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ANESTHESIA MACHINE

An anesthesia machine is a device that **delivers oxygen and anesthetic gases** to the patient and **removes carbon dioxide** during surgery.

First machines developed in the early 1900s (e.g., Boyle’s machine).

PURPOSES

- Provide oxygen and anesthetic gases safely.
- Support or control patient’s breathing.
- Allow precise control of anesthetic depth.
- Monitor patient and prevent complications

Main Components

Gas supply: Oxygen, air, nitrous oxide (from cylinders or pipeline).

Flowmeters: Control how much gas flows to the patient.

Vaporizers: Change liquid anesthetic into vapor and add it to gases.

Breathing system (circle system): Delivers gases to the patient and removes CO_2.

Reservoir bag & APL valve: Store gas, allow manual ventilation, prevent high pressure.

Scavenging system: Removes waste gases from the OR.

Monitors: Track oxygen, CO_2, anesthetic levels, and vital signs.

Types of anesthesia machine

Continuous Flow Machines

Most common type in hospitals.

Provide a **steady flow** of oxygen and anesthetic gases.

Use **flowmeters, vaporizers, and breathing circuits**.

Examples: Modern anesthesia workstations.

2. Intermittent (Draw-over) Machines

Simple, portable design.

Patient's own breathing **draws in air/oxygen through a vaporizer**.

Do not need compressed gas supply.

Useful in **field settings, emergencies, or low-resource areas**

- Key Safety Features

Oxygen alarm: Alerts if O_2 supply fails.
Hypoxic guard: Prevents delivery of gas mix with <21% oxygen.
Vaporizer interlock: Only one anesthetic vaporizer can be used at a time.
Pressure relief (APL valve): Prevents barotrauma.

WE WILL BE STARTING SHORTLY: 2 PM CAT

WELCOME TO

TODAY'S PARTNER TALK

"UNDERSTANDING ANAESTHESIA TECHNOLOGY BEHIND THE AEONMED 7200A MODEL"

OXYGEN ALLIANCE

1 **Pipeline**

2 **Gas Cylinder**

3 **Vaporizer**

4 **Flow meter**

5 **Breathing Circuit**

6 **Circle System**

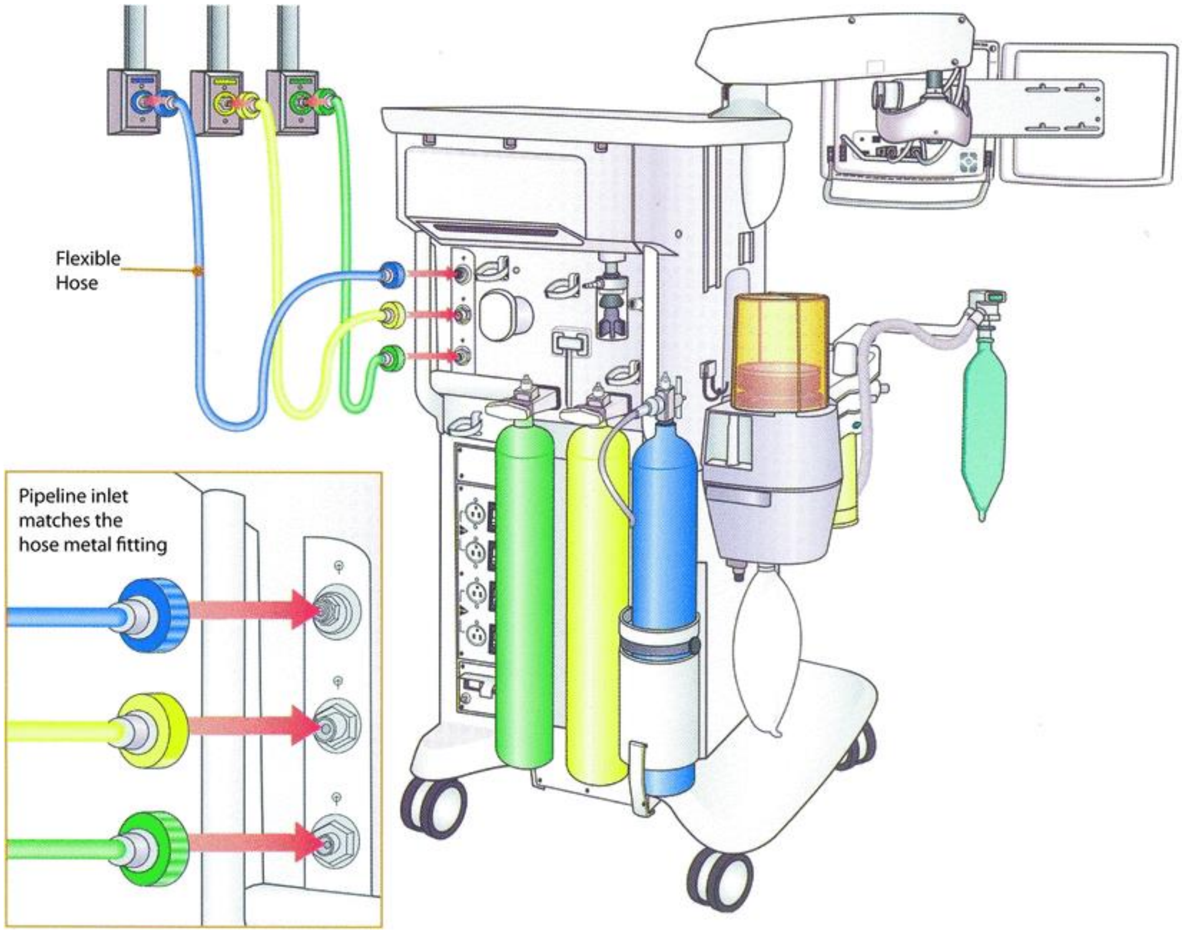
7 **Mapleson**

8 **Mechanical Ventilation**

9 **O_2 Delivering**

10 **Humidification**

Pipeline & Gases Cylinders



Pipeline
& Gases Cylinders

Pipelines : Are the hoses which deliver medical gases from their central supply to their own tube in Flow meter . As a safety measures each hose can connect to its port (orifice) and can't fit on other port to prevent deliveing gases to wrong Tube

Pipeline
& Gases Cylinders

Gases Cylinders : For further safety measure there is a reserve gas cylinders connected to the Flow meter and used when Central supply cut off

Flow Meter

Flow Meter

Flow Meter : one of the important component of this machine is flow meter . By this device you can adjust the gas flow for 3 gases (O_2/ N_2O/ medical air) by opening flow meter valve . When you open the valve the flow indicator raises and these gases flow from Flow Meter to Vaporizer

There is a safety feature of this device that when you open N_2O valve the O_2 valve open automatically

Flow Meter

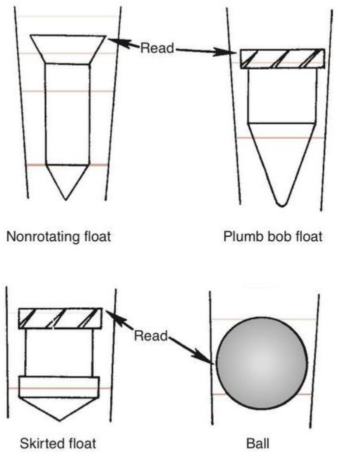
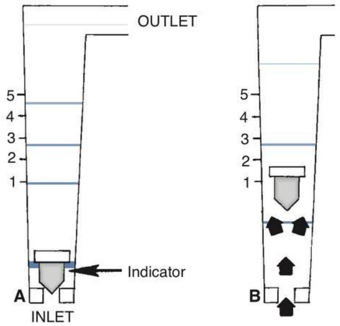


Figure 3.24 Flow indicators. The plumb bob and skirted floats are kept centered in the tube by constant rotation. The reading is taken at the top. The ball indicator is kept centered by rib guides. The reading is taken at the center. The nonrotating float does not rotate and is kept centered by gas flow. (Adapted from Binning R, Hodges EA. Flowmeters. Can they be improved? Anaesthesia 1967;22:643–646.)

