Techniques for Improving and Understanding Spirometry Results

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Conflicts of Interest

- NIOSH Course Director
Objectives

- Discuss techniques for obtaining good pulmonary function tests (PFTs) with children.
- Review PFT interpretation for asthma.
- Identify resources that support PFT interpretation and processes.
Overview

■ General testing issues
  • Laboratory environment
  • Technician ability

■ How to get maximal effort and compliance

■ Test quality assessments
Adults vs. Pediatrics

- Quality control and test performance standards
- Special considerations
  - equipment selection
  - environment
  - technologist skill and training
  - child’s developmental age and test performance
General Issues

- Technologist trained in pediatric testing
- Non-threatening, friendly environment
- Le Souef et al (Perth, Australia)
  - 20% of age 3 children perform spirometry after intensive coaching
  - In other studies, five or older perform spirometry and bronchial challenge testing
Equipment Selection

- Evaluate accuracy at low flows and volumes
  - Accuracy for volume should be + or – 50 ml to below 0.5L

- Visible real-time display

- Mouthpiece and equipment design should allow flexibility for a wide range of ages from 4 to 18 years of age and heights as low as 120 cm.
  - Noseclips
Equipment Selection

- Appealing colors
- Simulate objects familiar to children
- Must be able to physically hold required devices
- Visual and auditory clues for test performance
- Ease of use for children
- Chair is adjustable
Selecting Appropriate Environment

- Appealing to children
- Calm, quiet atmosphere
- Freeing the area of all distractions
- Free area of instruments associated with painful procedures
Technologist Selection

- Desire to work with children
- Positive, enthusiastic, and friendly
- Patient and relate well to each child
Communication Skills

- **Age Appropriate**

- Joint Commission on the Accreditation of Healthcare Organizations (JCHAO) requires age specific training and documentation.
Other Issues

- Coordination
- Parental presence during test performance
- Attention span
- Time of day
- Other procedures
Obtaining Maximal Cooperation

- Understand issues which affect cooperation

- Consider the laboratory’s scheduling patterns
  - What is the best time of day for the child?
  - Is the child having other tests that may affect their cooperation?
  - Allow adequate time for the child to ask questions
  - Allow adequate time for patient instruction
Motivational Techniques

- Positive coaching
- Set goals
- Use and type of rewards is an organizational decision
- Competition between the parent and another sibling
- Develop positive relationships that affect cooperation level on subsequent visits
- Software enhancements
Spirometry

Guidelines for Testing Children


Spirometry

- Old enough to follow directions & give max effort
- Allow extra time for instructions
- Acceptability
  Good start (BEV < 80 mL or 12.5% of FVC)
  FET of $\geq$ 3 sec in children $<10$ yrs, and $\geq$ 6 sec if age $\geq$ 10 yrs; report but do not use FET to exclude maneuvers
  Blow until plateau (no $\Delta$ for $\geq$ 1 sec)
Spirometry

- If cessation of flow occurs at >10% PEFR, then classified as premature termination

- Use nose clip, if possible

- Repeatability
  2 highest FVC and 2 highest FEV1 values agree within 0.100 L or 10% of highest, whichever is greater

- Can report data despite not meeting repeatability criteria
Spirometry, Indices to Report

- FVC
- FEV0.5
- FEV0.75
- FEV1
- PEFR*
- Repeatability of parameters above
- Number of acceptable maneuvers
- Position (seated or standing)
- Use of nose clip
- Back-extrapolated volume*
- FET*

* Optional, or for QC purposes
Flow-Volume Loop

Asthma Initiative of Michigan, 2005.
Volume-Time Curve

The expiratory time should be at least 6 seconds and the plateau at least one second.

Expiratory time should be at least 6 seconds.

Volume in liters (Y-axis)

Time in seconds (X-axis)

FEV₁

FVC
Performance of Spirometry

- Peak flow – Assessment of effort
  - lung volume
  - elastic recoil
Patient Instruction

- Demonstrate the procedure
  - Patient posture during test performance
    - Head and neck position
    - Bending
    - Sitting or standing (recommend sitting for safety)
Maneuver Performance

- Three acceptable maneuvers

- Practical upper limit of 8-clinical judgement
End of test criteria

- **Obvious plateau of 1 second**
- **Minimum exhalation time**
- **Six seconds (3 seconds in children less than 10)**
Satisfactory start of test

- Back extrapolated volume less than 5% or 150 ml

- Pause at TLC greater than 4-6 seconds decreases PEF and FEV₁
Bronchodilator

Should children always have pre and post spirometry?
Reversibility

• Adults
  FEV1 increase of >12% and 0.2 L

• Children
  FEV1 increase > 12%
# Pre-Bronchodilator

<table>
<thead>
<tr>
<th>Spirometry</th>
<th>Actual</th>
<th>Predicted</th>
<th>% Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>2.86</td>
<td>2.54</td>
<td>113</td>
</tr>
<tr>
<td>FEV₁ (L)</td>
<td>2.00</td>
<td>2.27</td>
<td>88</td>
</tr>
<tr>
<td>FEV₁/FVC (%)</td>
<td>70</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>FEF 25 - 75% (L/sec)</td>
<td>1.43</td>
<td>2.51</td>
<td>57</td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>5.32</td>
<td>5.38</td>
<td>99</td>
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</tbody>
</table>
### Post-Bronchodilator

<table>
<thead>
<tr>
<th>Spirometry</th>
<th>Actual</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>2.97</td>
<td>4</td>
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<tr>
<td>FEV$_1$ (L)</td>
<td>2.60</td>
<td>30</td>
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<tr>
<td>FEV$_1$/FVC (%)</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>FEF 25 - 75% (L/sec)</td>
<td>2.88</td>
<td>102</td>
</tr>
<tr>
<td>FEF Max (L/sec)</td>
<td>6.79</td>
<td>28</td>
</tr>
</tbody>
</table>

![Graph showing spirometry results](image)
Reference Ranges

- Selected reference ranges are based on the age and population to be tested (GLI 3 to 95)
- Verify range
- Male lung function variables discontinuous with age
  - Linear increase with standing height until puberty
  - After puberty, sudden pubertal rise and increase in height
    - A correction for varying thoracic sizes eliminated these changes
- In females, smooth curvilinear relationship is observed
Inspired and expired air should be similar.
Impact on Care

- Spirometry can be done in family physicians’ offices and alters clinical decisions in asthma and COPD*
  - Technical adequacy, accuracy of interpretation, and impact of office spirometry
  - 382 from 12 practices with asthma, COPD or staff
  - 368 tests over 6 months
    - 71% were technically adequate for interpretation
    - Interpretations concordant in 76% between family physicians and experts
    - Changes in management in 48% of subjects
    - 107 medication changes (>85% concordant with guidelines)
    - 102 nonpharmacologic changes
    - Concordance between family physician and experts higher in asthma

Summary

- PFTs in pediatrics is essential in diagnosis and monitoring of the disease process
- Children can and do successfully perform standard pulmonary function testing
- Successful testing occurs with a pleasant environment, trained personnel, trained patients, and relationships that grow with the child.
Resources

- AARC CPGs
- ATS Management and Procedure Manual for Pulmonary Function Laboratories
- ATS/ERS Statements
- Global Lung Initiative – 2012
- Respiratory Care Journal – January 2012
Spirometry results affect people!!!

- Further testing
- Labeling (COPD, Asthma)
- Medicine
- Disability
- Clinical Trials