

LEC NO. : 13
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Respiration

الجهاز التنفسي

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Wakeel

Objectives

- **1-The concept of anatomic dead space.**
- **2-Pulmonary ventilation and alveolar ventilation.**
- **3-The gas exchange between alveoli and pulmonary blood and factors affect the movement of gases across alveolar wall.**
- **4-How oxygen and carbon dioxide are transported to and from tissues in the blood .**
- **5-O₂ dissociation curve and physiologic factors that can influence it.**
- **6-The transport of carbon dioxide by blood**

خللي بالكم ان pulmonary ف هو related to lungs

الوظيفة الاساسية للRespiratory system هو الحصول على O₂ و اخراج CO₂ و هاتي العملية تتم بمراحل، اول مرحلة اني احصل على الأوكسجين من atmosphere بعد كده الاكسجين بيوصل للحوصلات الهوائية بتاعت الرئة و هي محاطة باوعية دموية pulmonary vessels بعد كده الدم حيوصل الاكسجين للانسجة عشان تستخدمه لأكسدة المواد الغذائية في الميتوكوندريا ف بطلع عندي طاقة و CO₂ الدم رح ياخذ CO₂ و يوصله للرئة و يتم التخلص منه عن طريق عملية الزفير

Respiration is divided into:

1) External respiration, consists of:

- Pulmonary ventilation** i.e renewal of air from atmosphere.
- Exchange of gases** between alveolar air and venous blood.

2) Respiratory function of blood: المٌحاهرة إجابي

- Carriage of O₂ from the lung to tissues.**
- Carriage of CO₂ from the tissue to lung.**

3) Internal respiration: Completed in tissue

تتم فيها أكسدة الغذاء داخل الانسجة و الحصول على الطاقة و CO₂

- It's utilization of O₂ in oxidation of food stuffs and production of **energy**.

Physiological anatomy of respiratory system:

- respiratory system is consist of:

الممرات الهوائية و الرئتين

1) **air passage and lungs:** which is divided into conducting zone and respiratory zones.

2) **respiratory muscles.** inhalation & exhalation عضلات موجودة في chest هي بتقوم ب

