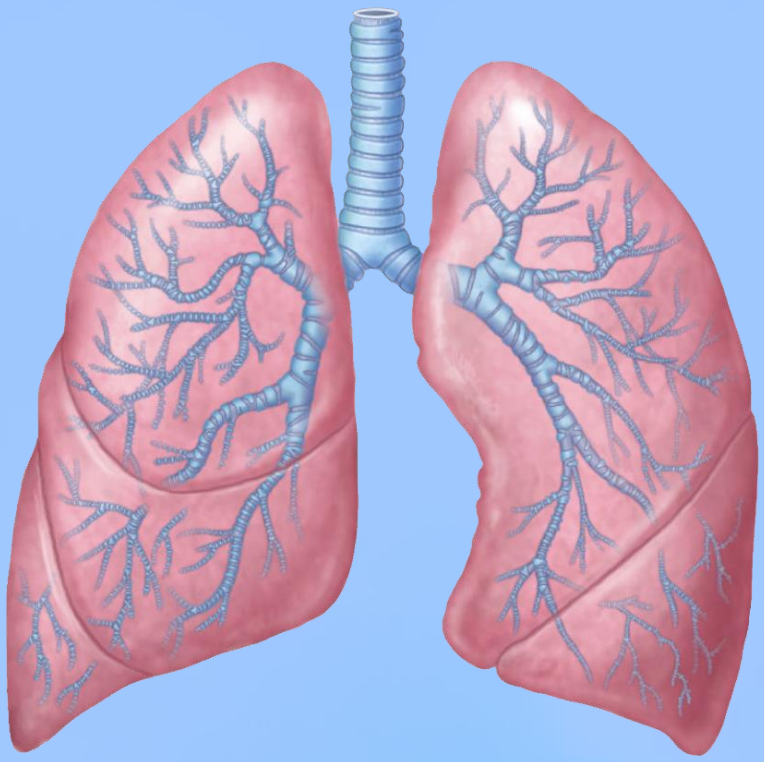
2 Mechanics of pulmonary ventilation



@PhysiologyTeam

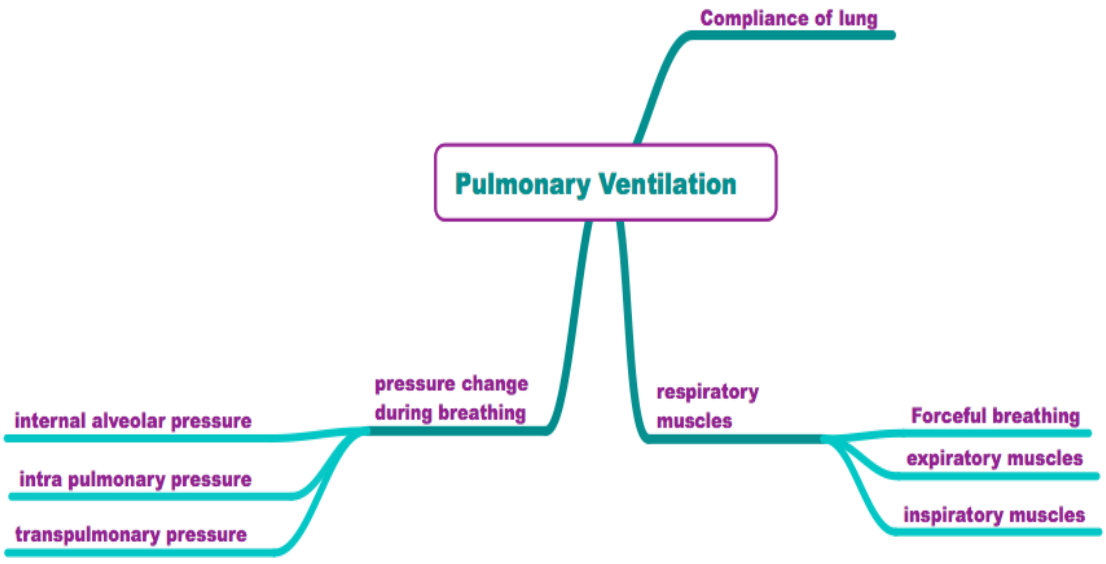
Pht433@gmail.com

Respiratory Block

Objectives:

1. List the muscles of respiration and describe their roles during inspiration and expiration.
2. Understand the importance of the following pressures in respiration: atmospheric, alveolar, intra-pleural, and transpulmonary.
3. Explain why intra-pleural pressure is always subatmospheric under normal conditions, and the significance of the thin layer of the intrapleural fluid surrounding the lung.
4. Define lung compliance and list the determinants of compliance.

