Ventilator Pocket Guide

### Foundational Equations

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|---|---|
| **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

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

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

### CPET Testing

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

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

#### Slope of work efficiency

$m(work_e) = \frac{\Delta VO_2}{\Delta WR}$

#### Slope of heart rate rise

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

## CARDS

$TPG = mPAP - PCWP$

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

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

### Swan-Ganz Equations

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