1. SPINAL CORD

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In the first part, we explore the overall structure and organization of the spinal cord. This includes a detailed examination of its gross anatomy, such as the spinal cord's segments, the protective meninges, and the surrounding vertebral column. We will also cover common spinal procedures, offering insights into standard practices and techniques used in spinal surgeries. Understanding these foundational elements is crucial for grasping the complexities of spinal cord functions and pathologies.

Case 1

Presentation

A patient presents with a complaint of severe back pain. He is a student who recently completed a period of intensive studying, involving prolonged sitting at his desk. The patient acknowledges being in poor physical condition. On the day following his exams, he decided to clean his room, which he had neglected during his study period. While attempting to lift and move his desk to vacuum the floor, he experienced a sudden, sharp back pain that radiated to his right lower leg. In distress, he called 911. Paramedics responded promptly and transported him to the neurological department, fortunately you are the neurosurgeon on call.

Relavant Anatomical Background

This is the case of lumbar disk herniation. Now to understand these terms, we need to first learn more about the general structure of the spinal cord and its organization.

The spinal cord is situated within the vertebral canal of the vertebral column and is surrounded by three coverings known as the meninges. The spinal cord is like a cylinder begins at the end of the brain and ends in the lumbar region of the vertebral column.[1]

The spinal cord is organized into nerve roots each of which exit from the gaps within the vertebral column. One such gap is visible in Figure 1

Along the entire length of the spinal cord, 31 pairs of spinal nerves consist of the anterior or ventral or motor roots and the posterior or dorsal or sensory roots. Each root also contains the dorsal root ganglion, the cells of which give rise to peripheral and central nerve fibers visible in Figure 2

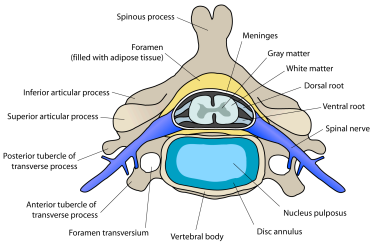

Figure 1. A figure showing a cross section through a vertebral bone.

[1] Difference between the vertebral column, vertebral canal and the spinal cord.

Vertebral column: the bony structure that houses the spinal cord.

Vertebral canal: the space inside the vertebral column that contains the spinal cord.

The spinal cord is the nervous tissue itself.

Lumbar Disk Herniation

Now coming back to the question of the medical student's injury, the herniation occurred on the right side and was relatively small. This herniation occurred between L5 and S1 spinal cord levels and the posterior (dorsal) roots of the spinal cord were compressed. Figure 3 shows the different severities of disk herniations.

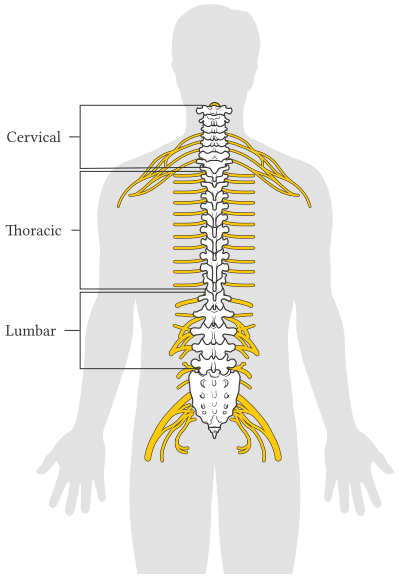

Figure 2. The vertebral column and spinal nerves exiting from it.

It is clearly visible how the contents of the intervertebral disks may compress the spinal nerves. See Figure 4 for a visualization. The symptoms may be motor or sensory function abnormalities.

Lumbar disk herniations occour most commonly in the lumbar region[2] as a relatively mobile part of the spinal cord meets the relatively immobile sacral part of the spinal cord. This area is also more common as the entire weight of the head and the thorax and the weight lifted by the upper limb is transmitted towards the legs through this region.

Figure 3 shows the pathology. The blue part in the intervertebral disk is the nucleus pulposus while the while part is the annulus fibrosus. The nucleus pulposus can be seen being squeezed into the cavity of the spinal cord where it compresses the nerves.

