Pulmonary Function Tests In Pediatrics Why, Who, When, and How

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October 29, 2011

Goals and Objectives

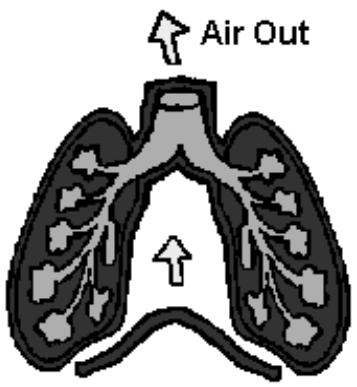
- Goals: Demonstrate value of ordering PFTs for patients with a respiratory problem and improve comfort levels in interpreting the results of the PFT
- Objectives: At the end of the workshop participants will be able to:
  - Define the most clinically significant measures: FVC, FEV1, FEV1/FVC and FEF 25%-75%
  - Recognize and describe the characteristic spirometry patterns of obstructive verses restrictive lung disease
  - Interpret the results of a bronchodilator challenge
  - Describe one way in which spirometry can impact the care of a patient with asthma
  - Perform spirometry

Case Study 1: AR

- 16 year old male with long-term history of SOB with exercise. Uses albuterol 4 times a week when playing soccer. Reports that it helps a little . Otherwise, has a nighttime cough about once a week. No family history of allergies or asthma. Father, who is accompanying teen, believes he does not have asthma, but is out of shape.
- **What would you do for this patient?**

Why do Spirometry?

- Spirometry measures *lung volume* and *airway flow* during a forced expiration
- These numbers and the resultant expiratory flow diagram can help us estimate
  - Strength and function of chest wall
  - Lung size and compliance ("restrictive lung disease")
  - Airway size and patency ("obstructive lung disease")
- Restrictive lung diseases are those affecting ***lung volumes***
- Obstructive lung diseases are those affecting ***airway flow***. Asthma is an obstructive lung disease



Who Should Get Spirometry?

- General indications:
  - Diagnosis of lung disease
  - Screening for individuals at risk of lung disease
  - Monitoring of response to treatments or exposures
  - Preoperative assessments
  - Disability evaluations
  - Public health concerns

Spirometry in Pediatric Asthma

- For Diagnosis
  - Document **presence and severity** of airway obstruction
  - Demonstrate **reversibility** of obstruction (after BD)
  - Document **reactivity** of obstruction (after exposure to allergen, trigger or with exercise)
- For Monitoring
  - Response to **treatment**
  - Evidence of **compliance**
  - Changes in disease **severity** over time

When should spirometry be done for asthma patients?

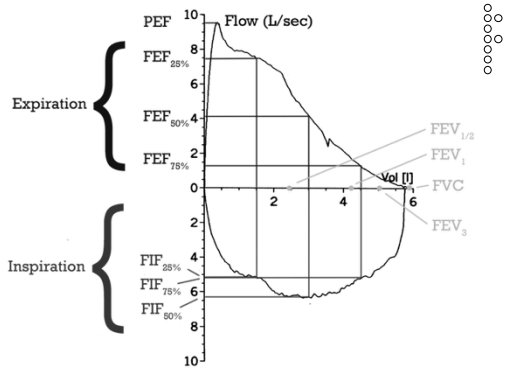
- At the time of initial diagnosis
  - Document airflow obstruction
  - Document reversibility
- When reducing the dosage of medications
- After patient has stabilized on treatment to check for persistent asymptomatic obstruction.
- At least every 1 – 2 years in moderate to severe asthmatics

Who should NOT get spirometry?

