SNS COLLEGE OF ALLIED HEALTH SCIENCE

Affiliated to The Tamil Nadu Dr. M.G.R Medical University, Chennai

DEPARTMENT OF OPERATION THEATRE AND ANESTHESIA TECHNOLOGY

COURSE NAME : 1138 - PRINCIPLES OF ANESTHESIA - 1

UNIT : 1 ANAESTHESIA MACHINE & MEDICAL GAS SUPPLY

TOPICS : **VENTILATOR AND ITS WORKING PRINCIPLES**

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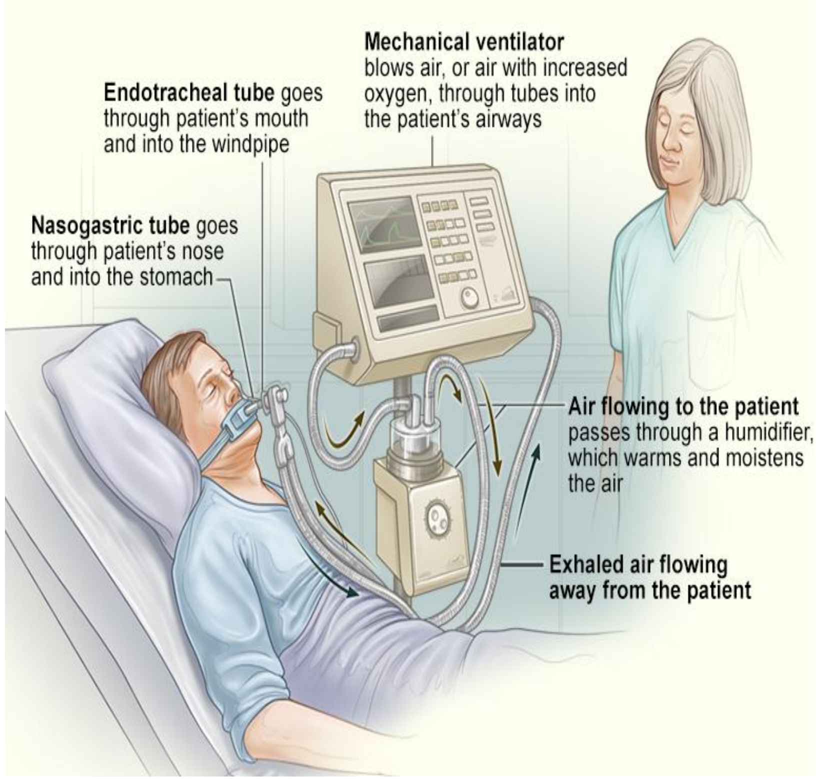
INTRODUCTION (Define)

- **Definition**: A mechanical ventilator is a machine that assists or replaces spontaneous breathing by delivering O2-rich air into the lungs and removing CO2.
- **Purpose**: Used in cases of respiratory failure, surgery, or critical illnesses to sustain life.
- **Importance**: Essential in ICUs, emergencies, and long-term care; helps maintain gas exchange when natural breathing is insufficient.

