LUNG FUNCTION TESTING: SPIROMETRY AND MORE

FILOMENA HAZEL VILLA, MD
UTHSCSA-PEDIATRICS
DIVISION OF PULMONOLOGY

OBJECTIVES

• 1. To describe other lung function testing for toddlers and those who cannot perform spirometry
• 2. To describe a lung function test on infants
• 3. To present different exercise challenge tests in diagnosing exercise intolerance

DISCLOSURE

• I have nothing to disclose.

PULMONARY FUNCTION TEST (PFT)

• Important tool
  – To evaluate signs and symptom of lung disease
  – To assess progression of disease
  – To monitor effectiveness of treatment
  – To evaluate pre-operative patients
  – To monitor potential effects of certain toxic drugs

TYPES OF PFT

• Spirometry
• Measurement of Lung volumes- body box, gas dilution technique
• Diffusion capacity
• Exercise challenge tests
• Bronchoprovocation tests (Methacholine, Cold air challenge)

INFORMATION YOU GET FROM PFT

• How much VOLUME can be moved in and out of the lung
• How FAST the air in the lungs can be moved in and out
• How STIFF the lungs and chest wall
• Diffusion characteristics of the membranes through which the gases move
• How the lungs respond to chest physiotherapy/treatment.
SPIROMETRY

- Most commonly used pulmonary function test
- Assessing airway response (bronchodilators and bronchoconstrictors)
- Parameters: FVC, FEV1, FEV1/FVC, FEF25-75

SPIROMETRY - NORMAL

ASTHMA

- Characteristics of asthma:
  - Reversible airway obstruction
  - Bronchial hyperresponsiveness
  - Airway inflammation

Bronchodilator reversibility
  - Give Albuterol
  - Increase in FEV1 by at least 12%
  - Increase in FEF25-75 by at least 30%

ASTHMA

Bronchial hyperresponsiveness- bronchoprovocation
  - Methacholine challenge test
  - Cold air challenge test
  - Exercise challenge test

Airway inflammation
  - Bronchoalveolar lavage
  - Sputum eosinophil
  - Fraction of exhaled nitric oxide (FeNO) = 20 → increased in asthma
**SPIROMETRY – THE MANEUVER**

• Direct airway challenge test
• Causes airflow limitation by its direct effect on the airway smooth muscles
• A change in the FEV1 is the primary outcome.
• **It is important that the child has had a successful valid spirometry.**

**SPIROMETRY- ASTHMA**

**BRONCHOPROVOCATION: METHACHOLINE CHALLENGE TEST**

<table>
<thead>
<tr>
<th>PC, mg/ml</th>
<th>Interpretation</th>
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</thead>
<tbody>
<tr>
<td>&gt;16</td>
<td>Normal bronchial responsiveness</td>
</tr>
<tr>
<td>4.0-16</td>
<td>Borderline BHR</td>
</tr>
<tr>
<td>1.0-4.0</td>
<td>Mild BHR (positive test)</td>
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<tr>
<td>&lt;1.0</td>
<td>Moderate to severe BHR</td>
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**COLD AIR CHALLENGE TEST**

• Indirect airway challenge - airway cooling causes release of mediators from inflammatory cells
• Patient hyperventilates to MVV (Maximum ventilatory volume)
• Inhales subzero dry air (-10 to -15 C) for 4 minutes
• Do series of spirometry. A drop in FEV1 by 9% is positive for BHR.

**EXERCISE CHALLENGE TEST**

• EIB or Exercise induced bronchospasm
• Based on the concept of hyperventilation inducing airway cooling and drying releasing inflammatory mediators leading to bronchoconstriction.
• Identifies hyperreactive airways utilizing exercise as a stimulus.
CASE 1

You first saw this 3 y/o girl when she was 1 year old for RSV bronchiolitis. This was then followed with recurrent cough and intermittent increase work of breathing. Albuterol seems to help. You never heard her wheeze. Mom asks does she have asthma?

IMPULSE OSCILLOMETRY (IOS)

- IOS- loudspeaker sends oscillating soundwaves as patient breathes. Soundwaves pass through the airway.
- IOS measures respiratory impedance → resistance
- Elevated resistance indicates narrowed airway
- Effortless normal “tidal” breathing
- For those unable to do the forced maneuvers.
- Highly sensitive.

CASE 2

- A 12 year old girl has history of prolonged cough with URI. She has been using Albuterol inhaler as needed which sometimes helps. At baseline she does not normally cough during the day except when she is playing soccer.
- You suspect asthma.
• What lung function will you request to strengthen a diagnosis of asthma?
  • A. Pre and Post bronchodilator spirometry
  • B. Cold air challenge test
  • C. Methacholine challenge test
  • C. Exercise bronchoprovocative challenge test

EXERCISE CHALLENGE TEST

• Indications:
  – To assess patients with breathlessness with exercise.
  – To evaluate the severity of airway response to exercise.
  – To evaluate effectiveness of medications in the prevention of symptoms of EIB

EXERCISE CHALLENGE TEST (BRONCHOPROVOCATION)

CASE 3

• An 11 year old girl is diagnosed with asthma since age 4. Her asthma is well controlled until recently, when she experienced chest tightness and sometimes wheezing in PE with inconsistent response to her rescue inhaler.
**CASE 3**

