KAZAN STATE MEDICAL UNIVERSITY

DEPARTMENT OF ANESTHESIOLOGY AND EMERGENCY MEDICINE

CENTRAL NERVOUS SYSTEM

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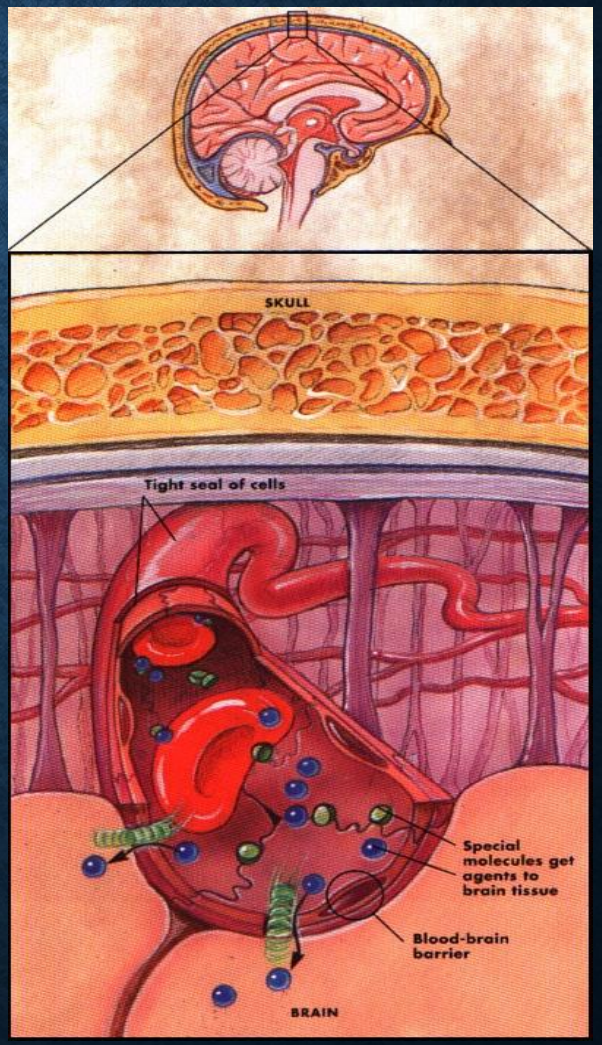
THE HUMAN BRAIN

- Complex
- 1.4 kg in weight
- Pre frontal cortex
- 2% of body weight
- 20% of oxygen
- 15% of our cardiac input
- 10% of all energy

THE BLOOD BRAIN BARRIER

- Brain protection system
- The BBB is both;
  - A physical barrier that restricts the entrance of potentially harmful substances
  - A system of cellular transport mechanisms that controls the entrance of essential nutrients



DIVISIONS OF CNS

- CNS - central nervous system:
  - consists of brain and spinal cord
  - • Nerves and associated structures within the brain and spinal cord Brain • Cerebrum • Brain stem Spinal cord • Gray matter White matter • Meninges; dura mater, arachnoid, pia mater • Epidural space • Subarachnoid space(intrathecal space)
  - CSF : Formed at choroid plexuses in the ventricles • Cushioning effect • Normal: 10 mmHg in pressure, 1.002 – 1.009 in SG, 7.32 in pH • Increased production, decreased absorption, and/or obstruction of flow of CSF all contribute to hydrocephalus symptom

A. CRANIAL NERVES

- 12 pairs & their branches
- Some responsible for special senses: sight, hearing, taste, smell
- Others receive sensations: touch, pressure, pain, temperature

