Human Physiology
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Week - 11
Lecture - 03

Hello everyone, welcome to another new class on human physiology. In this class, we will discuss the spinal cord and also different nerves, for example, cranial nerves and spinal nerves, and we will examine their functions. So, as you remember from our last few classes, we discussed the nervous system; we also discussed different types of nervous systems, for example, the central nervous system and the peripheral nervous system. In the last class, we also discussed thoroughly the brain and its functions. So, let us see what the role of the spinal cord is in this class. So, let us stick with it.

So, what different content will be covered in this class? So, we will first discuss the spinal cord, its different parts, and their functions. We also discuss two different areas, for example, the gray matter and the white matter. We will also discuss cranial nerves, spinal nerves, and their functions. So, start with, this is our spinal cord, which is a very important organ mainly for rapid reflexes.

It also acts to create a bridge between our peripheral nervous system and the central nervous system, where sensory types of neurons or responses are collected. From throughout the different parts of the body, signals are eventually transmitted to the spinal cord, and through the spinal cord, the signals can be transported to the brain. And once the brain processes the signal, it can eventually also send different types of signals, or motor signals, and through the spinal cord, those motor signals will eventually be transmitted to our skeletal muscles and other glands. So, in this way, the spinal cord basically serves to maintain the primary communication pathway between the brain and the peripheral nervous system. So, to start with a different anatomy of the spinal cord, the first thing we have to know is that the spinal cord also has a meninges-type membrane layer.

So, you remember that in the case of the brain, we discussed that there are three layers: the dura mater, the arachnoid mater, and the pia mater. In the same way, in cases of the spinal cord, the meninges layer, which is basically a protective layer of the spinal cord, is also present. It has three distinct sections. The first one, which is the outer side, that you can see, is the dura mater. So, basically, it is the outermost tough and fibrous layer, and it kind of creates a protective type of sac inside, right? Then, in between, you can see there is this arachnoid mater, which is mostly the middle and wavy layer, separated from the dura mater by the subdural space.

and the inner part, which is the pia mater. This is basically the innermost and very delicate layer directly attached to the spinal cord and the subarachnoid space, situated between the arachnoid mater and the pia mater, where the CSF fluid is also present. So, basically, this space between the arachnoid mater and the pia mater is where we have the cerebrospinal fluid. And if you remember that we said that cerebrospinal fluid has a crucial role not only in basically supplying the different types of nourishing nutrients to the spinal cord, nerves, and neuronal tissue, it can also carry different immune cells in cases of infection. So, to discuss the structure of the spinal cord, we first have to understand that there are two distinct areas.

So, this butterfly-type area you can see here, right? This butterfly-shaped region is mostly called the grey matter, and then this outside part is called the white matter. So, what is basically gray matter and white matter? So, you can see this is a nice structure of a neuron. So, in our next class, we will thoroughly discuss the structure of the neuron, and we will also see what the different components of the neuron are and their functions. But just to see, this is a neuron where these are the dendrites, this is basically the soma or the cell body, and now we have the axon and these are the axon terminals. So, many of you already know.

But here you can see in the action area there are fat sheets or membrane types; these are insulating sheets which are also called myelin sheets. And as I said, these myelin sheets are made of a lipid or fat component, and they are basically a little bit white. So, in cases of white matter. A lot of the majority of the portions are present with this myelinated action, which is why this is relatively white in color. But contrary to this, in this butterfly area in this gray matter, which is mostly located centrally, there are other neuronal cell body dendrites and unmyelinated axons.

So, relatively, this area, the butterfly area, is relatively dark in color because it does not have any myelin sheath or basically fat. So, just like it's easy to remember, the white area has a lot of fats, which are basically white in color, relatively white in color, but this dark area does not have fats. So, it is comparatively darker in complexion. So, apart from the dark matter and the white matter, we also have a central canal. So, you can see there is this central canal or central hole, which is basically a very small channel running through the center of the gray matter, and it contains the CSF or cerebrospinal fluid.

which is kind of a continuous pathway towards the ventricles of the brain. So, this small canal basically carries the CSF fluid and eventually connects the spinal cord directly to the brain ventricles. So, one by one, we will discuss their kind of anatomy. So, first we will start with the gray matter, and as we said, it is mostly centrally placed and a little bit dark in color because there are no myelinated axons present here. Rather, it is rich in different types of neuronal cell bodies, such as soma, dendrites, unmyelinated axons, and neuroglia.

