Inhalation Anesthetics

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Definition of general anesthesia

- General anesthesia ; is altered physiological state characterized by reversible loss of consciousness , analgesia of the entire body , amnesia , and some degree of muscle relaxation .

Diethyl Ether

- 1st inhaled anesthetic
- No longer used as an anesthetic agent
- Others anesthetic agent like chloroform
- later , another agents like cyclopropane ethylene .
- The main problem of these agents : toxicity and flammability .

Pharmacokinetics & Pharmacodynamics

- Pharmacokinetics : (how a body affects a drug) the relationship between a drug's dose, tissue concentration , and elapsed time

- Pharmacodynamics : (how a drug affects a body) the study of drug action including toxic responses .

Factors affecting inspiratory concentration (Fi)

1. The fresh gas flow rate
2. The volume of the breathing system
3. Any absorption by the machine or breathing circuit

Factors affecting alveolar concentration (fA)

- UPTAKE :

1. solubility in the blood
2. Alveolar blood flow (CO)
3. The difference in partial pressure between alveolar gas and venous blood .

- CONCENTRATION
- VENTILATION

FACTORS AFFECTING ARTERIAL CONCENTAION (Fa)

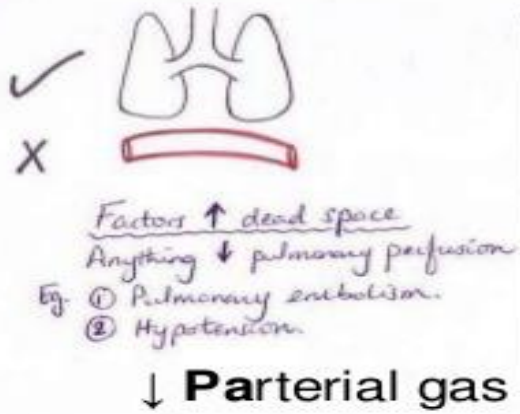
- Ventilation /perfusion mismatch

Factors Affecting Arterial concentration (Fa):-

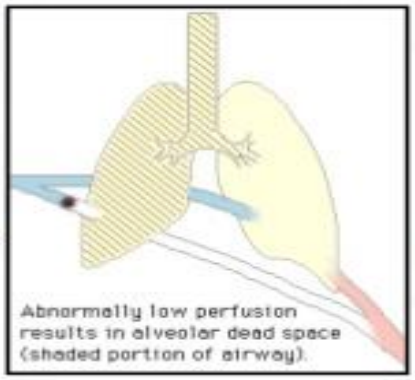
Ventilation/Perfusion Mismatch :-

- *General assumption: Partial Pressure $_{alveoli}$ = Partial pressure $_{arterial\ circulation}$* **(FA = Fa)**
- *Diseases such as emphysema and atelectasis, as well as congenital cardiac defects, produce substantial* ***deviations from equilibration***.

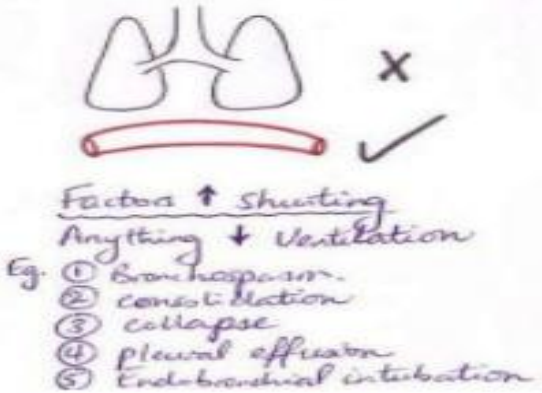
1) Ventilated non-perfused areas:

