Physiology of static lung volumes – Static lung volumes in COPD

Pr A. Legrand
Physiology & Respiratory Readaptation
University of Mons
Q&A : True or False?

• Pulmonary compliance depends on the mixture used to inflate the lungs.
• The determinants of RV are Expiratory muscle pressure generating ability and Respiratory system elastic recoil.
• FRC increases with the supine posture, age and obesity.
Q&A : True or False?

- The earliest alteration of static lung volume in COPD patient is the hyperinflation of TLC.
- A reduction of Slow VC reflects the hyperinflation in COPD.
- Forced VC is smaller than Slow VC in COPD.
Lung volume and divisions

- TLC
- VC
- IRV
- V_T
- ERV
- RV

IC = V_t + IRV

STATIC...
Pressure-volume relationship of the relaxed respiratory system

Volume (L)

Pressure (Cm H₂O)

FRC

Relaxed muscles

P_{transrespiratory}

P_{sys}

P_{ao}
Elastic Recoil

Volume (L)

\[ P_{\text{r sys}} = P_{\text{r lung}} + P_{\text{r thorax}} \]

FRC
Compliance

\[ \frac{1}{C_{sys}} = \frac{1}{Clung} + \frac{1}{C_{torax}} \]

\[ \frac{1}{0.2} + \frac{1}{0.2} = \frac{2}{0.2} \]
Surface tension

- **Saline solution**
- **Air**
- **Fibrosis**

**Surfactant**

**Pressure** – cm H$_2$O

**Volume** – ml
Elastic Recoil

Volume (L)

Pressure (Cm H₂O)

Rib cage
Abdomen + Diaphragm
Thoracic wall
Respiratory system
Lung
Elastic Recoil

- Volume (L)
- Pressure (Cm H₂O)

- Rib cage
- Abdomen + Diaphragm
- Thoracic wall
- Respiratory system
- Lung
- Ankylosing Spondylitis
Pressure–volume relationship during maximal efforts

Maximal Inspiratory Pressure

\[ P_{ao} = P_{sys} + P_{mus} \]
Pressure –volume relationship during maximal efforts

\[ P_{ao} = P_{sys} + P_{mus} \]

Maximal Inspiratory Pressure

Maximal Expiratory Pressure

Volume (L)

-150 -100 -50 0 50 100 150 200 250

Pressure (Cm H\(_2\)O)
Closing Volume

Pulmonary Volume (l)

Concentration $N_2$ (%)

Pure oxygen

↑Closing Volume

= ↑RV

Gas trapping
Spirometric results

![Volume vs Time Graph with SVC and FVC labels]
Normal values

- **TLC** = 7.99H - 7.08
- **RV** = 1.31H + 0.022A - 1.23
- **FRC** = 2.34H + 0.01A - 1.09
- **FRC/TLC** = 43.8 + 0.21A
- **RV/TLC** = 14.0 + 0.39A

♂

- **TLC** = 6.60H - 5.79
- **RV** = 1.81H + 0.016A - 2.00
- **FRC** = 2.24H + 0.001A - 2.00
- **FRC/TLC** = 45.1 + 0.16A
- **RV/TLC** = 19.0 + 0.34A

♀
GLI-2012
All-Age Multi-Ethnic
Reference Values for Spirometry

- FVC

- $\log(Y) = a + b \cdot \log(H) + c \cdot \log(A) + \text{age-spline} + d \cdot \text{group}$

- Mean, variance and skewness
Emphysema

Lost of elastic recoil of the lung

Volume
(L)

Pressure
(AO)
(Cm H$_2$O)

-50
Patm
50
Emphysema
Static hyperinflation $\uparrow$ FRC

$\Delta$FRC
Emphysema
Maximal efforts

Pressure $\text{ao}$
($\text{Cm H}_2\text{O}$)

Volume (% TLC)

↑TLC
Hyperinflation and Maximal isometric muscle tension

![Graph showing hyperinflation and maximal isometric muscle tension. The graph plots tension against muscle length as a percentage of its length at rest (Lo). It shows two curves: one for active tension and one for passive tension. The active tension curve reaches a peak at around 100% Lo, while the passive tension curve is more sigmoidal, peaking at around 60% Lo.](image-url)
Emphysema: ↑RV

Volume (L)

Pressure (Cm H₂O)

TLC

FRC

Trapping: ↑RV
Spirometric results
Normal

COPD

SVC > FVC

Air trapping
Crenel sign

Time

Volume

COPD
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Pr A. Legrand
Physiology and Respiratory re-adaptation
University Mons-Hainaut