PULMONARY FUNCTION TEST (SPIROMETRY)

PRACTICAL SESSION

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PHYSIOLOGY LAB OBJECTIVES

1. Explain that the spirometer is designed to measure Lung volume & the pneumotach to measure the flow rate (volume per unit of time).
2. Discuss the purpose of performing PFT.
3. What are the normal values for lung volumes & capacities? Discuss the effect of age, gender, body height, and race on lung volumes & capacities.
4. Demonstrate the recording of lung volumes & VC.
5. The recording of FVC, FEV1, FEV%, PEFR, FEF25% - 75%. Explain how they are used to differentiate obstructive from restrictive respiratory dysfunction.

DEFINITION:

Spirometry: meaning *the measuring of breath*.

Spirometry is the most common of the pulmonary function tests (PFTs).

It measures lung function, specifically:

1. The amount (volume).
2. The speed (flow) of air that can be inhaled and exhaled.

WHY DO WE DO SPIROMETRY?

Spirometry is helpful in assessing breathing patterns that **diagnose** conditions such as:

- Asthma
- Pulmonary fibrosis
- Cystic fibrosis
- Chronic obstructive pulmonary diseases (COPDs), **Chronic bronchitis** and **emphysema** are examples of COPD. In this case the FEV1/FVC is less than 70%, indicating that both FEV1 and FVC are reduced.

CLINICAL SIGNIFICANCE (DIFFERENTIAL DIAGNOSIS)

Spirometry is useful to **differentiate** between:

- Respiratory from cardiac disease as the cause of breathlessness
- Obstructive lung disease from restrictive lung disease (which is demonstrated by a decrease in the ***forced vital capacity (FVC)***, and a higher than 80% FEV1/FVC ratio). In restrictive lung disease the total lung capacity is 80% or less of the expected value. Restrictive lung diseases can be due to pulmonary causes (Fibrosis) or extra-pulmonary (e.g. pleural thickening, obesity, diaphragmatic hernia, or the presence of ascites).

SPIROMETRY IS ALSO USEFUL TO:

- Follow the natural history of disease in respiratory conditions
- Assess of impairment from occupational asthma
- Identify those at risk from pulmonary barotrauma while scuba diving
- Conduct pre-operative risk assessment before anesthesia or cardiothoracic surgery
- Measure response to treatment of conditions which spirometry detects
- Diagnose the vocal cord dysfunction

SPIROGRAMS OR PNEUMOTACHOGRAPHS

Spirometry generates **Spirograms** or **pneumotachographs** , which are charts that plot the volume and flow of air coming in and out of the lungs from one inhalation and one exhalation.

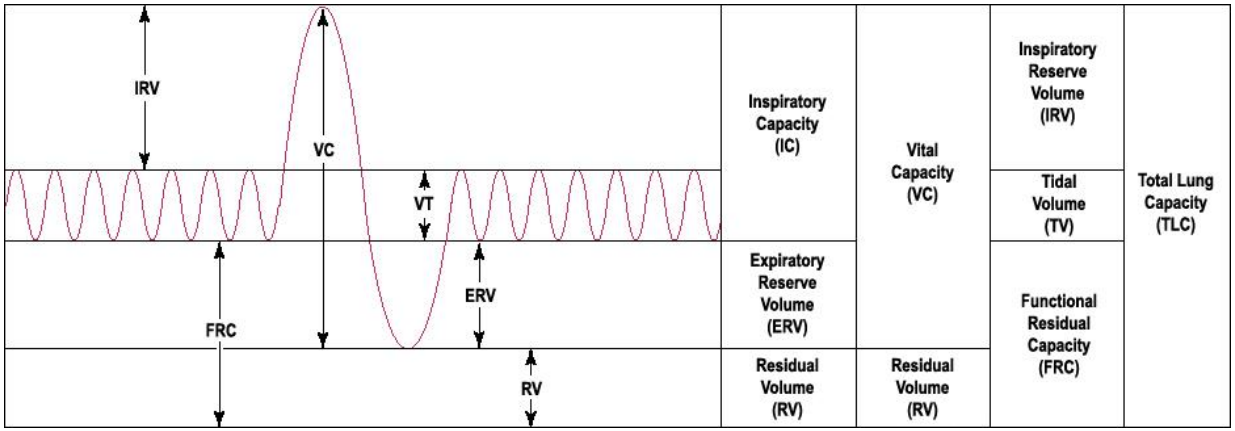
Spirograms are either:

1. A volume-time curve, showing volume (liters) along the Y-axis and time (seconds) along the X-axis.
2. A flow-volume loop, which graphically depicts the rate of airflow on the Y-axis and the total volume inspired or expired on the X-axis.