And you can see that it mostly has two components: one is the dorsal horn and the other is the ventral horn. So, in cases of the dorsal horn, it basically acts as a sensor input. So, all the signals from the peripheral part of the body are the sensory signals it kind of receives. In the dorsal horn, once these signals are processed, all the motor signals basically pass through the different parts of the organ or the muscles through this ventral horn. So, basically, the dorsal horn acts as a sensory type of input chamber, and the ventral horn serves as the outlet for all types of motor-related expressions or signals.

gets transmitted to different part of our body. And you can see in between there is another component where a bridging kind of happens, which is also called a lateran horn, and is basically mostly found in the thoracic region, like T1 to L2, and the upper lumbar segment, which is basically L1 to L2. This is only like two areas, mostly the T1L2 and the L1L2 of the spinal cord; this lateral horn can be seen. This also contains a lot of cell bodies of the autonomic motor neurons, and basically, as you know, the autonomic motor neurons can trigger a lot of sympathetic and parasympathetic activities. In the white matter, we said that they have a lot of myelinated axons, which means it contains a lot of fat, making it white in color.

So, in terms of organization, there are certain sections I will not go into too much depth, but you can see that there is this dorsal column, which basically contains the ascending tract. And then it has lateral columns that also have ascending tracts, for example, the spinothalamic tract and spinocerebellar tracts. You can see this area where the spinocerebellar tract and the spinothalamic tract are located. These are present in the lateral column and, in cases of the descending tract, there are the rubrospinal tract and lateral corticospinal tract. So, in the ascending column, there are the spinocerebellar and the spinothalamic tracts.

Eventually, what is their role, as you can see, is that for the spinothalamic tract, it transmits pain, temperature, and touch sensations to the thalamus. In cases of the spinocerebellar tract, it basically transmits proprioceptive information from the body to the cerebellum. This is why this is important: because it is highly important to maintain the coordination and balance of the body. And in terms of the descending tract, the lateral corticospinal tract has a major motor pathway that is responsible for different voluntary movements of the limbs, especially fine motor skills that it can manipulate. In terms of the rubrospinal tract, it also has a crucial role in maintaining motor coordination and posture.

So, they have different specific roles in different areas. Finally, as you can see, both the ventral columns and the inside of the ventral columns contain the vestibulospinal tract, which is highly important for maintaining balance and posture. And in terms of the tectospinal tract, it is involved in reflex movements of the head and eyes. In the same way, this type of tract also has an ascending tract and a descending tract. So, now, we will need to discuss the different cranial nerves.

So, as we know, we have 12 pairs of cranial nerves. They mostly start with 1 in terms of numeral nomenclature. We basically create the nomenclature from CN1 to CN12. Okay, and these cranial nerves can be either sensory, motor, or mixed. So, basically, some of the cranial nerves can be responsible only for sensory types of applications, some of them can be responsible for motor applications, or they can have both sensory and motor functions.

So, what are the different types of cranial nerves we have? So, let us see them one by one. So these are like total cranial nerves. So first, let's see what the different types of cranial nerves are. So we have the olfactory nerve, which is cranial nerve I. Then we have the optic nerve, which is cranial nerve II.

Then we have the oculomotor. We have a trochlear. We have trigeminal neuralgia. Then we have the abducens. We have a facial nerve. We have a vestibulocochlear nerve.

We have the glossopharyngeal nerve. We have a vagus nerve. Then we have accessory nerve. We have accessory nerves. And then finally, we have the hypoglossal nerve, which is CN XII, or the twelfth cranial nerve.

In terms of cranial nerves, as I said, there are three categories: it can be completely sensory, it can be motor, or it can be mixed, where both sensory and motor fibers are present. So, in the case of sensors, you can see the olfactory, which has a role in smell, and then the optic, which is cranial nerve II and has a role in vision, and then the vestibulocochlear, which has a role in hearing and balance. So, cranial nerves 1, 2, and 8 are all basically sensory nerves. So, only sensory nerves. That means they carry signals from the sensory receptors from different parts of the body, like the skin, eyes, and ears, and they send those signals directly to the CNS in the brain.

