Respiratory ventilation

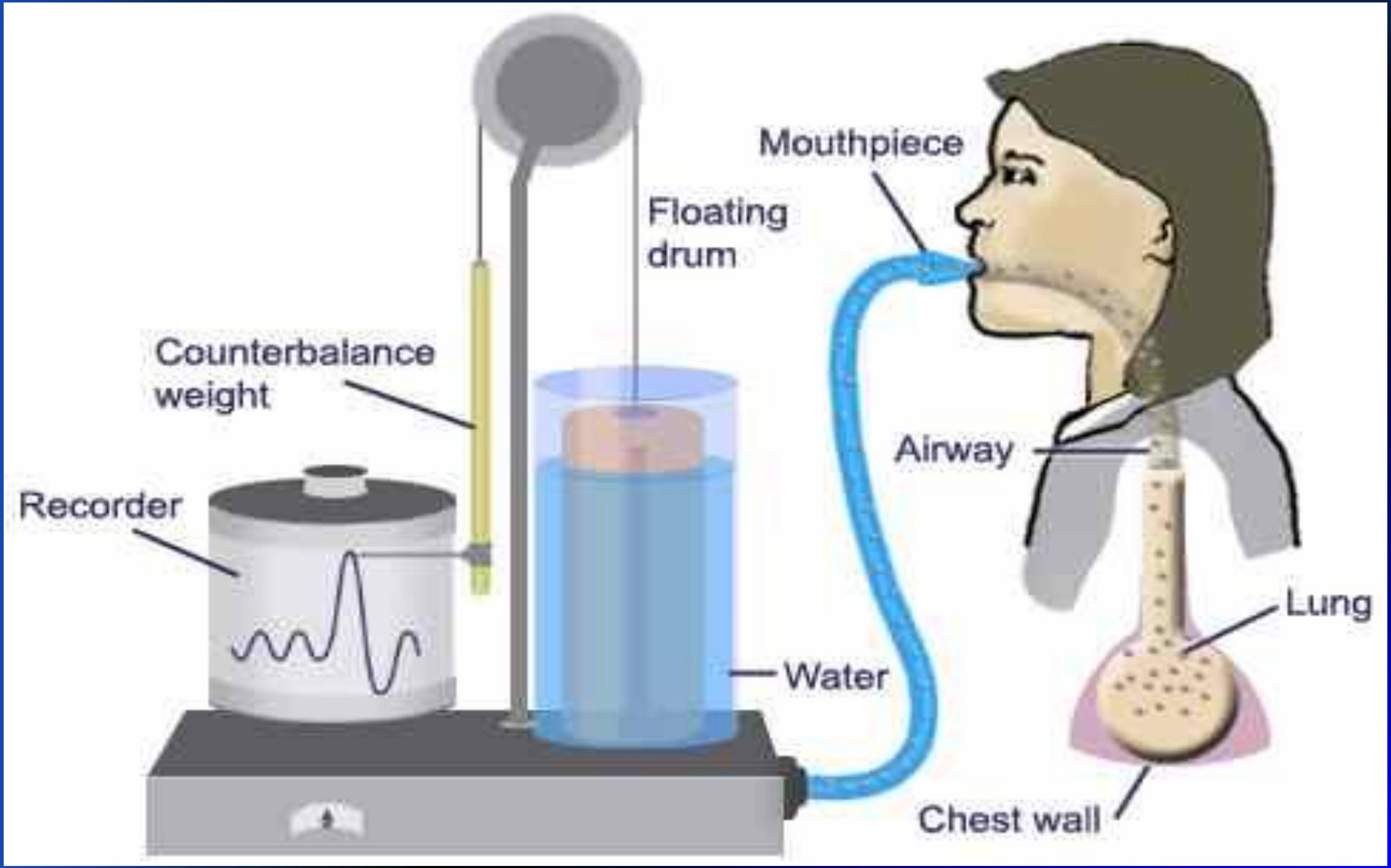
Learning objectives

- **By the end of the following 2 lectures you should be able to: -**
- 1-Define the various Lung Volumes and capacities and provide typical values for each.
- 2-Define ventilation rate, their typical values, and their measurement.
- 3- Describe $FEV_{1.0}$ and its role in differentiating obstructive and restrictive lung diseases
- 4- Understand air movement and airway resistance:

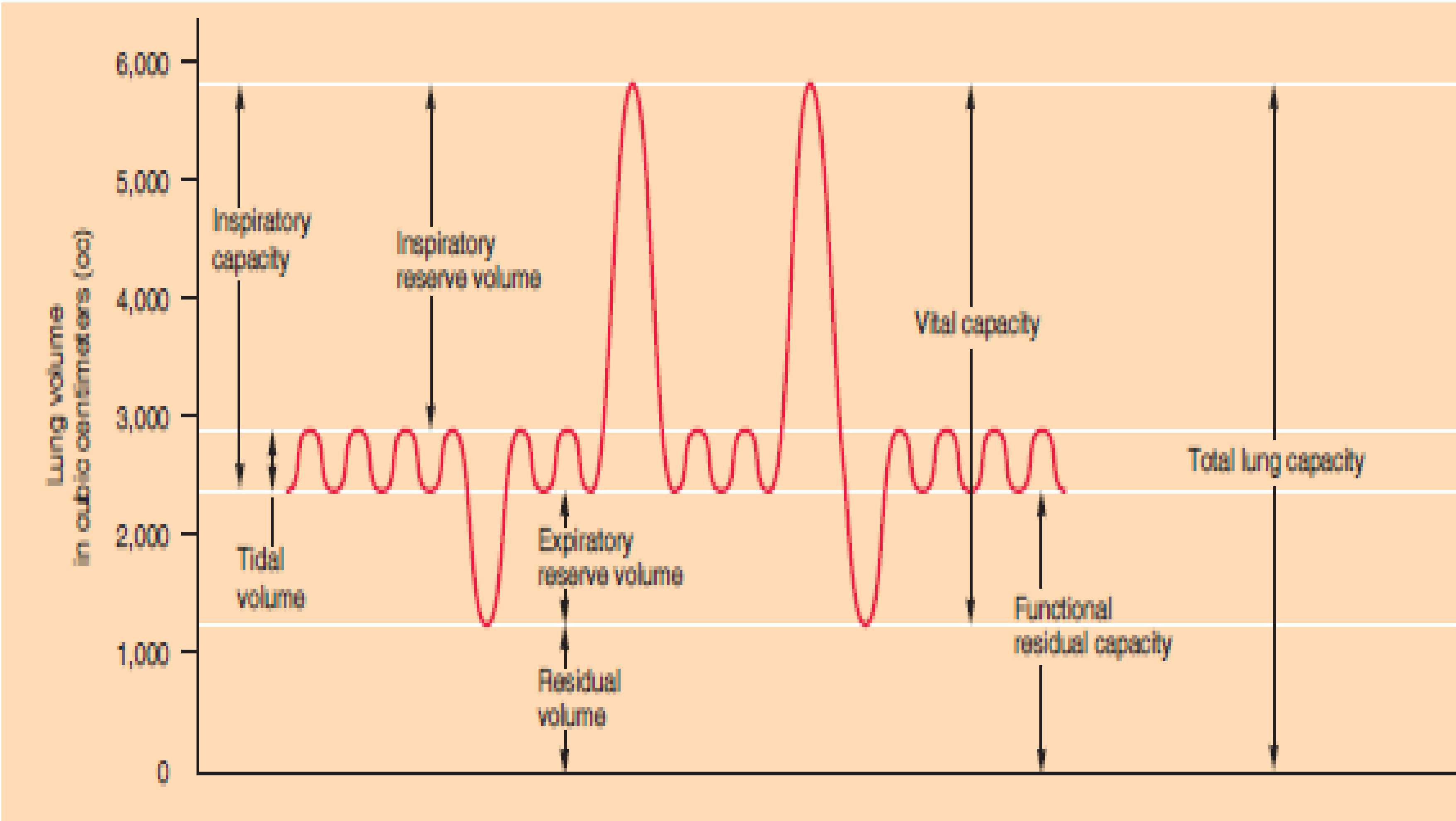
Definition, determinants, role of autonomic nervous system and mechanical factors