Table 1. Cranial nerves and their function

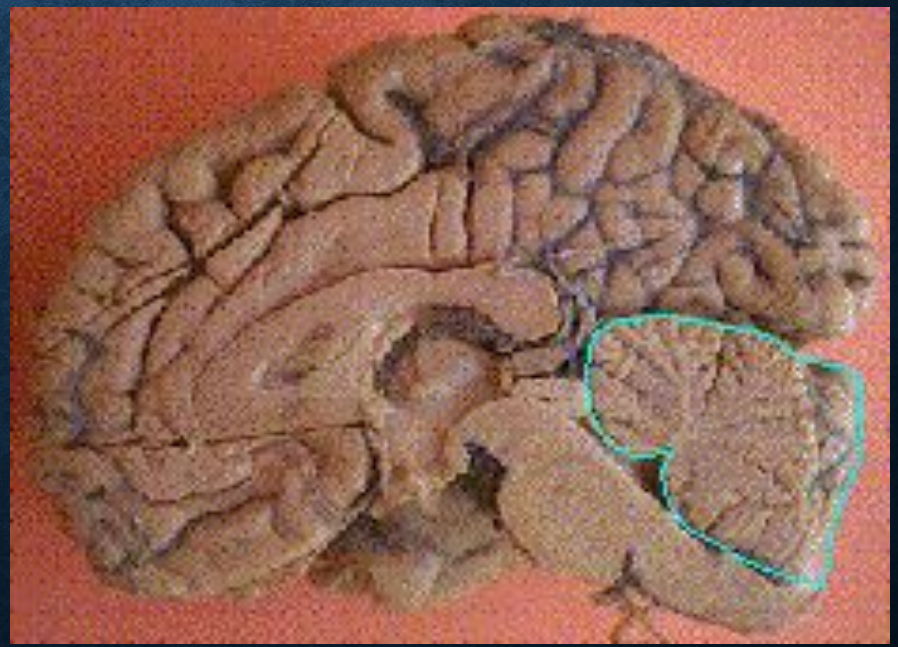
Nerves in order	Modality	Function
Olfactory (I)	Sensory	Smell
Optic (II)	Sensory	Vision
Oculomotor (III)	Motor	Levator palpebrae, superioris, superior, medial & inferior recti muscles
	Motor	Parasympathetic to ciliary and pupillary constrictor muscles
Trochlear (IV)	Motor	Dorsal oblique muscle
Trigeminal (V)	Motor	Muscles of mastication
	Sensory	Sensory for head/neck, sinuses, meninges, & external surface of tympanic membrane
Abducens (VI)	Motor	Lateral rectus muscle, retractor oculi muscle
Facial (VII)	Motor	Muscles of facial expression
		Parasympathetic to all glands of head except the parotid
	Sensory	The skin of external ear
		Taste buds of tongue
Vestibulocochlear (VIII)	Special Sensory	Hearing and Balance
Glossopharyngeal (IX)	Motor	Stylopharyngeus muscle
		Parotid and zygomatic salivary glands
	Sensory	Carotid body and sinus
		Sensation posterior one-third tongue & internal surface of tympanic membrane.
		Taste posterior one-third tongue
Vagus (X)	Motor	Muscles of pharynx, larynx and esophagus
		Parasympathetic to neck, thorax, and abdomen
	Sensory	Sensory from pharynx, larynx and viscera
		Sensory from external ear
Spinal Accessory (XI)	Motor	Muscles of the neck and head
Hypoglossal (XII)	Motor	Muscles of the pharynx, larynx and tongue

C. CEREBRUM

- Largest section of the brain
- Responsible for:
  - reasoning, thought, memory, speaking, sensstion, sight, hearing, voluntary body movement

