Non-rebreathing Circuits

The distinguishing feature of non-rebreathing circuits is that elimination of carbon dioxide is accomplished by removing all expired gases from the system and venting them to atmosphere. This is normally achieved by using the fresh gas flow from the anesthetic machine to direct the expired gases out of the circuit via a valve or other arrangement.

In general, non-rebreathing systems provide good control of the inspired gas concentrations, since fresh gas delivered from the anesthetic machine is inspired in each breath. They are, however, less economical in use than rebreathing systems because the minute volume of ventilation (or more) must be supplied to the patient to prevent rebreathing, and they contribute more to the problem of atmospheric pollution with anesthetic agents. They are also less forgiving of operator error since an inadequate fresh gas supply will result in rebreathing.

Mapleson's Classification of Non-rebreathing Circuits

Mapleson's classification divides non-rebreathing circuits into functionally similar groups, on the basis of the fresh gas flow required to prevent rebreathing and the ease with which intermittent positive pressure ventilation may be performed.

Magill Circuit

The original Mapleson A system.

Construction
A three-way T-tube is connected to the fresh gas outlet (F), a breathing bag (B) and a reservoir tube (R). The other end of the reservoir tube is connected to the patient (P) and a spring-loaded expiratory valve (V).

**Function**

**Inspiration** - The valve closes and the patient inspires fresh gas from the reservoir tube.

**Expiration** - The patient expires into the reservoir tube. Toward the end of expiration, the bag fills and positive pressure opens the valve, allowing expired gas to escape.

**Expiratory pause** - Fresh gas washes the expired gas out of the reservoir tube, filling it with fresh gas for the next inspiration.

**Lack Circuit**

A co-axial modification of the Mapleson A system, designed to facilitate scavenging of expired gas.

**Construction**

A four-way block is attached to the fresh gas outlet (F). This block is connected to an outer reservoir tube (R) attached to the patient (P), an inner exhaust tube (E), a breathing bag (B) and a spring-loaded expiratory valve (V).

Very similar in appearance to the modified Bain, except that the inner exhaust tube has a greater diameter than the fresh gas supply tube in the modified Bain.

**Function**
The Lack circuit is essentially similar in function to the Magill, except that the expiratory valve is located at the machine-end of the circuit, being connected to the patient adapter by the inner coaxial tube.

**Inspiration** - The valve closes and the patient inspires fresh gas from the outer reservoir tube.

**Expiration** - The patient expires into the reservoir tube. Toward the end of expiration, the bag fills and positive pressure opens the valve, allowing expired gas to escape via the inner exhaust tube.

**Expiratory pause** - Fresh gas washes the expired gas out of the reservoir tube, filling it with fresh gas for the next inspiration.

**Bain Circuit**

A co-axial modification of the basic T-piece system, developed to facilitate scavenging of waste anesthetic gases.

**Construction**

An tube carrying fresh gas (F) travels inside an outer reservoir tube (R) to the endotracheal tube connector (P).

**Function**

Essentially, the Bain circuit functions in the same way as the T-piece, except that the tube supplying fresh gas to the patient is located inside the reservoir tube.

**Inspiration** - The patient inspires fresh gas from the outer reservoir tube.

**Expiration** - The patient expires into the reservoir tube. Although fresh gas is still flowing into the system at this time, it is wasted as it is contaminated by expired gas.

**Expiratory pause** - Fresh gas from the inner tube washes the expired gas out of the reservoir tube, filling it with fresh gas for the next inspiration.

**Operational requirements**

- Generally similar considerations apply as for the T-piece.
• The Bain is more efficient at eliminating exhaled gas, since the fresh gas is directed down the endotracheal tube, which reduces dead-space.

**Modifications**
A bag may be added to the tail of the reservoir tube, as in the T-piece.

Alternatively, the circuit may be attached to a block assembly with a pop-off valve and mounted directly to the common gas outlet of the anesthesia machine. This arrangement facilitates scavenging and intermittent positive pressure ventilation.

**Advantages**
- Compact and inexpensive.
- Low dead-space.
- Low resistance to breathing.
- Facilitates scavenging of waste gases.

**Disadvantages**
- High fresh gas flow requirement in larger patients.
- High gas flow rates, e.g. if the oxygen flush valve is used, may cause lung barotrauma.
- As with other co-axial systems, if the inner tube becomes disconnected or breaks, the entire breathing tube becomes dead-space, leading to severe alveolar hypoventilation. This may be detected in systems fitted with a bag by closing the valve and activating the oxygen quick-flush. If the inner tube is intact, the venturi effect of the rapidly-moving stream of gas leaving the inner tube will suck gas out of the bag and the bag will empty. If the inner tube is damaged, the stream of gas will be directed into the bag and it will fill.
Alternatively, the so-called 'parallel Bain' system may be used. In this system, the inner and outer tubes are replaced by conventional circle-absorber-type tubing and Y-piece.

![Diagram of parallel Bain system](image)

**Uses**
In small patients under 10 kg body weight.

**Ayre's T-Piece**

The original Mapleson E system.

**Construction**

A three-way T-tube whose limbs are connected to (F) the fresh gas supply from the anesthesia machine, (R) a length of corrugated reservoir tube and (P) the patient connector.

**Function**

**Inspiration** - The patient inspires fresh gas from the reservoir tube.
**Expiration** - The patient expires into the reservoir tube. Although fresh gas is still flowing into the system at this time, it is wasted as it is contaminated by expired gas.
**Expiratory pause** - Fresh gas washes the expired gas out of the reservoir tube, filling it with fresh gas for the next inspiration.

**Operational requirements**

- The volume of the reservoir tube must be greater than the patient's tidal volume, otherwise the inspired gas will be contaminated by the surrounding air.
- Intermittent positive pressure ventilation may be performed by intermittently occluding the end of the reservoir tube.
Modifications
Jackson-Rees' modification of the Ayre's T-piece (sometimes known as the Mapleson F system) connects a two-ended bag to the expiratory limb of the circuit, gas escaping via the 'tail' of the bag. This allows respiratory movements to be more easily seen and permits intermittent positive ventilation if necessary. The bag is, however, not essential to the functioning of the circuit.

Intermittent positive pressure ventilation may be performed by occluding the tail of the bag between a finger and thumb and squeezing the bag. Alternatively, a 'bag-tail valve', which employs an adjustable resistance to gas flow, may be attached to the bag tail. This causes the bag to remain partially inflated and so facilitates one-handed performance of IPPV.

Another aid to IPPV is the Kuhn bag, which has the gas outlet on the side of the bag, rather than the tail. This allows the outlet to be occluded with the thumb during IPPV, but leads to difficulties in scavenging the waste gases.

A number of different designs of T-piece are available, which function in essentially the same way.

Modern T-pieces incorporate 15 mm fittings for the reservoir tube and endotracheal adapter.

Advantages of T-piece systems
- Compact
- Inexpensive
- No valves
- Low dead-space
- Low resistance to breathing
- Economical for controlled ventilation

Disadvantages
- Some T-pieces are rather heavy and difficult to keep connected to the endo-tracheal tube.
- The bag may get twisted and impede breathing.
• High gas flow requirement in larger patients.

**Uses**

• Small patients under 7 kg body weight.