3) **respiratory centers controlling respiration.**

مراكز في المخ تنظم عمل الجهاز التنفسي

Upper respiratory tract

Nasal cavity

Pharynx البلعوم

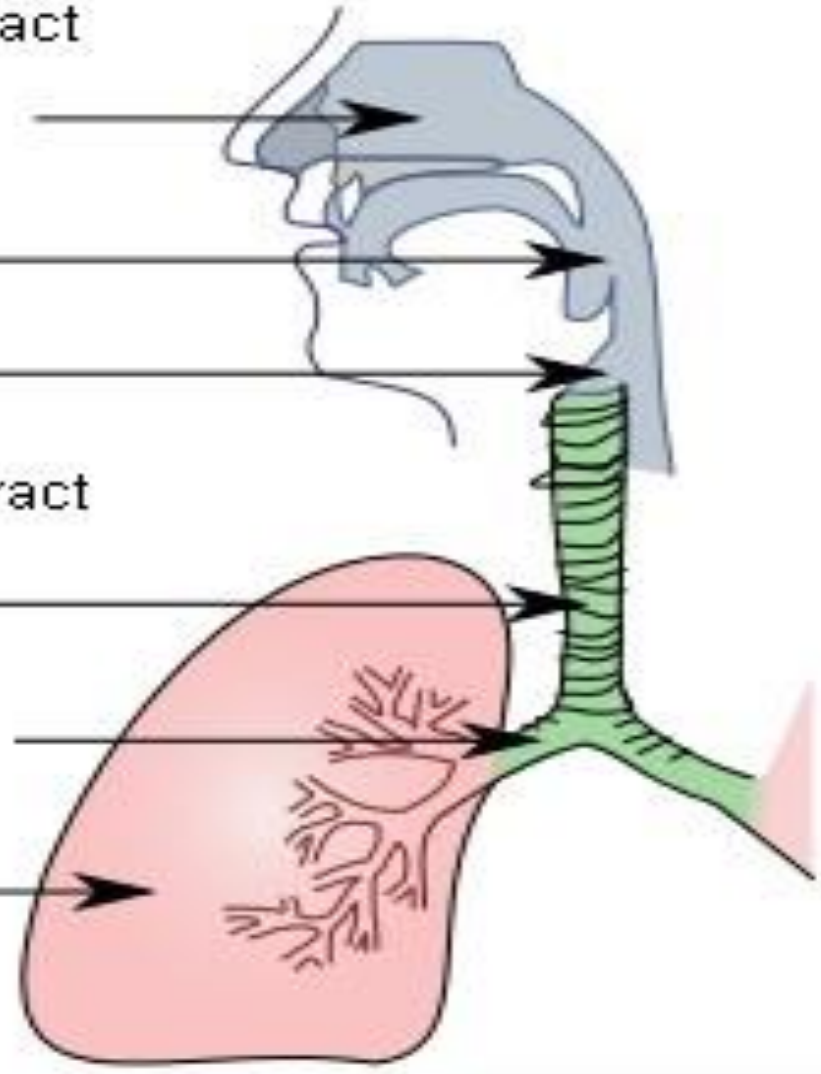
Larynx الحنجرة

Lower respiratory tract

Trachea القصبة الهوائية

Primary bronchi

Lungs



تتقسم الى secondary & tertiary و من ثم الى bronchioles و بعدين terminal bronchiole ثم respiratory bronchiole الذي يحوي duct يليه موجود فيها الحويصلات الهوائية

لأنه يقوم بتوصيل الهواء من الجو إلى الحويصلات الهوائية عشان هيكل اسمها conducting

A) Conducting zone

Anatomical

- It includes : ^① nose , ^{② part of pharynx} nasopharynx , ^③ trachea , ^④ bronchi , ^⑤ terminal bronchioles , ^⑥ till the end of terminal bronchiole and the start of ^⑦ respiratory bronchioles → Respiratory zone.
 conducting zone.
- walls of conducting zone are thick and don't allow gas exchange (Dead space)
 لا يتم فيه تبادل للغازات .

Function of conducting zone:

- 1) **Conduction** of air to the respiratory zone. (Respiratory bronchiole)
- 2) **Air conditioning:** زي كأنه مكيف
 - adjusting the temperature of inspired air to be equal to that of body by adding heat to cold air and remove of excess heat from hot air.
 السقي
 - this is achieved by the rich blood supply in the mucosa of nose , mouth and pharynx.
 conducting zone

ثبات البيئة الداخلية للجسم تعتمد انه درجة الحرارة لكل الاحشاء
تكون وحدة و ما ينفع الهواء الداخلي مرة باردة مرة سخن لانه
لازم air يوصل لل alveoli عند درجة حرارة 37
طيب ده هيتم ازاي؟



عنا ال mucosal layer يلي مغطيه conducting zone
يكون rich in blood supply لما ال cold air يدخل ف
درجة الحرارة رح تعمله warming اما ال hot air بصير
عنا removal of heat عشان توصل لل 37 و هاد نوع من
ثبات البيئة الداخلية لانه عند 37 تتم عملية تبادل الغازات
بالطريقة الصحيحة و ما بيحصلش injury of lung tissue

Lung tissues are very sensitive

3) **Humidification:** ترطيب injury يعني ممكن لو الهوا ناشف يعملها

– means **saturation of inspired air with water vapour** to protect the delicate

lung tissues from injury. يعني اني احط بخار ماء و يتحد مع air و يعمله ترطيب ف يمنعني من انه يصير اي تلف للرئتين

هاد fluid اثناء الشهيق يتبخر و يعلق بالهوا ف يعمله ترطيب

– **this occurs by transcapillary fluid in the mucous membrane.**

Nose : contains mucus membrane which secretes mucus & there is cilia

4) **Filtration:** هدول الاهداب و المخاط مسؤولين عن filtration يعني بينقي الهوا من البكتيريا او اي مواد غريبة و مهيجة للجهاز التنفسي

– means **filtering air from foreign particles and bacteria** , so that:

– large particles > 4-6 microns are trapped by ^{السِّبْرَانَة} hairs of the nose while

small particles are trapped by mucous secreted by goblet cells.

