentation are solely those of the author and do not represent an endorsement by or the views of the United States Air Force, the United States Army, the Department of Defense, or the United States Government.
Learning Objectives

• Identify the source and relevance of the ATS/ERS guidelines for lung function testing
• Discuss the ATS/ERS recommendations for correct performance of spirometry
• Identify ATS/ERS guidelines to interpret and classify the severity of identified abnormalities
Overview

• Background
• Data gathered
• ATS/ERS guidance
  • Performance of testing
  • Reference Equations
  • Approach to evaluation
  • Interpretation
  • Severity classification
Background

- **Pulmonary Function Testing**
  - **Spirometry**
  - Static lung volumes
  - Diffusion capacity
  - Maximal respiratory pressures
  - Oxygen desaturation with exercise
  - Arterial blood gas

- **Spirometry**
  - Measure of inhaled and exhaled volumes of air as a function of time
  - Forced Vital Capacity (FVC) – most widely utilized in practice
  - Slow Vital Capacity (SVC)
History

• 1846 - John Hutchinson publishes paper about his water spirometer
• A calibrated bell inverted in water
• Basic design still used today with some alterations
• Coined the term “vital capacity”

http://openi.nlm.nih.gov/
Instrumentation

http://respiratorysystema.blogspot.com
Instrumentation

Subject ➔ Transducer ➔ Signal Processing ➔ Display

http://respiratorysystema.blogspot.com
Instrumentation

Subject → Transducer → Signal Processing → Display

http://health.allrefer.com/pictures-images/spirometry.html
Basic Definitions

• 4 Lung volumes - cannot be further subdivided
  • Tidal volume (TV)
  • Inspiratory reserve volume (IRV)
  • Expiratory reserve volume (ERV)
  • Residual volume (RV)

• 4 Lung capacities - composed of 2 or more volumes
  • Total lung capacity (TLC)
  • Vital capacity (VC)
  • Inspiratory capacity (IC)
  • Functional residual capacity (FRC)
Technical Data

• All volumes & capacities except those including RV
  • Tidal Volume (TV)
  • Inspiratory reserve volume (IRV)
  • Expiratory reserve volume (ERV)
  • Inspiratory Capacity (IC)(SVC maneuver)
  • Vital Capacity (VC)
    • Forced Vital Capacity (FVC maneuver)
    • Slow Vital Capacity (SVC maneuver)

• Volume vs time (FVC and SVC maneuver)
• Flow vs volume (FVC maneuver)
Clinical Data

- Forced or FVC maneuver
  - FVC = forced vital capacity
  - FEV$_1$ = forced expiratory volume in one second
  - Ratio FEV$_1$/FVC
  - FEF$_{25-75}$, MMEF = midflows
  - PEFR = peak expiratory flow rate
  - FET = forced expiratory time
  - Graphic display of Flow Volume Loop and volume vs time curve

- Slow or SVC maneuver
  - SVC = slow vital capacity
  - IC = inspiratory capacity
  - Graphic display of volume vs time
Flow-Volume Loops

- Recognition of characteristic patterns of abnormalities
- Recognition of poor effort or mistakes by patient that make absolute numbers unreliable
- Directly determine peak flow
- Directly determine FVC
Flow-Volume Loops

![Flow-Volume Loops Graph]

- PEF
- FVC = 3.89

NIOSH Spirometry Training Guide - cdc.gov/niosh/
Volume vs Time Curve

- Recognition of characteristic patterns of abnormalities
- Recognition of duration of test and timing of events that make absolute numbers unreliable
- Directly determine FEV1
- Directly determine total expiratory time (TET)
- Directly determine FVC
Volume vs Time Curve

SVC Volume vs. Time

Vol(L)

V/T

Time(s)

V(1.5)

V(-2)
Volume vs Time Curve

FIGURE 2-1. NORMAL VOLUME TIME CURVE

- Volume (liters) vs Time (seconds)
Volume vs Time Curve

Note: Tracing begins at 0.2 seconds, hence FEV1 is measured at 1.2 seconds.