3. The Anesthesia Machine

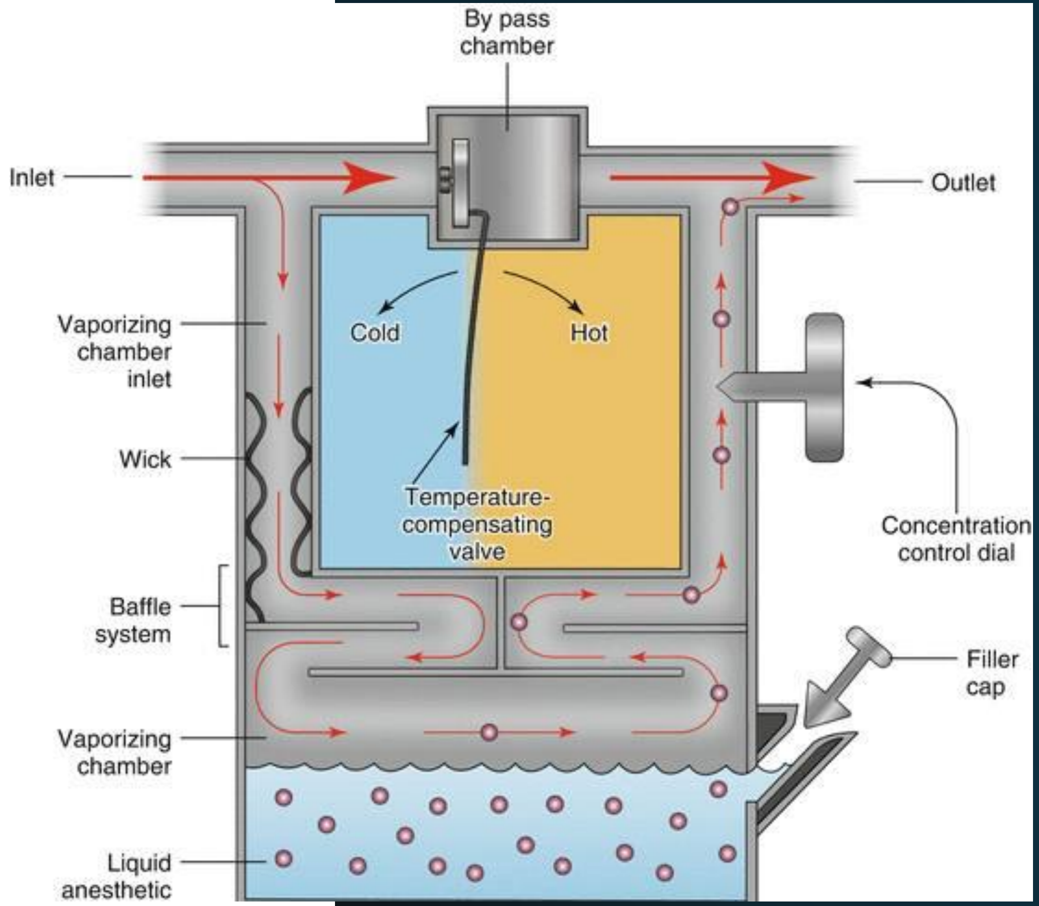
68 3. The Anesthesia Machine



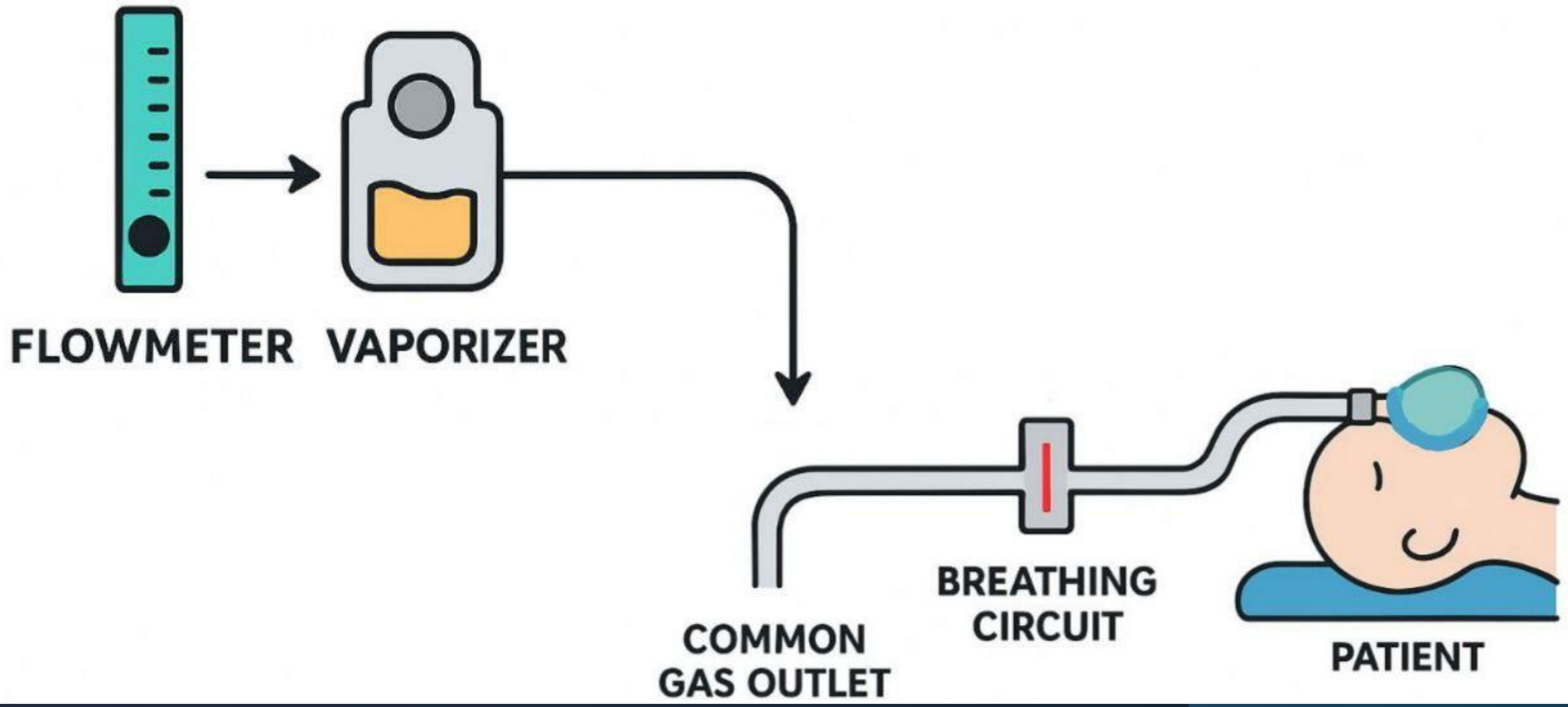
Vaporizer

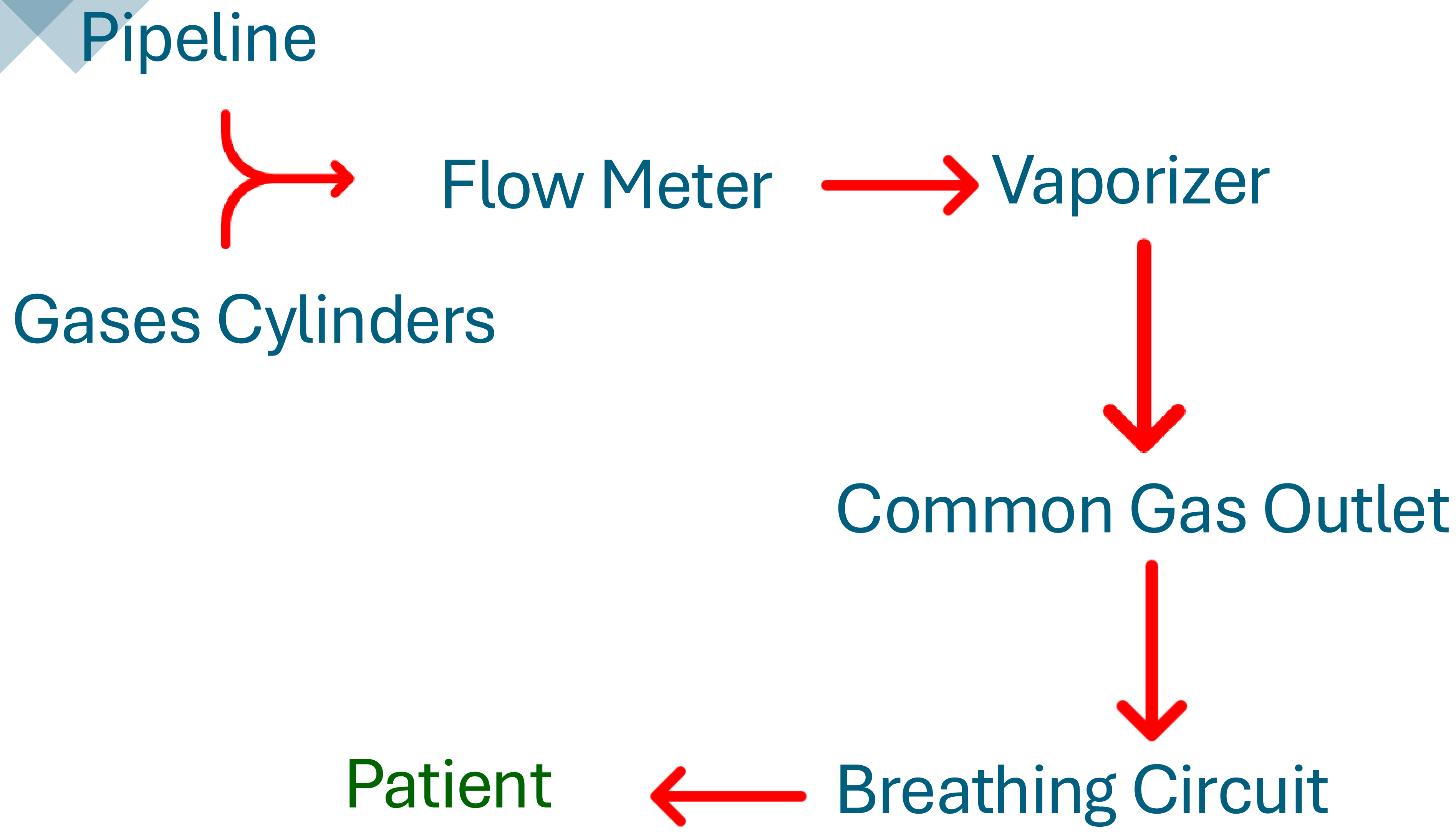
Vaporizer

- vaporizer is a device which turn the liquid anesthetic agent into gas state . These vaporized gases are carried by another gas (mostly O2) out of the device to be delivered to the patient . as you see there is a wheel that allow you to control over the concentration .
- Gases flow from Vaporizer to Common Gas Outlet and finally to Breathing Circuit



FLOW OF GASES




Pipeline
Gases Cylinders
Flow Meter
Vaporizer
Common Gas Outlet
Breathing Circuit
Patient

Bellow

Bellow

This device is connected to the breathing circuit and used as " Mechanical Ventilation "

Bellow

When this device stop moving this indicate a critical problem it would be one of these :

- 1- The breathing circuit is detached from or wrongly connected to endotracheal tube
- 2-Endotracheal tube is intubated into Esophagus
- 3-Endotracheal tube is extremely bent or closed by mucus

Breathing circuits

Done by Omar Ahmad al mseadeen
4th year MS
Mutah university

Breathing Circuit

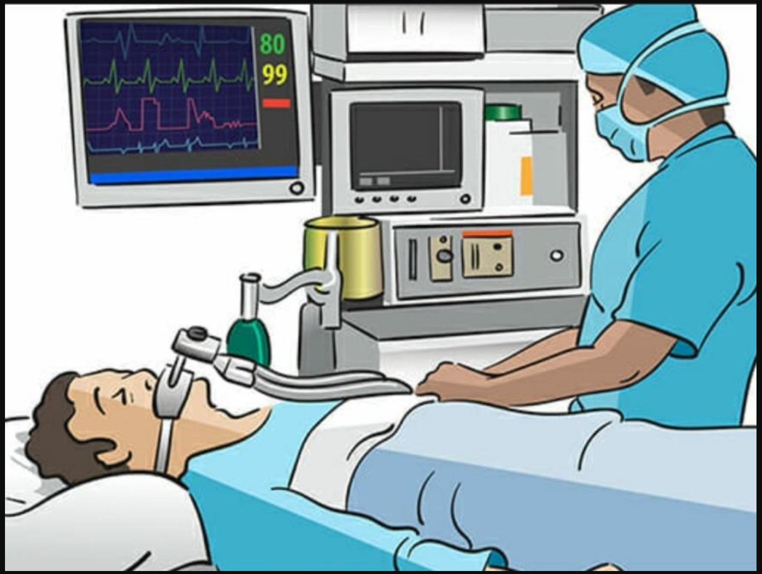
- A system that delivers oxygen and anesthetic gases to the patient and removes carbon dioxide (CO_2). It is essential in general anesthesia and mechanical ventilation.

