Mechanical Ventilation in Chronic Lung Disease

1. You are ventilating a patient on the Servo ventilator with a minute ventilation of 10 L/min. The pH is 7.26, $PaCO_2$ 70 mm Hg, HCO_3 30 mEq/L, PaO_2 62 mm Hg. The doctor asks you to correct the pH. What is the desired level of $PaCO_2$? How would you change the ventilator settings to correct to the new $PaCO_2$ level?
THE DESIRE IS TO RETURN pH TO 7.40. CORRECTING THE $PaCO_2$ TO NORMAL WILL OVER-CORRECT pH.

***DESIRED* RATIO IS 20 : 1**

$$\frac{1.2\ mEq/L}{24\ mEq/L} \times 30\ mEq/L = 1.5\ mEq/L$$ **$PaCO_2$ NEEDS TO BE CORRECTED TO 50.0 mm Hg**

$$\frac{1.5}{0.03} = 50.0\ \text{mm Hg}$$

***ACTUAL* $PaCO_2$ × ACTUAL $\dot{V}_E$ = *DESIRED* $PaCO_2$ × *DESIRED* $\dot{V}_E$**

70 mm Hg × 10 L/min = 50 mm Hg × DESIRED $\dot{V}_E$ (we will designate as χ)

$$700\ \text{mm Hg} \bullet L/min = 50\ \text{mm Hg} \times \chi$$

$$\frac{700\ \text{mm Hg} \bullet L/min}{50\ \text{mm Hg}} = 14\ L/min$$ **Minute Volume**

2. You are called to the Emergency Department to care for a closed head injured patient who is being intubated. He is placed on mechanical ventilation with the following settings: V_t: 600 mL, Mode: A/C, f: 12/min, FIO_2: .60, PEEP: 5 cm H_2O.

An arterial blood gas shows the following results: pH: 7.38, $PaCO_2$: 42 torr, PaO_2: 80 torr, and HCO_3^-: 24 mEq/L. The physician wishes to hyperventilate the patient to a $PaCO_2$ of 30 torr. What changes would you make to accomplish this goal?

***ACTUAL* $PaCO_2$ × ACTUAL f = *DESIRED* $PaCO_2$ × *DESIRED* f**

42 mm Hg × 12 = 30 mm Hg × DESIRED f (we will designate as χ)

$$504\ \text{mm Hg} = 30\ \text{mm Hg} \times \chi$$

$$\frac{504\ \text{mm Hg}}{30\ \text{mm Hg}} = 16.8\ \text{breaths/minute} = 17\ \textit{breaths/minute}$$

3. You are called to the ICU to help with the management of a patient with long standing COPD ($FEV_{1.0}$ of 0.7 L one month ago) who was intubated one hour ago. Arterial blood analysis demonstrates a pH: of 7.23, $PaCO_2$: 88 torr, PaO_2: 55 torr, and a HCO_3^- of 36 mEq/L. These values were obtained on the following ventilator settings:
V_t: 500 mL, Mode: A/C, f: 14/min, FiO_2: .50, PEEP: 0 cm H_2O.

What is the desired $PaCO_2$ level? How would you change the ventilator settings to correct to the new $PaCO_2$ level?

***DESIRED* RATIO IS 20 : 1**

$$\frac{1.2\ mEq/L}{24\ mEq/L} \times 36\ mEq/L = 1.8$$ **$PaCO_2$ NEEDS TO BE CORRECTED TO 60 mm Hg**

$$\frac{1.8}{0.03} = 60\ \text{mm Hg}$$

***ACTUAL* $PaCO_2$ × ACTUAL f = *DESIRED* $PaCO_2$ × *DESIRED* f**

88 mm Hg × 14 = 60 mm Hg × DESIRED f (we will designate as χ)

1232 mm Hg = 60 mm Hg × χ

$$\frac{1232\ \text{mm Hg}}{60\ \text{mm Hg}} = 20.53\ \text{breaths/minute} = 20\ \textit{breaths/minute}$$

4. You are caring for a 75-year-old female with a long history of diabetic ketoacidosis. She is on a ventilator with the following settings: V_t: 550 mL, Mode: A/C, f: 16/min, FiO_2: .40, PEEP: 5 cm H_2O. An arterial blood gas on these settings shows the following: pH: of 7.08, $PaCO_2$: 42 torr, PaO_2: 55 torr, and a HCO_3^- of 12 mEq/L. While attempts are being made to correct the patient's blood sugar (550 mg/dL) there is signs of cardiac decompensation with frequent PVCs and hypotensive episodes. What changes can you make to the ventilator to return the pH to near 7.4?

***DESIRED* RATIO IS 20 : 1**

$$\frac{1.2\ mEq/L}{24\ mEq/L} \times 12\ mEq/L = 0.6$$

$$\frac{0.6}{0.03} = 20\ \text{mm Hg}$$

***ACTUAL* $PaCO_2$ × ACTUAL f = *DESIRED* $PaCO_2$ × *DESIRED* f**

42 mm Hg × 16 = 20 mm Hg × DESIRED f (we will designate as χ)

672 mm Hg = 20 mm Hg × χ

$$\frac{672\ \text{mm Hg}}{20\ \text{mm Hg}} = 33.6\ \text{breaths/minute} = 34\ \textit{breaths/minute}$$