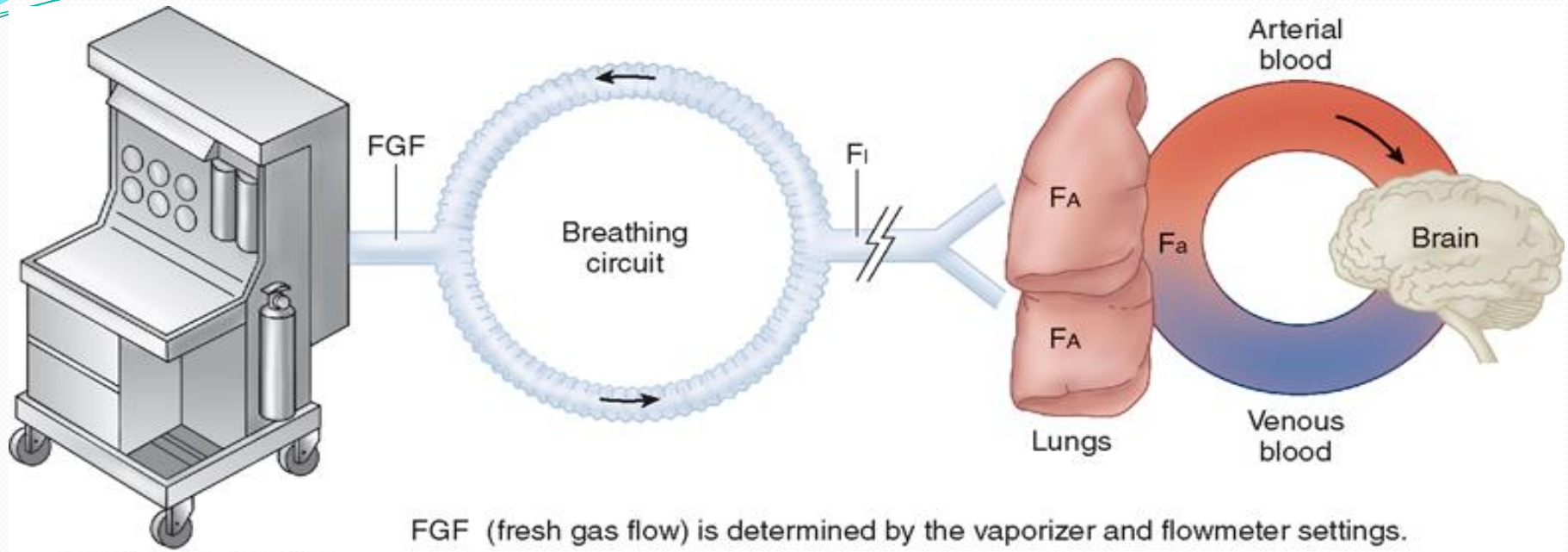


↓ **Pa**rterial gas



2) Perfused non-ventilated areas





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

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

F_A (aveolar gas concentration) is determined by (1) uptake (uptake = $\lambda b/g \times C(A-V) \times Q$); (2) ventilation; and (3) the concentration effect and second gas effect:

a) concentrating effect
b) augmented inflow effect

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

Source: Butterworth JF, Mackey DC, Wasnick JD: *Morgan & Mikhail's Clinical Anesthesiology*, 5th Edition: www.accessmedicine.com

Theories of anesthetics action

1. The reticular activating system
2. The cerebral cortex
3. The cuneate nucleus
4. The olfactory cortex
5. The hippocampus

How to determine the potency of the anesthtetic agent

Mac ????

Blood solubility ???

Meyer- overton role ???

MINIMUM ALVEOLAR CONCENTRATION

Pharmacologic Properties of Common Inhaled Anesthetic Agents

Agent	Blood/ Gas	Brain/ Blood	Muscle/ Blood	Fat/ Blood	Vapor Pressure (mm Hg, 20°C)	MAC (%) 30–60 yrs	MAC(%) >65yrs
Nitrous oxide	0.46	1.1	1.2	2.3	—	104	—
Halothane	2.5	1.9	3.4	51	243	0.75	0.64
Isoflurane	1.5	1.6	2.9	45	248	1.2	1.0
Desflurane	0.42	1.3	2.0	27	669	6.6	5.2
Sevoflurane	0.65	1.7	3.1	48	157	1.8	1.45

Source: Adapted from Barash PG, Cullen BF, Stoelting RK. Clinical Anesthesia. 6th ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2009:415

FACTORS AFFECTING MAC

- Tempreture
- Age
- Alcohol
- Anemia
- $PaO_2 < 40$
- $PaCO_2 > 95$
- Blood pressure
- Electrolytes (hypercalcemia , hyponatremia)
- Pregnancy
- Iv anesthetic agents
- Amphetamine
- Cocaine ??
- Ephidrine

Blood:Gas Partition Coefficient

- The measure of the solubility of an inhalation anesthetic in blood as compared to alveolar gas (air)
- Indication of the speed of induction and recovery for an inhalation anesthetic agent
- Low blood:gas partition coefficient
  - Agent is more soluble in alveolar gas than in blood at equilibrium
  - Agent is less soluble in blood
  - Faster expected induction and recovery

Halogenated Organic Compounds

- Isoflurane and sevoflurane are the most commonly used agents in this class
  - Others include Desflurane, Halothane, Methoxyflurane, and Enflurane, but these are not commonly used
- Liquid at room temperature
- Stored in a vaporizer on an anesthetic machine
- Vaporized in oxygen that flows through the vaporizer

