QUIZ 3

Thursday, April 29, 2004

Name: ________________________________
These are normal values of physiological parameters for a 70 kg person.

\[
\begin{align*}
R_{rs} \text{ (respiratory system R)} &= 4 \text{ mbar·s/l} \\
C_{cw} &= 200 \text{ ml/mbar} \\
C_{lung} &= 200 \text{ ml/mbar} \\
V_D \text{ (Anatomic)} &= 150 \text{ ml} \\
V'O_2 &= 274 \text{ ml/min} \\
V'CO_2 &= 220 \text{ ml/min} \\
RQ &= 0.8 \\
Q_s/Q_T \text{ (Shunt fraction)} &< 0.05 \\
Q_T \text{ (cardiac output)} &= 5 \text{ l/min} \\
P_{atm} &= 760 \text{ mmHg} \\
P_{vCO_2} &= 46 \text{ mmHg} \\
P_{vO_2} &= 40 \text{ mmHg} \\
P_{aco2} &= 40 \text{ mmHg} \\
P_{aO_2} \text{ (at room air)} &= 100 \text{ mmHg} \\
(A - a)DO_2 &\approx 6-10 \text{ mmHg} \\
pH &= 7.4 \\
cHb &= 15 \text{ g/100ml-blood} \\
Hb O_2 \text{ Binding capacity} &= 20.1 \text{ ml O}_2/100\text{ml blood} \\
FRC &= 2.4 \text{ l}
\end{align*}
\]

The normal hemoglobin O\textsubscript{2} saturation curve is also included and should be used only when there is no alternative data available.

**Figure 1:**

The first two problems are cases that include certain respiratory physiologic abnormalities. You can use the normal values as a reference, or in absence of additional information.
Problem 1 (Case 1)

A patient comes to the emergency ward with shortness of breath and wheezing. He is breathing room air at a rate of 30 breaths per minute, and the pulse oximeter shows his arterial blood saturation to be $S_{aO_2} = 0.80$.

Arterial and mixed venous blood samples are taken at arrival and reveal the following values:

\[
\begin{align*}
P_{vCO_2} &= 44 \text{ mmHg} \\
P_{vO_2} &= 27 \text{ mmHg} \\
P_{aCO_2} &= 39 \text{ mmHg} \\
P_{aO_2} \text{ (at room air)} &= 20 \text{ mmHg}
\end{align*}
\]

The blood gas data comes with a computer generated caution questioning the validity of the measurements.

A. Please identify which of the four blood gas values may have an error and explain your reasoning. (25%)

B. You need to make a best guess to treat the patient with the knowledge available to you; can you find an approximate value of the erroneous blood gas? (25%)

C. The patient is given 100% O\textsubscript{2} by mask and one hour later his blood gases come back:

\[
\begin{align*}
P_{vCO_2} &= 48 \text{ mmHg} \\
P_{vO_2} &= 47 \text{ mmHg} \\
P_{aCO_2} &= 42 \text{ mmHg} \\
P_{aO_2} &= 60 \text{ mmHg}
\end{align*}
\]

This time without caution notes.

What can you say about the cause of gas exchange impairment in this patient? (50%) Hint, you can ignore the oxygen carrying capacity of plasma in your calculations.
Problem 2 (Case 2)

The same patient eventually develops respiratory failure and is placed on a mechanical ventilator adjusted to parameters matching his tidal breathing:

\[
\begin{align*}
VT &= 390 \text{ ml} \\
f &= 30 \text{ bpm} \\
T_{ins} &= 40\% \\
T_{exp} &= 50\% \\
F_{i\text{O}_2} &= 0.50
\end{align*}
\]

And his blood gases are measured as:

\[
\begin{align*}
P_{\text{vCO}_2} &= 42 \text{ mmHg} \\
P_{\text{vO}_2} &= 45 \text{ mmHg} \\
P_{\text{aCO}_2} &= 40 \text{ mmHg} \\
P_{\text{aO}_2} &= 275 \text{ mmHg} \\
\dot{V}_{\text{O}_2} &= 274 \text{ ml/min} \\
\dot{V}_{\text{CO}_2} &= 220 \text{ ml/min}
\end{align*}
\]

The ventilator output shows the following screen

Figure 2:
A. Is this patient exhibiting dynamic hyper-inflation, and why or why not? (25%)

B. Can you estimate the patient’s respiratory system mechanical parameters: Resistance and Compliance? (25%)

C. The attending MD suggests decreasing frequency while keeping the inspiration (insufflation in Germanic English) and exhalation time % unchanged. What frequency and tidal volume would you choose? Assume that the VD physiologic remains unchanged. (50%)

(Note: if you decide to use VD anatomic in your calculation, you will lose 25% of the question points.)
Problem 3

Pulmonary fibrosis is a debilitating disease of the lung characterized by replacement of elastin by collagen and resulting in a decrease of lung compliance. In severe cases, lung transplant is the only option for survival. To maximize organ availability and reduce post-operative mortality, usually unilateral lung transplant is conducted.

A. First draw the normal chest wall and lung compliance curves. Then draw changes that result from pulmonary fibrosis ($C_L$ reduced by 1/2). Assume that compliances are linear and that the chest wall compliance does not change. What happens with FRC in pulmonary fibrosis? (25%)

B. Second, draw the effects of replacing one of the lungs with a normal donor lung. What will be the new FRC after surgery? You can assume that both right and left lungs have equal compliance before surgery. (25%)
C. How does the amount of pressure required to inspire a similar tidal volume compare between before and after surgery? (25%)

D. In what proportions is the tidal volume distributed between both lungs? (25%)