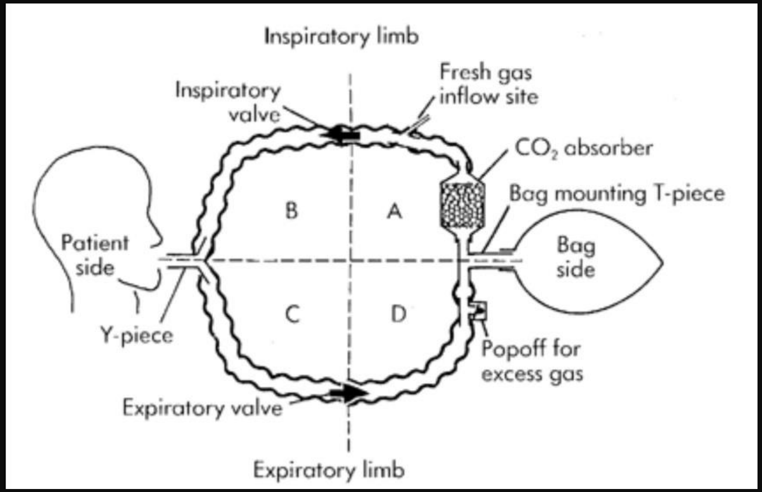
  Primary functions:

  1. Deliver O_2 and anesthetic gases to the patient.

  2. Remove CO_2 efficiently.

  3. Maintain appropriate airway pressure and flow.



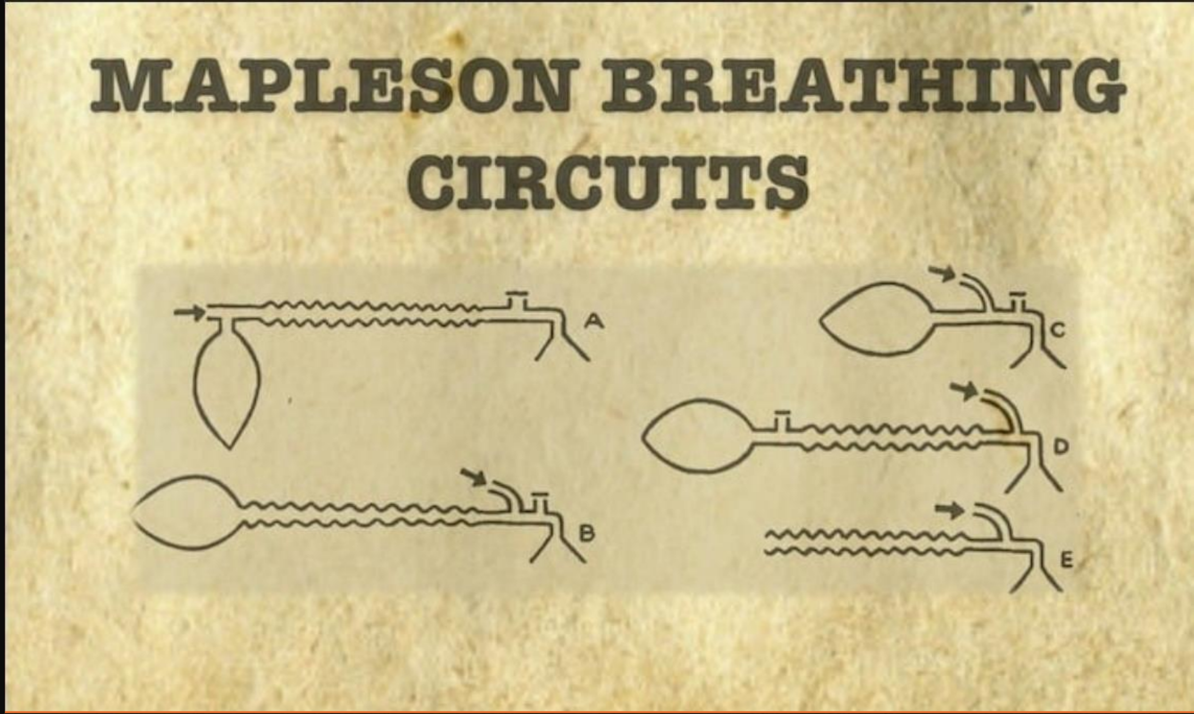


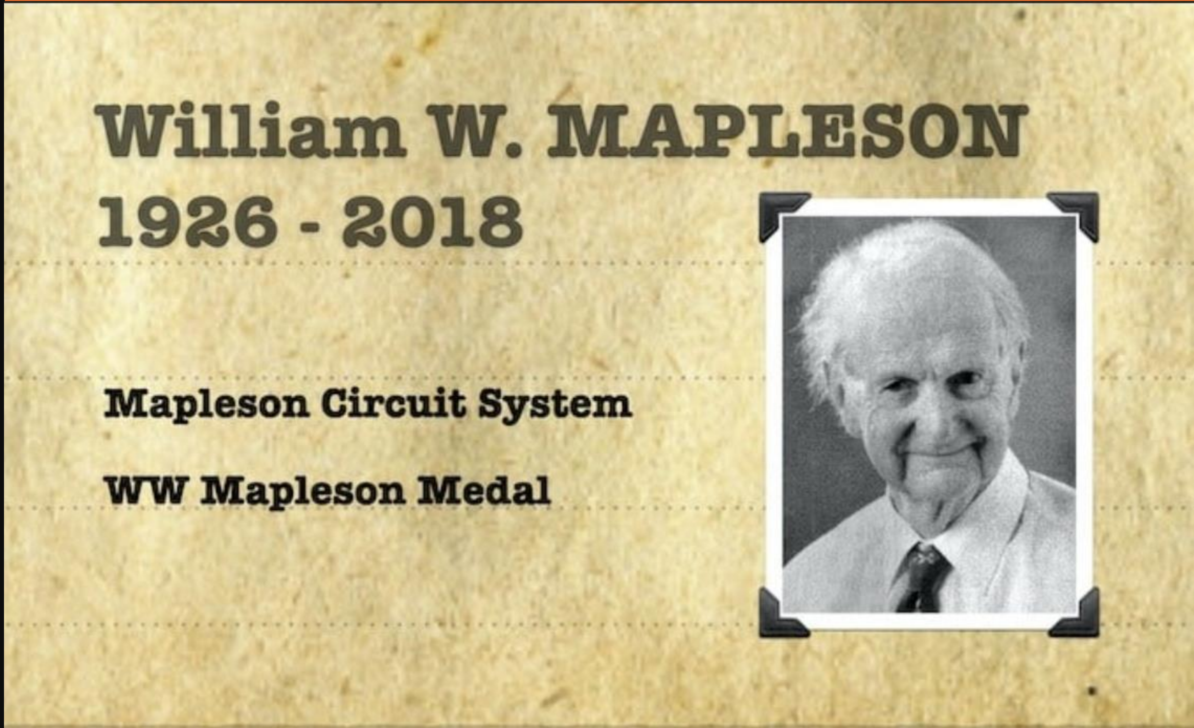
Types of breathing circuits

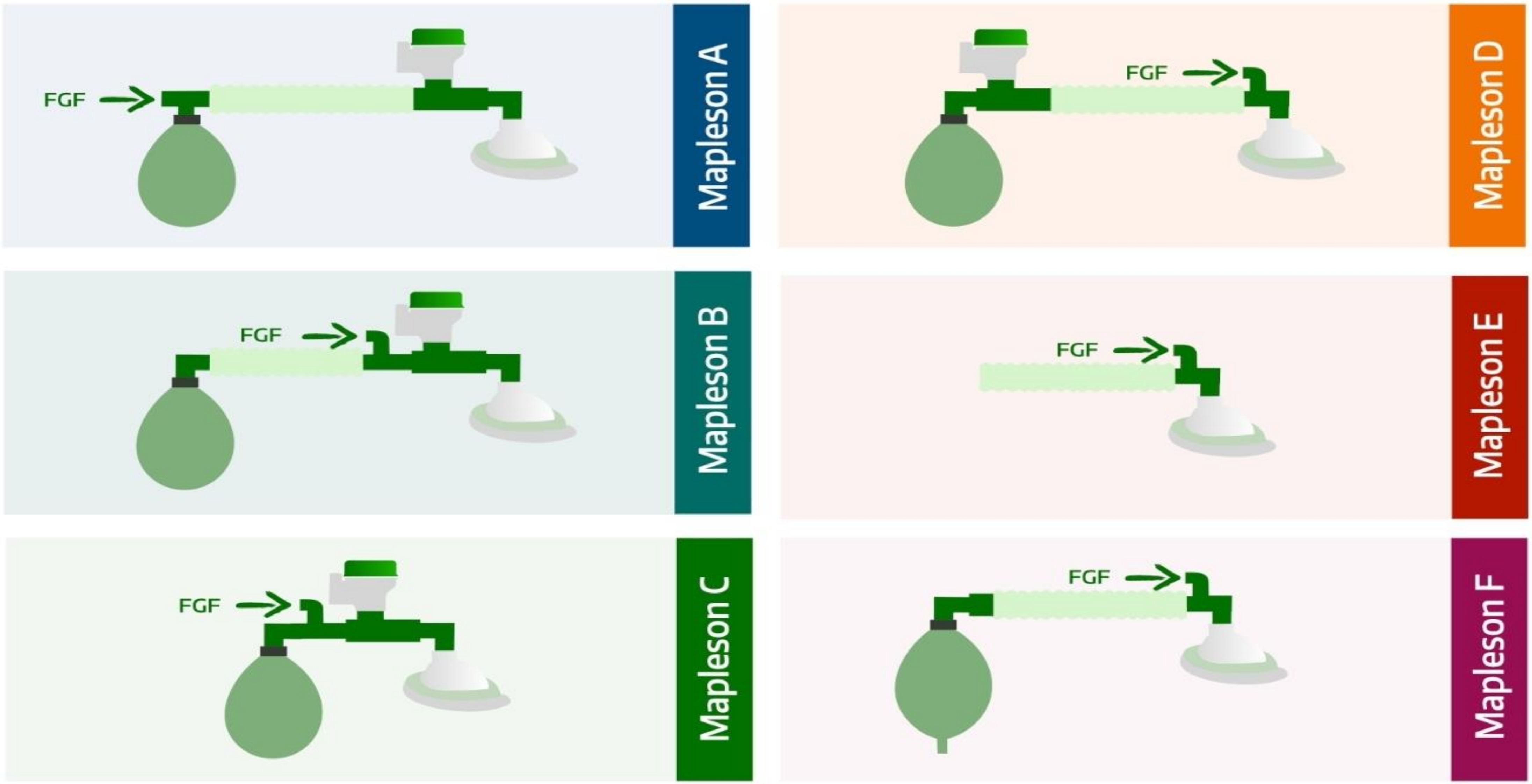
- Mapleson breathing system
- Circle system

Why are they called Mapleson circuits?

