ANATOMY OF THE NERVOUS SYSTEM

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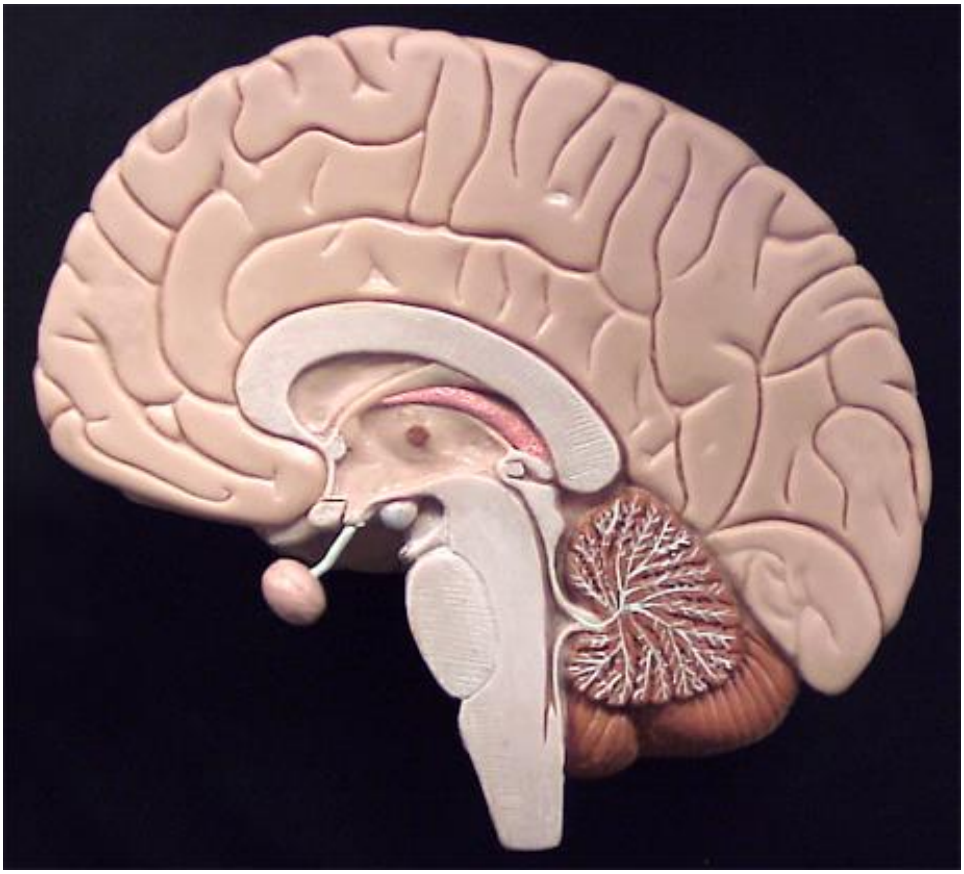

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1. ANATOMY OF THE NERVOUS SYSTEM

The nervous system can be separated into two parts based on structure and on function:

- Structurally, it can be divided into the central nervous system (CNS) and the peripheral nervous system (PNS);
- Functionally, it can be divided into somatic and visceral parts.

The CNS is composed of the brain and spinal cord, both of which develop from the neural tube in the embryo.

The PNS is composed of all nervous structures outside the CNS that connect the CNS to the body. Elements of this system develop from neural crest cells and as outgrowths of the CNS.

The PNS consists of the spinal and cranial nerves, visceral nerves and plexuses, and the enteric system.

CENTRAL NERVOUS SYSTEM

Functional subdivisions of the CNS

Functionally, the nervous system can be divided into somatic and visceral parts.

The **somatic part** (soma, from the Greek for "body") innervates structures (skin and most skeletal muscle) derived from somites in the embryo, and is mainly involved with receiving and responding to information from the external environment.

The **visceral part** (viscera, from the Greek for "guts") innervates organ systems in the body and other visceral elements, such as smooth muscle and glands, in peripheral regions of the body. It is concerned mainly with detecting and responding to information from the internal environment.

Somatic part of the nervous system

The somatic part of the nervous system consists of:

- nerves that carry conscious sensations from peripheral regions back to the CNS; and
- nerves that innervate voluntary muscles.

