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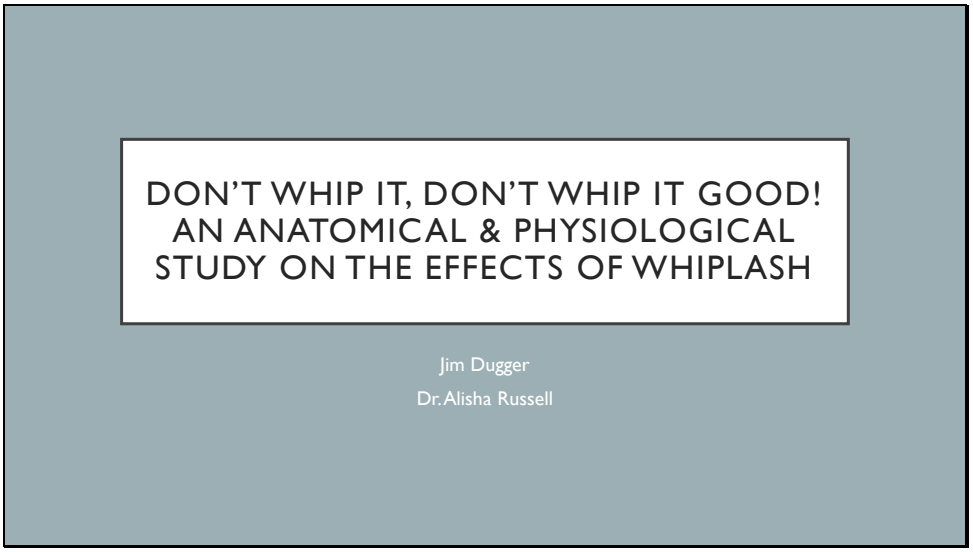

Abstract

Cervical Acceleration/Deceleration Syndrome, also known as Whiplash, is a very common cervical spine injury that has annual costs in the United States more than all cancer and cardiovascular treatments combined. Older research used traditional nMRI imaging techniques to diagnose structural damage occurred from Whiplash. Newer research that uses newer imaging techniques, fMRI and PET scans have indicated that even low grade whiplash injuries can have more sever and longer lasting effects on neurodegeneragtion than previously thought. The proposed presentation would cover a brief background to whiplash associated disorders with a structural overview of the cervical spine and the physiological effects of whiplash and how blood flow can be altered even with minor injuries. Physical therapy treatments and preventative exercises will be discussed as well as a brief mention of genetic disorders and common aging misalignment injuries that may contribute to neurodegeneragtion.

Slide 2

Slide 2: I chose this topic after viewing an ESPN: 30 for 30 documentary on the Superbowl champion 1985 Chicago Bears. One segment in this documentary featured the teams quarterback, Jim McMahon. Jim McMahon is known for his wild aggressive style of play. He was the type of player that would sacrifice his body to make a play and to do everything in his power to win a game. During the documentary, they showed interviews of McMahon during his playing years, shortly after he retired, and a current interview conducted for this documentary. During these interviews, the viewer can clearly see the cognitive decline from years of playing football. During the most recent interview, McMahon stopped speaking mid-sentence and asked the interviewer who he was and why there was a camera focused on him. It was speculated that Jim McMahon was suffering from CTE. CTE, or chronic traumatic encephalopathy is a neurodegenerative disease that is caused from repeated injuries to the brain. This diagnosis seemed odd to me, since the quarterback typically doesn't experience many direct contact blows to the head. Quarterbacks are typically hit in the torso and upper leg region. I wondered if McMahon suffered from a whiplash associated disorder, WAD, that may have caused severe concussions over his career. I focused my research on the physiological effects of whiplash.

