RSPT 1260 - MODULE D: EQUATIONS

1. Given a V_t of 500 mL and a f of 20/min, calculate the $\dot{V}_E$.

$$\dot{V}_E = f \times V_t$$
$$\dot{V}_E = 20/\text{min} \times .5L$$
$$\dot{V}_E = 10L/\text{min}$$

2. Given a V_t of 800 mL and a f of 12/min, calculate the $\dot{V}_E$.

$$\dot{V}_E = f \times V_t$$
$$\dot{V}_E = 12/\text{min} \times .8L$$
$$\dot{V}_E = 9.6L/\text{min}$$

3. Given a $\dot{V}_E$ of 20 L/min and a f of 20/min, calculate the V_t.

$$V_t = \frac{\dot{V}_E}{f} = \frac{20\,L/\text{min}}{20/\text{min}} = 1L$$

4. Given a $\dot{V}_E$ of 8 L/min and a f of 16/min, calculate the V_t.

$$V_t = \frac{\dot{V}_E}{f} = \frac{8\,L/\text{min}}{16/\text{min}} = 0.5\,L = 500\,mL$$

5. Given a $\dot{V}_E$ of 14 L/min and a V_t of 700 mL, calculate the f.

$$f = \frac{\dot{V}_E}{V_t} = \frac{14\,L/\text{min}}{.7\,L} = 20/\text{min}$$

6. Given a $\dot{V}_E$ of 16 L/min and a V_t of 800 mL, calculate the f.

$$f = \frac{\dot{V}_E}{V_t} = \frac{16\,L/\text{min}}{.8\,L} = 20/\text{min}$$

7. Given a V_t of 750 mL, a f of 12/min and a V_d of 175 mL, calculate the $\dot{V}_A$.

$$\dot{V}_A = (V_t - V_d) \times f = (750 - 175) \times 12 = 575 \times 12 = 6{,}900 = 6.9\,L/\text{min}$$

8. Given a V_t of 800 mL, F of 20/min, V_d of 130 mL, calculate the $\dot{V}_A$.

$$\dot{V}_A = (V_t - V_d) \times f = (800 - 130) \times 20 = 670 \times 20 = 13{,}400 = 13.4\,L/\text{min}$$

9. Calculate the normal range of tidal volume if the patient weighs 150 lbs.

$$\textbf{\textit{Normal}}\ V_t = \textbf{5 to 8 mL/kg}$$

$$\textbf{150 lb} \times \frac{\textbf{1kg}}{\textbf{2.2 lb}} = \textbf{68.2 \textit{kg}}$$

$$\textbf{5}\frac{\textbf{mL}}{\textbf{kg}} \times \textbf{68.2 kg} = \textbf{341 mL}$$

$$\textbf{8}\frac{\textbf{mL}}{\textbf{kg}} \times \textbf{68.2 kg} = \textbf{546 mL}$$

10. Calculate the normal range of tidal volume if the patient weighs 240 lbs.

$$\textbf{\textit{Normal}}\ V_t = \textbf{5 to 8 mL/kg}$$

$$\textbf{240 lb} \times \frac{\textbf{1kg}}{\textbf{2.2 lb}} = \textbf{109.1 \textit{kg}}$$

$$\textbf{5}\frac{\textbf{mL}}{\textbf{kg}} \times \textbf{109.1kg} = \textbf{546 mL}$$

$$\textbf{8}\frac{\textbf{mL}}{\textbf{kg}} \times \textbf{109.1kg} = \textbf{873 mL}$$

11. The best parameter for assessing the adequacy of alveolar ventilation is the patient's **$PaCO_2$**.

12. Given the following information, calculate the PAO_2, $PA\text{-}aO_2$ gradient and PaO_2/PAO_2 ratio.
Barometric pressure of 756 torr
FiO_2 .50
$PaCO_2$ 66 torr
PaO_2 55 torr

$$\textbf{\textit{PAO}}_2 = \left[\left(\textbf{\textit{P}}_{baro} - 47\right) \times \textbf{\textit{FIO}}_2\right] - \left(\textbf{\textit{PaCO}}_2 \times 1.25\right) = \left[\left(756 - 47\right) \times .5\right] - \left(66 \times 1.25\right) =$$

$$\left(709 \times .5\right) - 82.5 = 354.75 - 82.5 = 272.25 = 272.3$$

$$\textbf{\textit{P}}\left(\textbf{\textit{A}} - \textbf{\textit{a}}\right)\textbf{\textit{O}}_2 = \textbf{\textit{PAO}}_2 - \textbf{\textit{PaO}}_2 = 272.3 - 55 = 217.3$$

$$\frac{\textbf{\textit{PaO}}_2}{\textbf{\textit{PAO}}_2} = \frac{55}{272.3} = .20$$

