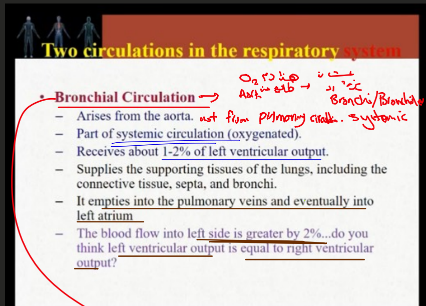
Pulmonary Circulation :-

Bronchial circulation



It's drainage 50% in Right Heart (R. Atrium) & other 50% in left atrium

so → mixture at Blood in left heart 2% is venous not arterial blood

98 arterial

So - blood that come from left side not 100% oxygenated

Bronchial/Cardiac vein/basin Thy empty in R + L of the Heart

deoxygenated

L.V output same for R. output ?

Ventricle ...

① pulmonary vein → capillary → pulmonary Artery → R. Atrium
5 liter → oxygenated Blood

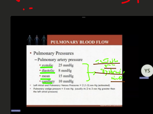
② 1-2% from bronchial veins → de-oxygenated blood.

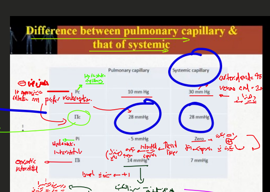
deoxygenated → that open inside left ventricle.

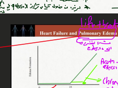
Systemic Circulation + Pulmonary

In oncotic pressure

π_c capillary oncotic

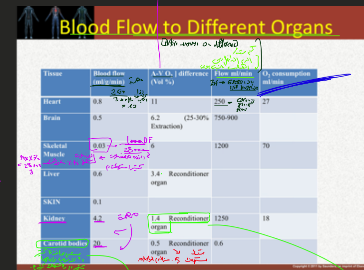




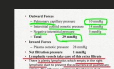


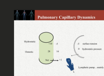
q = venous ...

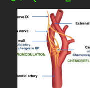
* Heart extracts most of O_2 delivered to it - so we won't tolerate ischemia in the heart.



Tissue	Blood flow (ml/g/min)	A-V O_2 difference (Vol %)	Flow ml/min	O_2 consumption ml/min
Heart	0.8	11	250	27
Brain	0.5	6.2 (25-30% Extraction)	750-900	
Skeletal Muscle	0.03	6	1200	70
Liver	0.6	3.4 Reconditioner organ		
SKIN	0.1			
Kidney	4.2	1.4 Reconditioner organ	1250	18
Carotid bodies	20	0.5 Reconditioner organ	0.6	

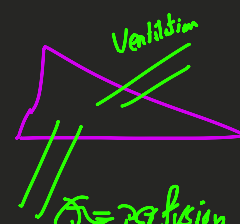






50	35
X	Y

Carotid bodies



The composition of alveolar air reflects the harmony by which respiratory & cardiovascular systems are working: Ventilation: Perfusion Ratio (V/Q).

Harmony
to be Ventilated & perfused

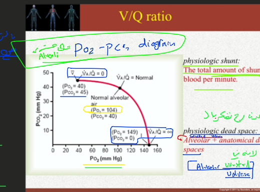
② Part of lung is ventilated not perfused → V/Q = ∞

$P_{O_2} = 150$ / $P_{CO_2} = 0$

Alveolar ventilation = 4.2 L/min

Cardiac output = 5 L

① $\frac{V}{Q} = \frac{4.2}{5} = .84$



about 2% is shunted

① 2% shunted (physiological)
② 1-2% Bronchial circulation (deep)
③ left ventricle

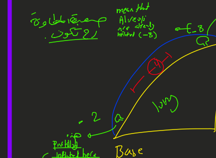
venous Mixing / venous pollution

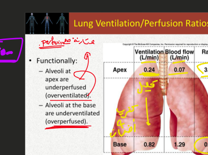
Arterial blood is polluted by venous blood so I don't expect that P_{O_2} to be 100 mmHg

Apex

Base

Most of ventilation ...





V apex < V base

Q apex < Q base

V/Q apex > V/Q base

30 cm

Heart

much pressure to pump toward base (Gravity)

Apical

Base

When we have expiration

Ventilation high

3 times

LA

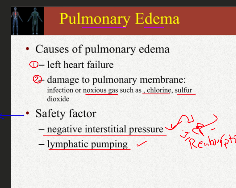
P_{O_2} = 130 + 90 ... = 95

Pseudo

Hyperventilated blood (Po2 High)

