

وَقُلْ رَبِّ زِدْنِي عِلْمًا



RESPIRATORY SYSTEM

HA4AT BATCH

SUBJECT : physiology
LEC NO. : - 1 -
DONE BY : Hala Al-Beshawe

Respiratory System

Mechanics of breathing

DR. WALEED R. EZZAT

LECTURE OBJECTIVES:

1. Review the physiological anatomy of the pulmonary system and define conducting and respiratory zones.
2. Identify the major functions of the lungs (the respiratory and non-respiratory functions).
3. Define cellular respiration and external respiration and understand the steps of external respiration.
4. Describe the generation of a pressure gradient between the atmospheres and the alveoli.
5. List the major muscles involved in respiration and state the role of each.
6. Define intrapleural pressure, alveolar pressure, transpulmonary pressure, and elastic recoil pressure.
7. Diagram how pleural pressure, alveolar pressure, airflow, and lung volume change during a normal quiet breathing cycle. Identify on the figure the onset of inspiration, cessation of inspiration, and cessation of expiration.

FUNCTIONS OF THE RESPIRATORY SYSTEM:

- The **primary role** of the **respiratory system** is to **maintain a constant internal environment by providing oxygen** for metabolic needs and **excreting CO₂**.
 - External respiration: includes mechanics of pulmonary ventilation, the transfer of gas across the respiratory membrane, and the transport of gas by the blood to and from the body cells. استهلاك الأوكسجين
 - Internal respiration: is concerned with intracellular oxygen utilization.
- Secondary roles of the respiratory system include:
 - Aiding in acid-base balance.
 - Enabling speech, singing, and other vocalization.
 - The nose, a part of the respiratory system, serves as the organ of smell, and defends the body against inhaled particles (e.g. bacteria, pollen).
 - Acting as a filter to prevent clots from entering the systemic circulation. تنتج الكثير من الدم أشياء من البقايا في circulation مثل الجلطات - أحيات metabolism
 - Acting as a reservoir for blood. الـ lung يستخرج الدم من الخرز لإزالة معظم السموم التي تدخل metabolism تخنير دم الـ lung
 - Regulating various hormonal and humoral concentrations by means of the pulmonary capillary endothelium. like angiotensin II
 - The respiratory muscles generate the large pressures needed during defecation, vomiting, and childbirth. تفريغ