- 5- Describe the types of dead space. State a volume for the anatomical dead space.
- 6- Define the term minute ventilation and state a typical value.
- 7- Distinguish minute ventilation from alveolar ventilation.
- 8-Understand the work of breathing

Spirometry


Mouthpiece
Floating
drum
Counterbalance
weight
Airway
Recorder
Lung
Water
Chest wall

Spiromgram


Lung volume
in cubic centimeters (cc)
6,000
5,000
4,000
3,000
2,000
1,000
0
Inspiratory
capacity
Inspiratory
reserve volume
Vital capacity
Total lung capacity
Tidal
volume
Expiratory
reserve volume
Residual
volume
Functional
residual capacity

Lung volumes and capacities

4 lung volumes:

Tidal volume (TV): is the volume of air inspired or

expired with each normal breath (~500 ml)

Inspiratory reserve (IRV): is the extra volume of air that can be inspired over and above the normal tidal volume when the person inspires with full force(~3000 ml)

Expiratory reserve (ERV): is the maximum extra volume of air that can be expired by forceful expiration after the end of a normal tidal expiration (~1100 ml)

Residual volume (RV) is the volume of air remaining in the lungs after the most forceful expiration (~1200ml):

Pulmonary capacities

- Two or more lung volumes are described as pulmonary capacity

1-Inspiratory capacity (IC):*is the*

amount of air a person can breathe in, beginning at the normal expiratory level and distending the lungs to the maximum amount.

IC= TV+ IRV= 500+ 3000= 3500 ml

2-The functional residual capacity (FRC)

Is the amount of air that remains in the lungs after normal tidal expiration. Acts as a buffer against extreme changes in alveolar gas levels with each breath.

