Spirometry in the Office Setting

Paul Moore, M.D.
Pediatric Allergy, Immunology, and Pulmonary Medicine

Objectives

• To understand what measurements spirometry provides.
• To provide an overview of the interpretation of spirometry.
• To demonstrate how the use of spirometry can be helpful in the diagnosis and management of asthma.

Spirometry

• Spirometry is used to measure the rate at which the lung changes volume during forced breathing maneuvers.

Chest. 2002;121(5 suppl):219S-223S.
Data from spirometry

- Subjects exhale through a flow meter.
- Volume exhaled is plotted as a function of time.
- Integration of flow provides volume: Flow-volume curve

Normal spirometry
Airway Obstruction

<table>
<thead>
<tr>
<th>Ref</th>
<th>Pre</th>
<th>%Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>4.00</td>
<td>2.24</td>
</tr>
<tr>
<td>FEV1 L</td>
<td>3.44</td>
<td>1.52</td>
</tr>
<tr>
<td>FEV1/FVC%</td>
<td>86</td>
<td>68</td>
</tr>
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</table>

Measurements

- **FVC** = Forced vital capacity or maximal volume that can be displaced from the lung
- **FEV<sub>1</sub>** = Forced expiratory volume in 1 second
- **FEF<sub>25-75</sub>** = Forced mean expiratory flow between 25% and 75% of FVC
- **PEF** = Peak expiratory flow

Normal values

- Predictive values have been based on size, gender, and age of subjects.
- Best values obtained from nonsmoking subjects.
- Race-specific values have not been applied consistently.
- The inherent variability in normal predictive values should be kept in mind.
Characteristics of the flow-volume curve that reflect good effort

• The curve shows a rapid climb to peak flow.
• The curve has a fairly smooth, continuous decrease in flow.
• The curve terminates at flow within 0-0.1 L/sec of zero flow.

Reproducibility: ATS standards

• Peak flows within 10% of each other.
• FVC and FEV$_1$ within 5% of each other.

Forced vital capacity (FVC)

• During expiration (for any given individual), there is a unique limit to the maximal flow that can be reached at any lung volume.
• This limit is reached with moderate expiratory efforts, and increasing the force does not increase the flow.
• Because this curve defines a limit to flow, the curve is highly reproducible in a given subject.

Reduced FVC reflects the lung’s mechanical properties

• Emphysema: lost lung tissue, decreased elasticity, narrowed airways
• Chronic bronchitis: mucosal thickening and thick secretions
• Asthma: bronchoconstriction and mucosal inflammation
• Pulmonary fibrosis: reduced lung volume
Forced expiratory volume in 1 second (FEV₁)

- The volume of air exhaled in the first second of the FVC test.
- When flow rates are slowed by airway obstruction, the FEV₁ is decreased by an amount that reflects the severity of the disease.
- Mild: 60-80% predicted
- Moderate: 40-60% predicted
- Severe: <40% predicted

FEV₁/FVC Ratio

- The amount exhaled in the first second is a fairly constant fraction of the FVC, irrespective of lung size.
- In children, this ratio is close to 90% and ranges from 75-85% in adults.
- The ratio guides whether the FEV₁ is reduced due to low FVC.

FEF₂₅-₇₅

- Defined as the average forced expiratory flow rate over the middle 50% of the FVC.
- FEF₂₅-₇₅ reflects flow in small airways and may be more sensitive than FEV₁ in detecting early airway obstruction.
Reversible airway obstruction

- Defined at 12% or 200 mL improvement in FEV₁.
- May be helpful for initial diagnosis of asthma.
- May be helpful for assessment of asthma control.

Peak expiratory flow

- Occurs shortly after the onset of expiration.
- Reported in L/sec in laboratory and in L/min by hand-held devices.
- Very dependent on patient effort.
Other causes of airway obstruction that may be identified by spirometry

<table>
<thead>
<tr>
<th>Condition</th>
<th>Graph Representation</th>
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<tbody>
<tr>
<td>Normal</td>
<td></td>
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<tr>
<td>Early-onset airway obstruction</td>
<td></td>
</tr>
<tr>
<td>Chronic obstructive disease</td>
<td></td>
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<tr>
<td>Fixed large airway obstruction</td>
<td></td>
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<tr>
<td>Variable obstructive disease</td>
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<tr>
<td>Restrictive disease</td>
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Utility of spirometry in evaluation of pediatric patients

- Reversible airway obstruction: asthma
- Fixed airway obstruction: subglottic stenosis, tracheomalacia
- Presence of restrictive lung disease may suggest alternative diagnoses
- The use of spirometry can be enhanced by performing spirometry before and after a bronchial challenge.

Monitoring pulmonary function in patients with asthma

- PEFR (performed in the office and/or at home) and spirometry (performed in the office) are the two most-commonly employed modalities for monitoring pulmonary function in children older than 5 years of age and in adults.
- The 2007 NAEPP guidelines state a preference for use of spirometry in medical offices, when available.
- Children older than 5 years of age are usually able to perform the peak flow or spirometric maneuver.

Components of asthma severity

- Impairment
  - Reported symptoms over the previous 2-4 weeks
  - Current level of lung function (FEV1 and FEV1/FVC values)
- Risk
  - Number of exacerbations requiring oral systemic corticosteroids
Lung Function by Severity in NAEPP Guidelines

- Intermittent: FEV₁ and FEV₁/FVC ratio normal between episodes
- Mild persistent: FEV₁ measurements in normal range (≥80% of predicted normal)
- Moderate persistent: FEV₁ measurements 60-80% of predicted normal.
- Severe persistent: FEV₁ measurements <60% of predicted normal.

Influence of PFTs on Management of Asthma in Children

- 367 children with asthma, ages 4-18 years
- Initial recommendations made after provider evaluation
- Recommendations updated after review of spirometry results
- Spirometry abnormal in 45% of visits and led to changes in 15% of visits
- Providers overestimated degree of asthma control prior to PFT results

<table>
<thead>
<tr>
<th>Peak Flow Meters</th>
<th>Limitation of peak flow meters</th>
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<tbody>
<tr>
<td>• PEFR can be a useful indicator of airflow obstruction, the hallmark finding of asthma.</td>
<td>• PEFR measurements are effort dependent; thus, values can be manipulated.</td>
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<tr>
<td>• PEFR can be measured with handheld peak flow meters in settings not equipped with a spirometer.</td>
<td>• Interpersonal variability can be substantial.</td>
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<tr>
<td>• Average normal values for men, women, and children have been developed.</td>
<td>• Circadian rhythms can influence.</td>
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<td>• Wide variation of recorded PEFR can be observed between devices, even of the same brand.</td>
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</table>

Application of peak flow meters

- Repeated measurements of PEFR in an individual patient are useful for determining relative changes or trends in asthma control.
- Monitoring may also be particularly useful in patients who perceive limitations in airflow poorly.