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Lung Volumes

Tidal Volume(TV)

Volume of air entering and leaving lungs during a single breath, this volume is~500 ml.

Inspiratory Reserve Volume(IRV)

The amount of additional air that you can inspire following a normal tidal inspiration. In a normal male,this volume is ~3L.

Expiratory Reserve Volume(ERV)

The amount of additional air that can be exhaled after a normal expiration , and is about 1L.

Residual Volume(RV)

The amount of air that left in the lungs even after a maximal expiration. This volume is about 1.2L.

Lung Capacities

Vital Capacity

The maximal amount of air that can normally be moved, and is the summation of tidal volume, inspiratory reserve volume and expiratory reserve volume. The vital capacity is about 4.5 L (500+3000+1000 ml)

Total lung capacity (TLC)

The total amount of air in the lungs, and is about 5.7L (summation of vital capacity and residual volume) = (4.5 + 1.2).

Inspiratory Capacity (IC)

Is the sum of the TV and the IRV

Functional Residual Capacity (FRC)

Volume remaining in the lungs after expelling a tidal breath.

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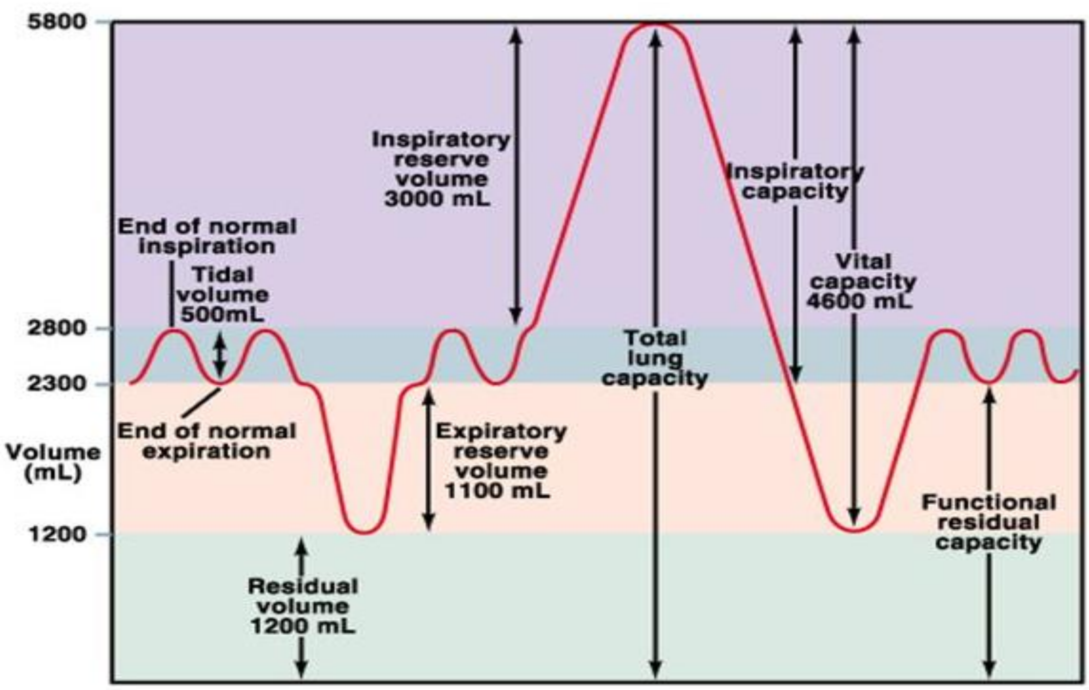

Effect of anaesthetic agents on Respiratory Drive

1. Most inhalational anaesthetic agents increase respiratory **frequency** by **shortening** inspiratory and to a larger extent expiratory time.
2. **Tidal volume** is **depressed**.
3. There is active **contraction** of the **abdominal muscles** during expiration and there may be **inward movement** of the **ribcage** in early inspiration.
4. Functional residual capacity **(FRC) falls** during the first 15–40 s after induction of anaesthesia. Fall in FRC has consequences for ventilation and perfusion.

Consequences of a fall in lung volume during Anaesthesia

- **A decrease in lung volume will**:

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1- Reduce traction on air passages
2- Lead to a narrowing of bronchi and bronchioles
3- Leading to increased airway resistance.
4- Leading to airway collapse and atelectasis.

This results in reduced compliance and increased work of breathing.

Atelectasis (collapse or closure) occurs by three methods:

1. Absorption of gases behind blocked airways.
2. Compression.
3. Loss of surfactant.

Surfactant

- Surfactants are typically lipoproteins.
- The lung secretes surfactants that disrupt cohesive forces between water molecules.
- The fluid that moisturizes the alveolar wall tends to produce surface tension, which increases the resistance of the lung to stretch or expand.
- Loss of surfactant leads to a reduction of lung compliance and many alveoli would collapse.
- Surfactants are not produced until about 8 weeks before birth, which explains why premature infants have a hard time in breathing.

Lung Compliance

The process of respiration depends on the lungs being able to stretch properly. If the compliance(the inverse of stiffness) of the lungs drops markedly, restrictive occur & breathing can be impaired. Thus, if lung compliance (C) is low, then it is difficult to increase lung volume (ΔV) at a particular distending pressure (ΔP)

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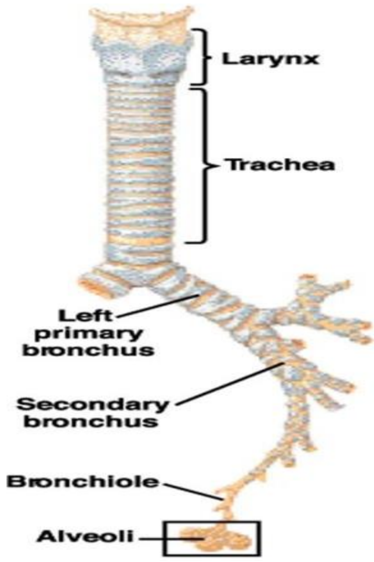
generated by the contraction of respiratory muscles.