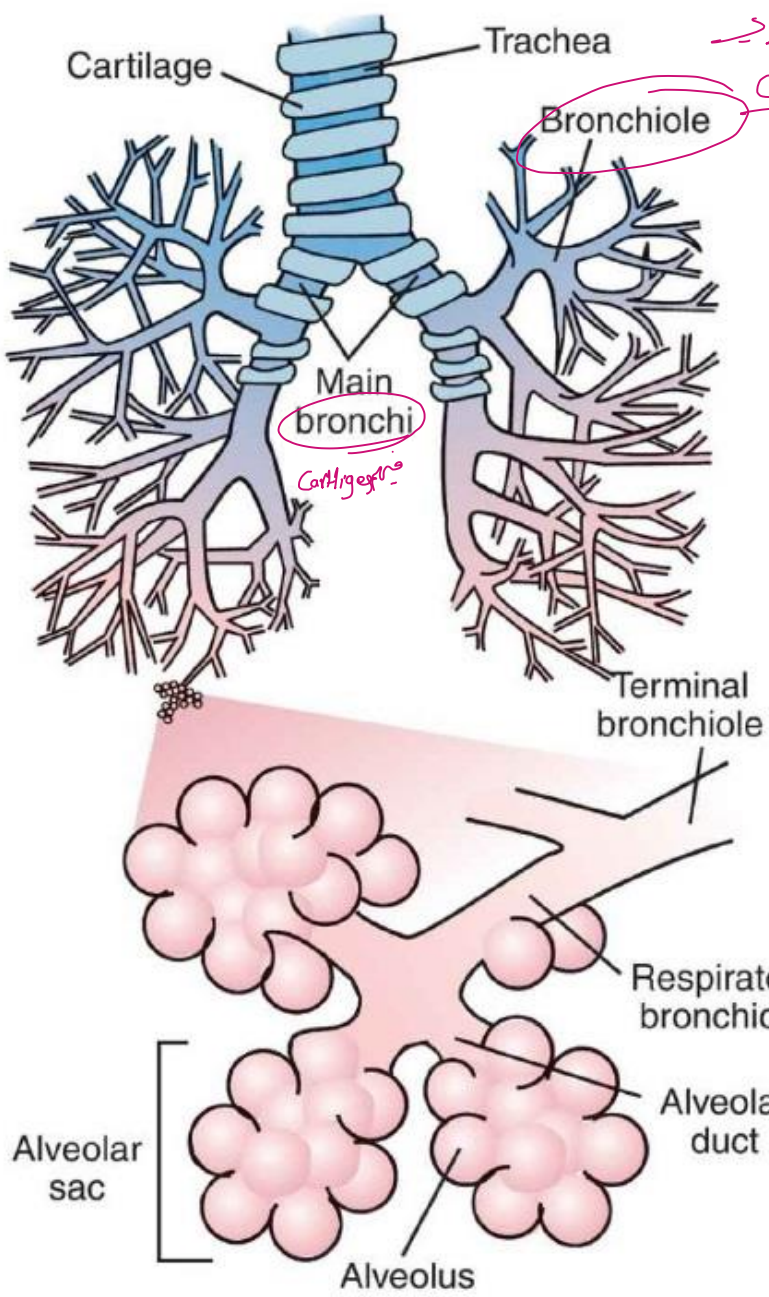
FUNCTIONAL ANATOMY OF THE LUNGS

- × The lungs alone cannot bring air in and out of the lungs or exchange oxygen and carbon dioxide from the blood.
- × Respiratory **muscles** and an airtight chest wall **to create a negative pressure** within the chest are essential for the proper functioning of the lungs.
- × The lungs comprise two tree-like structures, the vascular tree and the airway tree, which are **embedded** in highly elastic connective tissue.
- × The main airway, the **trachea**, branches into **two bronchi**. Each **bronchus enters a lung and branches many times** (on average **23 generations**) into progressively smaller bronchi, which, in turn, form **bronchioles**.
- × **The airways are divided into two functional zones:**
 1. The **first 16 generations** of branches comprising the **conducting zone** and functioning to conduct air to the deeper parts of the lungs. Because the conducting airways **contain no alveoli**, and therefore take **no part in gas exchange**, they constitute the **anatomic dead space**. Its **volume is about 150 ml**.

قناة نقل ك يتم فيها تبادل غازية
البرونشول → *terminal* → *البرونشول*
 2. The **last 7 generations** are **alveolated** and participate in **gas exchange** and comprise the **respiratory zone**. The **17th to 19th generations** of bronchioles constitute the transitional respiratory bronchioles. **The respiratory zone makes up most of the lung, its volume being about 2.5 to 3 liters during rest.**

تسمى هذه المنطقة بالمنطقة التنفسية

* both bronchi +
Bronchioles
sm. muscles قشور اس



ك يتوي
Cartilage

Cartilage

Airway generation

0	Trachea
1	
2	Bronchi
3	
4	Bronchiole
5	
6	
7	
8	
9-16	Terminal bronchiole
17	
18	Respiratory bronchiole
19	
20	
21	Alveolar duct
22	
23	Alveolar sac

Conducting zone

ك يوجد تباط
غازية

فلسه
Terminal bronchiole

بلش
مع

Respiratory zone

صليانه صويلان + التباط
الغازية عاليه
مير

FUNCTIONAL ANATOMY OF THE LUNGS (CONT.)

× The **conducting zone** has three important **functions**:

1. **Warm and humidify** inspired air

2. **Distribute air** evenly to all regions of the lungs

توزيع الهواء بالتساوي على جميع

3. **Serve as part of the body's defense system** (removal of dust, bacteria, and **noxious** gases from the lungs).

تسبب التبادل الغازي أيضا تضرير
التخريب

× The **conducting zone** has its own separate **circulation**, the **bronchial circulation**, which originates from the descending aorta and drains into the pulmonary veins.

× The **respiratory zone** is the **site of gas exchange**. The exchange of gases is accomplished **by diffusion** in thin-walled air sacs called **alveoli**.

① ② surfactant ③ defensive (macrophage)

× **Adult lungs** contain **300 to 500 million alveoli**, with a combined internal **surface area of ~75 m²**, which is approximately the size of a tennis court.

