Central Nervous System

Sheet 2#

Subject | Anatomy

Done by | Bahaa Jaradat

Correction | ...

Doctor | Mohammad Al-Salim

This sheet covers theses main topics:-
1-General description of somatic and autonomic motor nervous systems.
2-External anatomy of the spinal cord and its coverings (meninges).
3-Brief description of spinal cord segments including a clinical application (disk herniation).
Note:- this sheet was written based on the voice recording of the 2nd lecture from JU-medicine app, it is strongly advised to listen to it.

---

as we know, the nervous system can be anatomically divided into CNS and PNS, the PNS can be further divided into Somatic and Autonomic nervous systems (SNS and ANS, respectively), both of which have sensory and motor functions. Last lecture was sealed with a conceptual description of the sensation part, and this lecture will begin with a description of the motor nervous system (in both SNS and ANS).

1-Somatic nervous system, motor part (figure 1) :-

The general idea is that a higher motor neuron whose cell body is in the primary motor cortex, controls a lower motor neuron whose cell body can be found either in the anterior horn of the gray matter of spinal cord (in case of spinal nerves) or in one of the somatic motor nuclei in the brain stem (in case of cranial nerves). Lower motor neurons stimulation will always stimulate skeletal muscles innervated.
Please note that: -
A- in case of spinal nerves, the axon of the lower motor neuron leaves the CNS through ventral root of the corresponding spinal nerve (see Figure 3).

B-the synapse between higher and lower motor neurons happens indirectly through an inter-neuron in case of spinal nerves (in other words, the higher motor neuron synapses with an inter-neuron which then synapses with the lower motor neuron.)

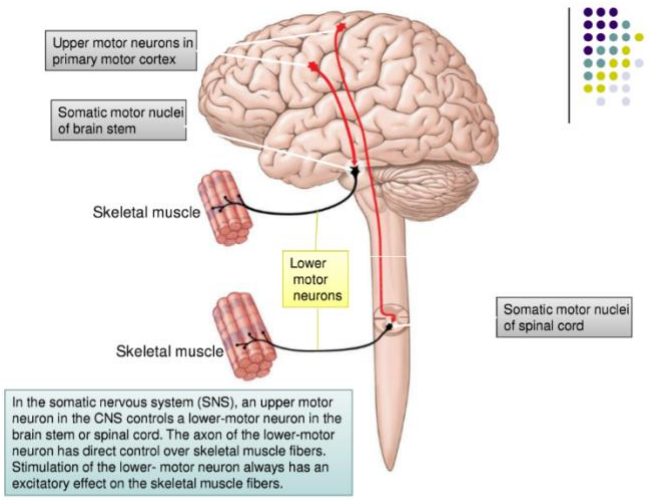


Figure (1), general description of motor division in SNS, 1st slide on this lecture.

2-Autonomic Nervous system, motor part (Figure 2):-

here, a preganglionic nerve which leavs the CNS controls a gangilonic nerve in the periphrey, by synapsing in an autonomic ganglia. The pregangilonic nerve's cell body can be found either in one of the parasympathatic nuclei in the brain stem (In case of cranial nerves,), or in the lateral horn of the gray matter of spinal cord (in case of spinal nerves), wheras the cell body of the ganigilonic neuron is found in the autonomic gangilia. Activation of the gangilonic neuron would cause activiation or inhibitoin of the innervated organ.
Please note that:-

a- The brain stem only contains para-sympathatic nuclei (e.g dorsal vegal nucelus..etc), but it DOESN't contain any symapathatic nuclei, consequently, cranial nerves only caries para-sympathatic fibers (remembar that sympathatic division has a thoraco-lumbar out-flow in contrast to the cranio-sacral out-flow of the parasympathatic divison).

b- Cell bodies of pregangilonc neurons in the lateral horn of the grey matter-in case of spinal neurons- are under control of the hypothalmus which contaons the "visceral motor nuclei", the same concept apply to cranial parasympathatic neurons.

c- Lateral horn is only found in the gray matter of thoracic, first two lumbars and the sacral segments of the spinal cord.

d- pregangilonic spinal neurons leaves the spinal cord through the ventral root (see Figure 3) .