[2] see Figure 2

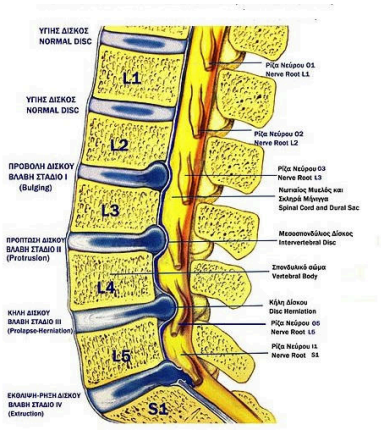

Figure 3. Lumbar Disk Herniation visualization

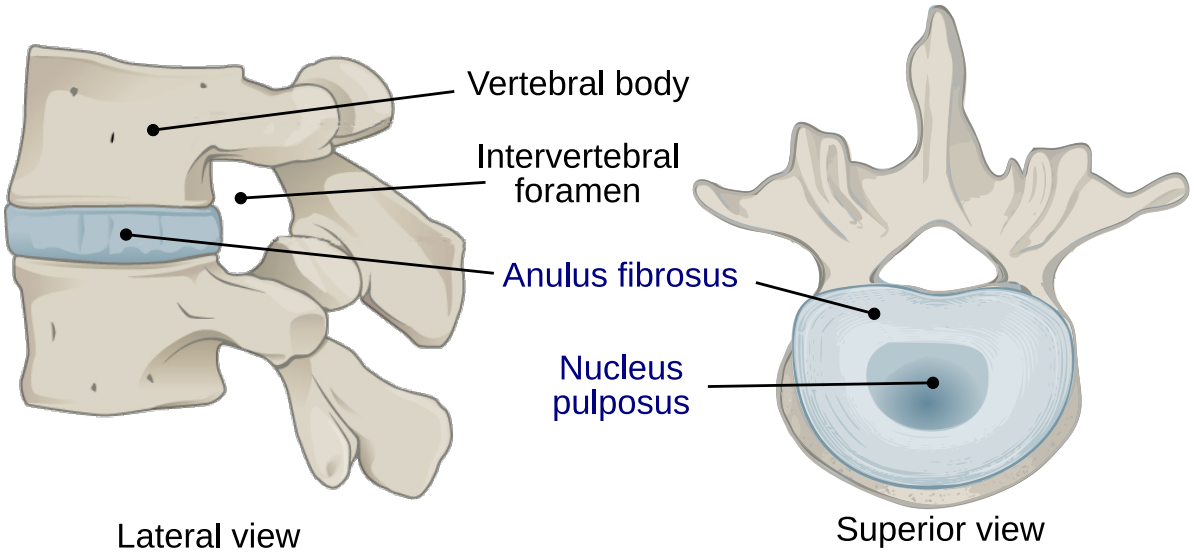

Figure 4. Views of the Intervertebral disk. The substance that can cause hernia (nucleus pulposus) is clearly visible and labelled.

This can lead to pain being felt in the leg on the side where the nerve is being compressed. As was the case of our student, his spinal nerves L5 and S1 were most probably compressed leading to him experiencing the pain. His condition is known as 'Sciatica'[3].

[3] Compression of the sensory roots will lead to pain being felt while compression of the motor roots will produce weakness of the muscles.

Case 2

Presentation

A man was involved in a motor car accident. The car hit the person head-on. First responders noticed that the person's breathing was severely affected. What is the major muscle controlling respiration and how is injury to the spinal cord related to breathing?

Relavant Anatomical Background

The major muscle controlling respiration is the Diaphragm. It is located below the lungs and can be seen in Figure 5. Its contraction leads to the increase in volume of the thoracic cavity which causes the lungs to fill up with air[4].

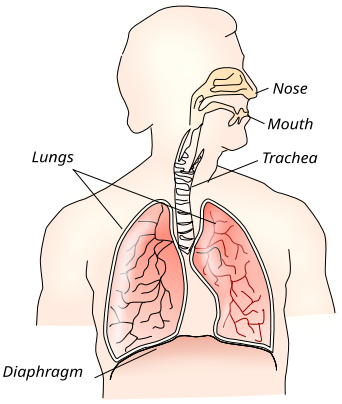

Figure 5. Diagram showing the position of the diaphragm.

[4] Further anatomical details of the diaphragm are beyond the scope of this book but more information can be found in Gray's Basic Anatomy section on Thorox and the heading is Diaphragm

The spinal nerves C3 to C5[5] which are known as phrenic nerves innervate the diaphragm. If the spinal cord is damaged above this level, control of the diaphragm is lost which could lead to death.