5) **Protective reflexes:**

- **for removal of F.B and irritant sub. from respiratory passages, they include:**

a) ^{السعال} cough reflex

b) ^{الخطاس} sneezing reflex

6) **Non respiratory function:**

a) ^{الشم} **Smell:** by the olfactory epithelium in the nose.

b) **Phonation:** by vibration of vocal present in the larynx.

^{الكلام عن طريق الحبال}
^{الصوتية في الحنجرة}

B) respiratory zone

Which is considered to non conducting part / respiratory zone ?

Larynx

Pharynx

Respiratory bronchiole

- **Thes includes respiratory bronchioles and alveoli** → الجدار بتاعها رقيق جدًا فده بيسمح بعملية تبادل الغازات
- **The membrane separating blood in pulmonary capillaries and air in alveoli is very thin so gas exchange occurs freely and rapidly.**

External respiration

- **Consists of: 1) Pulmonary ventilation.**
2) Exchange of gases.

Related to lungs.
I-Pulmonary ventilation (Minute respiratory volume)
علية التنفسية

Definition: It is the total amount of air inspired per minute
كمية الهواء يلي بدخلها بالشهيق خلال الدقيقة

It equals the respiratory rate per minute (respiratory cycles) x tidal volume
معدل التنفس في الدقيقة

Tidal volume: The volume of air inspired or expired with each normal quite breath
شهيقي زعير

It equals 500ml in the normal young adult male

I) Pulmonary ventilation

Number of cycles: 12-16 per minute

The respiratory cycle, each cycle consists of:

a) **Inspiration** = 1.3 sec.:

السهيبي

- active process , the thoracic cavity \uparrow in all dimensions \rightarrow the lung distends and air rushes into the lungs .

b) **Expiration** = 1.7 sec (longer than inspiration): relaxation

العضلات بدل ما تنقبض رح يصير لها

- passive process , the thoracic cavity \downarrow in all dimensions \rightarrow the lung recoils and the air is forced outside the lung .

c) **Expiratory pause** = 0.7 sec. : Between inspiration + expiration.

- some time present specially during rest and sleep.
- disappears during rapid respiration e.g exercise.

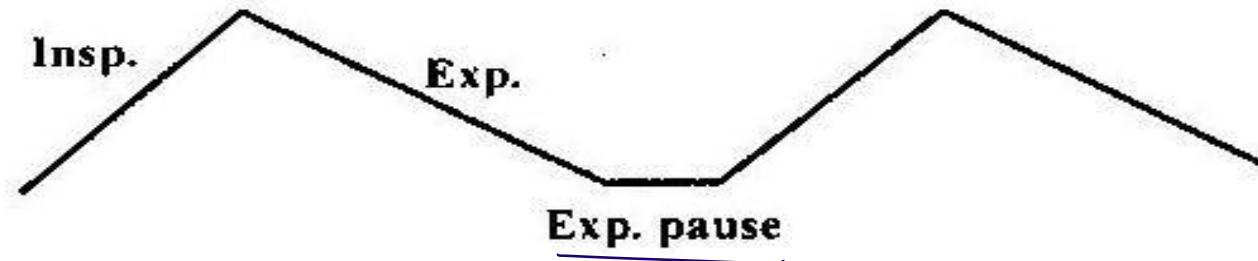
contractions of respiratory muscles (external intercostal & diaphragm)

لانهما تتم عن طريق energy

تحتاج إي

تتمدد / تنفخ

تكمش



N.B: - Respiratory cycle = $1.7 + 1.3 + 0.7 = 3.7$ sec.

- **Respiratory rate (number of respiratory cycle/min.):**

$$= \frac{60}{3.7} = \text{about } 16 \text{ cycle / min.}$$

It ranges from 12-16 cycles per minute ممكن ييجي ك سؤال

-In children the rate is about 25 /min

So pulmonary ventilation = $12 \times 500 = 6 \text{ L per minute}$
of air.

Mechanism of Respiration

a) Inspiration:

- Occurs as a result of contractions of the diaphragm and external

intercostal ms. Respiratory muscles

abdominal cavity و thoracic cavity تفصل ما بين

- Contraction of the diaphragm → ↑ the vertical diameter of chest cavity.

