RESPIRATORY BLOCK

Physiology Team~ 430

3rd and 4th Lectures

Respiratory ventilation

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VENTILATION: (breathing); the exchange of air between the lungs and the environment, including inhalation and exhalation, as a result of difference in pressure caused by changes of lung volume.

•Physical properties that affect ventilation :

1- Lung Elasticity : Due to their high content of elastin Proteins, they are very elastic and resist distension

2- Lung Compliance :(flexibility) It is the ability of the lung to stretch.

3- Surface tension

Lung Elasticity : the ability of tissue to regain its original shape and size after being stretched, squeezed, or otherwise deformed, lungs contain elastin proteins

Lung Compliance : It is the ability of the lung to stretch. The extent to which the lungs expand for each unit increase in the transpulmonary pressure .

Surface tension : (Is a result of the attraction forces between the water molecules found in the thin film of fluid normally present in alveoli.

•Lung compliance :

- It is the ability of the lung to stretch.
- It is a change in lung volume per unit change in pressure

$$C\iota = \Delta v/\Delta p$$

Δv : Volume change

Δp : Transpulmonarypressure change

- **In normal adults** = 0.2liters/cm.H_2o .

- **Lung compliance increase in :**

  Emphysema and Ageing

  - Emphysema : (is a long-term, progressive disease of the lungs that primarily causes shortness of breath .) Increased compliance due to over dispensability of the lung during chronic coughing.

- **Lung compliance decreases in :**

  1- Decrease lung volumes due to :-

  Fibrosis, Pul.edema , consolidation , ↑ intra-abdominal pressure.

  2- Severe obesity.

  3- Constrictive bandages (or tight clothings)

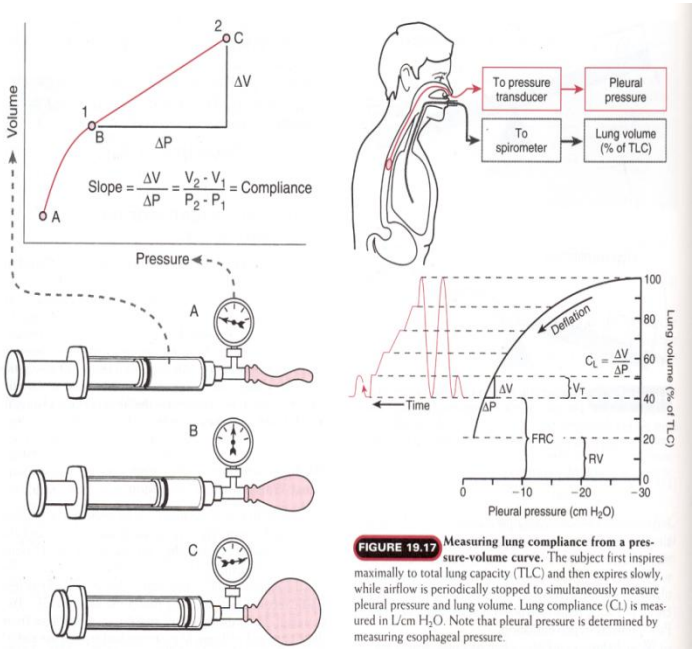

FIGURE 19.17 **Measuring lung compliance from a pressure-volume curve.** The subject first inspires maximally to total lung capacity (TLC) and then expires slowly, while airflow is periodically stopped to simultaneously measure pleural pressure and lung volume. Lung compliance (C_L) is measured in L/cm H_2O. Note that pleural pressure is determined by measuring esophageal pressure.

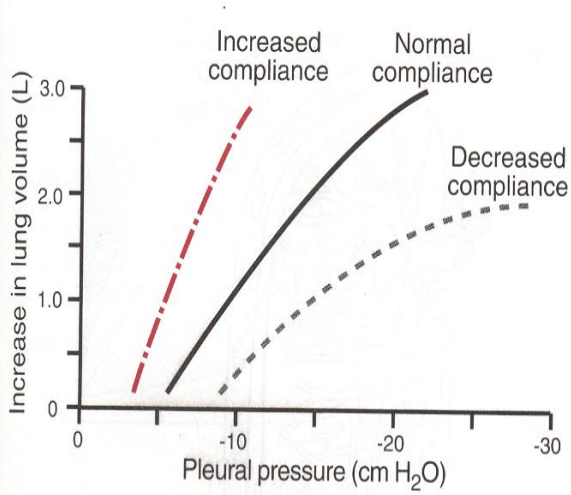

FIGURE 19.18 **Lung compliance in disease.** Lung compliance is abnormally high in patients with an obstructive disorder and abnormally low in patients with a restrictive disorder.