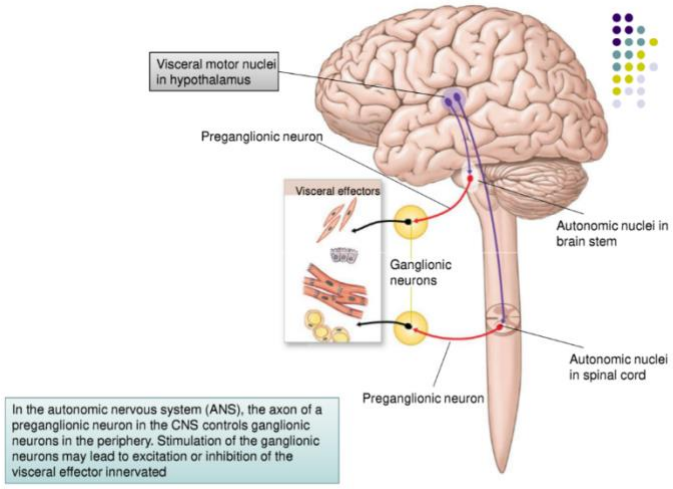


Figure (2), ANS motor division.

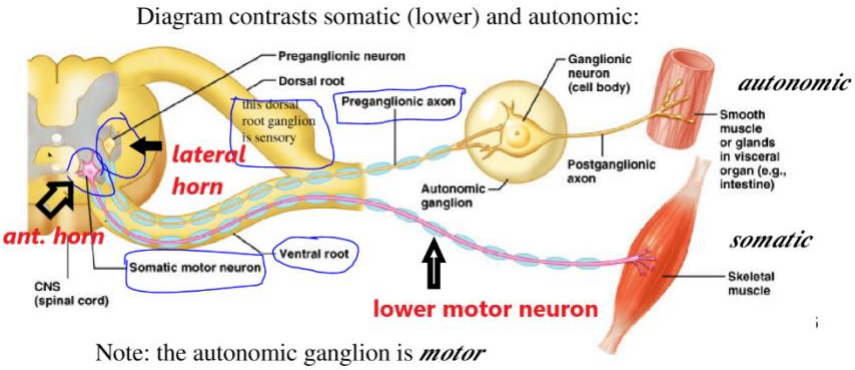


Figure (3), note that ventral root is always motor.

dorsal root always sensory, ventral root always motor whether we are talking about ANS or SNS

-External anatomy of the spinal cord: -

-the spinal cord extends up from foramen magnum, through the vertebral canal, down to the level of L1/L2 disk where it ends with a conical, tapered inferior structure called "Conus medullaris".
-it is flattened slightly anteriorly and posteriorly, and has two enlargements; cervical and lumbar enlargements which supply upper and lower limbs, respectively, thus the spinal cord is NOT a uniform, cylindrical structure. These enlargements are formed due to the fact that a high number of neurons is needed in these areas to form the brachial (root value C5-T1) and lumbar plexuses which supplies the upper and lower limbs, respectively.
-the spinal cord is divided into 31 segments, each segment gives rise to a corresponding spinal nerve-a mixed nerve.
-The spinal segments are distributed as follows: -

A- eight cervical segments, whereas there are only seven cervical vertebrae.

B-twelve thoracic segments.

C-five lumbar, 5 sacral and only 1 coccygeal.
-Coverings of the spinal cord *The Meninges*
the spinal cord, like the brain, has a three-layers covering, these are: -
1-Dura mater:- this dense irregular connective tissue layer is the outermost layer that lines the vertebral canal, thus it extends from foramen magnum above to the level of S2 below. After reaching the S2 level, the dura mater closes gradually forming a fold that is anchored to the coccyx and called "filum terminale externum" giving stability to the

spinal cord in the vertebral canal.

