Anesthesia device

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Anesthesiology machine is used to administer general inhalation anesthesia. It consists of a source of medical gases, a dosing device, a mixer, a vaporizer, a breathing system and additional devices.

Source of medical gases

The carrier anesthetic mixture of gases mainly consists of **oxygen** and **nitrogen oxide**, or **medical air**. Gases are delivered to sampling points by **central distributions** built into the walls, or they are kept in **pressure bottles** right next to the anesthesia machine. [1]

Pressure cylinders

Pressure cylinders are distinguished by color (O_2 – white stripe, N_2O – blue stripe), a written label and the geometry of the sampling valve to avoid gas confusion.

Gases in bottles have a high pressure (oxygen is stored in the gas phase under a pressure of 15 MPa, nitrous oxide especially in the liquid phase under a pressure of 5 MPa). In order for the gas to be introduced into the breathing system, the filling pressure is reduced to the working pressure (0.3-0.4 MPa) by a **reduction valve**.

Central distributions

Medical facilities are usually equipped with a central distribution of medical gases, which are led from the central reservoirs to the sampling points already at a reduced pressure. , N_2O - blue, air - white with black, vacuum (suction) - yellow, CO_2 - gray[1]) and shape - mechanical code to prevent user confusion. Medicinal air is supplied to the distribution system by powerful compressors so that it is free of dirt, oil impurities and moisture.

Note: Color coding of gases and mechanical code is not the same in all countries.

Dispensing device[2]

Medicinal gases are led into a *dosing device*, which allows the total quantity of the carrier mixture to be precisely defined, as well as the proportional representation of the individual gases. Dosing is most often done using **rotameters**. They are flowmeters consisting of a conical glass tube, expanding upwards. Inside is a rotating float carried by the gas stream to a height proportional to the flow rate. The position of the float indicates the gas flow, which is read on the scale (in liters per minute). However, there are other technical solutions, especially electronic ones.

Volatile Anesthetic Blender and Vaporizer

Rotameters and volatile anesthetic vaporizers.

The dosed carrier breathing mixture is led to a **mixer** - a device where it is perfectly mixed, either by simple turbulent flow or by a special mixing device.

The resulting homogeneous carrier mixture is fed to the "evaporator", where it is enriched with vapors of volatile (volatile, volatile) anesthetics. These substances are liquid at room temperature and atmospheric pressure, so they must be converted to gas in the vaporizer. Individual current volatile anesthetics have different properties and a small margin of safety (the difference between therapeutic and toxic concentration), therefore for each anesthetic there is usually a "specially designed vaporizer" allowing precise dosing.[1] In order for the anesthetic concentration to actually be set at the outlet of the vaporizer, the vaporizer must meet the basic safety criteria:

- independence from fresh gas flow,
- independence from ambient temperature,
- independence from atmospheric pressure,
- independence from temperature changes arising as a result of evaporation,
- independence from pressure fluctuations during artificial ventilation of the patient.[1]

Respiratory system

The finished mixture of carrier gases and anesthetics is led into the *breathing system* connecting the anesthesia machine and the patient's airways. Its arrangement can be different depending on the anesthesia system used.

Components of the respiratory system

- Breathing gases are usually passed through **wrapped tubing** which is attached to a standardized coupling to a mask or endotracheal tube.
- The direction of gas flow is determined by **one-way breathing valves**.[1]
- The system usually includes a *storage bag* - a reservoir for collecting the breathing mixture.
- According to the degree of rebreathing (i.e. re-inhalation of part of the gases whose composition has already been changed by previous breathing), which is determined by the layout of the respiratory system, the amount of minute ventilation and the input of fresh gases, a *carbon dioxide absorber* must be connected to the system . It is a cylindrical container filled with an absorbent mixture - "soda lime" (a mixture of moist "calcium hydroxide" and "sodium hydroxide") in granulated form to increase the absorbent surface. The passing carbon dioxide dissolves in the water to form carbonic acid, which reacts with the mixture. The resulting product is reaction heat and water. Absorber exhaustion is indicated by a colored indicator.[1]
- **Relief valve** removes excess breathing mixture from the system.
- The **PEEP valve** allows you to maintain a permanent excess pressure in the respiratory system.
- The **Humidifier** is included especially for longer procedures, before entering the patient's airways. It is used to moisten and possibly heat the respiratory mixture before entering the airways, thereby preventing fluid loss, heat and attenuation of the ciliated epithelium.[1]

Division of anesthesia systems

From a technical point of view anesthesia systems are divided into:


Schimmelbusch mask

- **open** - the carrier mixture for the inhalation anesthetic is the surrounding air and the patient's airways are permanently in contact with the atmosphere of the environment (example from history: Schimmelbusch mask for ether administration);
- **semi-open** - the inhalation anesthetic is transported by a mixture of anesthetic gases through a *one-way system*, while the fresh gases are strictly separated from the exhaled ones through a valve;
- **semi-closed** - the breathing system can be *one-way* or arranged in an *anesthesia circuit*, there is partial rebreathing of exhaled gases, so a CO_2 absorber must be included ;
- **closed** - the respiratory system is organized into an *anesthesia circuit*, the mixture of gases is (after absorption of CO_2 in its entirety re-inhaled), the supply of fresh gases corresponds to the patient's metabolic consumption, rarely used.[1]

According to rebreathing, anesthesia systems are divided into systems

- **no rebreathing**,
- **with partial rebreathing** - the intake of fresh gases is higher than their consumption,
- **with full rebreathing** - the fresh gas intake corresponds to the consumption by the patient.[1]

According to the direction of gas flow, anesthesia systems can further be divided into:

- **one-way systems** - fresh gases are supplied through one hose and the patient's exhaled air is removed through the other,
- **anesthesiological (breathing) circuits**.

Anesthesiology circuit[1]

Anesthesiological circuit is a system of arranged hoses in a ring, in which a CO_2 absorber is connected and the direction of gas flow is determined by valves. A distinction is made between the inspiratory and expiratory part. Such an arrangement **allows partial or complete re-inhalation of exhaled air**, thereby reducing the consumption of anesthetics and the loss of water vapor and heat.

Anesthesiological circuit can be administered **anesthesia with a low input of fresh gases** (semi-closed system with a high degree of rebreathing):

- *low-flow* anesthesia – fresh gas consumption of 1 l/min, still significantly exceeds consumption by the patient;
- *minimal-flow* anesthesia – fresh gas consumption 0.5 l/min, close to the actual consumption by the patient.

The transition of the anesthesia line with a low gas input can only take place after a sufficient depth of general anesthesia has been achieved.

Additional devices of the anesthesia machine

The dosing device allows increasing the gas flow only up to a certain limit. Therefore, in emergency situations, a "by-pass valve" can be used, which can deliver oxygen in a large flow rate (up to 40 l/min) directly into the respiratory system.

A **Ventilator** is a device providing artificial pulmonary ventilation. It is used when the patient's spontaneous respiratory activity is eliminated. Thanks to this device, the anesthesiologist does not have to manually compress the storage bag. Modern anesthesia devices offer a wide selection of ventilation modes.

Links

External links

- Virtual Anesthesia Machine (VAM) (http://vam.anest.ufl.edu/wip.html) — free anesthesia machine simulator

References

1. LARSEN, Reinhard. *Anesthesia.* 7. (2. Czech) edition. Grada, 2004. 1376 pp. pp. 420–446. ISBN 80-247-0476-5.
2. Wikipedia. *Flowmeter* [online]. ©2010. [cit. 2010-06-20]. <https://cs.wikipedia.org/wiki/Flow meter>.