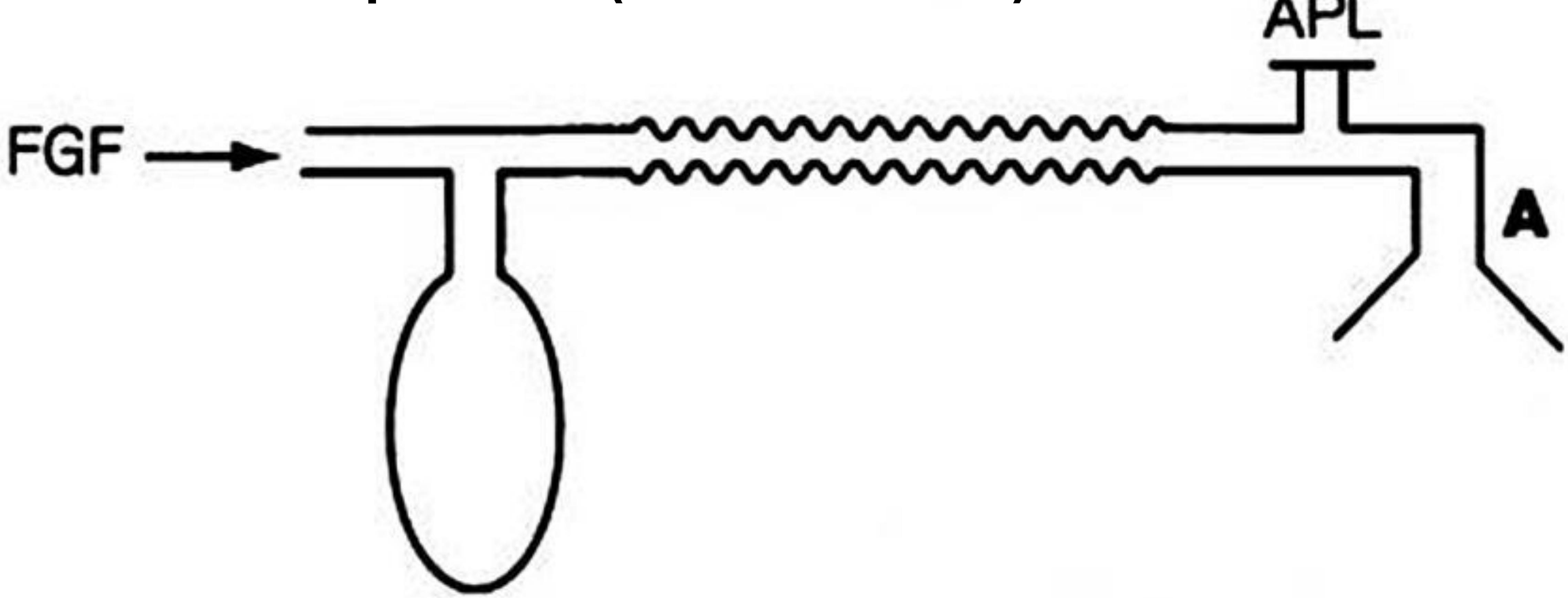
They are named after **William W. Mapleson**, who first classified these systems in **1954**. He described five types (A–E); later, type **F** was added (Jackson-Rees modification).



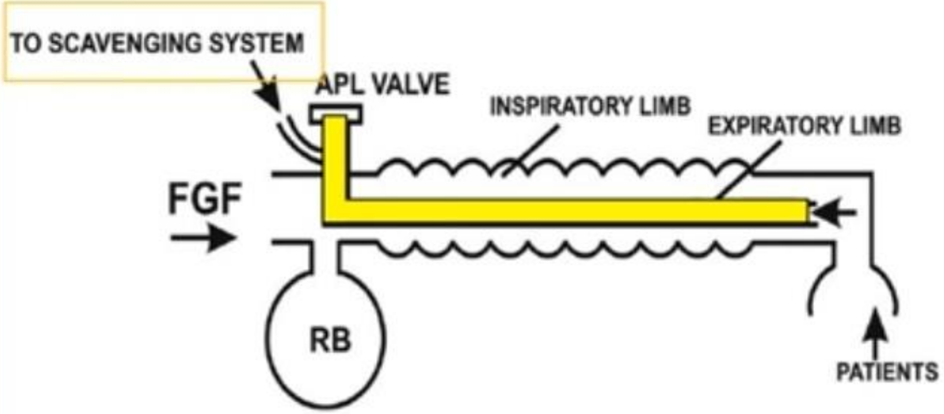



FGF
Mapleson A
FGF
Mapleson B
FGF
Mapleson C
FGF
Mapleson D
FGF
Mapleson E
FGF
Mapleson F

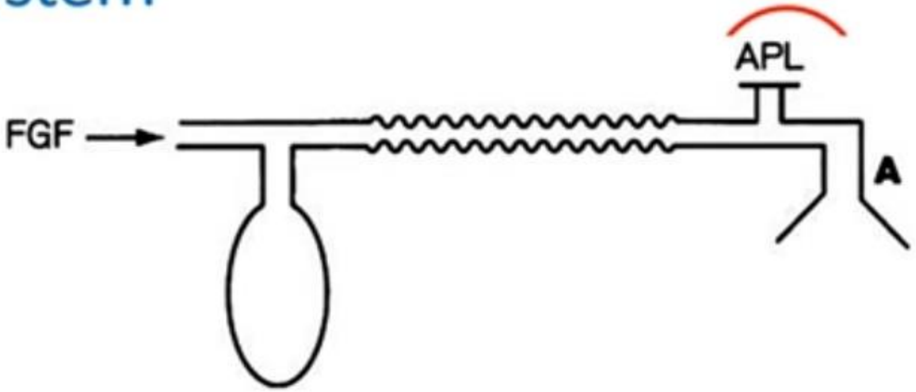
Mapleson A (MAGILL circuit)



Lack's System



Lacks modification



Mapleson A

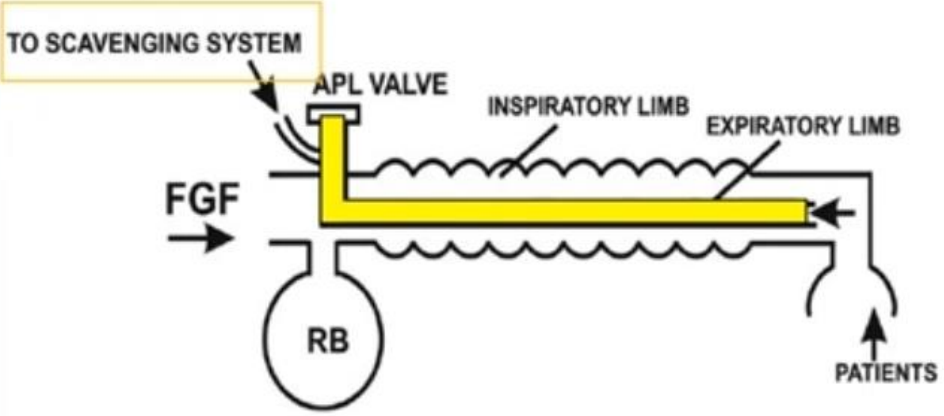
- Coaxially placed expiratory tube inside the inspiratory tube

- Better for scavenging of waste gas ✓

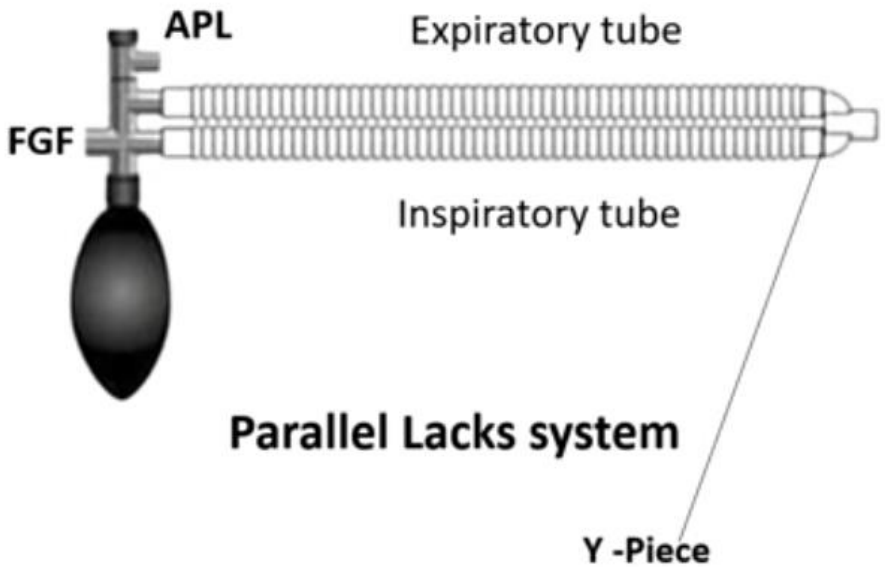
Leaking or disconnection of inner tube ✗

- APL valve near patient end

Lack's System



Lacks modification



Parallel Lacks system

- Coaxially placed expiratory tube inside the inspiratory tube
- Better for scavenging of waste gas ✓

Leaking or disconnection of inner tube ✗

MAPLESON A

SPONTANEOUS VENTILATIONBEST

CONTOLLED VENTILATIONWOREST

1. Mapleson A (Magill circuit)

Arrangement:

FGF inlet near the reservoir bag (machine end).

APL valve close to the patient.

Reservoir bag at the machine end.

Principle:

During expiration, exhaled gases (with CO_2) pass directly out through the APL valve.

FGF fills the bag with fresh gas, ready for the next inspiration.

Highly efficient for spontaneous breathing if FGF ≈ minute ventilation.

Use:

Best for **spontaneous ventilation**.

Inefficient for controlled ventilation (requires very high FGF).

Advantages:

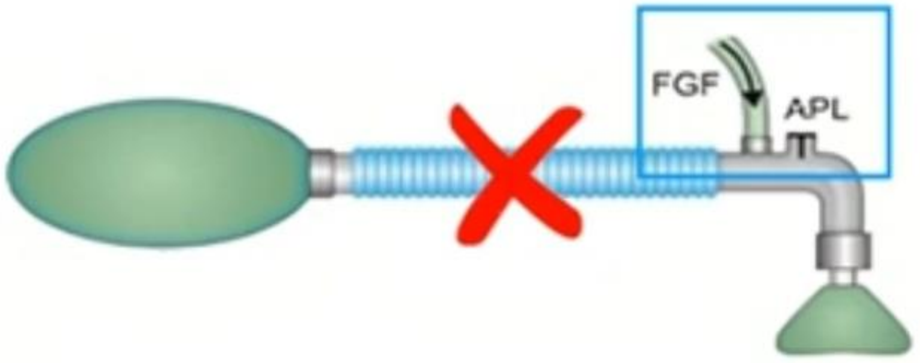
Most economical system for spontaneous breathing.

Simple design.

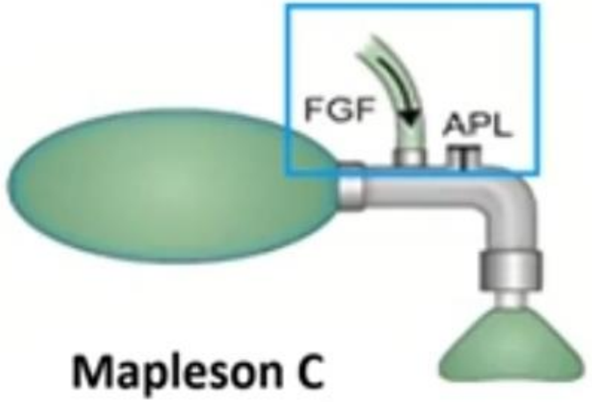
Disadvantages:

Not suitable for controlled ventilation.

MAPLESON B AND C



Mapleson B



Mapleson C

- FGF distal to APL valve at patient end
- Absence of corrugated tube in Mapleson C
- An attempt to lessen rebreathing but not economical (FGF=20-25 L/min)

MAPLESON B & C

BOTH INEFFICIENT

RARELY USED TODAY

Mapleson B

FGF inlet near the patient.

APL valve near the patient.

Reservoir bag at the far end.

Principle:

Exhaled gas may mix with incoming FGF → risk of CO_2 rebreathing.

