AMERICAN LUNG ASSOCIATION®

SPIROMETRY

Carol Martin, BS, RPFT, AE-C, CHES
Division Director, Health Promotions, Western
American Lung Association in Texas
January 12, 2019

Commercial Interest Disclosure

Carol Martin, BS, RPFT, AE-C, CHES

I have no relevant financial relationships with the manufacturers(s) of any commercial products(s) and/or provider of commercial services discussed in this CME activity.

I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.

CME Learning Objective

1. Develop deeper understanding of the CQN Texas asthma quality improvement data to focus your practice's improvement efforts
2. Discuss the importance of spirometry in the diagnosis/treatment of asthma in primary care settings
3. Discuss asthma education and demonstrate common asthma equipment and devices
4. Increase awareness of the need to review the use of written instructional materials regarding health literacy.
5. Demonstrate techniques (e.g. Teach-Back) to ensure patient and parent/caregiver understanding of treatment goals
6. Review, refine and sustain your practice's standards of care to support patients with asthma and their parents/caregivers
7. Develop actions and timelines to ensure all project activities are completed by end of project

Learning Objective:

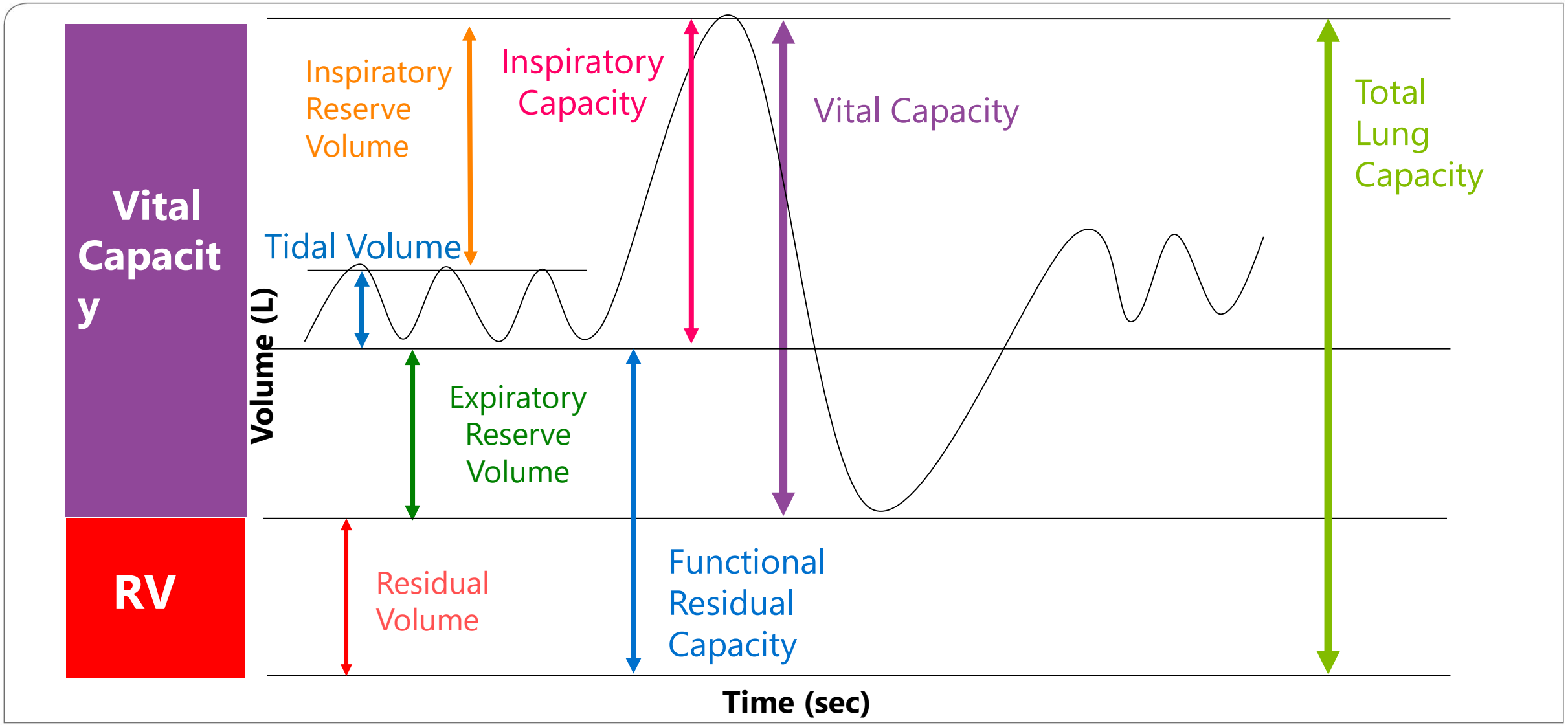
Understand key components of Spirometry and its role in asthma diagnosis and management

This session will cover:

- Lung volumes, capacities, and flow rates measured by spirometry
- Flow-Volume loops & Volume-Time curves
- Calculating percent predicted & change in FEV_1
- ATS/ERS Acceptability and Repeatability criteria
- Basic interpretation of obstructive and restrictive lung disease

DEMONSTRATION OF SPIROMETRY

Lung Volumes and Capacities

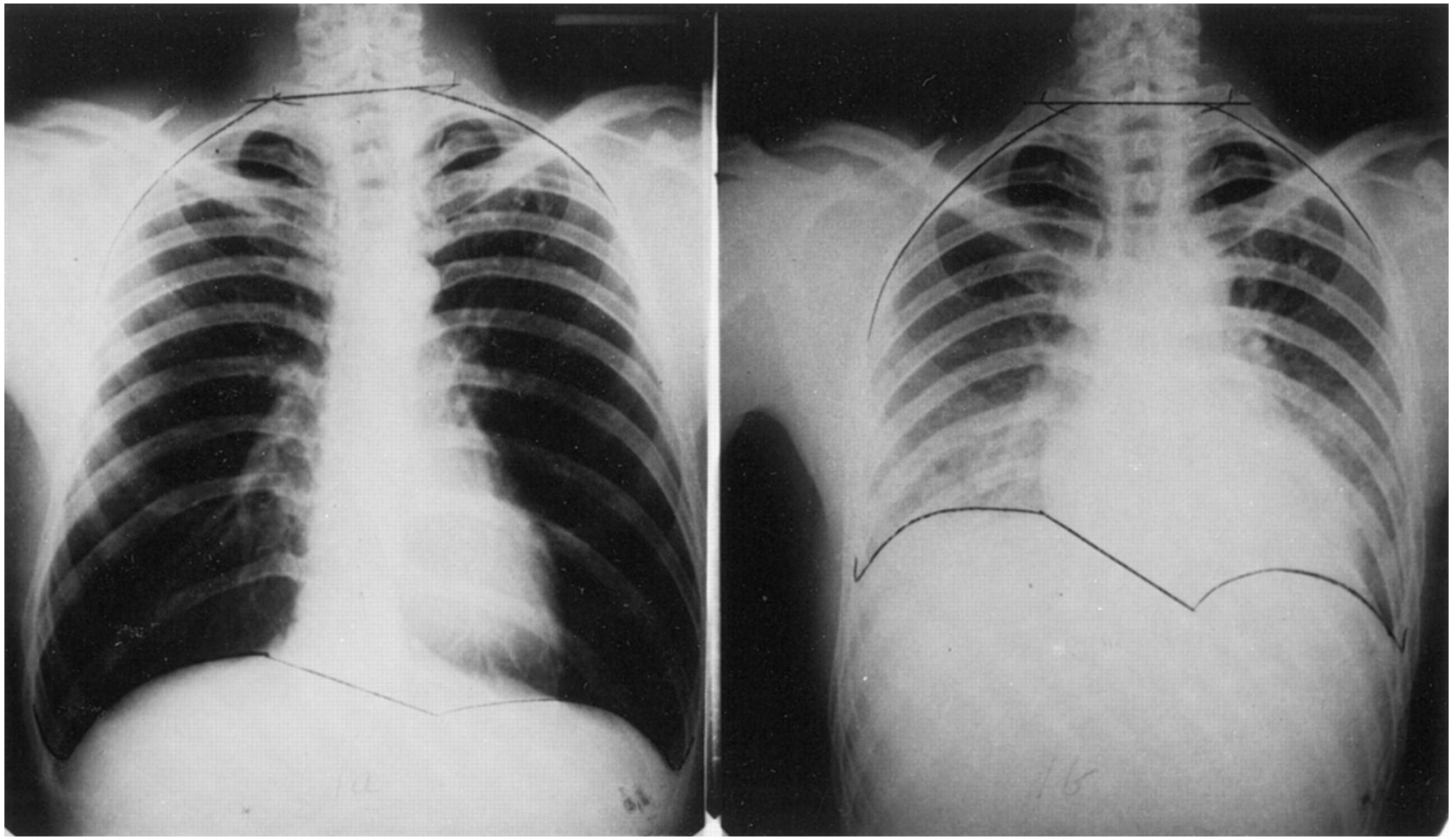


AMERICAN LUNG ASSOCIATION®

Mueller GA, et al. *Pediatr Clin North Am*. 1992;39:1243-1248.

What Goes on During a Spirometry Test?

Following a forced expiration, the lungs empty down to the residual volume, leaving a small amount of air in the upper portions of the lung.