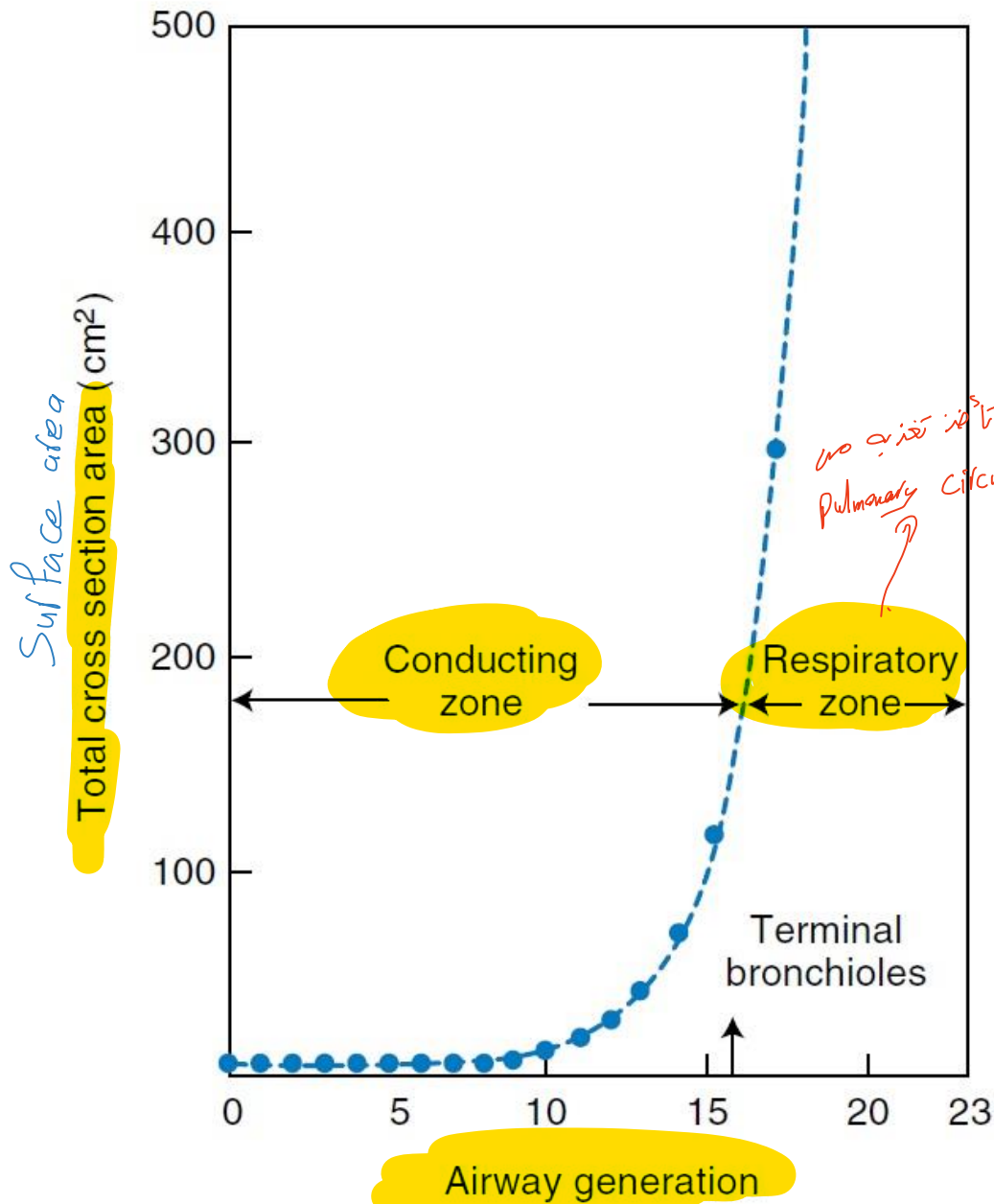
× The combined cross-sectional area of the airways in the respiratory zone is so enormous that makes the forward **velocity of the gas flow small and laminar**.