Requires very high FGF to avoid rebreathing.

Use:

Rarely used clinically.

Advantages:

Simple to manufacture.

Disadvantages:

Inefficient, uneconomical, high FGF requirement.

Still inefficient in terms of FGF.

3. Mapleson C (Water's circuit)

Arrangement:

Same as B but shorter tubing (no long breathing tube).

Principle:

Smaller system volume → easier to control pressures.

Still significant risk of CO_2 rebreathing unless FGF is high.

Use:

Resuscitation with face mask and manual ventilation.

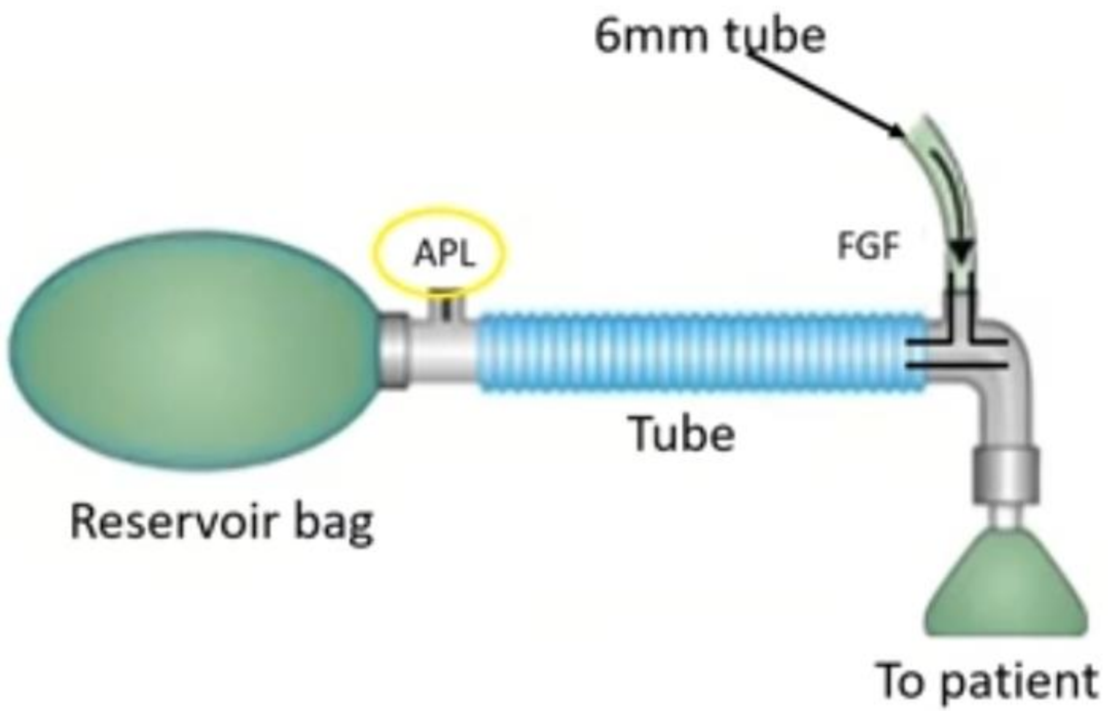
Short-term controlled ventilation.

Advantages:

Compact, portable.

Disadvantages:

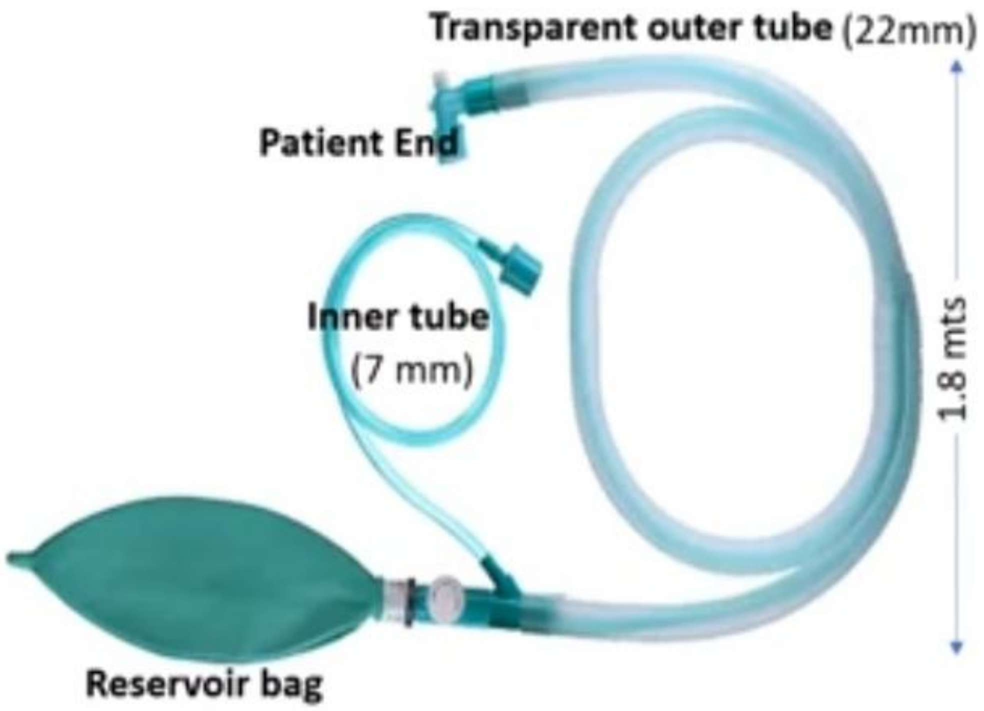
MAPLESON D SYSTEM

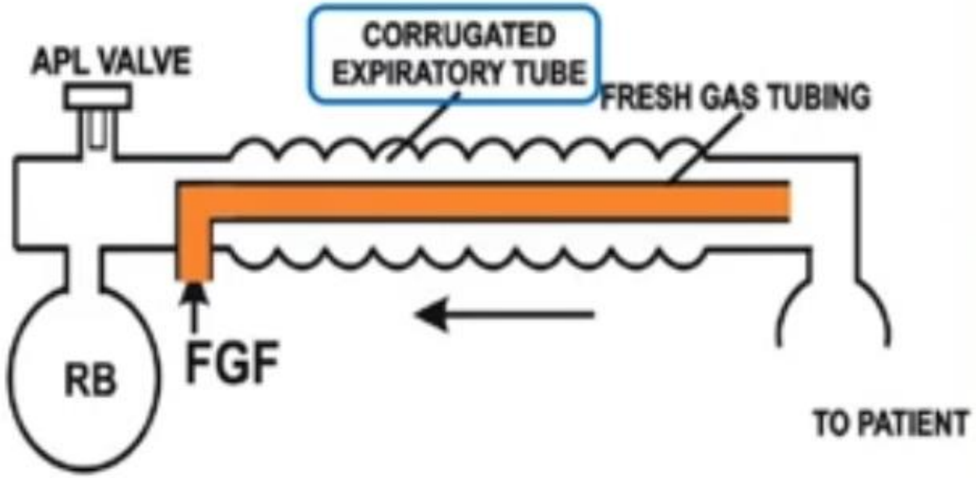


- FGF at patient end
- Bag at the expiratory end/valve

Bains System

- Inner tube for FGF coaxially inside the corrugated expiratory tube





MAPLESON D

CONTROLLED VENTILATION BEST

LIGHTWEIGHT

4. Mapleson D

Arrangement:

FGF inlet close to the patient.

Reservoir bag at the machine end.

APL valve at the machine end (with bag).

Principle:

Fresh gas is delivered directly to the patient during inspiration.

Expired gas flows away toward the bag and APL valve.

With adequate FGF, rebreathing is minimal.

Use:

Best for controlled ventilation (manual or mechanical).

Commonly used in adults.

Advantages:

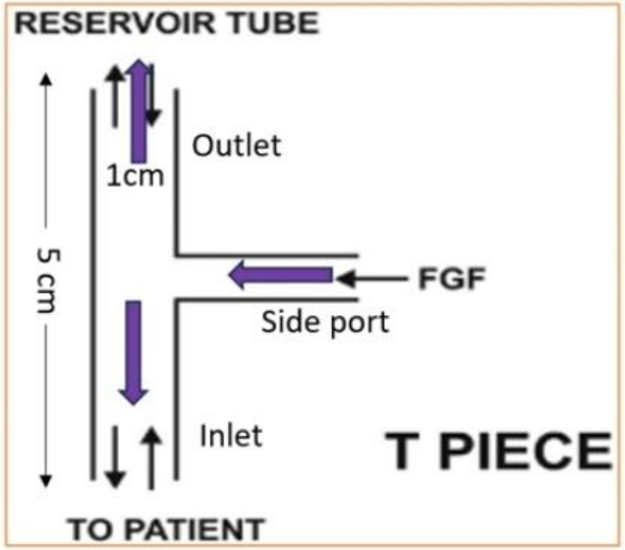
Efficient in controlled ventilation.

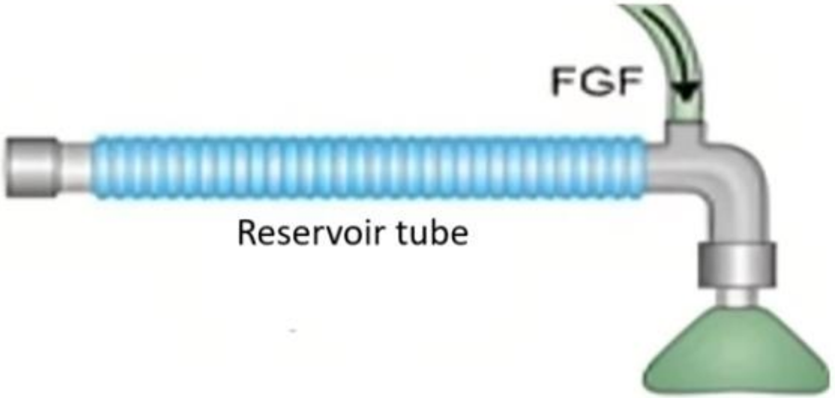
Bain circuit (coaxial Mapleson D) makes it lighter and conserves heat/humidity.

Disadvantages:

Less efficient for spontaneous breathing

Mapleson E System





Reservoir volume: > Tidal volume

Used in neonates-Less resistance (no APL Valve)

MAPLESON E

LOW RESISTANCE

RISK OF BAROTRAUMA

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5. Mapleson E (Ayre's T-piece)

Arrangement:

A simple T-shaped tube.

FGF from one side, patient at the other, third limb open to atmosphere.

No reservoir bag, no APL valve.

Principle:

CO_2 elimination depends entirely on high FGF.

If FGF is inadequate → significant rebreathing.

Use:

Common in **pediatrics and neonates** (minimal resistance, lightweight).

Advantages:

Very light, minimal resistance.

