MSRC AIR Course

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OBJECTIVE MEASURES

Objectives

- Explain the importance of objective measures in the management of asthma
- Explain the different types of objective measures used in the management of asthma, including spirometry, before and after bronchodilator testing, and peak flow monitoring
- Explain the methods used to ensure the reliability of objective testing

Measures of Asthma Assessment and Monitoring

- To establish a diagnosis of asthma, the clinician should determine that (EPR–2 1997):
  - Episodic symptoms of airflow obstruction or airway hyperresponsiveness are present
  - Airflow obstruction is at least partially reversible
  - Alternative diagnoses are excluded

Measures of Asthma Assessment and Monitoring

- Recommended methods to establish the diagnosis of asthma are (EPR–2 1997):
  - Medical history
  - Physical exam
  - Spirometry (5 years of age or older) to demonstrate obstruction and assess reversibility. Reversibility is determined by an increase in FEV1 after SABA inhalation
    - ≥ 12% from baseline or
    - ≥ 10% of predicted
  - Additional studies as necessary to exclude alternate diagnoses

Measures of Asthma Assessment and Monitoring

BOX 3–3. DIFFERENTIAL DIAGNOSTIC POSSIBILITIES FOR ASTHMA

Infants and Children

Upper airway diseases

- Allergic rhinitis and sinusitis

Obstructions involving large airways

- Foreign body in trachea or bronchus
- Vocal cord dysfunction
- Vascular rings or laryngeal webs
- Laryngotracheomalacia, tracheal stenosis, or bronchostenosis
- Enlarged lymph nodes or tumor

Obstructions involving small airways

- Viral bronchiolitis or obliterative bronchiolitis
- Cystic fibrosis
- Bronchopulmonary dysplasia
- Heart disease

Other causes

- Recurrent cough not due to asthma
- Aspiration from swallowing mechanism dysfunction or gastroesophageal reflux

Measures of Asthma Assessment and Monitoring

Adults

- COPD (e.g., chronic bronchitis or emphysema)
- Congestive heart failure
- Pulmonary embolism
- Mechanical obstruction of the airways (benign and malignant tumors)
- Pulmonary infiltration with eosinophilia
- Cough secondary to drugs (e.g., angiotensin-converting enzyme (ACE) inhibitors)
- Vocal cord dysfunction

Measures of Asthma Assessment and Monitoring

- Frequency of visits for review of asthma control
  - Every 6 months
    - Mild/intermittent persistent asthma
    - Under control at least 3 months
  - More often than 6 months
    - Severe persistent/uncontrolled asthma
    - Need supervision to follow asthma plan

Measures of Asthma Assessment and Monitoring

- Monitoring signs and symptoms of asthma
- Monitoring pulmonary function
  - Spirometry
  - Peak flow monitoring
- Monitoring quality of life
- Monitoring history of asthma exacerbations
- Monitoring pharmacotherapy for adherence and for potential side effects
- Monitoring patient–provider communication and patient satisfaction
- Monitoring asthma control with minimally invasive markers and pharmacogenetics (requires further evaluation)

Objective Measures

- Importance of Objective Measures
- Types of Objective Measures
- Reliability of Objective Measures

Objective Measures: Importance of Objective Measures

- Without objective measures
  - Medical history and physical examination are not reliable means of excluding other diagnoses or of characterizing the status of lung impairment
  - The degree of airflow obstruction and whether or not the obstruction is reversible are difficult to determine

Objective Measures: Importance of Objective Measures

- Pulmonary function measures often do not correlate directly with symptoms
  - One study reports that one-third of the children who had moderate-to-severe asthma were reclassified to a more severe asthma category with objective measures (Stout et al. 2006)
  - In another study, a majority of children who had mild-to-moderate asthma classified by symptoms had a normal FEV1 (Bacharier et al. 2004)

Objective Measures: Importance of Objective Measures

- The following frequencies for spirometry tests are recommended
  - At the time of initial assessment
  - After treatment is initiated and symptoms and PEF have stabilized
  - During periods of progressive or prolonged loss of asthma control
  - At least every 1–2 years

Objective Measures: Types of Objective Measures

- Spirometric Measures
- Pre- And Post-bronchodilator Testing
- Peak Flow Monitoring

Spirometry

Spirometric Measures: Purpose

- Spirometry helps determine whether there is airflow obstruction and, if present, determines its severity
- Patients' perception of airflow obstruction is highly variable, and spirometry sometimes reveals obstruction much more severe than would have been estimated from the history and physical examination
- For diagnostic purposes, spirometry is generally recommended over measurements by a peak flow meter in the clinician's office because there is wide variability even in the published predicted peak expiratory flow (PEF) reference values

Spirometric Measures: Technique

- Arrival in lab
  - Explain purpose of test
  - Determine indications and possible contraindications
  - Obtain height and weight
    - Arm span
  - Record medications
  - Record smoking history