(سرعة دخول الهواء للصويالات) انسياب
بطيء و انسياب في اتجاه التبادل

× In adults, alveoli, if damaged, have limited ability to repair themselves. Cigarette smoke, for example, can destroy alveoli and lead to concomitant decrease in alveolar surface area for gas exchange.

لك يمكن ان تاكل alveoli ان تاكل
لذلك ال (alveoli) التي تدمرت ضميرها
الذي يحول gas of surface area of exchange





↑ surface area of respiratory zone → ↓ velocity of gas

Diagram to show the extremely rapid increase in total cross-sectional area of the airways in the respiratory zone. As a result, the forward velocity of the gas during inspiration becomes very small in the region of the respiratory bronchioles, and gaseous diffusion becomes the chief mode of ventilation.

oxygen

the role of diffusion in ventilation:

the spontaneous movement of gases, without the use of any energy or effort by the body, between the alveoli

ATMOSPHERIC (BAROMETRIC) PRESSURE:

1. Air is a mixture of gases. Dry atmospheric air is approximately 79% N₂ and 21% O₂
2. Atmospheric pressure decreases as altitude increases. It is **760 mmHg** at sea level, **380 mmHg** at 18,000 feet, and **190 mmHg** at 34,000 feet
3. The total barometric pressure is the sum of the **partial pressure** of all gases (**Dalton's law**). The partial pressure of N₂ (PN₂) is 600 mmHg at sea level and PO₂ is 160 mmHg.

$$\frac{21 \times 760}{100} = \underline{160}$$

$$\frac{79}{100} \times 760 \rightarrow \frac{60040}{100} \rightarrow 600.4 = 600$$

ضغط (O₂) عند مستوى الهم 160 mmHg
عن مستوى الهم = الهم
100 mmHg

كيفية الهواء التي تدخل بالهفئة إلى
الجهاز التنفسي كامل في خروج منه

PULMONARY VENTILATION

Def. : The inflow and outflow of air between the atmosphere and the lung alveoli

* alveolar ventilation : تكون أقل من pulmonary ventilation
كيفية الهواء التي تدخل الحويصلات في وقتها

Mechanics of Pulmonary Ventilation:

1. Downward and upward movement of the diaphragm to increase or decrease the vertical dimension of the thorax.

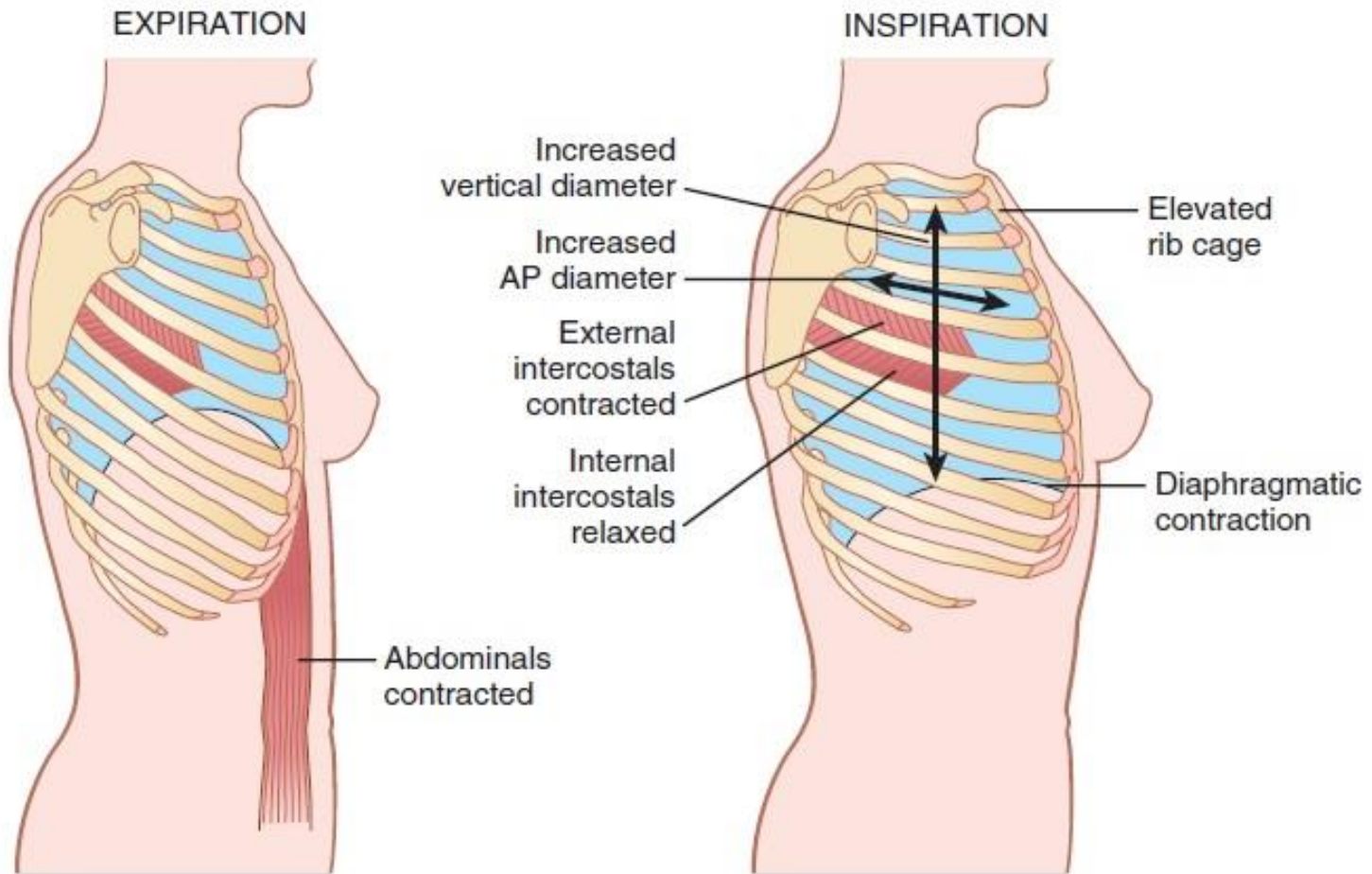
هي عضلة diaphragm
فيكده diaphragm
في ليصت ما لاء