- Inability to tolerate test
  - Symptoms such as severe cough, nausea, vertigo
- Risk of damage from performing test
  - Hemoptysis
  - Pneumothorax
  - Recent abdominal, thoracic or ocular surgery
  - Recent MI
  - Thoracic aneurysm

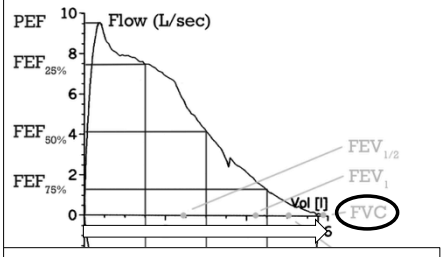
Tools for Interpreting spirometry: What Are We Measuring?

- FVC, FEV1, FEV1/FVC, FEF 25-75%
- Reported as both and *percent predicted*
- "Percent predicted"
  - Based on age, height, gender, and race
  - Most useful in interpretation



FVC

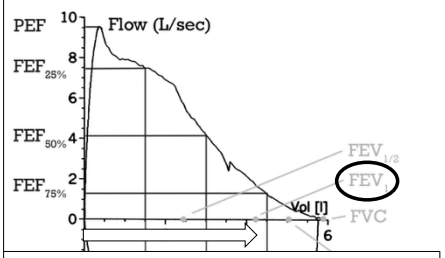
- Maximum volume expired during forced expiratory effort after maximum inhalation
- Normal = 80-120% of predicted
- Reduced in
  - Conditions which reduce lung **volumes**
  - E.g: restrictive lung disease (stiff lung, weak/stiff chest wall) or poor effort
- *Should NOT be reduced in asthma*
- *Results can be effort dependent*



FVC = Forced Vital Capacity

FEV1

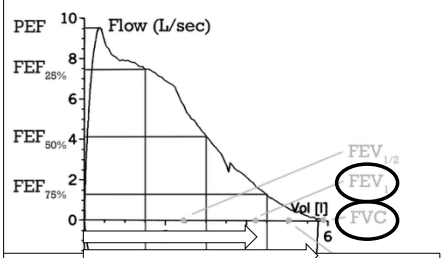
- Total volume expired in 1st second of forced expiratory effort after maximum inhalation
- Normal = 80-120% of predicted
- Reduced in
  - Conditions which obstruct expiratory airway **flow**
  - E.g: obstructive lung disease (asthma, COPD) or fixed obstruction (mass, foreign body)
  - *However, will be proportionately reduced in patients with low lung volumes as well!*
  - *It, also, can be effort dependent*



FEV1 =
Forced Expiratory Volume in 1st Second

FEV1/FVC Ratio

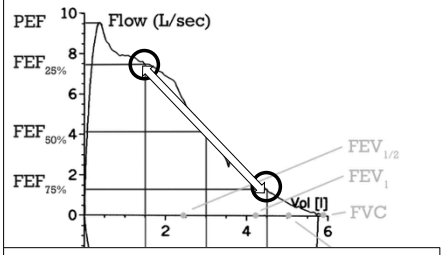
- One of the **key tools** for distinguishing diseases of airway obstruction from those of small lung volumes
  - Especially important when FVC is reduced, as ratio corrects for low volumes
- May be reported as an **absolute ratio**, or as a percent of predicted
  - In children, normal absolute **ratio** is 85% (in other words, the normal child can exhale 85% of their lung volume in 1 second)
  - If reported as **% predicted**, normal is 100%



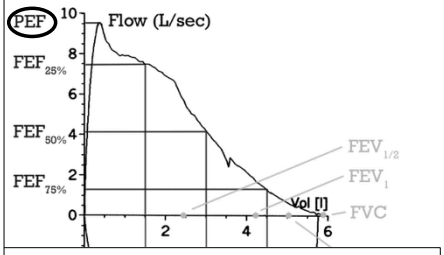
FEV1/FVC =
Percentage of FVC expired in the 1st second

FEF 25-75%

- Average expiratory *flow* rate over the middle 50% of the FVC, or the middle part of the expiration when small airways are being used
- Most useful when FEV1/FVC and FVC are normal
- What does this tell us?
  - Sensitive measure of small airway obstruction
  - Eliminates large airway emptying at the beginning of expiration, and fatigue at the end
  - Especially useful in pediatric asthma, and in mild obstruction
  - Not effort dependent