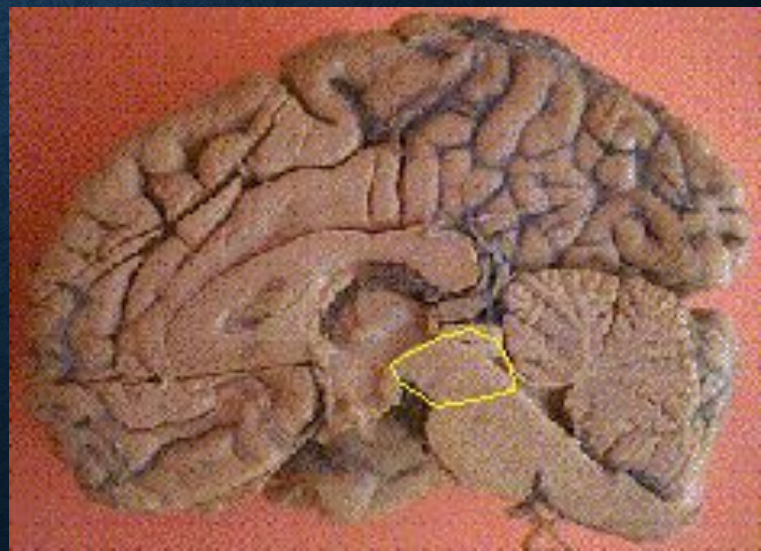
D. CEREBELLUM

- Responsible for:
  - coordination of muscles, balance, posture, & muscle tone

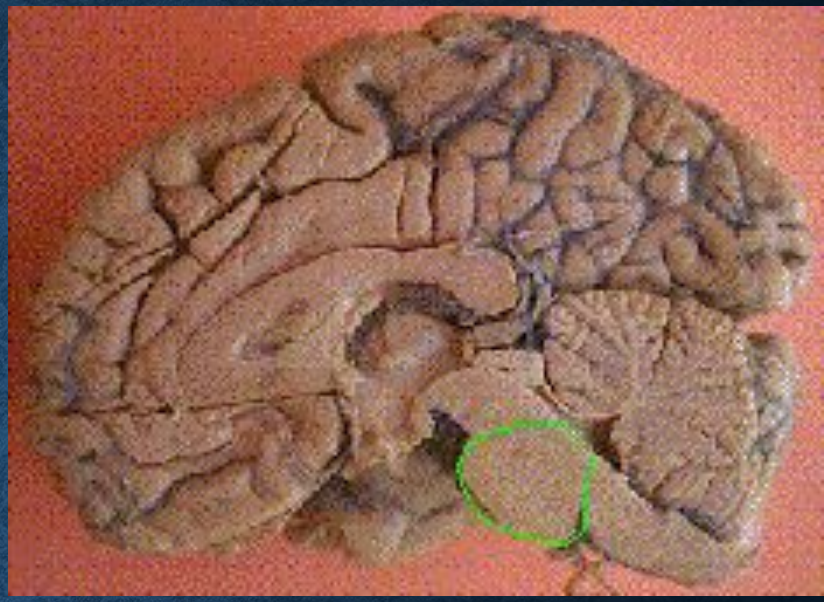


E. MIDBRAIN

- Responsible for:
  - conducting impulses between brain parts
  - certain eye reflexes



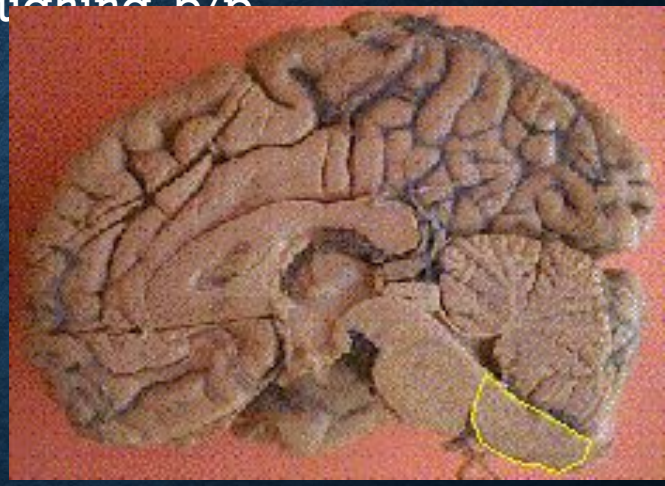
PONS



- Responsible for:
  - conducting messages to other parts of the brain
  - Reflex actions such as chewing, production of saliva

G. MEDULLA OBLONGATA

- Lowest part of brain stem
- Connects to the spinal cord
- Responsible for:
  - regulating heart beat, respirations, swallowing, coughing, b/p



2. SPINAL CORD

- Goes down back of body from Medulla Oblongata
- Surrounded and protected by vertebrae
- Responsible for reflex actions
- Carries sensory and motor messages