Mind Map:



RESPIRATORY MUSCLES AND PULMONARY

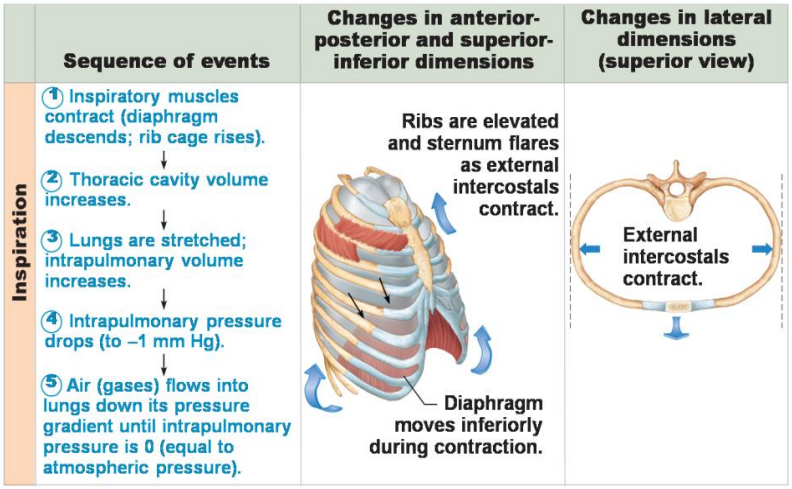
pulmonary ventilation

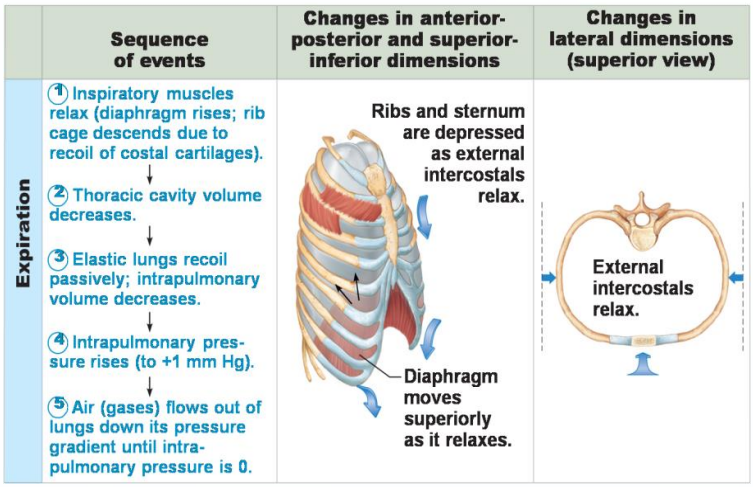
- **Inspiration**
- **Expiration**

Respiratory muscles

- **Inspiratory muscles** (resting- forced)
- **Expiratory muscles** (forced expiration- muscles that depress the rib cage).

Pulmonary ventilation: is the inspiration (inflow) and expiration (outflow) of air between the atmosphere and lungs.





