Respiratory system
Physiology

- E- Learning Activities & Calculations
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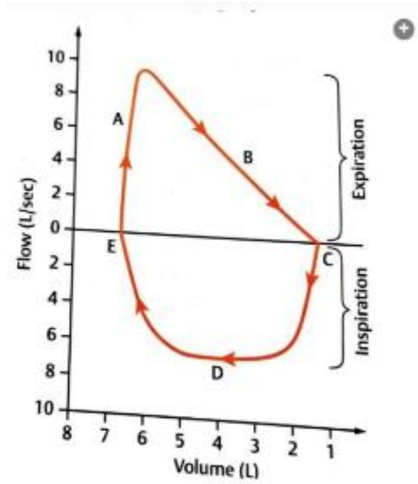
ELEARNING

★ **A healthy 21-year-old third year medical student participates in an experimental pulmonary function test. His flow-volume loop is shown. Which point on the loop indicates the residual volume?**

a) A
b) B
c) C
d) D
e) E



Ans: C:

★ **Acording to the figure what is**

FVC:(900 ml , 1200 ml,6700 ml, 5500 ml , 4500 ml)
RV: (900 ml , 1200 ml,6700 ml, 5500 ml , 4500 ml)
TLC: (900 ml , 1200 ml,6700 ml, 5500 ml , 4500 ml)

Ans: FVC= 5500ml , RV = 1200ml, TLC = 6700ml

Explanation
This image shows a flow-volume loop,
The upper curve represents expiration, starting from TLC (point E) and ending at RV (point B).
The lower curve represents inspiration, starting from RV (point C) and ending at TLC (point E).
Forced vital capacity (FRC) = TLC - RV

★ **In the adult, one of the following is NOT different between the systemic and pulmonary circulation?**
a) Volume of blood flowing through it
b) Vascular resistance
c) Capillary hydrostatic pressure
d) (systolic arterial pressure)
e) Pulse pressure

Ans: a

★ **Which of the following sets of differences best describe the hemodynamics of the pulmonary circulation when compared with systemic circulation?**

	Flow	Vascular resistance	Arterial Blood pressure
A	Same	Higher	Higher
B	Higher	Lower	Higher
C	Lower	Higher	Lower
D	Same	Lower	Lower
E	Lower	Lower	Lower

Ans: D

Explanation

The cardiac output (CO) is the same for both the pulmonary and systemic circulations because the heart pumps blood to both systems in a closed circuit.Thus, flow is same.

$$\text{Flow (Q)} = \frac{\Delta P}{R}$$

PS physiology lecture 6

★ **Which of the followings best describe the changes that would occur in arterial gases following hyperventilation at <u>rest</u>:**

a) Decrease in PO_2, decrease in PCO_2 and decrease in PH_2O.
b) Increase in PO_2, decrease in PCO_2 and unchanged in PH_2O.
c) Increase in PO_2, unchanged in PCO_2 and increase in PH_2O.
d) Unchanged in PO_2, increase in PCO_2 and unchanged in PH_2O.
e) Decreased in PO_2, increase in PCO_2 and unchanged in PH_2O.

Ans: b

Explanation

by definition, the Hyperventilation decreases arterial PaCO2.

↑ PO2, ↓ PCo2

$$\text{P alveolar CO2} = \frac{\text{V co2 (co2 production)}}{\text{V R (alveolar ventilation)}} \text{x } 0.863$$

★ **The following table of normal values (at sea level) contains one error. This error appears in which line**

		PO2	PCO2
A.	Pulmonary venous blood	100	40
B.	Alveolar air when hyperventilating	>100	<40
C.	Arterial blood during exercise	<90	>40
D.	Pulmonary arterial blood	40	45
E.	Alveolar air when hyperventilating	<100	>40

Ans: C

Explanation

A.Pulmonary venous blood: Correct, as it reflects blood that is fully oxygenated (PO_2 ~100 mmHg, PCO_2 ~40 mmHg).

B. Alveolar air when hyperventilating: Correct, as hyperventilation lowers PCO_2 (<40 mmHg) and slightly increases PO_2 (<100 mmHg).

C.Arterial blood during exercise: incorrect,Because arterial Blood gases (ABG) remain normal, since the production of CO2 is increased, and the alveolar ventilation is increased

D. Pulmonary arterial blood: Correct, as this blood has returned from systemic circulation, showing lower PO_2 (~40 mmHg) and higher PCO_2 (~45 mmHg).

