A Review of Pulmonary Function Tests

Objectives

- At the end of the lecture you should know:
  - Definition & normal values of TV, IRV, ERV, RV, IC, FRC, VC, TLC, TVC, $FEF_{25-75\%}$, MV, PEFR, MVV, Breathing Reserve & Dyspnoeic Index.
  - Clinical significance: obstructive & restrictive lung diseases.
  - Factors affecting VC.
  - Normal functioning of spirometer & normal spirogram.
  - Measurement of FRC by nitrogen washout and helium dilution method.
  - Dead space: definition, normal value, types, measurement and significance.

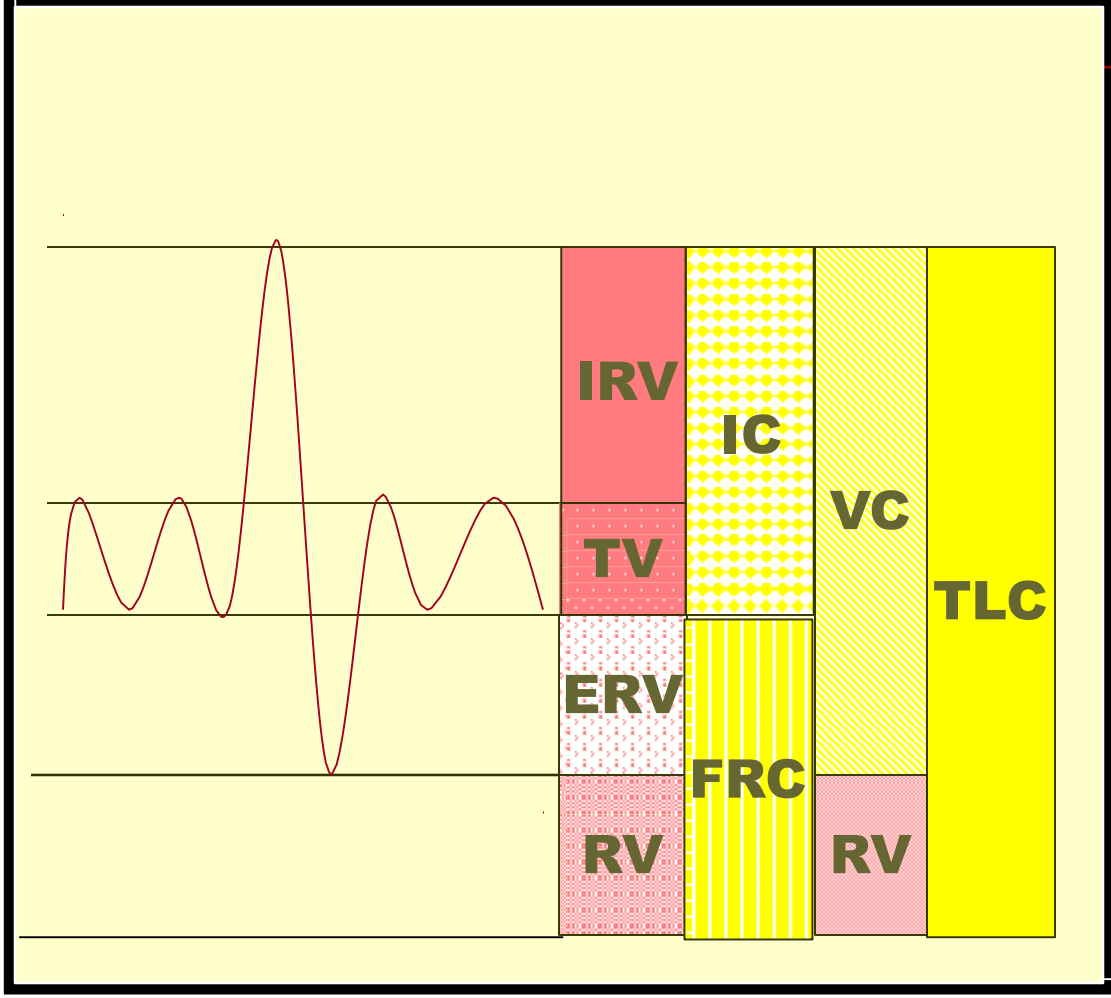
Indication

- Diagnostic—1st grade and 2rd grade
- Evaluation and control of treatment
- In surgery
- Occupational hazards--Bysinosis

Lung volumes & capacities

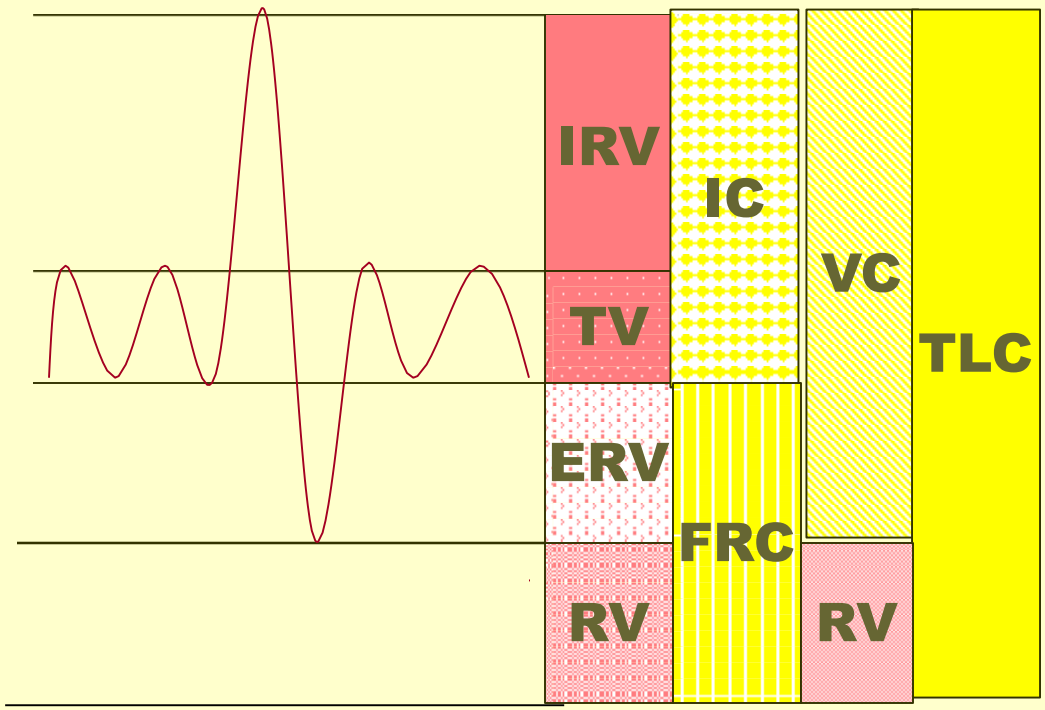
- It can be of two types:
  - Static lung volumes & capacities:
    - Time factor not involved.
    - Measured in ml or liters.
    - TV, IRV, ERV, RV, IC, FRC, VC, TLC
  - Dynamic lung volumes & capacities:
    - Time dependent.
    - Measured in ml/min or l/min.
    - TVC, $FEF_{25-75\%}$, MV, PEFR, MVV
- Most of these can be measured by spirometry