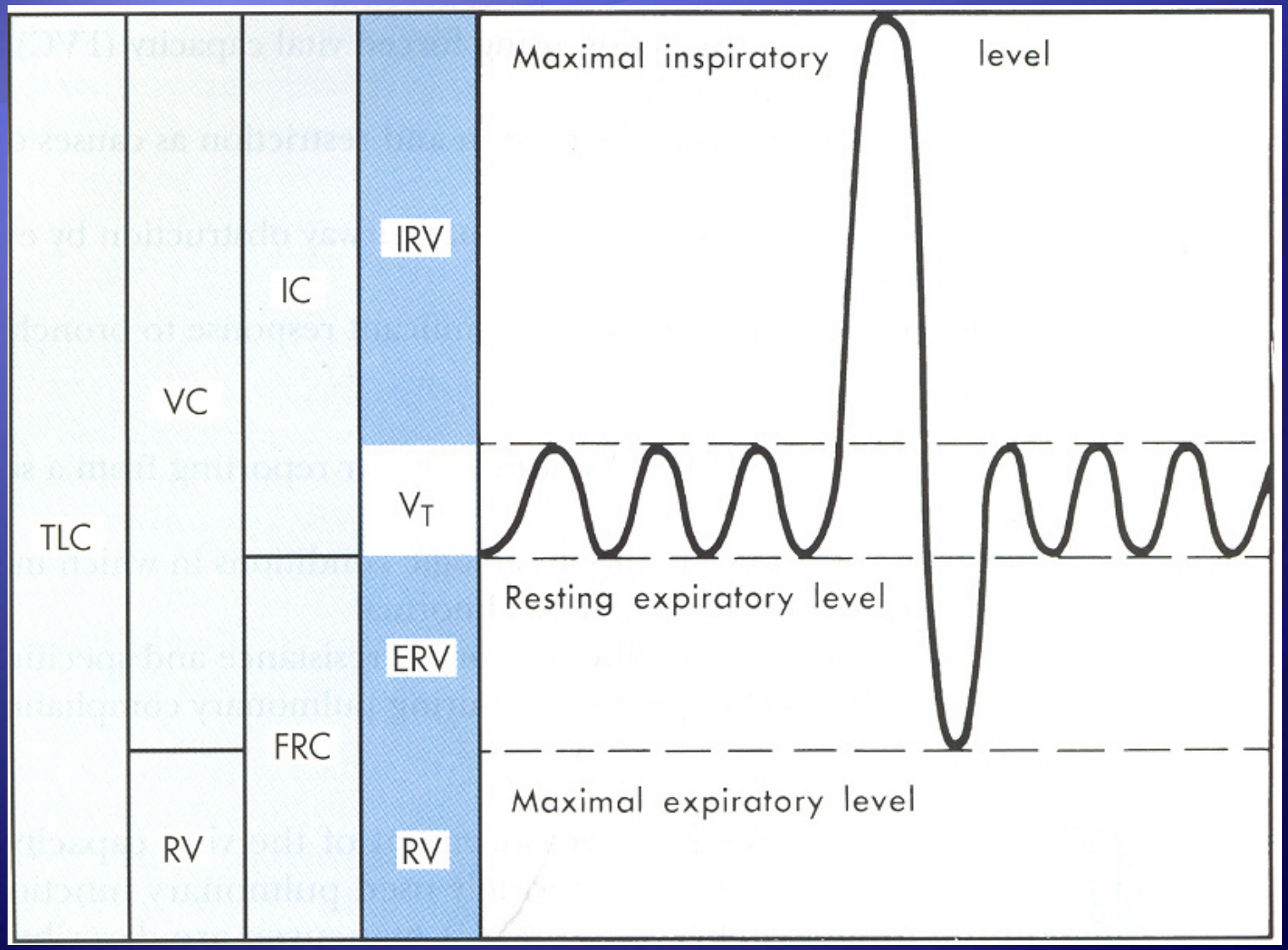
Spirometric Measures: Technique

- Explain the procedure
  - Mouthpiece position, dentures, nose clips
- Demonstrate the procedure with attention to patient posture during test performance
  - Head and neck position
  - Bending
  - Sitting or standing

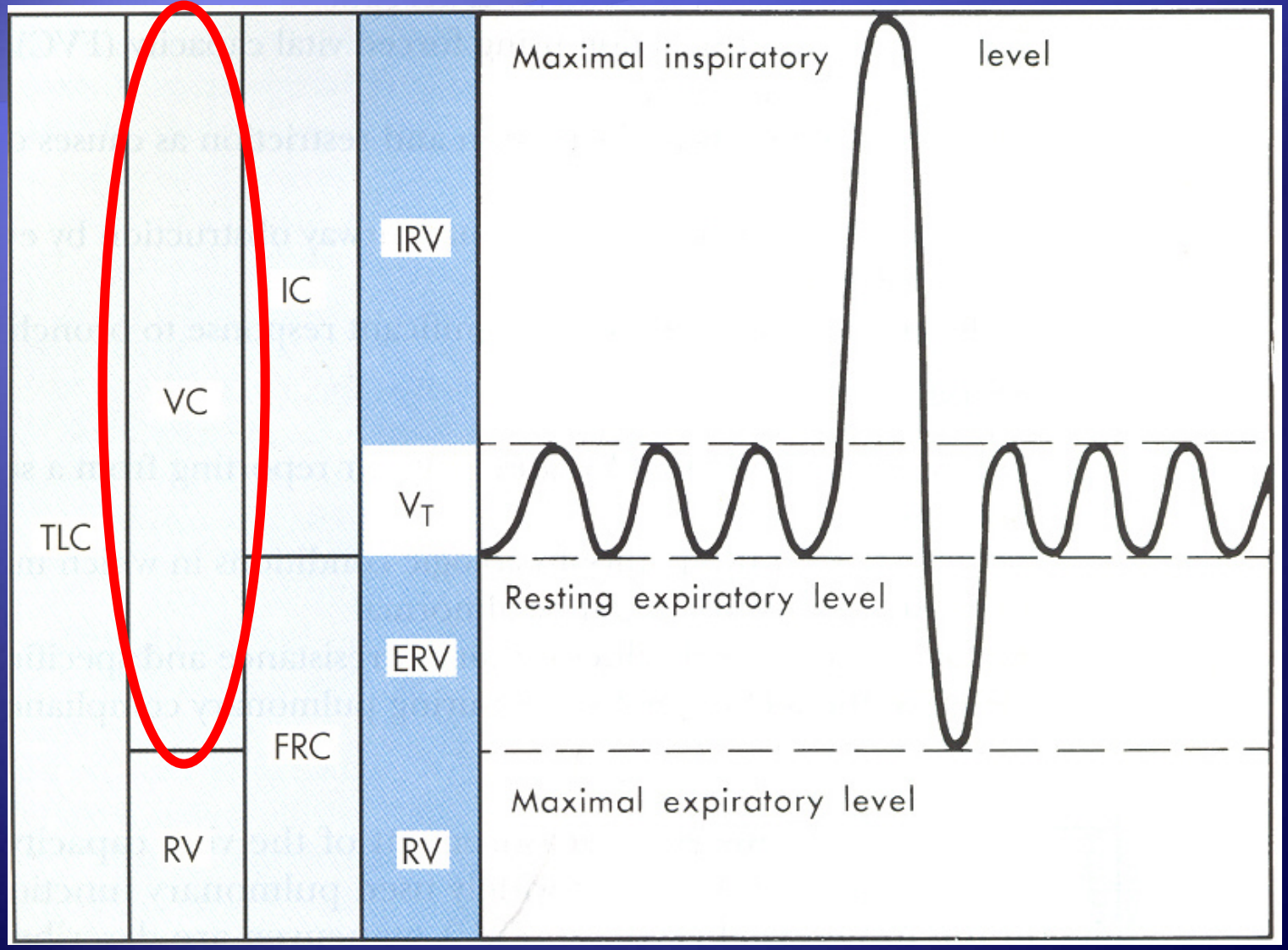
Spirometric Measures:

- **FVC** – Forced Vital Capacity
- **FEV1** – Forced Exhaled Volume in first second of a FVC maneuver
- **FEV_6** - Forced Exhaled Volume in first six seconds of a FVC maneuver
- **FEV1/FVC** – calculated as a % of total volume exhaled