$[O_2] = HbO_2$

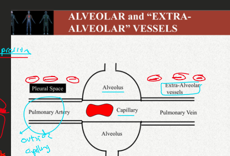
O2 curve is sigmoidal



That prevent pulm edema

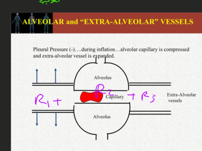
Reabsorption

↑TLC → by compression on capillary



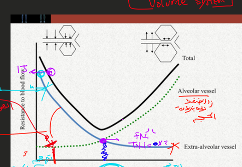
Residual volume

↑R in Extra ← compression on extra ← less negative



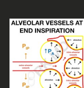
When we talk about Total Resistance: Resistance are connected in series = pulmonary vascular R

Resistance Volume system

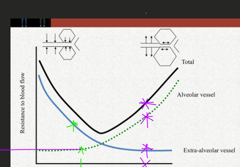


Resting state system

Total vascular Resistance is minimal at FRC



→ Emphysema patient



Restrictive disease

diffuse pulmonary hypertension

80 mPo2

$F = \frac{P}{R}$

↑FRC in COPD and then ↑R so to keep the flow constant

Lecture 2

V/Q at the apex → high →

↑ = PO_2 → less exchange

apical alveoli → will be high PO_2 → aerobic bacteria like Tuberculosis (TB) → They prefer this area to built there nets → shadow at apex ↳ we have to rule out TB

we have to rule out cancer in the base

Durung exercise → pulmonary vascular resistance ↓ → $\frac{1}{7}$ of TPR

$Q = \frac{\Delta P}{R}$ (ΔP = 100, Q = 5 liter)

$= \frac{100 \text{ systemic}}{100} = 1$ → 5 liter

$Q = 5L = \frac{\Delta P}{\Delta R} = \frac{\frac{1}{7} TPR}{\Delta R}$; $\frac{12}{12} = 1$; 14 − Pressure in left atrium (2) = 12 = 18

$\frac{1}{7} \times 100$

RA = 0 ; 100 − 0

∴ Pulmonary Vascular Resistance $= \frac{12}{100} = \frac{1}{7}$

During Exercise :-

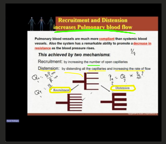
(1) more capillaries are opened → capillaries → 1/3 at rest

(2) distension of capillary

↓

(1) recruitment

(2) Distension



Question

During exercise, what will happen for TPR?

* will → decrease

$P = Q \times TPR$

$Q = \frac{\Delta P}{TPR}$

30 L ← 5L يزداد من

هل يزداد الضغط

exercise

ولا يزداد 10%

الفكرة انه R يقل

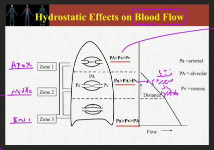
بيقسم على $\frac{1}{6} / \frac{1}{5}$

انا عارف انه Q يزداد 5 أضعاف للرياضي

marthon ← 7 times

public ← 2 ← 20 L

athlets ← 25 L

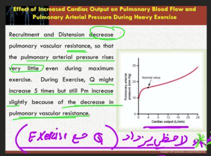


Zone 2 → There is flow in systole

Pa > PA > Pv

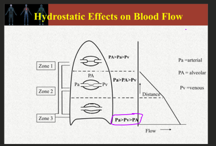
systole

Blood flow inside capillary



ويبقى ΔP ثابت تقريبا

لانه R تقل



→ Only Zone 3 where there is a flow during both diastole & systole more than alveoli

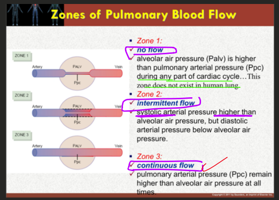
In Erect

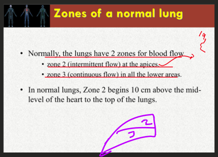
sleeping will be different

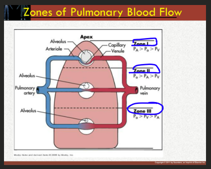
Normally we don't have Zone 1, in bleeding/pathologic we can find Zone 1

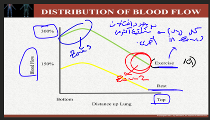
* During Exercise → flow to lung becomes → Homogenus