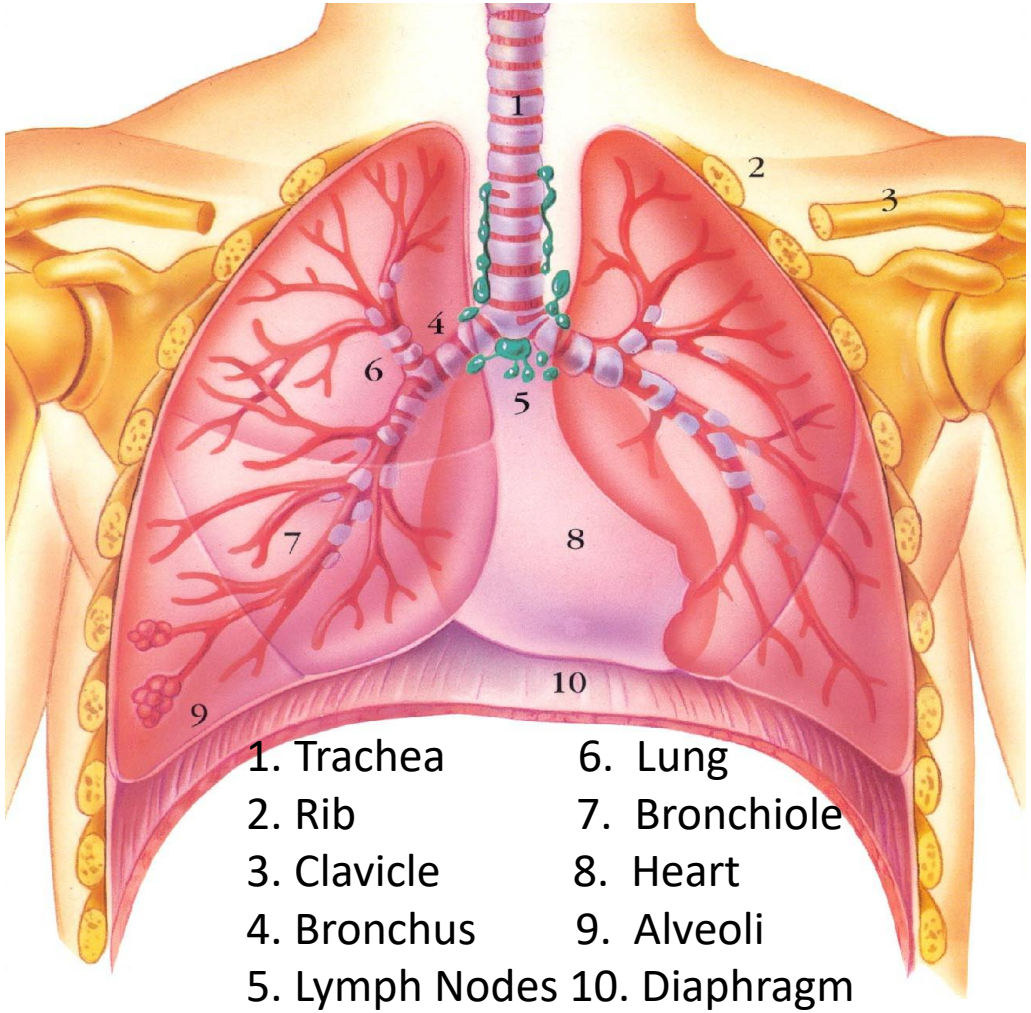
AMERICAN LUNG ASSOCIATION®

Petty T L Chest 2002;121:219S-223S

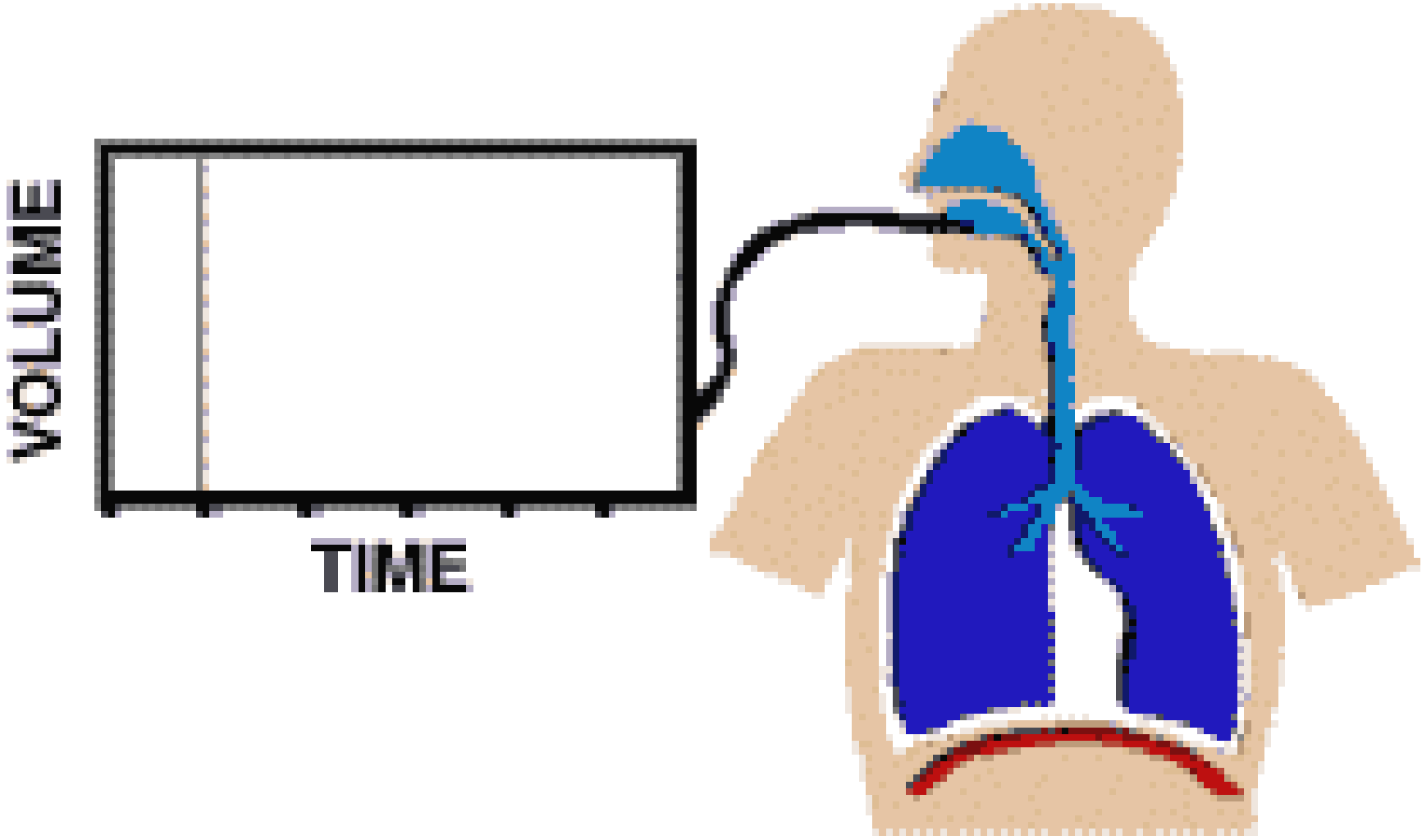
“Spirometry is a Simple Expression of a Complex Process”

Dr. Thomas Petty

- Airways
- Parenchyma
- Chest Wall
- Respiratory Muscle
- Anatomical Abnormalities
- Diaphragm dysfunction
- Body Mass Index (BMI)



Spirometry



Spirometry Components

- **Forced Vital Capacity** (FVC)
  - The maximal volume of air forcibly exhaled from the point of maximal inhalation
- **Forced Expiratory Volume in 1 second** (FEV_1)
  - The volume of air exhaled during the first second of the FVC
- **Ratio of FEV_1 to FVC** (FEV_1/FVC)
  - Expressed as a percentage
- **Peak Expiratory Flow** (PEF)
  - Maximum air flow (rate) during forced exhalation

What Does Spirometry Measure ?

- How Fast
  - Decreased flow rates = **Obstructive disease**
  - ATS -- FEV_1/FVC (ratio) below LLN = Obstruction
  - Rule of thumb
    - FEV_1/FVC --- down "10" or more from **predicted indicates obstruction**
- How Much
  - Flow Rates (FEV_1, FEV_1/FVC)
  - FVC = Forced Vital Capacity
  - Decreased Vital Capacity = **Possible Restrictive Disease**
- The predicted values depend on the individual's age, gender, height and race.

