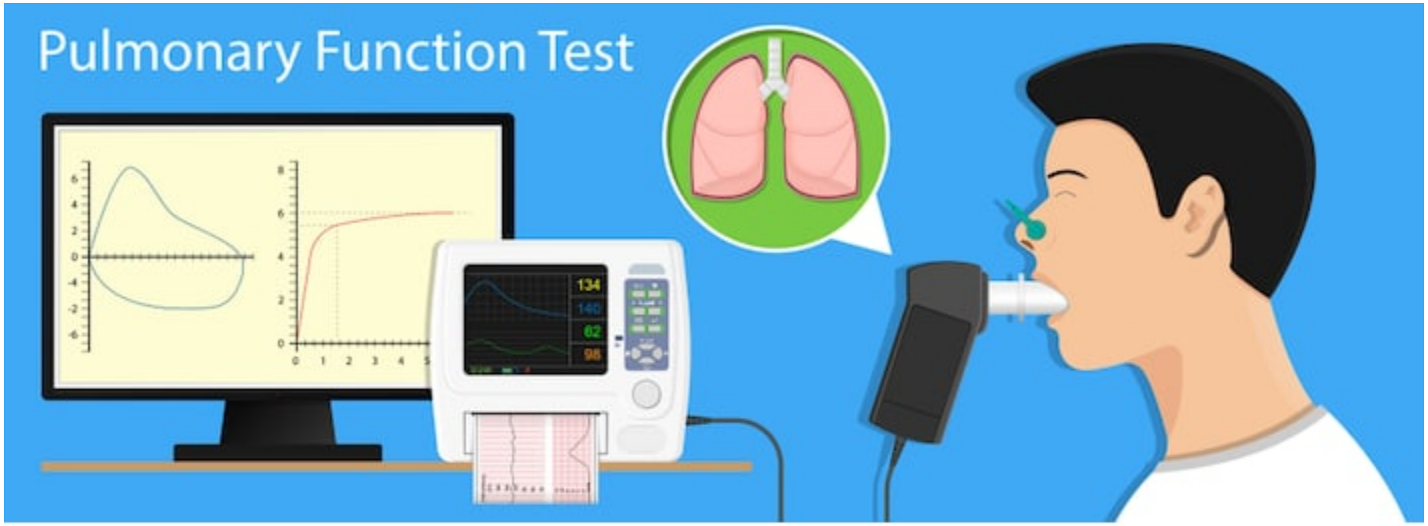

Respiratory ventilation

[Assessment of lung function]

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Learning objectives

- **By the end of the lecture 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 and its role in differentiating obstructive and restrictive lung diseases.

4- Describe the types of dead space. State a volume for the anatomical dead space.

5- Define the term minute ventilation and state a typical value.

6- Distinguish minute ventilation from alveolar ventilation.

Pulmonary Function tests (PFT)
(Measured by Spirometry)

Lung Volumes & Capacities: *Measured by Spirometry*

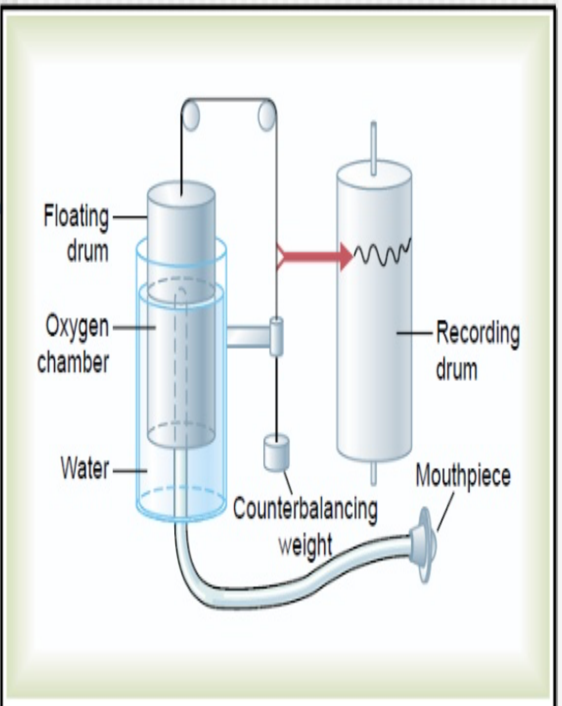


Figure 37-5

Spirometer.