-Dura mater is continuous with the epineurium of spinal nerves.

2-Arachnoid mater:- this is the intermediate layer, it is adhered to the inner surface of the dura mater (so it also extends down to the level of S2) and is formed by a thin web-like arrangement of delicate collagen and some elastic fibers.
3-Pia mater:- this one is the inner most layer, it is firmly attached to spinal cord (and brain), thus it ends with the spinal cord at the level L1/L2. This layer is associated with two important folds or ligaments, which are: -
1- the denticulate ligaments that attach the spinal cord to the arachnoid mater and inner surface of the dura mater. It gives more stability.
2- filum terminale internum; as the spinal cord comes to an end at the level L1/L2, and since the pia matter is tightly attached to the spinal cord, so the pia matter will close and form this fold at the level L1/L2, this then extends downward attaching the spinal cord (indirectly and through the filum terminale externum) to coccyx.

-Spaces :- the 3 above-mentioned layers are separated by the following spaces: -

a-epidural space, sometimes called extra dural space because it is the space outside the dura mater, between the dura and the vertebral canal. This space is fat-filled and is used to inject anesthetics (e.g. in case labor, commonly known as" ابرة الظهر " .

b-subdural space, this is a slit-like, narrow space that is filled with serous fluid.
c-subarachnoid space, this is probably the most important space, because it is the largest space, and it also contains the CSF making it of a great diagnostic value. In certain medical diagnostic conditions, a CSF specimen is needed, so in order to collect it, we perform a lumbar puncture (LP) also called “spinal tap” at the level of L3-L4 (opposite to supracristal line), why L3-L4? To avoid the spinal cord as we don’t want to accidently cause injury in it.

Note: -

-the brain has 4 hollow spaces called ventricles, 2 lateral ventricles that opens into a central 3rd ventricle, which in its turn communicates with the 4th ventricle.
-the 4th ventricle is located between the cerebellum and the brain stem, it is continuous with the central canal, and communicates with the subarachnoid space through its two lateral and single median apertures(foramina). CSF (Cerebrospinal Fluid) circulates between the subarachnoid space and the 4th ventricle.

-in case of meningitis, bacteria may be seen in CSF. In case of subarachnoid hemorrhage, blood will be seen in CSF upon performing a spinal tap.

-Spinal cord segmentation: -

As previously mentioned, the spinal cord is segmented into 31 segments, each segment gives rise to a corresponding spinal nerve. The spinal cord segments are not in line with the corresponded vertebrae and the difference increases as we go down (for e.g., S2 spinal segment is not at the level of S2 vertebra, instead it's at the level of L1, see table 1 for more details). The reason behind this contrast between the spinal segments and vertebrae is due to the difference in growth rates between bones and spinal cords, so in neonates, the spinal cord occupies the whole vertebral canal, but then, bone development will outgrow the spinal cord until in adults, the spinal cord will occupy only two thirds of the vertebral canal.