Note: Obesity, pregnancy, and tight clothing around the abdominal wall can impede the effectiveness of the diaphragm in enlarging the thoracic cavity.

ال Clinic Nerve سليم إذا كان القطع تحت C5
غير سليم من C5 في (C3-C5)
كيفية الحجاب

Damage to the phrenic nerves (C3-C5) can lead to paralysis of the diaphragm. When a phrenic nerve is damaged, that portion of the diaphragm moves up rather than down during inspiration.

2. Elevation and depression of the ribs to increase and decrease the anteroposterior diameter of the chest cavity.



Contraction and expansion of the thoracic cage during expiration and inspiration, demonstrating diaphragmatic contraction, function of the intercostal muscles, and elevation and depression of the rib cage. AP, anteroposterior.

INSPIRATION

- * mechanism of Inspiration :
- ① Increase the chest cage in all 3 dimension
 - ② distention → توسعة الصدر
 - ③ يقل الضغط في الرئة إلى (أ) بالنسبة للضغط الخارجي على (ب) اعتباراً من الصدر
 - ④ Air is forced in → chest cavity يندفع

- Respiratory cycle (Eupnea)
- ① Inspiration → active
 - ② expiration → Inspiration من المكون غير نشيط
 - ③ respiration pause → rapid respiration يفتقر في حالة

