Pathophysiology of anesthesia

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Anesthesia

= loss of perception of all modalities (touch, heat, cold, pain)
a) targeted
b) accidental

a) reversible
b) permanent = afferent pathway damage (therapy, injury...)

Methods of anesthesia induction:

- pharmacoanesthesia
- hypnoanesthesia
- audioanesthesia
- electroanesthesia
- acupuncture
- cryoanesthesia

Classification: general anesthesia X local anesthesia

General anesthesia (GA)

= complete loss of perception and consciousness

Fundamental attributes of GA

- Loss of consciousness – does not block autonomic reflexes to painful stimuli (perspiration, arrhythmia, hypertension, bronchoconstriction, bronchial hypersecretion)
- Vegetative stabilization
- Analgesia – loss of pain sensation, suppression of autonomic reactions
- Muscle relaxation

Induction of all the GA attributes achieved by combination of partial effects of several substances such as anesthetics, analgesics, anxiolytics, myorelaxants.

Types of GA according to administration mode

- inhalation
- intravenous
- intramuscular
- rectal – especially in children
- intraperitoneal – in animals

Stages of GA (Guedel I-IV)

- Obviously present in ether monoanesthesia (history)
- Nowadays shortcut stage I, suppressed stage II

I. stage of analgesia (induction)

- From the initial administration to the loss of consciousness
- Normally responsive pupils, later dilation
- Tachycardia
- Tachypnea
- Unchanged skin reflexes
- Marked analgesia – minute operations (e.g. painful re-bandage)

Stages of GA (Guedel I-IV)

II. stage of excitement

- From the loss of consciousness to the beginning of the automatic respiration
- Extremely marked excitation and motor agitation
- Hypersalivation, increased emetic reflex
- Arrhythmia, circulatory instability
- Irregular respiration
- No action is allowed during this stage. Rapidly acting drugs are used to minimize time in this stage and reach stage 3 as fast as possible.

Stages of GA (Guedel I-IV)

III. stage of surgical anesthesia

- Automatic respiration to respiration arrest
- Absent eye-lid and corneal reflex
- Absent reaction to pain
- Rhythmical eye-balls movements, sometimes nystagmus
- In this stage operations including tracheal intubation are performed.

Stages of GA (Guedel I-IV)

IV. stage of paralysis (overdose)

- After stage III if administration of medication continues
- Respiratory depression, first bronchial breathing, later abdominal breathing
- Cessation of respiration & circulatory collapse
- Lethal without cardiovascular and respiratory support
- Warning signs:
  - maximum pupil dilatation
  - fading photoreaction
  - irregular heart action
  - urinary and fecal incontinence

Monitoring depth of GA

- concentration inhalational anesthetics
- computerized EEG analysis
- vegetative response (perspiration, pupils, blood pressure, pulsation)
- clinical status, esp. waning muscle tonus (not available when muscle relaxants are used)

Inhalation anesthetics

- before inhalational induction 100% oxygen for 2-5 minutes → denitrogenation → faster induction
- at the end of anesthesia again 100% oxygen → faster excretion of anesthetic and waking up

According to physical properties:

Anesthetic gases

- stored in pressure tanks
- applied with anesthetic machine
- e.g. nitrous oxide – laughing gas (formerly: cyclopropane)

Volatile liquids

- liquids with low boiling-point (about 40°C)
- the light induces transformation in toxic aldehydes ⟶ stored in dark flaskets
- applied with vaporizers
- e.g. halothane, isoflurane, sevoflurane

Evaluation of inhalation anesthetics efficiency

Minimum alveolar concentration (MAC)

- Concentration of anesthetic in alveolar space, that prevents the reaction to a standard surgical stimulus (skin incision) in 50% of subjects
- The lower MAC, the more potent anesthetic
- Immobility in 95% subjects: increasing concentration of anesthetic 30% over MAC

Intravenous anesthetics

- Mostly used for induction (weak or no analgesic effects)
- Rarely for maintenance (TIVA)
- Combined with inhalational anesthetics and some other medicaments (opioid analgesics, neuroleptics…)
- Rapid onset of the effect, early arousal (redistribution)
- MIR (minimal infusion rate) – speed of anesthetics infusion, that prevents the reaction to a standard surgical stimulus (skin incision) in 50% of subjects