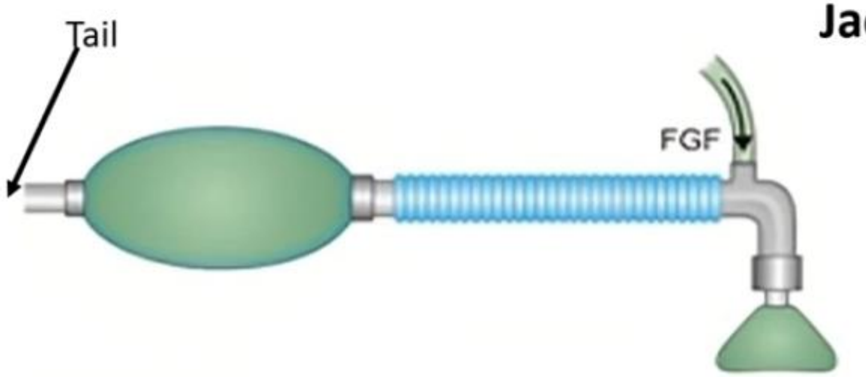
Disadvantages:

Cannot provide controlled ventilation.

High gas wastage.

Barotroma

Mapleson F



Mapleson E with a reservoir bag

Jackson Rees circuit

1. Respiratory monitoring
2. Assisted or Controlled ventilation
3. Vents out gas
4. Buffering of pressure build up

MAPLESON F

SAFER THAN MAPLESON E

HIGH FGF NEED

6. Mapleson F (Jackson-Rees modification of T-piece)

Arrangement:

Same as E, but with a reservoir bag attached (open-ended, no APL).

Principle:

Functions like E, but the reservoir bag allows:

- Storage of gas for inspiration.
- Manual ventilation by squeezing the bag.
- Monitoring of breathing patterns.

The open end of the bag must remain patent for gas escape.

Use:

Widely used in **children and infants** for spontaneous or assisted ventilation.

Advantages:

Better control than E.

Still lightweight and portable.

Disadvantages:

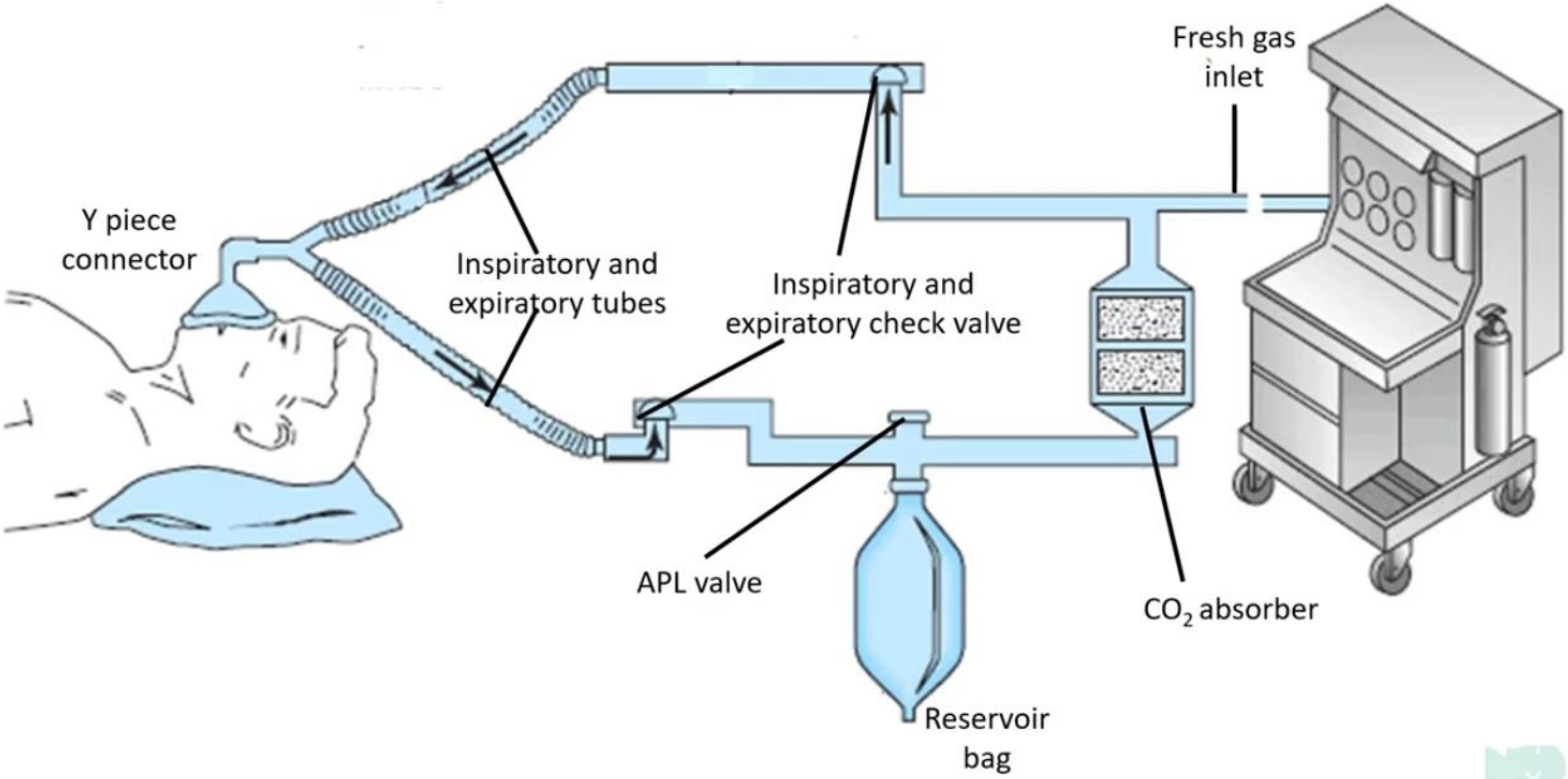
Risk if the bag outlet becomes obstructed (barotrauma).

Still requires high FGF.

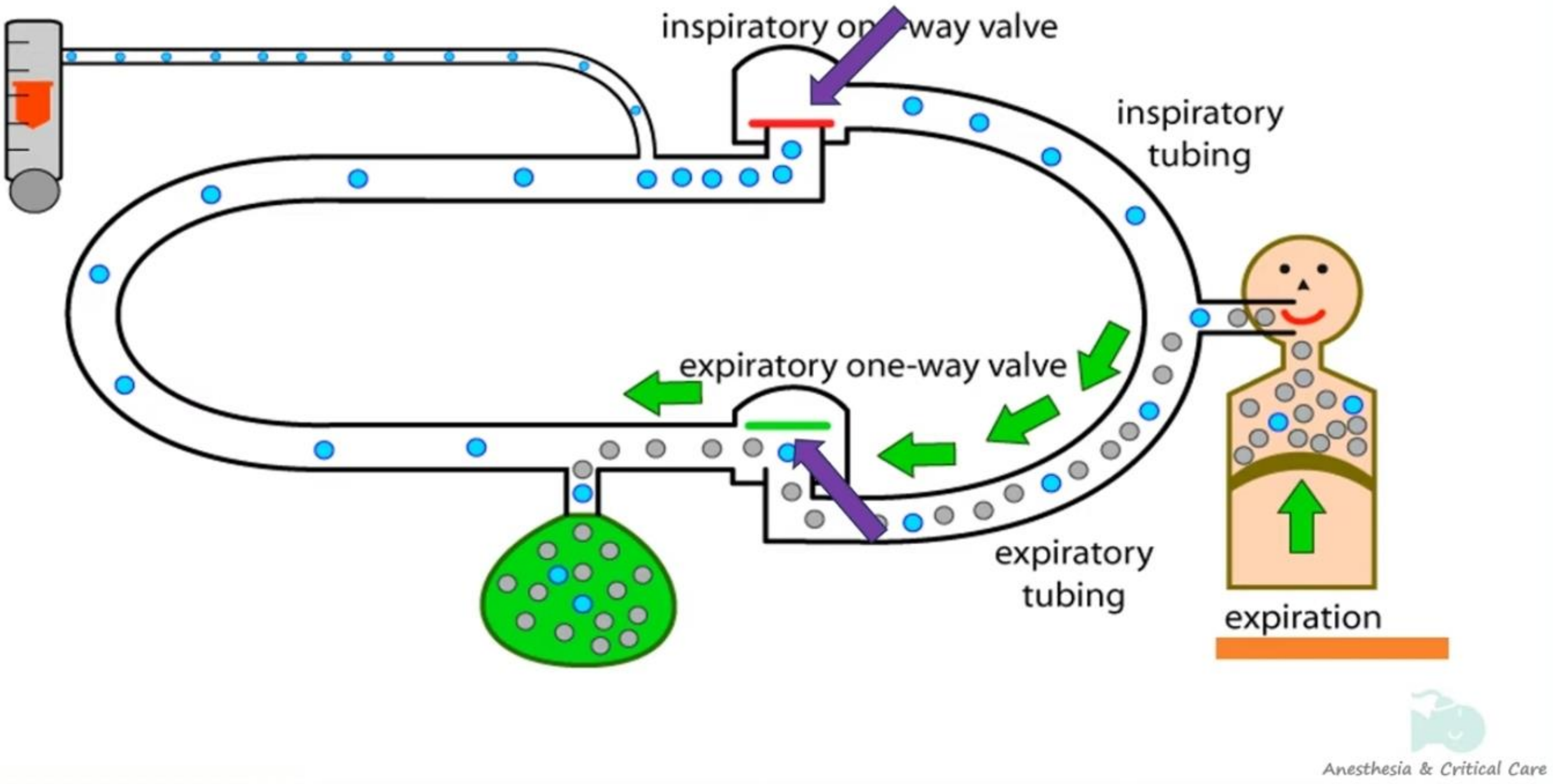
- **Summary Comparison**
- **Mapleson A:** Best for **spontaneous breathing**.
- **Mapleson B & C:** Inefficient, rarely used (require very high FGF).
- **Mapleson D:** Best for **controlled ventilation**.
- **Mapleson E:** Simple, pediatric use, but no bag or control.
- **Mapleson F:** Modified E with bag, excellent for pediatrics