Tidal Volume (TV)



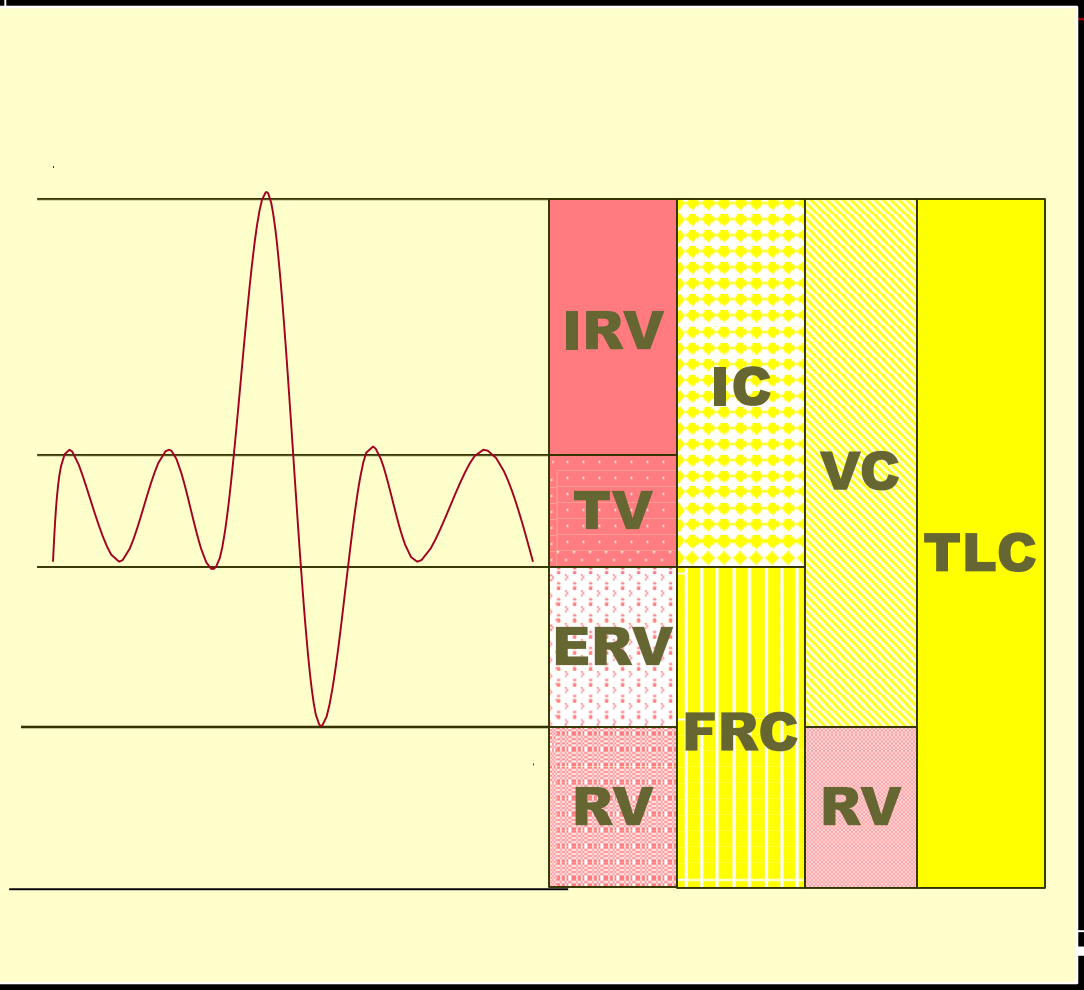
- Volume of air inspired or expired during normal quiet breathing.
- Males = 500 ml
- Females = 500 ml

Inspiratory Reserve Volume (IRV)



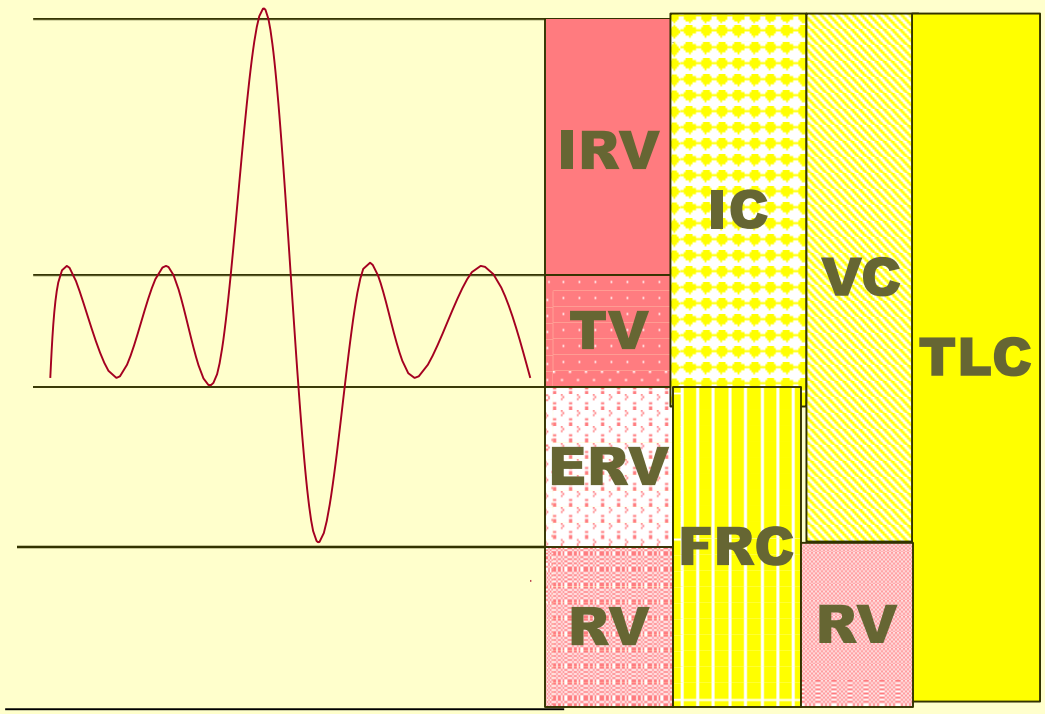
- The maximum amount of air that can be inhaled after a normal tidal inspiration.
- Males =3300 ml
- Females =1900 ml

