Lecture 13: Respiration (Part 2)

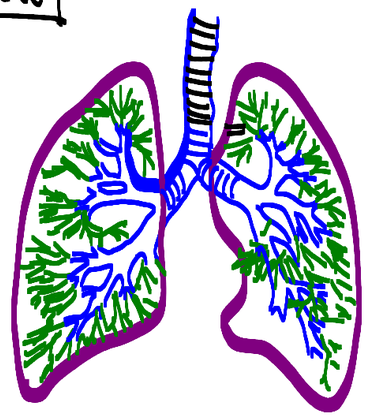
0. Review
1. Absolute Lung Volume
2. Whole-Body Plethysmography
3. Helium Dilution
4. Nitrogen Washout
5. MiniLab

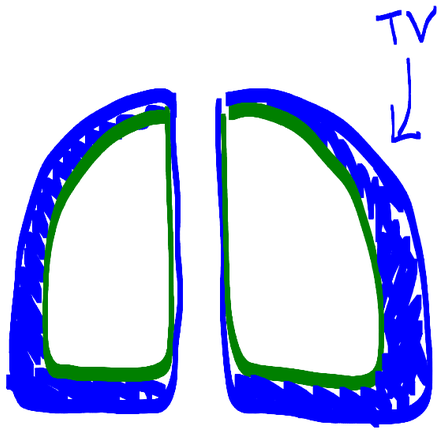
- Today: HW5 due ← Quiz next Tue
- Fri: Lab4 report due
- Next Mon (2/24): Email Buma (team + topic)
- PreLab6 due next lab session
- HW6 due next Thu (2/27)
- Lab 5 report due next Fri (2/28)

★ Student presentations (Mar 10+12)
→ Teams of 2-3 students (3 is preferable)
→ 15 min powerpoint
(See course website for guidelines)

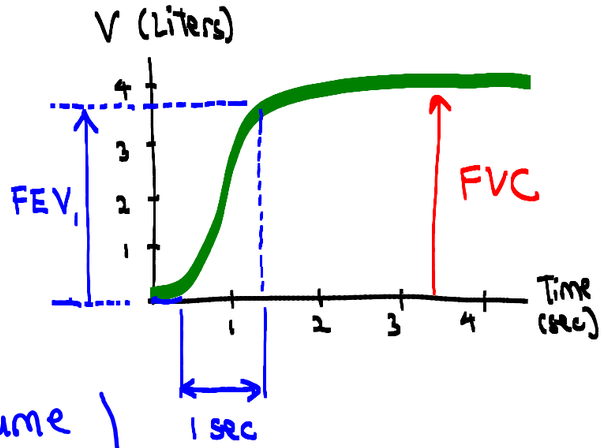
★ Ellis Hospital Tour Mar 10 (Tue)
Group1: Depart 12:45 PM
Group2: Depart 2:45 PM