FEF 25-75%= Forced Expiratory FLOW from 25th to 75th % of FVC

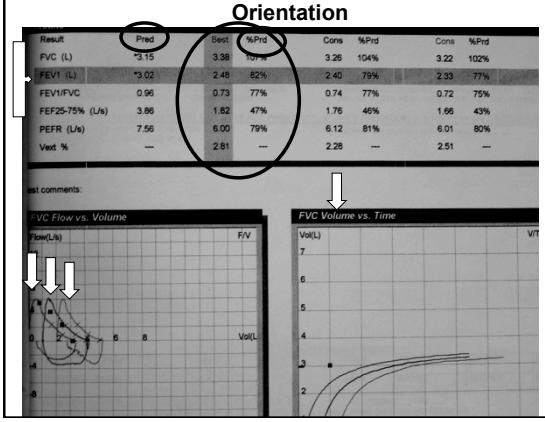


Peak Flow: The highest flow achieved at any point during the expiration

Interpreting Spirometry 3 important considerations

1. Is the test adequate?
2. Does this patient have restrictive or obstructive lung disease?
3. Is the obstruction reversible?

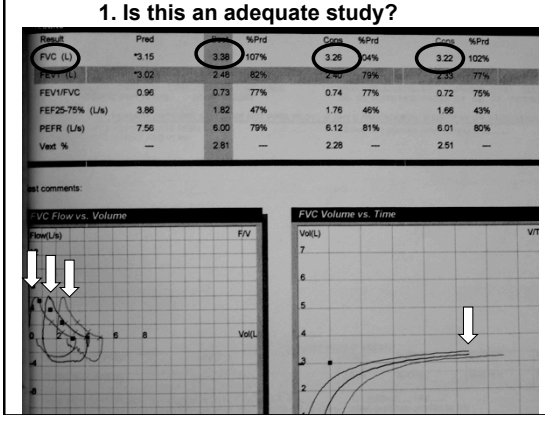
Orientation



1. Is it an adequate test?

- At least three adequate attempts
- Each expiration >6 seconds (3 sec for kids)
- Expiration should be smooth

1. Is this an adequate study?



2. Is it Obstructive or Restrictive Lung Disease?

- Abnormal spirometry may be indicative of 3 types of lung pathology
  - Obstructive
  - Restrictive
  - Mixed obstructive/restrictive
- The key is to identify a pattern suggesting one of the above pathologies

Pattern of Obstructive Lung Disease

- Hallmark: Obstruction to expiratory airway **flow**, usually from decreased airway size
- Examples:
  - ASTHMA, COPD, fixed airway obstruction (airway mass/foreign body)
- FVC: ⇔
- FEV1: ⇩
- FEV1/FVC: ⇩

Pattern of Restrictive Lung Disease

- Hallmark: Loss of lung **volume** without airway obstruction
- Examples:
  - interstitial lung disease, respiratory muscle weakness, thoracic wall deformities
- FVC: ⇩
- FEV1: ⇩
- FEV1/FVC: ⇔

Mixed Obstructive/Restrictive

- Obstruction to airflow AND reduced lung volumes
- Example: cystic fibrosis
- FVC: ⇩
- FEV1: ⇩
- FEV1/FVC: ⇩

Interpretation Based on FEV1/ FVC

- One of the **key tools** for distinguishing diseases of airway obstruction from those of small lung volumes
  - Especially important when FVC is reduced, as ratio corrects for low volumes
- In restrictive lung disease? ⇔
- In obstructive lung disease? ⇩
- In mixed restrictive/obstructive? ⇩