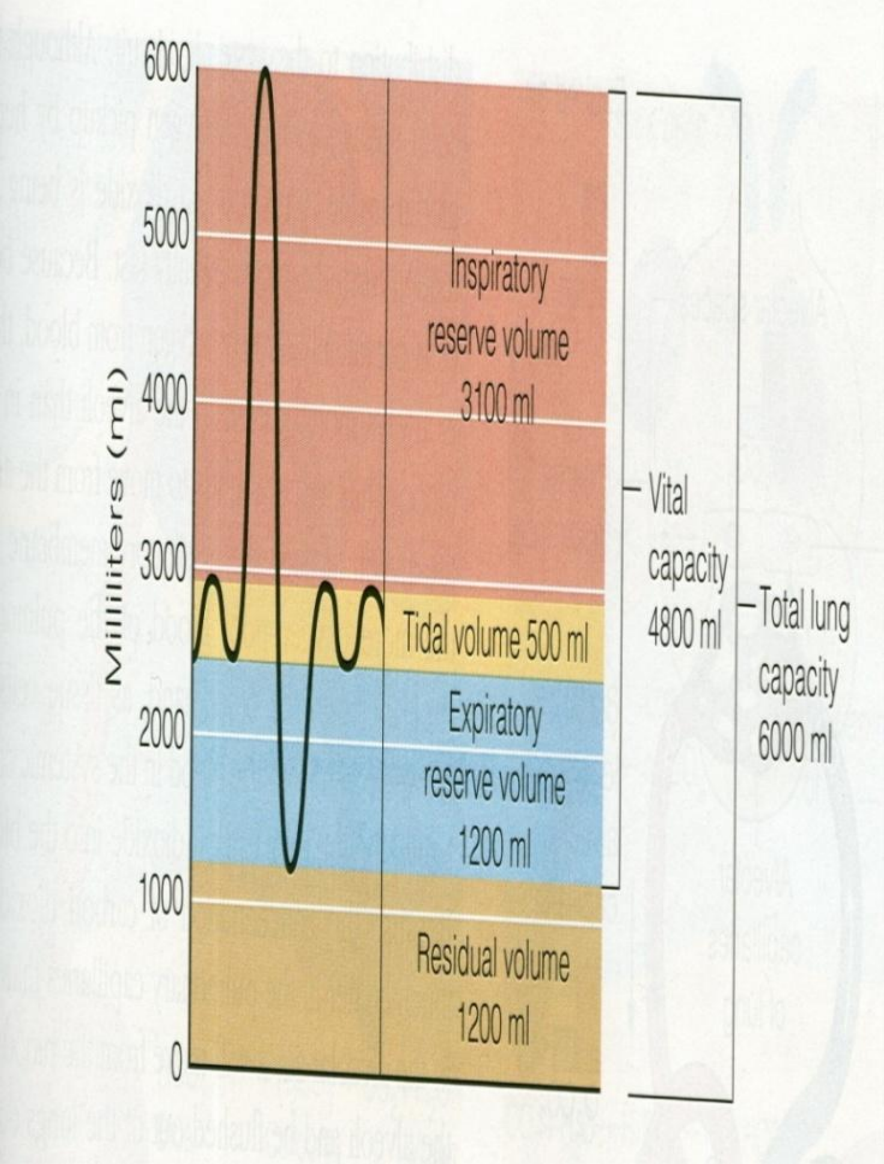
FRC= ERV+ RV= 1100+ 1200= 2300 ml

Cont… lung capacities

3-The vital capacity (VC):*the maximum amount of* air a person can expel from the lungs after first filling the lungs to their maximum extent and then recording expiring to the maximum extent.

= TV+IRV+ERV =

500+3000+1100 =4600 ml



Cont.. Lung Capacities

4-The total lung capacity (TLC): *is the maximum volume to* which the lungs can be expanded with the greatest possible effort

= TV+IRV+ERV+RV = 500+3000+1100+ 1200= 5800ml.

- ***All lung volumes and capacities*** are 20-25% less in women than men , they are greater in large athletic people than in small asthenic people.

**Determination of the FRC, RV, TLC

- ***Closed circuit Helium Dilution Method***

$$C1 \times V1 = C2 \times V2$$

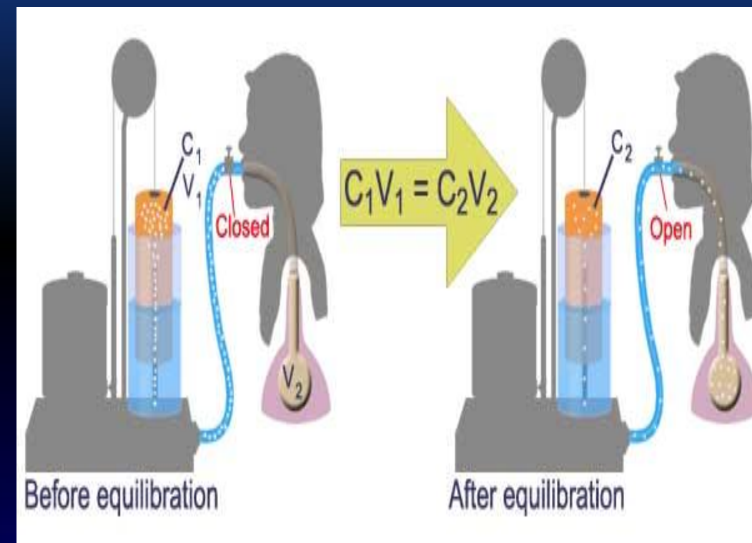
C1: concentration of Hi in spirometry

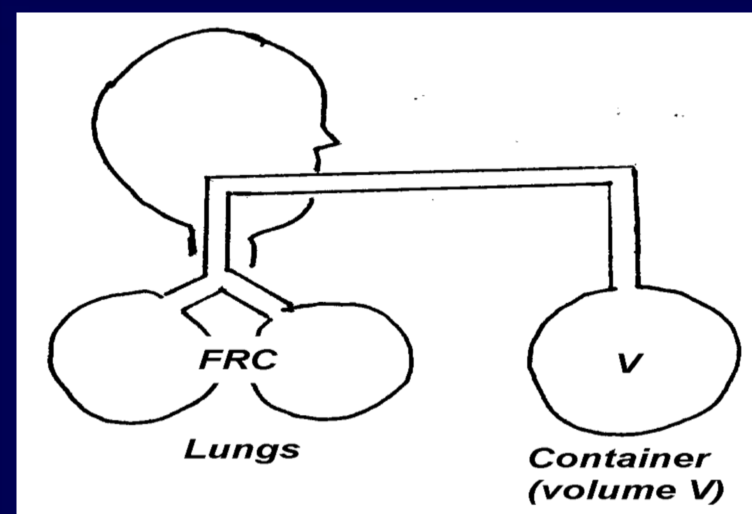
V1: volume of air in the spirometry.

