Respiratory ventilation

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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.

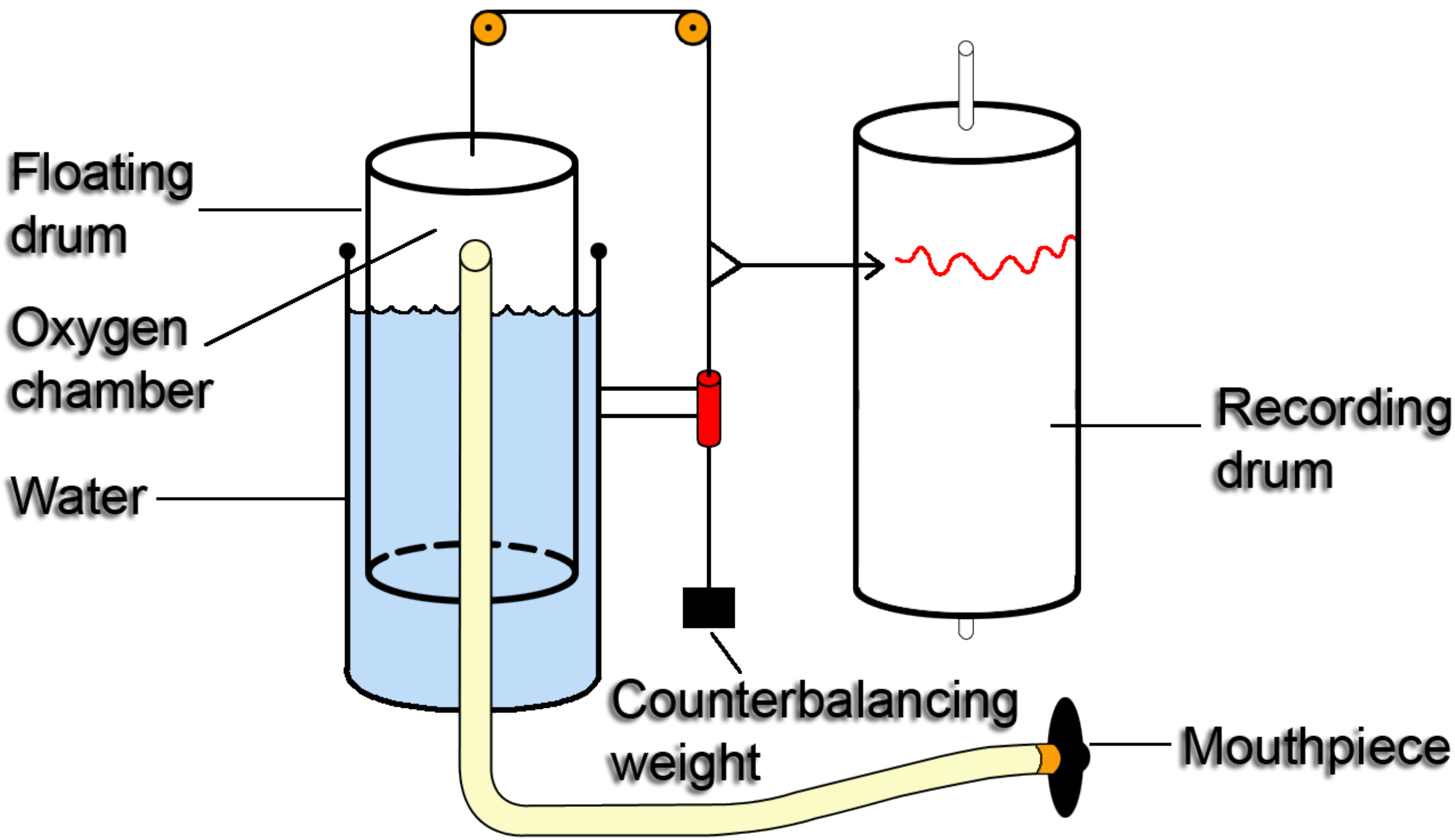
2-Define ventilation rates, their typical values, and their measurement.