FVC = 3.89
FEV1 = 3.44
Characteristics of Testing

- Quantifiable
- Objective
- Sensitive
- Requires cooperation – effort dependent
ATS/ERS Guidelines

- Series “ATS/ERS Task Force: Standardisation of Lung Function Testing”
Indications

- **Diagnostic**
  - Evaluate symptoms
  - Assess risk of procedure/surgery
  - Screen for patients at risk of pulmonary disease
  - Screen prior to vigorous exercise
  - Assess prognosis
  - Follow the course of disease

- **Monitoring**
  - Follow the course of therapy
  - Follow the course of disease
  - Monitor post-exposure
  - Monitor for adverse drug reactions for pulmonary toxicity

Indications

• Disability/Impairment Evaluations
  • Assess patients during rehab
  • Assess risks as part of an insurance exam or legal matter

• Public Health
  • Epidemiologic surveys
  • Derivation of reference equations
  • Clinical research

Contraindications

- Recent MI (within 1 month)
- Chest or abdominal pain
- Oral or facial pain induced by mouthpiece
- Stress incontinence
  - Maybe patient can void immediately prior to test
- Dementia or confusional state
- Pneumothorax
- Recent abdominal, thoracic surgery, or eye surgery
- Children under ?? years of age
Performing Spirometry

- Forced Vital Capacity Maneuver
  - Maximal volume of air exhaled with maximally forced effort from a maximal inspiration
  - 3 distinct phases
    - Maximal inspiration
    - “Blast” of exhalation
    - Continued complete exhalation to the end of test (no volume change = <0.025 L over 1 sec)
Performing Spirometry

- Preparatory instructions
  - Avoid smoking within 1 hour
  - Avoid alcohol within 4 hours
  - Avoid vigorous exercise within 30 minutes
  - Avoid constricting clothing of chest/abdomen
  - Avoid a large meal within 2 hours
  - Avoid loose fitting dentures
- Check spirometer calibration
- Explain the test
- Prepare the subject
  - Ask about smoking, medication, illness, pain, etc
  - Measure standing height and weight
    - Arm span/1.06
    - Knee height (J Am Dietetic Assoc 1994; 94: 1385)

Performing Spirometry

- Wash hands
- Instruct and demonstrate the test to the subject
- FVC
  - Correct posture with head elevated
  - +/- Relaxed tidal breathing
  - Inhale rapidly and completely
  - Exhale with maximal force and continue to completion

Performing Spirometry

- Patient in correct posture – seated now preferred
- Attach nose clips
- Ensure tight seal of mouth on mouthpiece (generally behind the teeth and on top of tongue)
- A well-motivated, enthusiastic nurse or technician is key
Performing Spirometry

- Inhale completely and rapidly with <1 sec pause at TLC
- Exhale maximally completely until no more air can be expelled while maintaining posture
- Repeat with coaching as necessary (warn patient)
  - “Blast it out !!!” as opposed to “blow”
  - “Keep going, keep going !!!”, “More, more, more !!!”
- Perform minimum of 3 maneuvers, no more than 8 are usually required
FVC

- Forced Vital Capacity
- Full inspiration to total lung capacity
- Rapid, forceful, maximal expiration
- Differs from slow vital capacity
- Effort dependent
- Presented as an absolute number and % predicted
FEV$_1$

- Forced expiratory volume in one second
- Based on FVC maneuver
- Volume expired in the first second
- Effort dependent
- Presented as an absolute number and % predicted
- Can be expressed as ratio of FVC
FEV₁/FVC Ratio

- Not an independent test - simply mathematical relationship
- Presented as an absolute ratio or % and % predicted
- ONLY use the absolute ratio or % NOT % predicted
- FEV₁/FVC ratio < lower limit of normal indicates obstructive pattern
- Severity of obstruction is determined by FEV₁
Midflows

