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Title: Inhalational Anesthesia

TABLE 8–6 Clinical pharmacology of inhalational anesthetics.

	Nitrous Oxide	Halothane	Isoflurane	Desflurane	Sevoflurane
Cardiovascular					
Blood pressure	N/C[1]	↓↓	↓↓	↓↓	↓
Heart rate	N/C	↓	↑	N/C or ↑	N/C
Systemic vascular resistance	N/C	N/C	↓↓	↓↓	↓
Cardiac output[2]	N/C	↓	N/C	N/C or ↓	↓
Respiratory					
Tidal volume	↓	↓↓	↓↓	↓	↓
Respiratory rate	↑	↑↑	↑	↑	↑
$Paco_2$					
Resting	N/C	↑	↑	↑↑	↑
Challenge	↑	↑	↑	↑↑	↑
Cerebral					
Blood flow	↑	↑↑	↑	↑	↑
Intracranial pressure	↑	↑↑	↑	↑	↑
Cerebral metabolic rate	↑	↓	↓↓	↓↓	↓↓
Seizures	↓	↓	↓	↓	↓
Neuromuscular					
Nondepolarizing blockade[3]	↑	↑↑	↑↑↑	↑↑↑	↑↑
Renal					
Renal blood flow	↓↓	↓↓	↓↓	↓	↓
Glomerular filtration rate	↓↓	↓↓	↓↓	↓	↓
Urinary output	↓↓	↓↓	↓↓	↓	↓
Hepatic					
Blood flow	↓	↓↓	↓	↓	↓
Metabolism[4]	0.004%	15% to 20%	0.2%	<0.1%	5%

N/C, no change.

Inhalational Anesthesia

Definition: An inhalational anesthetic is a chemical compound possessing general anesthetic properties that can be delivered via inhalation. They are administered through a face mask, laryngeal mask airway or tracheal tube connected to an anesthetic vaporizer and

an anesthetic delivery system.

The main use of inhalational was to maintain anesthesia, some of them can be used as induction

The dose of inhalational anesthetic was mentioned as MAC

MAC: The minimum alveolar concentration (MAC) of an inhaled anesthetic is the alveolar concentration that prevents movement in 50% of patients in response to a standardized stimulus (eg, surgical incision). e.g : Halothane MAC 0.75%

Factors Increasing MAC (need more volatile to maintain anesthesia)

- Hyperthermia
- Hypernatraemia
- Sympatho-adrenal stimulation
- Chronic alcohol abuse
- Chronic opioid abuse
- Increases in ambient pressure
- Hypercapnia
- Decreasing age
- Thyrotoxicosis

Factors decreasing MAC (need less volatile to maintain anesthesia)

- Nitrous oxide
- Hypothyroid/myxedema

- Hypocapnia
- Hypothermia-decrease is roughly linear
- Hyponatraemia
- Increasing age
- Hypoxaemia
- Hypotension
- Anemia
- Pregnancy
- CNS depressant drugs
- Other drugs: lithium, lidocaine, magnesium, Acute alcohol abuse

- **HINT: Sex, Weight and Duration of anesthesia does not affect MAC**

- **Nitrous oxide MAC105% , Halothane (Fluothane) 0.75% ,Isoflurane 1.2%, Desflurane 6.0% ,Sevoflurane 2.0 %**

Characteristic of IDEAL inhalational:

- Non-flammable, non-explosive at room temperature
- Stable in light.
- Liquid and vaporizable at room temperature
- Stable at room temperature, with a long shelf life
- Stable with soda lime, as well as plastics and metals
- Environmentally friendly - no ozone depletion
- Cheap and easy to manufacture
- Non toxic
- Rapid induction and rapid recovery
- Safe with no toxic side effect

There was no ideal inhalation till now

Pharmacokinetic of inhalational anesthetics

The forward movement of inhalational agent is determined by a series of partial pressure gradients, beginning at the vaporizer of the anesthetic

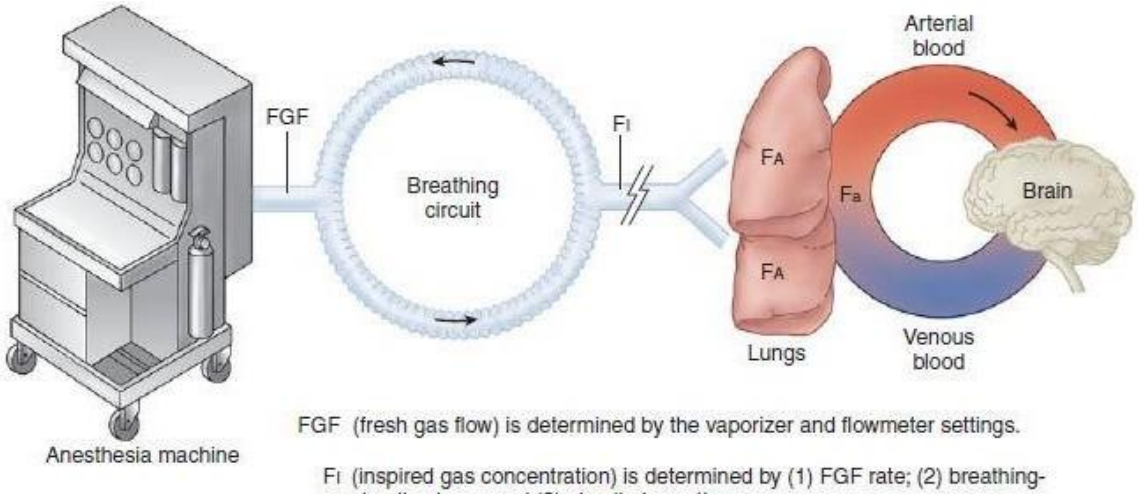
machine, continuing in the breathing circuit, the alveolar tree, blood, and then tissue.