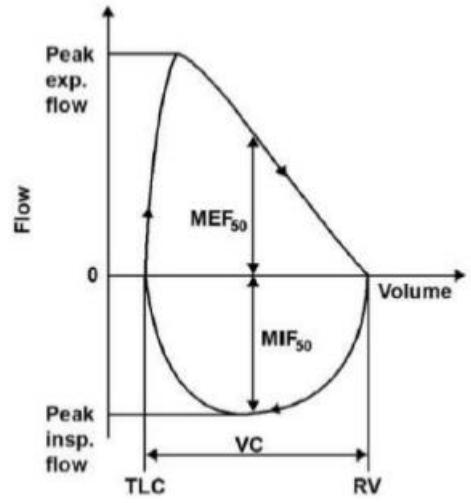
LIMITATION OF TEST:

1. Patient cooperation (not suitable for children less than 6 years old, unconscious, or heavily sedated patients). FVC can only be underestimated, never overestimated.
2. Many intermittent or mild asthmatics have normal spirometry between acute exacerbation.

PARAMETERS:



Volume-Time Curve



Normal flow volume loop

MEF50=maximum expiratory flow at 50% of VC;
MIF50=maximum inspiratory flow at 50% VC;
VC=vital capacity;
TLC=total lung capacity;
RV=residual volume.