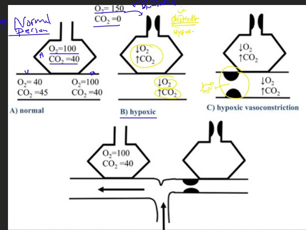
Zone 3 تصبح lung كل

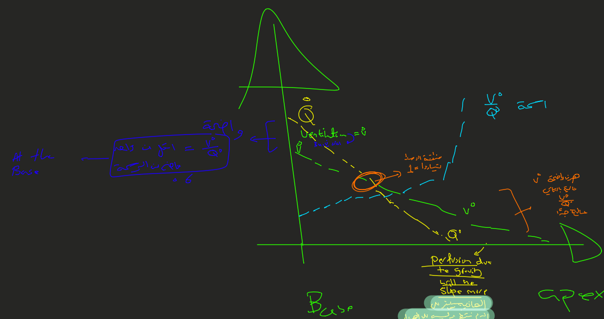


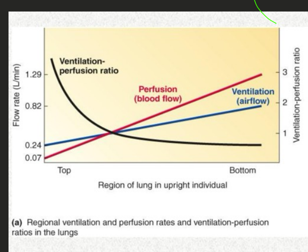




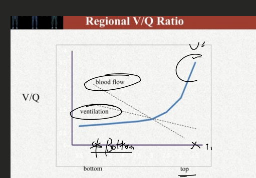


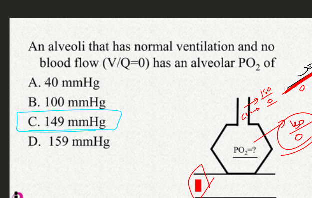




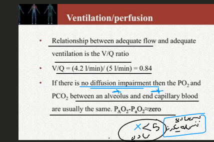


(a) Regional ventilation and perfusion rates and ventilation-perfusion ratios in the lungs




An alveoli that has normal ventilation and no blood flow (V/Q=0) has an alveolar PO_2 of
A. 40 mmHg
B. 100 mmHg
C. 149 mmHg
D. 159 mmHg

why PaO_2 = 95 not 100?


Ventilation/perfusion
- Relationship between adequate flow and adequate ventilation is the V/Q ratio
- V/Q = (4.2 l/min)/ (5 l/min) = 0.84
- If there is no diffusion impairment then the PO_2 and PCO_2 between an alveolus and end capillary blood are usually the same. P_AO_2-P_aO_2=zero

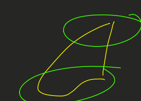
① Venous admixture

Cardiac veins — Bronchial circulation + physiological Shunting blood
2% not reach the alveoli
→ it will bypass capillary from vein to artery.

② Inadequate V/Q ratio
high in apex
low in base
V/Q not uniform

So why hyperventilated area can't correct hypoventilated area?

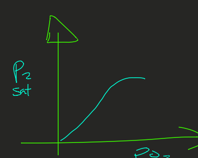
→ Bcz of shape of O₂-Hb dissociation curve is sigmoidal



Sigmoidal shape

↑ P_{O_2} doesn't affect [O_2]

[O_2] → will be less in artery



[O_2] blood
① dissolved = P_{O_2} × solubility = 100 × .003 = .3 ml/dl
② bound with HbO_2 → depend on [Hb]

1 gm of Hb can bind 1.34 ml of O_2
15 gm in male Hb → will be equal (19-15) concentration

20 from Hb

$$[O_2]_{blood} = 20 + .3 = 20.3$$

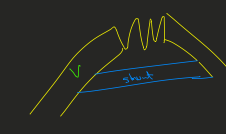
which mean O_2 is 1.5% dissolved
Bound [HbO_2] 98.5

$95 = P_{aO_2}$

$40 = P_{CO_2}$

O_2

P_{CO_2}



P_{O_2} 100 → 95
P_{aCO_2} 40 → 40

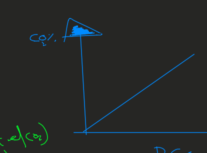
Mixing of venous blood
CO_2 = 45
arterial blood CO_2 = 40

Venous CO_2

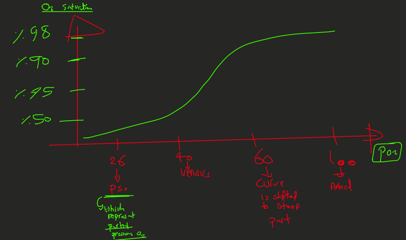
① [P_{CO_2}] curve is linear

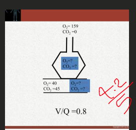
Respiratory center will be stimulated causing hyperventilation (washout of CO_2)