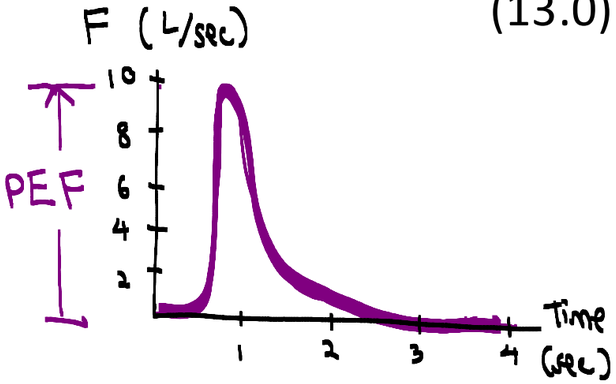
0. Review

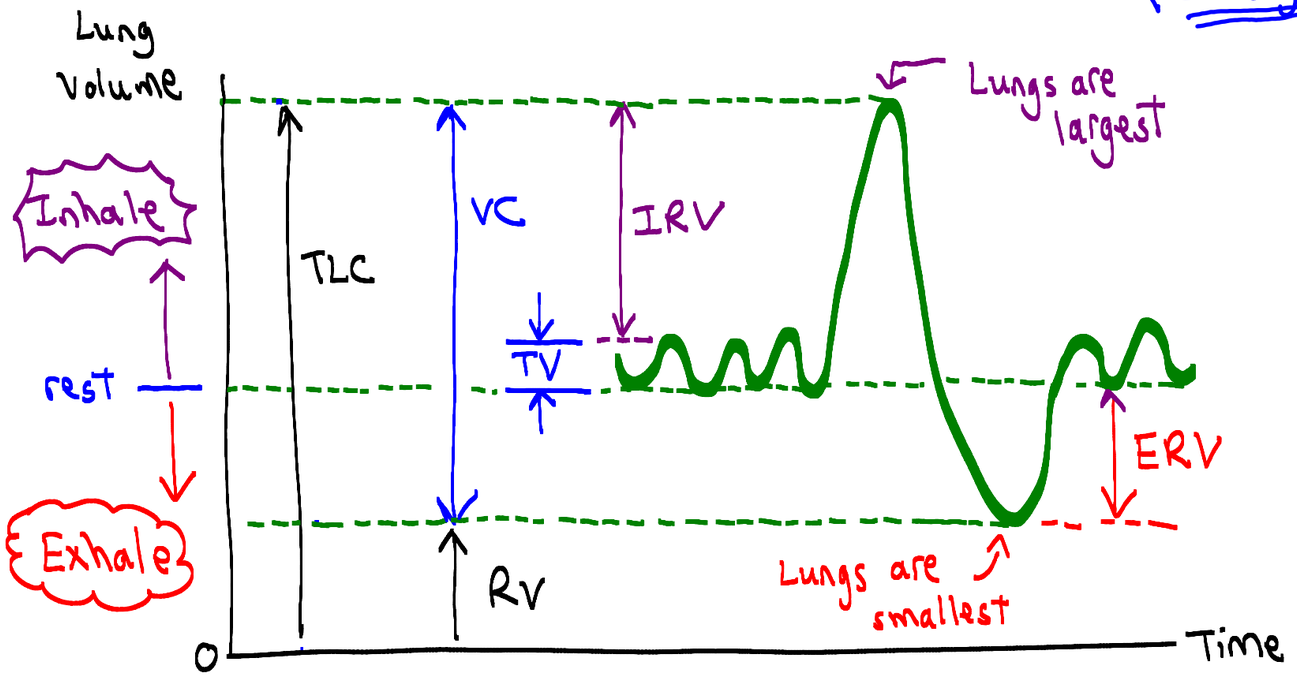




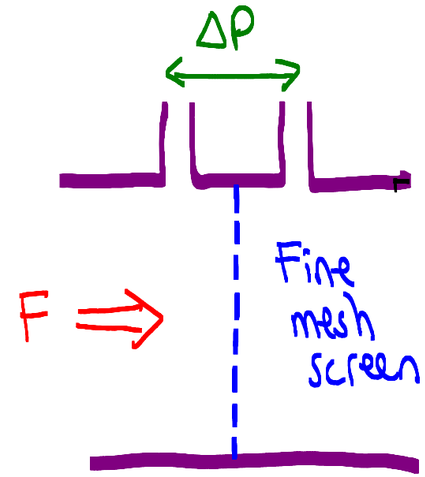
(Volume change)





