Ventilator Pocket Guide

Foundational Equations

Ohm's Law	$\Delta P = FR = P_{aw} - P_{alv} = P_{pl} - PEEP_{total}$
Equation of Motion	$P_{aw} = FR + \frac{V_{t}}{C} + PEEP_{total}$
Compliance	$C = \frac{\Delta V}{\Delta P}$
Natural Decay Equation	$V_i(t)= \frac{V_o}{e^{\frac{t}{RC}}} = \frac{V_o}{e^{\frac{t}{\tau}}}$
Calculating $\Tau$, General Case	$ \tau = \frac{V_t}{F} \Bigg(\frac{PIP - P_{plt}}{P_{plt} - PEEP_{total}}\Bigg) $
Alveolar Gas Equation	$P_AO_2 = F_iO_2(P_{atm}-P_{H_2O}) - \frac{P_aCO_2}{RQ} $, where $RQ = 0.80$
Mech Power, VC	${MP}_{VC} = 0.098 \cdot RR \cdot V_t[PIP-\frac{1}{2}(P_{plat}-PEEP)]$
Mech Power, PC	${MP}_{VC} = 0.098 \cdot RR \cdot V_t[PEEP + \Delta P_{insp}(1-e^{\frac{-T_{insp}}{RC}})]$

Respiratory Equations

Mechanical Power

Volume Control

${MP}_{VC} = 0.098 \cdot RR \cdot V_t[PIP-\frac{1}{2}(P_{plat}-PEEP)] \approx \frac{MV(P_{peak}+PEEP+\frac{Q_{insp}}{6})}{20}$

Pressure Control

${MP}_{VC} = 0.098 \cdot RR \cdot V_t[PEEP + \Delta P_{insp}(1-\exp(\frac{-T_{insp}}{RC}))]$

${MP}_{VC} = 0.098 \cdot RR \cdot V_t[PEEP + \Delta P_{insp}(1-e^{\frac{-T_{insp}}{RC}})] \approx 0.098 \cdot RR \cdot V_t(PEEP + \Delta P_{insp})$

- Vent Waveforms

Alveolar Gas Equation

$P_AO_2 = F_iO_2(P_{atm}-P_{H_2O}) - \frac{P_aCO_2}{RQ}$

substituting back in to RQ equation: $RQ = \frac{P_ACO_2}{\frac{V_AP_ACO_2}{kVO_2}}= \frac{VO_2}{V_a}k$

$V_T = V_A + V_D$, where $V_A = 350$ and $V_D = 150$

Shunt Equation (Berggren Equation)

$$\frac{Q_s}{Q_t} = \frac{C_{C_{O_2}} - C_{a_{O_2}}}{C_{C_{O_2}} - C_{v_{O_2}}}$$

where:

- $Q_s=$ pulmonary physiology shunt $(\frac{mL}{min})$
- $Q_t=$ cardiac output $(\frac{mL}{min})$
- $C_{C_{O_2}} = $ end-pulmonary-capillary oxygen content
- $C_{a_{O_2}} = $ arterial oxygen content
- $C_{v_{O_2}} =$ mixed venous oxygen content

So, you will need an ABG and a true mixed VBG (art line + SGC).

Derivation

Dead Space Fraction

$\frac{V_D}{V_T} = \frac{P_ACO_2 - P_ECO_2}{P_ACO_2}$

Formal measurement of P_ECO_2 requires volumetric capnography, which requires a capable ventilator or a dedicated measurement device.

Thankfull, $P_ECO_2 \approx ETCO_2$, so an approimation would $\frac{V_D}{V_T} = \frac{P_ACO_2 - ETCO_2}{P_ACO_2}$

Alveolar ventilation

$P_{A}O_2 = F_iO_2(P_{atm}-P_{H_2O}) - \frac{P_AO2}{RQ}$
$\dot{V}_A=k\frac{\dot{V}CO_2}{P_ACO_2}$ $\implies \dot{V}CO2 = \frac{\dot{V}_AP_ACO_2}{k}$

To convert F_ACO_2 into P_ACO_2, we have $F_ACO_2(P_{atm} - PH_2O = P_ACO_2$ Similarly, using F_ECO_2, we can show $P_ECO_2 = F_ECO_2(P_{atm} - P_{H_2O})$

$Volume_{expiredCO2} = Volume_{producedAlvCO2}$

$V_TF_ECO_2 = V_AF_ACO_2$

$V_TF_ECO_2 = (V_T - V_D)F_ACO_2$, and we can convert F_ACO_2 into P_ACO_2

PULM

Equation of Motion

$P_{delivered} = P_{resistive} + P_{elastic}$

$P_{aw} = \dot VR + \frac{V_t}{C} + PEEP_{total} + P_{musc}$

CARDS

$TPG = mPAP - PCWP$

$SVR =\frac{MAP-CVP}{CO}\cdot80$

$CO = LVOT_{area}\cdot LVOT_{VTI}\cdot HR$

Swan-Ganz Equations

$CO = \frac{VO_{2}}{C_a - C_v}$, where $C_v = ScvO_2$ (mixed venous oxygen content)