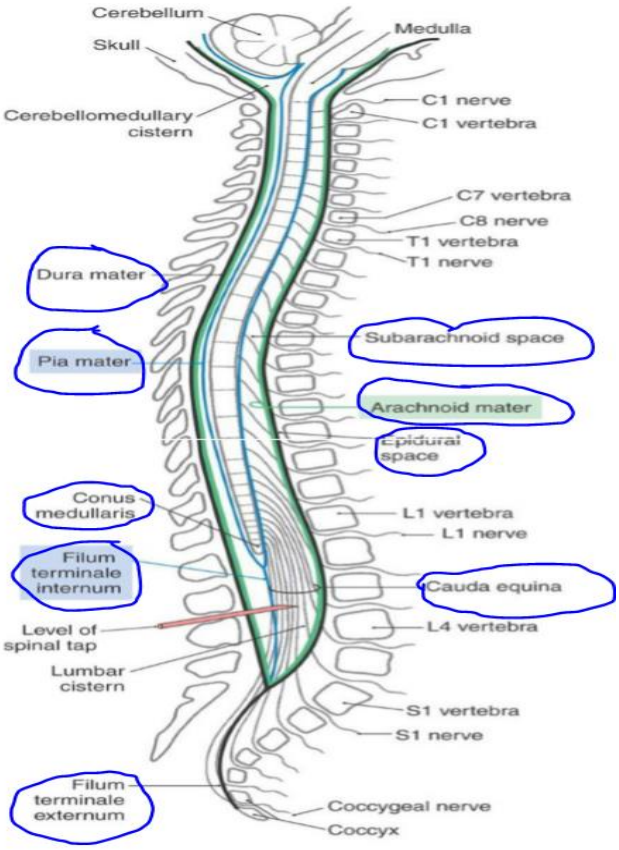


Figure (4), important figure showing the 3 coverings of the spinal cord, the corresponding spaces and other features.

Each spinal nerve emerges from the spinal column through inter-vertebral foramen by passing below their corresponding vertebra(except the first 7 cervical, they pass above their corresponding vertebra, see fig (6) at the end of the sheet), this means that the root of a spinal nerve will pass from their origin at the spinal segment, until they reach the intervertebral foramen below the corresponding vertebra, and since as we go down in the spinal cord, the corresponding vertebra will become more and more far away from the spinal segment, then the root of the nerve will be traveling further and further away from its point of origin, and thus will be longer. In other words, the roots of the spinal nerves increase in length as we go downward giving us the horse tail appearance we call "Cauda equina" in the lower third of the vertebral canal.

Spinous process	spinal cord segment
C7	C8
T3	T5
T9	T12
T10	L1-2
T11	L3-4
T12	L5
L1	S1-end

Table 1

Disk herniation (clinical application, very important)

-70% of the total body weight is beared by the vertebral column, and that's why disk herniations are common. The intervertebral disk has two main parts, an outer *Annulus fibrosus* made from fibrous cartilage, and an inner *nucleus pulposus* (see figure 5). Sometimes, and due to the very high pressure, nucleus pulposus may leak out through annulus fibrosus compressing certain spinal nerve root.

-most commonly, this leakage is posterolateral in direction because that's where annulus fibrosus is weakest and thinnest.

-95% of the cases involve L4/L5 IV disk or L5/S1 iv disk.
-this condition is what our community know as "الديسك".
-due to nerve compression, there will be many symptoms, determined specifically by the nerve compressed and its associated dermatomes and myotomes.
-a dermatome is the area of skin supplied be a certain spinal nerve, the myotome is the specific skeletal muscles innervated and supplied by a specific spinal nerve (Fig 7).
-although it's hard to memorize all dermatomes and myotomes, it's very important (for the clinical practice and exam material wise) to memorize and understand the common case scenarios of disk herniation summarized in table (2).

Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris	Anteriomedial leg (saphenous)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsifelxion (EHL) and TA	Big toe , anteriolateral leg (Common P)	~~Hamstring jerk~~
L5-S1	S1	45-50%	Foot planter flextion (Gastrocnemius)	Lateral border of foot (sural)	Ankle jerk

(table 2)