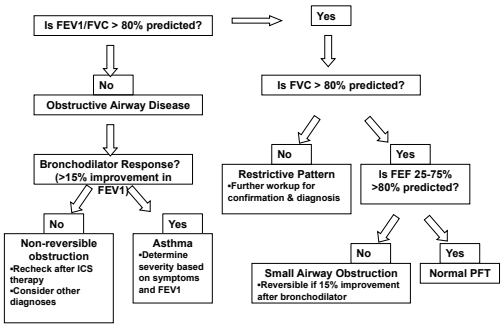
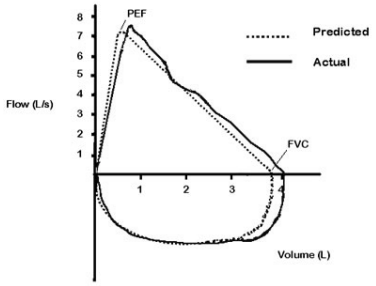
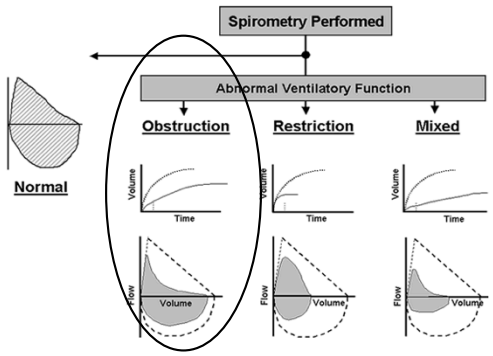


Figure 2: Algorithm for Interpreting PFT's in Asthma Patients

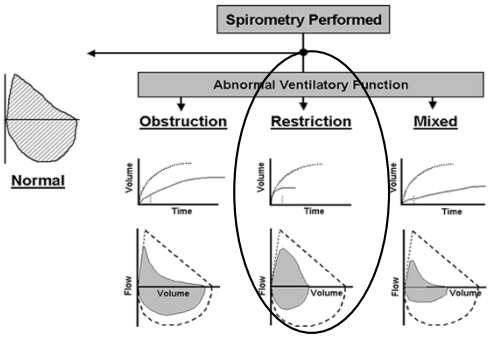
Visual Diagnosis

- A picture is worth a thousand words…

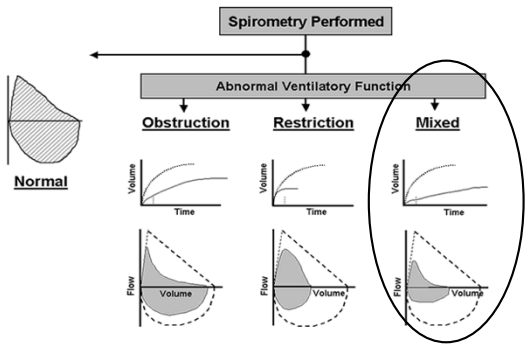




FVC normal, FEV1 reduced, FEV1/FVC reduced, FEF 25-75 also reduced



FVC reduced, FEV1 reduced, FEV1/FVC normal



FVC reduced, FEV1 reduced, FEV1/FVC reduced

3. Are the results reversible?

- Obstructive airway disease
  + reversibility = asthma

However -

- Absence of reversibility DOES NOT rule out asthma
  - Recheck after 1-3 months of inhaled corticosteroid

Bronchodilator challenge

- Perform baseline spirometry
- Administer inhaled albuterol or levalbuterol
  - Patient has not had any BD for at least 6 hours
  - (if LABA 12 hours)
  - Perform spirometry 15-20 minutes after BD
- Positive for asthma if
  - 15% increase in FEV1 OR
  - 15% increase in FEF 25-75%

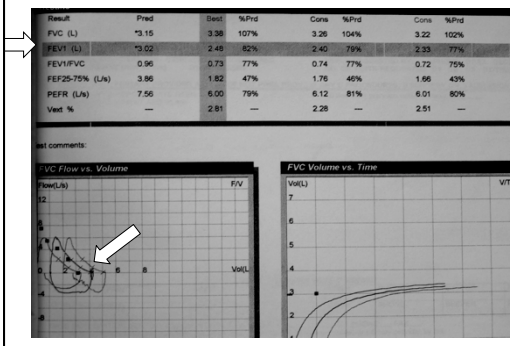
Case Studies

- Is the study adequate?
- Is there evidence of obstructive, restrictive lung disease or both?
- What is the response to bronchodilator?
- What has spirometry added to our understanding and management of the patient?