Lung Volumes & Capacities



Focus on Spirometry - FVC



Spirometric Measures: FVC

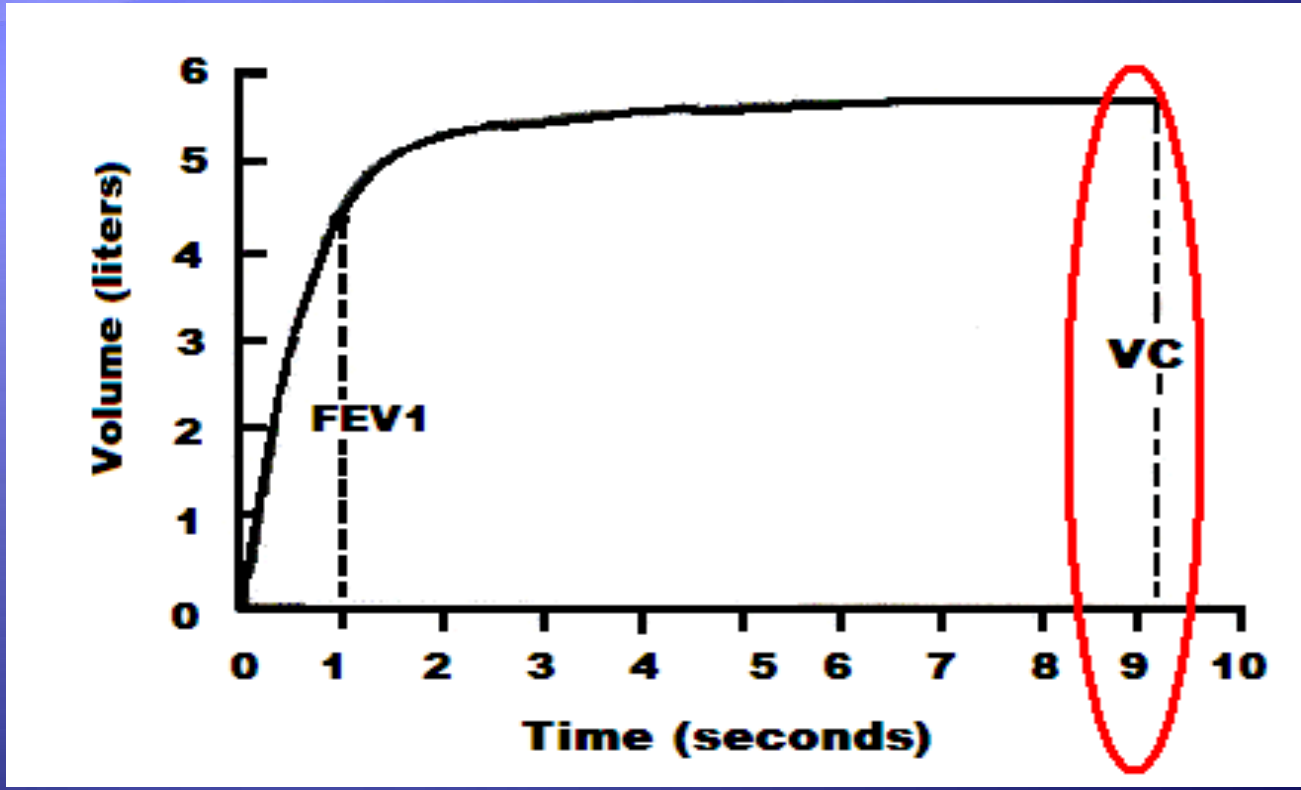
- Defined
  - The maximal volume of air forcefully exhaled from the point of maximal inhalation
- General normal value for adults
  - 4800 mL
- Use in asthma
  - To express the FEV_1 as a % of total exhaled volume

Spirometric Measures: FEV_1

- Defined
  - The volume of air exhaled in the first second of the FVC maneuver
- General normal value for adults
  - 4200 mL
- Use in asthma
  - An accurate means for determining the presence of airway obstruction

Volume -Time Curve

Volume (L)



Time (seconds)

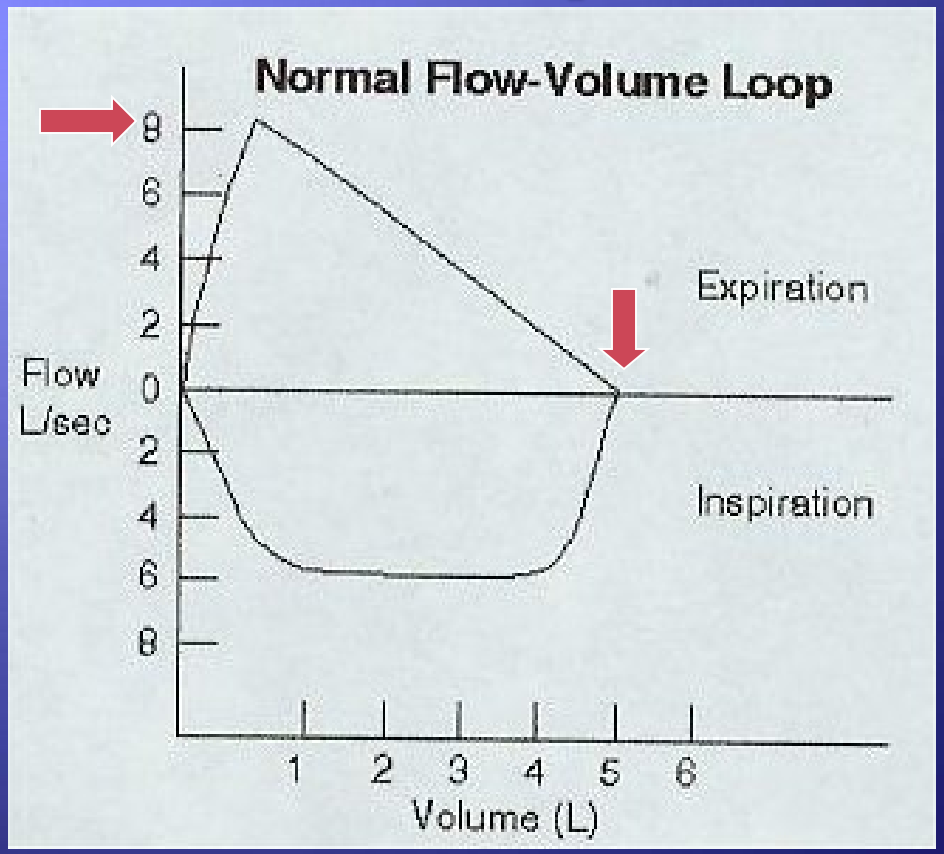
Spirometric Measures: FEV_6

- In Section 3, Component 1: Measures of Asthma Assessment and Monitoring 44 August 28, 2007, FEV6 has been shown to be equivalent to FVC for identifying obstructive and restrictive patterns, using the American Thoracic Society (ATS) algorithm, and to be more reproducible and less physically demanding than FVC (Swanney et al. 2004).