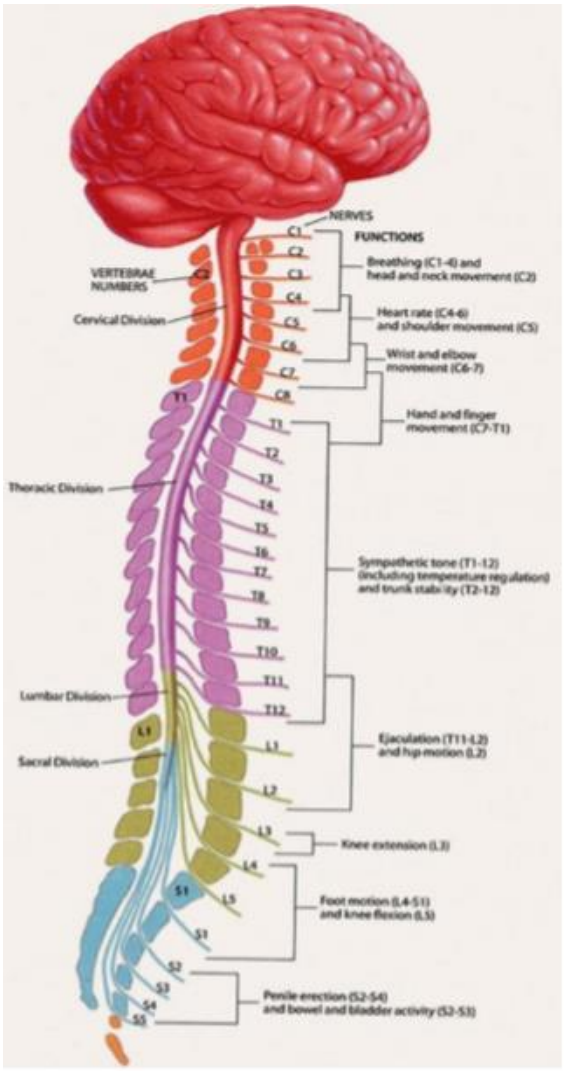
please note that:-
1- in case of L4-L5 disk herniation, its most commonly L5 root to be affected (because the leakage is posterolateral) but in some rare cases, if the leakage is far lateral in direction, the affected root will be L4.
2-knee jerk is reflex where the knee joint extends upon tapping on patellar tendon.
3-Quadriceps femoris is supplied by femoral nerve(root value L2,L3&L4),saphenous is branch of femoral.

-sensation won't be lost because the nerve is not teared, but will instead by affected (paresthesia=abnormal sensation).

-EHL; - extensor halluces longs, TA; - tibialis anterior, Common P branch of sciatic (root value L4-S3, ventral rami), sural nerve is a branch of tibial, which is a branch of sciatic.

Test L5: by asking the patient to stand on his heels.

Test S1: by asking the patient to stand on his tiptoes.



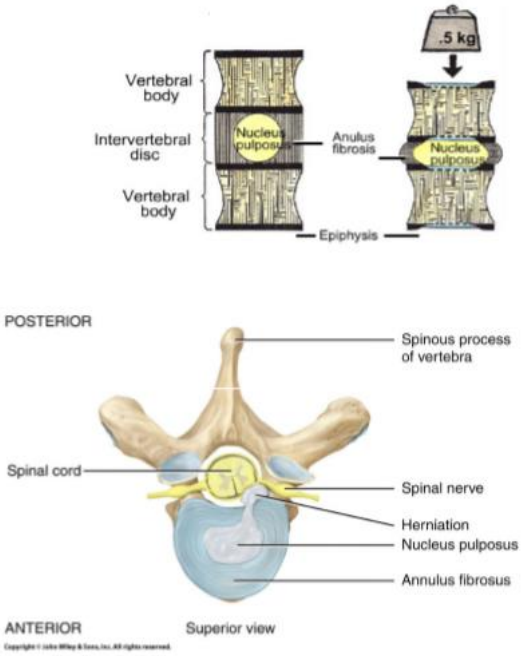


Figure 5, structure of intervertebral (IV) disk.

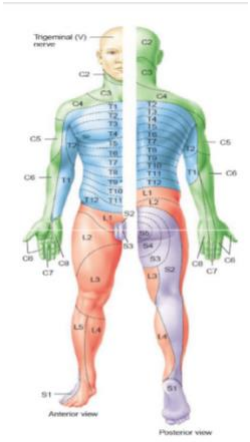


Fig 6

Fig (7)

The End.
Feel free to reach me upon any mistake or inconvenience, thank you and good luck.