Al Mustaqbal University

College of Health and Medical Techniques

Department of Anesthesia

Practical Anesthesia

Stage Two

Lecture 4

Anesthetic Circuits

By Lectures

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BSc. Anesthesia & Intensive Care

2025-2026

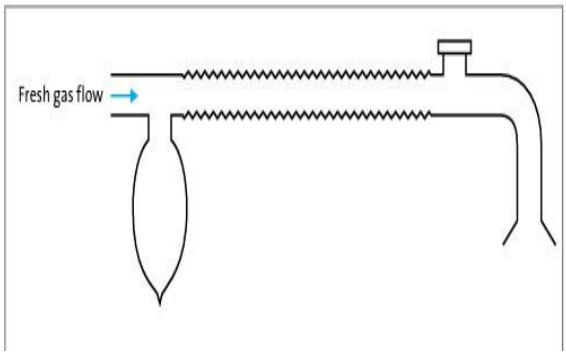
Anesthetic Circuits

A breathing system is a device that conducts gases such as oxygen and anaesthetic agents to the patient and conducts waste gases such as CO2 away.

Classically, breathing systems are classified as **open**, **semi-open(The Mapleson system)**, **semiclosed(THE CIRCLE SYSTEM)** **and** **closed**. Semi-closed systems are further divided into rebreathing systems with CO2 absorption, rebreathing systems without CO2 absorption and non-rebreathing systems.

The Mapleson system

→ Magill system (Mapleson A)



Fresh gas flow enters at the machine end, just proximal to the reservoir bag, which is connected by approximately 1.6 m of tubing to the APL valve at the patient end. The volume of this tubing must exceed one tidal volume to ensure efficient spontaneous ventilation.

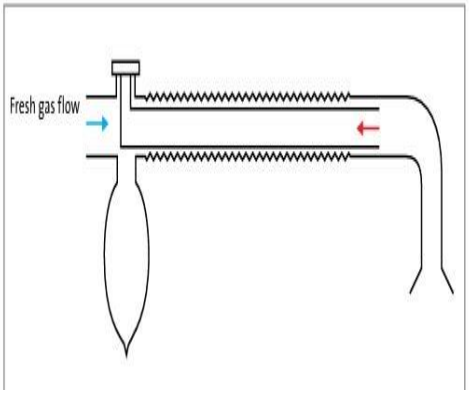
Advantages

- Efficient for spontaneous ventilation.

Disadvantages

- Inefficient for controlled ventilation.
- The APL valve at the patient end adds bulk and drags on breathing circuit connections, particularly if connected to scavenging.
- Not suitable for paediatrics

→ Lack system (Coaxial Mapleson A)



The Lack system is a modification of the Magill system, designed to eliminate the problem of having the APL valve at the patient end. It consists of a 30 mm outer tube for inspiration, and a 14 mm inner tube for expiration. This wider bore tubing is required in order to reduce resistance to expiration.

The Lack system has similar characteristics to the Magill system, being efficient for spontaneous ventilation and inefficient for controlled ventilation.

Advantages

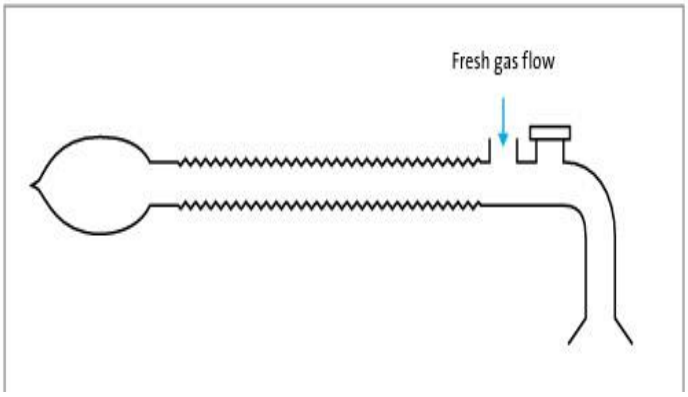
- Efficient for spontaneous ventilation.
- Bulky components are all at the machine end.