E. Alveolar air when hyperventilating: ???

Calculations

★ A person has a hemoglobin concentration of 10 gm/dl. The arterial oxygen content is 6.5 ml O2 /dl. What is the saturation?

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

Calculation: 10gm/dl x 1.34 = 13.4 ml O2 /dl (the normal arterial concentration of oxygen - This is max oxygen carrying capacity -)

$\frac{6.5 \text{ ml } O2/dl}{13.4 \text{ ml } O2/dl}$= ~50%

Answer: B. 50%

★ Calculate oxygen content, Patient has saturation of 60%, Hb of 15 gm/dl?

Answer:

15 gm/dl x 1.34= ~20 ml O2/dl - This is max oxygen carrying capacity -

$\frac{?}{20.1}$= 60% 20.1 x 60% = ~12 ml O2/dl = oxygen concentration

★ Asume Hb is 10 gm/d、 100% saturation give a content of 13.4 ml of O2/dl in blood. At. Rest body uses 5 ml O2 Idl, this leaves a mixed venous content 8.4 ml/dl, venous saturation is?

Answer:

Venous saturation is 8.4/13.4 = 63%

★ What happens to mixed venous PO2 in an anemic person? Check the answer for calculations

A. Normal
B. Lower
C. Higher

Answer:

Initial Conditions in an Anemic Person Arterial PO_2: 100 mmHg.Oxygen saturation: 100%. **Oxygen content ($[O_2]$) in arterial blood:** Hb concentration × 1.34 since the oxygen carrying capacity is reduced lets assume it= **10 ml /dL.**

During capillary oxygen exchange, 5 mL/dL of oxygen diffuses through the capillary wall.the oxygen content in the venous blood decreases to 5 mL/dL

$$\text{Venous } [\text{Oâ}] = \text{Arterial } [\text{Oâ}] - \text{Oxygen diffused} = 10 - 5 = 5\,\text{mL/dL.}$$

$$\text{Venous Oâ saturation} = \frac{\text{Venous } [\text{Oâ}]}{\text{Maximum carrying capacity}} = \frac{5}{10} = 50\%.$$

From the oxygen saturation curve, at 50% saturation, PO2 = **26** you should memorize this value

★ **Arterial PO2 is 100 mmHg, and the oxygen content is 20mLO2/dL What is arterial PO2 if ½ of all the red blood cells were removed?**
A. PO2 = 0 mmHg
B. PO2=30 mmHg
C. PO2 =50 mmHg
D. PO2 =60 mmHg
E. PO2 =100 mmHg

Answer:

you should note is that as long as alveolar PO2 remains unchanged, arterial PO2 will also stay the same. Therefore, **PO2** after we remove half of the RBCs in our body is **100 mmHg**

what changes happen regarding [O2], and O2 saturation

At PO2 of 100, **O2 saturation is 100%,** meaning that all Hb is bound to O2.

when half the RBCs are removed, Hb content decreases from 15 to 7.5. This decreases the oxygen-carrying capacity of the blood. To calculate it, we use the same equation: **7.5*1.34 = 10mL of O2,**

★ **A person is breathing from a gas tank containing 45% oxygen. What is the alveolar PO2?**
A.149 mmHg
B.250 mmHg
C.270 mmHg
D.320 mmHg
E. 340 mmHg

Answer:

$$PO2A = PO2i - \frac{PaCO2}{R}$$

760-47= 713. (47 is PH2O, added to the gas in anatomic dead space). 713*45% = 321.➔ PO2i = 321 mmHg.- Arterial PCO2 (which is the amount of CO2 in the pulmonary arteries, not systemic) is 40.- R is 0.8 (usually constant)PO2A = 321 – (40/0.8) = 271 ≈ **270**

- **An alveoli that has normal ventilation and no blood flow (V/Q= ∞)has an alveolar PO2of**
  A.40 mmHg
  B. 100 mmHg
  C.149 mmHg
  D. 159 mmHg

Answer:

$$PO2A = PO2i - \frac{PaCO2}{R}$$

No exchange happen PAO2 = PO2i =760-47= 713. (47 is PH2O, added to the gas in anatomic dead space). 713*21% = **150**.