Expiratory Reserve Volume (ERV)



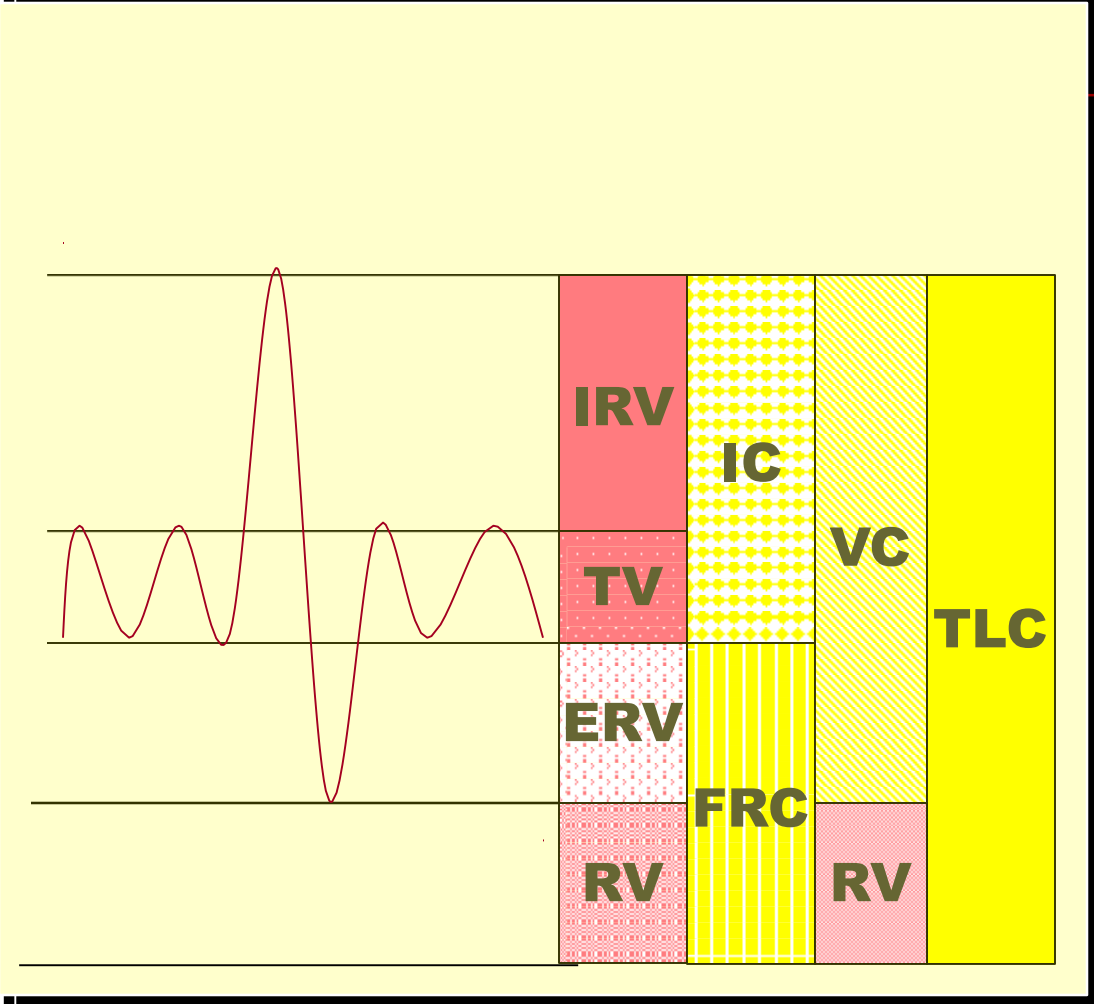
- Maximum volume of air that can be expired after a normal tidal expiration.
- Males =1000 ml
- Females = 700ml

Residual Volume (RV)



- Volume of air remaining in the lungs after maximal expiration.
- Males =1200 ml
- Females =1100 ml

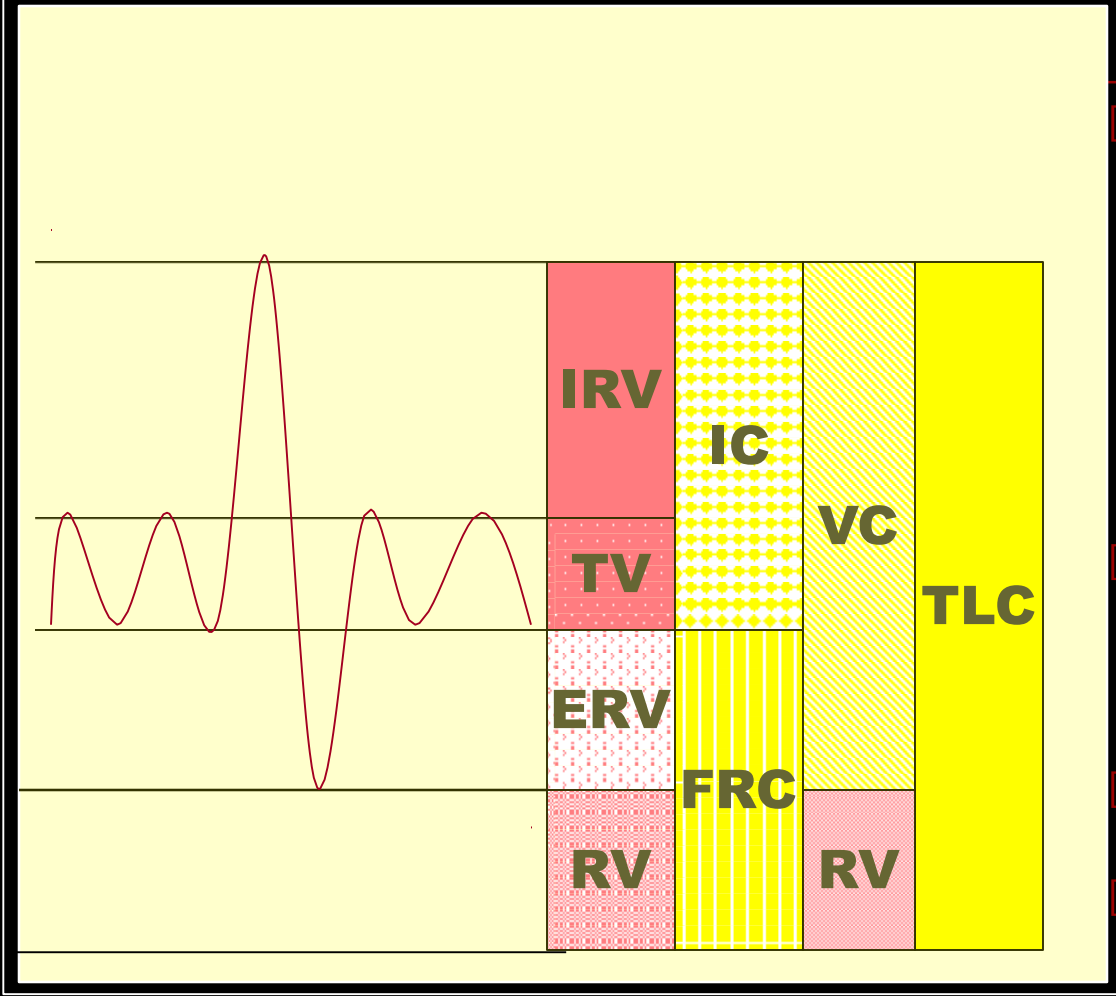
Inspiratory Capacity (IC)



- Maximum amount of air which can be inspired after completing tidal expiration.