Disadvantages

- Inefficient for controlled ventilation.
- If the inner tube develops a leak, the entire system becomes dead space and CO2 rapidly builds up

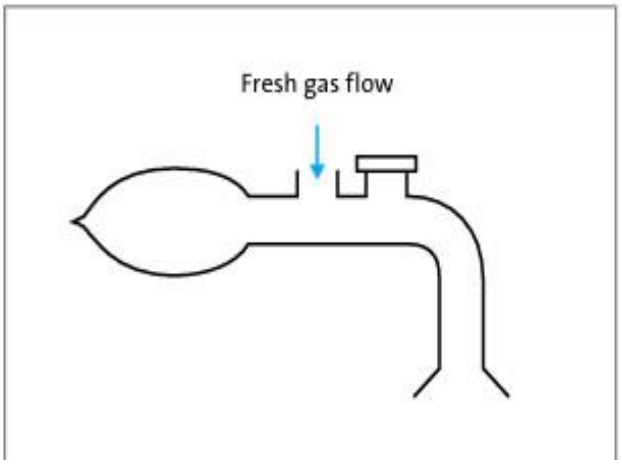
→ Mapleson B

This circuit is not in common usage. The FGF and APL valve are at the patient end of the tubing, which causes complete mixing of fresh and expired gas. It is therefore inefficient for both spontaneous and controlled ventilation.
Fresh gas flows of 2–3 times MV are required (this is slightly more efficient than Mapleson A for controlled ventilation, but significantly worse during spontaneous ventilation).



→ Mapleson C

This system is similar to a Mapleson B system, but without the reservoir tubing. The bag, FGF and APL valve are all at the patient end. It is inefficient for both spontaneous and controlled ventilation and requires FGFs of 2–3 times minute volume. It is used in resuscitation situations as an alternative to a selfinflating bag. In these situations, volatile anaesthetics are not used and therefore efficiency is less important than portability.



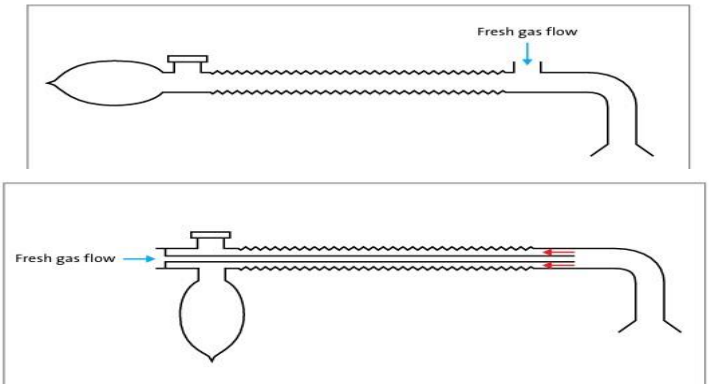
Advantages

- Simple and lightweight.
- Useful for resuscitation, allowing PEEP to be applied and giving a visual and tactile indication of ventilation.

Disadvantages

- Inefficient, CO2 accumulates over time.
- APL valve adds bulk at the patient end.

→ Bain system (Coaxial Mapleson D)



In a Mapleson D system, the FGF enters at the patient end, with the APL valve and bag being located at the machine end. Most Mapleson D systems in use are the coaxial Bain modification, in which fresh gas flows down a narrow (6 mm) inner tube and exhaled gas passes down the 22 mm outer tube. This is the reverse arrangement to the co-axial Mapleson

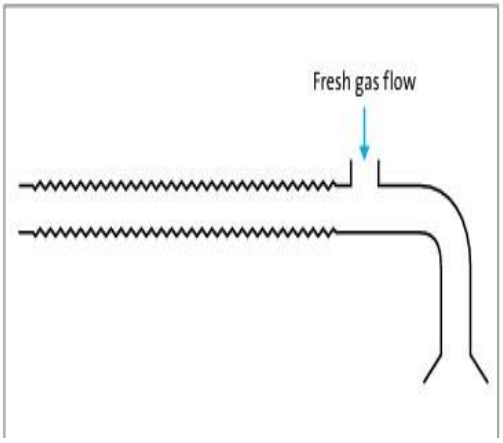
Advantages

- Compact system with all the major components at the machine end, facilitating scavenging.
- Low dead space because the APL valve is at the machine end.