The principal objective of that movement is to achieve equal partial pressures on both sides of each single barrier.

The alveolar partial pressure governs the partial pressure of the anesthetic in all body tissues; they all will ultimately equal the alveolar partial pressure of the gas. After a short period of equilibration, the alveolar partialpressure of the gas equals the brain partial pressure.

So, there was an **uptake, ventilation and concentration** that effect the induction rate and awaking time

Partial pressure is the ratio of the amount of substance in one phase to the amount in another phase



FGF (fresh gas flow) is determined by the vaporizer and flowmeter settings.

FI (inspired gas concentration) is determined by (1) FGF rate; (2) breathing-circuit volume; and (3) circuit absorption.

FA (aveolar gas concentration) is determined by (1) uptake (uptake = λb/g x C(A-V) x Q); (2) ventilation; and (3) the concentration effect and second gas effect:
a) concentrating effect
b) augmented inflow effect

Fa (arterial gas concentration) is affected by ventilation/perfusion mismatching.

Recovery from anesthesia depends on lowering the concentration of anesthetic in brain tissue. Anesthetics can be eliminated by biotransformation, transcutaneous loss, or exhalation.

Biotransformation usually accounts for a minimal increase in the rate of decline of alveolar partial pressure.

Diffusion of anesthetic through the skin is insignificant. So The most important route for elimination of inhalation anesthetics is the alveolus.

Mechanism of Action

The exact mechanism of action for inhaled anesthetics remains mostly unknown. they work within the central nervous system by **augmenting** signals to (GABA receptors) while **depressing** neurotransmission pathways of acetylcholine to muscarinic and nicotinic receptors

Nitrous oxide (N2O): Inhalational anesthetic agent, being a useful analgesic for dental extraction

Properties:

- Colorless
- Slightly sweet-smelling gas
- MAC 105%.
- Non-flammable but supports combustion
- Breaking down to O2 and nitrogen at high temperatures.
- Supplied as a **liquid/gas** in French blue cylinders
- Ice often forms on the cylinder during use

CNS effect:

- Fast onset and recovery; strongly analgesic but weakly anaesthetic.

Increases cerebral metabolism, cerebral blood flow and ICP slightly.

Respiratory System:

- Non-irritant. Depresses respiration slightly.
- May cause diffusion hypoxia at the end of surgery.

Cardiovascular system:

- Little effect on heart rate and BP usually

Other:

- Post operative nausea and vomiting
- Does not affect hepatic or renal function, nor uterine or skeletal muscle tone.
- Prolonged use may cause bone marrow depression, megaloblastic anaemia and peripheral neuropathy.
- Generally considered as being safe during pregnancy

Halothane: Halothane is a halogenated alkane, it was nonflammable and no explosive. Sensitive to light so thymol preservative and amber-colored bottles retard spontaneous oxidative decomposition. Its use rapidly spread because of its greater potency, ease of use, non-irritability and non

inflammability, Risks of arrhythmias and liver damage on repeated administration (halothane hepatitis)

Properties:

- Colorless liquid
- Pleasant smell
- MAC 0.75%.
- Non-flammable.
- Supplied in liquid form with thymol 0.01%
- Decomposes slightly in light.

Central nervous system Effects:

- Smooth rapid induction, with rapid recovery.
- Anticonvulsant action.
- Increases cerebral blood flow but reduces intraocular pressure.

Respiratory system:

- Non-irritant. Pharyngeal, laryngeal and cough reflexes are abolished early
- Respiratory depressant, with increased respiratory rate and reduced tidal volume.
- Bronchodilatation and inhibition of secretions.

Cardiovascular system:

- Myocardial depression and bradycardia.
- Hypotension is common.
- Myocardial O2 demand decreases.
- Arrhythmias are common, e.g. Bradycardia ,ectopic
- Sensitizes the myocardium to catecholamines, e.g. Endogenous or injected adrenaline.

Other:

- Dose-dependent uterine relaxation.
- Nausea/vomiting is uncommon.
- May precipitate Malignant Hyperthermia.
- Up to 20% is metabolized in the liver.
- Repeat administration after recent use may result in hepatitis.

Isoflurane:

Properties:

- Colorless liquid
- Pungent odor
- MAC 1.20
- Non-flammable, non-corrosive.
- With no additive.