لما تنقبض بتنزل لتحت و يطول ال chest في

- Contraction of external intercostal ms → ↑ the transverse and antero-

posterior diameters.

chest diameter in transverse يزيد ف رح يزد rib below ل rib above من ماسكة
air in lungs و يدخل و pressure in alvoli و يقل lung volume و بالتالي رح يزد dimension

- So the chest cavity increases in all its dimensions → ↑ in the lung volume → ↓ pressure inside the lung alveoli → rush of air into the lung.

b) Expiration: *passive* → No contraction

- Relaxation of diaphragm and external intercostal ms decrease the chest in all diameters → ↓ in the lung volume → ↑ pressure inside the lung alveoli → rush of air out of the lung.

Factors affecting pulmonary ventilation

مقاومة الممرات الهوائية

1) Resistance of air passage:

- The resistance depend on the diameter of respiratory passages:
 \downarrow diameter of the air way \rightarrow \uparrow resistance \rightarrow \downarrow pulmonary ventilation

القطر

factors

Diameter of air passages is affected by:

كل الشعب الهوائية محاطة ب عضلات ملساء في بعض احيان تنقبض و بعض احيان بتعمل relaxation ولو

انقبضت رح تضيق الممرات الهوائية لو صار عنا relaxation رح توسع

1-Bronchomotor tone:-affected by autonomic nervous system and

inflammatory mediators such as histamine and prostaglandins

Constriction

Dilation

2-Bronchial mucosa :Presence of secretions (mucus) or **increased thickness**

لو thickness of mucus membrane يزيد بسبب

increase the resistance inflammation ف رح يسبب edema للجدار او ممكن

يفرز مخاط كثير

3-Lung volumes : the diameter increases as lung expands

لو اخذت نفس عميق رح اخلي الرئة تتمدد

ف رح توسع الممرات الهوائية

Factors affecting pulmonary ventilation

ببساطة هي بتحكي لي اول ما
يصير connection بين
(2) الماء او fluid مع الهواء رح
تلقق ال molecules ببعضها

معامل التوتر السطحي

Surfactant:

الاطفال يلي بنولدوا ب الشهر السابع يكون عندهم حاجة اسمها
respiratory distress syndrome عندهم اختناق ف
بحطوهم على جهاز تنفس صناعي عشان يقدر و يعيشو لحد ما
يتكون surfactant

- **Surfactant is a complex substance secreted by the alveolar epithelium and acts mainly to ↓ surface tension (when the water forms a surface with air, the water molecules on the surface are strongly attracted to each other) inside the lung** ^{بترمحن التوتر السطحي}
- **alveoli (due to thin water film lines the alveoli in contact with air). So prevent lung collapse** <sup>بحسب رايه التماس ←
د بطلع الحوا بين فيها
التماس الرئة. → collapse</sup>
- **Decrease of surfactant e.g. respiratory distress syndrome → ↑ surface tension inside alveoli → ↓ pulmonary ventilation. (alveolar collapse)**

عالية القدر أو المرونة.

3) **Lung and chest compliance:**

- **Def:** is the extent to which the lung expands for each unit increase in the pulmonary pressure.

$$\text{Compliance} = \frac{\text{Change in volume (rV)}}{\text{Change in pressure (rP)}}$$

- The normal compliance of the lungs in the average adult human is approximately $200 \frac{\text{ml}}{\text{cm}}$ of water pressure.

Significance of measuring compliance: بقيس هل عندها قدرة تتمدد او لا

- it is a measure of the expansibility of the lung.

- any condition that decreases lung compliance (e.g) pulmonary fibrosis

→ ↓ pulmonary ventilation.

طيب ايه اللي يقلل compliance ؟

الجدار بتاع الرئة اللي المفروض يتمدد يروح يتحول ل

fibrous tissue و هاد بمنع انها تتمدد

او edema

او مثلاً في اعوجاج في القفص الصدري

4--Intra pleural pressure

الرئة حواليتها غشاء بلوري مكون من طبقتين وحدة ماسكة فيها و الثانية ماسكة بالقفص الصدري من برا

Each lung is enclosed in a double walled sac called pleura :

-The part that lines the ^{البحير} thoracic cavity is called parietal layer

-the part that covers the ^{ملاوة يعني تريب} lung firmly is called visceral pleura

- The cavity in between is filled with serous fluid that prevent friction between the 2 layers and cause the lung to slide on the chest wall and resist their separation

لو حصل ثقب في pleural رح تنفصل الرئة عنه وتنكمش

Definition It is the pressure inside the pleural cavity.