Disadvantages

- Inefficient for spontaneous ventilation.
- If the inner tube becomes disconnected or breaks, the entire system becomes dead space.

→ Ayre's T-piece (Mapleson E)



A Mapleson E system consists of a T-shaped rigid tube, with connections for the FGF, the patient, and a variable length of reservoir tubing. It is a valveless, bagless breathing system. Whilst intermittent positive pressure ventilation (IPPV) is possible by intermittently occluding the expiratory limb, this affords little control and there is the risk of high pressures occurring. Mapleson E systems have been superseded in clinical use by the Mapleson F system

Advantages

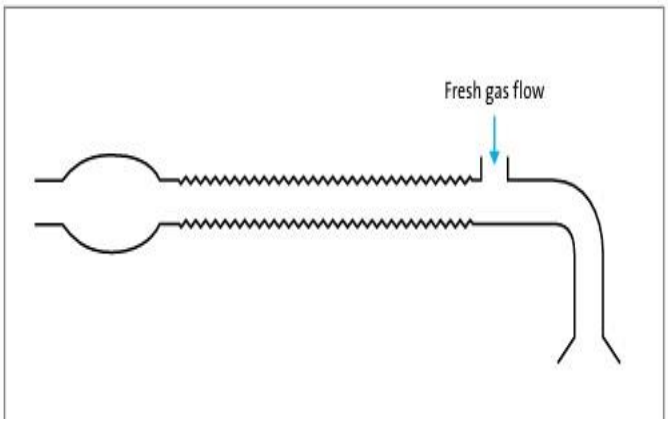
- There is minimal dead space.
- It is a valveless system. There is therefore minimal resistance to breathing, and the high pressures that would be encountered in the event of valve failure, are avoided.
- It is suitable for paediatric patients (up to 25 kg).

Disadvantages

- Application of PEEP is not possible. This is particularly important in anaesthetized paediatric patients who are dependent on positive airways pressure to maintain functional residual capacity (FRC).
- Positive pressure ventilation is difficult and potentially hazardous

→ Jackson–Rees modification (Mapleson F)

The Jackson–Rees modification of Ayre's T-piece incorporates an open-ended bag attached to the end of the reservoir tubing. Partially occluding the 'tail' of the bag permits positive pressure ventilation or the application of PEEP. The bag also gives a visual indication of ventilation. Gas dynamics during spontaneous or controlled ventilation are similar to Mapleson E systems. FGF of 2–3 times MV is required.

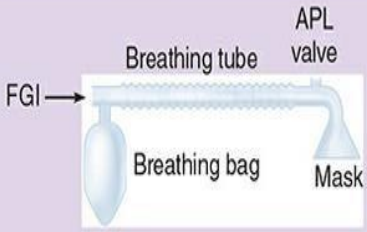
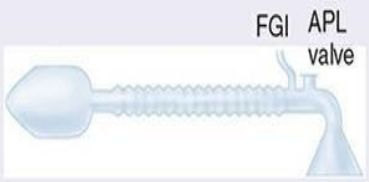
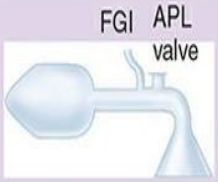
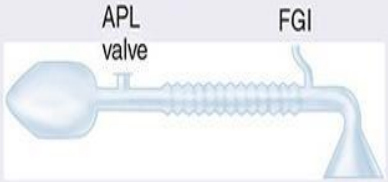
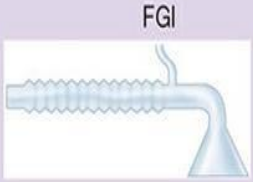


Advantages

- As for Mapleson E.
- Positive pressure ventilation and PEEP are possible.
- More suitable for inhalational induction than a circle system.
- This is the standard breathing system for paediatric patients (up to 25 kg) although a small calibre circle system may also be used.