Flow-Volume Loop

FLOW-VOLUME LOOP PARAMETERS

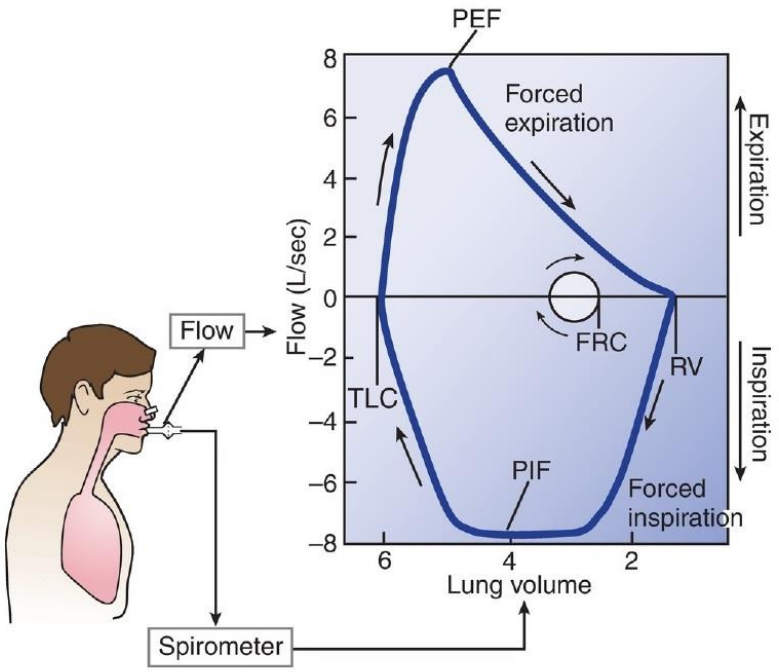
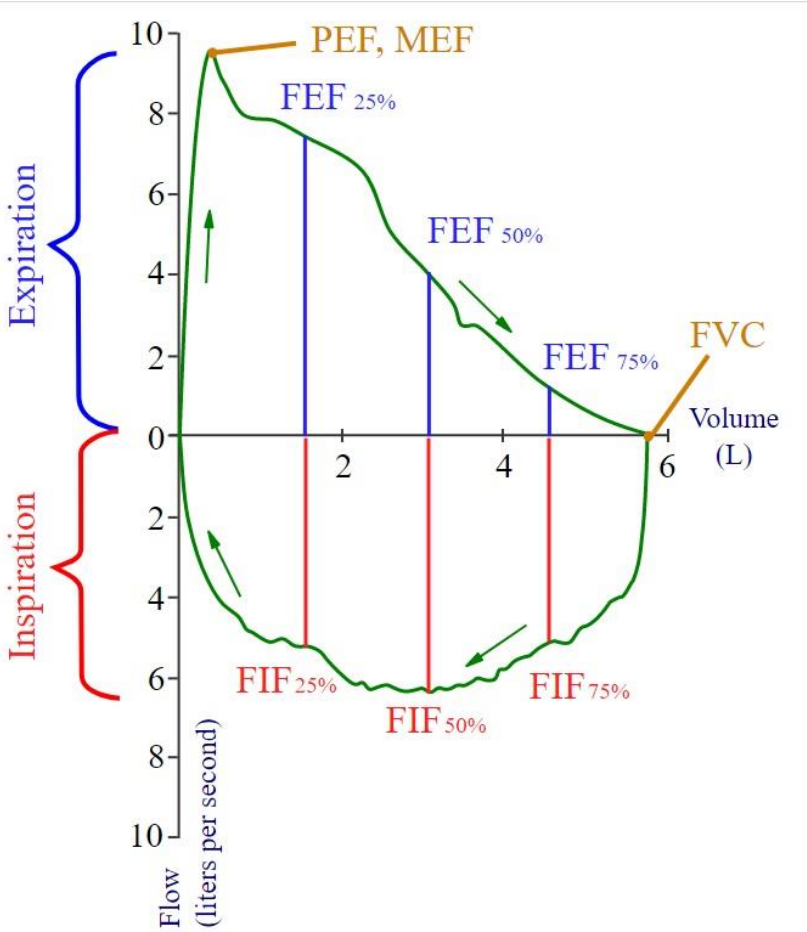
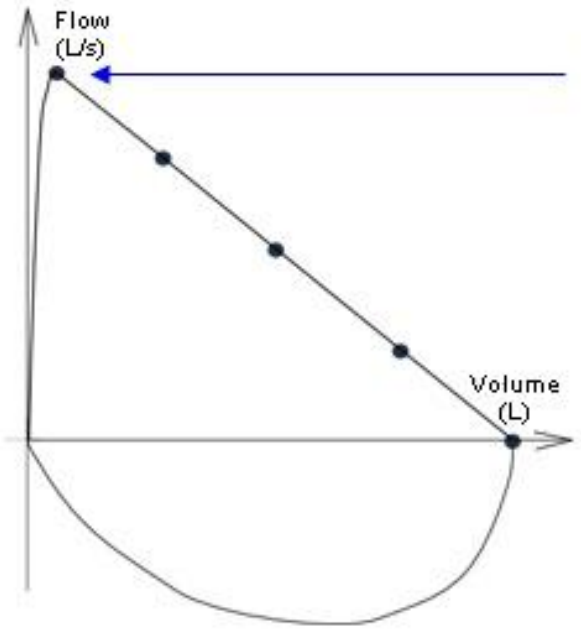