Value:

It is a ⁽⁻⁾ negative pressure → ^{ببسمح للرئة تتمدد قد ما بدها طيب هو ليه negative ؟ لانه ما في هوا}

Causes of

negative intrapleural pressure:

a. No air in the pleural cavity.

b. Continuous traction of the lung against a rigid chest wall. ^{الرئة فيها elastic tissue و بتحب تنكمش during rest وال chest wall ثابت ف بتعمل اشى زي غرفة ال pressure فيها negative}

4--Intra pleural pressure

Importance of negativity of IPP:

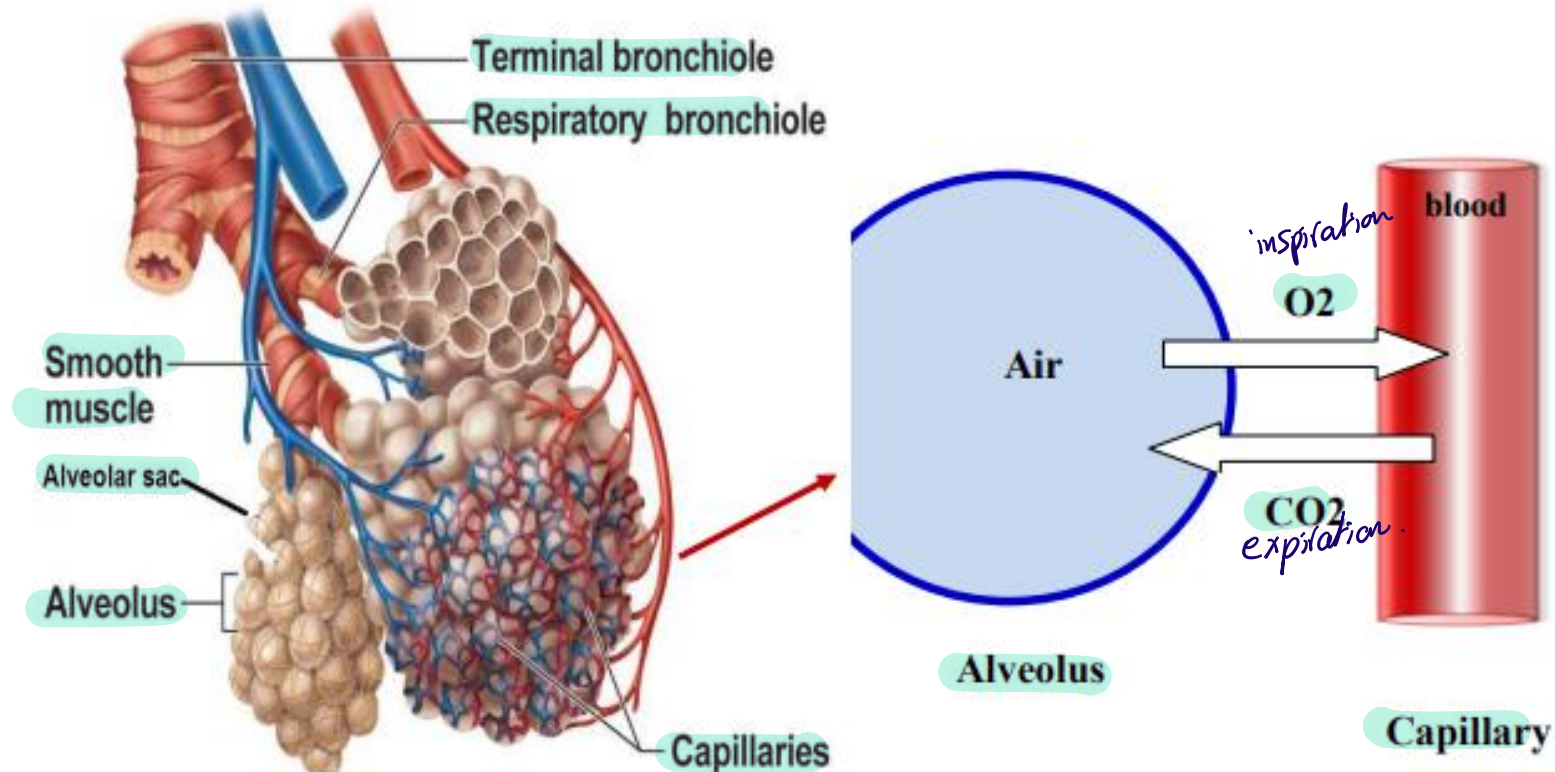
- a. **It helps expansion of the lungs. (so help pulmonary ventilation)**
- b. **It helps venous return.**
- c. **It helps flow of lymph.**

