

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	$V_i(t) = \frac{V_o}{\tau} \{ e^{\frac{t}{RC}} - 1 \} = \frac{V_o}{\tau} \{ e^{-\frac{t}{\tau}} \}$
Calculating τ, General Case	$\tau = \frac{V_t}{F} \cdot \left(\frac{PIP - P_{plt}}{P_{plt} - PEEP_{total}} \right)$
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: $RQ = \frac{P_{ACO_2}}{\frac{V_{AP_{ACO_2}}}{kV_{O_2}}} = \frac{V_{O_2}}{V_a} k$

$$V_T = V_A + V_D, \text{ where } V_A = 350 \text{ and } V_D = 150$$

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 approximation would $\frac{V_D}{V_T} = \frac{P_{ACO_2} - ETCO_2}{P_{ACO_2}}$

Alveolar ventilation

$$P_{AO_2} = F_{iO_2}(P_{atm} - P_{H_2O}) - \frac{P_{AO_2}}{RQ}$$

$$\dot{V}_A = k \frac{\dot{V}CO_2}{P_{ACO_2}} \implies \dot{V}CO_2 = \frac{\dot{V}_A P_{ACO_2}}{k}$$

To convert F_{ACO_2} into P_{ACO_2} , we have $F_{ACO_2}(P_{atm} - P_{H_2O}) = P_{ACO_2}$ Similarly, using F_{ECO_2} , we can show $P_{ECO_2} = F_{ECO_2}(P_{atm} - P_{H_2O})$

$$Volume_{expiredCO_2} = Volume_{producedAlvCO_2}$$

$$V_{TF_{ECO_2}} = V_{AF_{ACO_2}}$$

$$V_{TF_{ECO_2}} = (V_T - V_D)F_{ACO_2}$$
, and we can convert F_{ACO_2} into P_{ACO_2}

PULM

Equation of Motion

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

$$P_{aw} = \dot{V}R + \frac{V_t}{C} + PEEP_{total} + P_{muscle}$$

CPET Testing

$$\text{Heart rate reserve } HRR = HR_{achieved}^{max} - HR_{predicted}^{peak}$$

$$\text{where } HR_{predicted}^{peak} = 220 - \text{age}$$

Slope of work efficiency

$$m(\text{work}_e) = \frac{\Delta VO_2}{\Delta WR}$$

Slope of heart rate rise

$$\frac{\Delta HR}{\Delta VO_2}$$

CARDS

$$TPG = mPAP - PCWP$$

$$SVR = \frac{MAP - CVP}{CO} \cdot 80$$

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

Swan-Ganz Equations

$$CO = \frac{VO_2}{C_a - C_v}$$
, where $C_v = ScvO_2$ (mixed venous oxygen content)

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