Central nervous system Effects:

- Smooth, rapid induction, but speed of uptake is limited by respiratory irritation.
- Recovery is slower than with sevoflurane and desflurane.
- Anticonvulsant properties
- Reduces Cerebral Metabolic Rate of O2.
- Increases cerebral blood flow and ICP.
- Decreases intraocular pressure.
- Has poor analgesic properties.

Respiratory System:

- Irritant; more likely to cause coughing and laryngospasm
- Respiratory depressant, with increased rate and decreased tidal volume.
- Causes bronchodilatation.

Cardiovascular system:

- Myocardial depression is less than with halothane
- Vasodilatation and hypotension commonly occur
- Compensatory tachycardia is common
- Myocardial O2 demand decreases, but tachycardia may reduce myocardial O2 supply.
- Coronary steel may occur

Other:

- Dose-dependent uterine relaxation.
- Nausea/vomiting is uncommon.
- Skeletal muscle relaxation
- May precipitate MH.
- Widely used in neurosurgery

Sevoflurane

Properties:

- Colorless liquid
- Pleasant smelling
- MAC 2.
- Non-flammable, non-corrosive.
- Supplied in liquid form with no additive.
- Interacts with soda lime to produce compounds A

Central nervous system Effects:

- Smooth, extremely rapid induction and recovery.
- Early postoperative analgesia may be required as emergence
- Is so rapid.
- Increases the risk of emergence agitation
- Anticonvulsant properties.
- Reduces cerebral metabolic rate of O2
- Decreases intraocular pressure.
- Has poor analgesic properties.

Respiratory System:

- Well-tolerated
- Minimal airway irritation.
- Respiratory depressant, with increased rate and decreased tidal volume.
- Causes bronchodilatation.

Cardiovascular system:

- Vasodilatation and hypotension may occur
- Myocardial O2 demand decreases.
- Arrhythmias uncommon

Other:

- Dose-dependent uterine relaxation.
- Nausea/vomiting occurs.
- Skeletal muscle relaxation
- May precipitate MH.
- Tracheal intubation may be performed easily with spontaneous Respiration.
- Considered the agent of choice for inhalational induction in pediatrics because of its rapid and smooth induction characteristics.
- Has also been used for the difficult airway, including airway obstruction.

Desflurane

Introduced in the UK in 1994, a colorless liquid with slightly **pungent vapor**, boiling point: 23°C, MAC: 5%–7% in adults; 7.2%–10.7% in children, non-flammable, non-corrosive, supplied in liquid form with no additive, may react with dry soda lime to produce carbon monoxide, **requires the use of an electrically powered vaporizer** due to its low boiling point.

Effects:

On central nervous system:

1) Rapid induction (although limited by its irritant properties) and recovery.

2) May increase cerebral blood flow, although the response of cerebral vessels to CO2 is preserved.

3) ICP may increase due to imbalance between the production and absorption of CSF.

4) Reduces CMRO2 as for isoflurane.

5) Has poor analgesic properties.

On respiratory system:

1) Causes airway irritation; not recommended for induction of anesthesia because respiratory complications (e.g. laryngospasm,breath-holding, cough, apnea) are common and may be severe.

2) Respiratory depressant, with increased rate and decreased tidalvolume.

On cardiovascular system:

1) Vasodilatation and hypotension may occur, similar to isoflurane, may cause tachycardia and hypertension via sympathetic stimulation,especially if high concentrations are introduced rapidly.

2) Myocardial ischemia may occur if sympathetic stimulation is excessive, but has cardioprotective effects in patients undergoingcardiac surgery.

3) Arrhythmia as uncommon, as for isoflurane, little myocardialsensitization to catecholamines.

4) Renal and hepatic blood flow generally preserved.

Others:

1) Dose-dependent uterine relaxation (although less than isoflurane andsevoflurane).

2) Skeletal muscle relaxation; non-depolarising neuromuscular blockademay be potentiated.

MCQ TEST

1- Factors increase MAC(all true except one)

a) Hyporthermia
b) Hypernatraemia
c) Chronic alcohol abuse
d) Chronic opioid abuse
e) Hypercapnia

2- Not affect MAC

a) Hyponatraemia
b) Increasing age
c) Hypoxaemia
d) Hypotension
e) Sex

3- Pungent odor

a) Isoflurane
b) oxygen
c) Halothane
d) Sevoflurane
e) Nitrous oxide

4- Which one is true regarding MAC

a) Halothane=1.2
b) Isoflurane=0.75
c) Sevoflurane=2
d) Desflurane=5
e) Nitrous oxide=105

5- requires the use of an electrically powered vaporizer due to its low boiling point.

a) Desflurane
b) Isoflurane
c) Xenon
d) Halothane
e) Sevoflurane

6- Characteristic of IDEAL inhalational agents

a) flammable at room temperature
b) un stable in light.
c) Un Stable at room temperature
d) short shelf life
e) Rapid induction and rapid recovery

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GOOD LUCK

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