13. Given the following information, calculate the PAO_2, $PA\text{-}aO_2$ gradient and PaO_2/PAO_2 ratio.
Barometric pressure of 749 torr
FiO_2 .40
$PaCO_2$ 77 torr
PaO_2 78 torr

$$\textbf{\textit{PAO}}_2 = \left[\left(\textbf{\textit{P}}_{baro} - 47\right) \times \textbf{\textit{FIO}}_2\right] - \left(\textbf{\textit{PaCO}}_2 \times 1.25\right) = \left[\left(749 - 47\right) \times .4\right] - \left(77 \times 1.25\right) =$$

$$\left(702 \times .4\right) - 96.3 = 280.8 - 96.3 = 184.5$$

$$\textbf{\textit{P}}\left(\textbf{\textit{A}} - \textbf{\textit{a}}\right)\textbf{\textit{O}}_2 = \textbf{\textit{PAO}}_2 - \textbf{\textit{PaO}}_2 = 184.5 - 78 = 106.5$$

$$\frac{\textbf{\textit{PaO}}_2}{\textbf{\textit{PAO}}_2} = \frac{78}{184.5} = .42$$

14. Hyperventilation results in a decreased $PaCO_2$ while hypoventilation is characterized by increasing levels of $PaCO_2$. Describe each of the following patients as having either normal alveolar ventilation, hyperventilation or hypoventilation.

a. Patient A V_t 400 mL f 8/min $PaCO_2$ 60 torr **HYPOVENTILATION**

b. Patient B V_t 200 mL f 35/min $PaCO_2$ 70 torr **HYPOVENTILATION**

c. Patient C V_t 500 mL f 12/min $PaCO_2$ 38 torr **NORMAL VENTILATION**

d. Patient D V_t 1,200 mL f 12/min $PaCO_2$ 14 torr **HYPERVENTILATION**

e. Patient E V_t 800 mL f 25/min $PaCO_2$ 41 torr **NORMAL VENTILATION**

f. Patient F V_t 600 mL f 28/min $PaCO_2$ 29 torr **HYPERVENTILATION**

15. Given the following laboratory data, calculate the desired value:
Hb 12 gm%, PaO_2 77 torr, SaO_2 88%, PvO_2 22 torr, SvO_2 44%, $PaCO_2$ 88 torr

a. CaO_2: $$\boldsymbol{CaO_2 = (Hb \times 1.34 \times SaO_2) + (PaO_2 \times .003) = (12 \times 1.34 \times .88) + (77 \times .003) = 14.15 + .23 = 14.38 = 14.4\ vol\%}$$

b. CvO_2: $$\boldsymbol{C\bar{v}O_2 = (Hb \times 1.34 \times S\bar{v}O_2) + (P\bar{v}O_2 \times .003) = (12 \times 1.34 \times .44) + (22 \times .003) = 7.08 + .07 = 7.15 = 7.2\ vol\%}$$

c. $C(a\text{-}v)O_2$: $$\boldsymbol{C(a-\bar{v})O_2 = CaO_2 - C\bar{v}O_2 = 14.4 - 7.2 = 7.2\ vol\%}$$

d. What is the normal value for each?

i) CaO_2: **18-20 vol%**
ii) CvO_2: **12-15 vol%**
iii) $C(a\text{-}v)O_2$: **4-6 vol%**