[5] These are the nerves that exit from the cervical spinal cord levels of 5th, 6th and 7th vertebrae.

Case 3

Presentation

A person complains of continuous and severe headaches, high fever, stiff neck and drowsiness[6]. As a neurologist, how do you manage the patient?

[6] Most of the time headaches and fever are common complaints from patients and can be safely treated by prescribing an over-the-counter painkiller but if they accompany neurological symptoms, such as drowsiness or excessive sleeping or confusion, then a neurologist must take precautions to rule out more serious underlying causes.

Relavant Anatomical Background

The person is suspected of having meningitis. It is an inflammation of the layers covering the brain and the spinal cord. Figure 7 shows the layers over the surface of the brain.

The layers in order from outside to inside are:

1. Dura Mater
2. Arachnoid Mater
3. Pia Mater

The Dura Mater is the toughest outer covering over the brain. It lies directly beneath the bone[7]. The Arachnoid Mater contains the subarachnoid space[8]. The Pia Mater is a thin layer that directly covers the surface of the brain and is usually transparent.

To obtain a sample of CSF, a lumbar puncture or a spinal tap may be performed. Figure 6 shows an image.

[7] Seeing Figure 7 will help to visualize the concepts here.

[8] Where the CerebroSpinal Fluid is circulating.

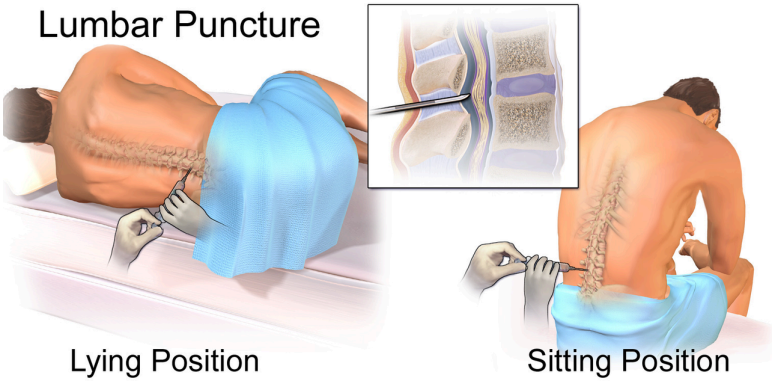

Figure 6. A lumbar puncture procedure

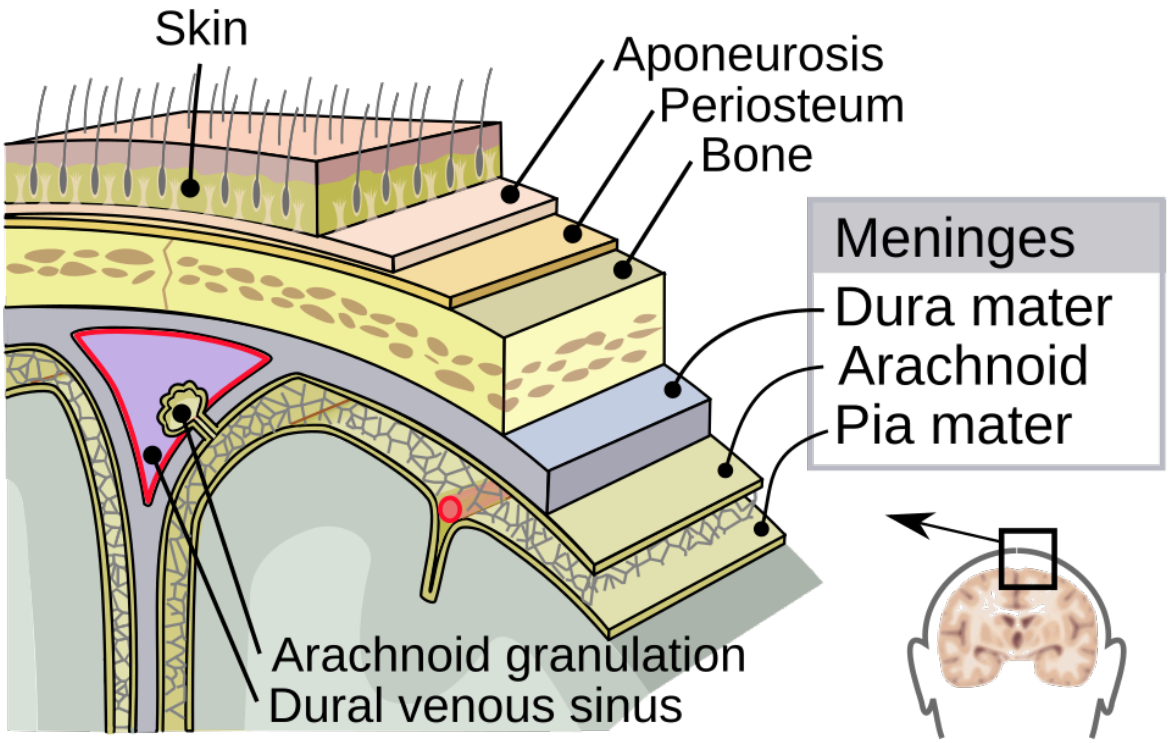

Figure 7. Image with the 3 coverings of the nervous system labelled. Namely the Dura, Arachnoid and Pia Mater. The subarachnoid space (the web-like space between the Arachnoid and Pia Mater) is also visible.

