Bio390 **Fick's Principle and the Estimation of Cardiac Output (SOLUTIONS)**

Given the following:

For an HCT = 40 **bound** O_2 at saturation = 20 ml/dl

HCT = 50

Solubility of O_2 = 0.01 mlO_2/torr * dl blood

P_{AO2} =100 torr

arterial P_{CO2} = 40 torr; arterial [bicarbonate] = 24 mM

Right Atrial blood P_{O2} = 50 torr

Right Atrial pH = 7.3

$\dot{V}_E$ = 6 L/min @ STPD

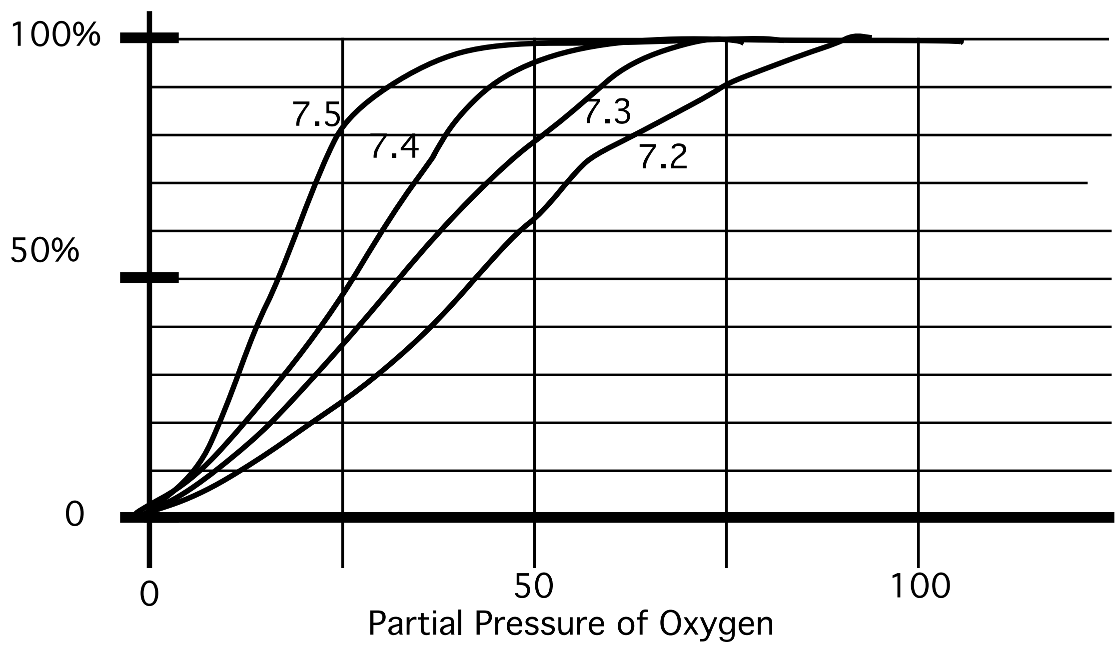
F_{EO2} = 0.16

F_{IO2} = 0.21

$\dot{V}O_2 = \dot{V}_E * (F_{IO2} - F_{EO2}) / (1 - F_{I)2})$

Heart rate = 60 beats / min

Here is the Hb - O_2 dissociation curve:



1. Find this persons cardiac output ($\dot{Q}$).

Recall that $\dot{Q} = \dot{V}O_2 / (C_{aO2} - C_{vO2})$

So, first we will find $\dot{V}O_2$

$\dot{V}O_2 = \dot{V}_E$ * (F_{IO2} - F_{EO2}) / (1 - F_{EO2})

$\dot{V}O_2$ = 6 L/min * (0.21 - 0.16) / (1 - 0.16) = 6 L/min * (0.05) / (0.84)

$\dot{V}O_2$ = 0.357 LO2 / min

Next we need to find (C_{aO2} - C_{vO2}).

- First, notice that the hematocrit is high -- 50%. Thus, this blood can hold 50/40 * 20 mlO2/dl = 25 ml $_{O2}$ /dl blood at saturation.

- We notice that the CO_2 and bicarb values for arterial blood are those for *p*H 7.4. We also see that P_{AO2} = 100, this should be very, very close to the P_{aO2} and so in the absence of other data we use P_{AO2} as our best estimate of P_{aO2} .
- In any case we notice that blood is saturated at any P_{O2} greater than about 70 torr. **So, the arterial blood is saturated.**

The **right atrial blood represents mixed venous blood from the entire body** (it is the only point that actually so represents mixed venous blood. So this is the best value we could possibly have for venous blood to use the Fick Principle to find cardiac output.
At a P_{O2} of **50 torr and *p*H 7.3, the right atrial blood is about 80% saturated**. This high degree in saturation reflects the fact that the subject is almost at rest (based on the metabolic rate) and on the person's high hematocrit which means that a smaller change in % saturation will accompany a given amount of O_2 that is unloaded.
Finally

We are now ready to calculate the A-V content of oxygen (C_{aO2} - C_{vO2}).

(art. % sat - venous % sat.)/100 * O_2 bound at saturation + Δ dissolved O_2

=(100 - 80)/100 * 25 ml $_{O2}$ /dl blood + (100torr - 25 torr) * 0.01 mlO2/torr * dl blood
= 5 ml O_2 / dl delivered from Hb + 0.75 ml O_2 / dl from A-V plasma difference
(C_{aO2} - C_{vO2}) = **5.75 ml O_2 / dl or 0.00575 L O_2 / dl**

Thus: $\dot{Q} = \dot{V}O_2$ / (C_{aO2} - C_{vO2})

$\dot{Q}$ = (0.357 LO2 / min) / 0.00575 L O_2 / dl = 62 dL/min =**6.2 L/min**

2. Find their average stroke volume.

Since $\dot{Q}$ = SV * HR

then:

SV = $\dot{Q}$ / HR = (6.2 L blood / min) / (60 beats min) = **1.03 dL / beat = 100 ml / beat**