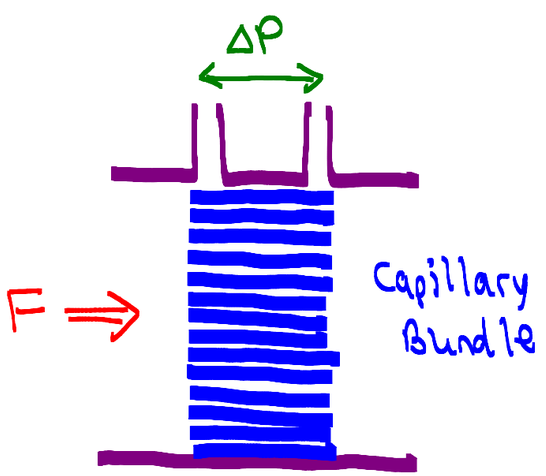


Pneumotachometer



Lilly

Linear flow: $\Delta P = F \times R$



Fleisch

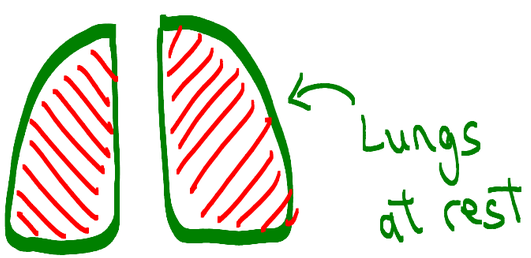
1. Absolute Lung Volume

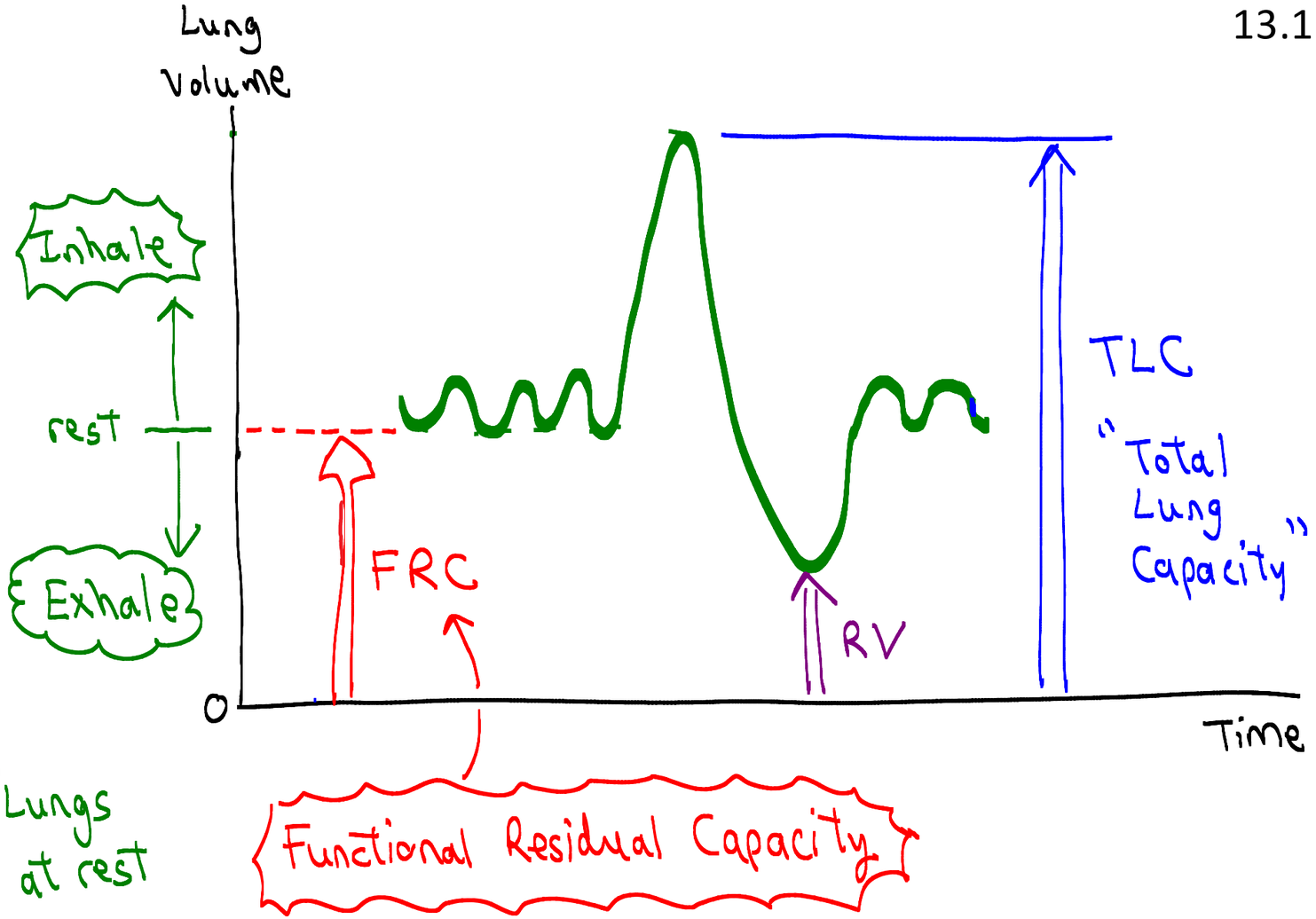
- Spirometers measure changes in lung volume

- Absolute lung volume is also clinically useful.

Example:

FRC is lung volume at rest





2. Whole Body Plethysmography

- BASIC IDEA: "body box"

