Clinical Engineering

Clinical Engineering Equipment (Medical Ventilator)

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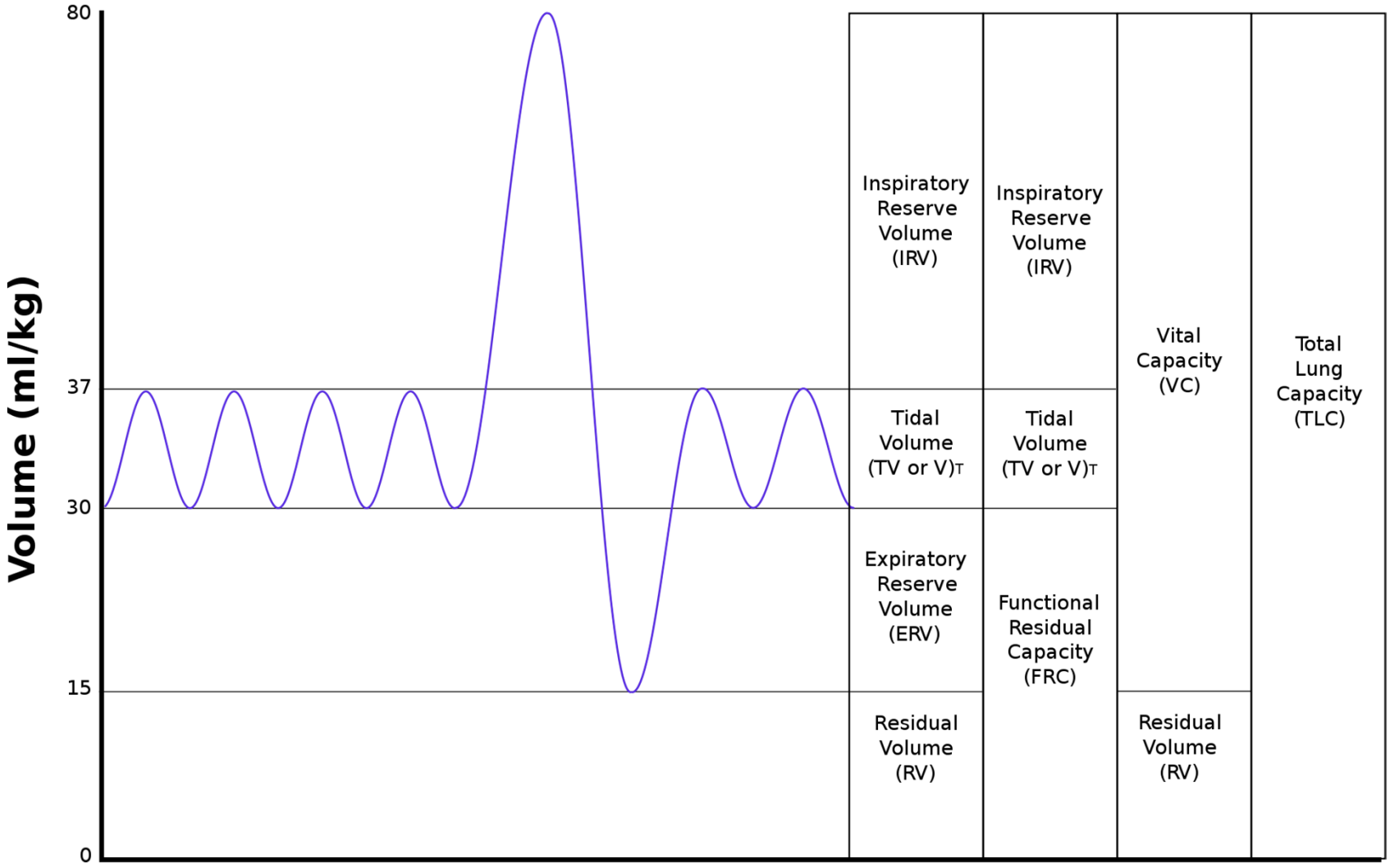
Human Respiration

- Respiration can be divided into 4 major functions:
  - pulmonary ventilation (inflow and outflow of air between the atmosphere and the lung alveoli)
  - diffusion of oxygen and carbon dioxide between the alveoli and the blood
  - transport of oxygen and carbon dioxide in the blood and body fluids to and from the body's tissue cells
  - regulation of ventilation and other facets of respiration.

Respiratory Volumes and Capacities



Medical ventilator

- Ventilator - used to artificially ventilate the lungs of patients with mixture of O_2 + air who are unable to breathe naturally
- Breathing circuit (humidified + heated)
- Model:
  - negative pressure ventilators
  - positive pressure ventilators