Muscles of normal inspiration

- Diaphragm
- External intercostal

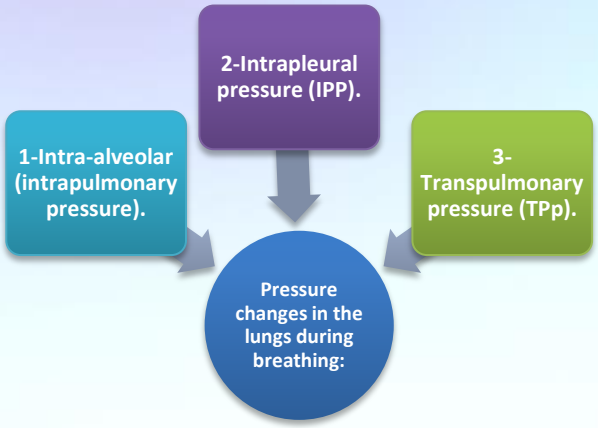
Muscles of normal expiration

- Normal expiration is due to elastic recoil of lungs and associated structures

Deep forceful breathing

Deep Inspiration (Passive process)			Deep Expiration (Active process)	
Accessory muscles of inspiration participate to increase size of thoracic cavity			Muscles of exhalation increase pressure in abdominal and thorax	
Sternocleidomastoid	**Scalenes**	**Pectoralis minor**	**Abdominal muscles**	**Internal intercostal muscles**
Elevate sternum	Elevate first 2 ribs	Elevate 3^{ed}-5th ribs		

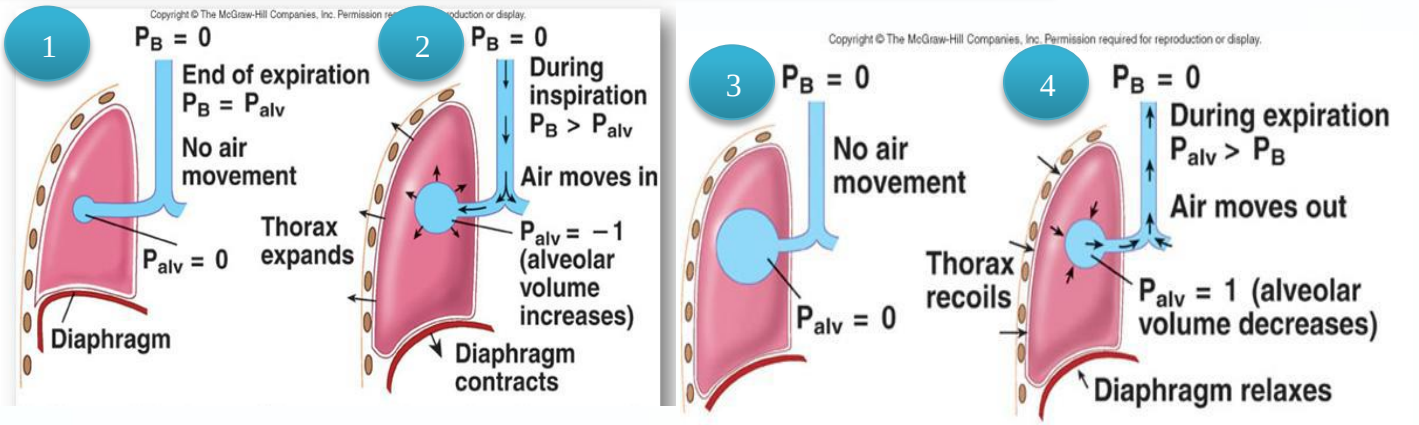
PRESSURE CHANGES IN THE LUNGS DURING BREATHING:



Remember

- The pressure tends to decrease as the volume increases.
- Air will flow from a region of high pressure to one of low pressure, the bigger the difference the faster the flow

1. INTRA-ALVEOLAR (INTRAPULMONARY



1 Between breathes

Between breathes = zero pressure
At the end of expiration

$P_{ALV} = P_B$

3 At the end of inspiration

Air flow stops → Thorax and alveoli stop expanding

$P_{ALV} = P_B$ = zero

note

P_B = Atmospheric pressure "760mmHg"
P_{ALV} = Intra-alveolar pressure

2 Inspiration

Air (tidal volume) flow from outside to inside the lungs) → centers send pulses to Inspiratory muscles → contraction of diaphragm and external intercostal muscles → ↑ volume of the chest → entrance of 500 ml of air → ↓ PALV.

$P_{ALV} < P_B$
P_{ALV} = -1 mmHg

4 Expiration

Centers stop send pulses → air flow out of the Lungs → ↓ volume of the chest → recoil of the lungs.