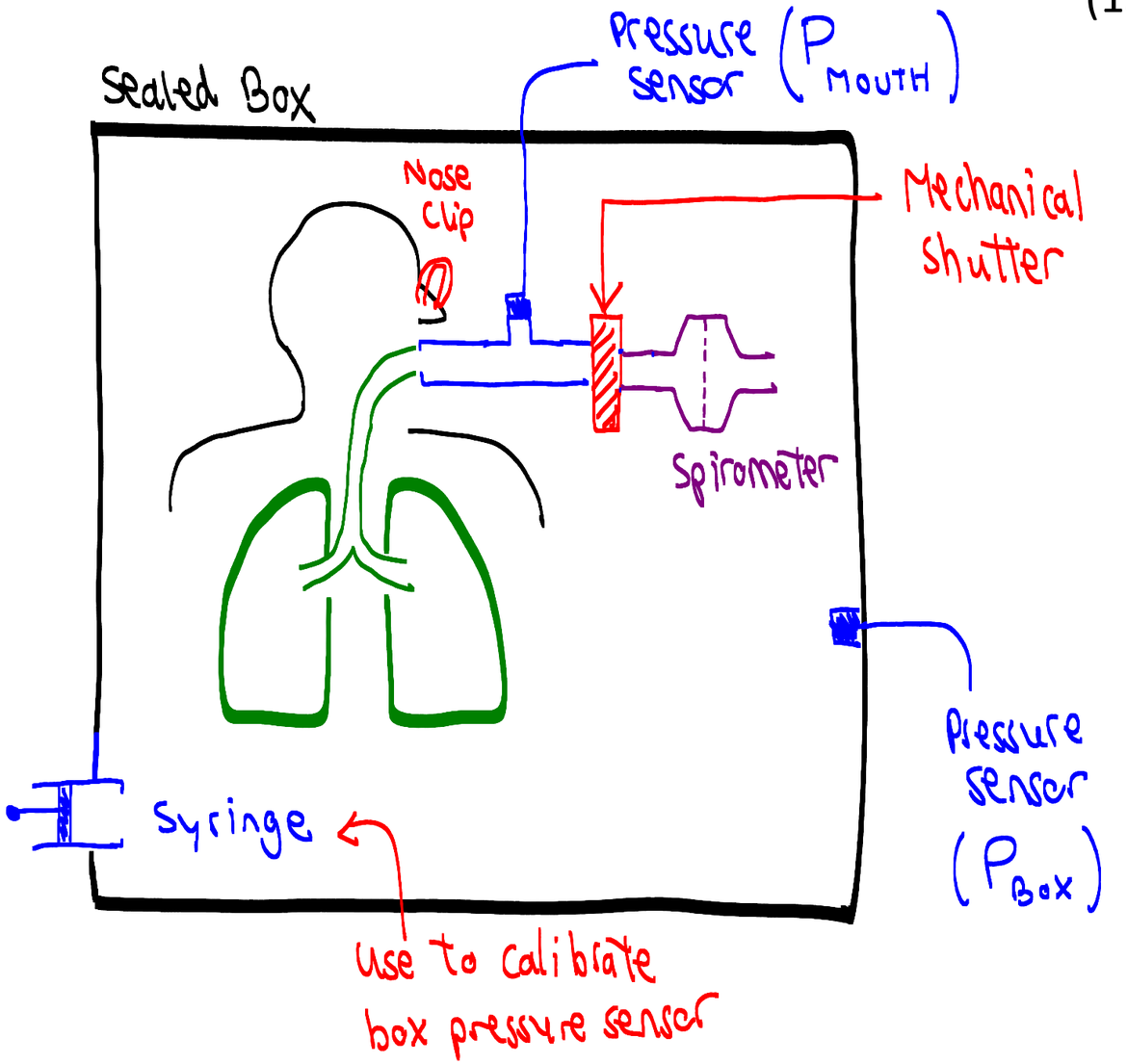
① Patient is inside a sealed chamber

② Breathe normally into spirometer (open shutter)

③ Try to breathe with closed shutter } "Panting Maneuver"

⇒ Measure mouth and box pressure

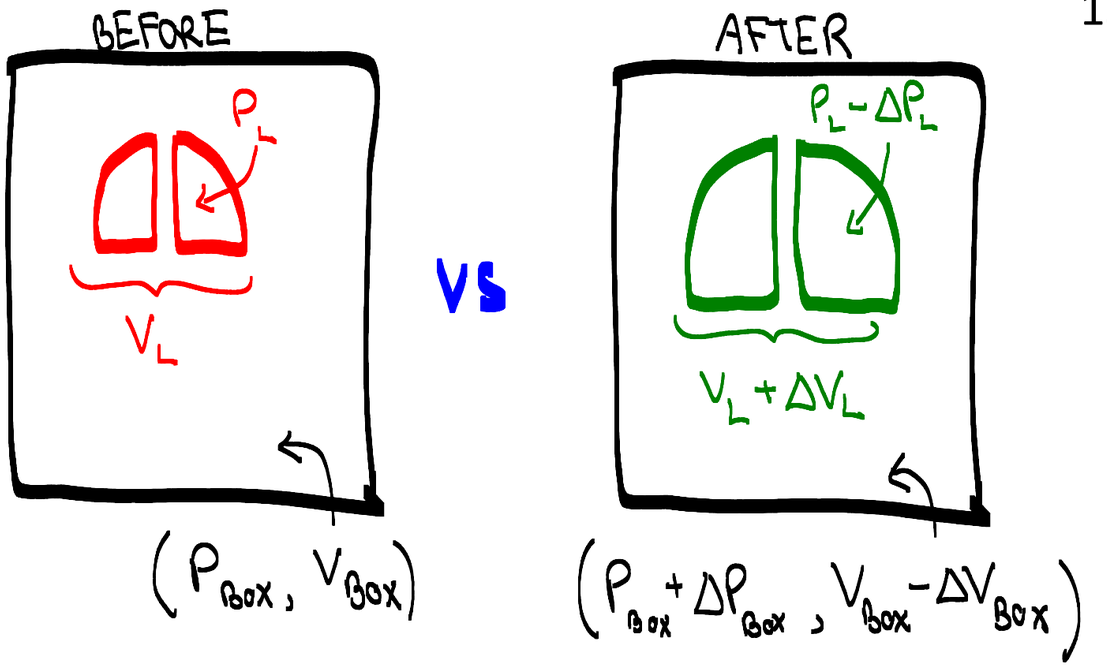
⇒ Compute FRC



Q: How to compute FRC?