Groups of intravenous anesthetics

1. barbiturates – thiopental
2. imidazoles – etomidate
3. alkyl phenols – propofol
4. steroids– althesin
5. eugenols – propanidid
6. phenylcyclidines – ketamine
7. benzodiazepines

Premedication

- Resting at night before operation (prepremedication)
- Calming down
- Basal analgesia
- Suppression of readiness to allergic reactions
- Suppression of vegetative reflexes (bradycardia, hypersalivation, bronchial hypersecretion)

e.g.: sedatives, hypnotics, anxiolytics, vagolytics (atropine), antihistamines

Muscle relaxants

Depolarizing muscle relaxants

- Cholinergic receptor depolarization → generation AP → initial muscle fiber contractions followed by preventing acetylcholine action and muscle relaxation
- Antagonism is not possible
- e.g.: Suxametonium (succinylcholine)

Non-depolarizing muscle relaxants

- Competitive block of cholinergic receptors without generation of AP
- So called curariform medicaments, e.g. Pancuronium, Atracurium
- Antagonist: neostigmine

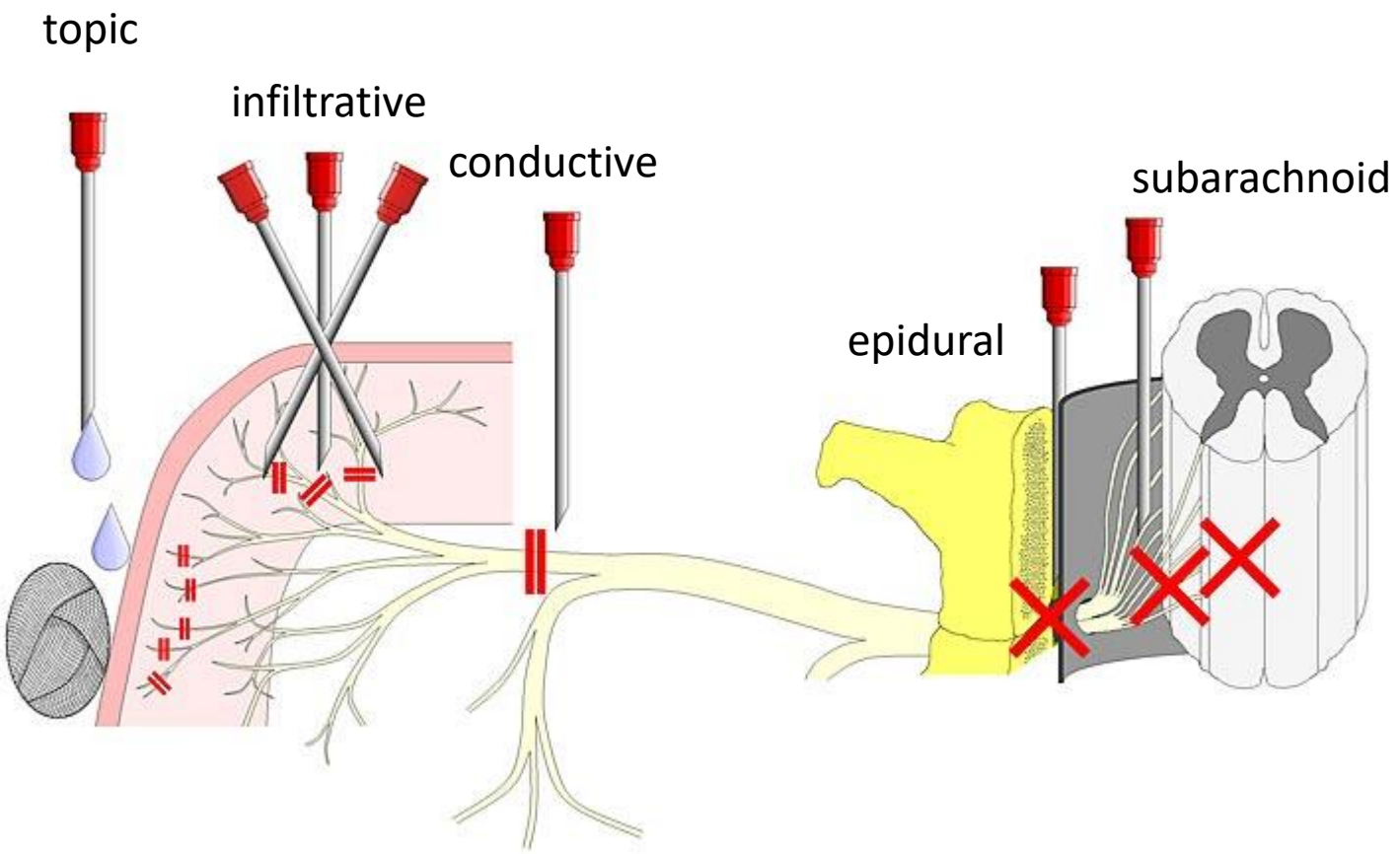
Local anesthesia (LA)