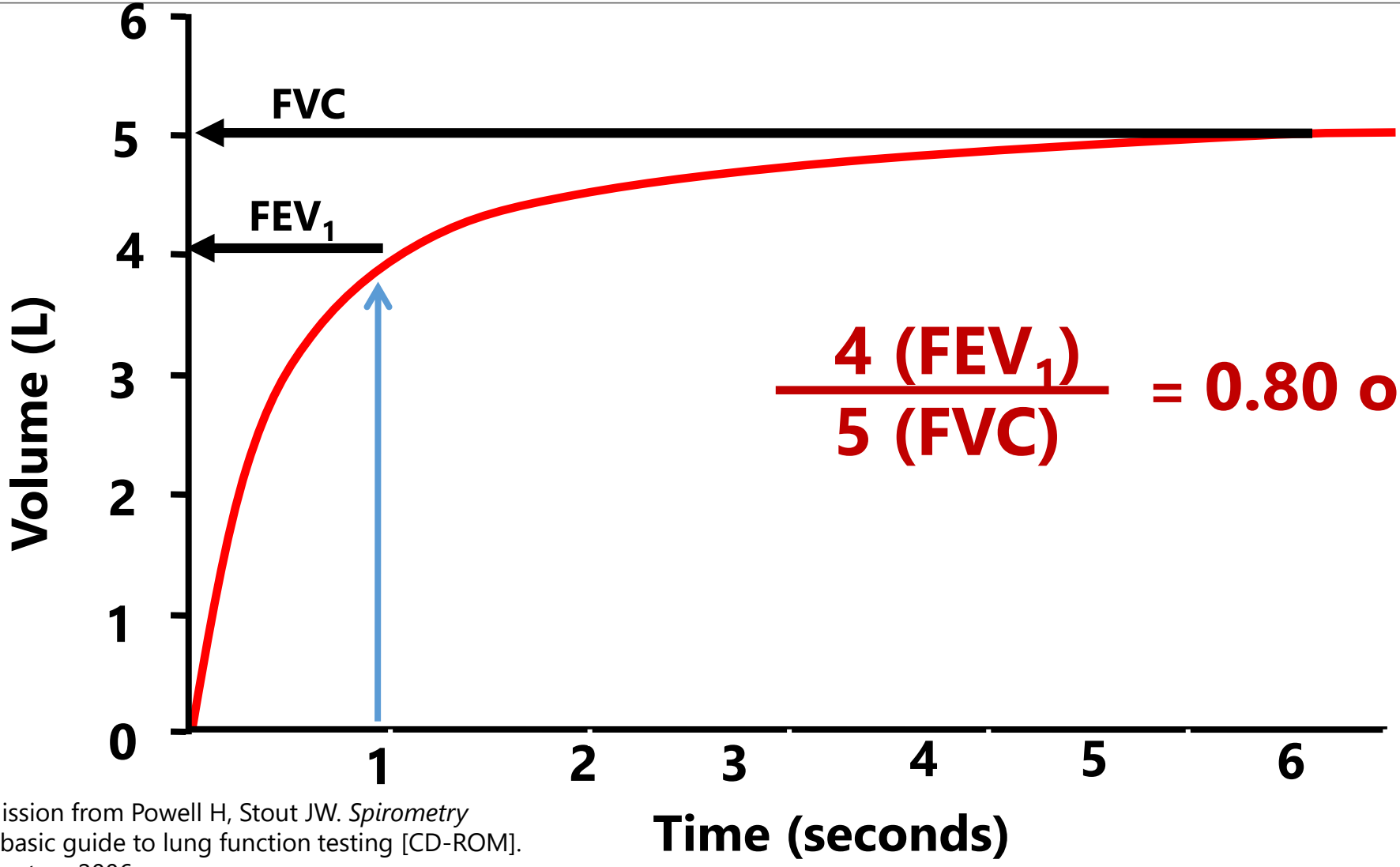
Calculating Percent Predicted

- FEV_1 Predicted: 4.00L
- Patient's FEV_1: 3.00L

- What is the percent predicted for this patient?

$$\frac{3.00}{4.00} = \frac{3}{4} = 75\%$$

Volume/Time Curve

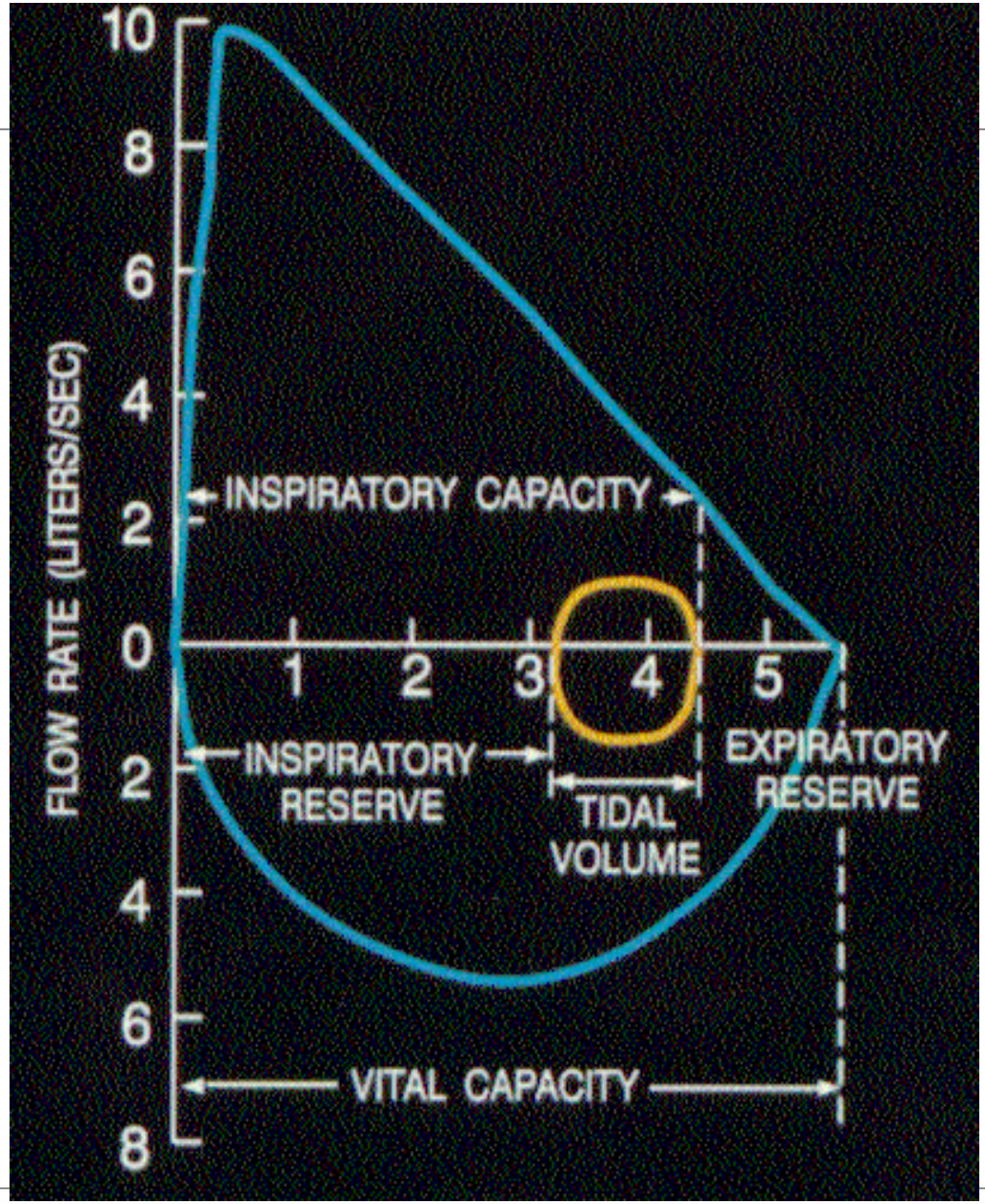


$$\frac{4\ (FEV_1)}{5\ (FVC)} = 0.80 \text{ or } 80\%$$

Adapted with permission from Powell H, Stout JW. *Spirometry Fundamentals™:* A basic guide to lung function testing [CD-ROM]. University of Washington; 2006.

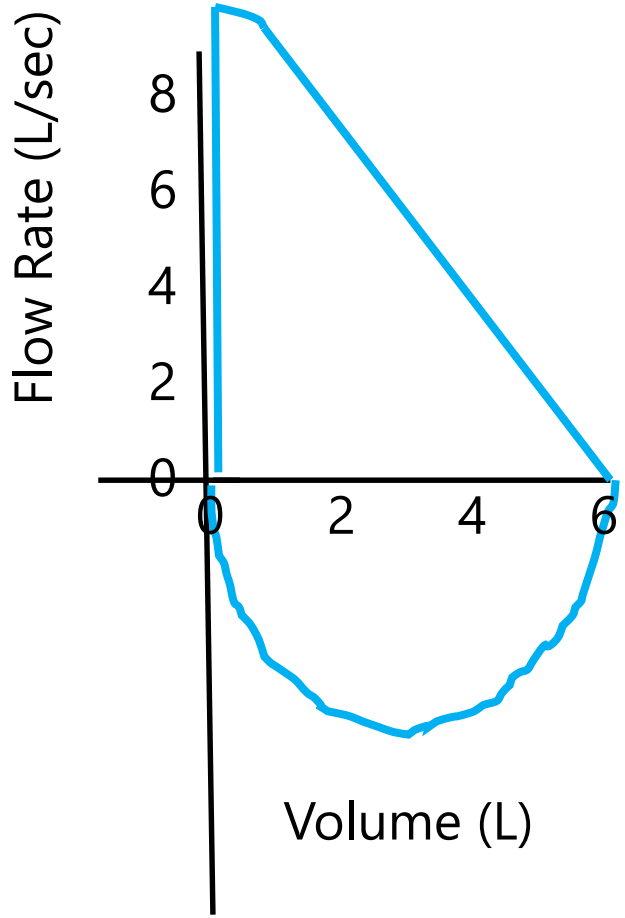
Flow Volume Loop

- A Flow Volume Loop is simply a graph that represents how fast the air comes out of the patient
- Airflow rates are proportional to airway diameter.