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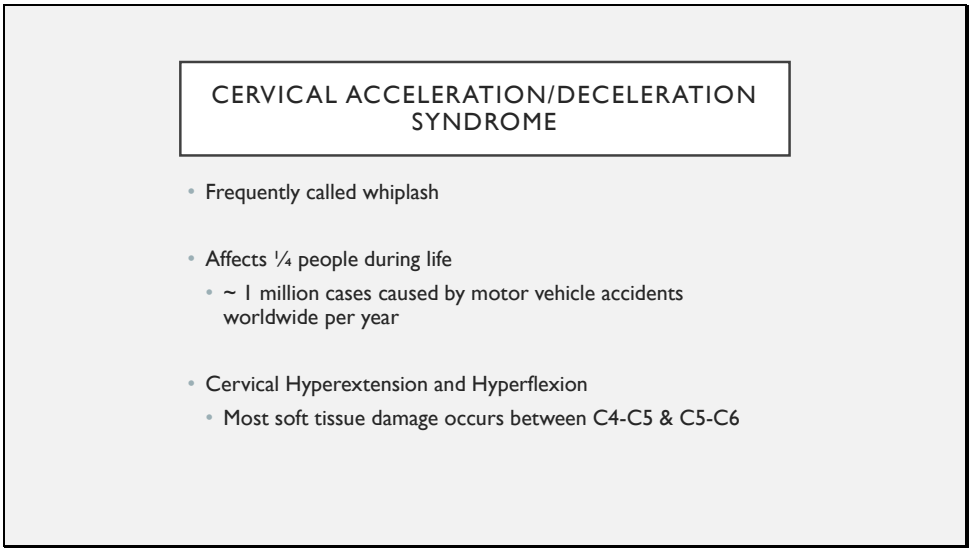

Slide 3: Whiplash is a very common and very expensive injury that affects millions of people worldwide. The total cost of whiplash related injuries is more than all cancer treatments and cardiovascular treatments combined. Most of the cost from whiplash associated disorders are due to litigation costs. Around 40% of all whiplash injuries occur via motor vehicle accidents, high contact sports and injury during a fall can also lead to a whiplash injury. Healthcare providers diagnose whiplash with standard nuclear magnetic resonance image, nMRI, machines. nMRI machines are only capable of showing a structural view of soft tissue and is not as efficient in diagnosing underlying effects of some injuries. Currently healthcare providers and researchers are using functional MRI, fMRI, machines and positron emission tomography, PET, scans to better diagnose soft tissue damage. The new imaging techniques are able to provide a functional view of how blood flows to a specific organ and or how oxygen and nutrients are delivered to an organ. A Dutch study, from December 2016, examined the effects of a low-grade whiplash injury on females. Low grade injuries are described as; no loss of consciousness by the patient, no structural damage to the spinal cord, and no permanent structural damage to the cervical spine. This study revealed that low grade whiplash injuries can have long term effects on regional cerebral blood flow. Reduced regional blood flow was observed in all female patients in the occipital lobe, the temporal lobes, and the parietal lobes of the brain, in comparison to healthy volunteers. Reduced blood flow to these regions can diminish vision, learning and short term memory as well as hearing, respectively. Other studies have shown correlations between reduced blood flow to many neurodegenerative diseases. Previously healthcare providers believed that the most severely affected areas in the cervical spine were the C4-C5 & C5-C6 region of the cervical spine. With functional imaging, researchers are concerned with the possible damage around the C1-C2 & C2-C3 region. Although the Dutch

study was unable to directly link the C1-C3 region and dementia. They hypothesize that this region contributes to dementia and Alzheimer's disease because the vertebral arteries exit the C1 vertebrae and enter the cranium to supply blood to the brain. Specifically, the Basilar artery, which penetrates the brain at the Periaqueductal Gray, PAG, region. The Pag region is the connecting point between the forebrain and the lower brainstem. This PAG region is thought to have a significant role in Alzheimer's disease progression.

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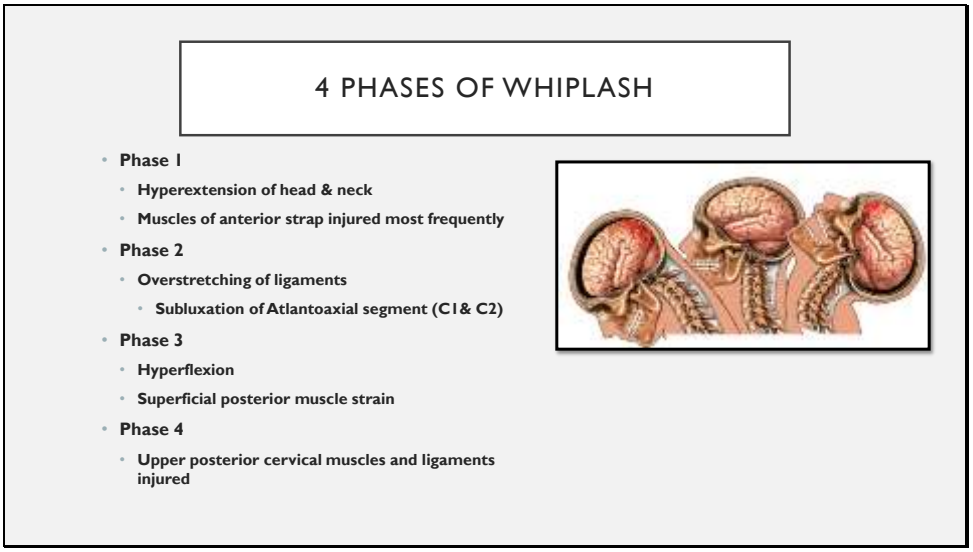