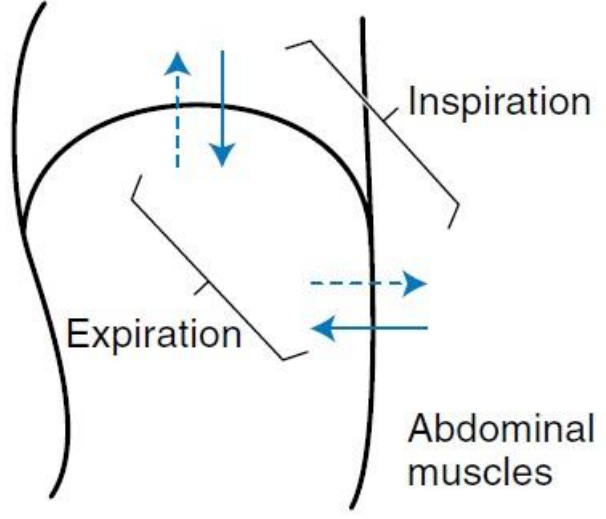
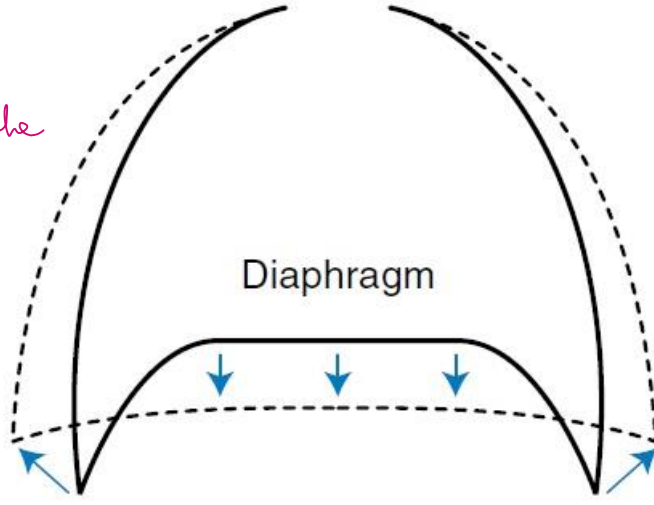
Inspiration is an **active process**, normally produced by contraction of the inspiratory muscles (**negative-pressure breathing**). Other than the diaphragm, Inspiratory muscles are:

1. **External intercostals muscles** (Bucket handle effect, most important) → يرفع الضلع للداخل فيزيد حجم الصدر → anteroposterior diameter يزيد
2. **Sternocleidomastoid muscles** (lift the **sternum**)
3. Anterior serrati
4. **Scaleni** (lift the first 2 ribs)

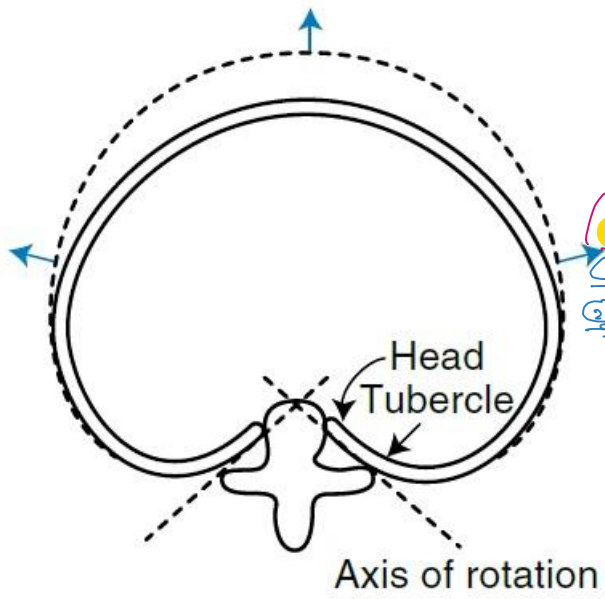
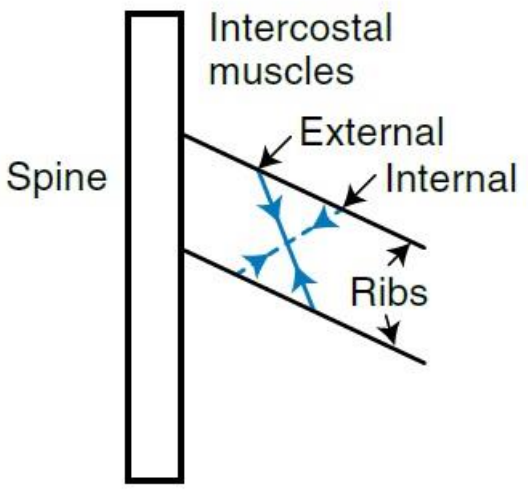
Impaired inspiratory force (e.g. muscular dystrophy, poliomyelitis) → respiratory failure. Such patients require mechanical respirators (positive-pressure breathing).

descent of the diaphragm

vertical dimension
 ↳ 00 (75%)
 ↳ 10%



→ Active
 - - - - -> Passive



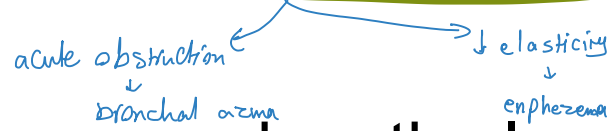
external intercostal muscle
 1 elevation of the ribs
 2 elevation anterior post