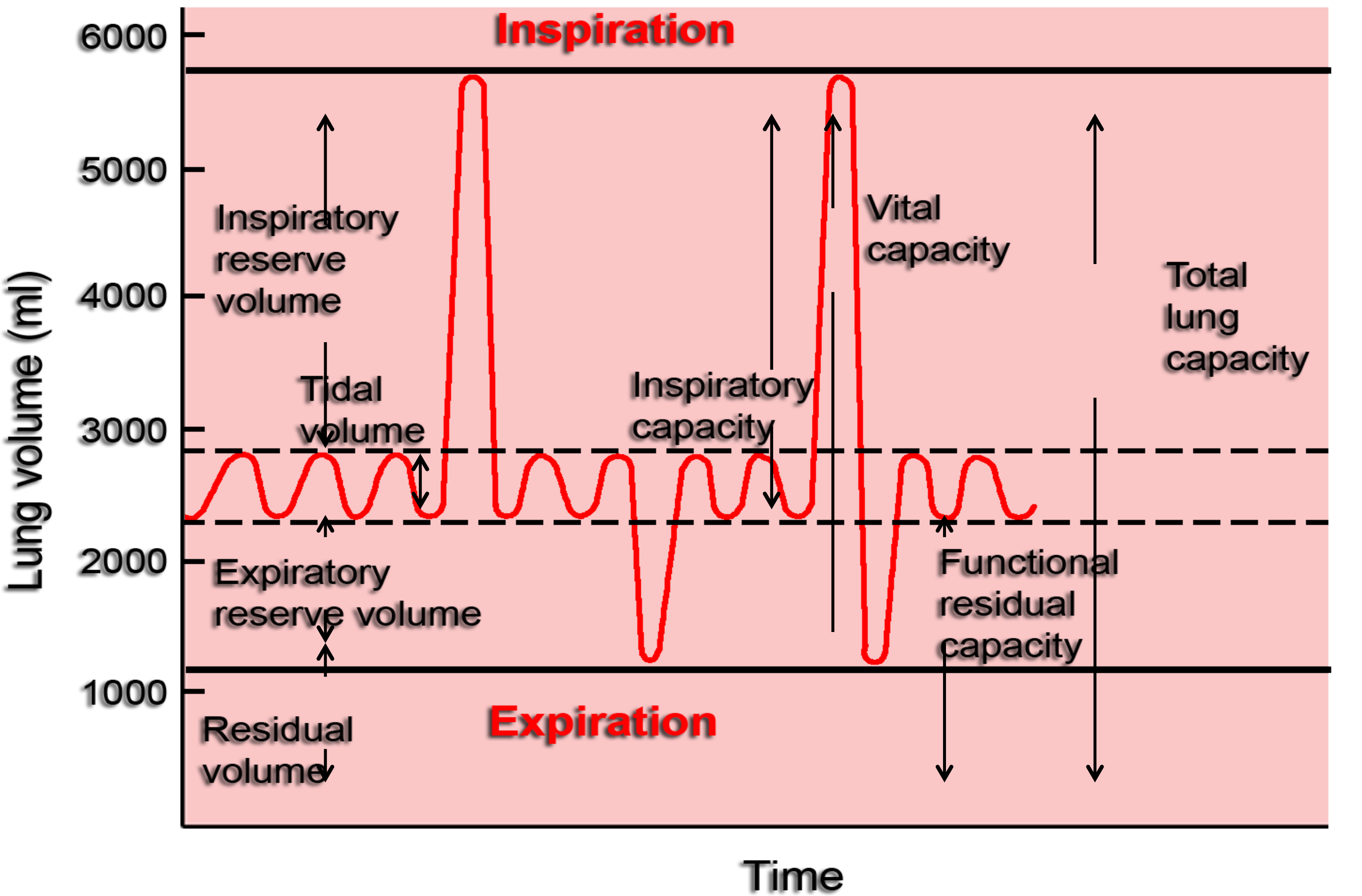
3- Describe FEV_1 and its role in differentiating obstructive and restrictive lung diseases.

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.


Floating drum
Oxygen chamber
Water
Counterbalancing weight
Recording drum
Mouthpiece



Inspiration
Expiration
6000
5000
4000
3000
2000
1000
Lung volume (ml)
Time
Inspiratory reserve volume
Tidal volume
Expiratory reserve volume
Residual volume
Inspiratory capacity
Vital capacity
Functional residual capacity
Total lung capacity

Pulmonary volumes and capacities

Pulmonary volumes (by using spirometer):

1) **Tidal volume –** *is the volume of air inspired or expired with each normal breath = 500ml in young adult man.*

2) **Inspiratory reserve volume –** *is the extra volume of air that can be inspired over and beyond the normal tidal volume = 3000ml.*

3) **Expiratory reserve volume –** *is the extra amount of air that can be expired by forceful expiration after the end of a normal tidal expiration ~ 1100ml.*

4) **Residual volume –** *is the volume of air that still remain in the lungs after the most forceful expiration ~ 1200ml.*

The pulmonary capacities

Comprises more than one volume:

1) Inspiratory capacity – is the volume of air inspired by a maximal inspiratory effort after normal expiration = 3500ml = inspiratory reserve volume + tidal volume.

2) The functional residual capacity – is the volume of air remaining in the lungs after normal expiration = 2300ml = expiratory reserve volume + residual volume.

3) The vital capacity – is the volume of air expired by a maximal expiratory effort after maximal inspiration ~ 4600ml = inspiratory reserve volume + tidal volume + expiratory reserve volume.