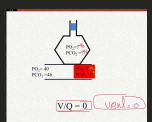
40 = P_{CO_2}

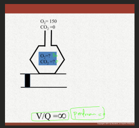


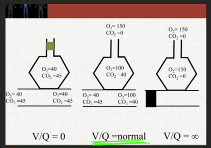
حفظ الأرقام

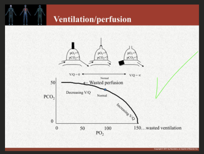


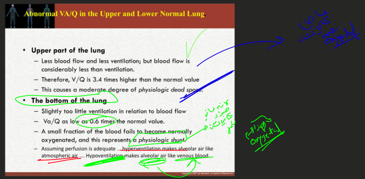


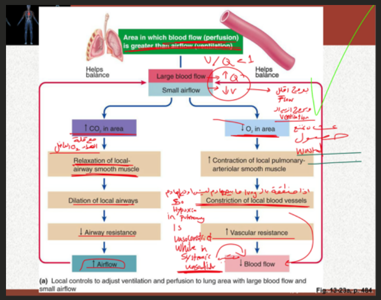












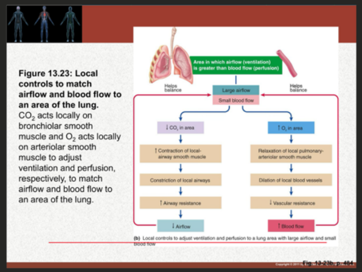


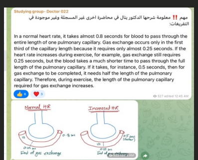
Figure 13.23: Local controls to match airflow and blood flow to an area of the lung. CO_2 acts locally on bronchiolar smooth muscle and O_2 acts locally on arteriolar smooth muscle to adjust ventilation and perfusion, respectively, to match airflow and blood flow to an area of the lung.

Lecture 3

Transport of O_2 / CO_2

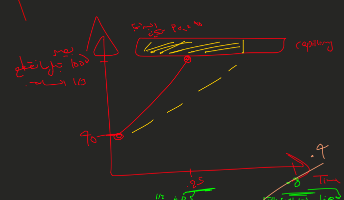
Diffusion capacity → This Membrane — how much O_2 can diffuse (flow, diffuse) per minute

pressure 1 mm Hg



Normally we utilize 1/3 of respiratory membrane

you will utilize most of length of capillary (exercise)



$V = \frac{Q}{A}$

Q = 150 bpm, 75 bpm

$$Diffusion = \frac{A}{dx} \cdot \frac{S}{\sqrt{MW}} = K = \frac{1}{R}$$

K = lung capacity

So → it's impossible to directly measure DLCO

K / R

250 ml/min

$DLO_2 = \frac{\dot{V}}{\Delta PO_2}$ — oxygen consumption per minute (diffuse)

$\Delta PO_2 (A - cap)$

ohms: flow = $\frac{DP}{R}$

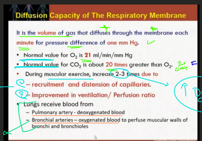
Diffusion capacity for O_2 → directly ✗ (can't be measured directly)

Flow = $\Delta PO_2 \times K$

O_2 consumption 250 ml/min

$P_A = 100$

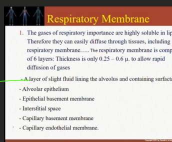
ΔPO_2

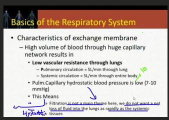


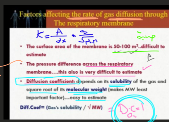
Increase 2-3 times — recruitment, improvement in V/Q, exercise

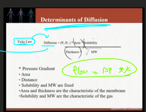
Diffusion capacity = K = permeability = $\frac{flow}{DPO_2}$

6 layers









ABG Test

↳ Air blood gases

$P_aO_2 = 100$

$P_aCO_2 = 40$

doesn't exclude the lung disease

$P_AO_2 = 80$

$$JO_2 = \frac{Area}{dx} \cdot \frac{Solubility}{\sqrt{MW}}$$

Flow = F ohms

JO_2 = flow = $\Delta PO_2 \times k$

$\frac{JO_2}{\Delta PO_2} = k$

Diffusion lung capacity = k

CO → carbon monoxide

lead to death

CO → Blood → the O_2 (250 with Hb)

$\frac{PO_2}{PCO_2} = \frac{100}{250} = 1$

$PO_2 = 100$, PCO = 1, PCO = .1 ml/mmHg

$\Delta PCO = PCO_A$

$PCO = 0$

$\Delta P_{CO} = .1$

DLCO

$DLCO = K = 17$ ml/min/mmHg

Can I extrapolate this to O_2 & CO_2? yes

know diffusion coefficient: $O_2 = 1$, $CO_2 = 20$, $CO = .8$

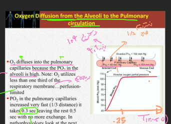
DLCO

coeff: 17 → .8, ? → 1

$17 \div .8 = ?$

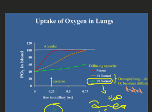
$KO_2 = \frac{17}{.8}$ = 21 ml/min/mmHg (Diffusion capacity)

For CO_2: 20 × 21 = 400 ml/min/mmHg



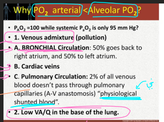
.25

Thickened membrane



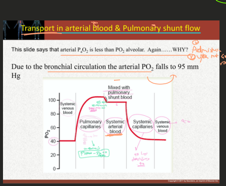
3.92

$60 < PO_{2a}$



Shunt in pulmonary arteries

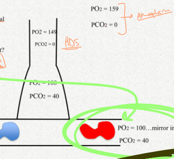
don't compensate the base in term of blood → bez sigmoidal curve.