- **A patient with HEMOGLOBIN = 10 G/DL, calculate the oxygen carrying capacity If the saturation is 90%:**

Answer:
10 G/DL × 1.34 ML/G × 100% (SATURATION LEVEL) = 13.4 ML/DL OF OXYGEN carried by hemoglobin at 100% saturation
.90% SATURATION = 13.4 × 0.9 = **12.06** ML/DL OF OXYGEN carried at 90% saturation.

- **Following the previous question: If the oxygen extraction ratio is 33%, the VENOUS OXYGEN CONCENTRATION would be:**

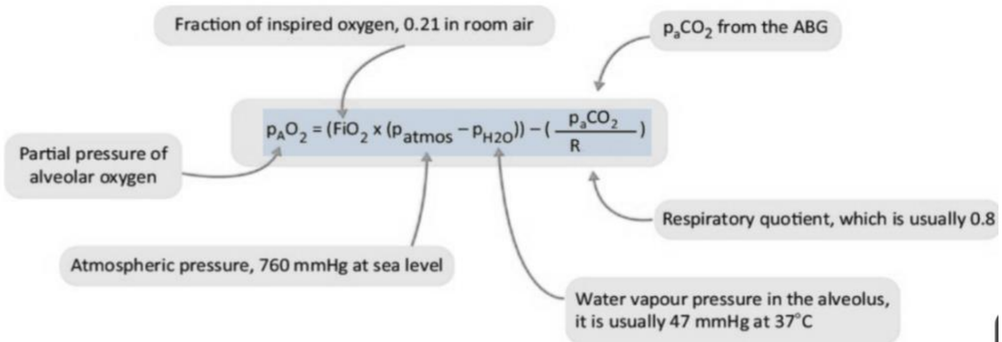
Answer:
This means the tissues have extracted one-third of the oxygen, and only two-thirds of the oxygen remains in the venous blood:§ 33% EXTRACTION of 12.06 mL = 4 ML of oxygen extracted.§ Therefore, the VENOUS OXYGEN CONCENTRATION would be: **12 ML/DL – 4 ML/DL = 8 ML/DL of oxygen remaining** in the venous blood.

★ **A patient with acute respiratory distress syndrome (ARDS) is connected to mechanical ventilation with an oxygen concentration of 70% (FiO_2 = 0.7) instead of the normal atmospheric oxygen concentration of 21% (FiO_2 = 0.21). The patient has an arterial partial pressure of oxygen (PaO_2) of 90 mmHg. Calculate the alveolararterial (A-a) gradient for oxygen .**

Answer:

Calculate the alveolararterial (A-a) gradient for oxygen using the alveolar gas equation

Very important equation we use to solve some of the previous questions



PaCO2 is assumed to be at normal levels: 40 mmHg then find PO2, which will be 449.1 mmHg. Then find the difference between alveolar and arterial PO2, which will be **359.1 mmHg**

★ **What is atmospheric PO, at 10,000 ft (barometric pressure = 508 mmHg)? Person has normal alveolar ventilation**

A. 95 mmHg

B.106

C. 149

D.159

Answer:

PO2 = P atm × gas fraction = 508×0.21 = 106

* **A woman has a respiratory rate of 18, a tidal volume of 350 ml and a dead space of 100 ml. Her PaCO2 was 40 mmHg. If she increases her tidal volume by 75 ml. Her PaCO2 will become approximately**

A. 15 mmHg.
B. 20 mmHg.
C. 25 mmHg.
D. 30 mmHg.
E. 35 mmHg.

Answer:

$$P_{A_{CO_2}} = \frac{\dot{V}_{CO_2} \times K}{\dot{V}_A}$$

where

$\dot{V}_A$ = Alveolar ventilation (mL/min)
$\dot{V}_{CO_2}$ = Rate of CO_2 production (mL/min)
$P_{A_{CO_2}}$ = Alveolar P_{CO_2} (mm Hg)
K = Constant (863 mm Hg)

$$\dot{V}_A = (V_T - V_D) \times \text{Breaths/min}$$

where

$\dot{V}_A$ = Alveolar ventilation (mL/min)
V_T = Tidal volume (mL)
V_D = Physiologic dead space (mL)

Since PaCOâ $\propto \frac{1}{\dot{V}_A}$, the new PaCOâ can be estimated as:

$$\text{New PaCOâ} = \text{Current PaCOâ} \times \frac{\dot{V}_A(\text{initial})}{\dot{V}_A(\text{new})}$$

Answer=30