Circle system

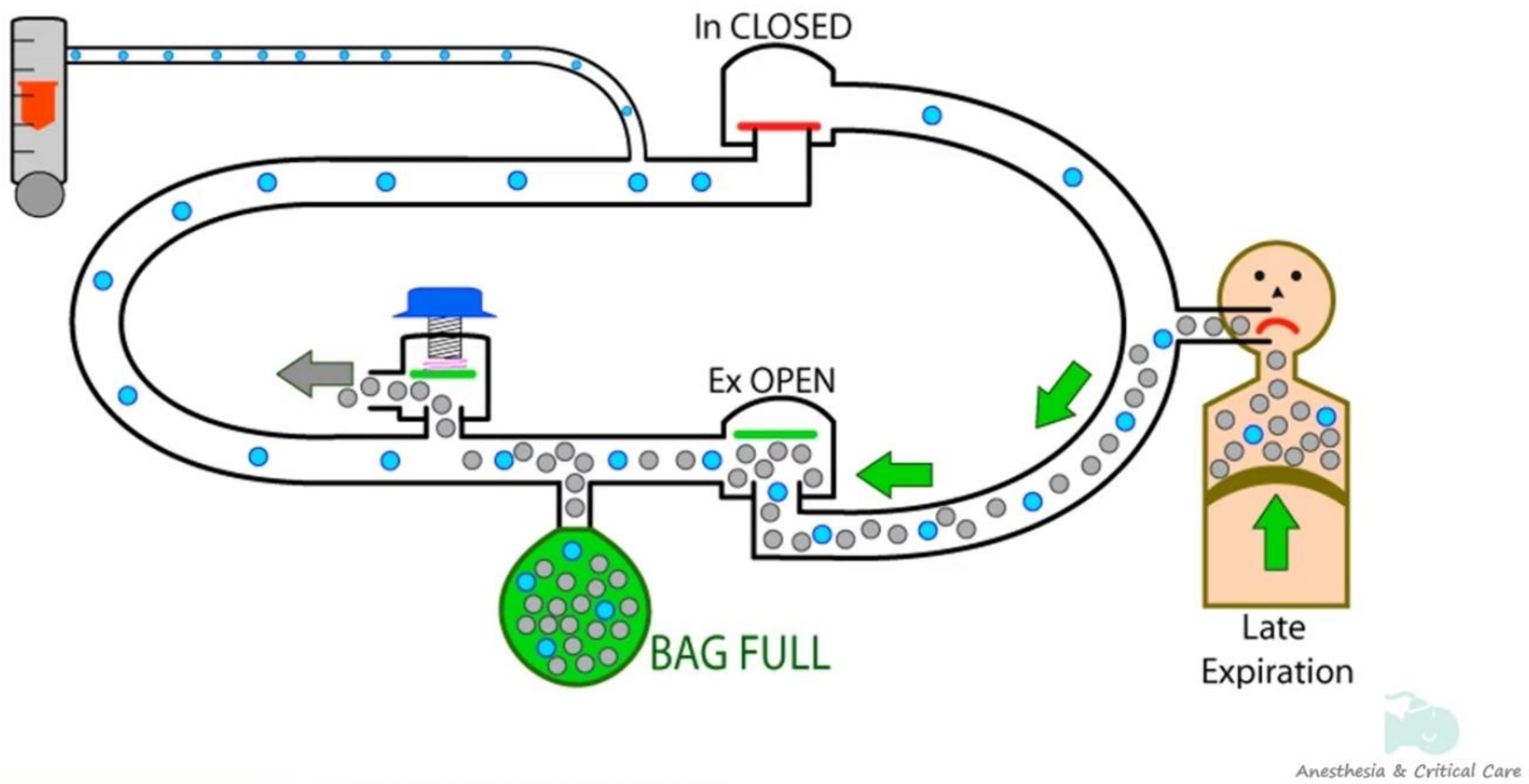
Components



Inspiratory and Expiratory Tube

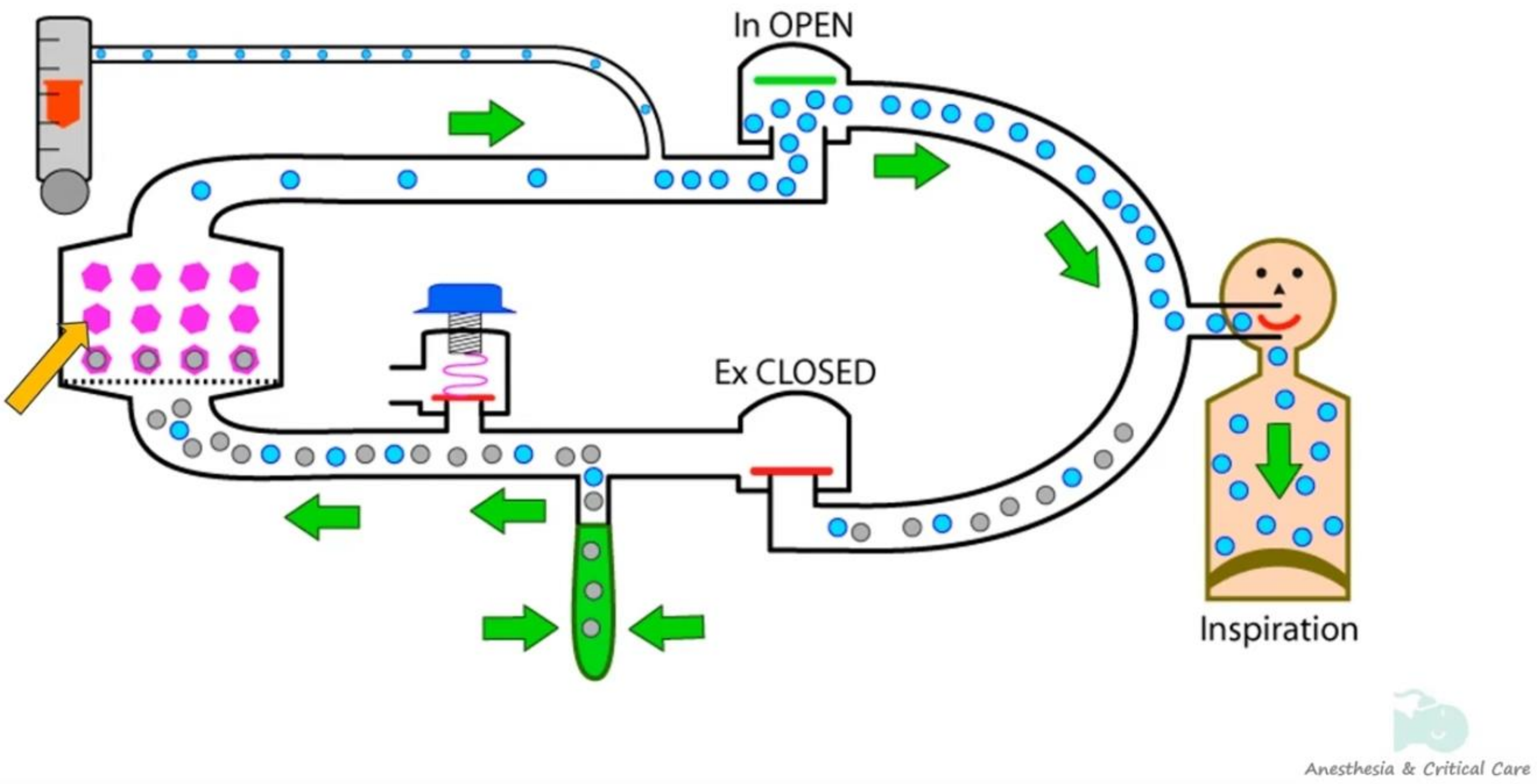


APL Valve

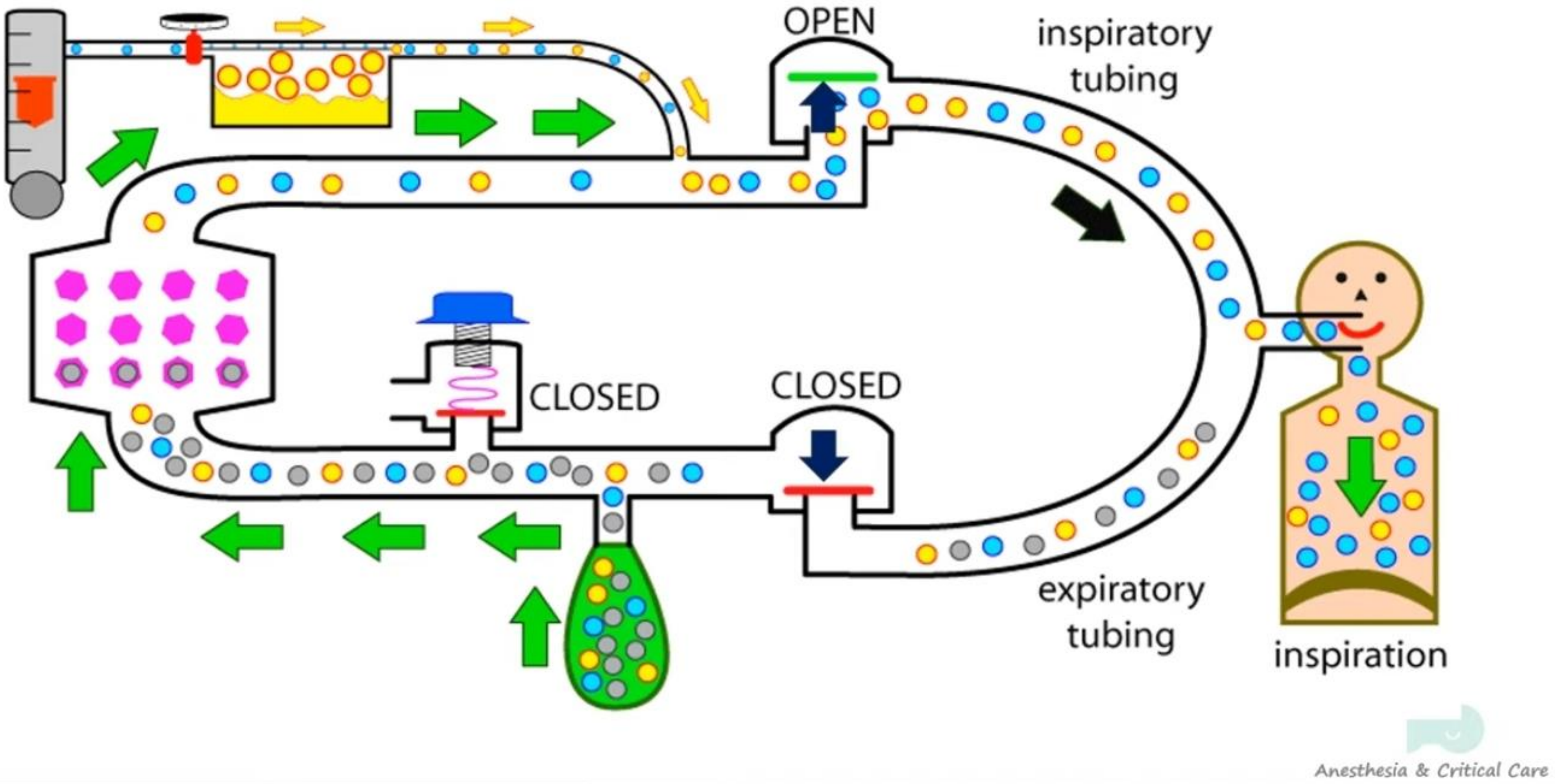


In CLOSED
Ex OPEN
BAG FULL
Late
Expiration
Anesthesia & Critical Care

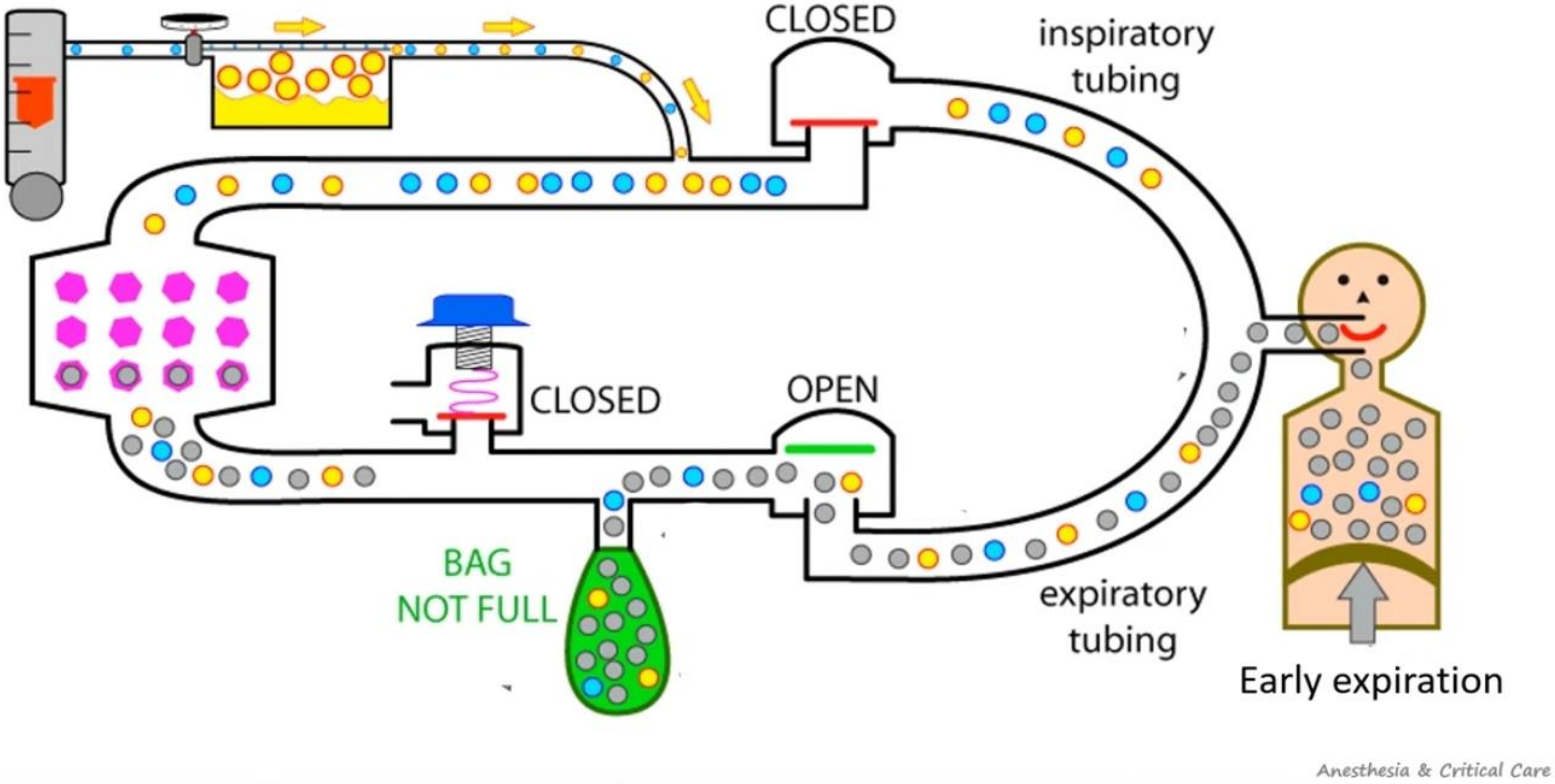
CO_2 Absorber



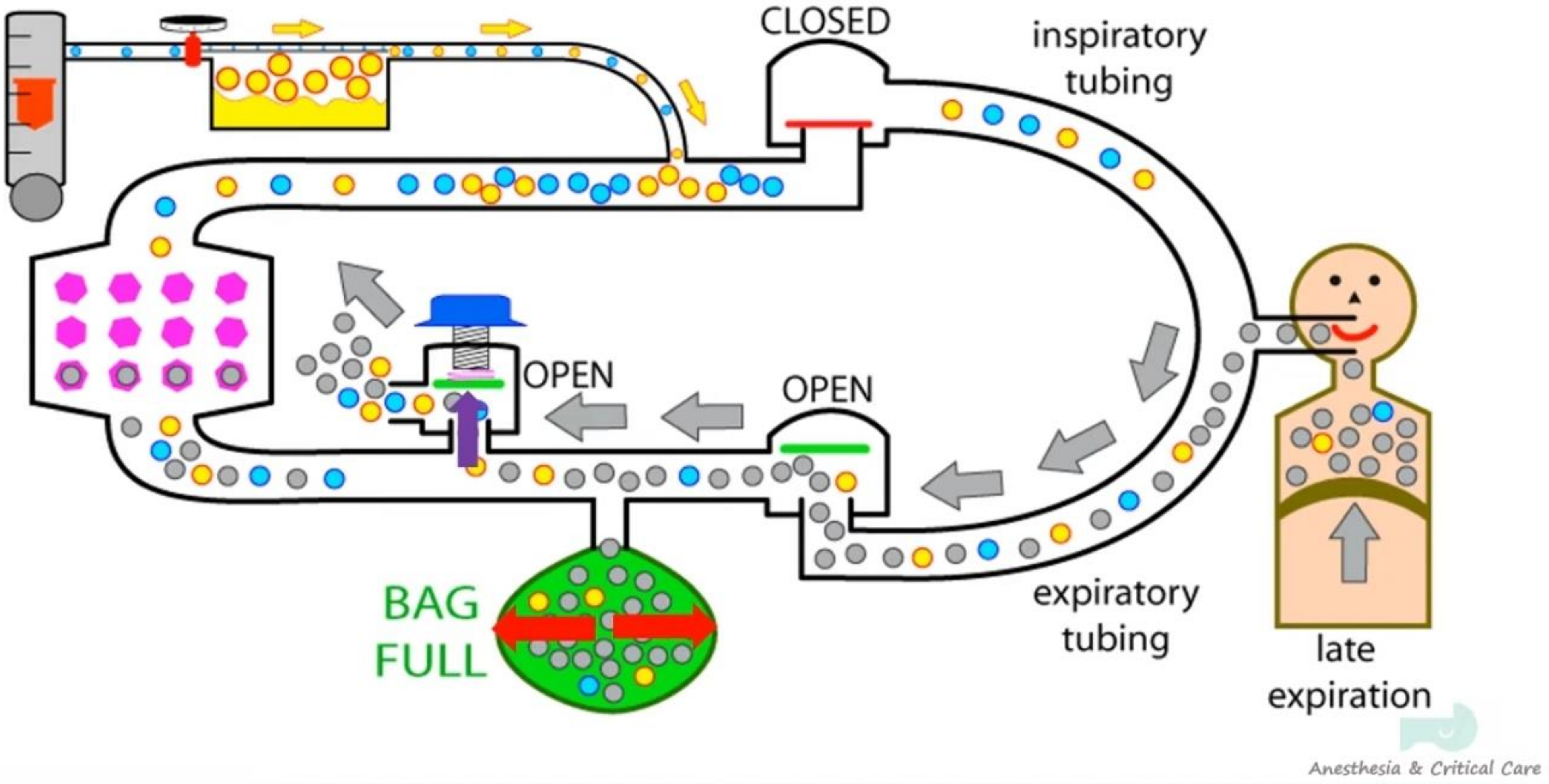
Spontaneous Ventilation



Spontaneous Ventilation



Spontaneous Ventilation



Fresh Gas Inlet (FGF):

Entry point for oxygen and anesthetic gases.

Inspiratory Unidirectional Valve:

Ensures gas flows **only toward the patient** during inspiration.

Inspiratory Limb (Tubing):

Transports gas from inspiratory valve to the patient.

Patient Connection (Mask or ETT):

Connects the circuit to the patient’s airway.

Expiratory Limb:

Carries exhaled gas away from the patient.

Expiratory Unidirectional Valve:

Ensures gas flows **only away from the patient** during expiration.

CO_2 Absorber (Soda Lime Canister):

Chemically removes CO_2 from exhaled gas, making it safe to rebreathe.

Reservoir Bag (Rebreathing Bag):

Stores gas, allows manual ventilation, and acts as a visual indicator of breathing

APL Valve (Adjustable Pressure Limiting / Pop-off Valve):

Releases excess gas to prevent high circuit pressure.

Scavenging System:

Collects waste anesthetic gases and prevents operating room pollution

Principle of Operation

Inspiration

Gas flows through the inspiratory valve → inspiratory limb → patient.

The inspired gas is a mixture of:

- Fresh gas from FGF, and
- Recycled gas that has passed through the CO_2 absorber.

Expiration

Exhaled gas flows through the expiratory valve → into the CO_2 absorber.

CO_2 is removed chemically.

The cleaned gas mixes with fresh gas and is stored in the reservoir bag.

Excess gas exits through the APL valve into the scavenging system

Advantages

Prevents CO_2 rebreathing

Conserves heat and humidity

Very economical (low FGF)

Works well in both spontaneous & controlled ventilation

Disadvantages

More complex than Mapelson circuits

Higher resistance → less suitable for neonates/infants

Malfunction of CO_2 absorber → dangerous CO_2 rebreathing

Mechanical ventilation

1. What?
2. When?
3. Modes?

What (definition)