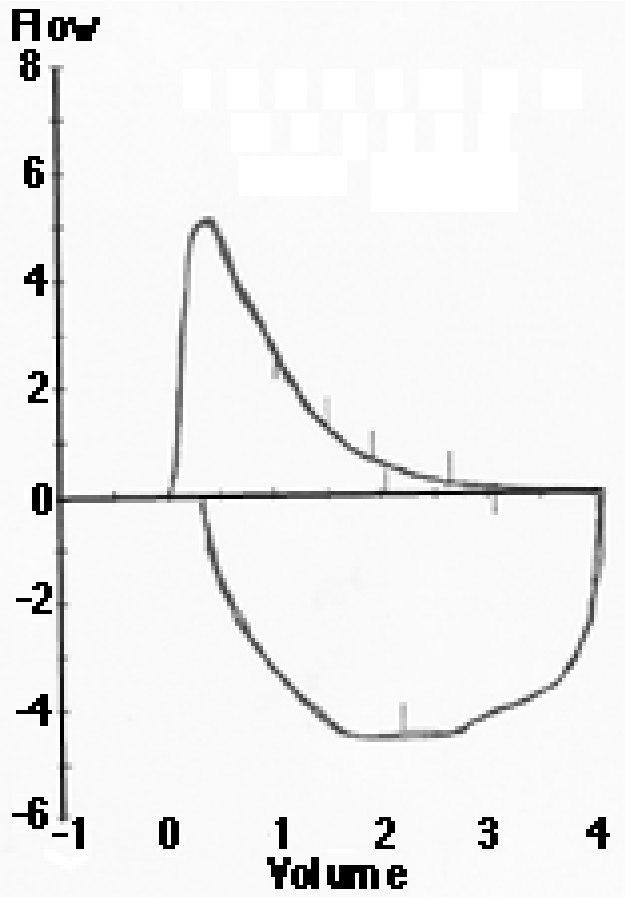


Flow Volume Loop

A normal flow volume loop has a rapid peak expiratory flow rate with a gradual decline in flow back to zero.



Obstruction

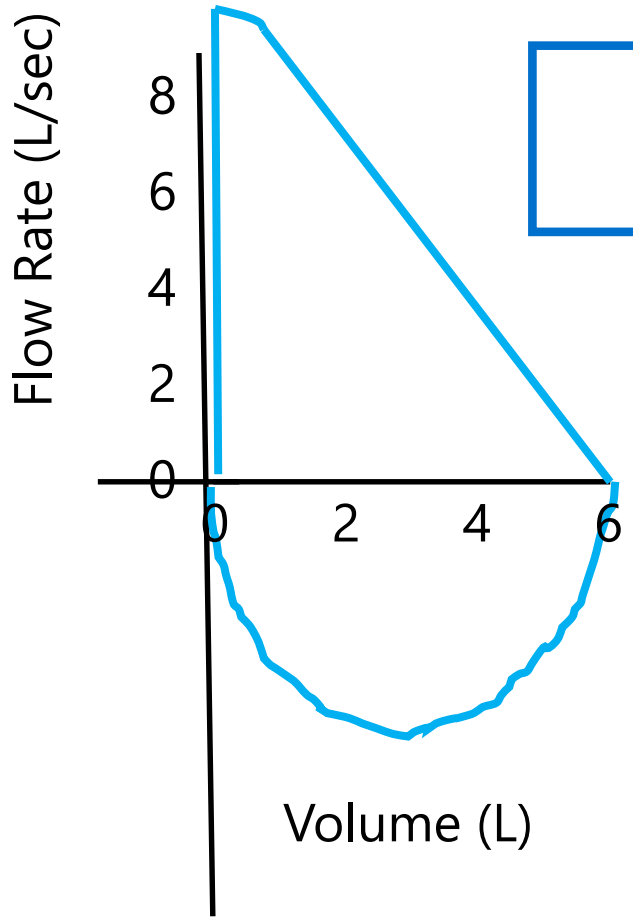


- Obstructive lung disease changes the appearance of the flow volume curve.
- As with a normal curve, there is a rapid peak expiratory flow, but the curve descends more quickly than normal and takes on a concave shape.

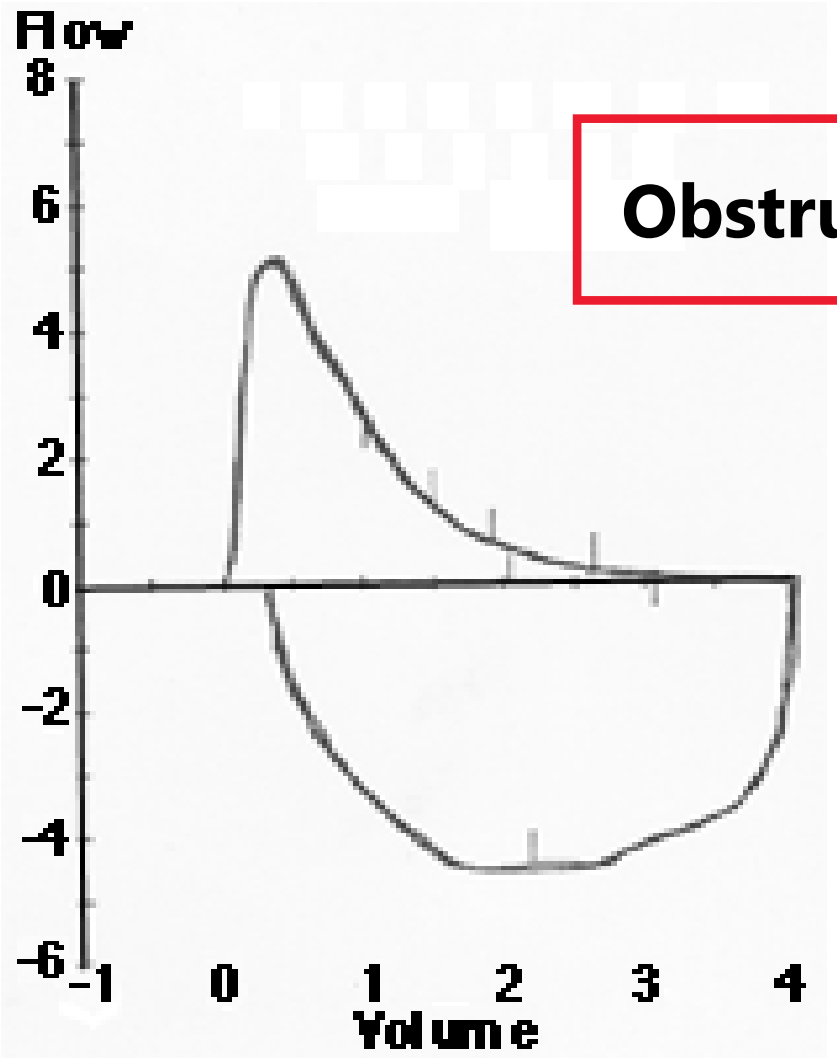
Spirometry Results Showing Obstruction

	Measured	Predicted	Percent (%) Predicted
FVC	4.09	4.25	96
FEV_1	1.95	2.88	68
FEV_1/FVC	48	68	
PEF	6.27	8.06	78

Normal vs. Obstructed

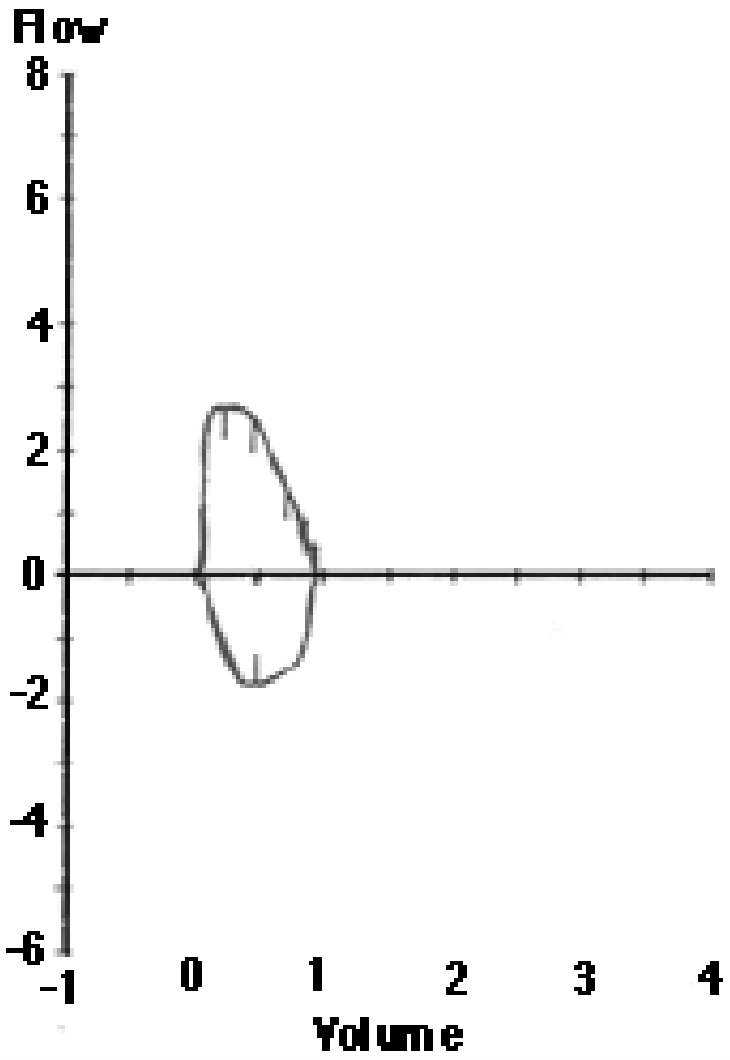


Normal



Obstruction

Restrictive Flow Volume Loop



The shape of the flow volume loop is relatively unaffected in restrictive disease, but the overall size of the curve will appear smaller when compared to normals on the same scale.

Restrictive Lung Disease

- Both the FEV_1 and FVC are reduced proportionately.
- FEV_1/FVC ratio is normal or even elevated.

	Measured	Predicted	Percent (%) Predicted
FVC	0.96	2.75	35
FEV_1	0.94	1.90	49
FEV_1/FVC	98	69	
PEF	2.98	5.40	55

Objective Measures: Spirometry

Is airflow obstruction present and is it at least partially reversible?