Spirometric Measures: FEV_1/FVC

- Defined
  - An expression of FEV_1 as a % of total volume exhaled
- General normal value for adults
  - >70%
- Use in asthma
  - An accurate means for determining the presence of airway obstruction

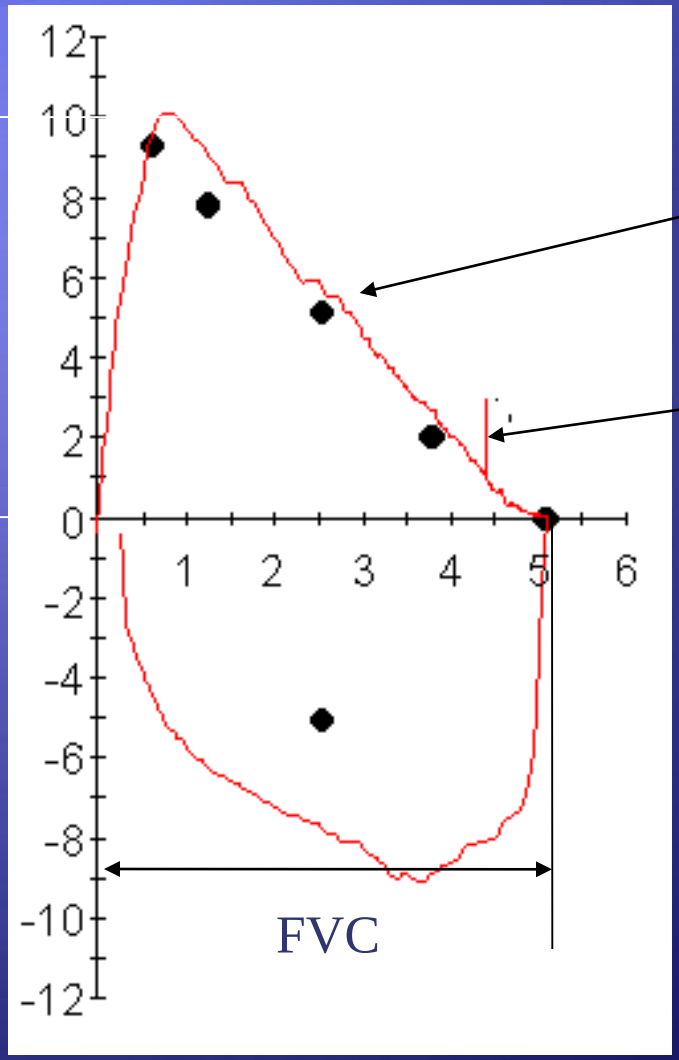
Spirometric Measures: Flow-Volume Loop



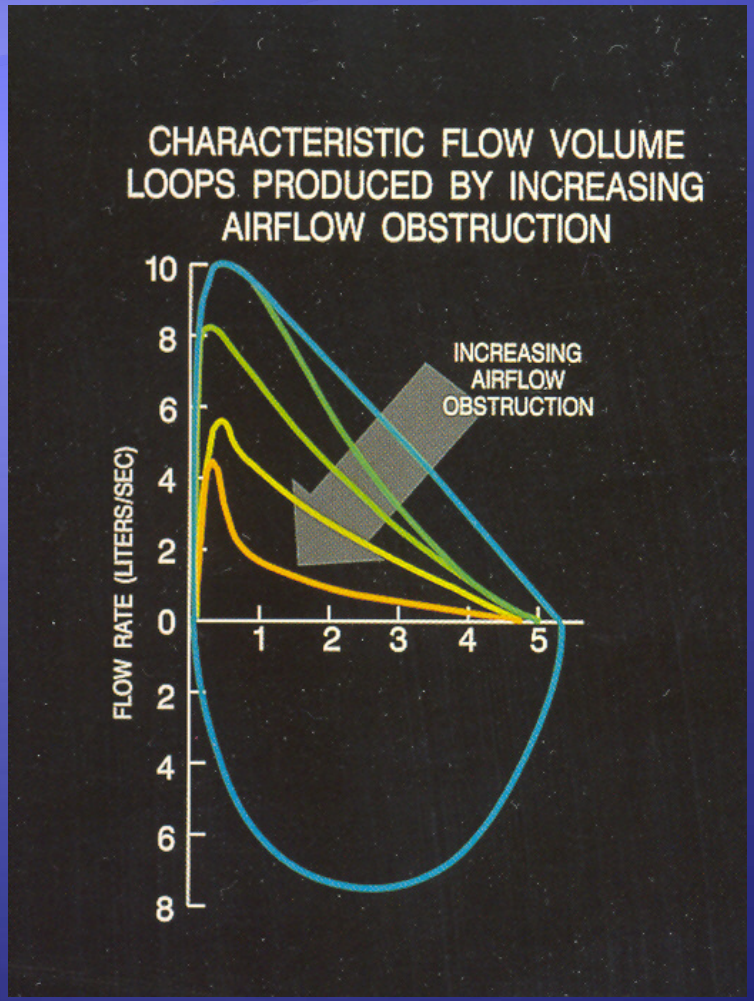
Spirometric Measures: Flow-Volume Loop

- Defined
  - A graphic loop created by exhalation and inhalation, recording both flow and volume
  - Can generate values for PEFR, FEV_1, and FEV_1 /FVC
- Primary use in asthma
  - The shape of the loop indicates the presence of airway obstruction