3. MENINGES

- Consists of 3 membranes
- Covers and protects the brain and spinal cord

THREE MEMBRANES

- C. Dura mater
  - thick, tough outer layer
- D. Arachnoid membrane
  - middle delicate weblike layer
- E. Pia mater
  - inner most layer with blood vessels to nourish the nerves

4. VENTRICLES

- Four hallow spaces located in the middle of the brain.
- Connected to each other
- Filled with fluid called cerebrospinal fluid

CEREBROSPINAL FLUID

- Circulates continuously
- Serves as shock absorber to protect brain and spinal cord
- Carries nurients to parts of brain and spinal cord
- helps remove metabolic products & wastes
- after circulation, absorbed into the blood vessels of the dura mater.

B. SPINAL NERVES

- 31 pairs & their branches
- carries messages to & from the spinal cord
- Both sensory and motor nerves

- 31 spinal nerves:
  - 8 cervical
  - 12 thoracic
  - 5 lumbar
  - 5 sacral
  - 1 coccygeal

3. AUTONOMIC NERVOUS SYSTEM

- Autonomic nervous system • It is further subdivided into sympathetic and parasympathetic divisions (see figure 3). • Because the autonomic nervous system regulates involuntary or automatic functions, it is called the involuntary nervous system. The Parasympathetic Nervous System (craniosacral) • Acetylcholine is transmitter both at pre and postganlionic (muscarinic) neurons • long preganglionic neurons, short postganglionic neurons; ganglia are diffusely spread; allows for discrete, localized innervation and control • Vagus nerve innervates heart, lungs, esophagus, stomach, small intestine, proximal colon, liver, gallbladder, pancreas, kidneys, upper ureters • Distribution of innervation to the heart is to the AV node, SA node, and atria (essentially none to the ventricles) • Sacral outflow from 2nd, 3rd, and 4th sacral segments of the cord; form the pelvic nerves, and innervate the bladder, distal colon, rectum, and sexual organs

NEUROTRANSMISSION

Neurotransmission • A nerve impulse is an electric current that passes along an axon to the presynaptic membrane. Upon reaching the presynaptic membrane, it causes the release of neurotransmitters into the synaptic cleft. • The neurotransmitter then interacts with receptors on effector cells to induce a response in the effector cell.

Neuroregulators: Neurotransmitters are released into the synaptic cleft in response to action potentials - release is voltage dependent and requires calcium influx • Neuropeptide modulators are released in smaller quantities than neurotransmitters in response to action potentials - they serve to amplify or dampen neural activity.

Cholinergic transmission •

Acetylcholine is the neurotransmitter • Primary means of terminating action is break down of acetylcholine into acetate and

NEUROTRANSMISSION

- and choline by acetylcholine esterase (AchE), found principally in neurons and neuromuscular junctions .
- • Cholinergic receptors are present in the parasympathetic nervous system, brain, ganglia of the sympathetic nervous system, and skeletal muscle • Two main types of receptors present • Muscarinic (principally autonomic nervous system) • Nicotinic (principally skeletal muscle)
- Adrenergic transmission • Catecholamines (dopamine,norepinephrine, epinephrine) are the neurotransmitters • Primary means of terminating action is by neural membrane reuptake of the transmitter, although metabolism by catechol-O-methyltransferase (COMT) and monoamine oxidase (MAO) is important in some tissues.

NEUROTRANSMISSION

Adrenergic receptors : Alpha receptors are mainly subdivided into alpha-1 and alpha 2 receptors • Alpha-1 o principally found in peripheral vascular smooth muscle • Alpha-2 o occur both presynaptically and postsynaptically o those occurring presynaptically on sympathetic nerve terminals reduce the release of norepinephrine, thus producing a negative feedback loop o also may modulate cholinergic, serotonergic, GABA-ergic neurons o central alpha-2adrenergic receptor stimulation results in sedation, analgesia, decreased sympathetic outflow, tranquilization o indirectly affects cardiac function by decreased sympathetic tone o act pre- and postjuntionally to decrease motility and secretions in the GI tract o produces diuresis by inhibiting ADH release, blocking ADH's effect in the renal tubule, increasing GFR, and inhibiting renin release o stimulate platelet aggregation