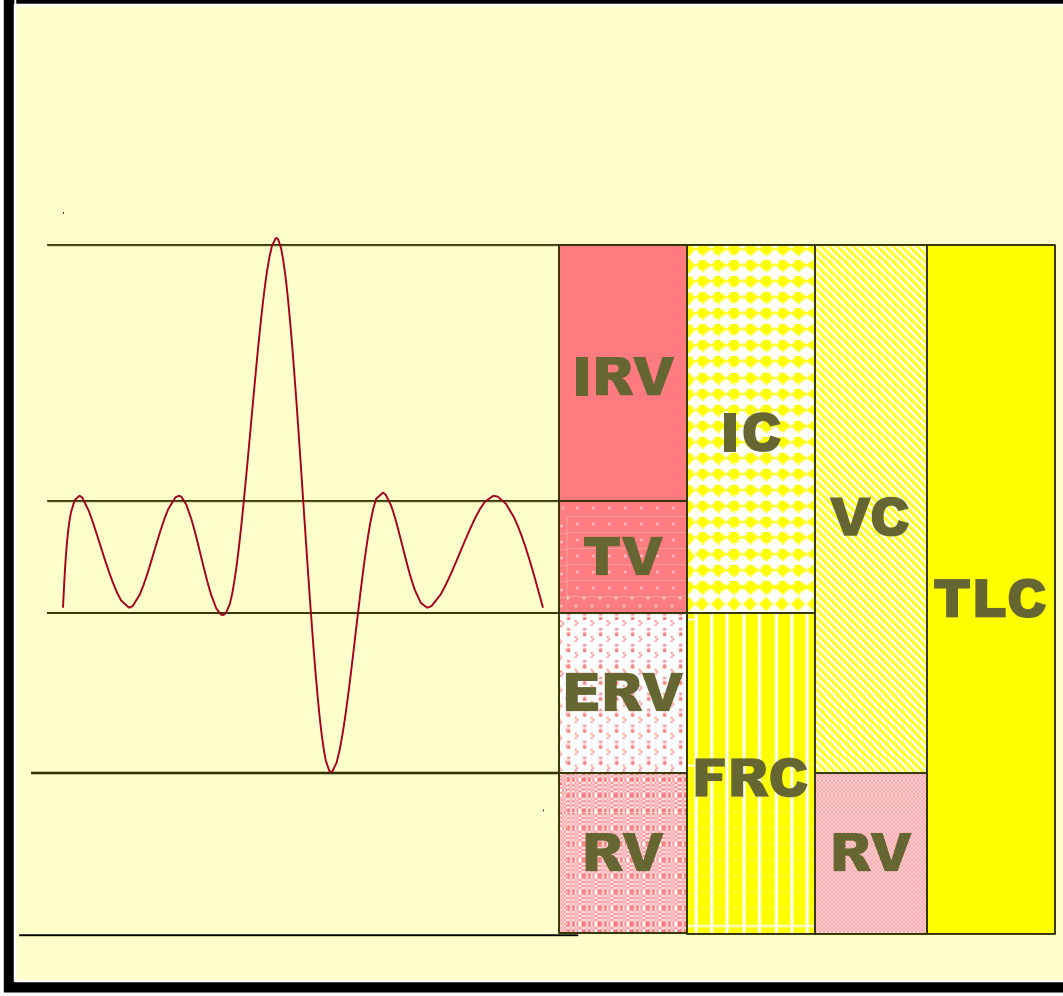
- **IC = IRV + TV**
- Males =3800 ml
- Females = 2400 ml

Functional Residual Capacity (FRC)



- Volume of air remaining in the lungs at the end of tidal expiration.
- **FRC = ERV + RV**
- Males = 2200 ml
- Females = 1800 ml

Vital Capacity (VC)



- Maximal volume of air that can be exhaled from the lungs after a maximum inspiration.

