Respiration Module

Session 3 – Lung Mechanics

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Lung mechanics

- during breathing work is done to
  - move around the lungs and thorax
  - move air through the airways

Lungs and thorax

- form a mechanical system
- lungs tend to collapse
- and are held at larger volume by
- the pleural seal

Pleural fluid

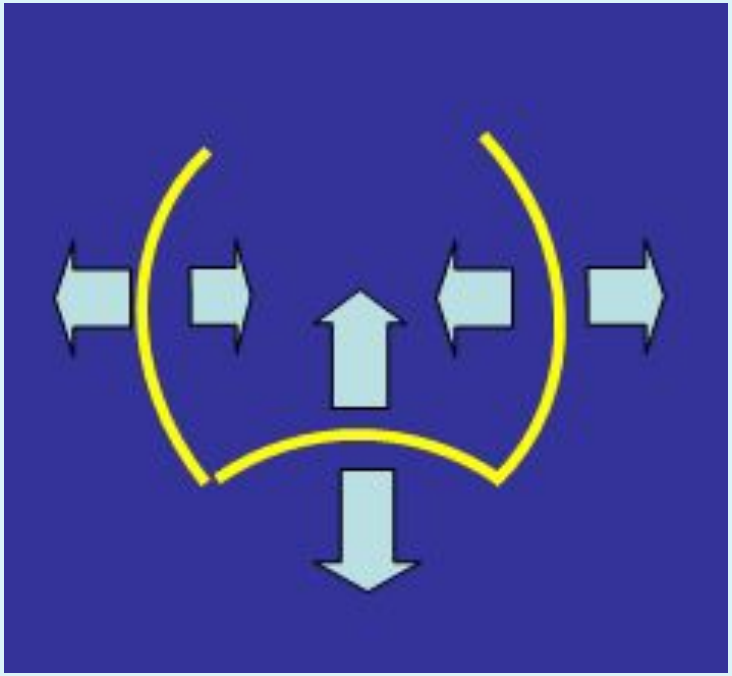
- a thin layer of fluid
- between visceral and parietal pleura
- ensures that lungs fill thoracic cavity
- and change volume as thorax does

Pneumothorax

- if the integrity of the pleural seal is broken
- lungs will tend to collapse

Equilibrium of forces

- lungs pull *in* and *up*
- thoracic cage pulls *out*
- passive stretch of diaphragm pulls *down*



At the resting expiratory level

- all forces in balance
- like a set of springs
- if disturbed will spring back to
- the resting expiratory level

Breathing in

- from resting expiratory level
- is active
- mainly by contraction of diaphragm
- and intercostals

Breathing out

- to resting expiratory level
- is passive
- just stop breathing in

In quiet breathing

- inspiration is active
- expiration is passive

Forced expiration

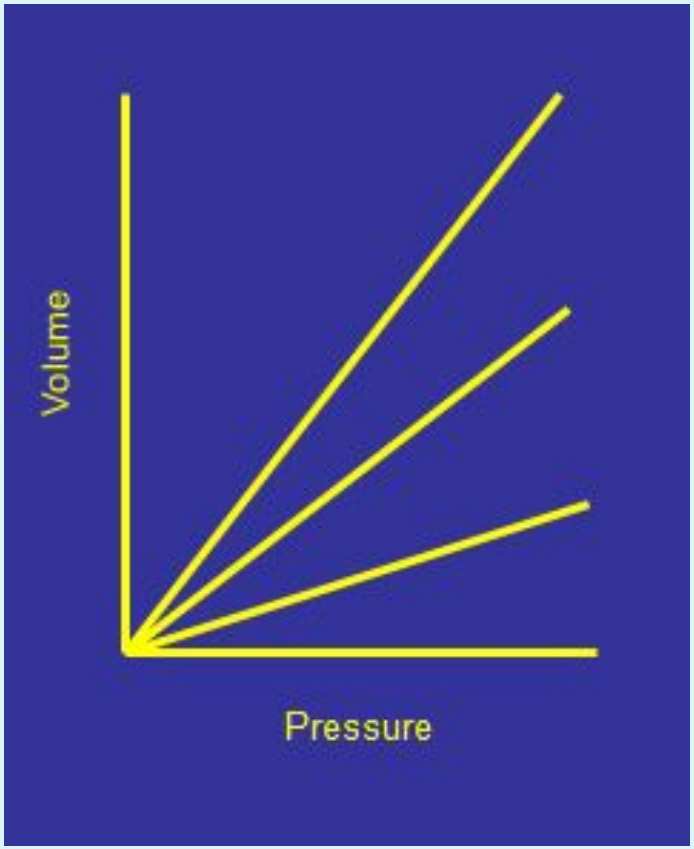
- breathing out beyond resting expiratory level
- requires force
- exerted by abdominal muscles
- then inspiration to resting expiratory level is passive

