The Respiratory System - 2
Lung volumes and compliance

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Respiratory System

1. Anatomy and mechanics
2. Lung volumes and compliance
3. Pressure changes and resistance
4. Pulmonary function tests and alveolar ventilation
5. Oxygen transport
6. \( \text{CO}_2 \) transport and V/Q mismatch
7. Regulation of breathing
8. Exercise and hypoxia
VC (vital capacity) = TV + IRV + ERV
TLC (total lung capacity) = TV + IRV + ERV + RV
FRC = ERV + RV

Residual volume (RV) is the amount of air that must remain in the lungs.

RV / TLC increases in disease
  - obstructive – RV increases
  - restrictive – TLC decreases

image by Vihsadas (modified), http://commons.wikimedia.org/wiki/File:LungVolume.jpg, public domain
Remember These Terms

• **Tidal Volume (TV)** = volume of air entering the lung (inspiration) or the volume of air leaving the lung (expiration). [approx. 0.5L, but depends on body size].

• **Inspiratory Reserve Volume (IRV)** = maximal amount of air that can be inspired above tidal volume. [approx. 3L].

• **Functional Residual Capacity (FRC)** = volume remaining in the lung after a normal expiration. [approx. 2.5L]. Decreases if chest muscles are weak. ERV+RV

• **Expiratory Reserve Volume (ERV)** = maximal volume of air expired after normal expiration. [approx. 1.5L].

• **Residual volume (RV)** = volume of air at end of maximal expiration. [approx. 1L]. Can not be measured with a spirometer.

• **Vital capacity (VC)** = the maximal amount of air that a person can expire after maximal inspiration. \( VC = TV + IRV + ERV. \)
Lung Diseases

Obstructive – hard to expire (need positive pressure from chest wall to expire but that also closes airways), RV increases

asthma (contraction of smooth muscle in airways due to inflammation), COPD (chronic obstructive pulmonary disease – chronic bronchitis or emphysema – alveoli are destroyed and have increased compliance, collapse of small airways)

Restrictive – lungs can’t expand to a normal volume, smaller TLC

fibrotic diseases (fibrosis, TB) or diseases that constrict the chest (scoliosis)
Compliance = Distensibility

1. Varies with lung size. Compliance decreases at high lung volumes.

2. When compliance is abnormally low, the lung is stiff, inhalation is difficult but exhalation is easy.

3. Increased compliance filling is easy, exhalation is difficult.

Compliance is the change in lung volume after a change in transpulmonary pressure

image by Rick Melges, Duke University
Lung Compliance

Elastic tissue
emphysema - destroys elastic tissue so compliance increases
fibrosis - lungs are not as distensible so compliance decreases

Surfactant
reduces surface tension of water in alveoli (attractive forces)
detergent like molecule – hydrophilic and hydrophobic portions
made by alveolar Type II cells (stretch activates release)
other types of surfactant molecules are part of lung defense system
SURFACTANT stabilizes alveoli

pressure = \( \frac{2T}{r} \) (Law of Laplace). Without surfactant, pressure would be greater in smaller alveoli. Surfactant lowers surface tension more in smaller alveoli.

without surfactant

if surface tension is equal, then pressure will be greater in #1 since it has a smaller radius (\( P=\frac{2T}{r} \))

with surfactant

since surface tension in #1 is lower, then the pressure in #1 and #2 is equal (\( P=\frac{2T}{r} \))
Key Concepts

• Total lung capacity comprises several volumes and overlapping capacities. All can be measured by a spirometer except residual volume (RV), functional reserve capacity (FRC), and total lung capacity.

• Compliance is a measure of lung distensibility. In restrictive lung disease (fibrosis) the lung has low compliance (i.e., hard to inflate). In the obstructive lung disease, (emphysema) the lungs have high compliance (i.e., easy to inflate but hard to deflate) due to loss of elastin fibers.