16. Given the following laboratory data, calculate the desired value:
Hb 8 gm%, PaO_2 66 torr, SaO_2 77%, PvO_2 35 torr, SvO_2 66%, $PaCO_2$ 55 torr

a. CaO_2: $$\boldsymbol{CaO_2 = (Hb \times 1.34 \times SaO_2) + (PaO_2 \times .003) = (8 \times 1.34 \times .77) + (66 \times .003) = 8.25 + .20 = 8.45 = 8.45\ vol\%}$$

b. CvO_2: $$\boldsymbol{C\bar{v}O_2 = (Hb \times 1.34 \times S\bar{v}O_2) + (P\bar{v}O_2 \times .003) = (8 \times 1.34 \times .66) + (35 \times .003) = 7.08 + .11 = 7.19 = 7.2\ vol\%}$$

c. $C(a\text{-}v)O_2$: $$\boldsymbol{C(a-\bar{v})O_2 = CaO_2 - C\bar{v}O_2 = 8.45 - 7.2 = 1.25\ vol\%}$$

17. Given the following ventilator parameters, calculate the desired value:
Peak Pressure: 60 cm H_2O, PEEP: 5 cm H_2O, Static Pressure: 40 cm H_2O, Flowrate 50 L/min, V_t : 800 mL.

a. Dynamic Compliance:

$$\textbf{Dynamic Compliance} = \frac{\textbf{Tidal Volume}}{\textbf{(Peak Pressure - TOTAL PEEP)}} =$$

$$\frac{.8L}{(60-5)cmH_2O} = \frac{.8L}{55\,cmH_2O} = 0.015\ L/cmH_2O$$

b. Static Compliance:

$$\textbf{Static Compliance} = \frac{\textbf{Tidal Volume}}{\textbf{(Plateau Pressure - TOTAL PEEP)}} =$$

$$\frac{.8L}{(40-5)cmH_2O} = \frac{.8L}{35cmH_2O} = 0.023\ L/cmH_2O$$

c. Airway Resistance:

$$\textbf{Airway Resistance } (R_{aw}) = \frac{\textbf{Peak Pressure - Plateau Pressure}}{\textbf{Flowrate in L/min}} \text{ x } 60$$

$$\frac{(60-40)cmH_2O}{50\,L/\text{min}} \times 60 = \frac{20cmH_2O}{50\,L/\text{min}} \times 60 = 0.4\,cmH_2O/L/\text{min} \quad x60 = 24\,cmH_2O/L/\text{sec}$$

18. Given the following ventilator parameters, calculate the desired value:
Peak Pressure: 45 cm H_2O, PEEP: 10 cm H_2O, Static Pressure: 20 cm H_2O, Flowrate 80 L/min, V_t : 700 mL.

a. Dynamic Compliance:

$$\textbf{Dynamic Compliance} = \frac{\textbf{Tidal Volume}}{\textbf{(Peak Pressure - TOTAL PEEP)}} =$$

$$\frac{.7L}{(45-10)cmH_2O} = \frac{.7L}{35\,cmH_2O} = 0.02\ L/cmH_2O$$

b. Static Compliance:

$$\textbf{Static Compliance} = \frac{\textbf{Tidal Volume}}{\textbf{(Plateau Pressure - TOTAL PEEP)}} =$$

$$\frac{.7L}{(20-10)cmH_2O} = \frac{.7L}{10cmH_2O} = .07\ L/cmH_2O$$

c. Airway Resistance:

$$\textbf{Airway Resistance } (R_{aw}) = \frac{\textbf{Peak Pressure - Plateau Pressure}}{\textbf{Flowrate in L/min}} \text{ x } 60$$

$$\frac{(45-20)cmH_2O}{80\,L/\text{min}} \times 60 = \frac{25cmH_2O}{80\,L/\text{min}} \times 60 = .31\,cmH_2O/L/\text{min} \quad x60 = 18.8\,cmH_2O/L/\text{sec}$$

19. Which of the following ABG results would indicate a need for mechanical ventilation?

Patient A	Patient B	Patient C	Patient D
pH 7.38	pH 7.22	pH 7.52	pH 7.44
$PaCO_2$ 61 mm Hg	$PaCO_2$ 60 mm Hg	$PaCO_2$ 20 mm Hg	$PaCO_2$ 36 mm Hg
PaO_2 55 mm Hg	PaO_2 40 mm Hg	PaO_2 60 mm Hg	PaO_2 55 mm Hg
HCO_3^- 35 mEq/L	HCO_3^- 24 mEq/L	HCO_3^- 16 mEq/L	HCO_3^- 24 mEq/L
FiO_2 .21	FiO_2 .40	FiO_2 .40%	FiO_2 .40%

Patient **B**