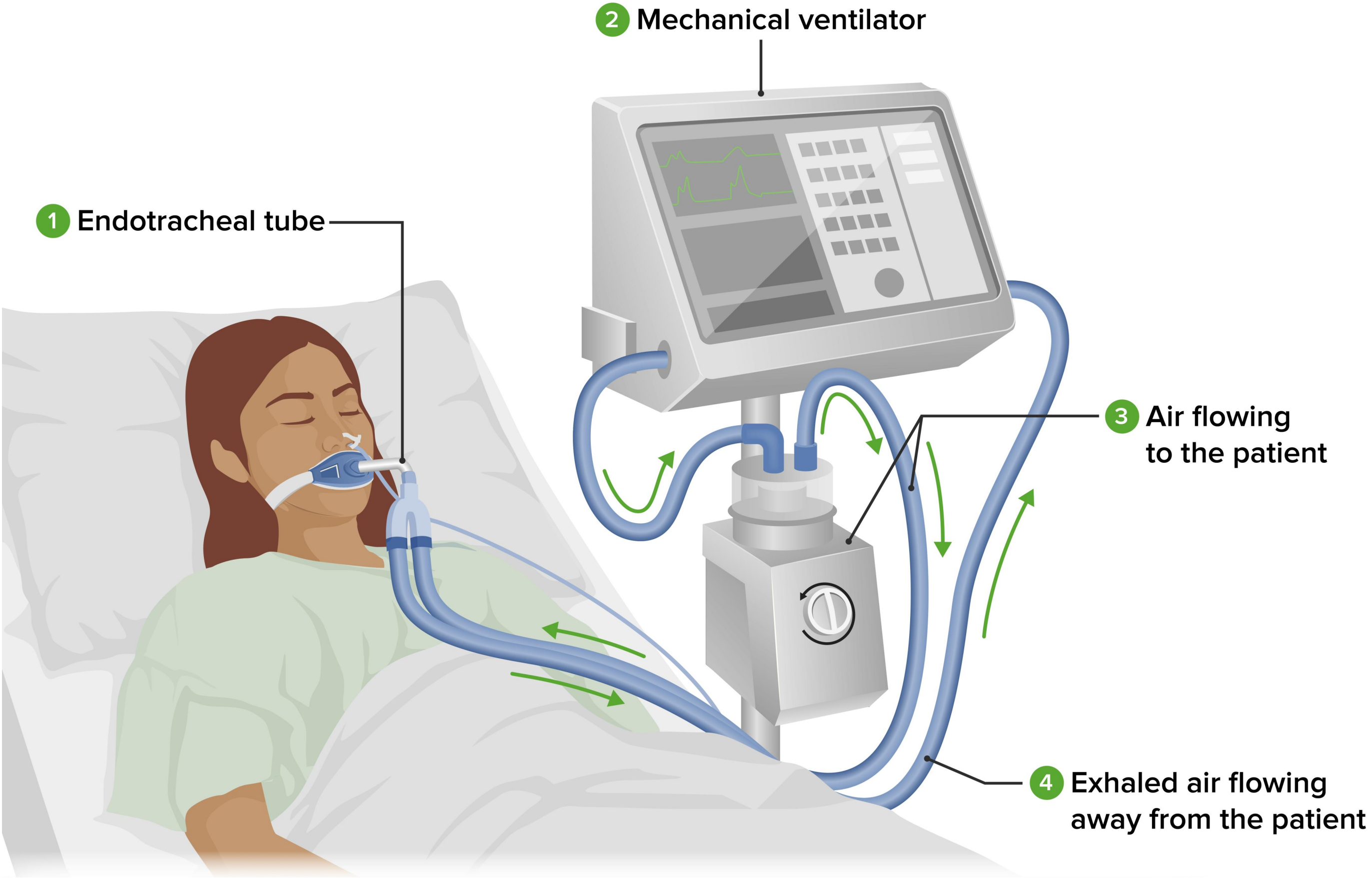


History of Ventilators

- **Early Developments:** Iron lung (1920s-1930s) used negative pressure to assist breathing during polio epidemics.
- **Shift to Positive Pressure:** 1950s onward, with advancements during the polio crisis; modern ventilators evolved from anesthesia machines.
- **Key Milestones:** 1960s - Volume-controlled ventilators; 1970s - Microprocessor integration for precise control; Today - Portable and smart ventilators with AI features.
- **Evolution**: From bulky negative-pressure devices to compact positive-pressure systems for invasive and noninvasive use.

Types of Ventilators

- Invasive Ventilators
- Noninvasive Ventilators
- Transport Ventilators
- Home Ventilators
- Classification by Function:
  - Volume-cycled,
  - pressure-cycled
  - time-cycled



Components of a Ventilator

- Gas Source
- Breathing Circuit
- Control System
- Monitors and Alarms
- Power Supply
- Humidifier