Flow-Volume Loop: Normal

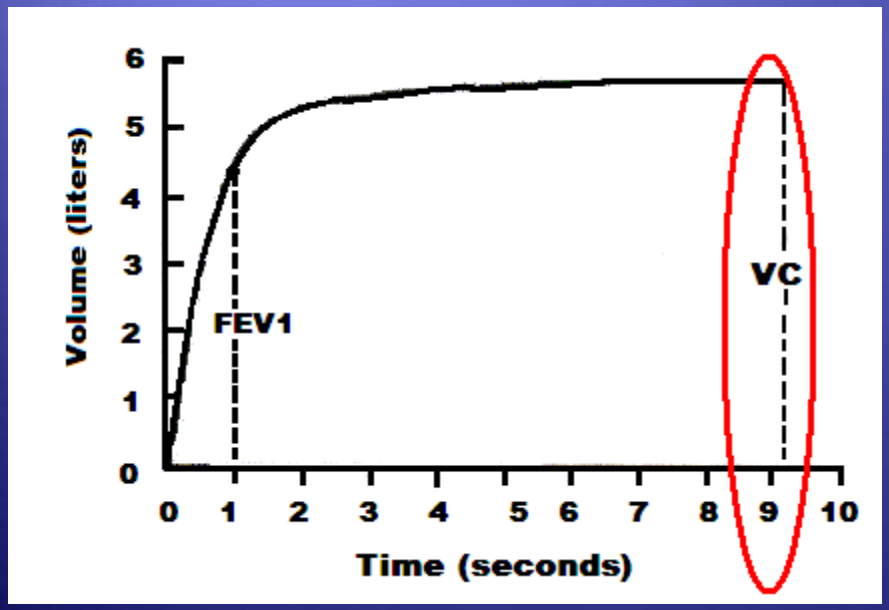


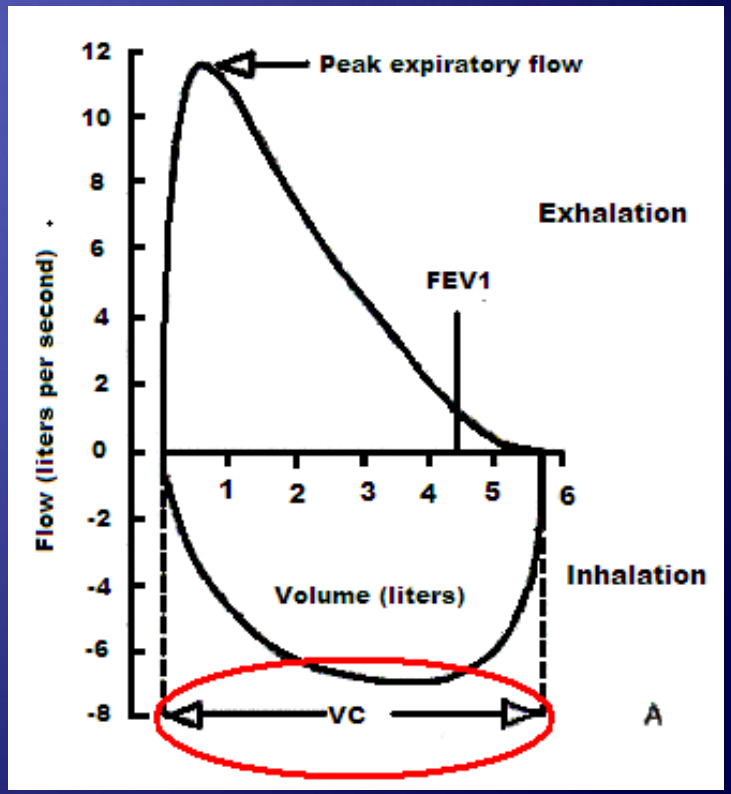
Flow Volume Loop



Spirometry Measurements
FVC - Forced Vital Capacity

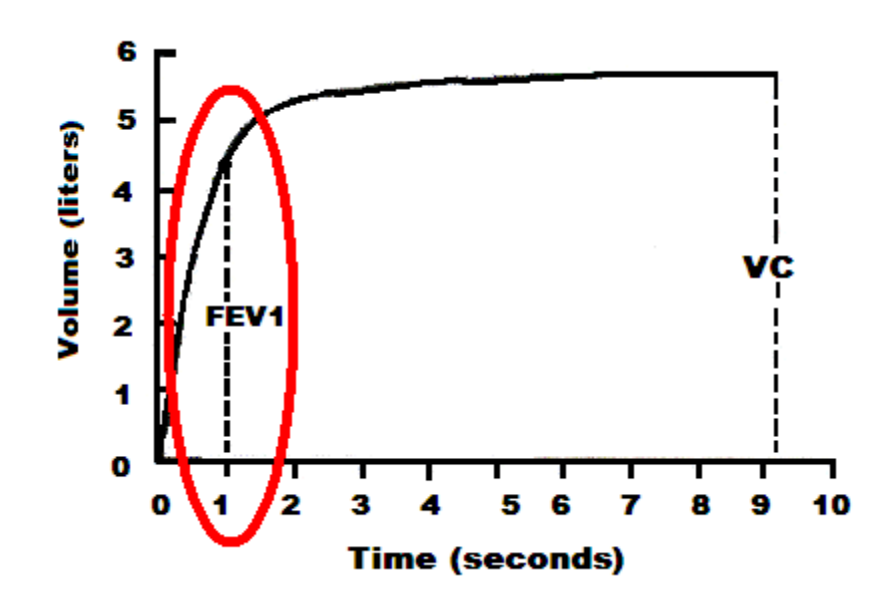
- Maximal volume of air forcibly exhaled from the point of maximal inhalation