C2: Final concentration of helium

V2 :Volume of spirometry+ FRC

$$FRC = \left(\frac{Ci\ He\ (C1)}{Cf\ He\ (C2)} - 1 \right) Vi\ Spi\ (V1)$$





Forced Vital Capacity (FVC) and FEV1

(Timed vital capacity)

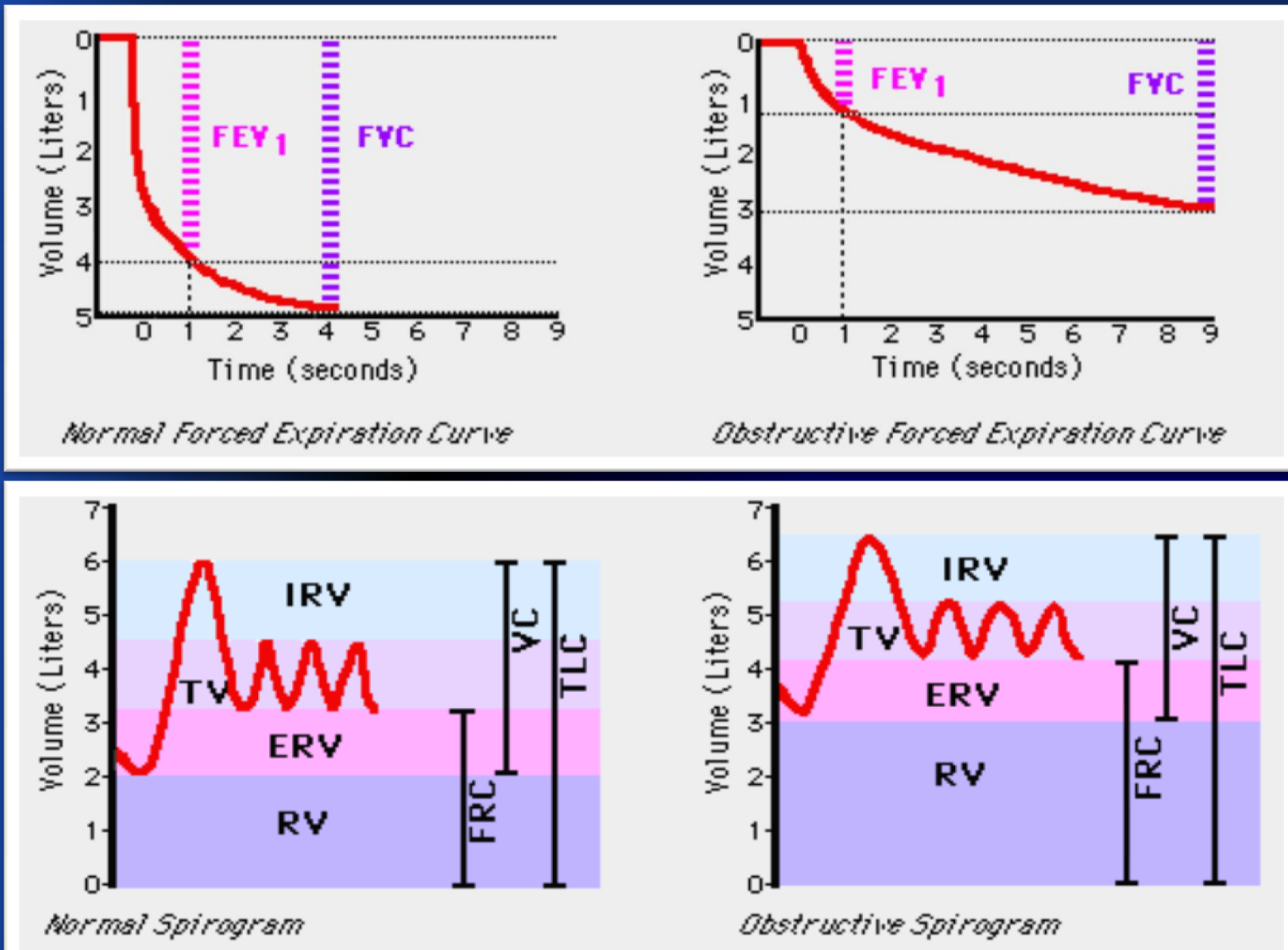
- *The person is asked to inspire as deeply as possible and then to breath out as hard and as fast as he can.* The expiration is continued until he expired all the air out and thus forced vital capacity is obtained. During this process the volume of air expired in the first second is collected and is known as **FEV1.**