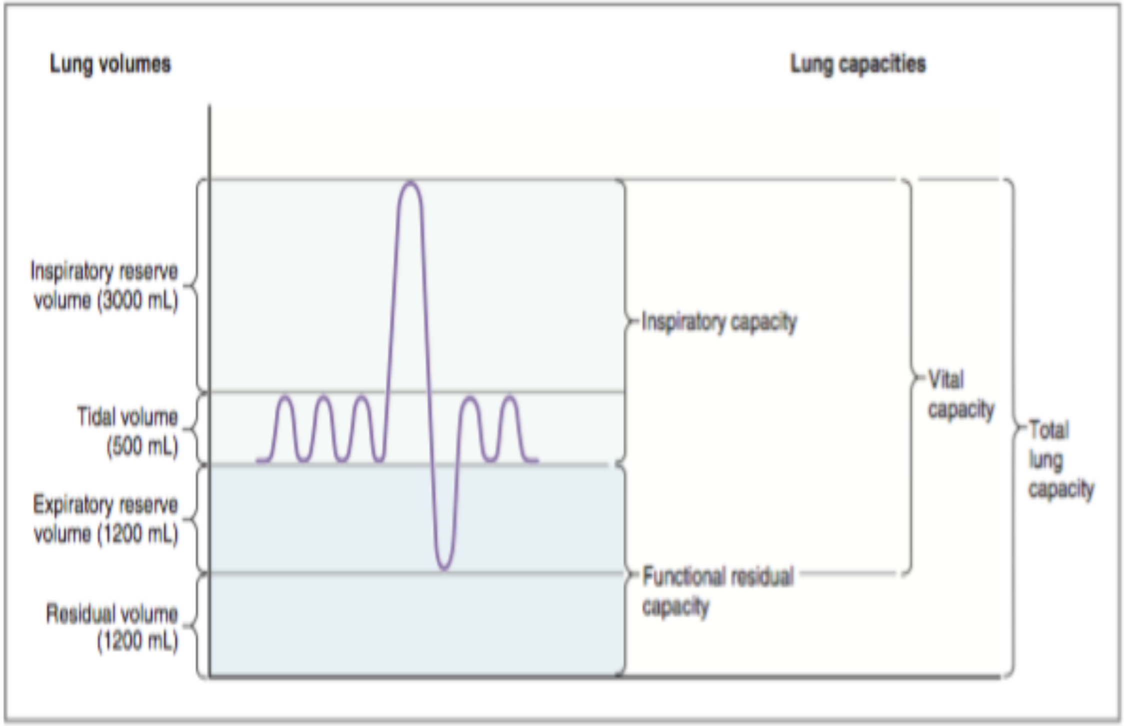


Fig. 5.2 Lung volumes and capacities. Measurements of lung volumes and capacities are made by spirometry. Residual volume cannot be measured by spirometry.

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)