NEUROTRANSMISSION

- • Beta receptors, again, are mainly subdivided into beta-1 and beta 2 receptors • Beta-1 are located in the myocardium, SA node, ventricular conduction system, and adipose tissue • Beta-2 are vascular smooth muscle of the skin, muscles, mesentery and bronchial tree; stimulation results in vasodilation and bronchodilation •
- Dopaminergic receptors are dopamine: splanchnic and renal vasodilation
- NANC(nonadrenergic & noncholinergic) – NO • In the brain, spinal cord, and peripheral nervous system. • L-Arginine and O2 produce L- Citrulline and NO by NO synthases • It activates guanyl cyclase to increase cGMP which leads to relaxation of smooth muscle. • NMDA glutamate receptor activation releases NO and in turn results in excitatory neurotransmission in the CNS. • NOS inhibitor causes dose-dependent MAC decrease

NEUROTRANSMISISON

Neuromuscular junction and neuromuscular blocker (NMB) • It consists of presynaptic nerve terminal and postsynaptic muscular membrane. • Mainly cholinergic nicotinic receptors, two at postsynaptic and one presynaptic • The neurotransmitter is the quaternary ammonium ester, acetylcholine • Acetate and choline through choline acetylase form Acetylcholine at motor nerve ending • Acetylcholinesterase at cholinergic receptors is responsible for hydrolysing Ach into Acetic acid and choline • Choline can reenter nerve terminal to again participate in the synthesis of new acetylcholine • Depolarizing neuromuscular blocker o Succinylcholine (suxamethonium in Europe), mimics the action of Ach by occupying postsynaptic nicotinic cholinergic receptor, thus depolarizing postsynaptic membrane. However, hydrolysis of Sch is slower, so postjunctional membrane does not respond to subsequently released Ach prolonging neuromuscular blockade (Phase I). o Side effects include hyperkalemia, hypertension, myalgia, cardiac arrhythmia, and increased intraocular pressure. Also known as a trigger for malignant hyperthermia in susceptible patients. • Nondepolarising NMBs o Some examples of drugs falling into this category are pancuronium, atracurium, doxacurium, vecuronium and mivacurium. o These agents bind to the post synaptic nicotinic cholinergic receptors without causing any activation of ion channel permeability, and yet impeding normal postjunctional depolarization with less Ach availability at the receptor leading to the neuromuscular blockade. o Occupation as many as 70 % does not produce neuromuscular blockade, but 80-90 % occupation fails neuromuscular transmission, indicating wide safety margin of the drug.

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THEORIES OF ANESTHESIA

- Wide range of compounds produce anesthesia, without any unifying chemical structure or activity • We don't as yet understand how general anesthetics function • A key concept in any theory regarding anesthetic mechanisms must be the ability of the anesthetic to disrupt cellular and intercellular communication, particularly in the CNS. • Many hypotheses have been proposed over the years; it appears that there is expansion and fluidization of the cell membrane by anesthetic agents that result in depressed synaptic transmission, and some anesthetic agents also hyperpolarize neurons by increasing potassium permeability.
- • Meyer-Overton hypothesis asserts that, anesthesia results from the presence of a certain concentration of the anesthetic at a hydrophobic site. Evidence for this has come from the fact that potency is strongly correlated with the lipid solubility of the drug. • Critical volume theory asserts that anesthetic's direct action on proteins (ion channel proteins - nicotinic Ach, GABA, glycine, NMDA; signal transduction pathways) will induce conformation change on lipoprotein (expansion beyond the critical volume) and lead to interruption of neurotransmission by obstructing ion flux with changes of electrical conductivity in the neurons. • The reticular activating system, a multi-synaptic structure, is believed to be the most important site within the central nervous system for anesthetic action. • We do have an understanding of how certain classes of drugs work - those that interact with specific receptor sites. o opioids (eg, morphine, butorphanol) o alpha-2 receptor agonists (eg, xylazine, medetomidine) o benzodiazepines (eg, diazepam, midazolam)

THANK YOU!!

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