Mirror image

Alveolar and Blood Gases

This slide says that for hypothetical situation arterial P_aO_2 should be a mirror image of alveolar P_AO_2. In actuality, P_aO2 is less than P_AO2 alveolar. WHY is that?



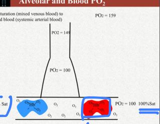
$\frac{7}{100} \times 70 = 5\ L$

In each 1 µl blood → contain 5×10^6 RBC

In each RBC → 280 million Hb

Alveolar and Blood PO_2

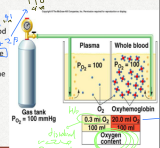
From 75% saturation (mixed venous blood) to fully saturated blood (systemic arterial blood)

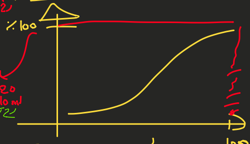


$\frac{3}{4} = 15$ ml

Hemoglobin and O_2 Transport

- RBC = 5 million per µl blood
- 280 million Hb/RBC.
- Each Hb has 4 polypeptide chains and 4 hemes.
- In the center of each heme group is 1 atom of iron that can combine with 1 molecule O_2.





Anemia

7.5 = Hb

[O2] → dissolved, Bound

[Hb] × 1.34

7.5 × 1.34 = 10

[O2] will be low

(15 × 1.34) = 20

Favorable

ALVEOLAR GAS EQUATION

$PA_{O_2} = FiO_2 \times (P_B - P_{H_2O}) - PaCO_2 / RQ$

$PA_{O_2} = 150 - PaCO_2 / RQ$

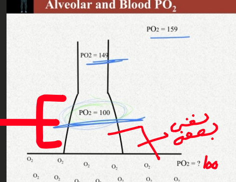
Question

A person is breathing from a gas tank containing 45% oxygen. What is the alveolar PO_2?

- A. 149 mmHg
- B. 250 mmHg
- C. 270 mmHg
- D. 320 mmHg
- E. 340 mmHg

Alveolar

Alveolar and Blood PO_2



Hypothetical

- What happens to *mixed venous* PO_2 in an anemic person?
- Normal
- Lower
- Higher

75% → 50%

A [O2] venous [O2]

20 → 15

10 → 5

Arterial PO_2 is 100 mmHg and content is 20 ml O_2/dl. What is arterial PO_2 if ½ of all of the red cells are removed?

- A. PO_2 = 0 mmHg
- B. PO_2 =30 mmHg
- C. PO_2 =50 mmHg
- D. PO_2 =60 mmHg
- E. PO_2 =100 mmHg

RBC ↓

↓ Content = Hb + Sat + PO_2

15 = Hb

7.5 = Hb

(bound + dissolved) → [O2]a

Extraction Ratio 25% always (while in Anemic patient)

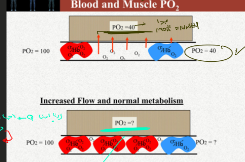
10 = Hb

Arterial 10 ml — Capillary 5 ml — Venous 5 ml

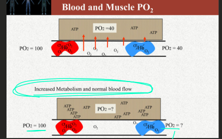
PO_2 = 26

50%

Blood and Muscle PO_2

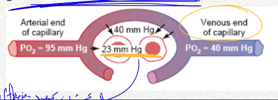


Blood and Muscle PO_2



PO_2 in systemic circulation (Diffusion from peripheral capillaries)

- Oxygen is always being used by the cells. Therefore, the intracellular PO_2 in the peripheral tissue cells remains lower than the PO_2 in the peripheral capillaries.



Increased Blood Flow to Tissue

- Normal blood flow
  - 200 ml O_2/lit of arterial blood * 5 lit blood/min= 1000 ml/min
  - VO_2/min…250 ml are consumed at rest (25%)
- **Utilization Coefficient or (Extraction ratio):**
- Is the % of blood that gives up its O_2 as it passes through tissue capillaries. Normally is 25%. In exercise 75% - 85%. In some local tissues with extremely high metabolic rate → 100%.