Generally, all sensory information passes into the posterior aspect of the spinal cord, and all motor fibers leave anteriorly.

Somatic sensory neurons carry information from the periphery into the CNS and are also called somatic sensory afferents or general somatic afferents (GSAs). The modalities carried by these nerves include temperature, pain, touch, and proprioception. Proprioception is the sense of determining the position and movement of the musculoskeletal system detected by special receptors in muscles and tendons.

Somatic motor fibers carry information away from the CNS to skeletal muscles and are also called somatic motor efferents or general somatic efferents (GSEs). Like somatic sensory fibers that come from the periphery, somatic motor fibers can be very long. They extend from cell bodies in the spinal cord to the muscle cells they innervate.

Dermatomes

Each spinal nerve carries somatic sensory information from a specific area of skin on the surface of the body. A dermatome is that area of skin supplied by a single spinal cord level, or on one side, by a single spinal nerve. There is overlap in the distribution of dermatomes, but usually a specific region within each dermatome can be identified as an area supplied by a single spinal cord level. Testing touch in these autonomous zones in a conscious patient can be used to localize lesions to a specific spinal nerve or to a specific level in the spinal cord.

Myotomes

A myotome is that portion of a skeletal muscle innervated by a single spinal cord level or, on one side, by a single spinal nerve.

Visceral part of the nervous system

The visceral part of the nervous system, as in the somatic part, consists of motor and sensory components:

- sensory nerves monitor changes in the viscera;

- motor nerves mainly innervate smooth muscle, cardiac muscle, and glands.

The visceral motor component is commonly referred to as the autonomic division of the PNS and is subdivided into sympathetic and parasympathetic parts.
Visceral sensory neurons and their processes are referred to as general visceral afferent fibers (GVAs), and are associated primarily with chemoreception, mechanoreception, and stretch reception. Visceral motor neurons contain general visceral efferent fibers (GVEs) and provide motor innervation to smooth muscle, cardiac muscle, and glands as part of the autonomic nervous system.
The visceral motor neurons located in the spinal cord are referred to as preganglionic motor neurons and their axons are called preganglionic fibers; the visceral motor neurons located outside the CNS are referred to as postganglionic motor neurons and their axons are called postganglionic fibers.
The cell bodies of the visceral motor neurons outside the CNS often associate with each other in a discrete mass called a ganglion. Visceral sensory and motor fibers enter and leave the CNS with their somatic equivalents. Visceral sensory fibers enter the spinal cord together with somatic sensory fibers through posterior roots of spinal nerves. Preganglionic fibers of visceral motor neurons exit the spinal cord in the anterior roots of spinal nerves along with fibers from somatic motor neurons. Postganglionic fibers traveling to visceral elements in the periphery are found in the posterior and anterior rami (branches) of spinal nerves.
Visceral motor and sensory fibers that travel to and from viscera form named visceral branches that are separate from the somatic branches. These nerves generally form plexuses from which arise branches to the viscera.

The enteric system

The enteric nervous system consists of motor and sensory neurons and their support cells, which form two interconnected plexuses, the myenteric and submucous nerve plexuses, within the walls of the gastrointestinal tract.

Nerve plexuses

Nerve plexuses are either somatic or visceral and combine fibers from different sources or levels to form new nerves with specific targets or destinations. Plexuses of the enteric system also generate reflex activity independent of the CNS.

Somatic plexuses

Major somatic plexuses formed from the anterior rami of spinal nerves are the cervical (C1 to C4), brachial (C5 to T1), lumbar (L1 to L4), sacral (L4 to S4), and coccygeal (S5 to Co) plexuses. Except for spinal nerve T1, the anterior rami of thoracic spinal nerves remain independent and do not participate in plexuses.

Visceral plexuses

Visceral nerve plexuses are formed in association with viscera and generally contain efferent (sympathetic and parasympathetic) and afferent components (such as cardiac plexus).
In the clinic

Referred pain

Referred pain occurs when sensory information comes to the spinal cord from one location, but is interpreted by the CNS as coming from another location innervated by the same spinal cord level. Usually, this happens when the pain information comes from a region, such as the gut, which has a low amount of sensory output. These afferents converge on neurons at the same spinal cord level that receive information from the skin, which is an area with a high amount of sensory output. As a result, pain from the normally low output region is interpreted as coming from the normally high output region.

