Diseases 1

[00:00:00.59] In this lecture, we're going to review some causes of diseases and injuries to the nervous system which might cause a person to seek a neural engineering treatment. For each disease or injury, I want you to be able to recognize one to three key symptoms, identify the specific region of the brain or body involved that causes those symptoms, and name one to two common currently available treatments that a person might currently receive for that disease or injury. I then want you to think about ways that neural engineering could be used to prevent injuries or diseases in rehabilitation in the short term or for long-term treatments.

[00:00:41.85] Now we're going to review some common injuries to the nervous system. One of the most recognizable injuries to the nervous system is spinal cord damage, which can come from a variety of causes. Traumatic causes include most commonly car accidents, also falls, violence, especially gunshot and knife wounds, and sports and recreation incidents. And non-traumatic causes include vascular injury, which is a stroke or an aneurysm, cancer, infections, degenerative diseases, and other rarer causes.

[00:01:16.29] The most common treatments for spinal cord damage today include mobility aids and occupational therapy. We're not really able to successfully restore spinal cord damage after an injury. And the best that we can do is occupational therapy to help route around an injury and use whatever portion of the cord is remaining.

[00:01:36.12] The effect of a spinal cord injury on symptoms is going to depend on the level of the injury in the cord, how far up the body did the injury occur; the location in the cord, what part of the spinal cord was damaged; and whether the damage was complete or incomplete. So the level of the chord, the information coming in and out of the spinal cord enters close to the level of the body where the sensory information is coming from and the motor information is going to. So injuries that are lower down in the spinal cord are going to affect less of the body than injuries that are higher up in the spinal cord. An injury in the cervical section of the spinal cord, which corresponds to the hand, part of the arm, and the upper torso and neck-- those injuries are less common and more severe because it doesn't just affect the cervical portion of the body. It affects everything below it.

[00:02:38.49] The location in the cord also matters as far as the symptoms. We're going to go more into spinal cord anatomy later. But for now, just know that there's parts of the spinal cord that handle exclusively sensory information and parts that handle exclusively motor information.

[00:02:55.49] Plus, the entire spinal cord is divided so that information from the right side of the body is mostly carried on the left side of the spinal cord and vice versa. There's some that's carried on the same side of the body that it corresponds to. And that you could have an injury that affects only motor function or only sensory function or only the left side of the body and so forth.

[00:03:18.10] And this brings up the final point, which I have been making implicitly all along, which is that injuries are mostly incomplete. A complete spinal cord injury at any level is relatively uncommon. The vast majority of injuries are incomplete, which means that some

function is preserved and occupational therapy can be very effective in routing some functions into the surviving portion of the spinal cord.

[00:03:48.48] I want to review concussion versus open head injury and the distinction between the two. A concussion is caused by the brain hitting the inside of the skull. That's what this diagram on the left is showing. And a severe concussion can cause a contusion or bruise on the surface of the brain. Whereas in contrast, an open head injury is caused by a breach of the skull and it usually leads to a significantly larger area and certainly more severe damage.

[00:04:17.04] This picture shows Phineas Gage, which was a famous example of an open head injury. He had this rod driven through his skull as a result of a mining accident. And the computer simulation on the right side models the path of the rod that went through his skull based on a reconstruction of his skull. And it destroyed most of his prefrontal lobe and one of his eyes. But he survived for 20 years after the fact and he had some pretty significant cognitive difficulties afterwards.

[00:04:51.45] Concussion is usually treated by rest, light physical activity, and pain killers. Open head injuries are far more complex and the treatment is generally more supportive and less successful. You don't generally see as much recovery of function in an open head injury as you do with a concussion.

[00:05:09.04] In case of repeating concussions, a person can develop Chronic Traumatic Encephalopathy or CTE, which has been in the news lately because it's increasingly recognized as an effect of playing football for many years. So it's caused by repeated small, usually subclinical or unrecognized brain injuries over the course of years. And you don't necessarily have to have had a concussion at all in order to develop CTE, the vast majority of people who develop CTE did have clinical level concussions.

[00:05:44.97] The cellular pathology is quite similar to Alzheimer's, but it has a very different distribution of what cells are affected in the brain. So you can see in this diagram on the right side of the screen that you have tau proteins which aggregate and damage neurons, leading to cell death. So you have the long axon and the tau proteins usually contribute to helping maintain the architecture of that long, skinny tube that is the axon. And when these tau proteins fall apart, then they form into these tangles. And that can kill the cell by inhibiting intracellular transport.

[00:06:23.95] It's most common in football, soccer, boxing, and rugby players, so high contact sports that are very likely to result in a concussion. As with Alzheimer's, which has very similar cellular pathology, there are currently no known treatments. And the effects on the cortex look very similar, as well. That's what you see on the left side of the slide, that you have a normal brain, an undiseased brain, and then you have an injured brain where the cortex has shrunk due to cell death. Many professional former football players and boxers are now donating their brains to science to help in the study of CTE in order to develop more effective treatments and to better describe the disease because it's only been recognized for about 10 years.

[00:07:13.97] Among the most common brain injuries are stroke, aneurysm, and hypoxia. So hypoxia is anytime oxygen doesn't reach the brain and it causes hypoxic damage or lack of

oxygen damage. And it's most commonly due to the blood supply being cut off, but it can also be due to suffocation.

[00:07:34.93] So on the left side of the slide, the blue background shows ischemic stroke, which is a blockage, usually a clot, that causes about 87% of strokes. And on the top is a thrombosis, which is a clot that actually developed in the brain. And it just clogs up whatever artery it's in and it prevents blood from reaching the part of the brain that that artery normally serves. And on the bottom, we have an embolism, which is a clot that developed elsewhere in the body, broke off, and then traveled to the brain. And on the right side, we have a hemorrhage or bleeding, which is 13% of strokes, which is a blood vessel bursts and leaks and that compresses the brain and it cuts off the blood flow.

[00:08:22.65] Some of these are aneurysms, which is ballooning and weakening of the vein. So it sort of pops up like a balloon animal. And then eventually, it will burst and the blood will pour out into the surrounding areas. And some hemorrhages are caused by arteriovenous malformations, which is just the blood vessel didn't form right in development and it weakens over time.

[00:08:49.92] So the treatment specifics for stroke, aneurysm, hypoxia and any other conditions that result in a loss of blood supply or oxygen or both to the brain depend on the location of the injury. So the treatment that is going to be helpful for, say, thalamic stroke are not going to be at all the same as the treatments that are helpful for a person who had occipital lobe stroke. But generally speaking, the treatments are different types of occupational therapy to help the person get used to using whatever function remains.