- $\text{FEF}_{25-75\%}$
- MMEF = maximal mid expiratory flow rate
- Largely effort independent
- Less sensitive and specific
Pulmonary Function Report

ALLERGY & IMMUNIZATIONS

Patient Information

Name: ID: 123456789
Birthday: 66
Height at test (in): 66.0
Sex: Male
Weight at test (lb): 157.0
Age at test: 50
Smoking History: Smoker
Predicted size: Hunkinson (NHANES III)

Comments:

Diagnosis:

NORMAL SPIROMETRIC VALUES indicate the absence of any significant degree of obstructive pulmonary impairment and/or restrictive ventilatory defect. This interpretation is valid only upon physician review and signature.

Physician:

Technician:

Effort protocol: ATS/ERS 2005
Test series date/time: 2/22/2013 10:06 AM

Results

<table>
<thead>
<tr>
<th>Result</th>
<th>Pred</th>
<th>Best</th>
<th>%Pred</th>
<th>Pred</th>
<th>%Pred</th>
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<tr>
<td>FVC (L)</td>
<td>4.41</td>
<td>5.45</td>
<td>107%</td>
<td>4.45</td>
<td>102%</td>
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<tr>
<td>FEV1 (L)</td>
<td>3.48</td>
<td>3.62</td>
<td>105%</td>
<td>3.62</td>
<td>105%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>0.77</td>
<td>0.70</td>
<td>100%</td>
<td>0.81</td>
<td>104%</td>
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<tr>
<td>FEF25-75% (L/s)</td>
<td>2.11</td>
<td>2.53</td>
<td>112%</td>
<td>2.61</td>
<td>121%</td>
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<tr>
<td>SVC (L)</td>
<td>4.41</td>
<td>4.71</td>
<td>107%</td>
<td>3.64</td>
<td>117%</td>
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<td>IC (L)</td>
<td>3.04</td>
<td>—</td>
<td>—</td>
<td>2.04</td>
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<tr>
<td>ERV (L)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1.67</td>
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</table>

FVC test comments:

SVC test comments:

ALLERGY & IMMUNIZATIONS

Pro-Re Trnd (FVC & SVC) Report

SVC Volume vs. Time

Spirometry History, Pre-Rx %Predicted

Trend Results

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>FVC</th>
<th>%Pred</th>
<th>FEV1</th>
<th>%Pred</th>
<th>FEF25-75%</th>
<th>%Pred</th>
<th>PEF</th>
<th>%Pred</th>
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<tbody>
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<td>2/22/2013 10:06 AM</td>
<td>4.54</td>
<td>100%</td>
<td>3.62</td>
<td>105%</td>
<td>3.59</td>
<td>105%</td>
<td>7.95</td>
<td>84%</td>
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<td>2/21/2013 11:09 AM</td>
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<td>3.55</td>
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Flow vs. Volume History

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<thead>
<tr>
<th>Date/Time</th>
<th>Flow</th>
<th>Volume</th>
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<td>2/21/2013 11:36 AM</td>
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<td>2/21/2013 11:15 AM</td>
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<td>4/7/2010 12:39 PM</td>
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Interpretation
Assessment of Normal Values

- Height
- Age
- Sex
- Race
- Weight
- Posture
  - Note on exam
  - Seated now preferred
  - Consistency
- Altitude/Temperature/Barometric Pressure
Reference Equations

- Comparison with “normal/healthy” subjects
- Anthropomorphically similar
  - Sex
  - Age
  - Height
  - Race – when relevant
    - Patient self report
    - Adjust for races in amounts in published data
    - When race adjustments unavailable
      - Blacks – reduce expected TLC, FEV1, FVC by 12% and FRC and RV by 7%
      - Asian Americans – reduce TLC, FEV1, FVC by 6-12%?