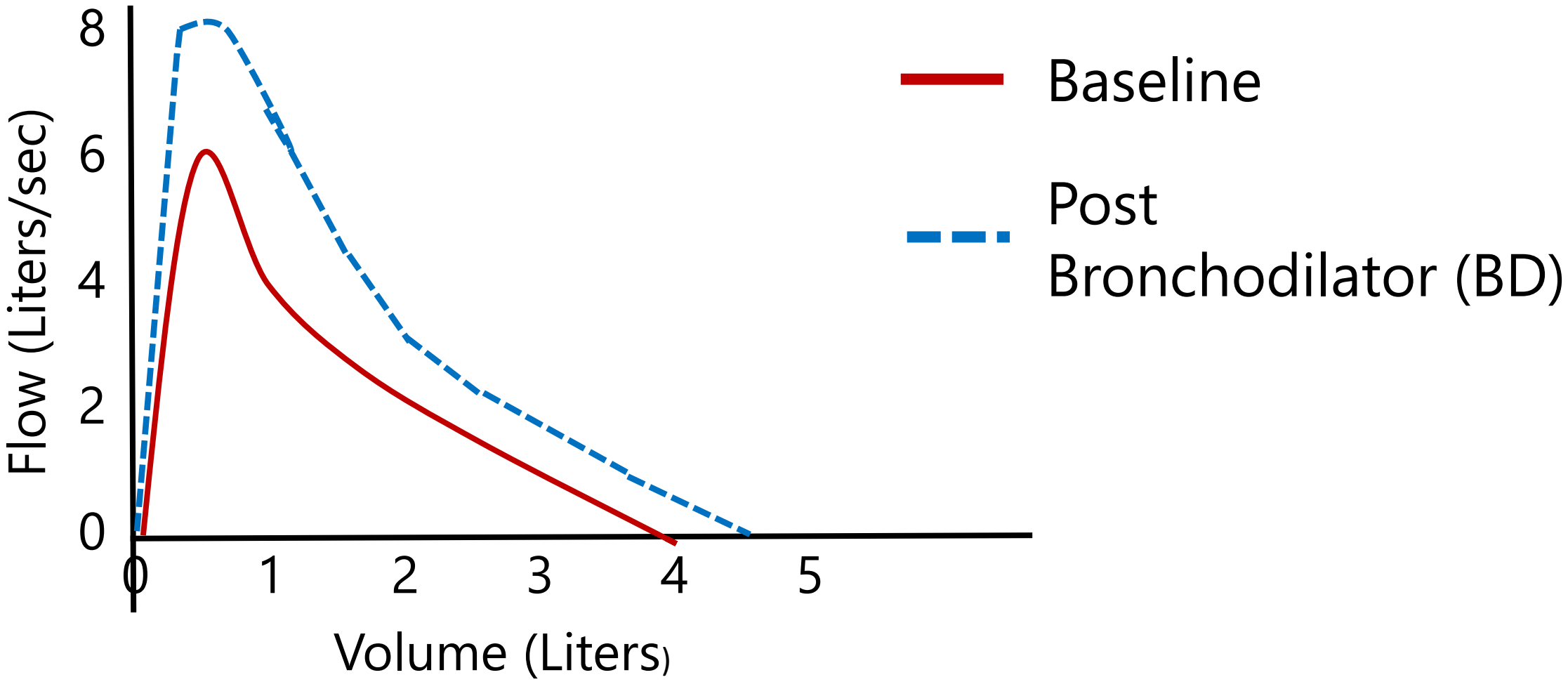
Use spirometry to establish airflow **obstruction**

- FEV_1 < 80% predicted
- FEV_1/FVC below the lower limit of normal, as compared to the individual's own predicted value

Use spirometry to establish **reversibility**

- FEV_1 increases ≥12% and
- ≥ 200 mL after using a short-acting inhaled $beta_2$-agonist
- 2- to 3-week trial of oral corticosteroid therapy may be required to demonstrate reversibility

Sample Spirometry Tracing Pre / Post BD Testing



Calculating Change in FEV_1

- $\frac{\text{Post BD } FEV_1 \text{ minus Pre BD } FEV_1}{\text{Pre BD } FEV_1}$

- Pre BD FEV_1 = 1.50L Post BD FEV_1 = 1.80L

- What is the % improvement in FEV_1?

- Example 2: $\frac{1.80L - 1.50L}{1.50L} = \frac{.30}{1.50} = \frac{1}{5}$ = **20% improvement**

Does this meet the NAEPP criteria?

Calculating Change in FEV_1

- Pre BD FEV_1 = 2.00 L Post BD FEV_1 = 2.40 L
- What is the % improvement in FEV_1?

- Example 1: $\frac{2.40\ L - 2.00\ L}{2.00L} = \frac{.40}{2.00} =$ 20% improvement

Does this meet the NAEPP criteria?

There is > 12% improvement.

Calculating Change in FEV_1

- $\frac{\text{Post BD } FEV_1 \text{ minus Pre BD } FEV_1}{\text{Pre BD } FEV_1}$

- Pre BD FEV_1 = 3.00L
- Post BD FEV_1 = 4.00L

- What is the % improvement in FEV_1?

- Example 3: $\frac{4.00L - 3.00L}{3.00L} = \frac{1.00}{3.00} =$ 33% improvement

- Does this meet the NAEPP criteria?

Calculating Change in FEV_1

Second requirement is >200ml increase

- Pre FEV_1=1 L
- Post FEV_1= 1.15 L
- 1.15 L minus 1.00 L is improvement of 0.15 L or 150 ml
- Does this meet the NAEAPP requirement?

  (Post BD – Pre BD = >200ml)

Reliability of Spirometry

- Spirometry is an effort-dependent maneuver that requires understanding, coordination and cooperation by the patient, who must be carefully instructed.
- Technicians must be trained and maintain a high level of proficiency to assure optimal results.
- Spirometry should be performed using equipment and techniques that meet standards developed by the American Thoracic Society.

Reliability of Spirometry

- Correct technique, calibration methods and maintenance of equipment are necessary to achieve consistently accurate test results.
- Maximal patient effort in performing the test is required to avoid important errors in diagnosis and management (reproducibility).
- Spirometry is generally valuable in children over age 4; however, some children cannot conduct the maneuver adequately until after age 7.

Reliability of Spirometry

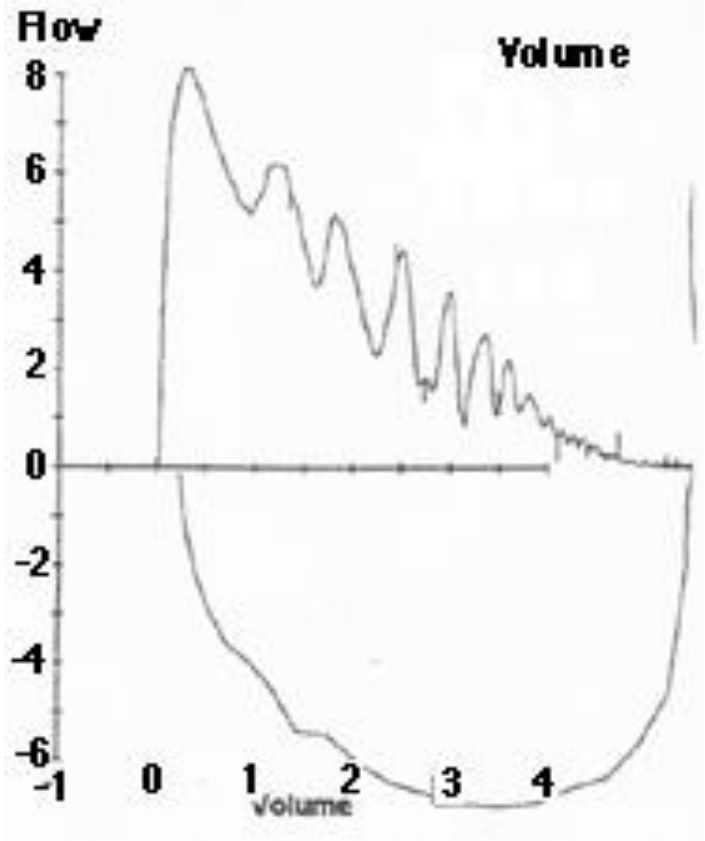
- Criteria for **acceptability** include:
  - Lack of artifact induced by coughing, glottic closure or equipment problems (primarily leak);
  - Satisfactory start to the test without hesitation; and
  - Satisfactory exhalation with six seconds of smooth continuous exhalation, or a reasonable duration of exhalation with a plateau.

Repeatability Criteria: ATS/ERS Guidelines

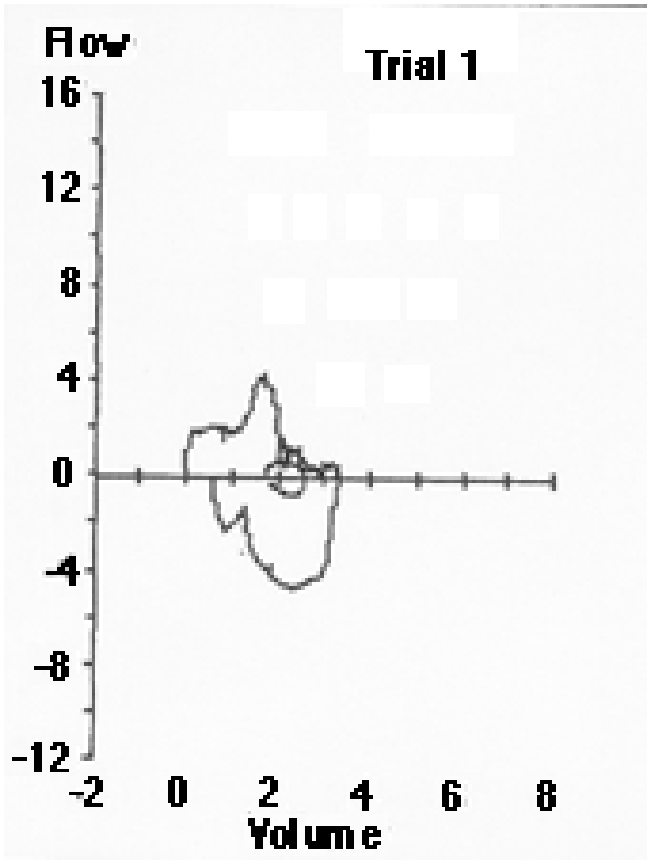
Three acceptable tests must be performed with 2 tests having FEV_1 and FVC within 0.15L or 150 mL of each other.