Disadvantages

- Scavenging is difficult.
- The system is inefficient, requiring high FGFs.
- Partially occluding the tail, whilst at the same time squeezing the bag is a moderately skilled technique

Mapleson Class	Other Names	Configuration[1]	Required Fresh Gas Flows: Spontaneous	Required Fresh Gas Flows: Controlled	Comments
A	Magill attachment		Equal to minute ventilation (≈80 mL/kg/min)	Very high and difficult to predict	Poor choice during controlled ventilation. Enclosed Magill system is a modification that improves efficiency. Coaxial Mapleson A (Lack breathing system) provides waste gas scavenging.
B			2 × minute ventilation	2–2½ × minute ventilation	
C	Waters' to-and-fro		2 × minute ventilation	2–2½ × minute ventilation	
D	Bain circuit		2–3 × minute ventilation	1–2 × minute ventilation	Bain coaxial modification: fresh gas tube inside breathing tube (see Figure 3–7).
E	Ayre's T-piece		2–3 × minute ventilation	3 × minute ventilation (I:E-1:2)	Exhalation tubing should provide a larger volume than tidal volume to prevent rebreathing. Scavenging is difficult.
F	Jackson-Rees' modification		2–3 × minute ventilation	2 × minute ventilation	A Mapleson E with a breathing bag connected to the end of the breathing tube to allow controlled ventilation and scavenging.

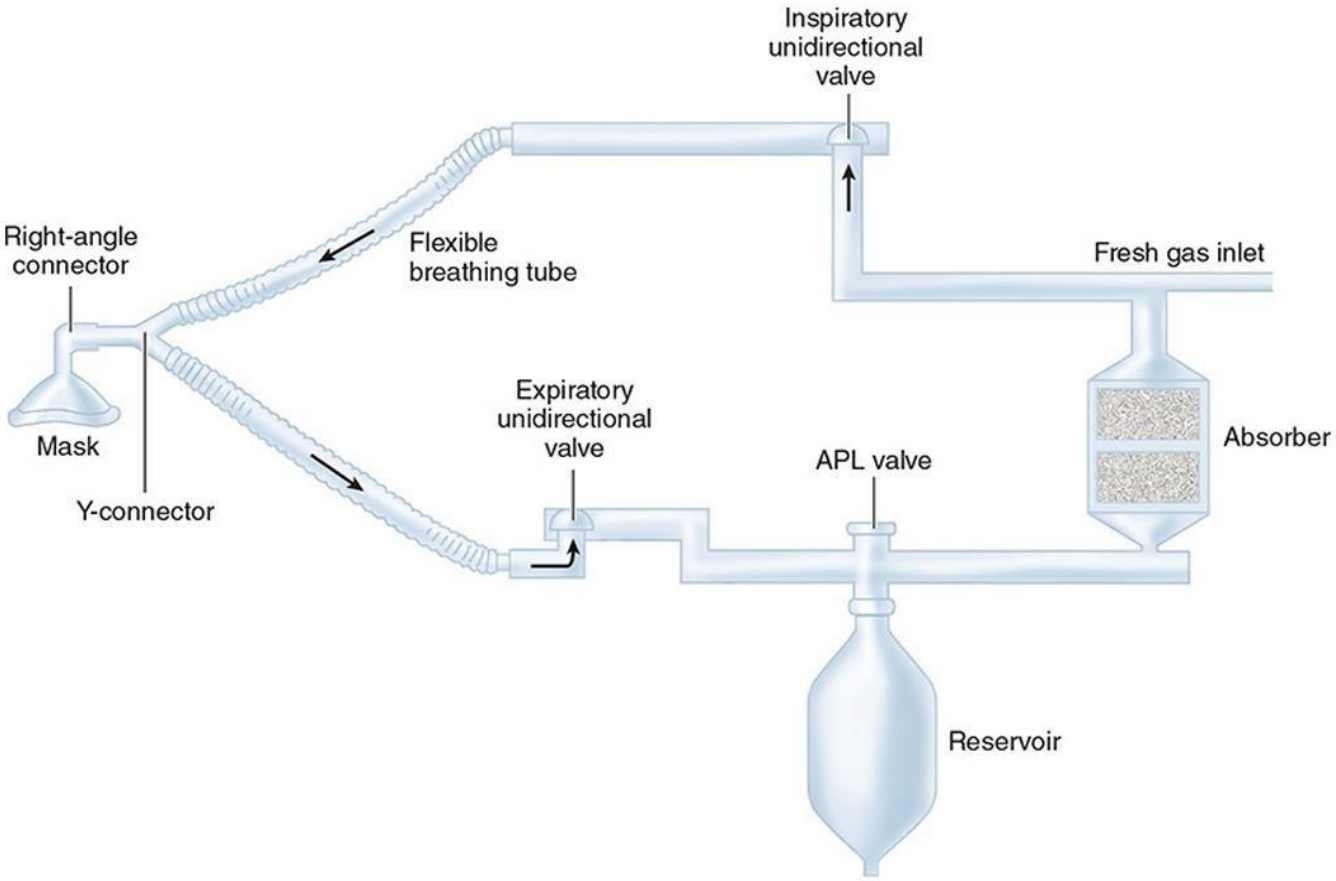
[1]APL, adjustable pressure-limiting (valve); FGI, fresh gas inlet.