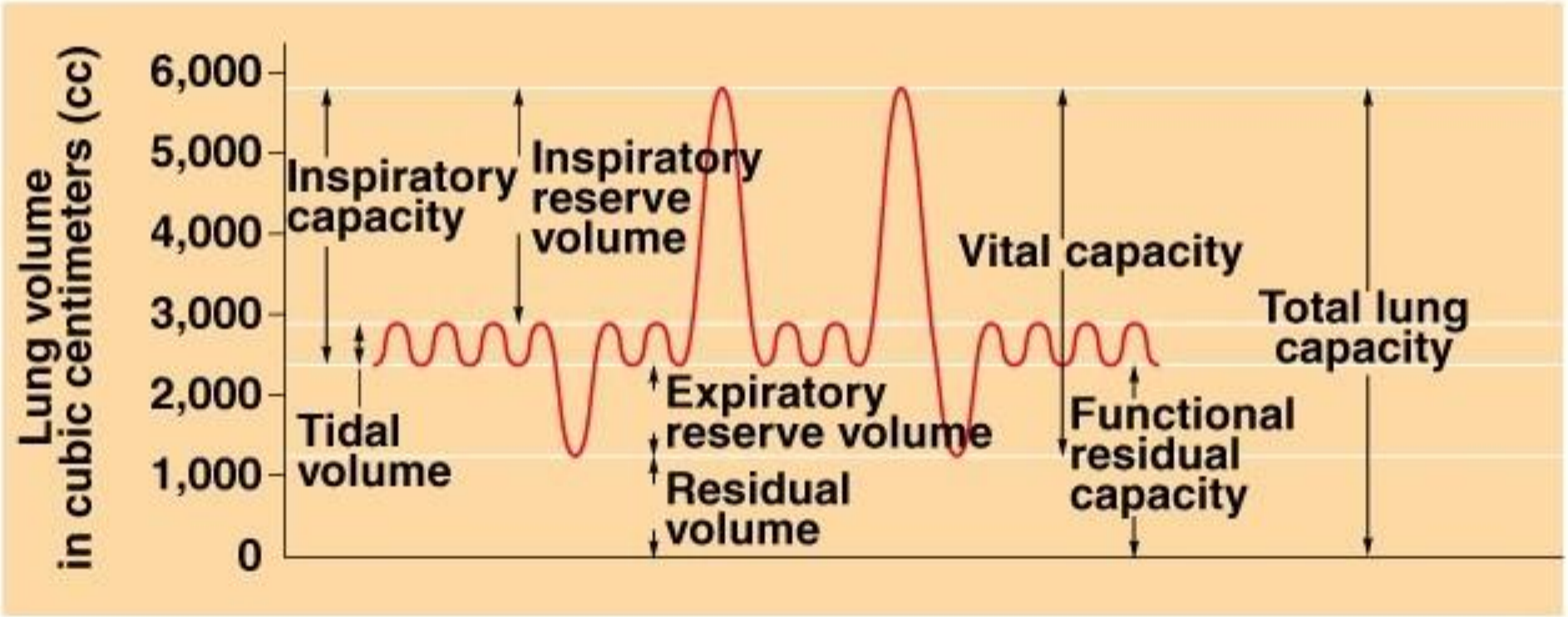
VC= IRV+TV +ERV

- Males =4800 ml
- Females =3100 ml

Factors affecting VC

- Physiological:
  - Physical dimensions –size & physical dev. (M>F)
  - Age –dec. in old age
  - Strength of respiratory muscles –inc. in swimmers & divers
  - Posture- standing > sitting > lying
  - Pregnancy- dec. VC

- Pathological:
  - Diseases of respiratory system- obstructive & restrictive
  - Diseases of the heart- CHF
  - Diseases of the pleura- pleural effusion
  - Diseases of the abdominal cavity- ascitis

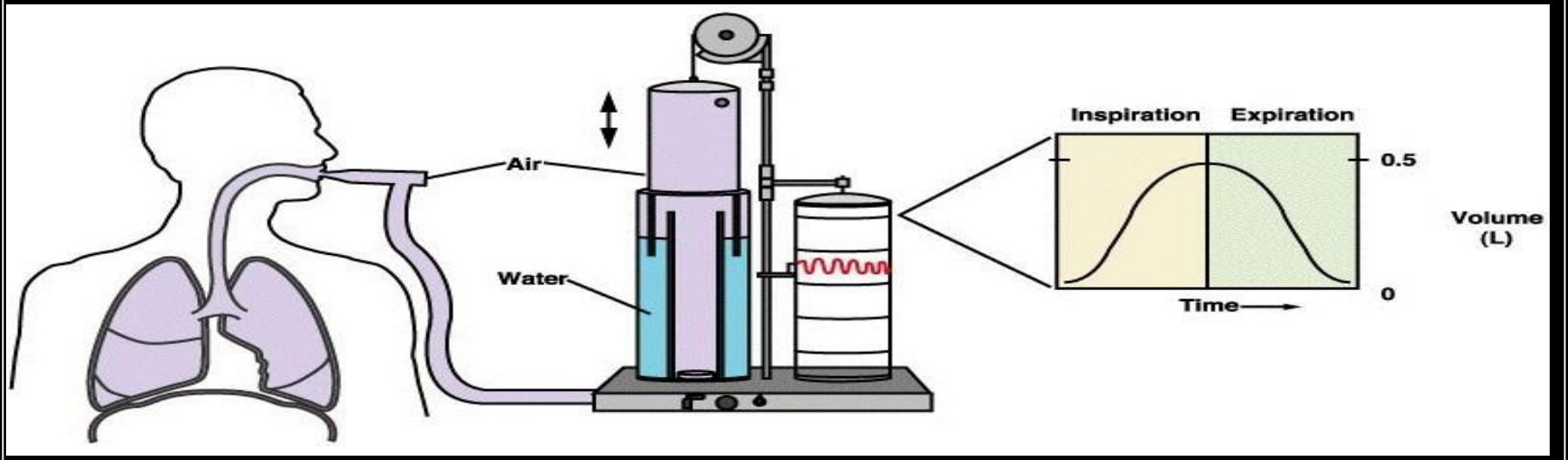


Important

Volume	Value (litres)	
	In men	In women
Inspiratory reserve volume	3.3	1.9
Tidal volume	0.5	0.5
Expiratory reserve volume	1.0	0.7
Residual volume	1.2	1.1

Volume	Average value (litres)	
	In men	In women
Vital capacity	4.8	3.1
Inspiratory capacity	3.8	2.4
Functional residual capacity	2.2	1.8
Total lung capacity	6.0	4.2