$[Hb] = 15$ g/dl

GAS CONTENT OF BLOOD

- One DL of Blood Contains 15 g of Hemoglobin
- One DL of arterial Blood Contains 20 ml of O_2
- Arterial Blood (PO_2 95 mm Hg; PCO_2 40 mm Hg; Hb 97% Saturated)
- Venous Blood (PO_2 40 mm Hg; PCO_2 45 mm Hg;

100 ml = 1 dL

- Hemoglobin
  - One gm of Hb can bind reversibly 1.34 ml of O_2
  - Normally in male adult we have
    - 15 gm Hb/100 ml blood that can bind:
    - 20 ml O_2 /100 ml blood (1.34 * 15)
  - Anemic
    - 10 gm Hb/100 ml blood binds only 13 ml O_2 /100 ml blood

- Since solubility of O_2 in blood is low then the amount transported, as dissolved O_2 is also low. Our body provides a mechanism for transporting O_2. the O_2 binding protein (Hb).
- Adult (A) HbA $\alpha_2\beta_2$ $\alpha = 141$ β 146 M.W 64.460
- Fetal (P) HbF $\alpha_2\gamma_2$ 2% of normal blood. γ chain doesn't bind 2,3,DPG….the curve is shifted to the left.
- Sickle (S) Hb^S $\alpha_2\beta_2^S$
- $Hb(A_2)$ $\alpha_2\delta_2$ 2% of adult Hb.

Hemoglobin (continued)

- Methemoglobin:
  - Has iron in the oxidized form (Fe^{+++}).
    - Blood normally contains a small amount. but ferric Fe^{+3} which is useless because it does not release O_2. NADH-meth-Hb reductase can convert ferric to ferrous form
- Carboxyhemoglobin:
  - The reduced heme is combined with carbon monoxide.
  - The bond with carbon monoxide is **250** times stronger than the bond with oxygen.
    - Therefore, transport of O_2 to tissues is impaired.

ferric → Fe^{+3} ferrous → Fe^{+2}

Hb is in its ferrous state F^{+2}, this can bind O_2 reversibly, but ferric Fe^{+3} is useless because it does not release O_2. NADH-meth-Hb reductase can convert ferric to ferrous form.
Hb: has 4 chains, each having heme group (iron – containing porphyrin rings)., which can bind one molecule of O_2.

Hb	or deoxygenated Hb or reduced Hb or ferrohemoglobin
HbO_2	oxy-Hb
Hb (ferric)	Oxidized or methHb . or ferrihemoglobin (1% of the total Hb).
HbCO	carboxy Hb.
$HbCO_2$	carbamino Hb.

O_2 Uptake during Exercise

maximal O_2 consumption during maximal exercise

- VO_2 increases during exercise until it reaches VO_2max…what limits VO_2max…lung? CVS? number of mitochondria?
- Increased cardiac output and thus muscle blood flow and extraction ratio…all make more O_2 available to the exercising tissues
- Decreased transit time…Normal lung can still oxygenate blood beside this issue
- Increased diffusing capacity
  - Opening up of additional capillaries
  - Better ventilation/perfusion match
- Equilibration even with shorter time

$\dot{V}O_2 = 3 L/min$

What will limit $\dot{V}O_{2max}$?

lung → not limit V_{max}

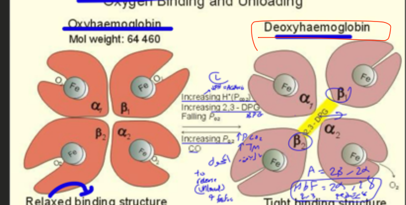
Mitochondria → Not limit V_{max}

Still reach VO_2 max

عوامل تسهم في تفكك O_2 من Hb ؟؟

1. ↑ H^+
2. ↑ 2-3 DPG
3. ↑ TM
4. ↑ CO_2

Oxygen Binding and Unloading

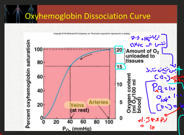


- The total amount of Oxygen carried by Hb in blood depends upon:
  - The percentage saturation of Hb.
  - The amount of Hb in the blood.

Oxygen Transport

- Partial Pressure (mm Hg)
  - driving force for diffusion
- Percent Saturation (no units)
  - HbO_2
  - ($Hb+O_2$) is called oxyHb
- Content (ml O_2/100 ml blood)
  - The absolute quantity of oxygen in the blood is the most important among others

Lecture 4 — 7/12/2024



CO - posioning → No Hyperventilation

Hb ... HbCO ... carboxy Hemoglobin

Doesn't warn the Hb about O2.

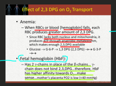
$PO_2 = 100$ — Respiratory center — Normal lung

$100 \neq O_2$ Stat

Hb ... CO

[O2] will be low value.

(Not Hyperventilation)

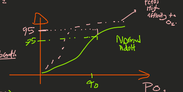


At High Altitude → PO_2 = low, O_2 saturation = low, [O2] = low

2,3 DPG

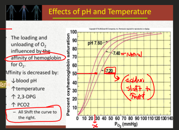
Baby exposed to low O_2 to supply him.

– So once the born and both ... He will have shifting in Hb ... HbF = ...



Normal person ... P_{50} ...

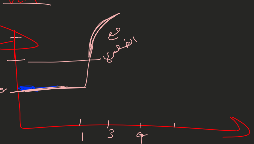
→ When the curve shifted to right P_{50} will increase



* During exercise all of the following will increase except?
① Alveolar ventilation ② Diffusion lung capacity for O_2 ③ P_{50} ④ ...