- All parameters from the same reference pool

Eur Respir J 2005;26:948-68.
Spirometric Reference Equations

- United States
  - Age 8-80 = Hankinson (NHANES III)
  - Age <8 = Wang (or Hankinson … is the perfect the enemy of the good enough?)

- Europe
  - No unanimous consensus
  - Age 18-70 = 1993 ERS statement of combined equations
  - Age <18 = Quanjer

Eur Respir J 2005;26:948-68.
<table>
<thead>
<tr>
<th>First author</th>
<th>Year</th>
<th>Country</th>
<th>Nature of study</th>
<th>Journal</th>
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<tr>
<td>Perez-Padilla</td>
<td>2003</td>
<td>Mexico: comparison with Mexican American children</td>
<td>Pediat Pulmonol</td>
<td>2003; 33:177-183</td>
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<tr>
<td>Torres</td>
<td>2003</td>
<td>Brazil: height and arm span in children</td>
<td>Pediat Pulmonol</td>
<td>2003; 36:255-262</td>
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<td>Goldstein</td>
<td>2003</td>
<td>Iran</td>
<td>Eur Respir J</td>
<td>2003; 23:529-534</td>
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<td>Mohamed</td>
<td>2002</td>
<td>Italy</td>
<td>Lung</td>
<td>2002; 136:181-189</td>
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<td>Zakaria</td>
<td>2002</td>
<td>Iran</td>
<td>Respiration</td>
<td>2002; 69:320-326</td>
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<td>Hatter</td>
<td>2002</td>
<td>Himalayan Sherpas</td>
<td>Respiration Physiol Neurosci</td>
<td>2002; 32:223</td>
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<td>Marson</td>
<td>2001</td>
<td>USA, American Indian</td>
<td>Chest</td>
<td>2001; 120:489-495</td>
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<td>Minni</td>
<td>2001</td>
<td>Germany, children aged 6-14 yrs from &quot;hospital normale&quot;</td>
<td>Eur J Pediatr</td>
<td>2001; 160:300-306</td>
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<td>Perez-Padilla</td>
<td>2001</td>
<td>Mexico, Mexican workers</td>
<td>Soc Pediatr Med 2001; 43:113-121 (Spanish)</td>
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<td>Petrella</td>
<td>2000</td>
<td>Italy</td>
<td>Am J Respir Crit Care Med</td>
<td>2000; 161:899-905</td>
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<td>Balakrishnan</td>
<td>2000</td>
<td>Greece, Greek elderly</td>
<td>Lung</td>
<td>2000; 176:201-212</td>
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<td>Quigley</td>
<td>1999</td>
<td>Italy</td>
<td>Respir Med</td>
<td>1999; 93:523-535</td>
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<td>Hamid</td>
<td>1999</td>
<td>USA population sample, aged 5-90 yrs (NHANES III)</td>
<td>Am J Respir Crit Care Med</td>
<td>1999; 159:179-187</td>
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<td>Baur</td>
<td>1999</td>
<td>Germany, comparison of lung function reference values</td>
<td>Arch Occup Environ Health</td>
<td>1999; 72:69-93</td>
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<td>McDonnell</td>
<td>1999</td>
<td>USA, older adults</td>
<td>Respir Med</td>
<td>1999; 92:914-921</td>
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<td>Liehrmann</td>
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<td>Germany, 7-15 yr old probands</td>
<td>Pneumologie</td>
<td>1997; 51:47-56 (German)</td>
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<td>Chin</td>
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<td>Singapore, nonsmoking adults</td>
<td>Respir Med</td>
<td>1997; 2:143-149</td>
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<td>Shaker</td>
<td>1996</td>
<td>Chile</td>
<td>Rev Med Chile</td>
<td>1996; 134:1305-1307 (Spanish)</td>
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<td>Guttierrez</td>
<td>1996</td>
<td>Chilean population, &gt;8 yrs old</td>
<td>Rev Med Chile</td>
<td>1996; 134:1205-1208 (Spanish)</td>
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<td>Enke</td>
<td>1996</td>
<td>USA, elderly Stadlen</td>
<td>Chest</td>
<td>1996; 112:1416-1424</td>
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<tr>
<td>Brikz</td>
<td>1996</td>
<td>Adult Swiss population</td>
<td>Thorax</td>
<td>1996; 51:277-283</td>
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</table>
Determining Acceptability