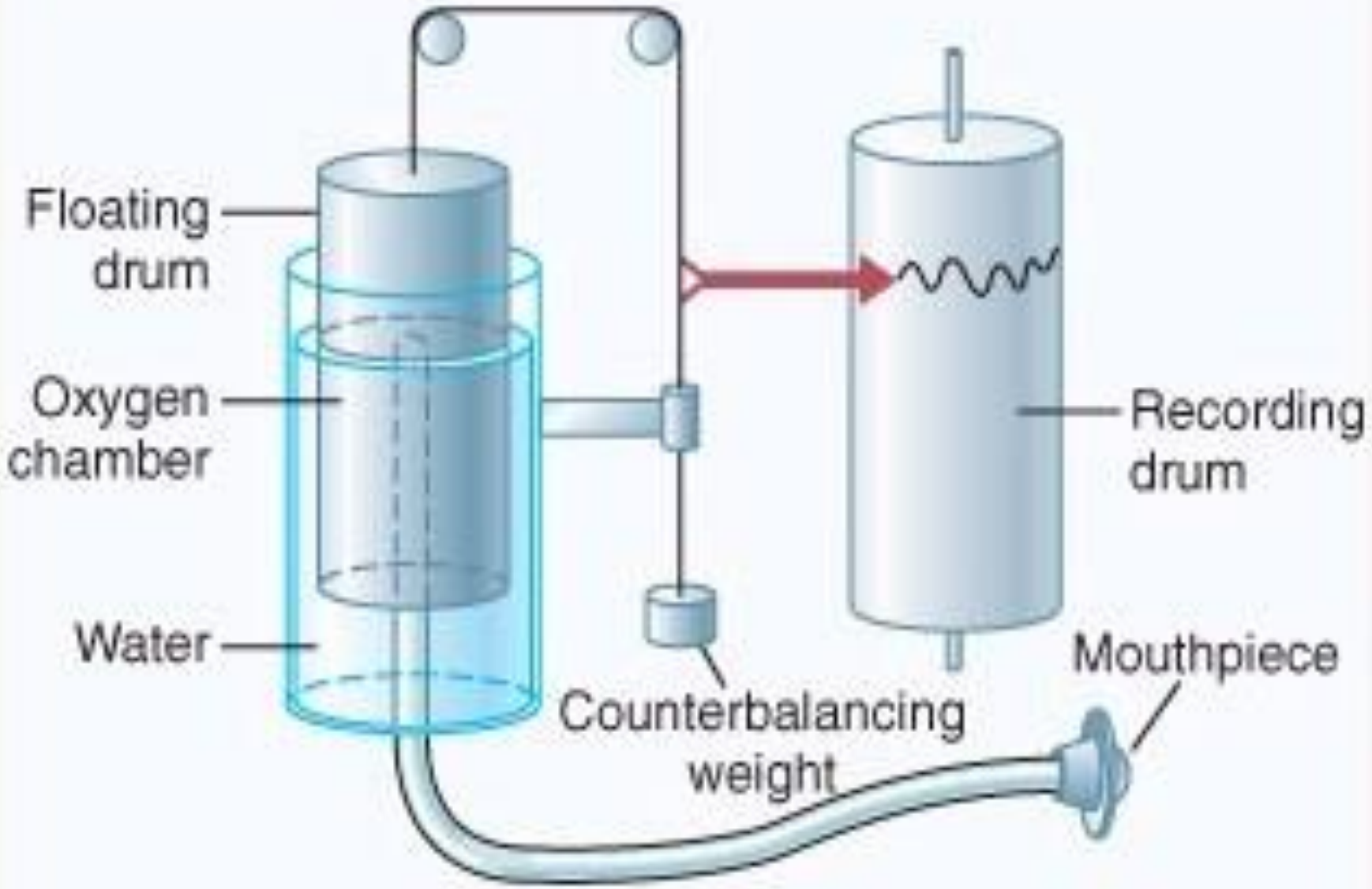
Spirometer



- Instrument used to measure lung volumes & capacities.

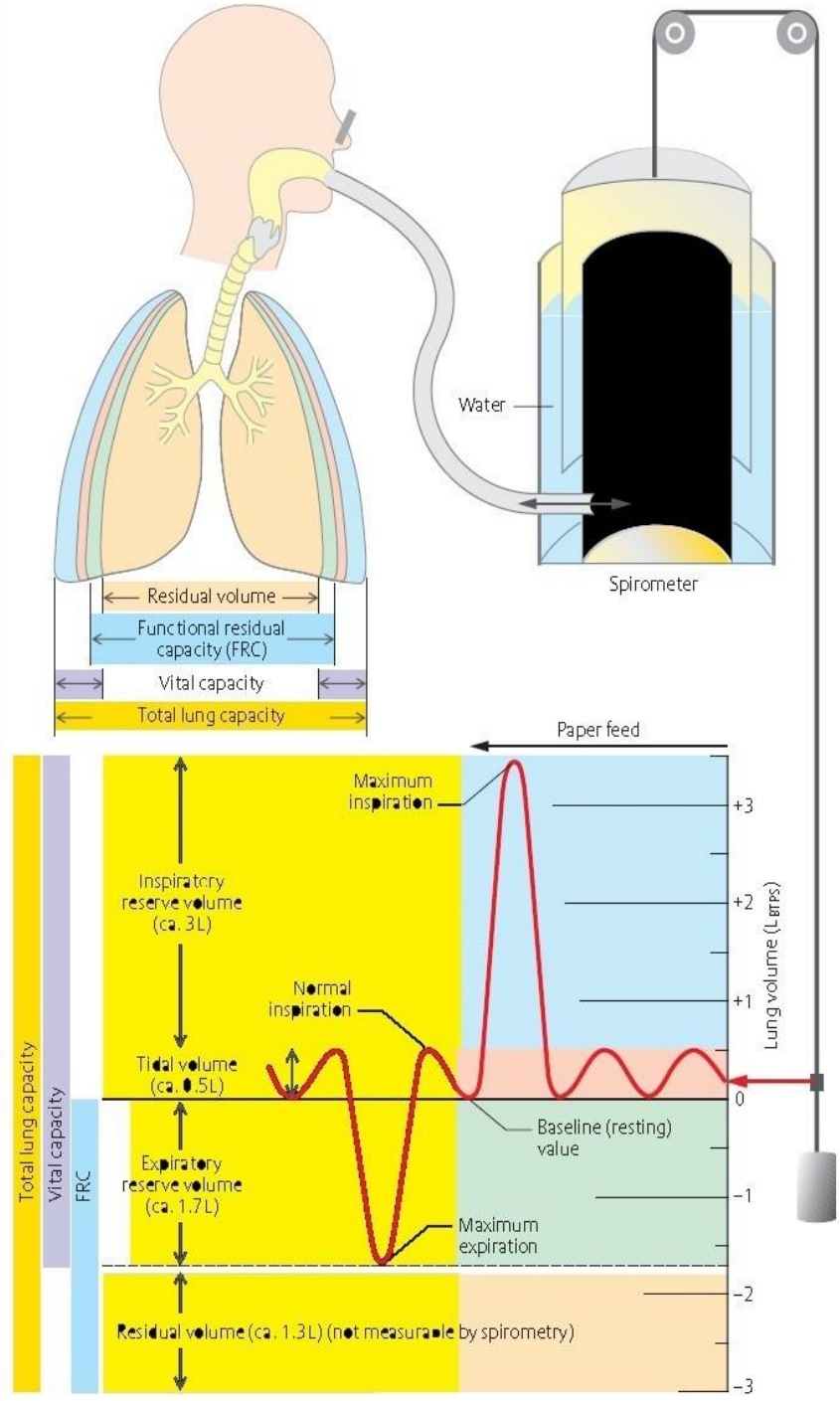
- It records the amount of air and the rate of air that is breathed in and out over a specified time.

Spirometer


Floating drum
Oxygen chamber
Water
Counterbalancing weight
Recording drum
Mouthpiece