- A. Ask if the problem is breathing in or breathing out.
- B. Demonstrate different kinds of airway noises:
  - Stridor or wheezing
- C. Request for spirometry
- D. Request for exercise test

**EXERCISE INDUCED ASTHMA IS NOT THE ONLY CAUSE OF DYSPNEA WITH EXERTION**

- Anxiety
- Cardiac Disease
- Poor Fitness
- Vocal Cord Dysfunction

**SPIROMETRY OF CASE 3**

- Truncation of inspiratory loop, or variable extrathoracic obstruction

**VOCAL CORD DYSFUNCTION (VCD)**

- Normal vocal cord movement:
  - Abduction on inspiration/Adduction on expiration
- VCD – Mediated by the vagus nerve altering the laryngeal tone precipitating the abnormal adduction of vocal cords
  - Paradoxical movement of the vocal cords.

**VCD**

- Signs and symptoms:
  - Shortness of breath – difficulty getting air in (common)
  - Throat or chest tightness
  - Feeling of choking
  - Noisy breathing
  - Hoarse voice

**VCD**

What can trigger VCD?

- GERD
- Post nasal drip
- URI
- Exercise
- Strong odors; smoke
- Strong emotions and stress
**EXERCISE LARYNGOSCOPY**

- Exercise test to exhaustion similar to bronchoprovocation.
- Flexible laryngoscopy immediately after exercise.

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**CASE 4**

- You see a 13 year old morbidly obese child with a history of intermittent asthma. He tires out easily in PE and is huffing and puffing even with prophylactic Albuterol.
- Mom asks you- Is this still asthma, or is this just because he is fat, should I be worried that he has a heart problem?
- Normal spirometry, normal echocardiogram.
**CARDIOPULMONARY EXERCISE TEST (CPET)**

- Determines what system limits the exercise (cardiac or pulmonary)
- Patients with unexplained exercise intolerance
- 20-30 minutes of treadmill or cycle ergometer exercise. HR, O₂ saturation, ECG, BP are monitored.
- Collects all exhaled gases for minute ventilation, O₂ uptake and CO₂ production.

**ABSOLUTE CONTRAINDICATIONS**

- Recent MI
- Unstable congestive heart failure
- Severe aortic stenosis
- Suspected myocarditis or pericarditis
- Suspected venous thromboembolic disease
- Recent acute cardiac event
- Uncontrolled Arrhythmia
- **If patient has significant cardiac disorder, will need clearance before conducting the test.**

**CASE 5**

- A 7 year old boy underwent chemotherapy for mixed germ cell tumor and received Bleomycin. Mom reports that child easily gets winded. His resting saturation is 94%.
- Assess child's functional capacity
- Do full PFT- spirometry, lung volumes and DLCO
- Ask for child's Activity of Daily Living (ADL)

**WHAT IS YOUR NEXT STEP TO ASSESS CHILD'S FUNCTIONAL CAPACITY IN THE CLINIC?**

- A. Request for a full PFT + DLCO
- B. Exercise test- Which one?

**6-MINUTE WALK TEST**

- Practical simple test
- Requires 100 ft hallway
- Measures the distance (6 MWD) that a patient can walk in 6 minutes (flat, hard surface)
- Indirectly evaluates function of organs involved in exercise
- Assesses submaximal level of functional capacity (better reflect daily physical activities)
CASE 6

- A 6 month old boy was born prematurely at 29 weeks, with history of prolonged mechanical ventilation. Discharge diagnosis was BPD (chronic lung disease of prematurity). There is no family history of asthma, but patient was given Albuterol for cough.

- Mom wants to know if baby has asthma and the impact of being born young on the function of his lungs.

INFANT PULMONARY FUNCTION TEST (IPFT)

- Asthma, cystic fibrosis and BPD start very early in life, but severity and effects of treatment are difficult to determine.
- Lung and airway function can now be measured in infants. Requires moderate sedation.
- Measures lung volumes, compliance, resistance.
- Measures parameters similar to spirometry (FVC, FEV0.5, FEV0.5/FVC, FEF25/75)

JUST LIKE BIG PEOPLE’S SPIROMETRY...

DO WE REALLY NEED PFT?

PFTS AVAILABLE IN OUR LAB

- 1. Spirometry, Full PFT
- 2. Impulse Oscillometry
- 3. Exercise Bronchoprovocative Challenge testing
- 4. Cardiopulmonary Exercise testing
- 5. Maximum inspiratory pressure/Maximum expiratory pressure
- 6. Exercise Laryngoscopy
- 7. Infant Pulmonary Function testing
- 8. High Altitude Simulation Test
- 9. Transtracheal pressure measurement for safe use of HME and speaking valve
- 10. Cold Air Challenge Testing
1. For first time PFT patients: Order:
   1. Spirometry pre and post bronchodilator. If unable to do Spirometry, proceed with Pre and post bronchodilator Impulse Oscillometry (IOS)
   2. Indicate diagnosis and referring physician.
   3. Results will be sent under Pediatric Pulmonary Progress Notes/Procedure Note/"Results/Pulmonary Function Test".

* RBG Contact number (210) 358-5490 (Pediatric PFT Lab)
* UH Contact number (210) 358-1415 (PFT Lab)

THANK YOU.