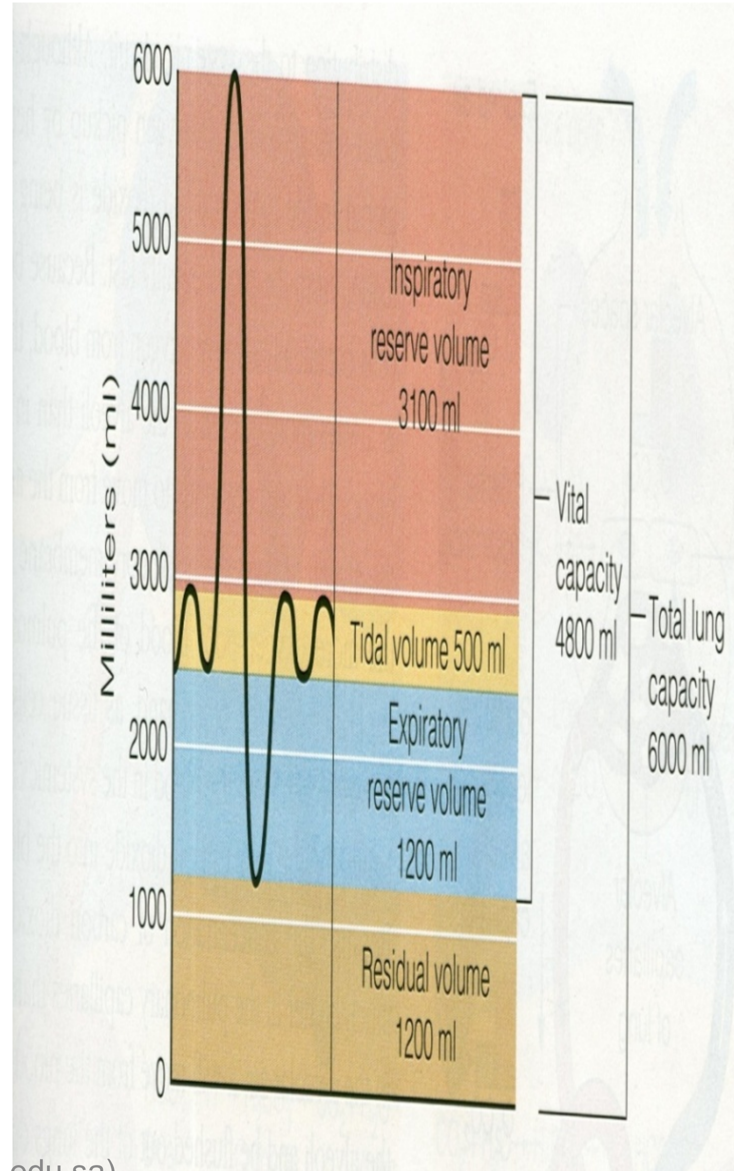
Is the amount of air that remains in the lungs after normal tidal expiration. Acts as a buffer against extreme changes in alveolar gas levels with each breath.

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.

Average Pulmonary Volumes and Capacities for a Healthy Young Adult Man

Pulmonary Volumes and Capacities	Normal Values (ml)
Volumes	
Tidal volume	500
Inspiratory reserve volume	3000
Expiratory volume	1100
Residual volume	1200
Capacities	
Inspiratory capacity	3500
Functional residual capacity	2300
Vital capacity	4600
Total lung capacity	5800