Spirometer

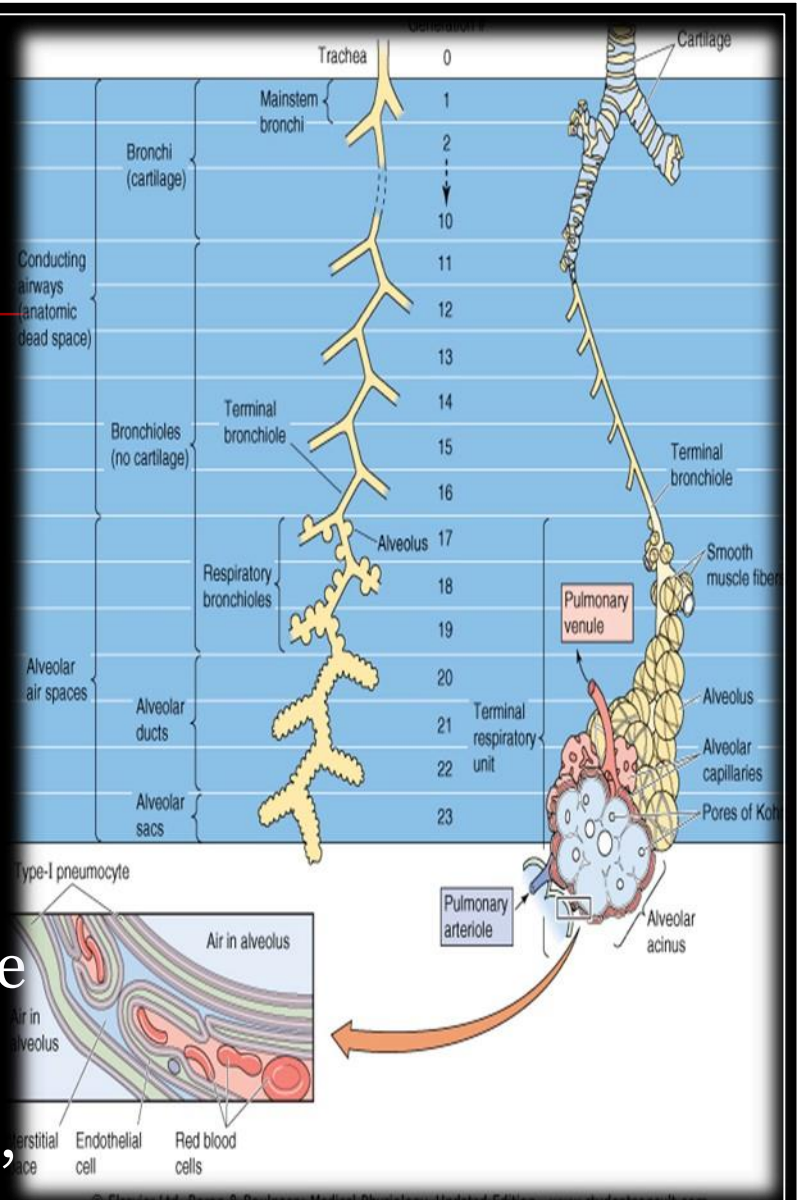
- Can not measure RV, FRC & TLC.
- FRC is measured by:
  - Nitrogen washout method
  - Helium dilution method
- RV = FRC – ERV



DEAD SPACE

Introduction

- Total 23 generations of airways b/w trachea & alveolar sac.
- First 16 generations:
  - Conducting zone
  - No gaseous exchange
  - Up to terminal bronchiole
- Last 7 generations
  - Transitional & respiratory zone
  - Gaseous exchange
  - Include respiratory bronchiole, alveolar ducts & alveoli



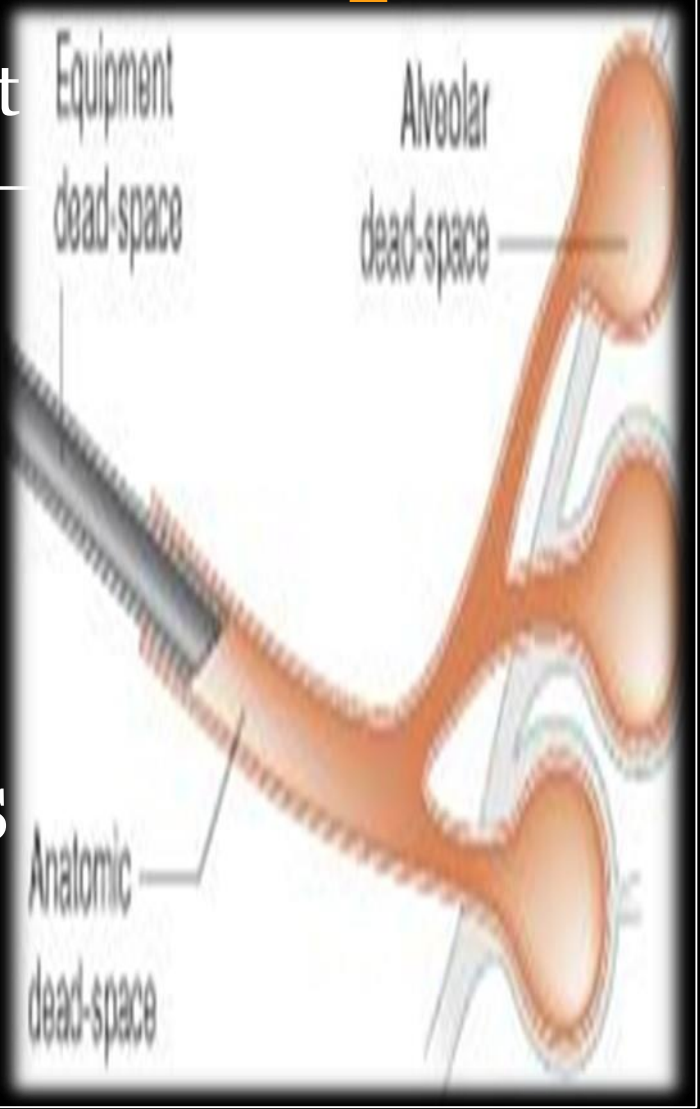
Dead Space

- Part of the tidal volume that does not take part in gaseous exchange with pulmonary capillary blood.

- This can be:
  - Anatomical dead space
  - Alveolar dead space
  - Total (Physiological) dead space

Total (Physiological) dead space

- Total volume of inspired air that ~~does not equilibrate with the~~ pulmonary capillary blood.
- Total DS = Anatomical DS + Alveolar DS
- In a healthy individual, Total DS and Anatomical DS are equal.



Measurement of dead space

- Anatomic dead space –Single breath N_2 curve

- Total dead space –Bohr's equation

$$PECO_2 \times VT = PaCO_2 \times (VT - VD) + PICO_2 \times VD$$

PCO 2 of the expired gas (PECO 2)
Arterial PCO 2 (PaCO 2)
PCO 2 of inspired air (PICO 2)
Tidal volume (VT)
Dead space volume (VD)

Minute ventilation (MV)
Pulmonary Ventilation (PV)

- Volume of air inspired or expired by lungs in one minute.