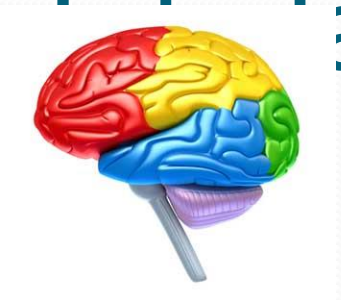
Uptake and Distribution of Halogenated Organic Compounds

- Liquid anesthetic is vaporized and mixed with oxygen
- Mixture is delivered to the patient via a mask or endotracheal tube (ET tube)
- Mixture travels to lungs (alveoli) and diffuses into the bloodstream
- Diffusion rate is dependent on concentration gradient (alveoli/capillary) and lipid solubility of the anesthetic gas
  - Concentration gradient is greatest during initial induction

Elimination of Halogenated Organic Compounds

- Reducing amount of anesthetic administered reduces amount in the alveoli
- Anesthetic will move from the brain into the blood and then into the alveoli where it is finally breathed out
- Patient wakes up

Inhalant Anesthetics



EFFECTS:

ADVERSE EFFECTS:

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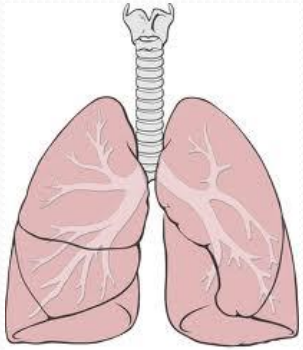

EFFECTS:

ADVERSE EFFECTS:

Isoflurane

- Most commonly used inhalant agent in North America
- Approved for use in dogs and horses; commonly used in other species

Isoflurane

- Properties
  - Low blood:gas partition coefficient: rapid induction and recovery
  - Not Good for induction with mask or chamber
  - MAC = 1.2 : helps determine initial vaporizer setting

Effects and Adverse Effects

- Maintains cardiac output, heart rate, and rhythm
  - Fewest adverse cardiovascular effects
- Depresses the respiratory system
- Maintains cerebral blood flow
- Almost completely eliminated through the lungs- 0.2% metabolized by the liver
- Induces adequate to good muscle relaxation
- Provides little or no analgesia after anesthesia
- Difficult to mask patient
- Can produce carbon monoxide when exposed to a desiccated carbon dioxide absorbent

Sevoflurane

- Low Blood:gas partition coefficient = rapid induction and recovery
- Good for induction with a mask or chamber
- High controllability of depth of anesthesia
- MAC = 2.0
- Cost about 10x more than Isoflurane
- Easier to mask a patient, more pleasant smelling

Effects and Adverse Effects of Sevoflurane

- Minimal cardiovascular depression
- Depresses respiratory system
- Eliminated by the lungs, minimal hepatic metabolism- 2-5%
- Maintains cerebral blood flow
- Induces adequate muscle relaxation
- Some paddling and excitement during recovery
- No post-op analgesia
- Can react with potassium hydroxide (KOH) or sodium hydroxide (NaOH) in desiccated CO_2 absorbent to produce a chemical (Compound A) that causes renal damage

Desflurane

- Closely related to isoflurane
- Expensive
- Lowest blood:gas partition coefficient: very rapid induction and recovery
- Used with a special heated electronic precision vaporizer
- MAC = 6.0
  - Least potent inhalant agent
- Eliminated by the lungs- 0.02% metabolized in liver

Effects and Adverse Effects of Desflurane

- Strong vapors cause coughing and holding the breath= difficult to mask
- Other effects are similar to isoflurane
- Transient increase in heart rate and blood pressure (humans)
- Produces carbon monoxide with spent soda lyme

Other Halogenated Inhalation Agents

- Halothane (Fluothane)
  - Not available anymore
  - replaced by isoflurane and sevoflurane
- B:G -2.54
- 20-46% metabolized in the liver
- MAC- 0.75
- *Sensitizes heart to catecholamine and induces arrhythmias*
- *Cardiac, respiratory depression*
- Increased cerebral blood flow

Nitrous Oxide

- Nitrous oxide
  - Used primarily in human medicine; some veterinary use
  - A gas at room temperature; no vaporizer is required

- Mixed with oxygen at 40-67%, then delivered to patient

- Reduces MAC 20-30%
  - Used with Halothane and Methoxyflurane to reduce the adverse effects of these gases