Unacceptable Efforts

Cough

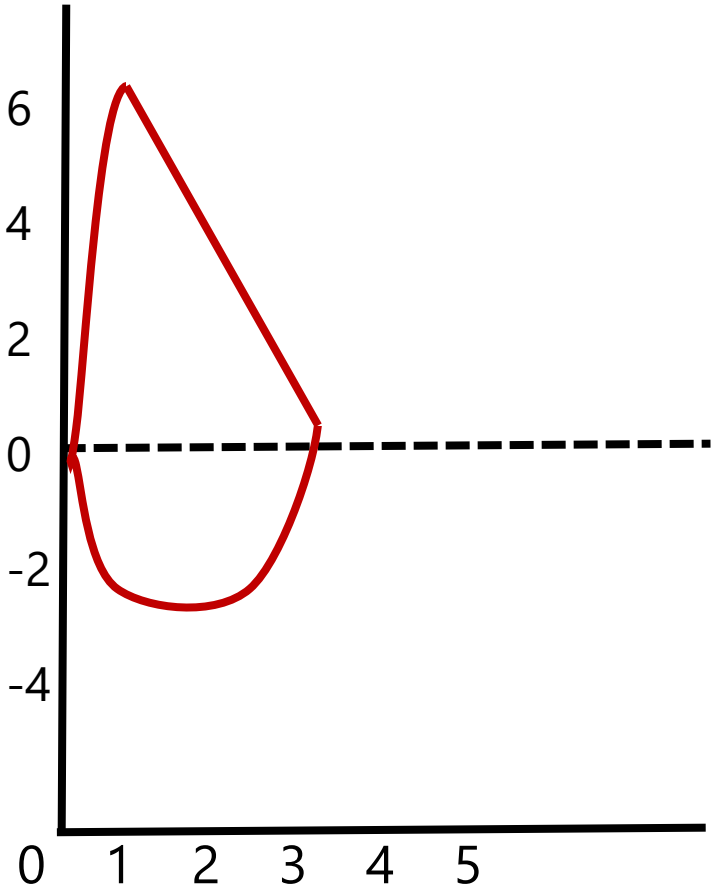


Variable Effort

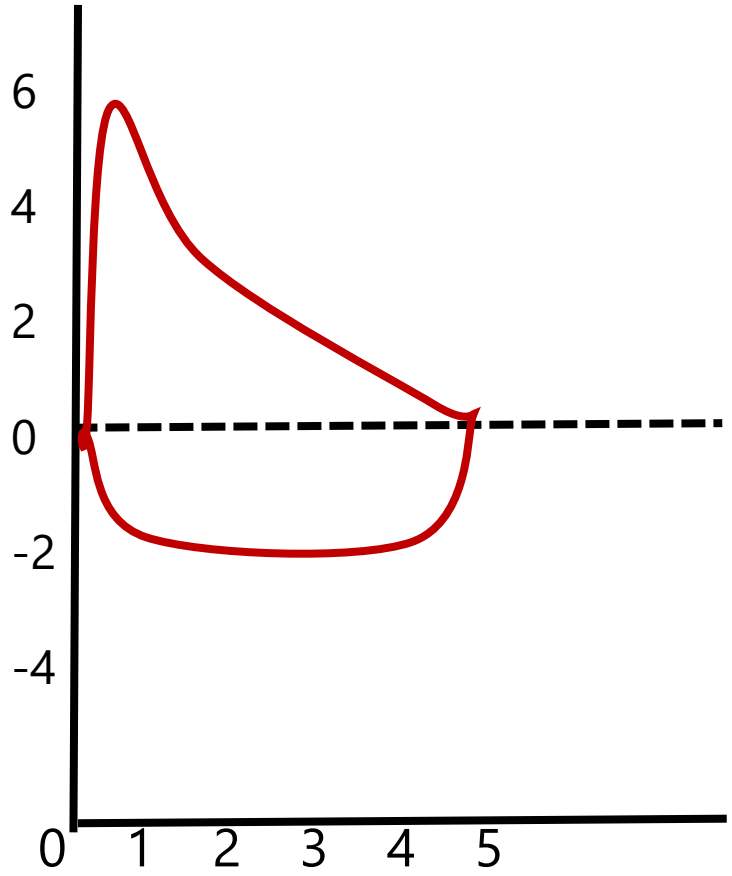


Putting it into Practice

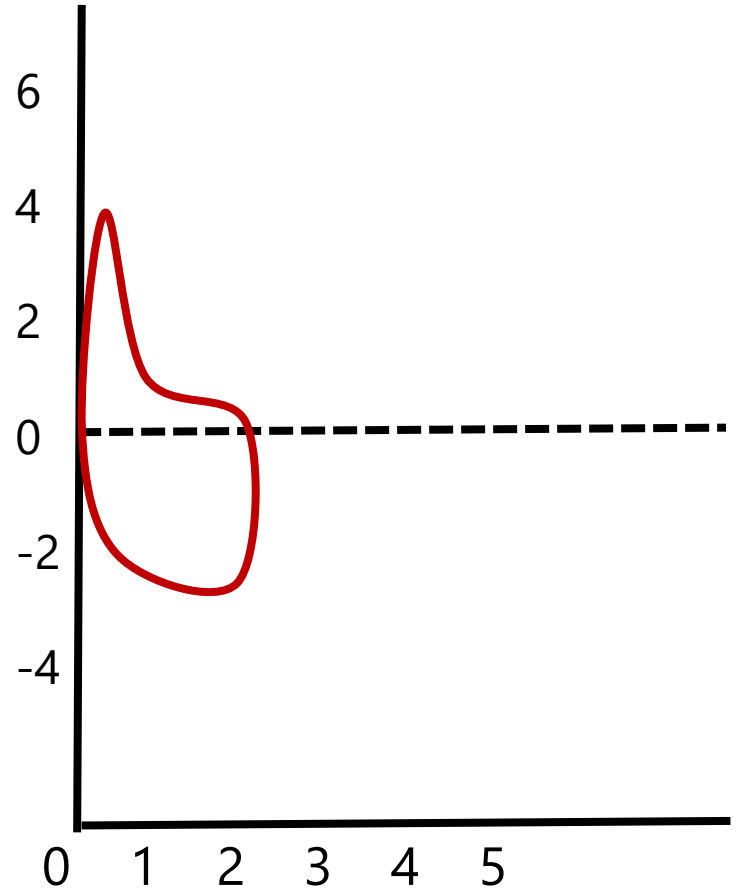
Normal, Obstructive, Restrictive?