- **Factors Affecting Ventilation:**

  - Airway Resistance (it will affect the surface tension)

  - Diameter

  - Mucous blockage

  - Bronchoconstriction : (constriction of the airways in the lungs due to the tightening of surrounding smooth muscle, with consequent coughing, wheezing, and shortness of breath)

  - Bronchodilation : (An increase in the caliber of a bronchus or bronchial tube, allowing increased airflow to and from the lungs.)

  - Alveolar compliance:

  - Surfactants and surface tension (Surfactant acts to decrease surface tension in alveoli ,and any deficiency in surfactant will cause an increase in surface tension.)

  - Alveolar elasticity

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- **Lung volumes and capacities :**

  - Lung Volumes :

There are four lung volumes, which, when added together, equal the maximum volume to which the lungs can be expanded:

1- Tidal volume (TV) :

The volume of air inspired or expired/breath = 500 mls. At rest

(هو تنفس عادي بدون بذل أي مجهود)

2- Inspiratory reserve volume (IRV) :

The volume of air inspired by maximum inspiration after normal inspiration = 3000 mls.

3- Expiratory reserve volume (ERV) :

The volume of air expired by maximum expiration after normal expiration = 1100 mls.

4- Residual volume (RV) :

the volume of air remaining in the lungs after maximum expiration= 1200 mls.

- Lung capacities :

A lung capacity is equal to the sum of two or more lung volumes. There are four lung capacities:

1- Inspiratory Capacity :

The maximum amount of air that can be inspired after a normal tidal expiration

TV + IRV = 3500 mls.

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2- Functional Residual Capacity :

The amount of air remaining in the lungs after a normal tidal expiration.

ERV + RV = 2300 mls.

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3- Vital Capacity (VC) : (It used in clinical diagnosis.)

The maximum amount of air that can be expired after a maximum inspiration.

IRV + TV + ERV = 4600 mls.

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4- Total Lung Capacity (TLC) :

The total amount of air in the lungs after a maximum inspiration.

TV + IRV + ERV + RV = 5800 mls.

-- When expiration is performed as rapidly and as forcibly as possible into a spirometer , this volume is called forced vital capacity (FVC) and is about 4600 ml.

-- To measure FVC, the individual inspires maximally and then exhales into the spirometer as forcibly, rapidly, and completely as possible.

-- The vital capacity and forced vital capacity are the same volume.

-- Total lung capacity varies from person to person, and is affected by sex, height, and weight.

-- All lung volumes and capacitiesare 20-25% less in women than men , they are greater in large athletic people than in small asthenicpeople

- **Obstructive and Restrictive Lung Disease :**

  -- Measurement of FVC, FEV_1/FVC, and FEF_{25-75}, are used to detect obstructive & restrictive disorders.

  -- Forced expiratory volume (FEV) is a test in which the percentage of the vital capacity that can be exhaled in the first second (FEV1) is measured, and is considered one of the most reliable spirometer measurements.

  -- The normal forced expiratory flow (FEF) equals or is higher than 400 L/min.

  -- Maximum Expiratory Flow (Forced Expiratory Flow)(FEF) : When a person expires with great force, the air coming out of the lung (expiratory airflow) reaches a maximum flow (or speed) beyond which the flow cannot be increased with greatly increased additional force.

  -- NOrmally, FEV1/FVC% is 80%

  -- meaning 80% of an individual's FVC can be exhaled in the first second of forced vital capacity.

  -- Any percentage significantly below 80% suggests the presence of obstructive pulmonary disease.

  -- In a normal lung:

  FEV1 = 4 L (in the first second).

  FVC = 5 L (total volume expired).

  FEV/FVC = 80%

  -- FEF_{25-75} detect early airway obstruction.

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- **In Obstructive Disorders :** (expiration is more difficult and takes a longer time because bronchoconstriction increases the resistance to air flow)

  - ↑ Expiratory work of breathing → ↑ compliance. (e.g. asthma)
  - FEF_{25-75} is significantly decreased
  - The FEV_1/FVC ratio is low
  - with ↑ residual volume

- **In Restrictive Disorders :** (The problem is in the inspiration; however the expiration is not affected.)

  - ↑ Inspiratory work of breathing → ↓ compliance.
  - RV, TLC, and FVC are reduced.
  - FEV_1 / FVC ratio is normal or increased.

↑ Inspiratory work of breathing in : ↓ surfactant → ↓ compliance. (important)

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- **Resistance to Airflow :**

  -- Airway resistance is the opposition to flow caused by the forces of friction.

  -- It is defined as the ratio of driving pressure to the rate of air flow.

  -- Largely determined by airway diameter.

  -- Is greatest in the large and medium sized airways.

  -- Resistance to flow in the airways depends on whether the flow is laminar or turbulent on the dimensions of the airway, and on the viscosity of the gas. the opposition of the tracheobronchial tree to air flow.

- **Air flow :**

  - Air flow occurs only when there is a difference between pressures.