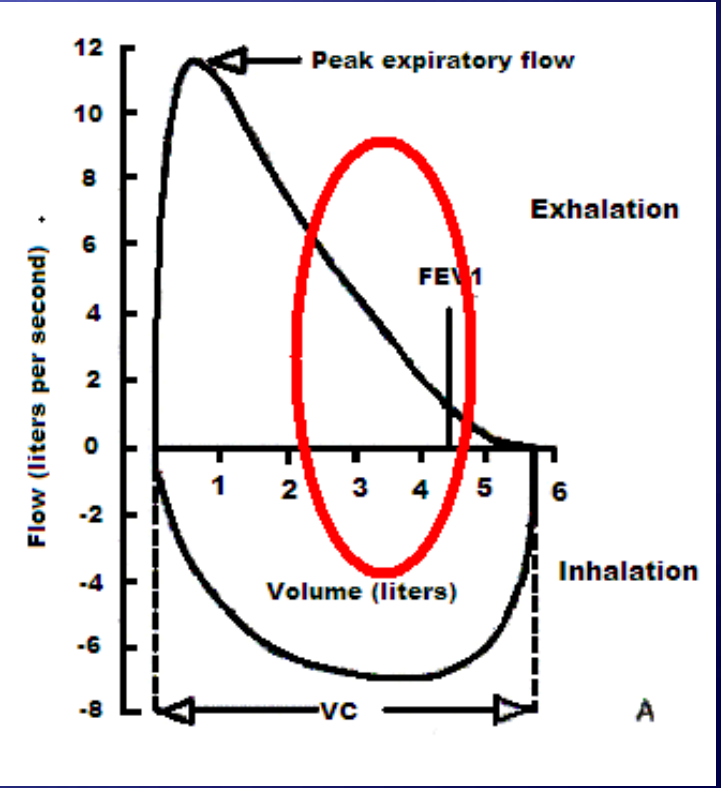




Spirometry Measurements
FEV_1

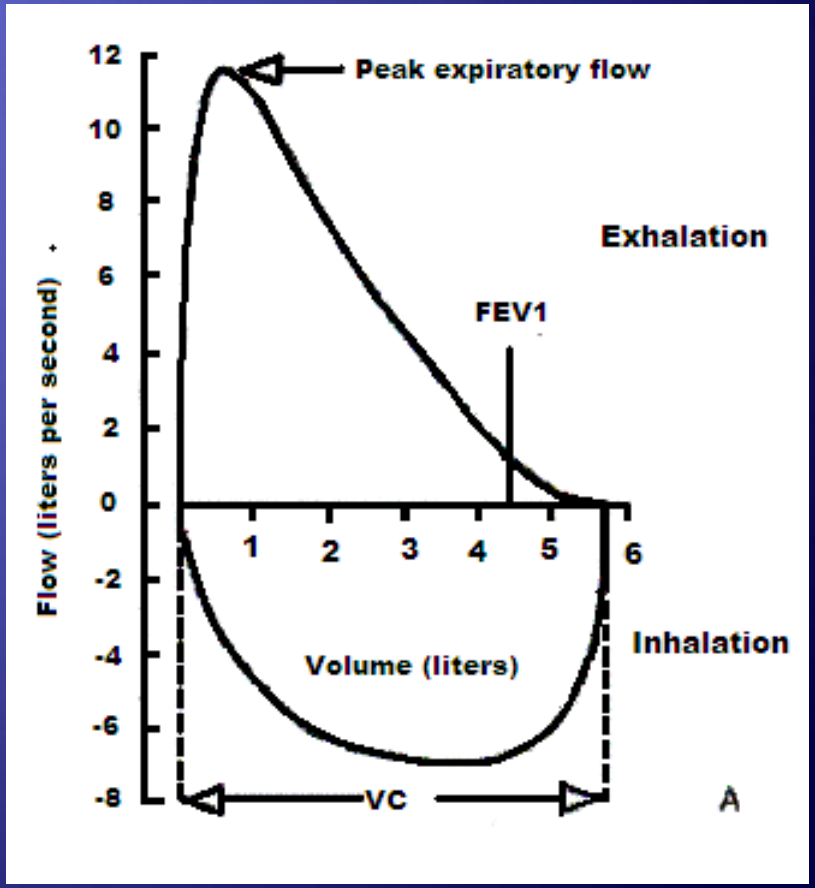
- Forced Expiratory Volume in first second
- Maximal volume of air exhaled in the first second





Spirometry Measurements
FEV1 / FVC

- FEV1 divided by FVC
- 4.50 / 5.50 = 82%



Spirometric Measures: Results

- Airflow obstruction is indicated by a reduction in the values for both the FEV1 and the FEV1/FVC (or FEV1/ FEV6) relative to reference or predicted values.
- Predicted values for FEV1/FVC are based on National Health and Nutrition Examination Survey (NHANES) data, National Center for Health Statistics, Centers for Disease Control and Prevention (CDC).

Pre- and Post-Bronchodilator Testing

Pre- and Post-Bronchodilator Testing: Purpose

- To establish a diagnosis of asthma, the clinician should determine that (EPR–2 1997):
  - Episodic symptoms of airflow obstruction or airway hyperresponsiveness are present
  - Airflow obstruction is at least partially reversible
  - Alternative diagnoses are excluded

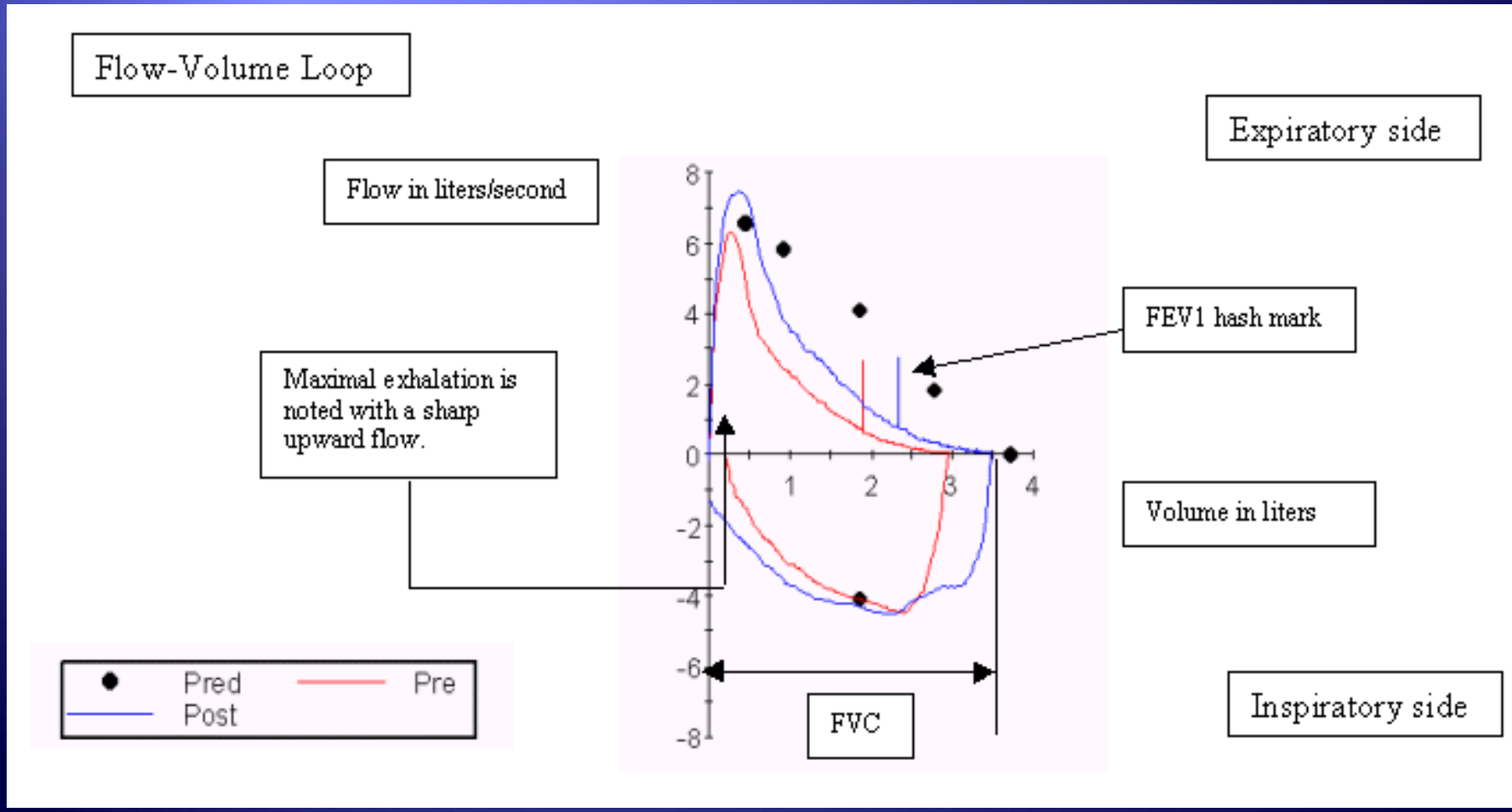
Pre- and Post-Bronchodilator Testing: Technique

- Spirometry is performed before and after a bronchodilator treatment (e.g. albuterol, 2–4 puffs of 90 mcg/puff)
- Significant reversibility is indicated by ATS standards as an increase in FEV1 of >200 mL and ≥12 percent from the baseline measure
- Some studies indicate that an increase ≥10 percent of the predicted FEV1 after inhalation of a short-acting bronchodilator may be less subject to bias than measuring percent change from baseline and may have a higher likelihood of separating patients who have asthma from those who have chronic obstructive pulmonary disease (COPD)

