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, PaCO₂ 70 mm Hg, HCO₃⁻ 30 mEq/L, PaO₂ 62 mm Hg. The doctor asks you to correct the pH. What is the desired level of PaCO₂? How would you change the ventilator settings to correct to the new PaCO₂ level?

**THE DESIRE IS TO RETURN pH TO 7.40. CORRECTING THE PaCO₂ TO NORMAL WILL OVER-CORRECT pH.**

\[
\frac{1.2 \text{ mEq}}{L} \times 30 \text{ mEq/L} = \frac{1.5 \text{ mEq}}{L} \quad \text{PaCO}_2 \text{ NEEDS TO BE CORRECTED TO 50.0 mm Hg}
\]

\[
\frac{1.5}{0.03} = 50.0 \text{ mm Hg}
\]

\[\text{ACTUAL PaCO}_2 \times \text{ACTUAL } \dot{V}_E = \text{DESIRED PaCO}_2 \times \text{DESIRED } \dot{V}_E\]

\[70 \text{ mm Hg} \times 10 \text{ breaths/min} = 50 \text{ mm Hg} \times \dot{V}_E \text{ (we will designate as } \chi\text{)}\]

\[700 \text{ mm Hg} \times \dot{V}_E = 50 \text{ mm Hg} \times \chi\]

\[\frac{700 \text{ mm Hg} \times \dot{V}_E}{50 \text{ mm Hg}} = 14 \text{ breaths/min, Minute Volume}\]

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:

\[V_t: 600 \text{ mL}, \text{ Mode: A/C, f: } 12/\text{min, FIO}_2: .60, \text{ PEEP: } 5 \text{ cm H}_2\text{O.}\]

An arterial blood gas shows the following results: pH: 7.38, PaCO₂: 42 torr, PaO₂: 80 torr, and HCO₃⁻: 24 mEq/L. The physician wishes to hyperventilate the patient to a PaCO₂ of 30 torr. What changes would you make to accomplish this goal?

\[\text{ACTUAL PaCO}_2 \times \text{ACTUAL f} = \text{DESIRED PaCO}_2 \times \text{DESIRED f}\]

\[42 \text{ mm Hg} \times 12 = 30 \text{ mm Hg} \times \dot{V}_E \text{ (we will designate as } \chi\text{)}\]

\[504 \text{ mm Hg} = 30 \text{ mm Hg} \times \chi\]

\[\frac{504 \text{ mm Hg}}{30 \text{ mm Hg}} = 16.8 \text{ breaths/min} = 17 \text{ breaths/min}\]
3. You are called to the ICU to help with the management of a patient with long standing COPD (FEV<sub>1.0</sub> of 0.7 L one month ago) who was intubated one hour ago. Arterial blood analysis demonstrates a pH of 7.23, PaCO₂: 88 torr, PaO₂: 55 torr, and a HCO₃⁻ of 36 mEq/L. These values were obtained on the following ventilator settings: V<sub>t</sub>: 500 mL, Mode: A/C, f: 14/min, FiO₂: .50, PEEP: 0 cm H₂O.

What is the desired PaCO₂ level? How would you change the ventilator settings to correct to the new PaCO₂ level?

**DESIRED RATIO IS 20 : 1**

\[
\frac{1.2 \text{ mEq}}{L} \times \frac{36 \text{ mEq}}{L} = 1.8 \quad \text{PaCO}_2 \text{ NEEDS TO BE CORRECTED TO 60 mm Hg}
\]

\[
\frac{1.8}{0.03} = 60 \text{ mm Hg}
\]

**ACTUAL PaCO₂ × ACTUAL f = DESIRED PaCO₂ × DESIRED f**

88 mm Hg \times 14 = 60 mm Hg \times \text{DESIREd f (we will designate as } \chi)\]

1232 mm Hg = 60 mm Hg \times \chi

\[
\frac{1232 \text{ mm Hg}}{60 \text{ mm Hg}} = 20.53 \text{ breaths/minute} = 20 \text{ breaths/minute}
\]

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<sub>t</sub>: 550 mL, Mode: A/C, f: 16/min, FiO₂: .40, PEEP: 5 cm H₂O. An arterial blood gas on these settings shows the following: pH: of 7.08, PaCO₂: 42 torr, PaO₂: 55 torr, and a HCO₃⁻ 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**

\[
\frac{1.2 \text{ mEq}}{L} \times \frac{12 \text{ mEq}}{L} = 0.6
\]

\[
\frac{0.6}{0.03} = 20 \text{ mm Hg}
\]

**ACTUAL PaCO₂ × ACTUAL f = DESIRED PaCO₂ × DESIRED f**

42 mm Hg \times 16 = 20 mm Hg \times \text{DESIREd f (we will designate as } \chi)\]

672 mm Hg = 20 mm Hg \times \chi

\[
\frac{672 \text{ mm Hg}}{20 \text{ mm Hg}} = 33.6 \text{ breaths/minute} = 34 \text{ breaths/minute}
\]