$P_{ALV} > P_B$
P_{ALV} = +1 mmHg

Then Return to the starting point, which is: 1

2- INTRAPLEURAL PRESSURE (IPP):

Pressure in the pleural is negative with respect to atmospheric pressure at the end of normal expiration (-5cmH2O).

WHY NEGATIVE??

A) The pressure in the pleural cavity becomes negative because of 2 opposing forces: (1)

1- The lung's elastic tissue causes it to recoil,
2- The chest wall causes it to expand.

B) The pleural space is a potential space, empty due to continuous suction of fluids by lymphatics.

note

Pleural cavity: is the potential space between the two pleurae (visceral and parietal).

(1) القوتين الناتجتين عن ميل الرئة للانكماش للداخل وميل الاضلاع للبروز للخارج هما سبب كون قيمة الضغط سالبة

Values of IPP:

$-5\ cm\ H_2O$ $-7.5\ cm\ H_2O$

During position between breathing → Become more negative → During resting inspiration

Forced ventilation

Insp.: -20 to -40 cm H_2O

Exp.: + 30 cm H_2O

3-TRANSPULMONARY PRESSURE (TPP)(EXTENDING PRESSURE):

The difference between the alveolar pressure (P_{alv}) and the pleural pressure (TPp)

$$TPp = Palv\text{-}Ppl$$

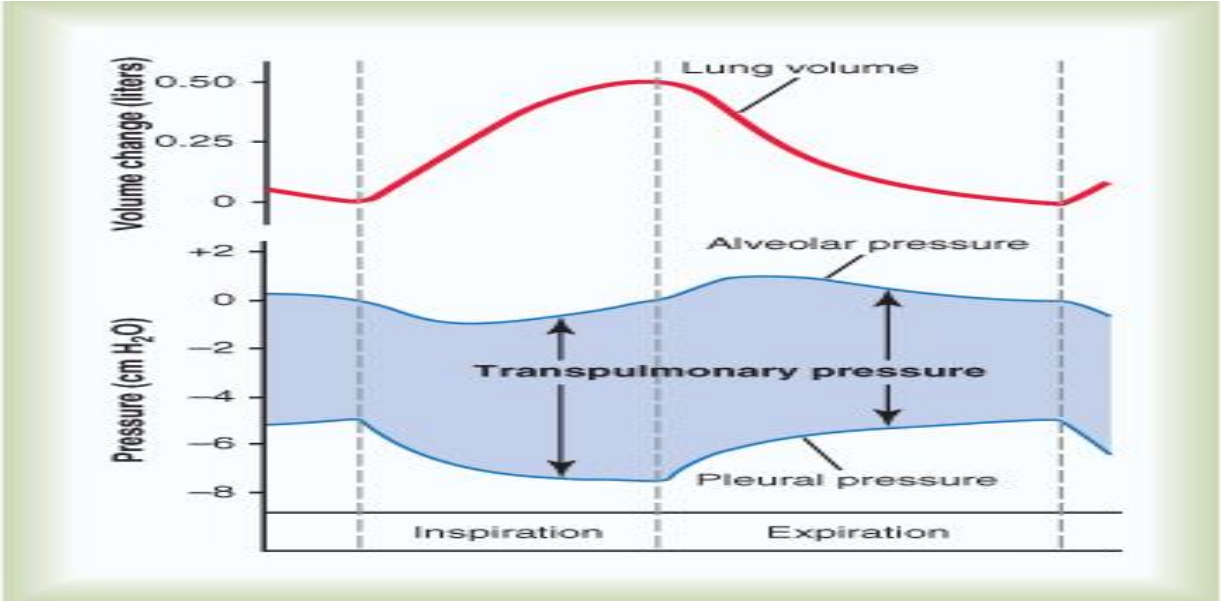
- ✓ • It is a measure of the elastic forces in the lungs that tend to collapse the lungs (the recoil pressure).
- ✓ It prevents lung collapse.
- ✓ •The bigger the volume of the lung the higher will be its tendency to recoil.