- Restricted to certain area, consciousness is preserved

- Places of action:
  - spinal roots
  - nerve plexi
  - peripheral nerves

- Types of local anesthesia
  - topic (surface, mucosal)
  - infiltrative
  - conductive
  - spinal
    - epidural
    - subarachnoid

Local anesthesia



Topic (surface, mucosal) anesthesia

- Aerosol administration on the mucous surface, liniments with LA (EMLA)
- ORL, ophthalmology, anesthesia in oral or nasal cavity, conjunctiva and cornea, in urology for anesthesia of mucosa of the urinary tract (urethral catheterization)

Infiltrative anesthesia

- Infiltration in zone of operation
- Reversible block of terminal parts of nerve fibers
- IVRA – intravenous regional anesthesia (Bier´s block)
  - application into peripheral veins previously emptied of blood
  - diffusion and infiltration of surrounding tissue
  - danger of toxic effects of anesthetic in the blood circulation after the turnstile is released

Conductive anesthesia

- Targeted application of anesthetic near nerve or nerve plexus
- Anesthesia of all parts controlled by the particular nerve
- Usually also motor paralysis (dependent on dose of anesthetic)
- Examples of usage:
  - conductive LA of peripheral nerves (n. radialis, medianus, ulnaris, femoralis, ischiadicus...)
  - anesthesia of II. or III. branch of trigeminal nerve (stomatology)

Epidural anesthesia

- Application of LA into the epidural space
- Block of impulse conduction in nerve exit from the dural sac
- Affected sensitive, sympathetic, motor nerves

Subarachnoid anesthesia (spinal, intrathecal)

- LA administered into the subarachnoid space (CSF)
- Isobaric LA - stays where applied + diffusion
- Hyperbaric LA – spread dependent on gravity → range of anesthetized zone can be influenced by positioning
- Risk of severe complications (respiration center paralysis)

Pharmacology of LA

Amino-esters

- Less stable, shorter duration, hydrolyzed in liver and also in plasma by cholinesterase
- More often allergic reactions
- e.g.: Procaine, Tetracaine

Amino-amides

- More stable, longer lasting effect, hydrolyzed in liver only
- Allergic reactions uncommon
- e.g.: Trimecaine (Mesokain), Prilocaine

Mechanism of LA effect

- Blockade of the inner orifice of sodium channel → inhibition of action potential

- Non-ionized form of LA – penetration through connective tissue, myelin sheath and cell membrane
- Intracellularly ionization and attachment to the sodium channel

- Ionized vs. non-ionized form of LA ratio dependent on pH of the tissue
  - healthy tissue: slightly alkaline pH → more non-ionized form → easy penetration of LA into cells → quick effect onset
  - inflammation: acid pH → less non-ionized form → poor penetration into the cell (fiber) → weak LA effect

Vasoconstrictive addition agents (epinephrine)

- Reduction of absorption → longer effect persistence, lower toxicity, less bleeding

Effects of LA on nerve fibres

1. Block of sympathetic division (warming of skin)

2. Loss of sensation of heat and pain

3. Loss of sensation of touch and pressure

4. Loss of motor neuron function

THE END