FEV1/FVC ratio

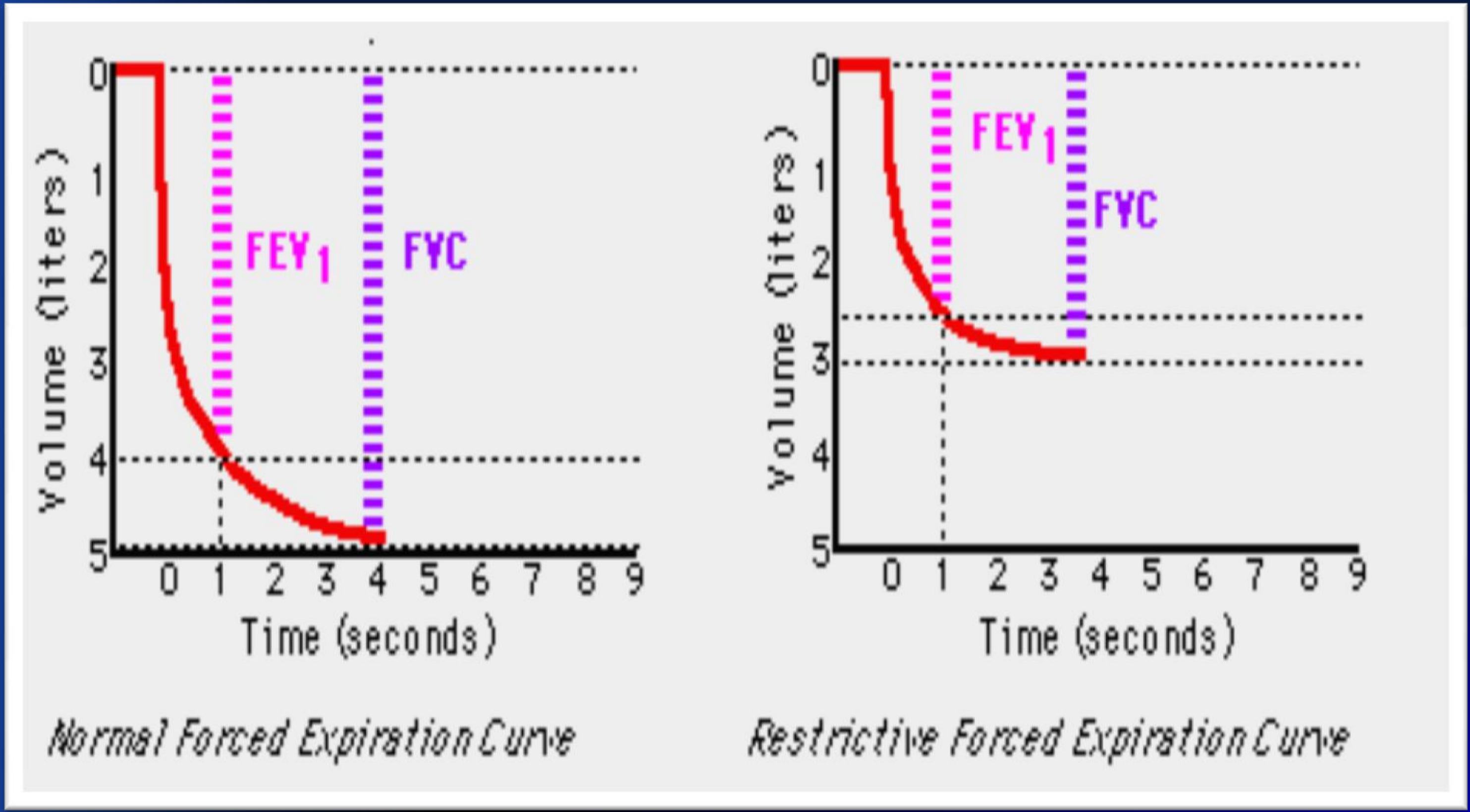
Normally it is about 80%.