(COMPLIANCE OF THE LUNG)

In a single respiratory cycle

COMPLIANCE is defined as, the ratio of the change in the lung volume produced per unit change in the distending pressure

- ✓ The extent to which the lungs expand for each unit increase in the transpulmonary pressure.



لتوضيح العلاقة بين حجم الرئة و مقدار التغير في الضغط نستخدم مصطلح "Compliance" وهو نسبة بين التغير في حجم الرئة والتغير في الضغط وهي علاقة طردية بمعنى أنه كلما زاد الضغط "transpulmonary pressure" عن قيمته الابتدائية زاد تبعا لذلك حجم الرئة وكلما قل الضغط قل حجم الرئة للتوضيح رياضيا:

١- نحسب transpulmonary pressure من العلاقة : TPp = Palv-Ppl

٥-(٥-)=٥٠ وهو قيمة الضغط في حالة resting

٢- حتى يدخل الهواء للرئة لابد أن نغير الضغط الداخلي ليصبح أقل من الضغط الخارجي "لأن الهواء ينتقل من منطقة ضغط مرتفع إلى منخفض" فيقل الضغط الداخلي بقمية ١- والضغط "Ppl"تقل قيمته الى ٧,٥- فتصبح قيمة transpulmonary pressure ٦ وهو في حالة الشهيق فيزيد حجم الرئة تبعا للزيادة في قيمة الضغط .

ولكل زيادة في الضغط بمقدار ١ يزيد حجم الرئة بمقدار ١١٠ $cm\ H_2O$

(COMPLIANCE OF THE LUNG) CON.

In a single respiratory cycle

$$CL = \frac{Volume\ change\ (\Delta V)}{Transpulmonary\ pressure\ \text{change}\ (\Delta P)}$$

$$CL = \frac{(\Delta V)}{(\Delta P)}$$

Values of compliance

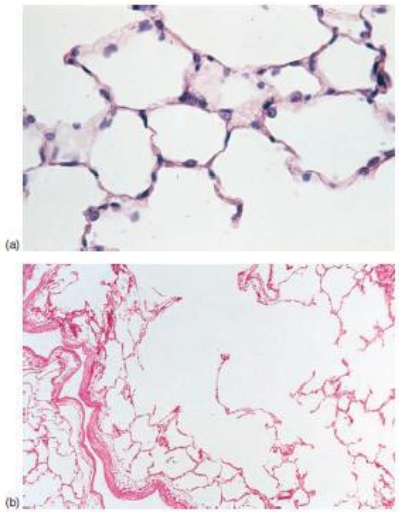
- ✓ For both lungs in adult = 200 ml of air /cm H_2O.
- ✓ For lungs and thorax together = 110 ml/cm H20.

REDUCED

IN PULMONARY FIBROSIS, PULMONARY EDEMA, DISEASES OF THE CHEST WALL (KYPHOSIS, SCOLIOSIS)

INCREASESED

BY EMPHYSEMA because it destroy the alveolar septal tissue rich with elastic fibers that normally opposes lung expansion



NOTE

معظم حالات التغير في مرونة الرئة تكون بان مرونتها تنقص إلا في حالة واحدة وهي "emphysema" حيث أن مرونة الرئة تزيد بسبب أن الرئة لم تعد تستيطع التخلص من "trypsin"الذي تنتجه البكتيريا بواسطة ما تنتجه خلاياها "Alpha-1 antitrypsin" حيث يقوم بتكسير بروتين الحويصلات الهوائية ويجعلها حويصلة واحدة كبيرة ممايزيد من مرونة الرئة ولكن بشكل سلبي كما في المدخنين.

1. Inspiration begins as …

A- The diaphragm relaxes.
B- The diaphragm contracts.
C- The lungs expand.
D- The lungs contract.

2. Which of these muscles we use during forced inspiration:

A- Diaphragm.
B- External intercostal muscles.
C- Scalene muscles.
D- All of the above.

3. The result of the process of inspiration is :

A- Increased alveolar volume causes increased alveolar pressure.
B- Increased alveolar volume causes decreased alveolar pressure.
C- Decreased alveolar volume causes increased alveolar pressure.
D- Decreased alveolar volume causes Decreased alveolar pressure.

