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CENTRAL NERVOUS SYSTEM DISEASES AND SPINAL TAP DIAGNOSIS

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Central Nervous System Diseases and Spinal Tap Diagnosis

Spinal taps, also known as lumbar punctures, are a procedure to identify and help diagnose types of central nervous system conditions and infections, neurological diseases, and even mental disorders. Spinal taps date back to the 19th century; however, many of the different factors and aspects of the procedure have changed, such as the

location of where the needle is inserted, the needle size, and the sterilization.

Spinal taps are first introduced when a patient's condition must be tested further before making a firm diagnosis. Doctors first numb the lower back before the procedure is done and then place a needle between the vertebrates of the spine. Before this step, an x-ray is usually done to see where the needle should be placed. The doctor then removed a small amount of cerebrospinal fluid (CSF), a clear, fluid plasma surrounding the brain and spine, protecting both body parts from damage. The fluid is then tested for protein presence, glucose levels, and white blood cell count, among other tests. Doctors take the test results and the patient's symptoms to make a more accurate diagnosis (NIH, 2016).

Diseases Diagnosed

Some of the infectious disorders that are commonly diagnosed by spinal taps are meningitis, encephalitis, and

syphilis. These infectious diseases can be passed from person to person and are caused by microscopic organisms such as bacteria, fungi, or parasites.

Meningitis is one of the few infectious disorders that spinal taps can diagnose. It is caused when the membranes around the spinal cord and brain are inflamed, which makes the area much more susceptible to infection, and without treatment, it can be deadly. Some symptoms include headaches, fevers, and a stiff neck (Cleveland Clinic, n.d.). In severe cases, patients can have a particular sensitivity to light as well as a compromised mental state. This is all due to brain tissue being susceptible to damage from the inflammation, which can cause neurological damage,

Another infectious disorder that a spinal tap can diagnose is encephalitis. This disease occurs when the brain tissue becomes inflamed, usually due to infection of an external bacteria entering the body or by another viral

infection. While rare, there are cases where encephalitis is caused by an autoimmune response from the body, where the immune system starts attacking the tissue. Some of the symptoms of encephalitis include headaches, compromised mental state, and sometimes even seizures. If encephalitis is not diagnosed fast enough, the neurological damage can be permanent, which can affect an individual's mobility and can even cause death.

Spinal taps can also diagnose syphilis, a sexually transmitted infection that is caused by the bacteria treponema pallidum. Symptoms can include sores, rashes, headaches, and muscle aches. While there are multiple stages of such infection, syphilis can affect the central nervous system at any time. Called neurosyphilis, this is when treponema pallidum is present in the central nervous system, and while sometimes it can be undetectable, the presence of the bacterium can cause mobility issues, a

change in behavior or thinking, and even seizures (Cadavid, 2010).

Other than infectious diseases, spinal taps can also detect and identify autoimmune disorders. Autoimmune disorders occur when the body cannot distinguish between healthy cells or viruses. This causes the immune system to attack healthy cells in the body, ultimately compromising the function of the cells. A few of the autoimmune disorders that can be diagnosed through spinal taps are multiple sclerosis, neuromyelitis optica spectrum disorder, and Guillain-Barré syndrome.

One of the most common autoimmune disorders that are identifiable by spinal taps is multiple sclerosis. This occurs when the immune system attacks the layer around nerve fibers or the myelin. The myelin wears out, directly affecting the transmission of electrical impulses to nerve cells disrupting communication from the brain to the rest of the body. The disorder cannot be born with and can only be

developed. Some symptoms include troubled vision, coordination issues, loss of senses, and overall mobility (Johns et al.). Since this disorder directly impacts the CNS and the PNS (peripheral nervous system) as well, many who are diagnosed with multiple sclerosis report that they have a lack of control over what they can do in terms of physical movement. This is due to the signals that the brain sends to make movement possible compromised because of the deterioration of the nerve fibers.

Neuromyelitis optica spectrum disorder is another disorder that a spinal tap can diagnose. It can often be mistaken for multiple sclerosis, with many patients being misdiagnosed with it. When someone gets diagnosed with this disorder, doctors identify that myelin and axons of neurons, as well as the optic nerves contained in the retina of the eyes, are being targeted and attacked by the immune system. Symptoms are very similar to multiple sclerosis, but those with NMO are more susceptible to permanent

damage in the eye (Mayo Clinic, 2022). Many autoimmune disorders that affect the CNS have similar symptoms as many bodily functions are compromised due to parts of the brain or connecting body parts being inflamed or damaged. Since they are damaged, the signals the brain sends out are not being processed or sent out in the first place.