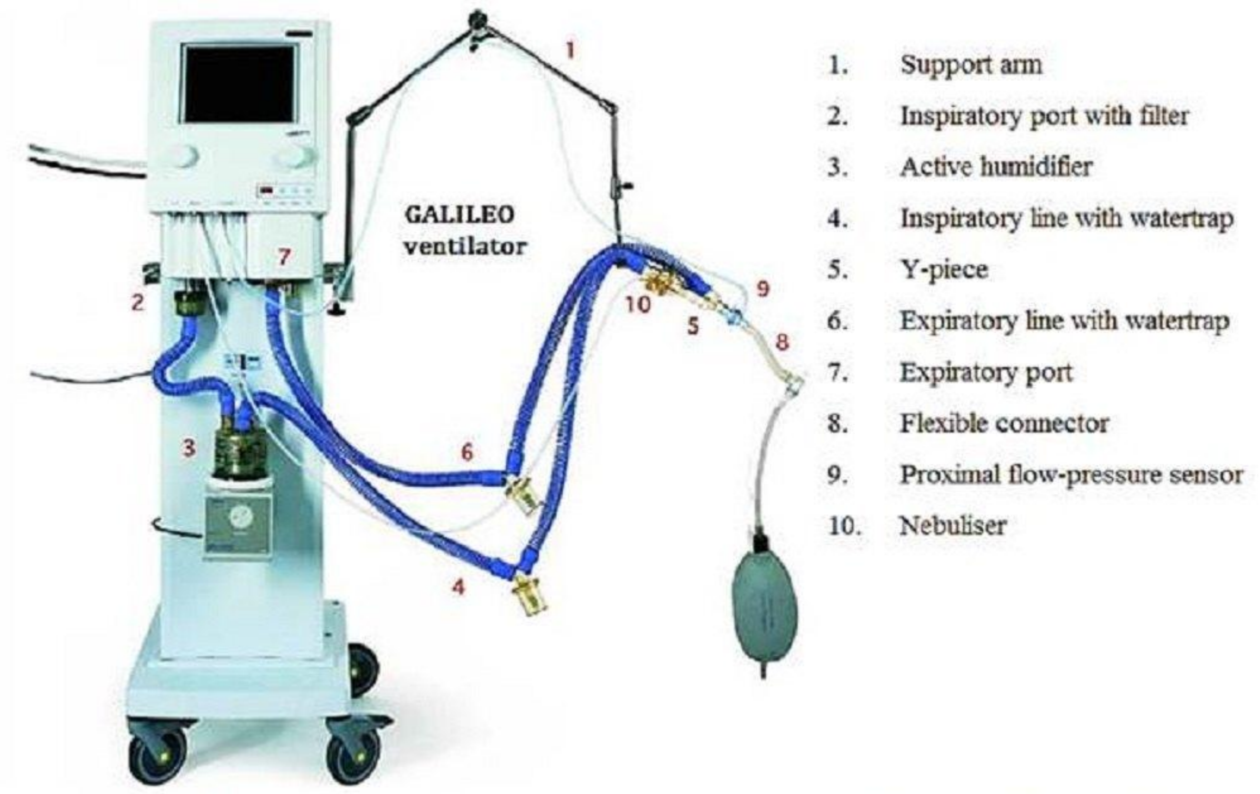
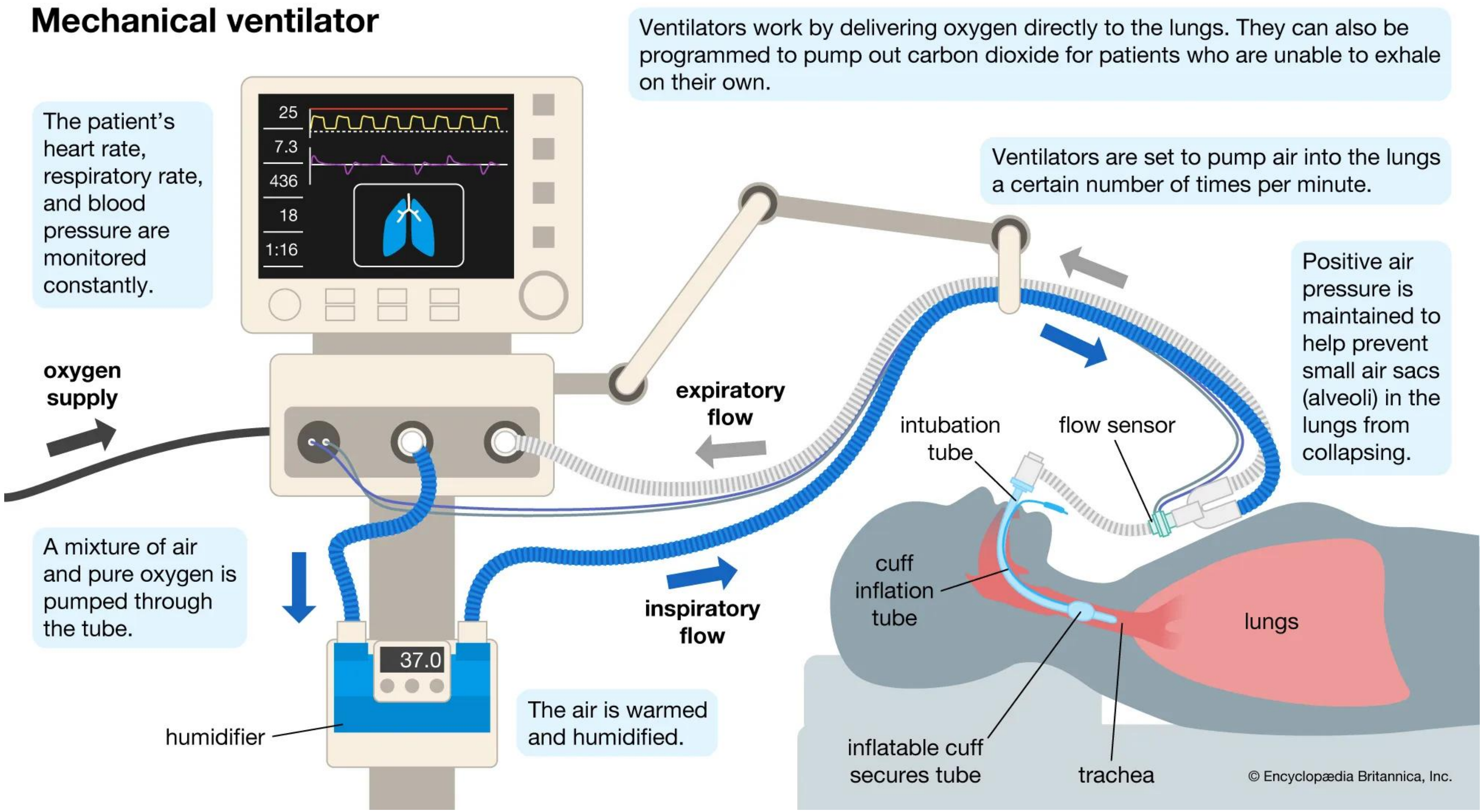