- Direct observation for proper effort
- Examination of tracing and values within maneuver
  - Flow/volume loop smooth without notching or cough or early termination/glottic closure (both FVC and SVC)
  - No hesitation with sharp peak in first 25% of FVC and extrapolated volumes of <5% or FVC or 0.15 L
  - No change in volume for >1 second (plateau in VT curve)(FVC only)
    - Effort is ≥ 3 sec in children <10 yo
    - Effort is ≥ 6 sec in subject age > 10 yo
  - Relatively normal expiratory flow (increased FEV₁/FVC), normal MMEF
- Comparison between maneuvers
  - 3 acceptable spiromgrams
  - 2 best FVC and FEV₁ measures
  - 2 best SVC within 0.150 L of each other

Eur Respir J 2005;26:948-68.
Interpretation

• Comment on quality of test and effort
  • Less than optimal may still contain useful data
  • Identify the problem, direction and magnitude of possible error

• Comparisons
  • Reference values from healthy subjects
  • Known disease or physiologic patterns
  • Self (changes over time)

• Answer clinical question posed or that prompted test
Approach to Evaluation

- Epidemiologically and specialty based bias puts us generally on the hunt for obstructive lung disease
- Begin with the most sensitive and a defining measure of obstructive lung disease
- Begin with FEV1/FVC
Approach to Evaluation
<table>
<thead>
<tr>
<th>Organisation</th>
<th>Year/Ref</th>
<th>Criterion</th>
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<tr>
<td>ECACS</td>
<td>1983³</td>
<td>FEV₁/VC or FEV₁/FVC &lt; LLN</td>
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<tr>
<td>ATS</td>
<td>1987⁶</td>
<td>FEV₁/FVC &lt; 0.75</td>
</tr>
<tr>
<td>ATS</td>
<td>1991⁴</td>
<td>FEV₁/FVC &lt; LLN</td>
</tr>
<tr>
<td>ECACS/ERS</td>
<td>1993⁵</td>
<td>FEV₁/VC or FEV₁/FVC &lt; LLN</td>
</tr>
<tr>
<td>ERS</td>
<td>1995⁷</td>
<td>FEV₁/VC &lt; 88% predicted (males) or 89% (females)</td>
</tr>
<tr>
<td>BTS</td>
<td>1997⁹</td>
<td>FEV₁/FVC &lt; 0.70 and FEV₁ &lt; 80% predicted</td>
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<tr>
<td>NLHEP</td>
<td>2000¹²</td>
<td>FEV₁/FVC or FEV₁/FEV₆ &lt; LLN and FEV₁ &lt; LLN</td>
</tr>
<tr>
<td>GOLD</td>
<td>2007¹¹</td>
<td>FEV₁/FVC &lt; 0.70 post-bronchodilator</td>
</tr>
<tr>
<td>NICE</td>
<td>2004¹⁰</td>
<td>FEV₁/FVC &lt; 0.70 and FEV₁ &lt; 80% predicted</td>
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<tr>
<td>ATS/ERS</td>
<td>2004¹¹</td>
<td>FEV₁/FVC &lt; 0.70 post-bronchodilator</td>
</tr>
<tr>
<td>ATS/ERS</td>
<td>2005¹³</td>
<td>FEV₁/VC &lt; LLN</td>
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</tbody>
</table>