4) Total lung capacity – is the maximum volume of air that can be accommodated in the lungs ~ 5800ml = vital capacity + residual volume.

5) Minute respiratory volume – is the volume of air breathed in or out of the lungs each minute = respiratory rate x tidal volume = 12 X 500ml = 6000ml/min.

All lung volume and capacity are about 20 to 25% less in women than in men and are greater in athletic persons than in small and asthenic persons.

Closed circuit Helium Dilution Method

- ***C1xV1 = C2xV2***

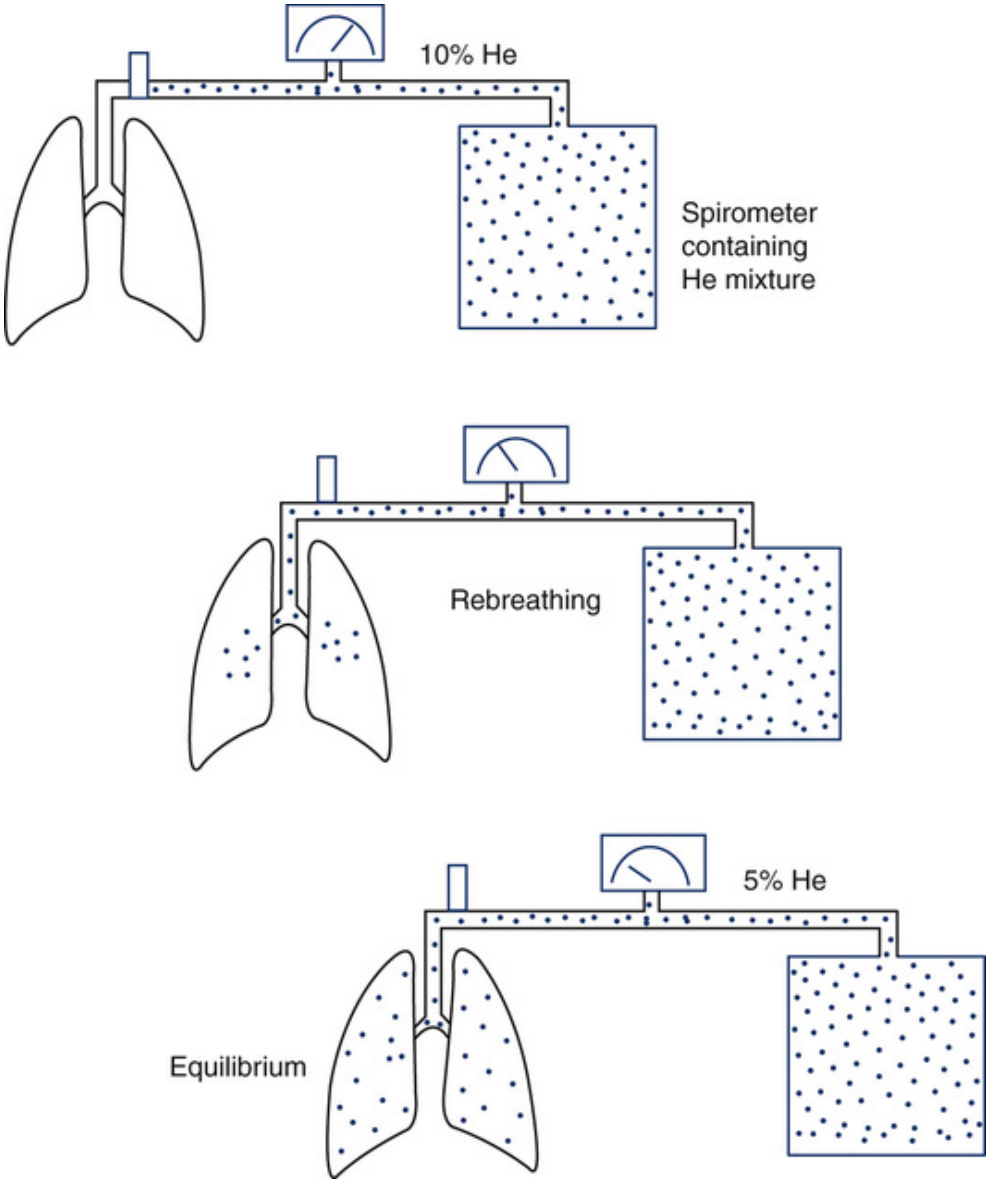
C1: concentration of Hi in spirometry

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

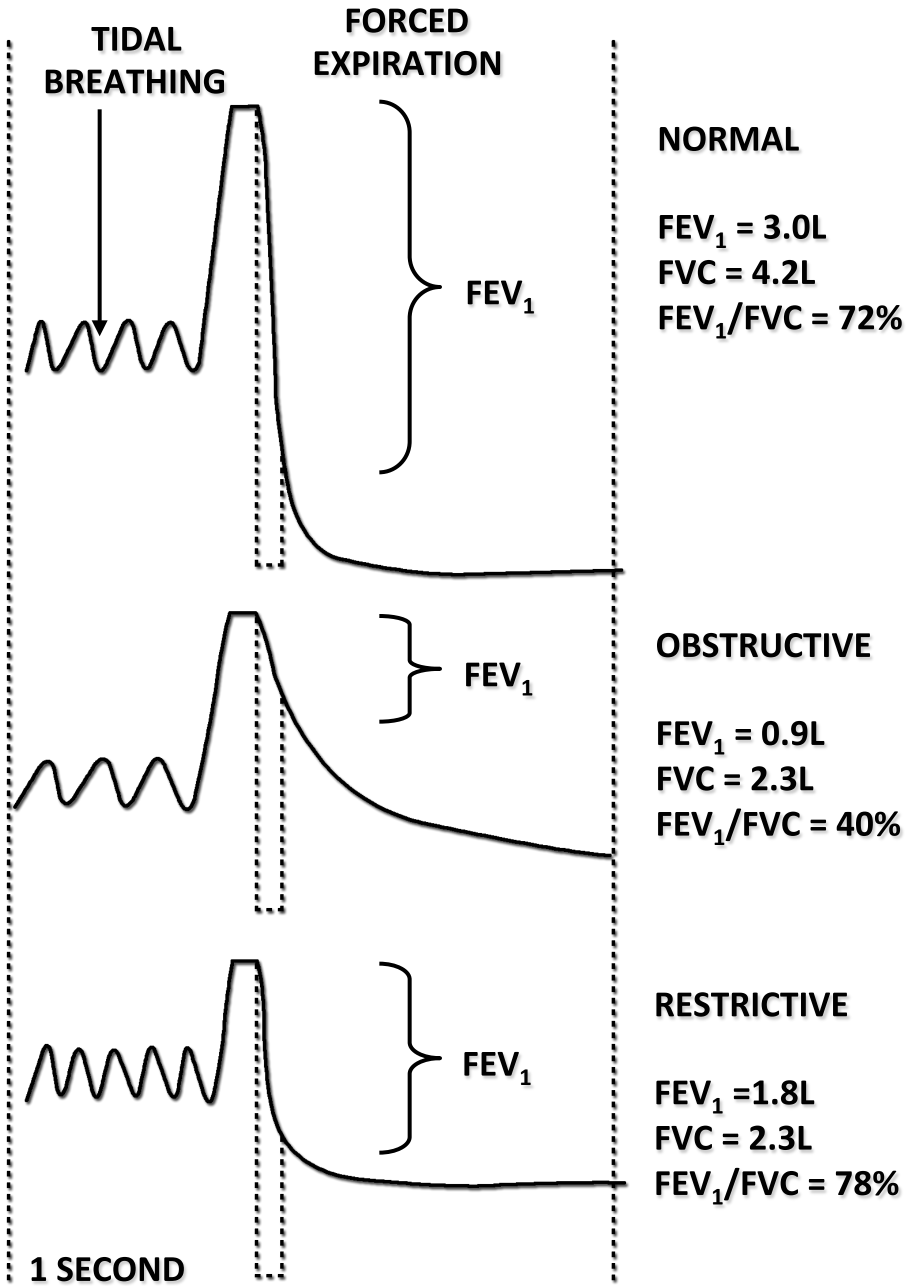
(Timed vital capacity)

- *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.**

FEV1/FVC ratio

Normally it is about 80%.

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


TIDAL BREATHING
FORCED EXPIRATION
NORMAL
FEV_1
FEV_1 = 3.0L
FVC = 4.2L
FEV_1/FVC = 72%
OBSTRUCTIVE
FEV_1
FEV_1 = 0.9L
FVC = 2.3L
FEV_1/FVC = 40%
RESTRICTIVE
FEV_1
FEV_1 =1.8L
FVC = 2.3L
FEV_1/FVC = 78%
1 SECOND

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

- **Anatomical dead space:-**
  - Occupies the air-conducting system down to the terminal bronchioles
  - No gas exchange
  - Volume ≅ 150ml
  - Physiological dead space =

    anatomical dead space + alveolar dead space

- **Respiratory zone:-**
  - Occupies the space distal to the terminal bronchioles start from the respiratory bronchioles down to the alveolar sacs
  - Gas exchange takes place
  - Volume ≅ 350ml/min

The rate of alveolar ventilation

Alveolar ventilation per minute is the total volume of new air entering the alveoli and other adjacent gas exchange areas each minute.

Va = Respiratory rate X (Vt – Vd)

= Respiratory rate X (Vtidal volume – Vdead space)

= 12 X (500 – 150) = 4200ml

Thank You