The circle system

The circle system is a highly efficient breathing system that conserves anaesthetic gases, heat and moisture, therefore, it is particularly useful for long. By actively removing carbon dioxide from exhaled gas, the circle system allows re-breathing of anaesthetic gases. In theory, the fresh gas flow (FGF) that is added to the circle system need only match the oxygen consumption of the patient and any anaesthetic losses through leaks, absorption or metabolism

A circle system comprises:

- a fresh gas inlet
- a reservoir bag
- two one-way valves (one in each of the inspiratory and expiratory limbs)
- a Y-piece connector from the one-way valves to the patient
- an APL valve
- a soda lime canister that absorbs carbon dioxide
- lengths of corrugated (kink-resistant) tubing to connect the components to one other and the patient.



Nots…

- Volatile anaesthetic agents may be added to the gas mixture in two ways. A vaporizer May be included in the circuit itself, so that gas flows through it on its way round the circle(VIC). More commonly, the vaporizer is located outside the circuit (VOC) and fresh gas flows through it before entering the circle.
- Fresh gas flow and the reservoir bag are usually found in the inspiratory limb of the circuit **to reduce the resistance to inspiration**.
- The APL valve is ideally located in the expiratory limb of the circuit so that only CO2containing gas is expelled through it.
- The soda lime canister is situated after the APL valve and removes carbon dioxide through an exothermic reaction.

Advantages

- The circle system conserves anaesthetic gases, heat and moisture.
- Low flow anaesthesia is possible provided concentrations are monitored.
- There is a low dead space. The Y-piece tubing creates mechanical dead space, but this is no greater than in non-rebreathing circuits.
- The soda lime canister is distant from the patient's airway, reducing the risk of soda lime dust inhalation.
- Reduced atmospheric pollution because anaesthetic gases can be recycled.

Disadvantages

- The circle system apparatus is bulkier than Mapleson breathing systems.
- Complexity of connections mean that leaks and disconnections are more difficult to identify quickly.
- The extra valves, tubing and soda lime canister increase the resistance.
- Soda lime may degrade sevoflurane into harmful substances such as compound A. compound A can produce hepatic and renal toxicity. As it is only produced in very low concentrations in circle systems, its clinical significance is debated.