**Determination of the FRC, RV, TLC

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

C1xV1 = C2xV2

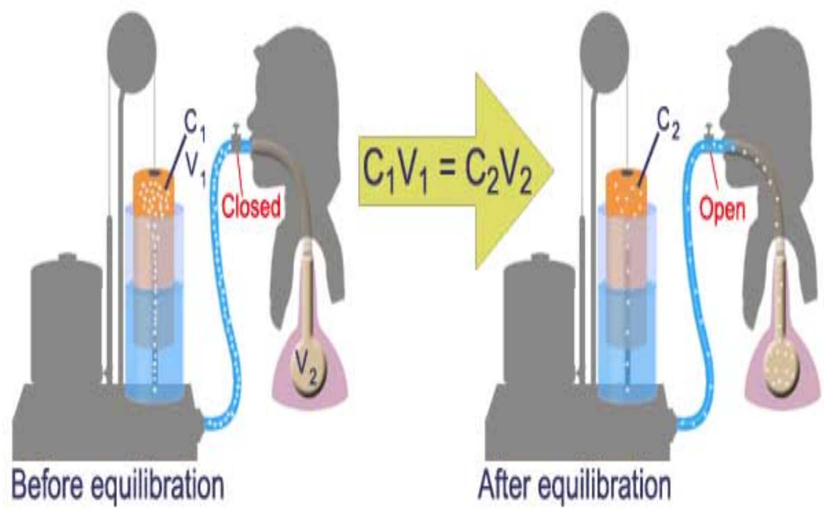
C1: concentration of Hi in spirometry

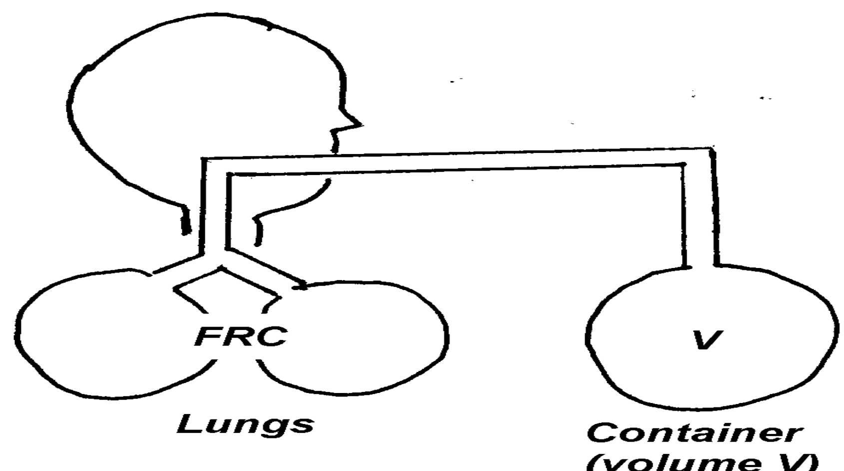
V1: volume of air in the spirometry.

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

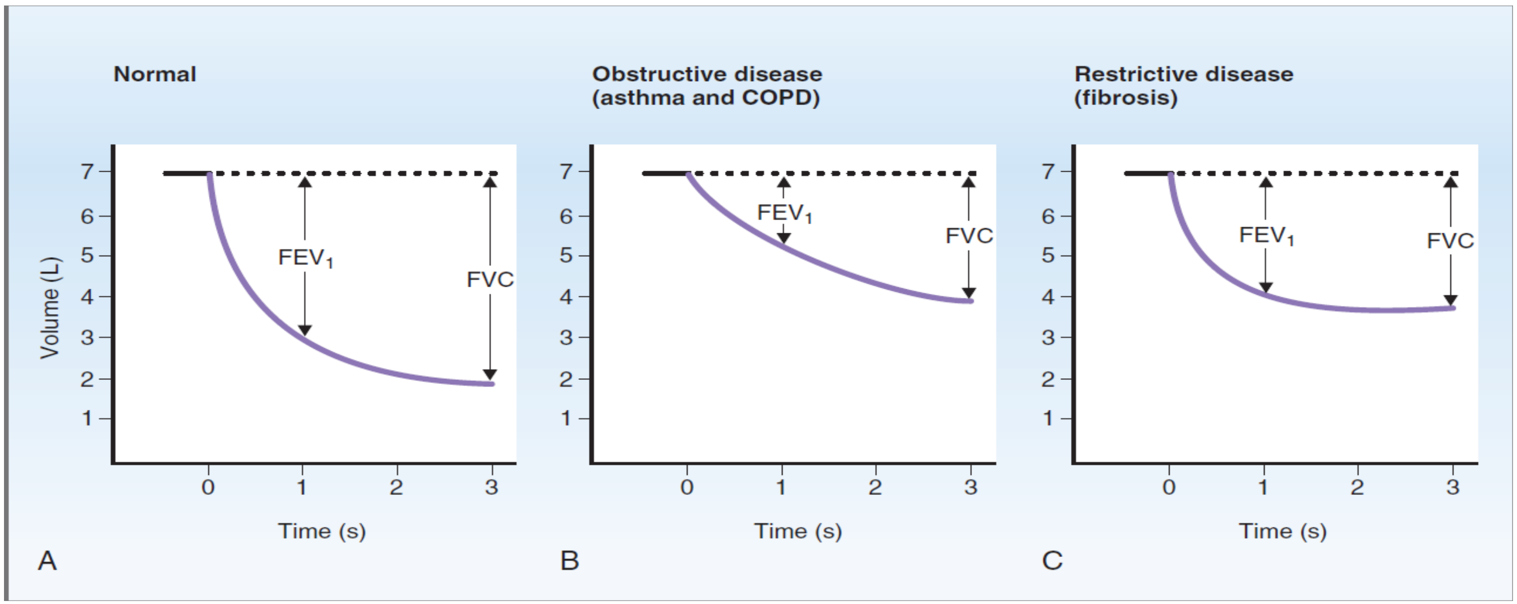
(Timed vital capacity)