- This ratio differentiate between obstructive and restrictive lung diseases
- **is normal** in restrictive lung diseases (pulmonary fibrosis)
- It decreases in obstructive (bronchial asthma, emphysema)

Obstructive Ventilatory Defect



Restrictive Ventilatory Defect



Minute respiratory volume

- ***MRV = Respiratory rate x Tidal volume***
- ***= RR X TV***

= 12 X 500 = 6L/min.

it could rise to 200 L/min or more than 30 times normal if RR = 40 TV= 4600 ml in young adults man

Dead space and its effect on alveolar ventilation

- the volume of air present in the conductive part of the respiratory passages= 150 ml

- Anatomical versus physiological dead space:

  On occasion some of the alveoli are none functioning or partially functioning due to absent or poor blood flow so when the alveolar dead space is included, this called physiologic dead space

Alveolar ventilation

- *Rate of alveolar ventilation per min*

Is the total volume of new air entering the adjacent gas exchange area each minute.

- It = (TV - Dead space volume) x RR
- = 12 (500-150) = 12x 350
- = 4200ml/min

Work of breathing

- During normal quiet respiration almost all respiratory muscles contraction occurs during inspiration,
- whereas expiration is a passive process caused by elastic recoil of the lungs and chest cage structures.

Energy required for respiration

- 3-5% of total energy expended by the body
- Can increase 50 folds during heavy exercise.
- During ***pulmonary disease*** all the three types of work are increased

The work of *inspiration* can be divided into

Compliance work or elastic work

(expand the lungs against the lung and chest elastic forces.

Tissue resistance work

to overcome the viscosity of the lung and chest wall structures)

Airway resistance work

(required to overcome airway resistance ***during the movement of air in the lungs.***