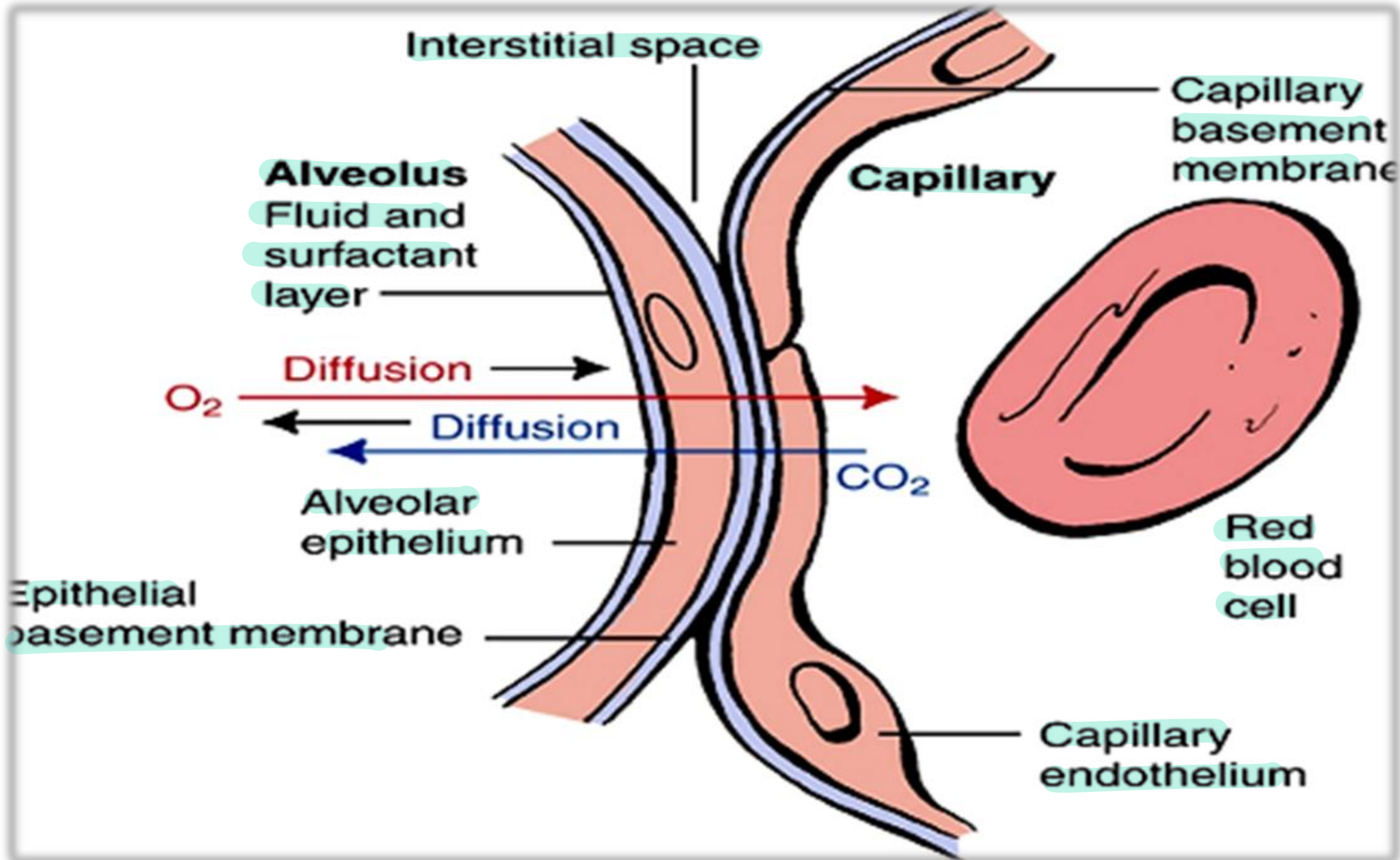
II- Exchange of gases

- is the change of O_2 for CO_2 through the respiratory membrane.

ده بي فصل ما بين الشعيرة الدموية و الحويصلة

ده عبارة عن كرات دم حمراء
و في عنا endothelial
برضو plasma
fluid و membrane
lining of alveoli





Factors affecting gas exchange:

- 1) Properties of respiratory membrane.
- 2) Properties of respiratory gases.
- 3) Ventilation / perfusion ratio.

1- Properties of respiratory membrane. يفصل ما بين الحويصلة و الوعاء الدموي

تناسب عكسي

a) Thickness of the respiratory membrane: كل ما كان ارفع التبادل رح يكون احسن

- normal thickness of resp. memb. = 0.6 micro-meter.
- the rate of gas diffusion → is inversely proportional to the thickness. so any factor that ↑ the thickness of resp. memb → ↓ gas exchange .
- Any factor that increases the thickness (such as pulmonary edema and pulmonary fibrosis) can interfere with exchange of gases. Accumulation of a fluid instead of air , fibrous tissues لما كان يقوى ر

b) Surface area of the respiratory membrane: كل ما كانت مساحة السطح اكبر كل ما كان التبادل اسرع

- Normal surface area = 60 m² . علاقة طرقيه
- the rate of gas diffusion → is directly proportional to the surface area of the Respiratory. During exercise the surface area could increase
Due to increasing of air inside alveoli so it expand also
blood flow will increase

II- Properties of the respiratory gases:

- the **rate of diffusion** of respiratory gases is affected by :

a) **Pressure gradient:** (*high* → *low*)

الأرقام هي	Alveolar air	Venous blood
O₂ pressure	100 mmHg	40 mmHg
Co₂ pressure	40 mmHg	46 mmHg

• according to conc. **Gradient** :

- i. O₂ diffuses from the alveoli ^{venous blood.} into pulmonary capillaries
- ii. CO₂ diffuses from pulmonary capillaries into alveoli .