MV=TV x RR

=500 x 12

=6 liter/min

Peak Expiratory Flow Rate (PEFR)

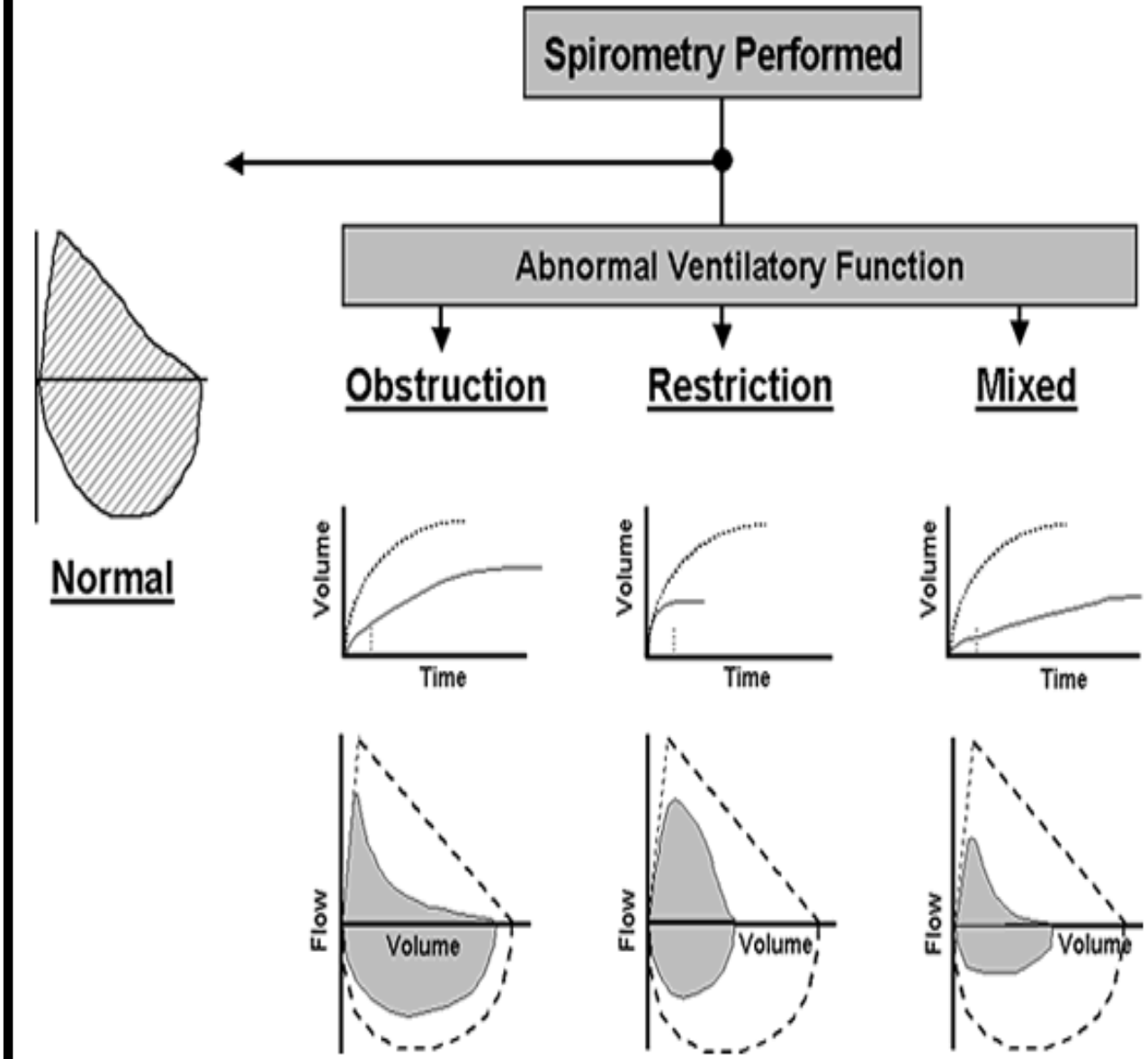
- Maximum velocity with which air is forced out of the lungs in a single forced expiratory effort.
- Normal –350-400 l/min
- Usually indicate large central airway obstruction.
- Measured by Wright's peak flow meter.

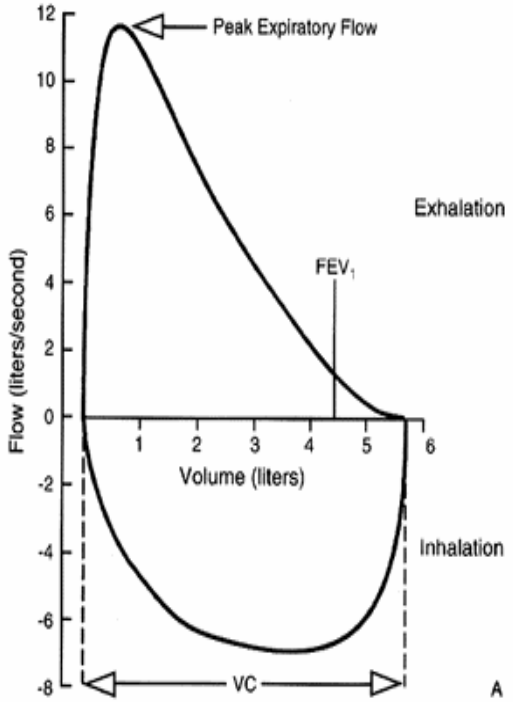
Obstructive vs Restrictive d/s

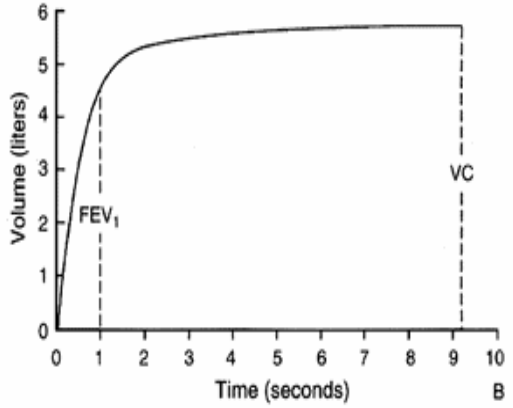
- **Obstructive**
  - Asthma
  - Chronic obstructive lung disease (chronic bronchitis, emphysema)
  - Bronchiectasis
  - Cystic fibrosis
  - Bronchiolitis
- **Restrictive—Parenchymal**
  - Sarcoidosis
  - Idiopathic pulmonary fibrosis
  - Pneumoconiosis
  - Drug- or radiation-induced interstitial lung disease
- **Restrictive—Extraparenchymal**
- Neuromuscular
  - Diaphragmatic weakness/paralysis
  - Myasthenia gravis
  - Cervical spine injury
- Chest wall
  - Kyphoscoliosis
  - Obesity
  - Ankylosing spondylitis*a*

Obstructive vs Restrictive d/s

Test	Obstructive	Restrictive
FEV_1	↓↓	↓
VC	↓ or normal	↓↓
FEV_1/VC	↓	Normal or ↑


Spirometry Performed
Abnormal Ventilatory Function
Obstruction
Restriction
Mixed
Normal
Volume
Time
Flow
Volume


Peak Expiratory Flow
Exhalation
FEV1
Flow (liters/second)
Volume (liters)
Inhalation
VC
A


Volume (liters)
FEV1
VC
Time (seconds)
B