Fig - A mechanical ventilator for intensive care, with the external circuit

Working Principle - Overview

- **Basic Mechanism:** Ventilators use positive pressure to inflate lungs (inspiration) and allow passive deflation (expiration).
- **Pressure Gradient:** Air flows from high pressure (ventilator) to low pressure (lungs); based on airway resistance and lung compliance.
- **Cycle:** Inspiration phase delivers breath; expiration phase vents CO_2.
- **Key Equation:** Pressure = Flow × Resistance + Volume / Compliance.

Working Principle - Overview

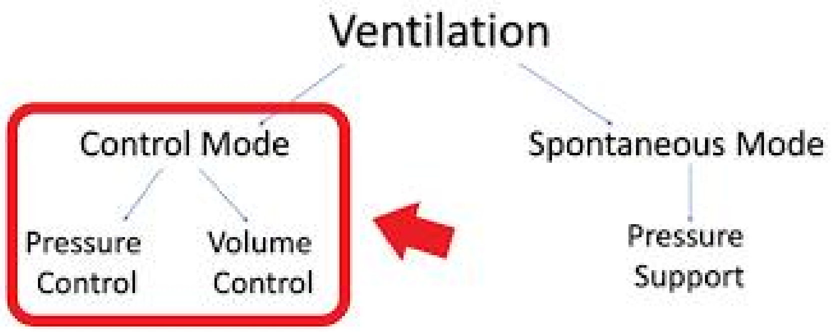


Positive Pressure Ventilation

- **How It Works**: Ventilator pushes air into lungs via positive pressure, unlike natural negative-pressure breathing.
- **Phases:**
  - Inspiration: Constant pressure or volume until set limit.
  - Expiration: Valve opens, lungs recoil passively.
- **Advantages**: Precise control of oxygen delivery and CO_2 removal.
- **Risks:** Barotrauma if pressure too high