- *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.**

Forced Expiratory Volumes

- The volume of air that can be forcibly expired in the first second is called **FEV1.**
- Normally, the entire vital capacity can be forcibly expired in 3 seconds
- FVC and FEV1 are useful indices of lung disease. Specifically, the fraction of the vital capacity that can be expired in the first second, FEV1/FVC, can be used to differentiate among diseases.
- In a **normal** person, FEV1/FVC is approximately 0.8, meaning that 80% of the vital capacity can be expired in the first second of forced expiration.
- In patients with obstructive lung diseases such as **asthma** and **chronic obstructive pulmonary disease (COPD),** FEV1 is decreased Thus FEV1/FVC is also decreased, which is typical of airway obstruction with its increased resistance to expiratory air flow.
- In a patient with a restrictive lung disease such as **fibrosis,** both FVC and FEV1 are decreased in comparison to normal but FEV1 is decreased *less* than FVC is. Thus in fibrosis, FEV1/FVC is normal or increased.

FVC and FEV1 in normal subjects and patients with lung disease



FEV1/FVC ratio

normal Value: Normally it is about 80%.

- Importance: This ratio differentiate between obstructive and restrictive lung diseases
- Is normal (or increased) in restrictive lung diseases (e.g interstitial pulmonary fibrosis)
- It decreases in obstructive (bronchial asthma, emphysema)

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

- Dead space: is the volume air not participating in gas exchange.
- **Anatomical dead space**: volume of air present in the conducting respiratory passages (150 ml)=1/3 of tidal volume. {On expiration, this air is expired first, before any of the air from the alveoli reaches the atmosphere}
- **Non functioning alveoli**: alveoli that cease to act in gas exchange because they are not perfused by capillary blood supply.
- **Physiological dead space**: summation of non functioning alveoli and anatomical dead spaces.
- In healthy subjects both anatomical dead space= Physiological dead space.

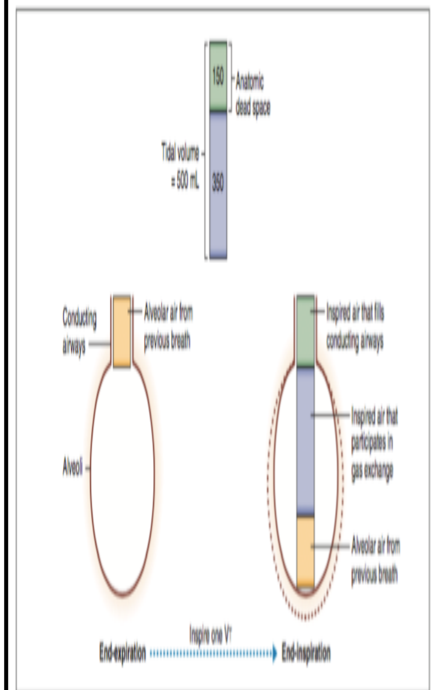


Fig. 5.3 Anatomic dead space. One third of each tidal volume (VT) fills the anatomic dead space.

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Alveolar ventilation

- ***Rate of alveolar ventilation per min:***

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

- It is = (TV - Dead space volume) x RR

  = 12 (500-150) = 12x 350

  = 4200ml/min

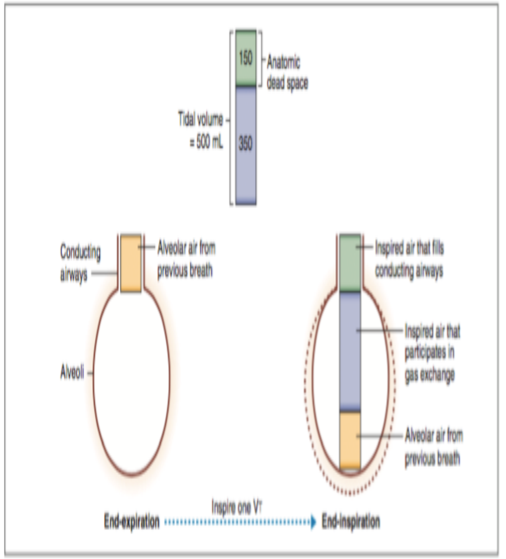

Fig. 5.3 Anatomic dead space. One third of each tidal volume (V_T) fills the anatomic dead space.

Alveolar ventilation is one of the major factors determining the concentrations of oxygen and carbon dioxide in the alveoli.