Medical ventilator

Negative pressure ventilators

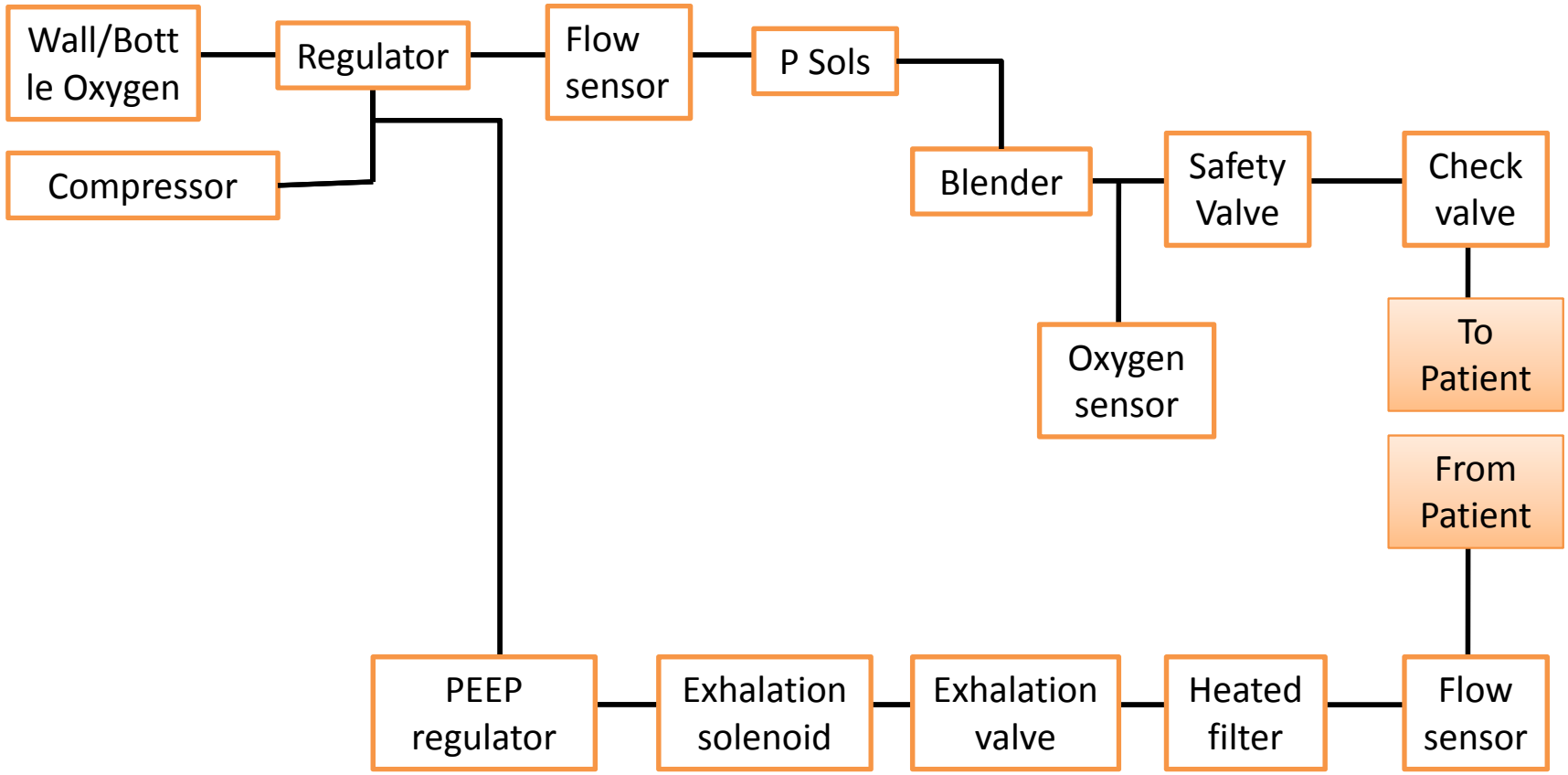
- generating a negative pressure around the patient's thoracic cage
- pressure gradient between the atmosphere and the lungs

Positive pressure ventilators

- applying a positive pressure (> atmospheric pressure) to the patient airways *(patient circuit)*
- Types - neonates & adults

Medical ventilator

- Block diagram



Medical ventilator

Gas supply

- 100% O_2
- Medical air (21% O_2 + 79% N_2)
- Bottled gases (15 Mpa) + Regulator (to 350-400 kPa)
- Wall (350-400 kPa)
- Colour coded + Pin indexed

Medical ventilator

Filters + Water traps

- To filter water, dust, bacteria
- To protect equipment and also the patient

Pressure Regulators

- 350-400 kPa to 110-170 kPa (depand on brand)

Medical ventilator

Solenoids valve (P Sols)

- Solenoids control flow & mix of gases
- Changing current = changing flow
- electromechanical valve for use with liquid or gas controlled by running or stopping an electric current through a solenoid

Blender

- To control:
  - Tidal volume
  - Patient flow rates
  - Respiratory rates
- Gases mixed in tubing @ separate chamber

Medical ventilator

Oxygen sensor

- Only measured O_2
- In-line with inspired gas

Humidification (Heated humidifier)

- To warm & humidified air

Medical ventilator

CPU

- Controls regulation of all parameters
- Checks alarm conditions
- Keeps a record of all errors
- Attached to the user interface (control)
- Calibrated flow sensor & O_2 sensor
- Checks for leaks in the system

Breathing circuit

- Inspiratory tubing
- Humidifier
- Heated wire
- Y-piece
- Expiratory tubing
- Water trap

Medical ventilator

Endotracheal tubing

- Connects patient to ventilator
- Ballon at the end that inflated

Medical ventilator

Medical Terminology

- FiO_2 (Fractional Inspired Oxygen) – fraction (%) of the gas inspired
- T^I (Inspiratory time)
- T^E (Expiratory time)
- I/E ratio (T^I/T^E ratio)
- MAP (Mean Airway Pressure)
- PEEP (Positive End Expiratory Pressure) – pressure remaining in the patient circuit & lung at the end of expiration
- PIP (Peak Inspiratory Pressure) – maximum pressure generated by the ventilator during inspiration

Medical ventilator

Modes

- Spontaneous Ventilation
  - Continuous Positive Airway Pressure (CPAP) = small +ve constant pressure
  - Pressure Support
  - Synchronized Intermittent Mandatory Ventiilation (SIMV) = patient attempt to breath + ventilator delivers a breath in time
- Mandatory Ventilation
  - Controlled mandatory ventilation (CMV) = timing of breaths & pressure set by user
    - volume controlled ventilation
    - pressure controlled ventilation
  - Positive end expiratory pressure (PEEP)
- tidal volume / respiration rate / inspiratory flow pattern / oxygen concentration of the breath