b) Lipid solubility & molecular weight (M.W):

- all respiratory gases are lipid soluble.
- the rate of gas diffusion is :

i-directly proportional to lipid solubility. *sub*

ii-inversely proportional to M.W of the gas. *inversely*

The solubility of CO_2 is greater than O_2 but have larger molecular weight

The net result is that the diffusion rate of CO_2 through the respiratory membrane is about 20 times that of O_2 *more soluble*

Diffusion capacity

- **Def:** It is the volume of a gas that diffuses through the membrane each minute for a pressure difference of 1 mmHg.
 - For O_2 is 20ml./ min./ mmHg.
 - for CO_2 is 400 ml./min./mmHg. 20x20
 - This capacity increases during muscular exercise to 80 for O_2 and 1200 for CO_2
ليه اثناء exercise يزيد :
 - This increase is due to increase surface area for diffusion (expansion of alveoli and opening of more pulmonary capillaries and increase pulmonary blood flow) and also better ventilation perfusion ratio

3-Ventilation / perfusion ratio.

Def: it is the ratio between alveolar ventilation and pulmonary blood flow per minute. ✓
كل ما أجالها هوا او دم اكثر يكون التبادل احسن

Alveolar ventilation (Effective pulmonary ventilation) ✓

Defintion: The volume of air that enters the alveoli per minute and undergo gas exchange with blood in the pulmonary capillaries ✓
كمية من الهوا يلي بتدخل الى alveoli و بتعمل exchange

It equals 350 of the 500 ml inspired with each breath ✓
500 :
150 > dead space
350 > الحويصلات

So alveolar ventilation = resp rate x (MRV-Dead space ventilation) = 12x(500-150) = 4.2L per min ✓

Anatomic versus physiological dead space ✓

Anatomic : Air conducting part ✓

Physiologic : include anatomic + non functioning alveoli ✓

3-Ventilation / perfusion ratio.