Mechanical ventilation is a form of life support that helps you breathe (ventilate) when you can’t breathe on your own.

In a healthy human, the diaphragm is the primary ventilator

The mechanical ventilator tries to do its job

When (Indications)

1. Need for assisted ventilation

   Neuromuscular disease, surgery, drug overdose, respiratory depression, etc…

1. Airway protection

   Unconscious patients, protects from aspiration of blood, gastric content, or saliva

1. High oxygen demand

   Hypoxia due to pneumonia , ARDS, Pulm. edema+embolism, heart failure

1. Relief of obstruction

Modes

AC

PC

AC (Assist control/CMV)

- Patient triggers vent
- Inspiration creates negative pressure that is detected by the machine, the machine delivers a specific volume of gas
- Volume = 8ml/kg body weight (around 500-600 cc)
- Back-up mode:

If you set up 12 breaths per minute as the rate, the device will initiate the breath if the patient doesn't initiate any within 5 seconds

PC (Pressure control)

- Patient triggers vent too
- Instead of delivering specific tidal volume, you set pressure to ventilate patient with
- In low compliance lungs (Pulmonary fibrosis) you need higher pressure to deliver the same volume
- The machine monitors how much volume goes in with the set pressure, if compliance suddenly goes down, so will the volume
- You can set an alarm if volume goes below a certain amount

Humidification

In a normal human, the nasal cavity humidifies the air before it enters the lung to protect the lung and cilia from being dehydrated and damaged by dry air, as well as help prevent drying out lung secretions.

When air is delivered bypassing the nose (mouth, trachea) or if the amount exceeds 4L/min, you need to humidify the delivered air.

Types of humidifiers

Active

Adds moisture to the air by using energy, those can either heat up water to create steam or use ultrasonic humidifiers which create very fine mist without heating.

Passive

Doesn't use energy, could work by trapping exhaled moisture and heat from exhaled air and sending it back during inspiration (Heat and Moisture Exchangers (HMEs)/Condensers), or pass the air to a water reservoir where it passively picks up moisture (Wick Humidifiers and Passover humidifiers)