ATS, American Thoracic Society; BTS, British Thoracic Society; ECACS, European Community for Coal and Steel; ERS, European Respiratory Society; FEV₁/FVC, forced expiratory volume in 1 s/forced vital capacity; GOLD, Global Initiative for Chronic Obstructive Lung Disease; LLN, lower limit of normal; NICE, National Institute for Health and Clinical Excellence; NLHEP, National Lung Health Education Program; VC, vital capacity.
Reference Equations

• Use published reference pools established LLN (NHANES/Hankinson)

• Fixed value
  • EPR3 for FEV1/FVC
    • 6-19 yo <85%
    • 20-39 yo <80%
    • 40-59 yo <75%
    • 60-80 yo < 70%

• Other Set Cut Offs
  • FEV1/FVC ratio < 70% (Underestimates in children/young adults)
  • FEV1 and FVC less than 80%
  • Lung volumes < 80% and > 120%
Facility name: ALLERGY & IMMUNIZATIONS

Patient Information

Name:  
Height at test (in): 65.0  
Weight at test (lbs): 135.0  
Birthdate:  
Sex: Male  
Age at test: 39  
Predicted set: Hankinson (NHR ES III)  
Ethnic group: Caucasian

Diagnosis:

Interpretation

Site: Koro700261  
Effort protocol: ATS/ERS 2005  
Test date/time: 10/14/09 09:06:51 AM  
Physician:  
Technician: BAB  
Bronchodilator: Pre-ED Number of efforts performed: 3  
Post-ED Number of efforts performed: 3

Results

<table>
<thead>
<tr>
<th></th>
<th>Predicted</th>
<th>LLN</th>
<th>Pre-ED</th>
<th>Post-ED</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>4.20</td>
<td>3.44</td>
<td>3.69</td>
<td>3.97</td>
<td>95%</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>3.39</td>
<td>2.76</td>
<td>2.19</td>
<td>2.84</td>
<td>84%</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>0.80</td>
<td>0.70</td>
<td>0.61</td>
<td>0.71</td>
<td>60%</td>
</tr>
<tr>
<td>FEF25-75% (L/s)</td>
<td>3.40</td>
<td>2.11</td>
<td>1.94</td>
<td>2.12</td>
<td>62%</td>
</tr>
<tr>
<td>PEFR (L)</td>
<td>6.99</td>
<td>6.82</td>
<td>5.30</td>
<td>5.79</td>
<td>67%</td>
</tr>
<tr>
<td>Vent (%)</td>
<td>--</td>
<td>--</td>
<td>1.21</td>
<td>1.81</td>
<td>49%</td>
</tr>
</tbody>
</table>

Test comments (Pre):  
Test comments (Post):

[Graphs: FVC Flow vs. Volume, FVC Volume vs. Time]
Approach to Evaluation

[Flowchart showing the evaluation process with decision points for FEV1/VC, TLC, VC, and types of defects: Normal, Restriction, Obstruction, Mixed defect]

Eur Respir J 2005;26:948-68.
Approach to Evaluation

Flowchart:

- **FEV1/VC ≥ LLN**
  - Yes → **VC ≥ LLN**
  - No → **TLC ≥ LLN**

**VC ≥ LLN**
- Yes → Normal
- No → **TLC ≥ LLN**
  - Yes → Obstruction
  - No → **DL,co ≥ LLN**
    - Yes → Emphysema
    - No → Mixed defect

**TLC ≥ LLN**
- Yes → Normal
- No → Restriction

**DL,co ≥ LLN**
- Yes → PV disorders
- No → CW and NM disorders

**ILD Pneumonitis**
- Yes → Asthma CB
- No → Emphysema

Eur Respir J 2005;26:948-68.
Flow-Volume Loops: Other Patterns

- Normal
- Variable extrathoracic upper airway obstruction (e.g., tracheomalacia, vocal cord paralysis)
- Variable intrathoracic upper airway obstruction (e.g., tracheomalacia of the intrathoracic airway, tumors)
- Fixed upper airway obstruction (e.g., tracheal stenosis, goiter)

http://intechopen.com
Obstructive Abnormalities

- Disproportionate reduction in maximal airflow (FEV$_1$) in relation to the maximal volume (VC)
- Implies airway narrowing
- Defined by FEV$_1$/VC ratio below LLN
- Earliest changes are slowing in terminal portion of spirogram leading to concave shape “scooping”
Obstructive Abnormalities