Pre- and Post-Bronchodilator Testing: Technique

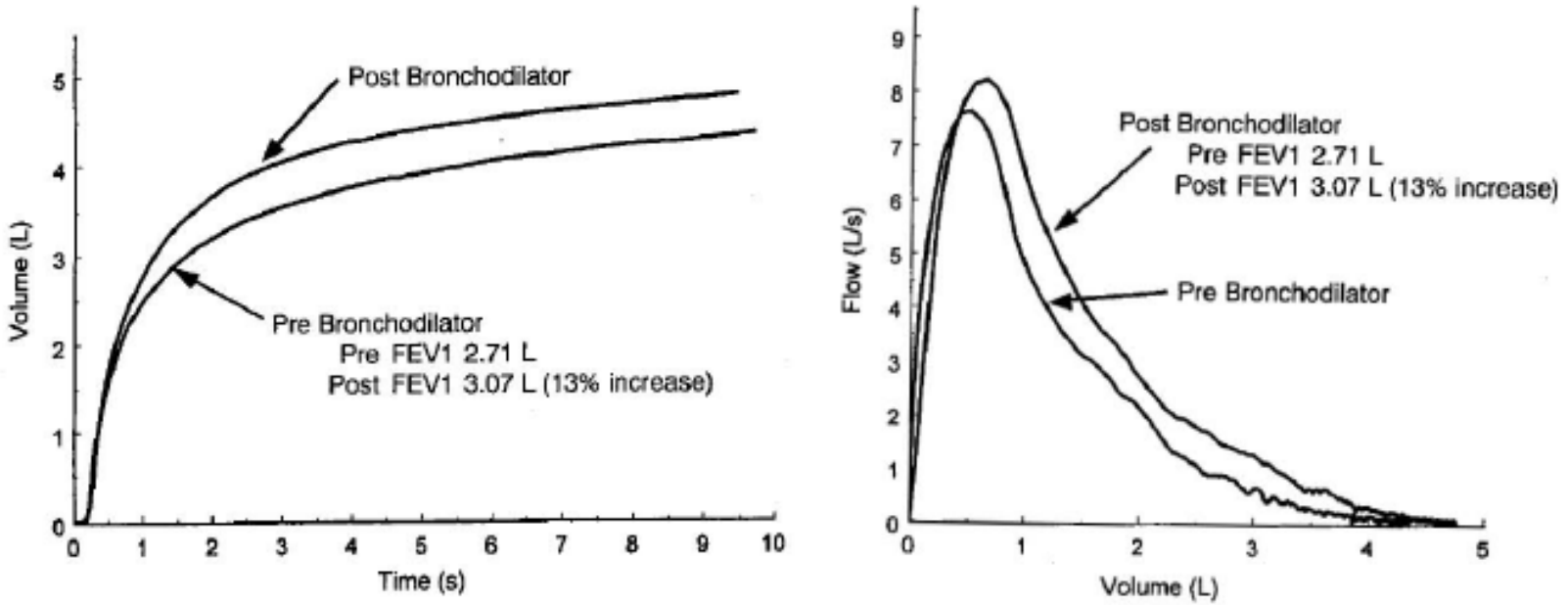
- Some patients who have signs and symptoms of asthma may not demonstrate reversibility until after a 2- to 3-week trial of oral corticosteroid therapy is administered to help improve their asthma control.
- Furthermore, the spirometry measured after a single treatment with SABA or after a short course of oral systemic corticosteroid treatment plus acute administration of a bronchodilator may not indicate the patient's best achievable lung function; thus, follow-up spirometry measures are indicated as asthma control improves.

Flow-Volume Loop: Obstruction



Pre- And Post-Bronchodilator Testing: Results

FIGURE 3–3a. SAMPLE SPIROMETRY VOLUME TIME AND FLOW VOLUME CURVES



Key: FEV_1, forced expiratory volume in 1 second

Pre- And Post-Bronchodilator Testing: Results

FIGURE 3–3b. REPORT OF SPIROMETRY FINDINGS PRE- AND POSTBRONCHODILATOR

Prebronchodilator

Study: bronch	ID:	Test date: 8/7/06	Time: 9:38 a.m.
Age: 59	Height: 175 cm	Sex: M	System: 7 20 17

Trial	FVC	FEV_1	FEV_1/FVC (%)
1	4.34	2.68	61.8%
2	4.44	2.62	58.9%
3	4.55	2.71	59.6%
Best Values	4.56	2.71	59.4%
Predicted Values*	4.23	3.40	80.5%
Percent Predicted	107.8%	79.7%	73.8%

Interpretations:

FEV_1 and FEV_1/FVC are below normal range. The reduced rate at which air is exhaled indicates obstruction to airflow.

*Predicted values from Knudson et al. (1983)

Postbronchodilator

Study: bronch	ID:	Test date: 8/7/06	Time: 9:58 a.m.
Age: 59	Height: 175 cm	Sex: M	System: 7 20 17

Trial	FVC	FEV_1	FEV_1/FVC (%)
1	4.73	2.94	62.2%
2	4.76	3.07	64.5%
3	4.78	3.04	63.5%
Best Values	4.78	3.07	64.3%
Reference Values	4.56	2.71	
Difference (L)	0.22	0.36	
Difference (%)	4.8%	13.4%	

Interpretations:

Significant increases in FEV_1, with bronchodilator (≥12% increase after bronchodilator indicates a significant change).

Key: FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity

Pre- And Post-Bronchodilator Testing: Results

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Best Values	4.56	2.71	59.4%
Predicted Values*	4.23	[illegible]	80.5%
Percent Predicted	107.8%	79.7%	73.8%

Interpretations:
FEV_1 and FEV_1/FVC are below normal range. The reduced rate at which air is exhaled indicates obstruction to airflow.
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Key: FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity

Using FEV1 to Determine Significant Reversibility

- Post 3.07 L = 3070 ml Pre 2.71 L = 2710 ml
- 3070ml – 2710 ml = 360 ml difference

- 3.07 divided by 2.71 = 1.13
- 13% difference

- Does this meet ATS standards for significant reversibilty?

Objective Measures: Reliability of Objective Measures

- Acceptability Criteria
  - Did the subject understand the instructions?
  - Was inspiration performed with maximum effort?
  - Was exhalation smooth and continuous?
  - Was effort maximal on expiration?
  - Are there at least 3 acceptable maneuvers?