Case Study 2: DB

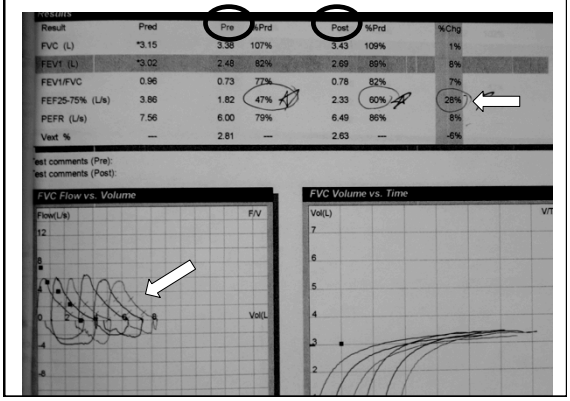
- 16 yo girl with a long history of poorly controlled asthma
- At her first visit, she reports no daytime or nighttime symptoms
- She is on no daily meds for her asthma, and reports infrequent use of albuterol

1. Is this an adequate study?



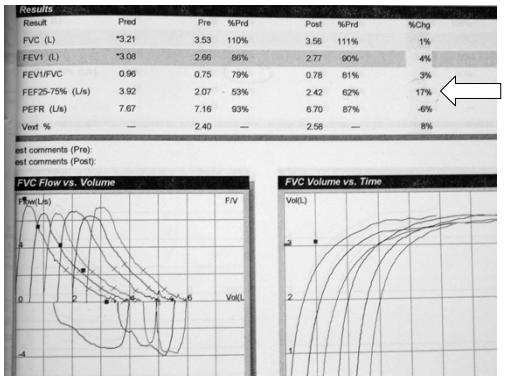
2. Does this patient have obstructive or restrictive lung disease?

3. Is it reversible?



Case Study 3: LR

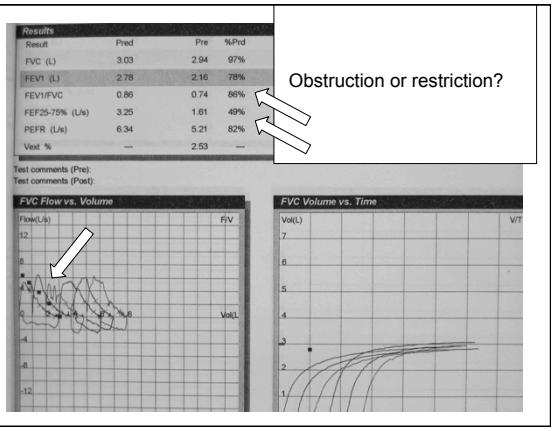
- 10 yo girl who has been on daily Qvar for a month after a severe exacerbation
- Mother wishes to stop her daily medications since she is no longer coughing at night
- You perform spirometry pre- and post-bronchodilator