A: Recall Boyle's Law for an ideal gas (constant temp)

$$P_{Before} V_{Before} = P_{After} V_{After}$$



$$\cancel{P_L V_L} = (P_L - \Delta P_L)(V_L + \Delta V_L)$$

$$= \cancel{P_L V_L} - V_L \Delta P_L + (P_L - \Delta P_L)\Delta V_L$$

$$V_L = \frac{P_L - \Delta P_L}{\Delta P_L} \Delta V_L$$

(V_L: FRC)

In terms of measurements

Assume $P_{LUNG} = P_{MOUTH}$

$$\frac{P_M - \Delta P_M}{\Delta P_M} \times (\Delta V_{Box}) = \frac{P_M - \Delta P_M}{\Delta P_M} \times (K \times \Delta P_{Box})$$

Open shutter

Closed shutter

Const is determined by calibration

3. Helium Dilution

- BASIC IDEA

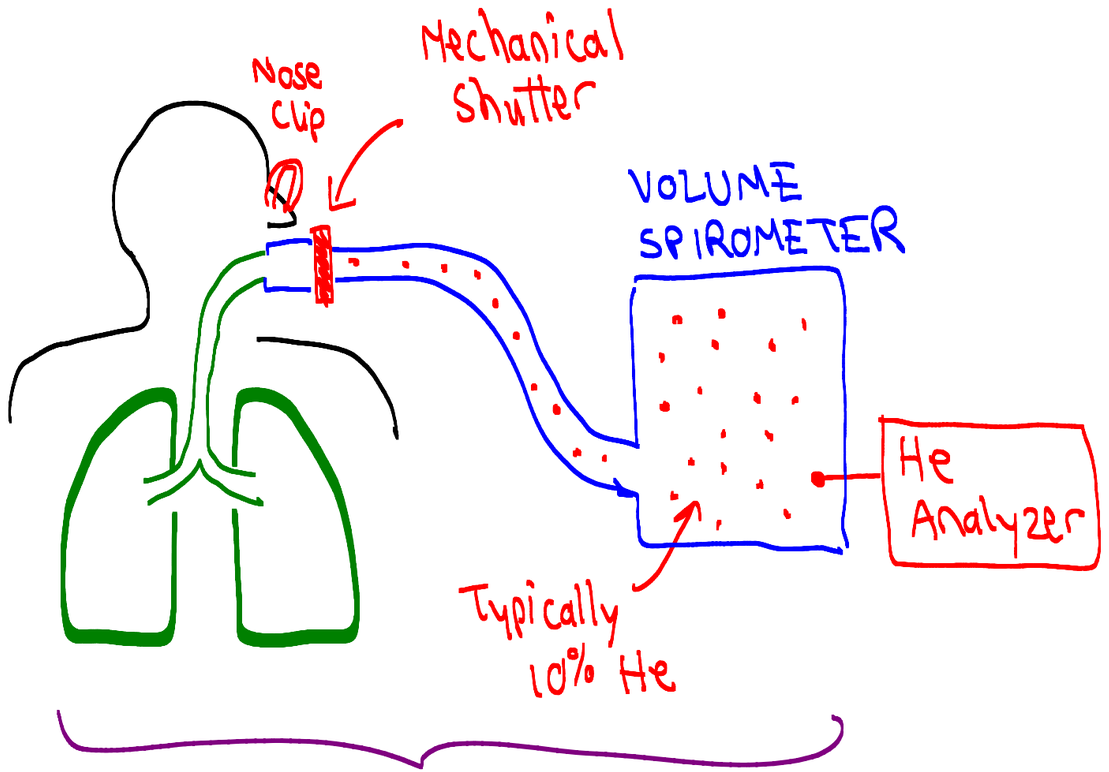
① Patient breathes normally

② Valve opens to let helium mixture into patient's lungs

③ Patient rebreathes helium for a few minutes

→ measure He concentration

⇒ Compute FRC



"CLOSED-CIRCUIT" SYSTEM

↑ Isolated from ambient air

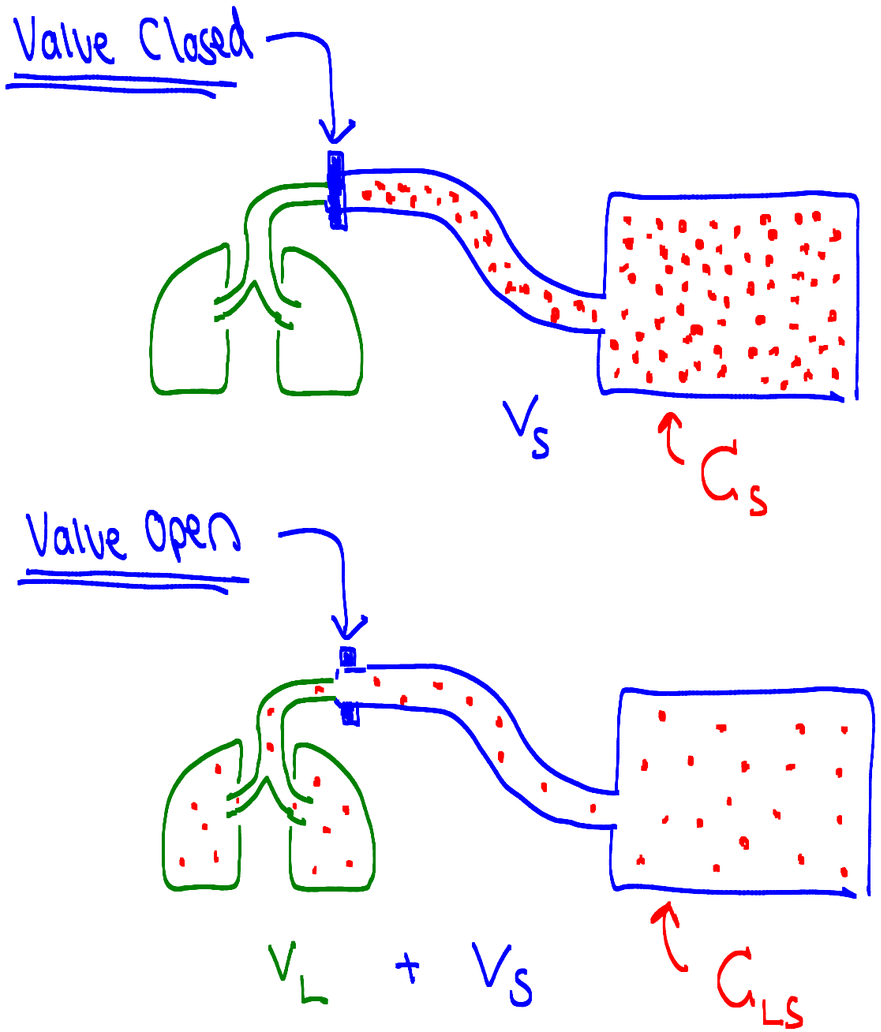
Q: How to compute FRC?

A: Total amount of He stays the same, but concentration changes!