Guillain-Barré syndrome is a rare disease where the immune system starts attacking the nerves in the PNS, which directly affects the CNS as the signals sent out from the CNS can not reach their final destination if the PNS is damaged. The main symptom is paralysis, where the patient starts feeling a tingling sensation in their limbs, which starts to spread throughout their body, causing unable to move (NINDS, n.d.). The body then begins to lose its senses, and in worst-case scenarios, the patient might forget how to breathe. Guillain-Barré syndrome does not have a cure, but some treatments can help slow the process of paralysis and also gain senses back.

Spinal taps can also identify mental disorders, particularly dementia. Dementia is a memory disorder most common in older people, usually 60 years or older. Some symptoms include short or long-term memory loss, cognitive deterioration, and sometimes visual challenges. While there are different stages and types of dementia, the most commonly known is Alzheimer's. Alzheimer's occurs when there is an excess of a protein in the brain, usually a protein that is not commonly found in the CNS.

Lab Analysis

When the CSF, collected by a spinal tap, is sent out to labs, they are studied in multiple ways. The first thing that is looked at is the color and clarity of the fluid (Testing.Com, 2021). Any abnormal coloring or cloudiness in the fluid can mean an abnormality or infection in the CNS. They then do chemical testing to show blood, glucose, cell count, antibody abnormality, and protein levels. The lab can also test the CSF by doing a CSF

culture, where the lab identifies if the CSF has any bacteria, fungi, or viruses present in the fluid. With the lab results, the doctors can more likely make an accurate diagnosis because CSF abnormalities directly connect with the different infections and diseases someone can have (Hirsch, 2021).

All patients with an infectious disease affecting the CNS have increased white blood cells, elevated protein levels, and changes in glucose levels in their CSF lab results. The increase of white blood cells is a bodily reaction where the immune system tries to fight off the infection with the white blood cells. The protein level increase is commonly found in bacterial meningitis, encephalitis, and syphilis, which helps doctors determine what type of meningitis a patient might have, depending on which proteins are present. However, in most cases, increased proteins are another bodily response due to brain inflammation. Glucose levels decrease because the immune

cells fight the infection, consuming more glucose to have energy to fight off the infection that bacterial meningitis can cause. However, unlike meningitis, both syphilis and encephalitis have limited change in glucose levels, usually staying consistent in patients who carry these infectious diseases. For syphilis, however, other tests can be run on the CSF for specific antibodies, such as treponema pallidum antibodies that are found in patients who have syphilis. On the other hand, encephalitis must be tested for genetic material most commonly found in the virus through PCR (Polymerase Chain Reaction), where DNA fragments are replicated at a large scale to identify/study a specific gene. For meningitis, the CSF must be tested for specific bacteria such as streptococcus pneumonia, haemophilus influenzae, and Neisseria meningitidis (WHO), the three most commonly found bacteria that are known for causing meningitis.

Unlike infectious disorders, autoimmune disorders are particular, and the CSF has to be tested for specific abnormalities to identify what disorder a patient might have. Multiple sclerosis can be identified when tested for immunoglobulin. This antibody is a glycoprotein plasma cells produce (Justiz Vaillant, 2023). They are made when the body responds to fight against a virus, infection, or other unwanted things entering the body. But when a patient has multiple sclerosis, the CSF has elevated levels of this antibody since the body is attacking the CNS mistakenly with said antibody. For NMO, the CSF must be tested for an antibody for Aquaporin-4. Aquaporin-4 is a protein that acts as a water channel to let water into cells, and the antibody is a clear indicator of NMO and helps doctors differentiate the difference between multiple sclerosis and NMO (Jarius, 2013). For Guillain-Barré syndrome, tests look specifically for any sign of albuminocytological dissociation. This is when the CSF test

results show that there are elevated levels of proteins present in the CSF with little to no change in the levels of white blood cells, which reflects the breakdown of the blood-nerve barrier caused by the disorder making the immune system react abnormally (Brooks, 2019). Other than Guillain-Barré syndrome, most autoimmune disorders that require a spinal tap have signs of elevated levels of white blood cells as the immune system is still sending the white blood cells out to fix whatever is wrong with the body, even if it is mistakenly causing the issue.

Unlike both infectious diseases and autoimmune disorders, mental disorders, especially those that are related to dementia, have an increased level or just a presence of specific proteins. Found in both Frontotemporal Dementia and Alzheimer's Disease, there is a presence of Tau proteins that are found in the CSF. Tau protein helps stabilize the internal skeleton of neurons in

the brain, but when the proteins build up in the brain, they can cause the brain's processing abilities to slow and break down the internal skeleton of the brain (Alzheimer's Association, 2021).

Conclusion

Diseases within the CNS, such as infections, autoimmune, or mental disorders, can have similar symptoms, which can make it difficult for doctors to diagnose their patients properly. Doctors run the risk of misdiagnosing patients, prescribing them the wrong medicine, and giving them improper treatments. With spinal taps, doctors can look at what is occurring inside the CNS and identify the disease. The CSF can differ from person to person, but diagnosis can be a much more accurate process through spinal taps and analysis of the CSF.

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