A lumbar puncture procedure may be performed to withdraw a sample of CSF to check for infections (such as meningitis in our case) or to inject drugs in response to infections or induce anesthesia[9].

One extremely important feature of our spinal cord is that the nervous tissue (of adults) ends at the level of L1 vertebra but the subarachnoid space (containing the CSF) extends until the level of S2[10]. A needle inserted into this space here, will generally not damage the spinal nerves as they will be pushed to one side owing to the fact that there is a lot of space here for the spinal cord.

Figure 8 shows the level of the lumbar puncture procedure. At the level of L4, the illiac crest of the illiac part of the hip bone can be felt. This a safe site for this procedure.

[9] This is the case for having a painless childbirth. The mother will not feel the contraction during the first stage of labour. For more details, search for 'Caudal Analgesia for Labour'.

[10] For a visualization of specific levels of the spinal cord, refer to Figure 2

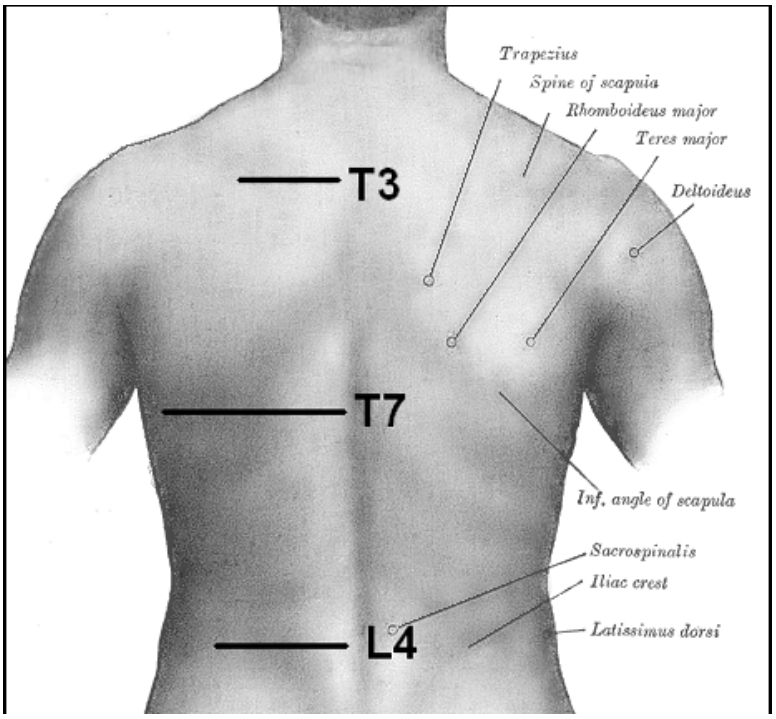

Figure 8. An image showing imporatant vertebral column levels.

After a small amount of local anesthetic, the physician can pass a spinal needle just above the L4 spinal level. After inserting the needle, depending upon the physique of the patient as for a child, the needle may have to be inserted just 1cm while for an obese adult, the physician may have to intert the needle 10cm into the lumbar spine.

This needle can be used to retrieve a small sample of the CSF for examination. The CSF pressure can be measured as well. The spinal needle fitted with a manometer can measure the CSF pressure where higher or lower values of the pressure indicate different problems. The normal pressure is around 60 to 150 mm of water.