Slide 4: Rear-ended motor vehicle accidents are the most common cause of whiplash. During an accident, whiplash can be described in four phases. When a car hits another car from behind it pushes the car in front with a great force. As the front car comes to a stop, the car seat is still accelerating forward. At this point the torso of the passenger in the car seat is accelerating faster than the head and neck. During phase one and two the head and neck, specifically the C1 & C2 vertebrae experience a slight flexion. The chin is slightly tilted downward at first. A rapid hyperextension is experienced in the cervical spine, where the head and neck are flung backwards. The head and neck are accelerating faster than the torso at this point. This hyperextension over stretches the anterior side of the neck. The most common injuries occur in a region called the anterior strap. The anterior strap is a group of four muscles; the sternohyoid, sternothyroid, thyrohyoid, and omohyoid. These four muscles are frequently the most severely injured because they are long cylindrical muscles that work independently during articulation. The Sternocleidomastoid and Scalene muscles are also hyperextended Ligamental damage is common in the C1-C2 cervical vertebrae called the Atlantoaxial segment. During phases three and four the head and neck experience a hyperflexion, where the head is flung forward. The superficial posterior neck muscles, the trapezius is most commonly injured during phase three. The posterior neck muscles experience less severe injuries because they are large bulky muscles that work in groups during articulation. Subluxation in ligaments can also occur in the upper cervical vertebrae.

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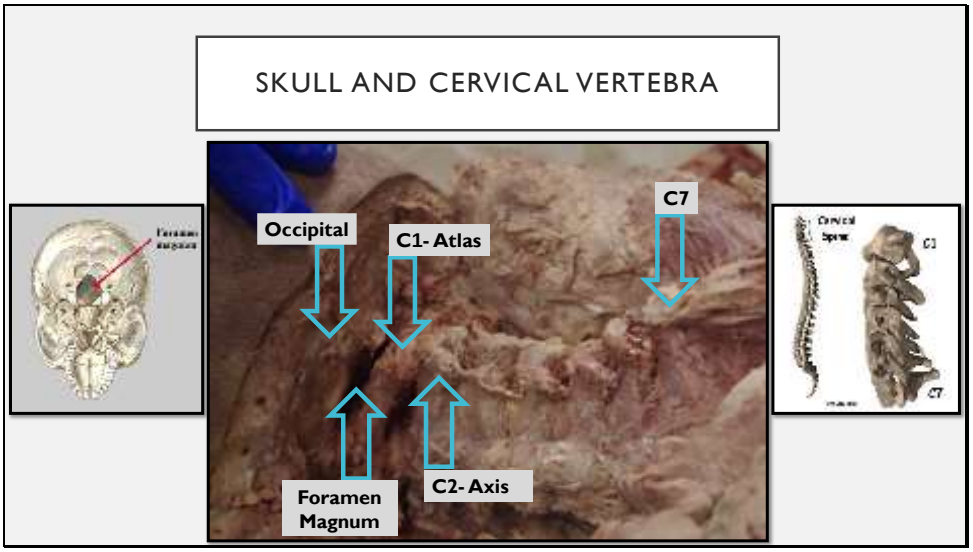

Slide 5: During my year of research, I examined the structural features of the cervical spine. I was able to examine the anterior and posterior vertebrae in five subjects, three males and 2 females. This image shows the Occipital bone on the back of the skull, the Foramen Magnum, and the C1 through C7 vertebrae. The Occipital bone attaches to the C2 vertebrae. The Foramen Magnum is a large opening at the base of the skull where arteries and the spinal cord connect to the brain.