- **(C) = ΔV/ΔP**

- Compliance changes as the lungs inflate:
- At low lung volumes the compliance is relatively high.
- At high lung volumes, the compliance is relatively low.
- Chest wall compliance is additive with lung compliance, and must also be overcome to allow for lung expansion and filling.

Effect of anaesthesia on upper airway

- Upper airway patency relies on the muscles of the upper airway.
- Anaesthesia lowers the tone of the upper airway muscles and further promotes airway occlusion.



Effect of Anaesthesia on Respiratory Muscles

The size of the closed thoracic cavity can be altered by the actions of the respiratory muscles.

The enlargement of the thoracic cavity increases negative intrathoracic pressure, which “sucks” air into the lungs (like a vacuum cleaner).

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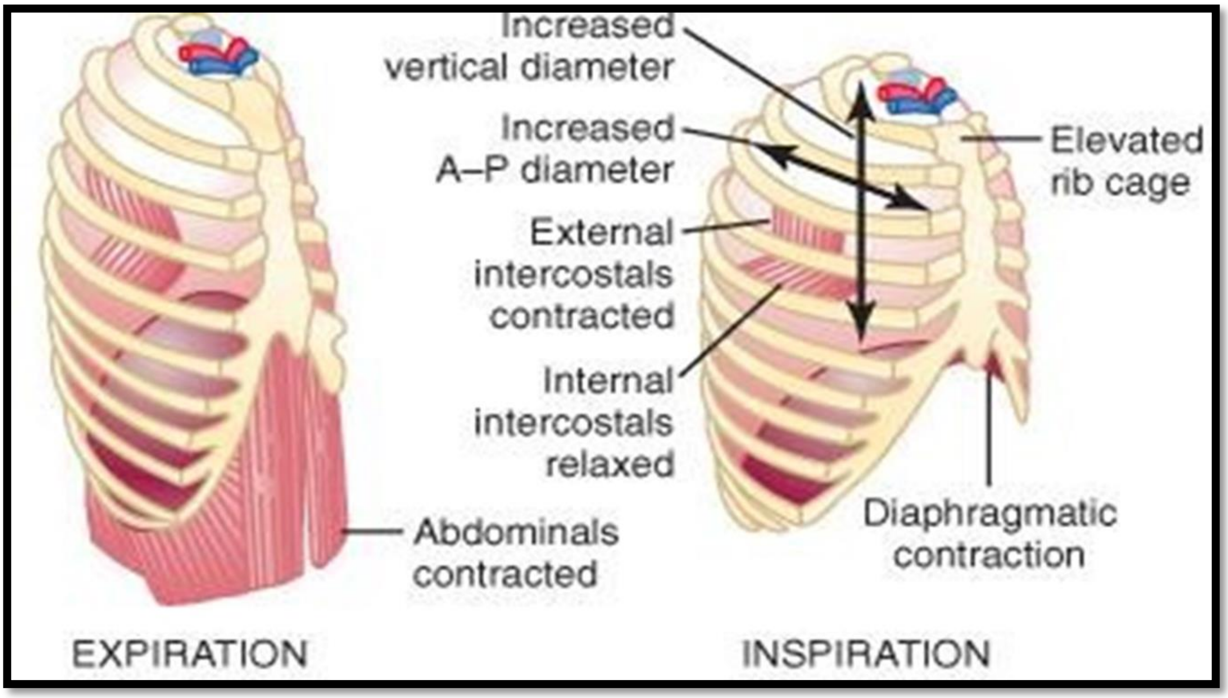

Pulmonary Ventilation

Total pulmonary ventilation: The amount of air moved into and out of the lungs per minute.

Total Pulmonary ventilation = Tidal Volume (VT) x Ventilation Rate (VR)

Total pulmonary ventilation = 500 ml/breath * 12 breaths/min = 6000 ml/min

Part of the air remains in the conducting passageways, which are referred to as Dead space (because they are not involved in gas exchange).

Thus, to determine total alveolar ventilation, dead space volume should be subtracted from tidal volume.

Alveolar Ventilation = Ventilation rate x (Tidal Volume - Dead Space Volume)

=12 breaths/min x (500 ml/breath - 150 ml/breath) =4200 ml/min

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Ventilation-Perfusion Mismatch in Anaesthesia

- Changes in lung volume and airway patency cause mismatch of lung ventilation and perfusion (V/Q)
- The V/Q ratio may be very low or zero in areas that are per fused but not ventilated, or extremely high in those areas where there is ventilation but no perfusion (dead space).
- A range of states between these two extremes may exist, usually with good matching in most of the lung.
- During anaesthesia, these two extremes are more prevalent than in awake subjects.
- This has been confirmed by the finding of an increased spread of V/Q ratios during anaesthesia.

Effect of regional anesthesia on physiology, morbidity and mortality

The effects depend on the extent of the blockade. Blocks which affect all lumbar and thoracic segments decrease inspiratory capacity by 20% and reduce expiratory reserve to almost zero.

Expiratory muscle strength is greatly reduced during the action of lumbar spinal anaesthesia, temporarily reducing cough efficiency.

Overall mortality is reduced by one-third in patients undergoing local anaesthesia. This is due to the significant reduction in respiratory complications including pulmonary emboli, respiratory depression and pneumonia especially after general, orthopedic, urological and vascular surgery.