Amount of He = Concentration × Volume

$$= C_s V_s = C_{LS} \times (V_L + V_S)$$

$$\Rightarrow \boxed{FRC = V_L = \frac{(C_s - C_{LS})}{C_{LS}} \times V_S}$$



4. Nitrogen Washout

- BASIC IDEA

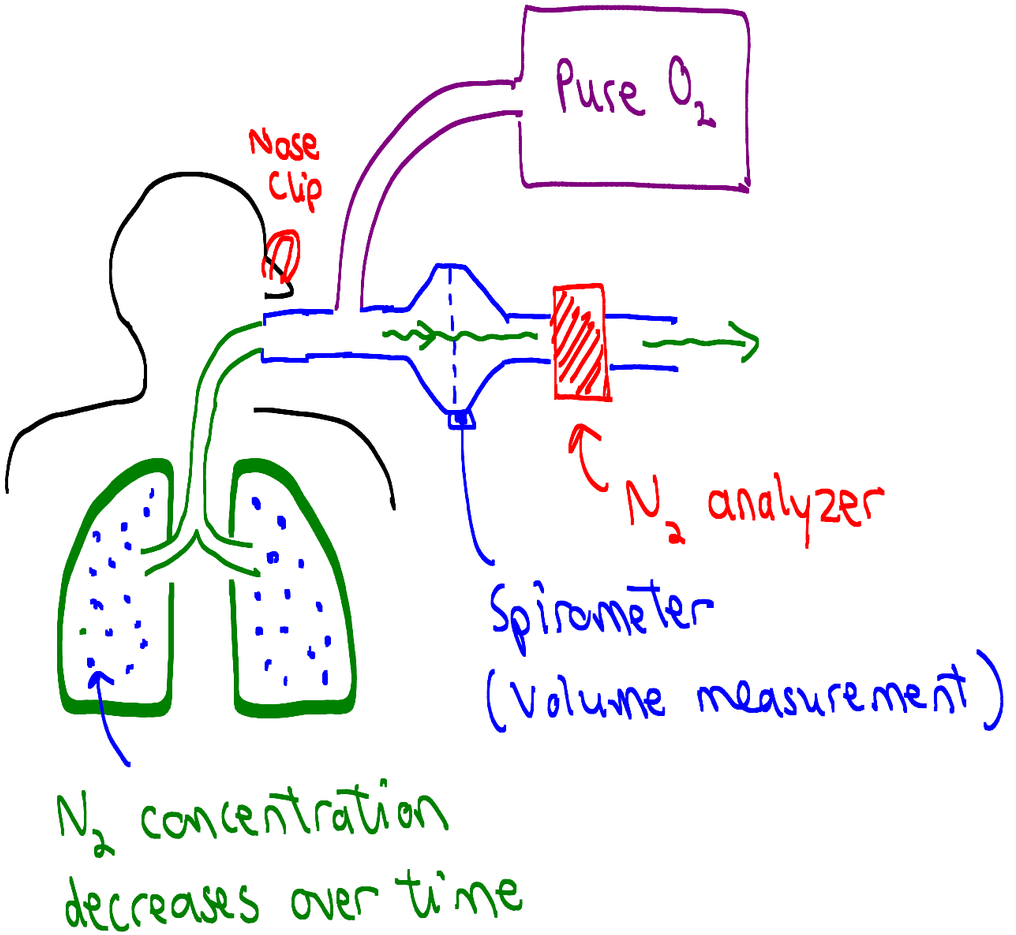
① Patient breathes normally

② Valves let patient breathe in pure O_2

③ Patient breathes normally for several minutes

→ measure N_2 concentration and volume per breath

⇒ Compute FRC



Q: How to compute FRC?

A: Total amount of N_2 in lungs is related to FRC!

