LUNG MECHANICS

DR. NAJEEB LECTURE NOTES

BY FATIMA HAIDER

KGMC

http://koracademy.com/

Study of those forces and factors which are responsible for bringing the air in and out of lungs is called lung mechanics.

INSPIRATORY MUSCLES

Major muscle of inspiration during quite breathing is **Diaphragm.**

During quiet breathing, diaphragm is enough for inspiration but in forced breathing, **external intercostal muscles** also plays a role. Due to external intercostal muscles, sternum moves upward and outward and chest cavity increase in size.

Accessory muscles of inspiration are involved in rapid, deep and fast inspiration. These accessory muscles include sternocleidomastoid, scalene and sometimes pectoralis major muscle.

EXPIRATORY MUSCLES

During quiet breathing, expiration is passive. It is mainly mediated by elastic recoil of the lungs and assisted by simultaneous relaxation of muscles of inspiration.

Accessory muscles of expiration involved in forceful breathing:

1. Internal intercostals – pull the ribs downward and eventually reduce the size of chest cavity
2. Rectus abdomini – contracts strongly hence push the contents of abdomen backward and upward so diaphragm is more rapidly going up and reducing the size of chest cavity

ANTI EXPANSION FORCES

Anti-expansion forces include:

1. Elasticity of lungs
2. Tissue resistance
3. Airway resistance

LUNG ELASTICITY: Lungs have elastic fibers and collagen fibers and these fibers prevent the expansion of the lungs. To counter of the force of this elasticity, intercostal muscles are used.

TISSUE RESISTANCE: When lungs are expanding, both layers of pleura glide against each other, thereby producing resistance.

AIRWAY RESISTANCE: When lungs are expanding, air is moving in. when air moves in, layers of air resist against each other and against the airways.

TERMS RELATED WITH RESPIRATORY MECHANICS

1. **INTRA ALVEOLAR PRESSURE** - Pressure within the alveoli
2. **INTRA PLEURAL PRESSURE** – pressure inside the pleural cavity. Interpleual pressure is normally negative.
3. **ATMOSPHERIC PRESSURE** – pressure outside the body
4. **TRANSMURAL PRESSURE** – The pressure across the wall of a structure. Transmural pressure can be positive, negative or zero.
    - Positive transmural pressure inflate the structure
    - Negative transmural pressure deflate the structure

    Transmural pressure = Pressure inside the wall – Pressure outside the wall

5. **TRANS PULMONARY PRESSURE** – Transmural pressure which is across alveolar wall (between alveoli and plura)
   Trans Pulmonary Pressure = Intra alveolar Pressure – Intra pleural pressure
6. **TRANS THORACIC PRESSURE** – Transmural pressure which is across the chest wall
   Trans Thoracic Pressure = Intra Pleural Pressure – Atmospheric pressure
7. **TRANS RESPIRATORY PRESSURE**
   Trans Respiratory Pressure = Intra Alveolar Pressure - Atmospheric Pressure

PRESSURE MEASUREMENT

- To Determine Intra alveolar Pressure, manometer is connected with airways
- To determine intrapleural pressure, a catheter is pushed into esophagus. There is a monometer at the end of the catheter. When the catheter goes in, a balloon is inflated and lower third of the esophagus is disconnected with the oral cavity. After inflation of balloon, whatever is the pressure in esophagus measured by manometer will be same as inetrpleural pressure.

COMPLIANCE AND ELASTANCE

Compliance is the measure of distensibility. Those structures which are easily distended are said to be more compliant.

Elastance is reciprocal of compliance. If lung elastance is increased, then their compliance is decreased.

All those diseases which destroy elastic tissue in lungs, reduce the elastance and thereby increase the compliance. A high lung compliance means that the lungs are too pliable and have a lower than normal level of elastic recoil.

Pulmonary fibrosis stiffens the lungs through deposits of scar tissue, decreasing compliance and making it more difficult for the lungs to inflate or deflate.

Compliance = $\frac{\Delta V}{\Delta P}$

Elastance = $\frac{\Delta P}{\Delta V}$

RESTING VOLUME

Resting Volume of a structure is the volume when transmural pressure across the wall of the structure is zero.

COMPLIANCE FORMULAS

- Compliance of lungs = $\frac{\Delta V}{\Delta P}$

  Here ΔP is change in Transpulmonary pressure so

  Compliance = $\frac{\Delta V}{interalveolar\ pressure - interpleural\ pressure}$

- Compliance of chest wall = $\frac{\Delta V}{\Delta P}$

  Here ΔP is transthoracic pressure so

  Compliance = $\frac{\Delta V}{Interpleural\ pressure - Atmospheric\ pressure}$

  Atmospheric pressure is considered zero so
  Compliance of chest wall = $\frac{\Delta V}{Interpleural\ pressure}$

- Compliance of Rspiratory system i.e. lungs and chest wall together = $\frac{\Delta V}{\Delta P}$

  Here ΔP is transrespiratory pressure so

$$\text{Compliance} = \frac{\Delta V}{Alveolar\ pressure - atmospheric\ pressure}$$

SOME TERMS

- **Residual volume** – volume left in lungs even after forceful expiration
- Lung operating normally at:
  - **Functional Residual capacity** during expiration
    Functional residual capacity is the combined resting volume of lungs and chest wall
  - Adds **tidal volume** during inspiration
- **Inspiratory Reserve Volume** – air that can be forcibly inhaled after a normal tidal volume

GRAPHS CORRELATING INTERPLEURAL PRESSURE AND CHANGE IN VOLUME