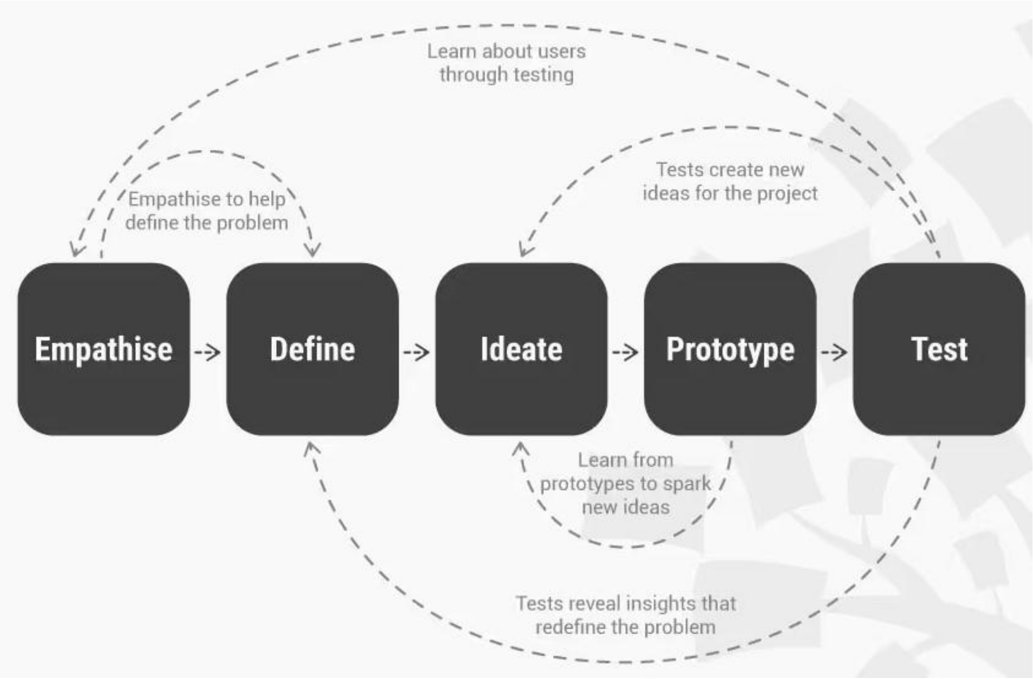
Modes of Ventilation

- **Volume-Controlled:** Delivers fixed tidal volume; pressure varies.
- **Pressure-Controlled:** Delivers fixed pressure; volume varies based on lung compliance.
- **Assist-Control:** Patient-triggered breaths with full support.
- **SIMV (Synchronized Intermittent Mandatory Ventilation):** Mix of mandatory and spontaneous breaths.
- **CPAP/PSV:** Continuous pressure for noninvasive support.



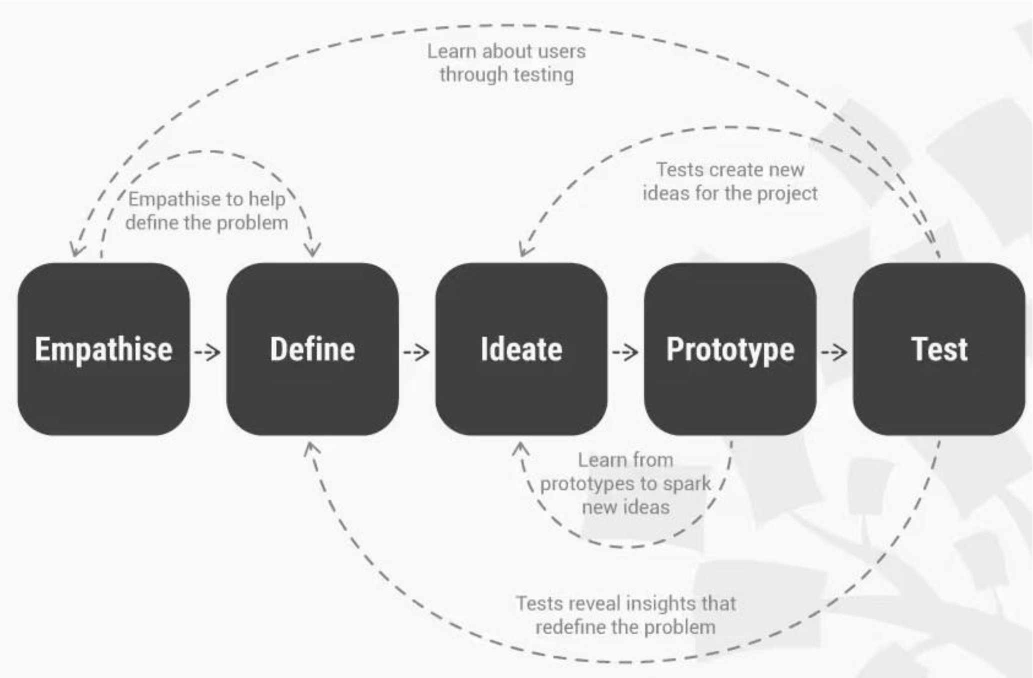
Design Thinking - Define Stage

- **Purpose**: Clearly define the problem to guide innovation in ventilator design.
- **Problem Statement:** Patients with respiratory failure need reliable, safe, and adaptable breathing support to prevent hypoxia and hypercapnia.
- **Key Elements:** User needs (e.g., portability for home use), constraints (cost, ease of use), and empathy mapping for patients/doctors.