4. As the volume in the alveoli increases, the pressure decreases.

A- True.

B- False.

5- Pressure in the pleural space has a positive value equal +5:

A- True.

B- False.

6-compliance of lung increased in:

A- Pulmonary fibrosis.

B- Kyphosis.

C- Emphysema.

D- Scoliosis.

7-Forced ventilation in inspiration:

A- (-20 to -40) cm H2O
B-(20 to 40) cm H2O
C-(-60) cm H2O
D-(-35) cm H2O

.

8- Compliance (CL):

A-CL=Transpulmonary change (Δ P)/volume change (Δ V)

B- CL= Volume change (Δ V) /Transpulmonary change (ΔP)

Answers: 1- B 2- D 3- B 4- A 5-B 6-C 7-A 8-B

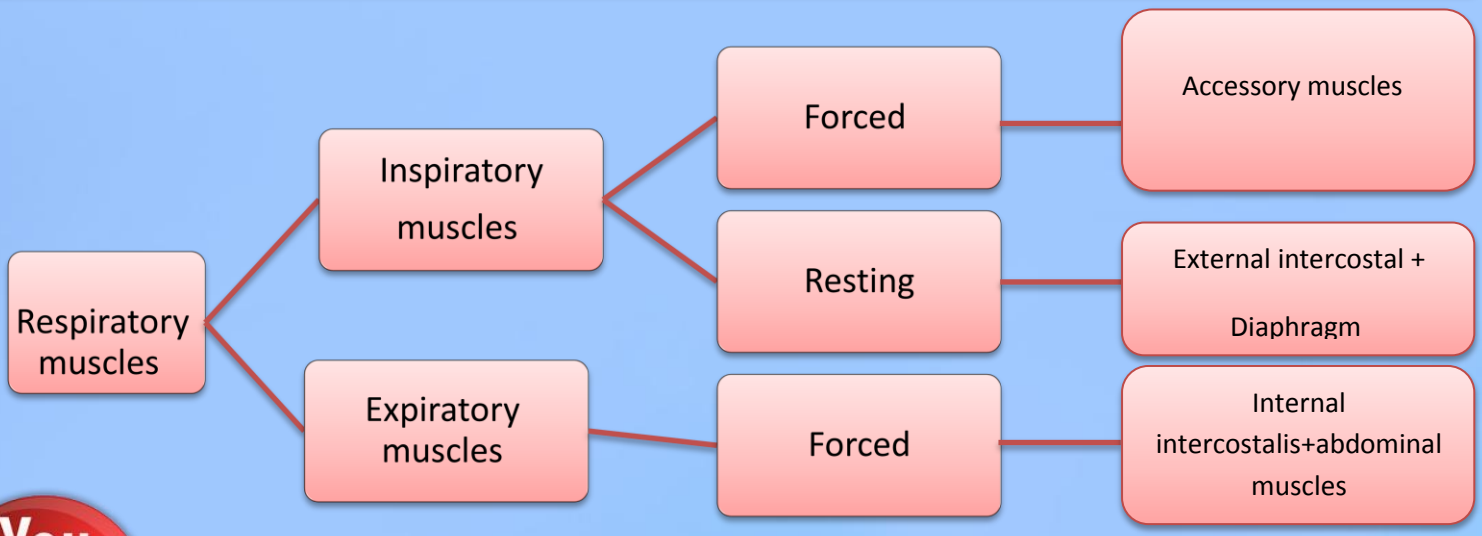
Summary

***During deep forceful inhalation accessory muscles of inspiration participate to increase size of thoracic cavity.**

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

***Compliance is reduced in pulmonary fibrosis , pulmonary edema, diseases of the chest wall ((kyphosis, scoliosis)**

***Emphysema increases compliance**



https://www.youtube.com/watch?v=xMJYNN3YpaQ Transpulmonary Pressure and Intrapulmonary Pressure – Respiratory

https://www.youtube.com/watch?v=cGhKJYfXW-c Compliance an Elastance