So, you have to remember that these cranial nerves are directly connected to our brain and the spinal cord. Then, in terms of motor nerves, CN3, which is the oculomotor nerve, has an important role in eye movement; CN4, the trochlear nerve, also has an important role in eye movement; CN6, which is the abducens nerve, also has an important role in eye movement; and CN11 and CN12 have roles in shoulder and neck movement and tongue movement. And as by the same responses or by the applications of the function, you can see that this type of nerve has an important role in terms of various sorts of movements of different parts, which means they are motor nerves. So, basically, this CN 3, 4, 6, 11, and 12 carry signals from the CNS, like the brain and spinal cord, and then they send these effector signals to different parts, like muscles and glands. Lastly, the CN5, which is a trigeminal nerve, has a sensory role for the face and also has a motor role in terms of chewing muscles.

In the same way as 7, 9, and 10, in the case of 7, it is present in the facial area. So, it has a sensory role in terms of having taste, and it also has a motor role in terms of facial muscles. In the case of the glossopharyngeal nerve, it has a sensory role in the throat and taste; along with that, it also has a motor role in terms of swallowing muscles. And then, in cases of the vagus nerve, it has a sensory role in terms of an organ motor role for the heart, lungs, and digestive system. So, you can see that these cranial nerves, which are like 5, 7, and 9, are all types of mixed nerves, right? So, they basically contain both sensory and motor fibers.

You can see there are about three distinct categories, and this is a very nice chart from which you can easily distinguish which cranial nerves have which type of function, such as sensory neurons, motor neurons, or mixed nerves. So, in terms of detailed application, we have already said about this, but let us quickly touch base on it. So, in terms of the cranial or olfactory nerve, it is like a sensory nerve and it has a function in terms of the sense of smell. In terms of the optic nerve, it has been responsible for vision; it is also a sensory nerve. In terms of the oculomotor nerve, it is primarily a motor nerve that controls eye movement, and you can see its areas; the olfactory nerve is located here, the optic nerve is located over here, and the oculomotor nerve is located over here.

So, you can see their location inside a brain and spinal cord. The trochlear nerve, as we said, has a motor role, and it functions in terms of controlling the superior oblique muscles of the eye. In terms of the trigeminal nerve, which is CN V, it is mixed; basically, it has sensory and motor roles, and it has three major branches, including the ophthalmic, maxillary, and mandibular, each with different types of roles. In the case of the abducens nerve, it is mostly motor and controls the lateral rectus muscle of the eye. In cases of the facial nerve, as you can understand, it is mostly mixed, having both sensory and motor functions.

In terms of motor function, it controls the muscles of facial expression. In terms of sensory, it kind of helps with the taste sensation from the anterior two-thirds of the tongue. In cases of autonomic dysfunction, it stimulates the salivation and lacrimation processes. In the cranial 8, or the vestibulocochlear nerve, it primarily has a sensory role and is also called the auditory nerve. In terms of cranial nerve IX or the glossopharyngeal nerve, it is a mixed nerve that has both sensory and motor functions.

It also has an important role in terms of taste sensation, and in terms of motor application, it controls different types of muscle movements; for example, swirling, and it also has some sort of autonomic response or function; basically, it stimulates salivation. In the case of the vagus nerve or cranial nerve X, as we already said, it has a mixed type of application or function, both

sensory and motor. In terms of the accessory cranial nerve XI, it is primarily a motor nerve, right? So, basically it controls different muscle movements that are needed for the head, neck, and shoulders. In the case of the hypoglossal nerve, which is the last cranial nerve, it primarily has motor activity and controls the muscles of the tongue, which are very important for speech, chewing, and swallowing. So, lastly, we will also introduce different types of spinal nerves that are mostly present near the cervical area.

So, in terms of our spinal cord, as we know, there are four distinct areas. So, this is basically the cervical area where eight cervical nerves are present, which are termed as C1. To C8, and then we have the thoracic area. So, from the thoracic area on both sides, there are almost 12 pairs of thoracic nerves, which are termed T1 to T12, and then after the thoracic region, we have the lumbar region.