A



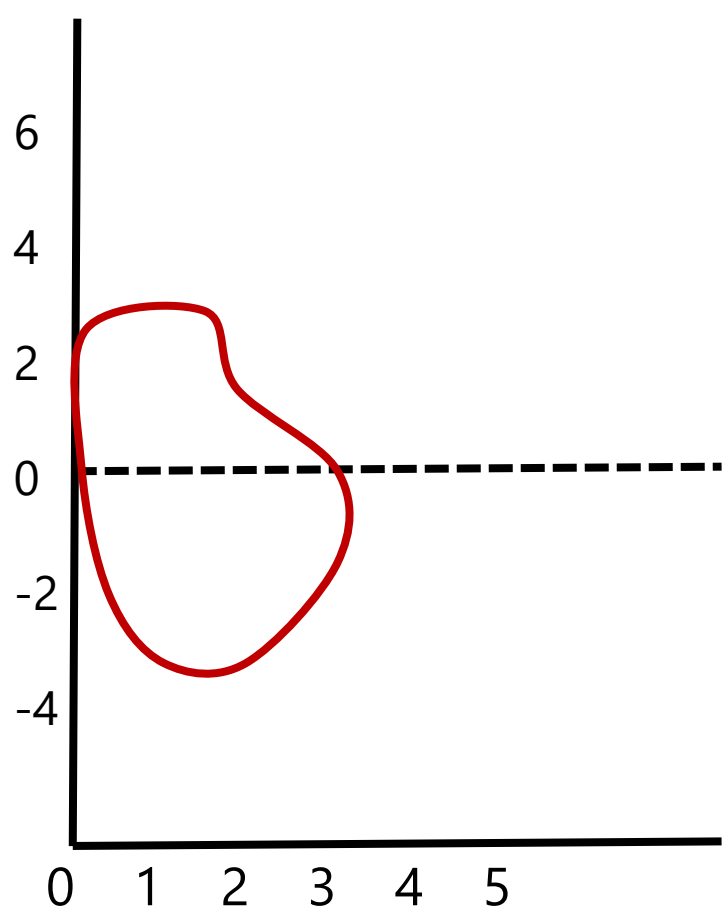
B



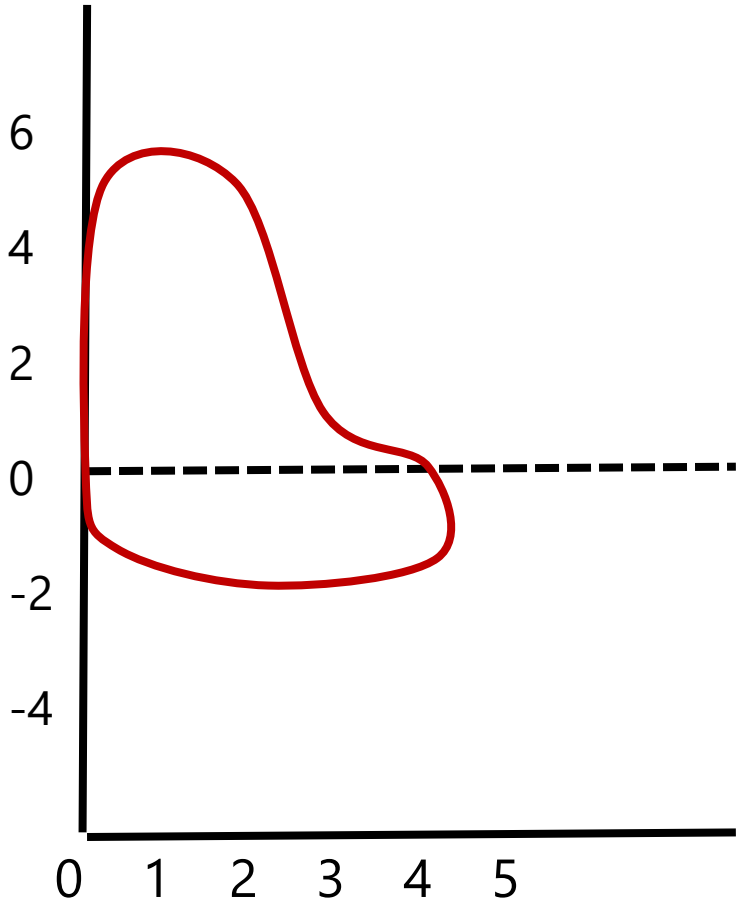
C

Putting it into Practice

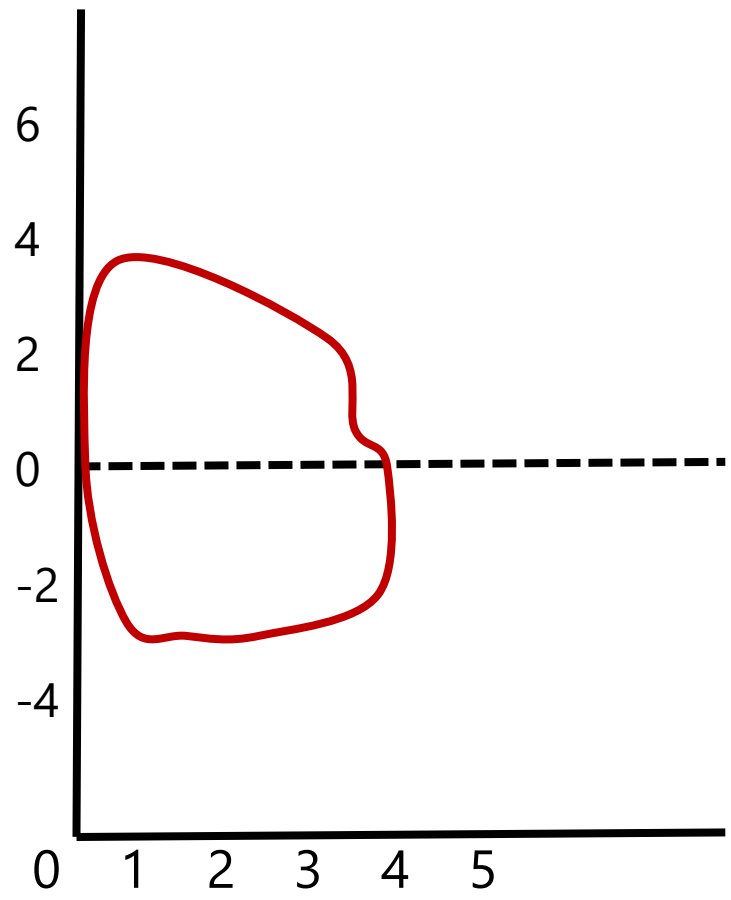
Normal, Obstructive, Restrictive?



D



E



F

CASE STUDIES

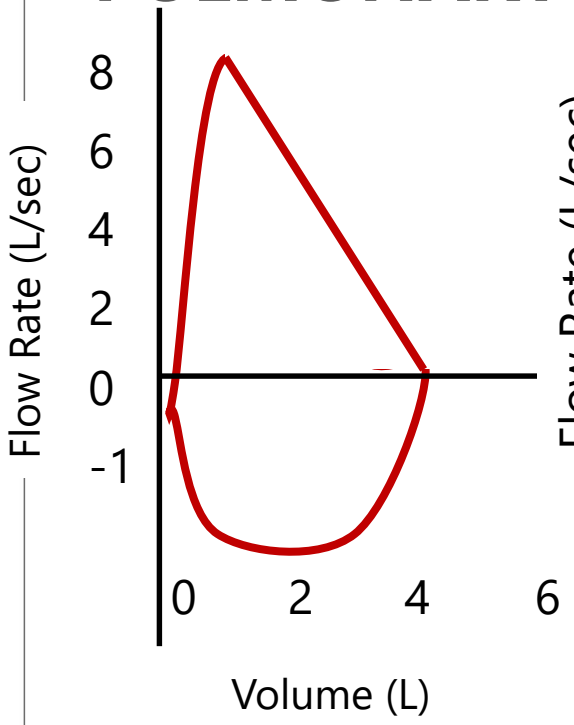
Putting it into Practice

REVIEW THE PULMONARY FUNCTION RESULTS, THEN SELECT THE CORRECT BASIC INTERPRETATION.

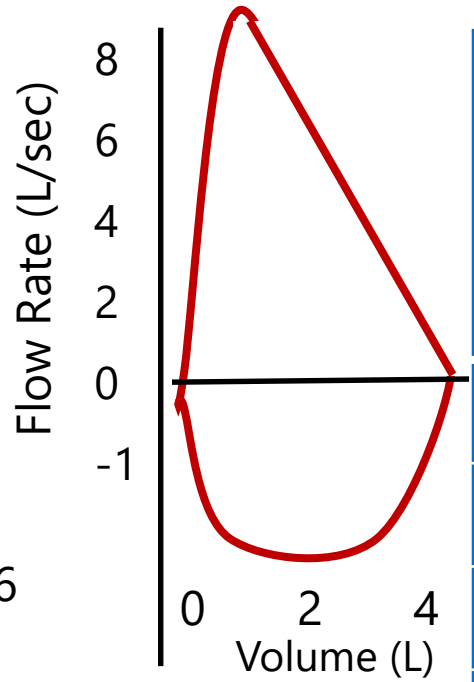
Choose from the following answers:

A. Normal
B. Mild to moderate obstruction
C. Severe obstruction
D. Severe obstructive ventilatory defect, cannot exclude a concomitant restrictive defect
E. Restrictive ventilatory defect, lung volumes necessary for confirmation
F. Cannot be interpreted; does not meet acceptability criteria.