Hyperventilation → Respiratory Alkalosis

High altitude → PO_2 ↓ drives ventilation → Hyperventilation

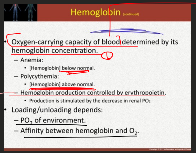


ventilation at sea level

ventilation will increase

CO_2 ... R. center in Medulla

In CSF: CO_2 will Bind with water → H_2CO_3 → $H^+ + HCO_3^-$



O2 ... Blood; Saturation

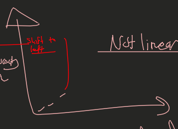
↓Hb ... Anemia

↑[Hb] ← Polycythemia

Hb ↑ by erthyropiote that secreted from Kidney when there Hypoxia in kidney.

TEPO — High altitude → Hypoxia → in kidney → ↑EPO → In 5 week Hb = ..., Hematocrit = ... 75 ...

Viscosity; Resistance



Pulm. circulation → Pulm. Hypertension

At High Altitude → we will have Hypoxia then → Hyperventilation

Trying to make the Alveolar air close to the atmospheric air

PO_2 ↑, PCO_2 ↓

Hyper P_aCO_2 (↓)

Exercise ... Hyperven...

ABG Normal

at rest ... 5 ml of O_2; 1 dL = 100 ml we extract 5 ml O_2

Cardiac output = 5 L × ... = 250 ml ... O_2 consumption

250 ml O_2

Respiratory exchange ratio $= \frac{VCO_2}{VO_2} = \frac{4}{5} = \frac{200}{250}$ ml/min

Capillary

Tissue

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2$

Mixed food / Protein = 0.8 / ... 0.7

1 = exchange ratio

$PH = 6.1 + \log \frac{HCO_3^-}{CO_2}$

HCO_3^- from kidney; CO_2 from lung

PO_2 ...

CO_2 ... ↑PH

PH will Be Normal

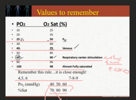
HCO_3^- Bicarbonate

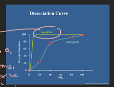
Inhibition — Respiratory Center

O_2

CO_2 Hypoxia

PH Normal





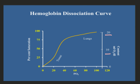
Anemia

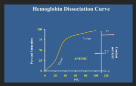
[O2]

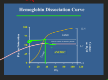
Anemia Curve

Hb 15 → 7.5

Anemia patient at rest Arterial ... What's the expected PO_2 in Bi venous?







Anemia ... reduce PO_2 in venous ...

Bohr effect

Shifts of Dissociation Curve

- Right shift occurs at tissue level…Bohr's effect
  - ↑$PaCO_2$ or ↑ arterial H^+ → ↓ affinity for oxygen or increase O_2 release…this occur at the tissue level
- Left shift at lungs…Haldane's effect is the reverse Bohr's effect
  - loss of carbon dioxide at lungs → ↑affinity of Hb towards oxygen

O_2 — CO_2

* When CO_2 bind, O_2 will release.

* When H^+ " , O_2 " "

Tissue هذا بال

Bohr

يعني Release O_2

In each RBC بالتالي

Have 280 million

Hb with DPG

Same

① 2,3 DPGs → Hb لكل عند تحميل

1,3 DPG → (Normal pathway) → Glucose → Mutase

بدال ما يصير 2.3 DPG

السؤال

What are the advantages of Hb inside RBC?

شو ميزة بالخلايا

RBC ميزات

① Mutase → Reductase, Fe^{3+} → Fe^{2+}

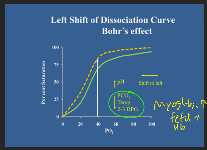
Carbonic anhydrase

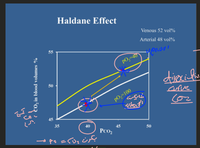
$CO_2 + H_2O$ → H_2CO_3

② Prevent Hb degradation by enzymes of plasma

③ Prevent viscosity of blood

④ Prevent filter Hb in urine





عكس بوهر

A person has a hemoglobin concentration of 10 gm/dl. The arterial oxygen content is 6.5 ml O_2/dl. What is the saturation?

A. 25%
B. 50%
C. 75%
D 100%

Whatever

[Hb] = 10 mg

10 × 1.34 = 13.4

6.5 ml

saturation 50%

13.4 → 100%
6.5 → ??

Calculations

- Calculate % saturation
  - Patient has Hb of 10 gm/dl
  - Venous oxygen content is 6.5 ml O_2/dl
- Calculate oxygen content
  - Patient has saturation of 60%
  - Patient has Hb of 15 gm/dl

15 = [Hb]

20 ml

Sat — التركيز

100% — 20 ml

60% — ?