  - Air will flow from a region of high pressure to one of low pressure--the bigger the difference, the faster the flow

(لكي تتم عملية مرور الهواء يجب أن يكون هناك فرق بين الضغط الجوي والضغط داخل الرئة ،ولهذا يتغير حجم الرئة فيتغير تبعا له الضغط داخلها ،، ويصبح هناك فرق بين الضغوط)
(وكلما كان الفرق في الضغط اكبر ،، كان مرور الهواء أسرع)

- Factors that influence pulmonary air flow :

-- F (flow)= P(pressure)/R (resistance)

-- Diameter of airways, esp. bronchioles

-- Sympathetic & Parasympathetic NS

-- At low lung volumes airways are compressed → ↑ Airway resistance.

-- Airway resistance is inversely related to lung volume.

- **Dead space volume :**

Not all of the inspired air reaches the alveoli with each breath, some air remains in the conducting airways and does not undergo gas exchange; this volume of wasted air is known as dead space volume (VD).

1- Anatomic dead space :-

Is the volume of air in the conducting airways = 150mls.

2- Alveolar dead space :-

occur when there is decrease air flow or decrease blood flow to the alveoli.

3- Physiological dead space :-

= Anatomic dead space + alveolar dead space.

--In normal individuals, physiological VD is approximately the same as anatomical dead space = 150mls.

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- **Respiratory Minute Volume and Alveolar Ventilation :**

Normal respiratory rate at rest ranges from 12—18 breaths⁄min.

--Respiratory minute volume:

- The respiratory minute volume (RMV) is the total amount of new air (Is the volume of air) which enters or leave the lungs per minute, irrelevant of gas exchange.

- The respiratory minute volume is equal to the tidal volume times the respiratory rate (RMV = TV × RR).

- The normal tidal volume is about 500 ml, and the normal respiratory rate is about 12 breaths per minute.

- Therefore, the minute respiratory volume averages about 6 L/min.

RMV = Tidal volume(TV) x respiratory rate (RR)

= 500 x 12 = 6.0 liters.

- **Alveolar ventilation :-**

- Alveolar ventilation (AV) is the volume of new air entering the alveoli and gas exchange areas per minute.

AV = (Tidal volume — Anatomic dead space volume) x Respiratory rate / min.

= (500 — 150) x 12 = 350 x 12 = 4.2 Liters.

For alveolar ventilation it is more important to increase the depth rather than the rate of breathing.

-- Notice that : Rapid shallow breathing is more serious than gasping breathing because it reduces alveolar ventilation very much.

- **Ventilation perfusion ratio : It is the ratio of air flow (ventilation), and blood flow (perfusion.)**

$\dot{V}/Q$ ratio

The average ratio = 0.8 for the two lungs.

This ratio is important for proper gas exchange in the lung .

perfusion means : a liquid poured over or through an organ or tissue.