Normal FVC=3.11, FEV1=2.76, FEV1/FVC%=88.6% (———)
Obstructive FVC=2.93, FEV1=1.67, FEV1/FVC%=56.9% (———)
Obstructive Abnormalities

Normal: FVC = 3.11, FEV1 = 2.76, FEV1/FVC% = 88.6%

Obstructive: FVC = 2.93, FEV1 = 1.67, FEV1/FVC% = 56.9%
### Severity Classification

**TABLE 6** Severity of any spirometric abnormality based on the forced expiratory volume in one second (FEV1)

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

% pred: % predicted.
### Classification of Asthma Severity

(Youths ≥ 12 years of age and adults)

<table>
<thead>
<tr>
<th>Intermittent</th>
<th>Persistent</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 days/week</td>
<td>&gt;2 days/week but not daily</td>
<td>Daily</td>
<td>Throughout the day</td>
<td></td>
</tr>
<tr>
<td>4x/month</td>
<td>3–4x/month</td>
<td>&gt;1x/week but not nightly</td>
<td>Often 7x/week</td>
<td></td>
</tr>
<tr>
<td>2 days/week</td>
<td>&gt;2 days/week but not &gt;1x/day</td>
<td>Daily</td>
<td>Several times per day</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>Minor limitation</td>
<td>Some limitation</td>
<td>Extremely limited</td>
<td></td>
</tr>
<tr>
<td>Normal FEV₁ between exacerbations</td>
<td>FEV₁ &gt;80% predicted</td>
<td>FEV₁ ≥80% predicted</td>
<td>FEV₁ &gt;60% but &lt;80% predicted</td>
<td></td>
</tr>
<tr>
<td>FEV₁/PVC normal</td>
<td>FEV₁/FVC normal</td>
<td>FEV₁/FVC reduced 5%</td>
<td>FEV₁/FVC reduced &gt;5%</td>
<td></td>
</tr>
</tbody>
</table>

EPR3 - www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf
Restrictive Abnormalities

- Defined by TLC below 5th percentile (80%?) and a normal FEV1/VC
- Spirometry
  - Reduced VC
  - Increased FEV1/VC
  - Convex pattern to FV loop
  - Spirometry can be misleading – need lung volumes
    - Effort
    - Obstruction with air trapping
    - Pattern is associated with low TLC only ~ 50% time
Restrictive Abnormalities

NIOSH Spirometry Training Guide - cdc.gov/niosh/
Restrictive Abnormalities

![Graph showing Normal and Restrictive Spirometry Values]

- Normal: FVC = 4.21, FEV1 = 3.46, FEV1/FVC% = 82%
- Restrictive: FVC = 3.16, FEV1 = 2.59, FEV1/FVC% = 82%
Mixed Abnormalities

- Coexisting restriction and obstruction
- Defined by abnormally reduced FEV1/VC and low TLC
Mixed Abnormalities

- Normal: FVC=3.73, FEV1=2.83, FEV1/FVC%=75.8% (---)
- Mixed: FVC=3.00, FEV1=2.06, FEV1/FVC%=68.6% (----)
Mixed Abnormalities

Normal: FVC=3.73, FEV1=2.83, FEV1/FVC%=75.8% (---)
Mixed: FVC=3.00, FEV1=2.06, FEV1/FVC%=68.6% (-----)
Summary

- Background
- ATS/ERS sources
- ATS/ERS guidance
  - Performance of testing
  - Reference Equations
  - Approach to evaluation
  - Interpretation
  - Severity classification