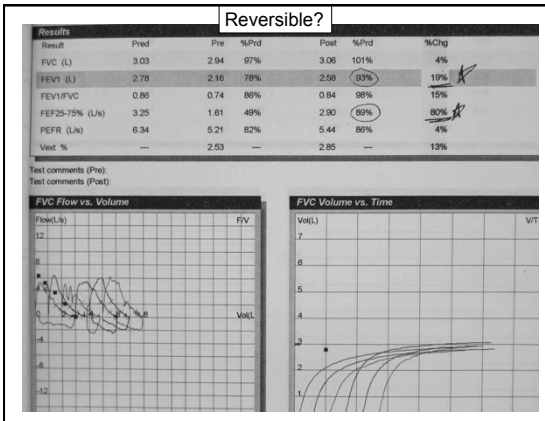


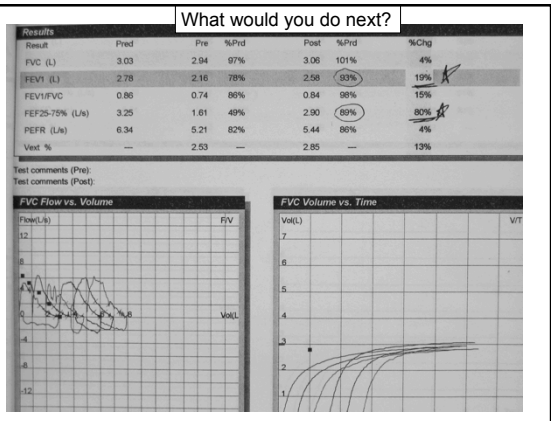
- Would you stop her daily ICS?

Case Study 4: HC

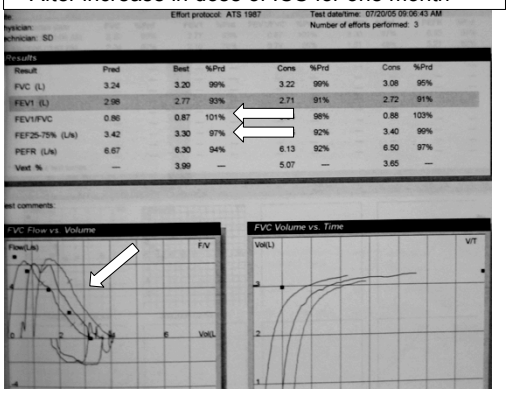
- 8 yo boy recently discharged after an admission for asthma exacerbation
- Discharged on Qvar 40, 1 puff twice daily
- Reports daily symptoms requiring use of albuterol





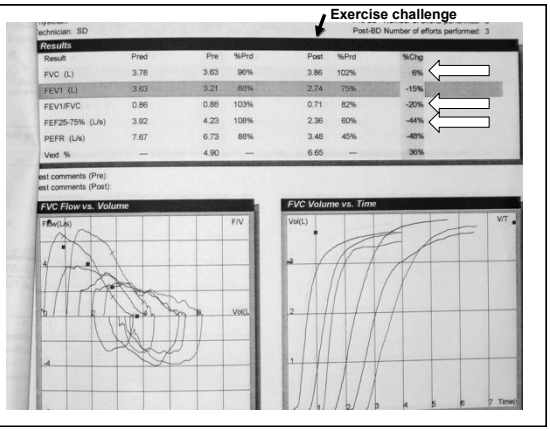


- After increase in dose of ICS for one month



Case Study 5: GV

- 16 yo girl whose symptoms of cough and shortness of breath are isolated to exercise
- She wishes to play on the soccer team, but feels that she is too "out of shape" to play
- Unclear if symptoms are due to asthma or poor conditioning



Review of Key Points

- Ensure an adequate study
- Look at FEV1/FVC ratio and FVC and to determine if obstructive or restrictive disease is present
  - FEF 25-75% useful in cases of mild obstruction
- Reversibility confirms asthma

PFT Results	Pre-tx %	Post-exercise %	% Change	Post-tx %	% Change
FVC:	82	38		104	
FEV1:	65	27		89	
FV1/FVC:	86	79		92	
FEF 25-75%:	53	21		78	

Albuterol in last 4 hours: ○ Yes ◉ No

Long-acting Bronchodilator [i.e., Advair, Serevent] in past 12 hours: ○ Yes ◉ No

Additional Notes:
post-exercise wheezing

Thank you!