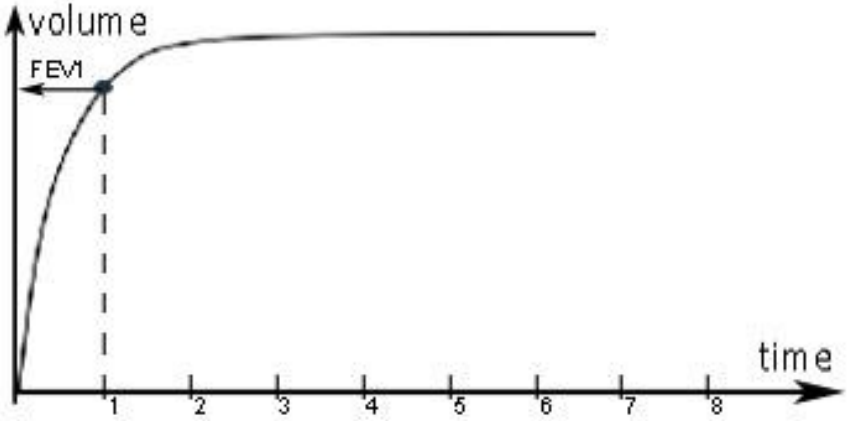
Figure **Flow–volume curve illustrates the functional importance of airflow.** The relationship between lung volume and airflow can be seen from a flow–volume curve. During tidal breathing, airflow is small (small loop labeled FRC [functional residual capacity]). However, during forced expiration, airflow rises rapidly and reaches a maximum, termed *peak expiratory flow* (*PEF*). PEF occurs before there is much change in lung volume. However, during the last part of the expiratory portion of the flow–volume curve (or a forced vital capacity), airflow is effort independent because of dynamic airway compression. Once PEF is achieved, airflow rate decreases proportionately as lung volume decreases to residual volume (RV). Maximum airflow during inspiration, termed *peak inspiratory flow* (*PIF*), is maintained over a large change in lung volume because airways are distended and not compressed. TLC, total lung capacity.



