Causes of Carbon Dioxide Retention in Anesthetic Breathing Systems
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Carbon dioxide (CO2) is produced by cellular metabolism and eliminated in the lungs. However, hypercarbia can occur with otherwise adequate ventilation if CO2 is not removed from the inspired gases.

CO2 ABSORPTION

CO2 is chemically neutralized by soda lime or baralyme in the anesthetic circle system. CO2 absorber function is dependent on canister design, moisture content, particle size of absorbent, and degree of channeling of gas within the canister. Hypercarbia can occur if the absorbent becomes exhausted or the gases are allowed to bypass the absorbent (see Ch. 103).

REBREATHING

Even when the valves on the anesthesia circle are functioning properly, there is some rebreathing. Dead space exists in the part of the circle between the Y-piece and the patient. This contributes slightly to hypercarbia by adding apparatus dead space to the patient's physiologic dead space. A normal apparatus will increase VD/VT from 33% to 46% in an intubated patient and to 64% in patients ventilated with a mask. This leads to varying amounts of rebreathing. Rebreathing gases from the anatomic dead space or from the alveoli result in warmer gases saturated with water vapor. However, alveolar gases consist of 5% to 6% CO2. Therefore, rebreathing alveolar gases from which CO2 has not been removed will cause hypercarbia.

The Mapleson breathing circuits (Fig. 104-1) are listed in order of increasing rebreathing during ventilation.
- Spontaneous ventilation: Mapleson A < D < C < B
- Controlled ventilation: Mapleson D < B < C < A

No rebreathing of exhaled gases will occur if the fresh gas inflow is adequate. Different Mapleson circuits have different fresh gas inflow requirements to prevent rebreathing (Table 104.1). A low fresh gas flow in systems without CO2 absorption will result in rebreathing and hypercarbia.

The Bain system is a modification of the Mapleson D system, which brings the fresh gas flow to the patient by a small tube fixed inside a larger expiratory tube. With the Bain system, hypercarbia will occur if the inner tube becomes kinked, if the inner tube has a leak, or is absent or if it is dislodged and does not extend to the patient port or if fresh gas flows are too low.
The Bain System is a coaxial version of a Mapleson D system in which the fresh gas inflow enters through a narrow tube within the corrugated expiratory limb.

Controlled Ventilation requires a fresh gas inflow rate equal to about 70 ml/kg to maintain normocarbia.

A similar fresh gas inflow rate during Spontaneous Ventilation may result in hypercarbia because the patient may not be able to sufficiently increase alveolar ventilation in the presence of anesthetic induced depression of ventilation. Therefore, fresh gas inflow rates of 100-300 ml/kg are recommended during spontaneous ventilation.

Advantages:

- warming of the fresh gas inflow by the surrounding exhaled gases in the expiratory limb
- improved humidification as a result of partial rebreathing
- ease of scavenging waste anesthetic gases from an overflow valve

Complications:

- hypercarbia
- increased resistance to breathing
- rebreathing of exhaled gases due to unrecognized disconnection of the inner tube
- absence of fresh gas inflow due to unrecognized kinking of the inner tube

Fig. 11-7. Schematic diagram of the Bain system showing fresh gas flow (FGF) into a narrow tube within the corrugated expiratory limb(A). The only valve in the system(B) is an adjustable pressure-limiting valve (overflow valve) located near the FGF inlet and reservoir bag(C).
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