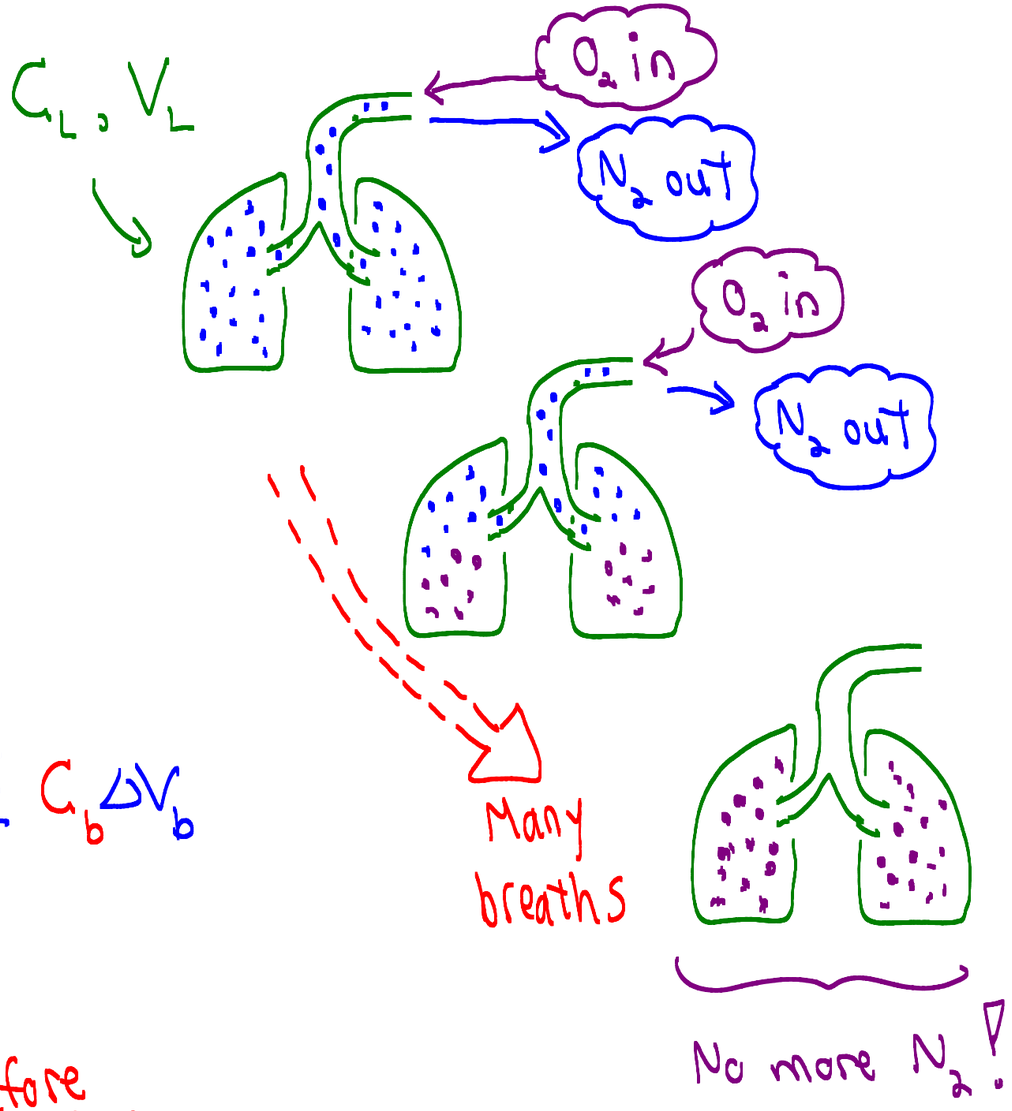
Amount of N_2 = Concentration × Volume

$$= C_L V_L = \left[\begin{array}{l} N_2 \text{ from} \\ \text{Breath \#1} \end{array}\right] + \left[\begin{array}{l} N_2 \text{ from} \\ \text{Breath \#2} \end{array}\right] + \cdots$$