BRAIN

The brain is a component of the central nervous system.
During development the brain can be divided into five continuous parts. From rostral (or cranial) to caudal they are:

1) telencephalon (cerebrum), which becomes the large cerebral hemispheres, the surface of which consists of elevations (gyri) and depressions (sulci) and is partially separated by a deep longitudinal fissure, and which fill the area of the skull above the tentorium cerebelli and are subdivided into lobes based on their position.

There are 4 lobes in the brain:

1- Frontal lobe
2- Temporal lobe
3- Parietal lobe
4- Occipital lobe

2) diencephalon, which is hidden from view in the adult brain by the cerebral hemispheres, consists of the thalamus, hypothalamus, and other related structures, and classically is considered to be the most rostral part of the brainstem. (However, in common usage today, the term brainstem usually refers to the midbrain, pons, and medulla);

3) mesencephalon (midbrain), which is the first part of the brainstem seen when an intact adult brain is examined, and is at the junction between and in both the middle and posterior cranial fossae;

4) metencephalon, which gives rise to the cerebellum (consisting of two lateral hemispheres and a midline part in the posterior cranial fossa below the tentorium cerebelli) and the pons (anterior to the cerebellum, a bulging part of the brainstem

5) myelencephalon (medulla oblongata), the caudalmost part of the brainstem, which ends at the foramen magnum.

The cerebral hemispheres consist of an outer portion, or the gray matter, containing cell bodies, an inner portion, or the white matter, made up of axons forming tracts or pathways, and the ventricles, which are spaces filled with cerebrospinal fluid (CSF).

The cerebellum has two lateral lobes and a midline portion. The components of the brainstem are classically defined as the diencephalon, midbrain, pons, and medulla. However, in common usage today, the term "brainstem" usually refers to the midbrain, pons, and medulla.

SPINAL CORD

The spinal cord is the part of the CNS in the superior two- thirds of the vertebral canal. It is roughly cylindrical in shape, and is circular to oval in cross-section. Internally, the cord has a small central canal surrounded by gray and white matter. The spinal cord extends from foramen magnum to second lumbar vertebra.It gives rise to 31 pairs of spinal nerves (cervical, thoracic, lumbar, sacral and coccygeal). All are mixed nerves. Spinal nerves arise as rootlets then combine to form dorsal and ventral roots. Dorsal and ventral roots merge laterally and form the spinal nerve. Dorsal root is related to the sensory information, whereas the anterior root is related to the motor information.

Meninges

The meninges are three connective tissue coverings that surround, protect, and suspend the brain and spinal cord within the cranial cavity and vertebral canal, respectively:

- Dura mater is the thickest and most external of the coverings;
- Arachnoid mater is against the internal surface of the dura mater;
- Pia mater is adherent to the brain and spinal cord.

Between the arachnoid and pia mater is the subarachnoid space, which contains CSF.

CSF (Cerebrospinal fluid, BOS; beyin omurilik sıvısı)

Liquor cerebrospinalis, is a clear, colorless, bodily fluid that occupies the subarachnoid space and the ventricular system around and inside the brain and spinal cord. In essence, the brain "floats" in it.

It acts as a "cushion" or buffer for the cortex, providing a basic mechanical and immunological protection to the brain inside the skull. CSF is produced in the brain by choroid plexus (approx. 50-70%), and the remainder is formed around blood vessels and along ventricular walls. It circulates from the lateral ventricles

to the third ventricle, fourth ventricle,; subarachnoid space over brain and spinal cord. CSF is reabsorbed into venous sinus blood.

Blood supply

The brain receives its arterial supply from two pairs of vessels, the vertebral and internal carotid arteries, which are interconnected in the cranial cavity to produce a cerebral arterial circle (of Willis).
The two vertebral arteries enter the cranial cavity through the foramen magnum and just inferior to the pons fuse to form the basilar artery.The two internal carotid arteries enter the cranial cavity through the carotid canals on either side.

Venous drainage

Venous drainage of the brain begins internally as networks of small venous channels lead to larger cerebral veins, cerebellar veins, and veins draining the brainstem, which eventually empty into dural venous sinuses. The dural venous sinuses eventually lead to the internal jugular veins.

CRANIAL NERVES

The 12 pairs of cranial nerves are part of the peripheral nervous system (PNS) and pass through foramina or fissures in the cranial cavity. All nerves except one, the accessory nerve [XI], originate from the brain.