$\frac{60}{100} \times 20 = 12$ ml

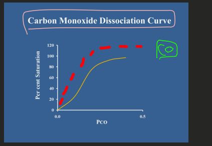
Sat = 60%

(15 × 1.34)

100% → 20.1

60% → ?

Shift to left



Lung بال بينما

H^+ ↑ O_2 ↑ CO_2

Reverse Bohr

= Haldane effect

Hb in Urine

Hemolysis

Albumin

* When it exceeds in plasma

Hemoglobin urea

Kidney → will be filtered

RBC في Hb فوائد

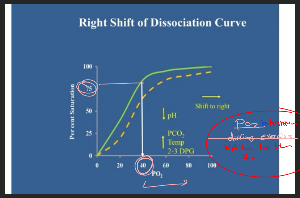
↑ viscosity ← Hb in plasma

RBC contain 2,3 DPG

Downward Right

anerobic metabolism ← RBC ما في mitochondria

Glucose, ↳ glycolysis → ↑ 2.3DPG → pyruvate



Transport of Carbon Dioxide

- Dissolved
  - solubility is 20-times of oxygen
  - venous blood: 2.7 ml/100 ml blood
  - arterial blood: 2.4 ml/100 ml blood
  - transported : 0.3 ml/100 ml blood
  - 7% total

Which of the following is least important for the transport of carbon dioxide?

a. hydrogen ions bound to hemoglobin
b. carbonic anhydrase
c. CO_2 dissolved in plasma
d. CO_2 bound to plasma proteins

$\frac{8.4}{13.4}$

Calculations

- Assume Hb is 10 gm/dl
- 100% saturation give a content of 13.4 ml/dl blood
- At rest body uses 5 ml O_2/dl → 8.4 venous
- This leaves a mixed venous content of 8.4 ml/dl
- Saturation is now 8.4/13.4 = 63%

$\frac{8.4}{13.4}$ = 62% venous saturation

CO2 found in three forms

not two?

① dissolved and this more than O_2 dissolved

$[O_2]$ = 100 × .003 = 3

Lecture 5

Inhibitory

Venous

RBC

Carbonic Anhydrase

CO_2

Interstitium

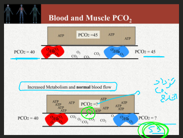
Capillary

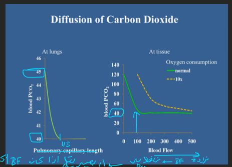
CO_2 diffuses to interstitium then to plasma

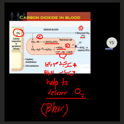
Tissue

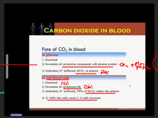
3 form: HCO_3^- 70%, $HbCO_2$ Carbamino 20%

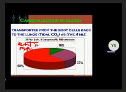
2 form of O_2: dissolved 1.5%, bound 98.5%











Control of Breathing

What is expected

ABG: $P_{O_2} = 100$, $P_{CO_2} = 40$, PH = 7.4

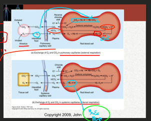
Respiratory Medulla center

$P_{CO_2} = \frac{V_{CO_2}}{V_A} \times K$

Control of Breathing....Introduction

- Q: What the controller system is going to do?
- A: Homeostasis of O_2, CO_2, H^+. Normal ABGs
- Q: How? What are the tools?
- A: by: ↑ventilation or ↓ventilation
- Q: What is the feedback system....
- A: ↓ $PaCO_2$, ↑$PaCO_2$, ↓ PaO_2 (below 60 mmHg), ↓ H^+, and finally ↑H^+
- Note: ↑PaO_2 has almost no effect on the controller system

$PH = 6.1 + \log \frac{HCO_3^-}{CO_2}$



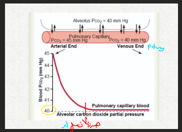
HbO — Oxyhemoglobin

$H^+ + HCO_3^-$

Haldane effect

CO2 TRANSPORT

	Arterial	Venous	A-V difference
Bicarbonate	43.2 (90%) 22.73 mM/l	45.6 (88%) 24 mM/l	2.4 (60%)
$HbCO_2$	2.4 (5%)	3.6 (7%)	1.2 (30%)
Dissolved CO_2	2.4 (5%)	2.8 (5%)	0.4 (10%)
Total	48 (100%)	52 (100%)	4 (100%)



Hyperventilation

VA

VR

P_{O_2}

Kidney

HCO_3^-

We expect that kidney to make more HCO_3^-

Increased Oxygen Delivery to Tissue

- Two means by which oxygen delivery to tissue can be increased. Name them….
  - 1:
  - 2:

① Cardiac output

② ↑ Extraction ratio — Shift to Right

④ Sympathetic