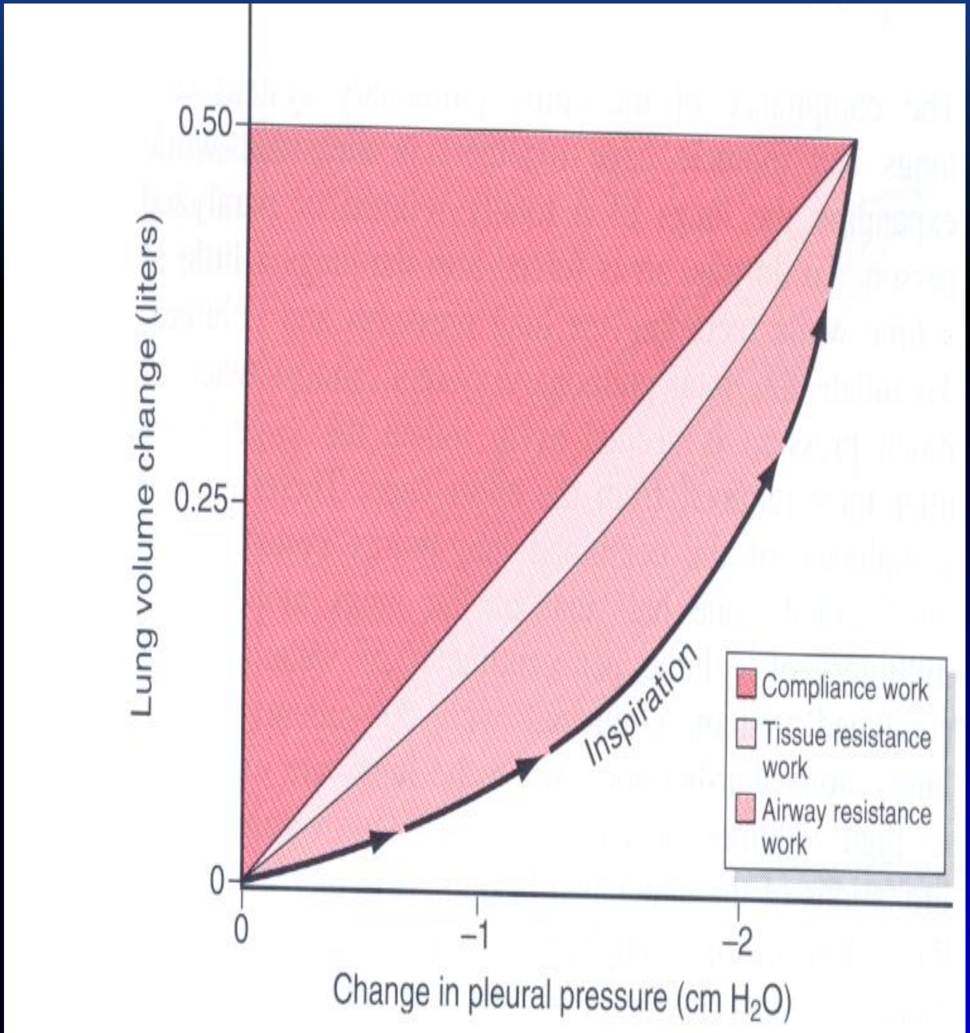
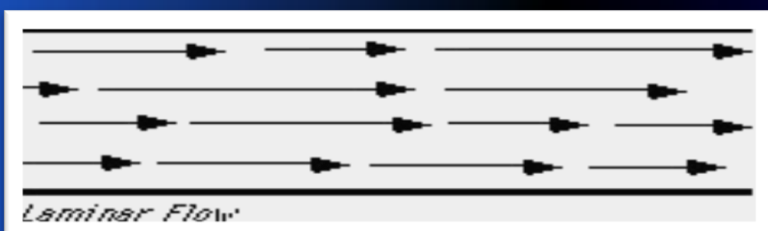
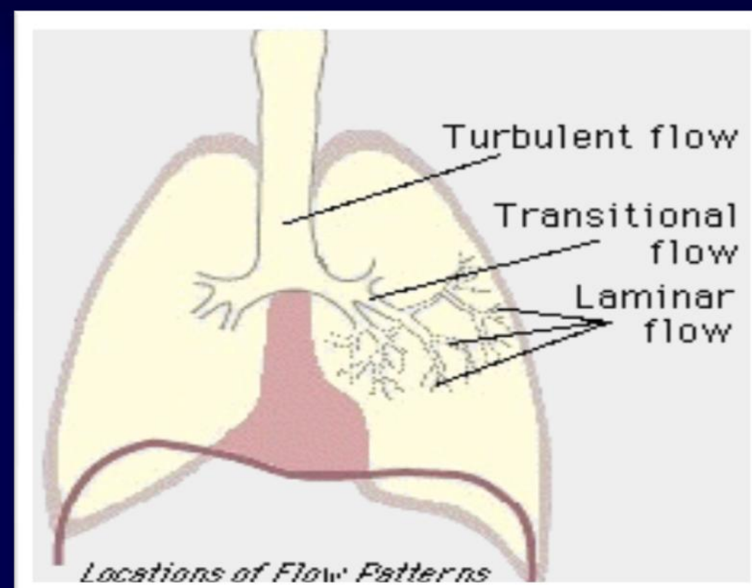


FIGURE 37–5

Factors that influence pulmonary air flow

- F (*flow*)= P(*pressure*)/R (*resistance*)
- Diameter of airways, esp. bronchioles
- Sympathetic & Parasympathetic NS





Factors affecting pulmonary ventilation

- Lung compliance
  - Elasticity:
  - Surface tension of alveolar fluid.
- Airway resistance

Which is the opposition to flow caused by the forces of friction

It depends on

1-whether the flow is laminar or turbulent

2- the dimensions of the airway

3-The viscosity of the gas.

Airway resistance decreases as lung volume increases