NORMAL SPIROMETRY

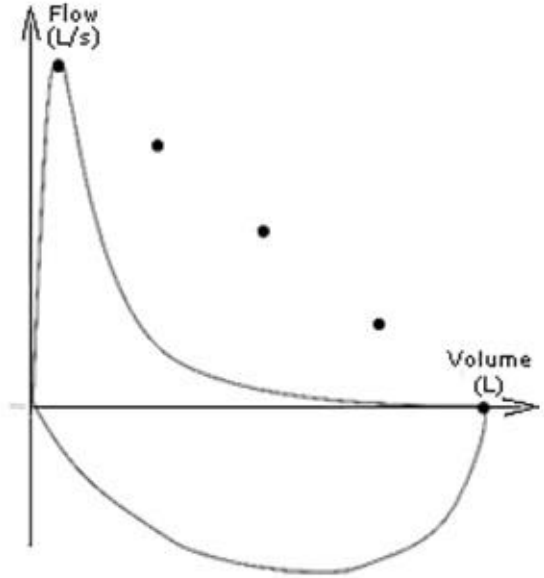


A normal flow-volume loop

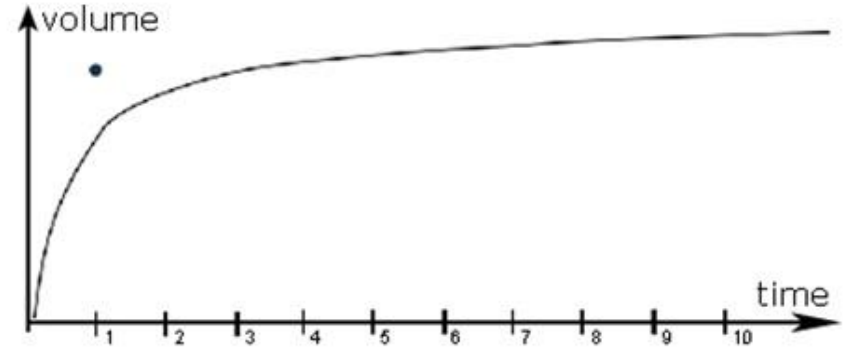


A normal volume-time curve

OBSTRUCTIVE LUNG DISEASE

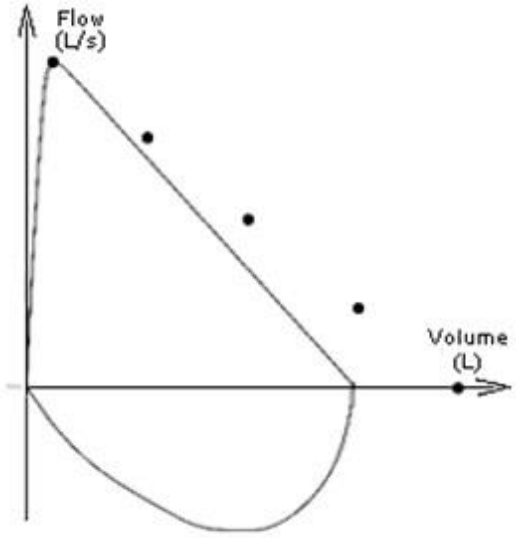


Flow-volume in obstructive lung disease is concave, FEF25-75 too low, FVC normal

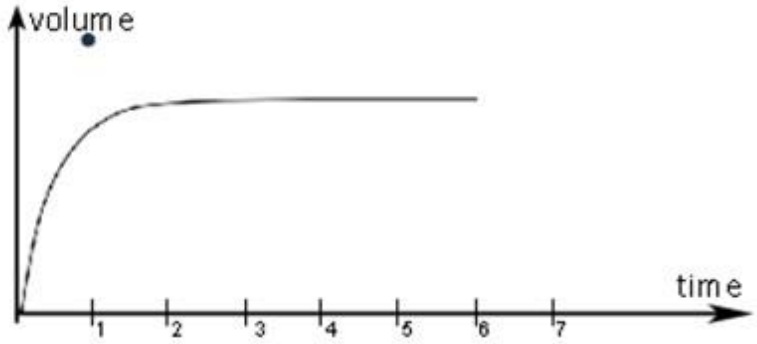


Volume-time curve in obstructive lung disease: FEV1 low, FET higher

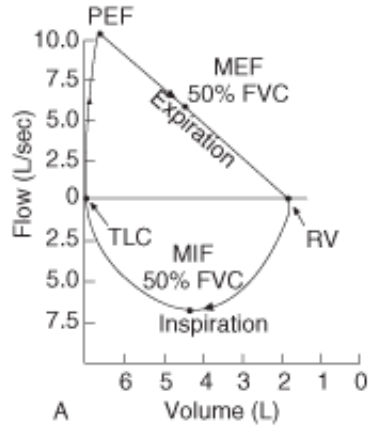
RESTRICTIVE LUNG DISEASE

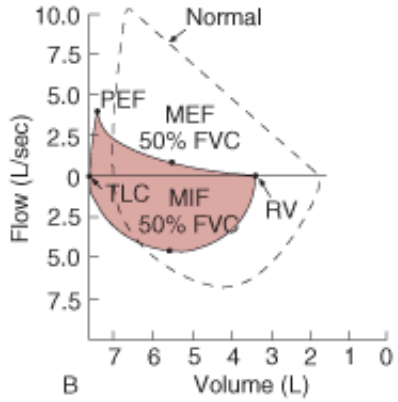


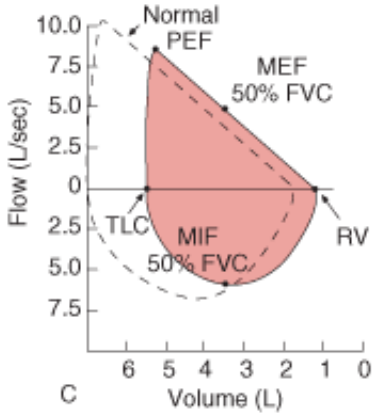
Flow-volume in restrictive lung disease:
shape normal, FVC low. PEF can be normal or low

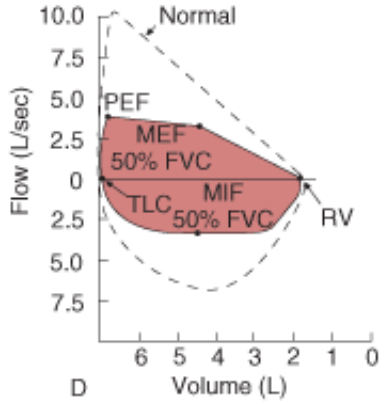


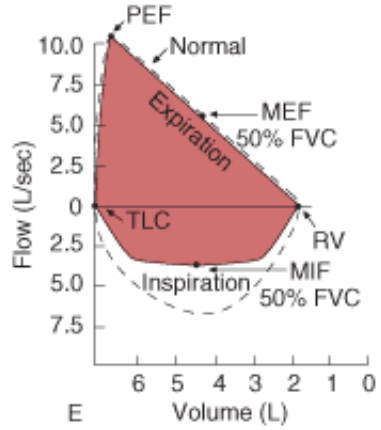
Volume-time curve in restrictive lung disease:
FEV1 too low, FET normal