Work of breathing

- in quiet breathing
- most effort required to stretch the lungs
- if
  - diaphragm cannot easily move into abdomen
    - pregnancy
    - obesity
    - corsets

Lung compliance

- the stretchiness of the lungs is known as *compliance*
- volume change per unit pressure change
- higher compliance means easier to stretch



Elastic properties of the lungs

- airways have elastic walls
- but elastic tissue cannot explain how stiff the lungs are
- compliance reduced by surface tension of lining fluid

Surface tension

- interactions between molecules at surface of a liquid
- makes the surface resist stretching
- the higher the surface tension the harder the lungs are to stretch

Surface tension in the lungs

- at low lung volumes much less than expected
- if lungs lined with saline
- something is reducing surface tension

Detergents

- reduce surface tension by disrupting interactions between surface molecules
- lung has a mixture of detergents
- *surfactant*
- produced by type 2 alveolar cells

Surfactant

- reduces surface tension when lungs are deflated
- but not when fully inflated
- so little breaths are easy
- big breaths are hard

Bubbles

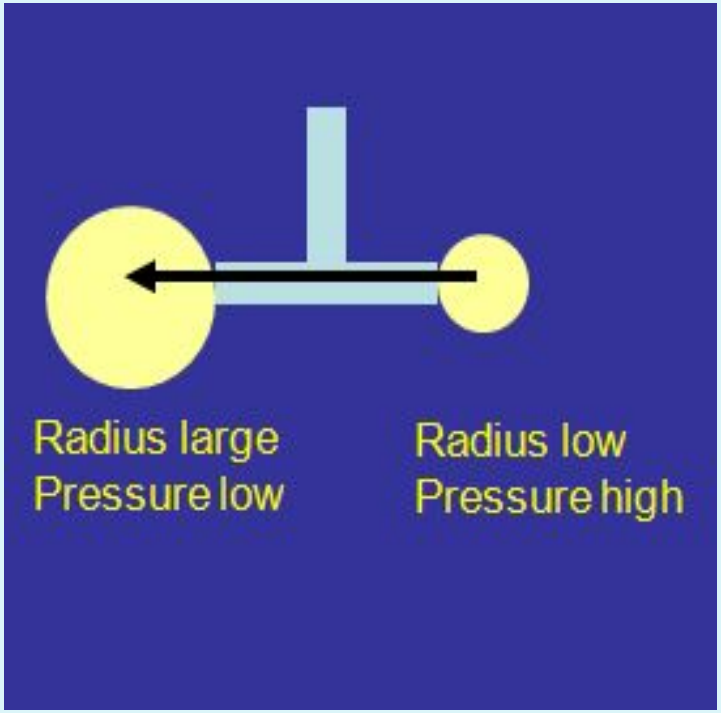
- formed when a film of fluid surround gas
- film shrinks to compress gas
- until eventually
- equilibrium between tension and pressure

Laplace's law

- pressure = 2 x surface tension/radius
- big bubbles have low pressure
- little bubbles have high pressure

Law of bubbles

- if a big bubble is connected to a small bubble
- air will flow from high pressure to low
- small bubble collapses into big
- *'big bubbles eat little bubbles'*



Bubbles in the lung

- alveoli form an interconnecting set of bubbles
- if Laplace's law applied
- big alveoli would eat little ones
- and the lungs become a physical impossibility

Surfactant

- as alveoli get bigger
- surface tension in their walls increases because surfactant is less effective
- so pressure stays high
- and stops them eating little alveoli

Respiratory Distress Syndrome

- babies born prematurely
- have too little surfactant
  - lungs very stiff
  - few, large alveoli
- breathing and gas exchange compromised

Moving air through airways

- remember Poiseulles law
- small tubes have high flow resistance
- many airways very small
- so individual resistance high
- but

Over the whole tree of airways

- at each branch
- the increase in the number of airways
- in parallel
- compensates for the increase in their resistance

Airway resistance

- at normal lung volumes in normal lungs
- highest resistance in the trachea
- lowest in the small airways
- so breathing is easy

Forced expiration

- when the lung is compressed
- small airways are narrowed
- resistance increases dramatically
- and air is trapped
- in the alveoli

Obstructive airway disease

- if the small airways
- are narrowed by disease
  - asthma
  - chronic bronchitis
- resistance increases much earlier in expiration
- breathing out can become very difficult


Thank you