$$= C_1 \Delta V_1 + C_2 \Delta V_2 + \cdots = \sum_b C_b \Delta V_b$$

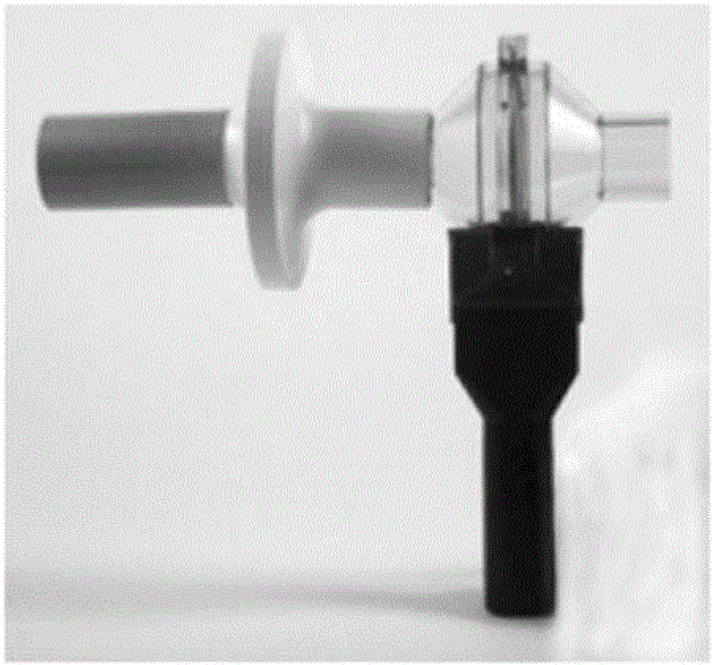
$$\Rightarrow \boxed{FRC = V_L = \frac{\sum_b C_b \Delta V_b}{C_L}}$$

C_L ← Measure before procedure

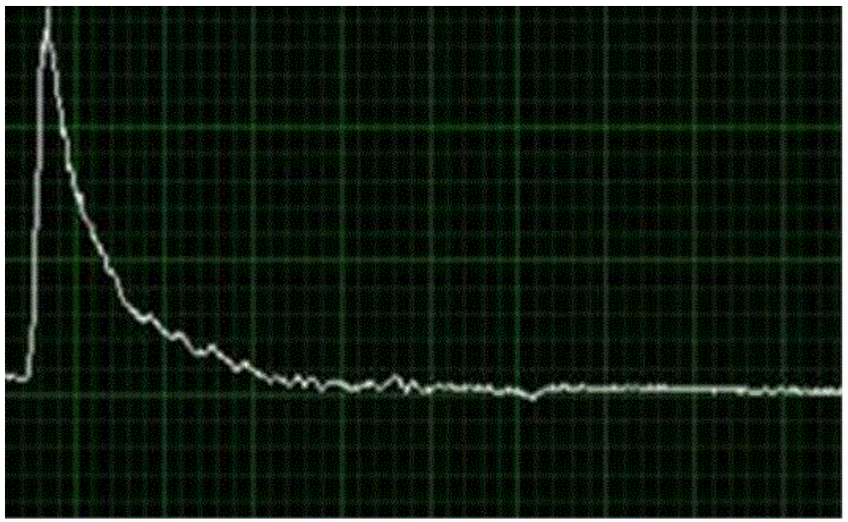


5. MiniLab

Spirometer



Scope



Peak Expiratory Flow (PEF) (Liters/sec)