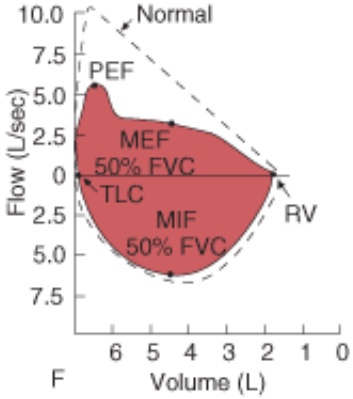












Flow –Volume Loops of Different Respiratory Diseases

(A) Normal. Inspiratory limb of loop is symmetric and convex. Expiratory limb is linear. Airflow at the midpoint of inspiratory capacity and airflow at the midpoint of expiratory capacity are often measured and compared. Maximal inspiratory airflow at 50% of forced vital capacity (MIF 50% FVC) is greater than maximal expiratory airflow at 50% FVC (MEF 50% FVC) because dynamic compression of the airways occurs during exhalation.

(B) Obstructive disorder (e.g. emphysema, asthma). Although all airflow is diminished, expiratory prolongation predominates, and MEF < MIF. Peak expiratory flow is sometimes used to estimate degree of airway obstruction but depends on patient effort.

(C) Restrictive disorder (e.g. interstitial lung disease, kyphoscoliosis). The loop is narrowed because of diminished lung volumes. Airflow is greater than normal at comparable lung volumes because the increased elastic recoil of lungs holds the airways open.

(D) Fixed obstruction of the upper airway (e.g. tracheal stenosis, goiter). The top and bottom of the loops are flattened so that the configuration approaches that of a rectangle. Fixed obstruction limits flow equally during inspiration and expiration, and MEF = MIF.

(E) Variable extrathoracic obstruction (e.g. unilateral vocal cord paralysis, vocal cord dysfunction). When a single vocal cord is paralyzed, it moves passively with pressure gradients across the glottis. During forced inspiration, it is drawn inward, resulting in a plateau of decreased inspiratory flow. During forced expiration, it is passively blown aside, and expiratory flow is unimpaired. Therefore, MIF 50% FVC < MEF 50% FVC.

(F) Variable intrathoracic obstruction (e.g. tracheomalacia). During a forced inspiration, negative pleural pressure holds the floppy trachea open. With forced expiration, loss of structural support results in tracheal narrowing and a plateau of diminished flow. Airflow is maintained briefly before airway compression occurs.

Measurement	Approximate value	
	Male	Female
Forced vital capacity (FVC)	4.8 L	3.7 L
Tidal volume (Vt)	500 mL	390 mL
Total lung capacity (TLC)	6.0 L	4.7 L

Note:

Flow-volume loops require that absolute lung volumes be measured. Unfortunately, many laboratories simply plot airflow against the FVC; the flow-FVC loop does not have an inspiratory limb and therefore does not provide as much information

Table Common medical conditions and lung function testing

	FEV_1	FVC	FEV_1/FVC	Bronchodilator response	MEF	RV	K_{co}
Asthma	Normal or ↓	Normal or ↓	Normal or ↓	Yes	Normal or ↓	Normal	Normal
Small airways disease	Reduced	Normal or ↓	↓	Yes	↓	↑	Normal
Emphysema	Reduced	Normal or ↓	↓	No	↓	↑	↓
Pulmonary fibrosis	Normal or ↓	↓	↑	No	Normal or ↓	↓	↓
Obesity	Normal or ↓	Normal or ↓	Normal or ↑	No	Normal	↓	Normal
Kyphoscoliosis	Normal or ↓	↓	↑	No	Normal	↓	Normal
Respiratory muscle disease	Normal or ↓	↓	↑	No	Normal	↓	Normal
Pneumonectomy	↓	↓	Normal	No	Normal	↓	Normal