EXPIRATION

* mechanism of expiration
① decrease the chest cage in all 3 dimension
② Recoil → تقوس في جميع الاتجاهات
③ (زيادة) الضغط في الرئة إلى (4) بالنسبة للضغط الخارجي على
اعتباراً من صغر
⑤ Air is forced out → chest cavity من خروج

Expiration is a **passive process** during quiet normal breathing. **Expiratory muscle contraction is required** when respiration is increased during **exercise** or in the presence of severe **respiratory disease**.

Expiratory muscles are:



1. **Abdominal** recti (pull downward on the lower ribs and compress the abdominal contents upward against the diaphragm)
2. **Internal** intercostals → تدخل في expiration، تسريح

+ في حالة لظرد اصابع خنزيرية في الرئة

RESPIRATORY CYCLE

- يتحول إلى قفص مرن في حالة
 ① valsalva experiment → الحالة المفرطة → **تسبب حجم الرئة و قفص الصدر أن ينفخ**
 ② Pneumothorax → مزعج الرئة بالسكتة → **فيكون قفص**

Note: Pressure is taken in reference to atmospheric pressure.

→ It is the **(-ve)** pressure in the pleural sac

Pleural pressure: → يوجد بين الرئتين و الغشاء السري

Def.: Is the pressure of the fluid in the narrow space between the lung pleura and chest wall pleura (range -5 cm H₂O to -7.5 cm H₂O). The negative pressure is because of the balanced forces generated by the **chest wall** (tends to increase lung volume, i.e. **inspiratory force**) and the **lungs** (tends to shrink, i.e. **elastic recoil of the lung**).

② surface tension

→ Intra pulmonary
Alveolar pressure: → التغيير في الحويصلات الهوائية

Def.: Is the pressure of the air inside the lung alveoli. It is equal to 0 cm H₂O (atmospheric) when no air is flowing into or out of the lungs.

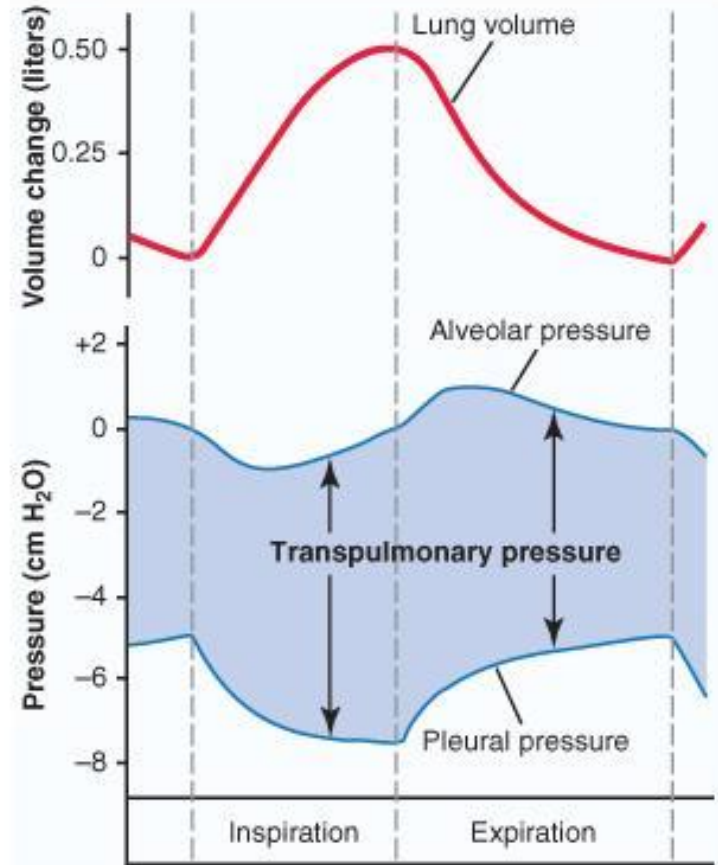
During the respiratory cycle alveolar pressure ranges between -1 cm H₂O to +1 cm H₂O, but in patients with airway obstruction, it may be many times that.