Design Thinking - Ideate Stage

- **Purpose**: Brainstorm diverse ideas without judgment to innovate ventilator solutions.
- **Techniques**: Mind mapping, sketching, group sessions.
- **Ideas Generated:** Portable battery-powered units, AI-monitored modes, low-cost DIY designs using 3D printing, noninvasive hybrids.
- **Focus**: Quantity over quality; e.g., integrate sensors for real-time adjustments or modular components for easy maintenance.

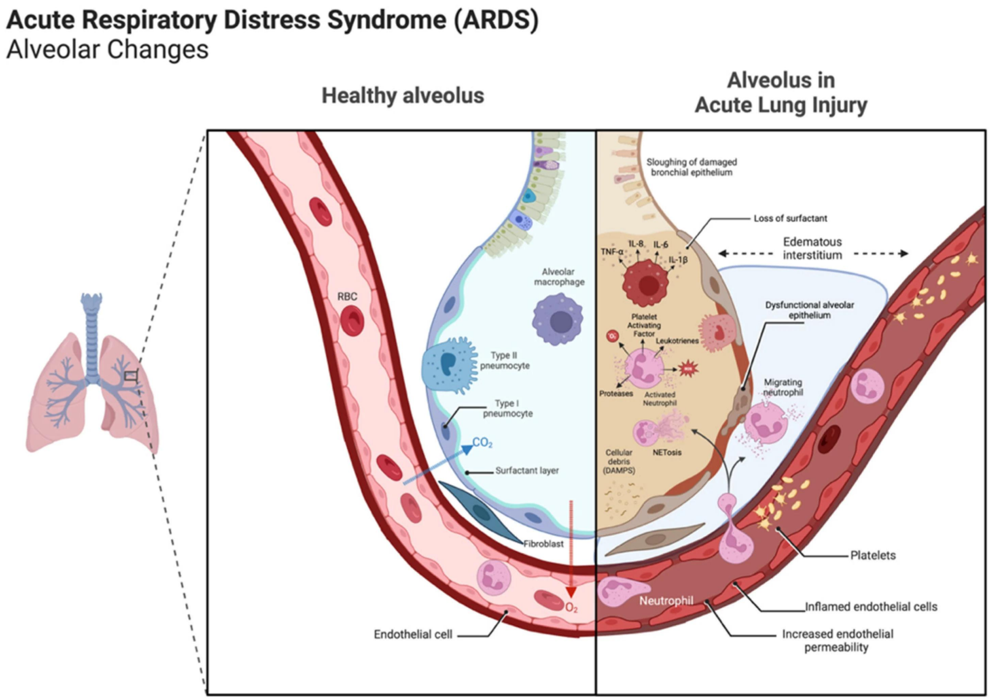


Monitoring, Alarms, and Complications

- **Monitoring**: Tracks tidal volume, peak pressure, PEEP, FiO2, and patient synchrony.
- **Alarms**: For high/low pressure, disconnection, apnea, or low battery.
- **Common Complications:** Ventilator-associated pneumonia, barotrauma, volutrauma, oxygen toxicity.
- **Prevention**: Regular checks, humidification, and weaning protocols.

Applications and Importance

- **Clinical Uses:** ARDS, COVID-19, post-surgery, trauma, chronic respiratory diseases.
- **Importance**: Saves lives by supporting vital functions; enables other treatments during critical care.
- **Future Trends**: AI integration for predictive adjustments, telemonitoring, and eco-friendly designs.
- **Global Impact:** Crucial in pandemics; over 100,000 units used worldwide during peaks.



SUMMARY

- Ventilators assist breathing by delivering oxygen and removing CO_2 using positive pressure.
- Key components include gas sources, circuits, controls, and monitors.
- Working principle relies on pressure gradients for inspiration and passive expiration.
- Design Thinking: Define focuses on problem clarity; Ideate generates innovative ideas for better ventilators.
- Essential in critical care, with modes like volume- and pressure-controlled for tailored support.

REFERENCE

Books:

- Yadav, A. (2025). Short Textbook of Anesthesia (7th ed.). Jaypee Brothers Medical Publishers.

Websites:

- https://my.clevelandclinic.org/health/treatments/15368-mechanical-ventilation
- https://www.ncbi.nlm.nih.gov/books/NBK539742/

THANK YOU