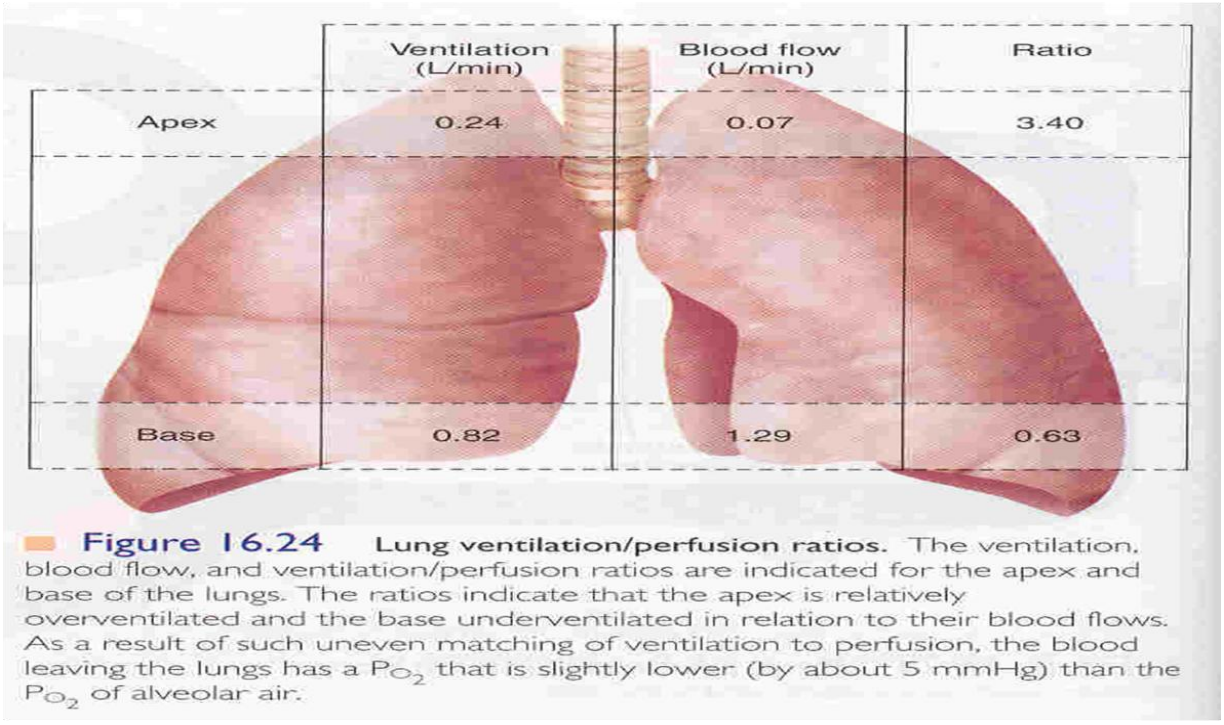

Figure 16.24 **Lung ventilation/perfusion ratios.** The ventilation, blood flow, and ventilation/perfusion ratios are indicated for the apex and base of the lungs. The ratios indicate that the apex is relatively overventilated and the base underventilated in relation to their blood flows. As a result of such uneven matching of ventilation to perfusion, the blood leaving the lungs has a P_{O_2} that is slightly lower (by about 5 mmHg) than the P_{O_2} of alveolar air.

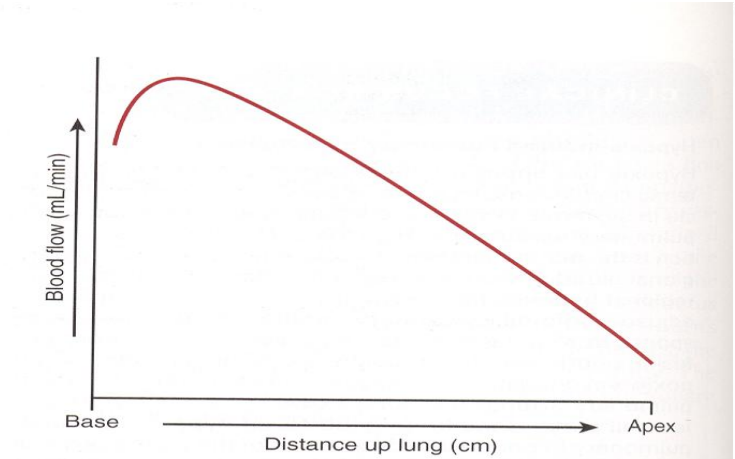

FIGURE 20.9 **Effect of gravity on pulmonary blood flow.** Gravity causes uneven pulmonary blood flow in the upright individual. The downward pull of gravity causes a lower blood pressure at the apex of the lungs. Consequently, pulmonary blood flow is very low at the apex and increases toward the base of the lungs.

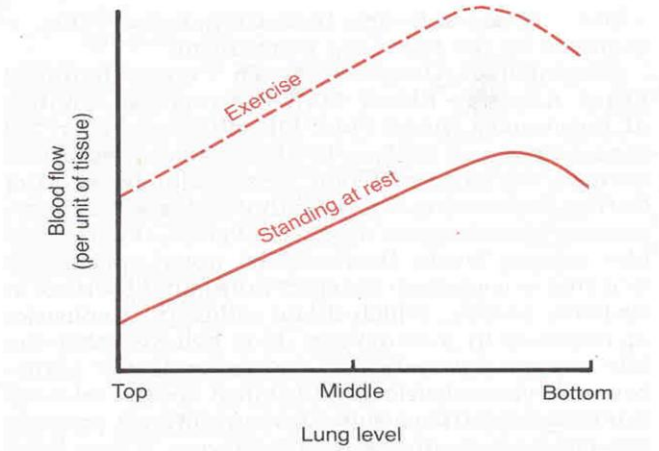

Figure 27–9 Blood flow at different levels in the lung of an upright person, both at rest and during exercise. Note that when the person is at rest, the blood flow is very low at the top of the lungs and most of the flow is through the lower lung.

■ Quiz – 2

If the tidal volume is 1000 mls.

and the respiratory rate is 6 breaths / min.

What is the ?

1- Respiratory Minute Volume.

2- Alveolar Ventilation.

1- **RMV = 1000 x 6 = 6.0 Liters.**

2- **Alv. Vent. = (1000 — 150) x 6 = 5.1 Liters.**

Lung Compliance (Cι)
Tidal Volume (TV)
Inspiratory Reserve Volume (IRV)
Expiratory Reserve Volume (ERV)
Residual Volume (RV)
Vital Capacity (VC)
Total Lung Capacity (TLC)
Forced Vital Capacity (FVC)
Forced Expiratory Volume (FEV)
Forced Expiratory Flow (FEF)
Respiratory Minute Volume (RMV)
Respiratory Rate (RR)

Good Luck