The quiet cycle is made of inspiration (2 seconds) and expiration (2-3 seconds).

- Negative → Inspiration → mid inspiration -1 يكون أقل قفص و ضغط
- Positive → expiration → mid expiration +1 يكون أعلى قفص و ضغط
- Zero → at the end of inspiration + expiration

pleural pressure ← بين lung و chest wall ← دائما يأمل بجسوا
 pressure ← قفص
 ← elastic recoil
 ← Continuous tendency of lung to recoil
 ← the chest cavity to expand

+ maximum expiration → more negative pleural pressure
 * كلما انقلص الرئة يكون حجم lung + chest wall نفس الحجم ← يكون pleural pressure ← **زاد**

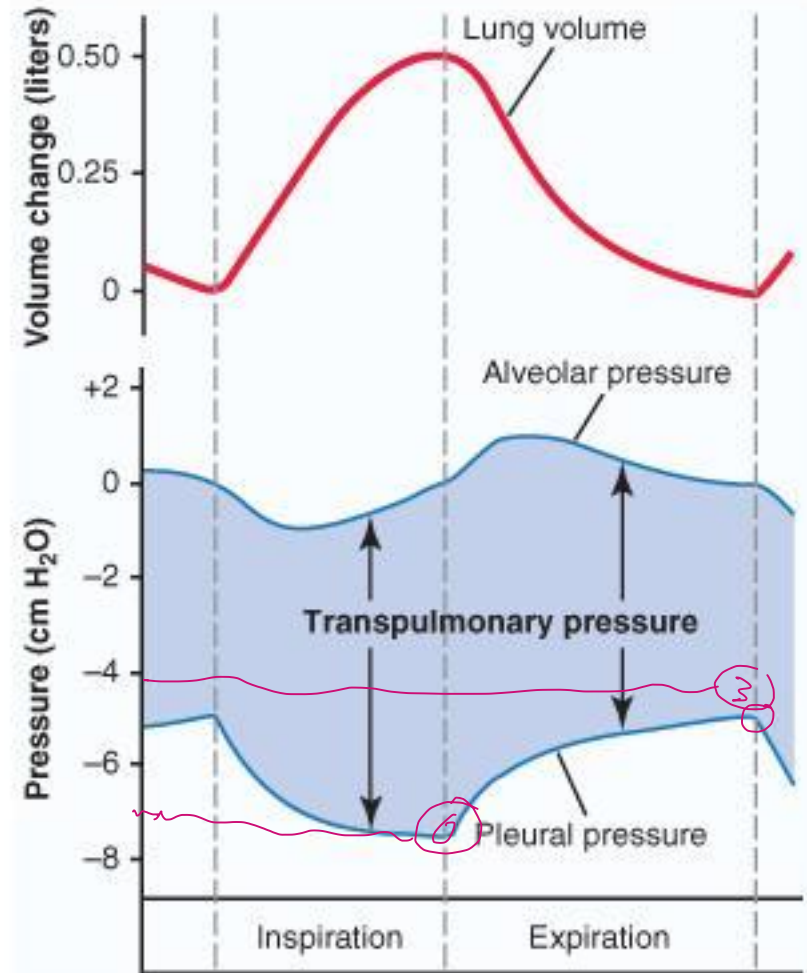


RESPIRATORY CYCLE

Transpulmonary pressure (P_L):

Def.: Is the pressure difference between the alveolar pressure and the pleural pressure ($P_L = P_A - P_{PL}$). It is a measure of the elastic force (**elastance**) in the lungs that tend to collapse the lungs, i.e. the **Recoil Pressure**. Elastance depends on the amount of elastic tissue.

* end of
 ↳ Inspiration → $0 - (-6) = +6$
 ↳ expiration → $0 - (-3) = +3$



TEST QUESTION:

- Q. Concerning the airways of the human lung:**
- A. The volume of the conducting zone is about 50 ml.
 - B. The volume of the lung at the end of quiet expiration is about 5 liters.
 - C. A respiratory bronchiole can be distinguished from a terminal bronchiole because the latter has alveoli in its walls.
 - D. On the average, there are about three branchings (i.e. generations) of the conducting airways before the first alveoli appear in their walls.
 - E. In the alveolar ducts, the predominant mode of gas flow is laminar rather than turbulent.