Objective Measures: Reliability of Objective Measures

- Acceptable criteria include:
  - Good start of test
    - **No hesitation or false starts**
    - **A rapid start to rise time**
  - No coughing during procedure
  - No early termination
    - **Minimum exhalation time of 6 secs**
    - **Or, no volume change for at least 1 sec**

Objective Measures: Reliability of Objective Measures

- Test result reproducibility
  - Is the variance less than 5% or 200 ml between the largest and second largest FVC
  - Is the variance less than 5% or 200 ml between the largest and second largest FEV_1
  - Is there documentation for lack of reproducibility

Objective Measures: Reliability of Objective Measures

- Criteria for selection of reference authors:
  - Studies should be done with equipment that meets or exceeds ATS criteria
  - Data obtained by trained operators with performance standards that meet ATS criteria

Objective Measures: Reliability of Objective Measures

- Criteria for selection of reference authors:
  - Reference population should match the population to be tested with respect to age, gender, height, and ethnic composition
  - Reference population should be comparable with respect to methods and instruments used in the laboratory

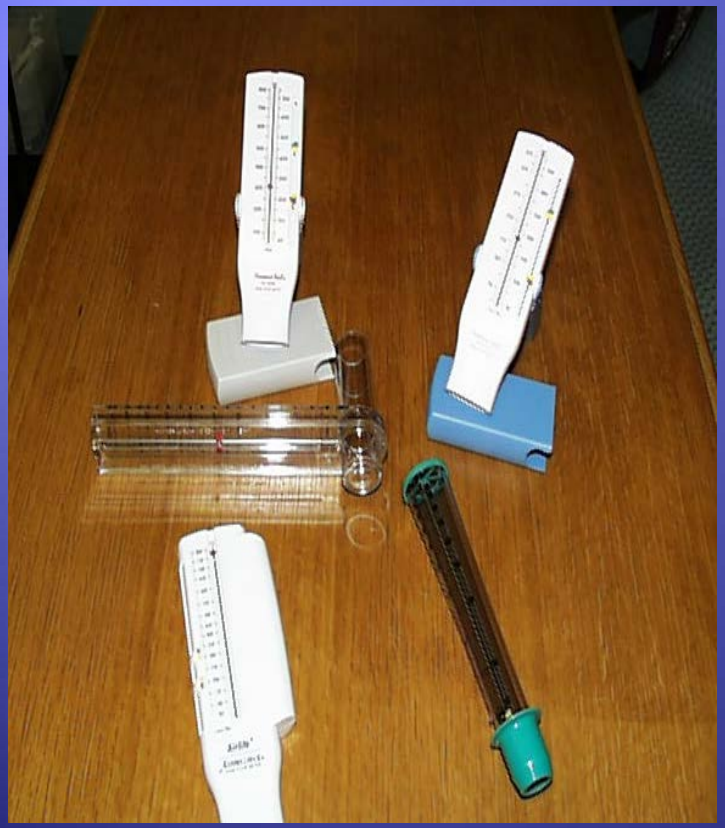
Objective Measures: Reliability of Objective Measures

- Use caution used when extrapolating for ages or heights not covered in the data generated by the reference set
- The ethnic origin of the population to be tested should be considered
  - For African-Americans, the actual values for TLC, FEV_1, FVC may be 12% lower than the rest of the population and the actual values for FRC and RV may be 7% lower

Objective Measures: Reliability of Objective Measures

- Begin the interpretation with a statement about test quality
- Consider the clinical question asked of the tests
- Be conservative when suggesting a diagnosis based on pulmonary function tests

Peak Flow Monitoring



Various Peak Flow Meters

Peak Flow Monitoring: Purpose

- "Polaroid" view of lungs
- Quick, portable, cheap, easy to use
- Extremely useful for monitoring at home

Peak Flow Monitoring

Device limitations

- Different brands of PEFM can give varying values.
  - Do not compare values from different PEFM
    - When patients replace their peak flow meter, have them reestablish their personal best PEF with the new meter, regardless of whether the replacement meter is the same brand as the original.

Peak Flow Monitoring: Purpose

- Defined
  - The maximum flow generate on exhalation; generally occurs toward the beginning of exhalation
- General normal value for adults
  - 600 LPM (10 Lps)
- Primary use in asthma
  - A rough means for determining the presence of airway obstruction

Peak Flow Monitoring: Purpose

- The relative usefulness of peak flow measurements as monitoring tools can be individualized, based on
  - the patient's age (decreased utility in preschool children and the elderly)
  - socioeconomic status (minority and poor children show greatest benefit)
  - asthma pattern (of questionable utility to monitor individuals who have histories of rapid onset of severe airflow obstruction)
  - asthma severity
  - ability to perceive signs and symptoms of early worsening of asthma
  - the clinician's and patient's opinions as to their contribution in achieving and maintaining acceptable asthma control

Peak Flow Monitoring: Purpose

- *It must be stressed that peak flow meters function best as tools for ongoing* ***monitoring,*** *not* ***diagnosis****.*

Peak Flow Monitoring: Technique

Inspect peak flow meter and slide the indicator tab to zero.

Peak Flow Monitoring: Technique

Stand tall and hold the peak flow meter level.

Peak Flow Monitoring: Technique

Inhale deeply.

Peak Flow Monitoring: Technique

Exhale forcefully!

(fast blast!)

Peak Flow Monitoring: Technique

Read the results and repeat the procedure 2 more times.

Peak Flow Monitoring: Technique

- Watch for erroneously high or low readings.
- Record the highest of the three readings
  - **Do not** average the results.
- The procedure should be done at the same time each day
  - Diurnal variation

Peak Flow Monitoring: Technique

- Because the measurement of PEF is dependent on effort and technique, patients need instructions, demonstrations, and frequent reviews of technique.

Peak Flow Monitoring: Results

Personal Best

- Estimated after two to three weeks daily PEF measurements, after maximal therapy has stabilized the patient.
- Usually achieved in early afternoon.
  - Once Personal Best is determined the patient should monitor PEF in the morning prior to asthma meds for AAP ZONE monitoring (Green, Yellow and Red Zones).
- Children should determine personal best every six months to establish changes due to growth.

Peak Flow Monitoring: Results

- Consider long-term daily peak flow monitoring for:
  - Patients who have moderate or severe persistent asthma
  - Patients who have a history of severe exacerbations
  - Patients who poorly perceive airflow obstruction and worsening asthma
  - Patients who prefer this monitoring method

Peak Flow Monitoring: Results

- Long-term daily peak flow monitoring can be helpful to
  - Detect early changes in disease states that require treatment
  - Evaluate responses to changes in therapy
  - Afford a quantitative measure of impairment

Peak Flow Monitoring: Results

- Consider home peak flow monitoring during exacerbations of asthma for:
  - Patients who have a history of severe exacerbations
  - Patients who have moderate or severe persistent asthma
  - Patients who have difficulty perceiving signs of worsening asthma

Peak Flow Monitoring: Results

- *Peak Flow Versus Symptom-Based Monitoring Action Plan*
  - Either peak flow monitoring or symptom monitoring, if taught and followed correctly, may be equally effective
  - Either peak flow or symptom self-monitoring appears to increase patients' awareness of the disease status and control, thereby helping patients "tune in" to their disease; and action plans enhance clinician–patient communication
  - Thus, the nature of the plan, whether it is based on symptoms or based on peak flow, is not the important issue; rather, it is having a plan in place versus not having one at all

QUESTIONS