The normal alveolar ventilation in an adult is 4 L / min. •

The total perfusion (the blood flow through the lungs) •

is equal to the cardiac output = 5L/min.
• كمية الدم الخارجة من RV الى lungs.

So the ratio is about 0.8. • $\frac{4}{5} = \frac{\text{ven}}{\text{per}}$

This ratio differ from one part of the lung to another •

3-Ventilation / perfusion ratio. •

The lung is divided into three zones according to its blood •

flow.(change in blood flow is due to effect of gravity on the blood

column from the top of the lung to its base)

Zone I ➤

عُوقَة

و انا نايم ما بتكون في zones بس اقوم
و اوقف رح يصير عنا جاذبية ف الدم رح
ينزل لتحت بسببها و الهوارح يرتفع
لفوق

Present at the apex of the lung. •

It is hyper ventilated (ventilation is high). •

Blood flow is little so it is called hypoperfused. •

المكان ده معرض ل infection لانه
الهوا زيادة ف ممكن يدخل
microbes و ما في مقاومة لانه ما
في WBCs

This area is more liable to be infected with T.B. •

V/P ratio = 3.3. •

3-Ventilation / perfusion ratio.

Zone 2 :- ➤

The blood flow begins to occur at the top of the zone increasing down its length. •

Zone 3:-this region is hyper perfused and hypo ventilated. ➤

This unequal distribution of blood flow can be explained by the hydrostatic pressure difference(effect of gravity) between the top and bottom of the lung. •

V/P mismatch

Local autoregulatory mechanisms contribute to match alveolar air flow and blood flow:

لما يكون عنا حويصلة فيها دم كثير وما في هوا ايه اللي هيحصل؟
Pulmonary vessels رح تتضيق
ف الدم يروح لحتته تانية بكون الهوا فيها كثير عشان تتم عملية تبادل الغازات.

I. Pulmonary vessels

pressure

vasoconstriction

- Low PO_2 causes V.C. of pulmonary blood vessels and decrease in pulmonary blood flow.
- While, high PO_2 causes V.D. of pulmonary blood vessels and increase in pulmonary blood flow.
- This helps to redistribute blood flow from areas poor in O_2 to areas rich in O_2 producing normal V/P ratio.

vaso dilatation

II. Respiratory air way

- High CO_2 level dilates the airways and increases airflow in the alveoli.
- While low CO_2 level constricts the airways and decrease airflow in the alveoli.
- This helps to match alveolar air with the pulmonary blood flow.

Questions

1-Mention 3 functions of the respiratory conducting zone of the respiratory tract •

2-Which of the following is considered internal respiration? •

Carriage of O₂ by the blood (a

Carriage of Co₂ by the blood (b

Pulmonary ventilation (c

Oxidation of food stuff by the tissues (d

Exchange of gases (e

2- which of the following is considered part of the respiratory zone of the respiratory system ?

The nose (a)

The nasopharynx (b)

The larynx (c)

The respiratory bronchioles (d)

The terminal bronchioles (e)

4- which of the following values is considered the value of respiratory rate?

30cycles per min (a)

16 cycles per minute (b)

5cyclesper minute (c)

10 cycles per min (d)

40 cycles per minute (e)

5- Describe factors affecting pulmonary ventilation

6- Which of the following defects in pulmonary ventilation is considered the cause of respiratory distress syndrome?

Decreased surfactant (a)

-ve intrapleural pressure (b)

Decreased lung compliance (c)

Decreased chest compliance (d)

Narrowing of air passages (e)

6- Enumerate 3 causes of –ve intrapleural pressure and mention the significance of these negativity

7-Which is considered the value of O₂ pressure in alveolar air? •

40 mmHg (a)

100mmHg (b)

46mmHg (c)

80mmHg (d)

20mmHg (e)



7-Mention how mismatch between pulmonary and alveolar ventilation is autoregulated

8--Discuss factors affecting gas exchange through the respiratory membrane



Thank You