And then finally, we have the sacral region. So, in the lumbar region, we have L1 to L5. So, a total of 5 pairs of nerves, and even in the sacral region, we have 5 pairs of nerves, which are S1 to S5. So, basically, each of these spinal nerves is formed by a collection of neurons, right? So, as we already said, we will thoroughly discuss the neurons and their functions in our next class, but nerves are basically a collection of combined or coiled forms of too many neurons together. Right and contrary to the cranial nerves, all these spinal nerves are mixed nerves. So, here in the cases of spinal nerves, both mixed types of motor and sensory nerves are present.

and they have like distinct function. So, in cases of cervical nerve issues, as you see, this controls the muscles in the neck, shoulders, arms, and hands. The thoracic nerves supply the skin over the chest and back muscles. Lumbar nerves supply responses to areas such as the legs, bowels, and bladder. Sacral nerves supply responses such as those to the skin over and between the coccyx and the anus. So, these nerves, in this way, kind of have a mixed role.

So, basically, they are also sensory nerves. So, they will receive the sensory signals from all these respective areas mentioned here, and they will send the efferent signals or the motor signals to all the peripheral body. And then finally, we'll quickly touch base on the combination of spinal nerves, which is also called the spinal nerve plexus, which is basically a network of intersecting nerves that have a specific region in the body and a specific function. So, for example, there is a network of nerves you can see in the cervical area, which ranges from C1 to C5 and is also called the cervical plexus. So, these innervate the muscles and skin of the neck, upper chest, and shoulders. And then in the brachial plexus, which mostly has a network between the C5 and T1, it innervates the upper limb; for example, the shoulder, arm, forearm, and hand.

And finally, the lumbosacral plexus is mostly located from L1 to S4. So, like in the L1 to S4, you will also see a network of nerves, mostly the inner weights: the lower limb, like the thigh, leg, foot, pelvis, and the perineum. And there are different key nerves also present in the lumbosacral plexus; for example, the femoral nerve and the sciatic nerve. So, all these nerves have different types of functions because they are present in different areas. More interested, you can kind of go through the reference books which are given here.

You can also consult different web content if you have further questions to discuss with us during live sessions. Along with that, you can drop your questions via email. So, what are some basic differences between the cranial nerves and the spinal cord? Let us quickly differentiate them. So, in terms of origin, the cranial nerves arise from the brain or brainstem, while the spinal nerves arise from the spinal cord. So, this is the primary kind of difference, right? The

spinal nerves mostly arise from both sides of the spinal cord, while cranial nerves can originate from either the brain, the spinal cord, or the brain stem.

Then, in terms of cranial nerves, what are the numbers? So, basically, there are a total of 12 pairs of cranial nerves. In cases of spinal nerves, you remember we said there are a total of 31 pairs of spinal nerves present. So, how they number basically in terms of their nomenclature, cranial nerves are termed as C1 to C12 and Cn1 to Cn12; they are written as Cn1 to CN12. In cases of spinal nerves, they are termed as C1 to C8, T1 to T12, L1 to L5, and S1 to S5, and there is also one coccygeal nerve. In terms of function, cranial nerves either have sensory function, motor function, or can also be mixed.

But in the case of spinal nerves, as we said, all the spinal nerves are basically mixed nerves. So, it has both sensory and motor functions. Some examples, for example, the optic nerve, the facial nerve, and the spinal nerve; similarly, the radial nerve, the femoral nerve, etc. And in terms of ganglia location, it may have sensory ganglia near the brain stem, but in the case of spinal nerves, it has a dorsal root ganglion near the spinal cord. So, do you know that your spinal cord can react to certain stimuli before your brain even processes it? So, if there is a quick reflex, for example, if I touch a hot plate, the sensory signal of the pain and the heat can eventually bypass the brain.

And the spinal cord itself can create a reflex action so that we can quickly remove our hand from the source of heat. Because in this way we kind of save some time, the signal does not need to be processed in the brain. So, for any rapid and quick reflex, the spinal cord can help in a quick way. So, imagine a patient presenting with the following symptoms. For example, loss of smell, difficulty moving their eyes laterally, and drooping on the left side of their face.

So, can you tell me which cranial nerves you suspect might be affected for all these conditions? So, you go through all these cranial nerves we discussed along with their functions and try to predict based on their function and location what type of cranial nerves might be responsible for this type of malfunction. So, thank you again for attending another class of human physiology. Hopefully, you are enjoying the neuroscience class. Let us meet with another new class soon. Thank you.