In addition to having similar somatic and visceral components as spinal nerves, some cranial nerves also contain special sensory (such as hearing, seeing, smelling, balancing, and tasting). The special sensory components are associated with.

I Olfactory Purely sensory Telencephalon
Smelling
II Optic Sensory Retinal ganglion cells
Seeing
III Oculomotor Mainly motor Midbrain
Eye movements & pupillary reflex
IV Trochlear Motor Midbrain
Intorts the eyeball.
V Trigeminal Both sensory and motor Pons
Receives sensation from the face and innervates the muscles of mastication
VI Abducens Mainly motor Pons
Abducts the eye.
VII Facial Both sensory and motor Pons
Provides motor innervation to the muscles of facial expression. Also receives the special sense of taste from the anterior 2/3 of the tongue and provides secretomotor innervation to the salivary glands (except parotid) and the lacrimal gland.
VIII Vestibulocochlear Mostly sensory Pons
Hearing and balance
IX Glossopharyngeal Both sensory and motor Medulla
Receives taste from the posterior 1/3 of the tongue, provides secretomotor innervation to the parotid gland, and provides motor innervation to the stylopharyngeus. Some sensation is also relayed to the brain from the palatine tonsils.
X Vagus Both sensory and motor Medulla
Supplies branchiomotor innervation to most laryngeal and pharyngeal muscles (except the stylopharyngeus, which is innervated by the glossopharyngeal). Also provides parasympathetic fibers to nearly all thoracic and abdominal viscera till the proximal two-thirds of the transverse colon. Receives the special sense of taste from the epiglottis. A major function: controls muscles for voice and resonance and the soft palate.

XI Accessory (often separated into the cranial accessory and spinal accessory nerves) Medulla

Mainly motor Cranial and Spinal Roots

Controls the sternocleidomastoid and trapezius muscles, and overlaps with functions of the vagus nerve (CN X). Symptoms of damage: inability to shrug, weak head movement.

XII Hypoglossal mainly motor Medulla

Provides motor innervation to the muscles of the tongue (except for the palatoglossus, which is innervated by the vagus nerve) and other glossal muscles. Important for swallowing (bolus formation) and speech articulation.

EYE

The eye is the organ of vision and consists of the eyeball and the optic nerve. The orbit contains the eyeball and its appendages. The orbital region is the area of the face overlying the orbit and eyeball and includes the upper and lower eyelids and lacrimal apparatus.

The orbits are bilateral bony cavities in the facial skeleton that resemble hollow quadrangular pyramids. The eyelids and lacrimal fluid, secreted by the lacrimal glands, protect the cornea and eyeballs from injury and irritation (e.g., by dust and small particles). The eyeball contains the optical apparatus of the visual system. It occupies most of the anterior portion of the orbit, suspended by six extrinsic muscles that control its movement, and a fascial suspensory apparatus. The inner layer of the eyeball is the retina. It is the sensory neural layer of the eyeball. The iris, which literally lies on the anterior surface of the lens, is a thin contractile diaphragm with a central aperture, the pupil, for transmitting light.

EAR

The ear is the organ of hearing and balance. It has three parts:

the first part is the external ear consisting of the part attached to the lateral aspect of the head and the canal leading inward;

the second part is the middle ear-a cavity in the petrous part of the temporal bone bounded laterally, and separated from the external canal, by a membrane and connected internally to the pharynx by a narrow tube;

the third part is the internal ear consisting of a series of cavities within the petrous part of the temporal bone between the middle ear laterally and the internal acoustic meatus medially.

The tympanic membrane separates the external acoustic meatus from the middle ear.

Auditory ossicles

The bones of the middle ear consist of the malleus, incus, and stapes. They form an osseous chain across the middle ear from the tympanic membrane to the oval window of the internal ear.

Muscles associated with the auditory ossicles modulate movement during the transmission of vibrations.

The inner ear is the innermost part of the ear. It consists of the bony labyrinth, a hollow cavity in the temporal bone of the skull with a system of passages comprising two main functional parts:

The cochlea, dedicating to hearing; converting sound pressure impulses from the outer ear into electrical impulses which are passed on to the brain via the auditory nerve.

The vestibular system, dedicated to balance.