PULMONARY FUNCTION CASE 1



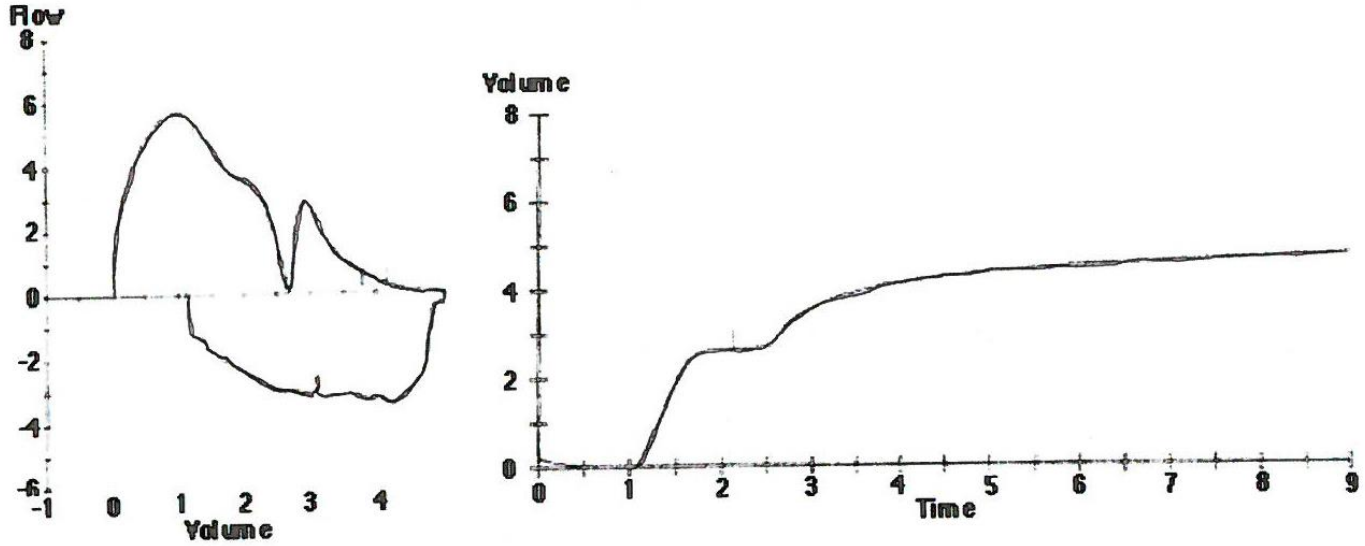
Pre-Bronchodilator



Post-Bronchodilator

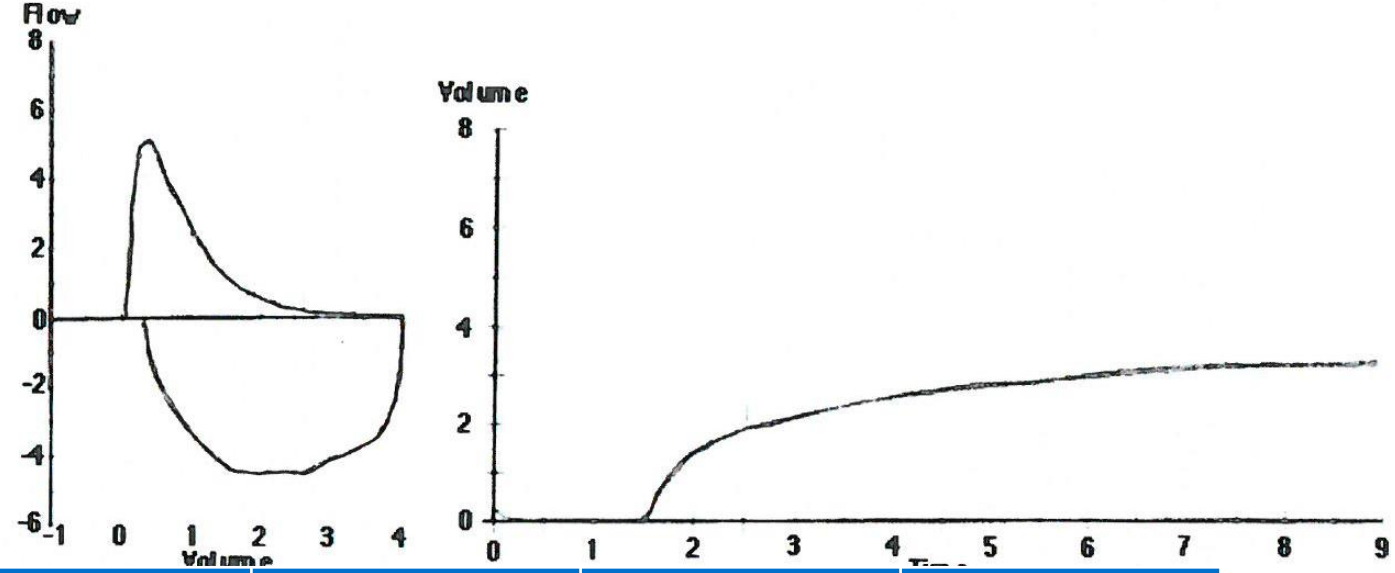
Test	Pre-Bronchodilator	Post-Bronchodilator	Predicted	% Predicted
				Pre
FVC	2.10	2.32	2.58	81
FEV_1	1.65	1.77	1.85	89
FEV_1/FVC				
$FEF_{25-75\%}$	1.82		2.23	82
PEF	5.67		5.20	109

PULMONARY FUNCTION CASE 2



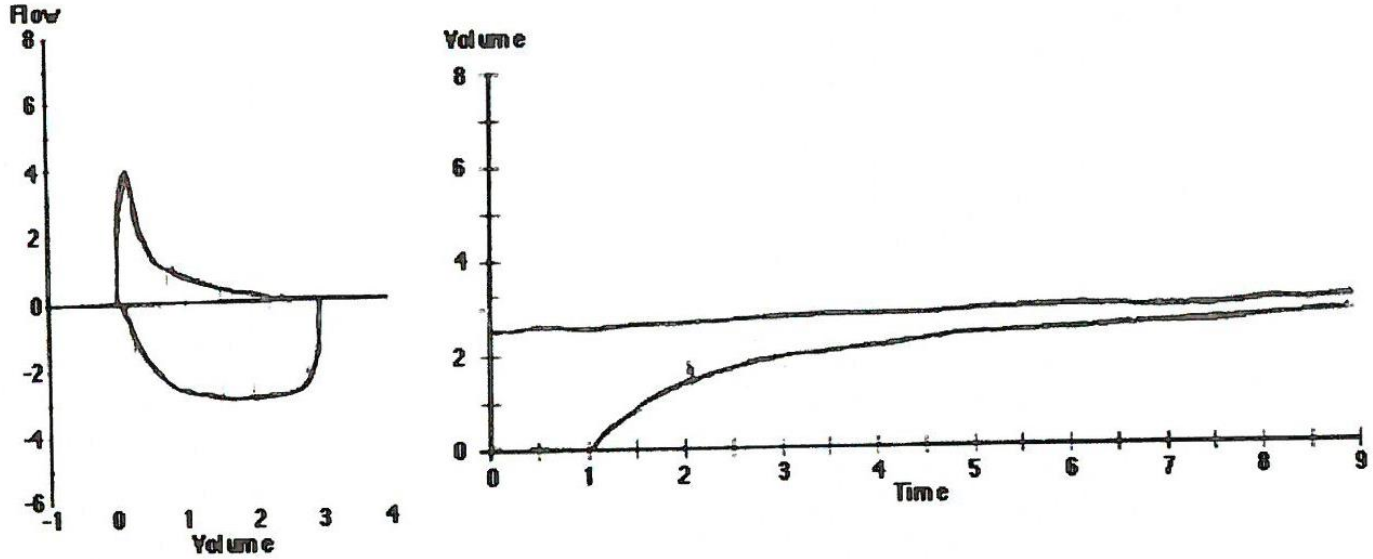
Test	Measurement	Predicted	% Predicted
FVC	5.08	4.94	
FEV_1	2.66	3.58	
FEV_1/FVC			
$FEF_{25-75\%}$	1.40	3.47	
PEF	6.49	9.1	

PULMONARY FUNCTION CASE 3



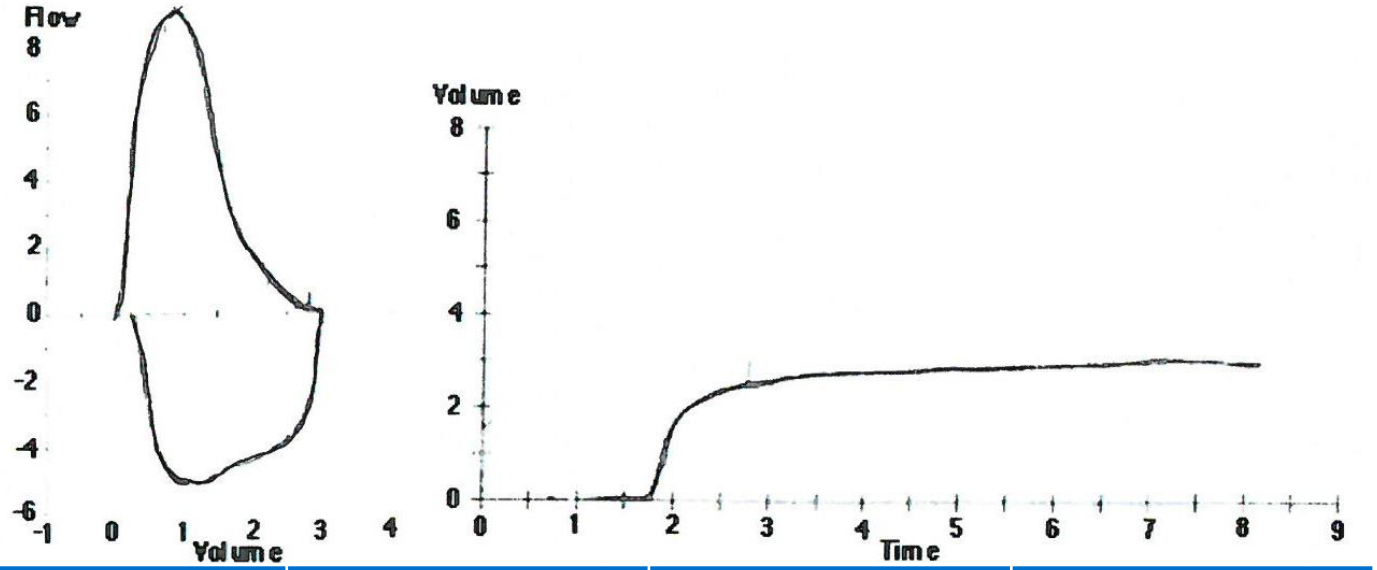
Test	Measurement	Predicted	% Predicted
FVC	4.09	4.25	
FEV_1	1.95	2.88	
FEV_1/FVC			
$FEF_{25-75\%}$	.48	2.65	
PEF	6.27	8.06	

PULMONARY FUNCTION CASE 4



Test	Measurement	Predicted	% Predicted
FVC	3.02	3.41	
FEV_1	0.98	2.53	
FEV_1/FVC			
$FEF_{25-75\%}$	.41	2.77	
PEF	3.95	6.10	

PULMONARY FUNCTION CASE 5



Test	Measurement	Predicted	% Predicted
FVC	3.00	4.79	
FEV_1	2.54	3.28	
FEV_1/FVC			
$FEF_{25-75\%}$	3.25	2.97	
PEF	9.12	8.92	

References

- Mueller GA, et al. Pediatr Clin North Am. 1992;39:1243-1248
- Petty T L Chest 2002;121:219S-223S
- Miller, M.R., et al., "Standardization of Spirometry, Series "ATS/ERS Task Force: Standardisation of Lung Function Testing," ed. By Brusasco, V., Crapo R. and Viegi G. , Number 2 in the Series, Eur Respir J 2005; 26: 319-338 copyright ERS Journals Ltd 2005 http://erj.ersjournals.com/content/26/2/319.long last accessed 9/10/2018

AMERICAN LUNG ASSOCIATION®

ASTHMA EDUCATOR INSTITUTE