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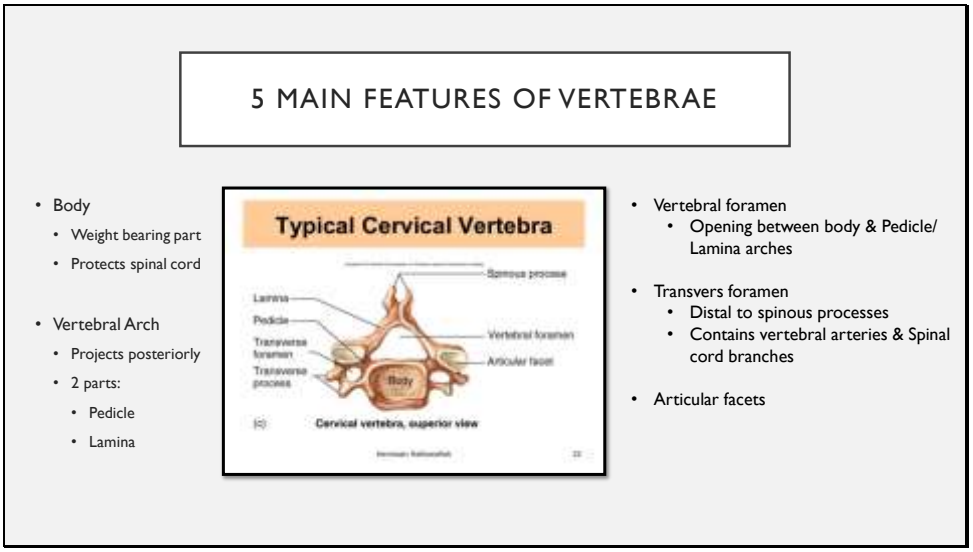

Slide 6: There are five main features of typical vertebrae. The most prominent structure of a vertebrae is the body. The body is the support structure of the spine. The body lies anterior to the spinal cord and helps protect the spinal cord from injury. Two vertebral arches project posteriorly from the body and connect to form a vertebral foramen. The point where the vertebral arches connect is called the spinous process. If you place your hand on the back of your neck and feel little bumps, you are feeling the spinous processes. The vertebral foramen is a ring like opening the allows the spinal cord to ascend to the brain stem. Two lateral projections called the transverse process are protrude from the body. The transverse process contains an opening called the transverse foramen. Vertebral arteries and nerve endings branch through the transverse foramen. Articulation facets along the body and vertebral arches allow for articulation movements in the spine.

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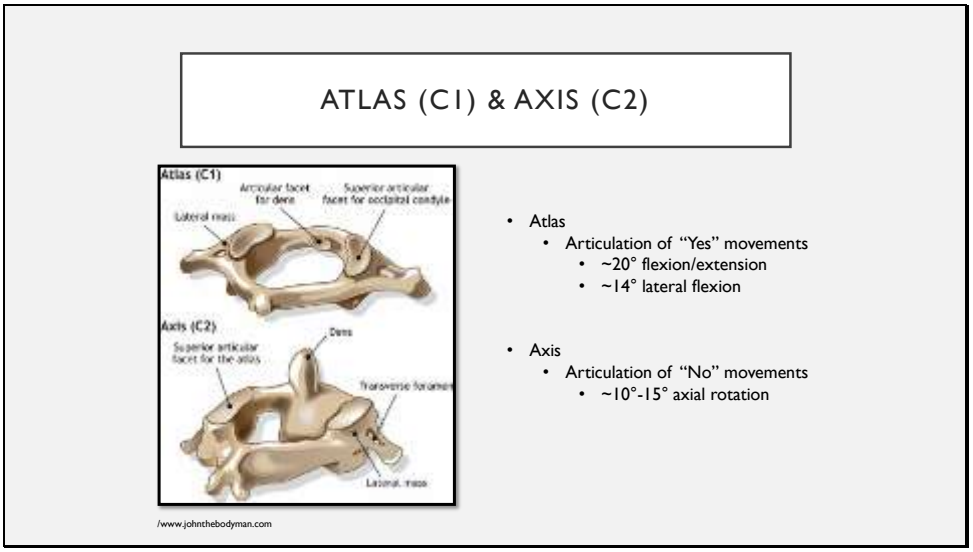

Slide 7: There are two vertebrae that are unlike any other vertebrae in the spine. The C1, also called the atlas, is unique because it is the only vertebrae that does not contain a body. It also does not have a spinous process. The C1 vertebrae is the thinnest vertebrae in the spine. The C1 allows for articulation of "yes" movements in head flexion and extension. The C2 vertebrae is called the axis. The axis is unique because of a vertical projection called the odontoid process, also known as the dens. The dens connects to occipital condyles located on the occipital bone of the skull. The axis allows for articulation movements of "no" during axial rotation.

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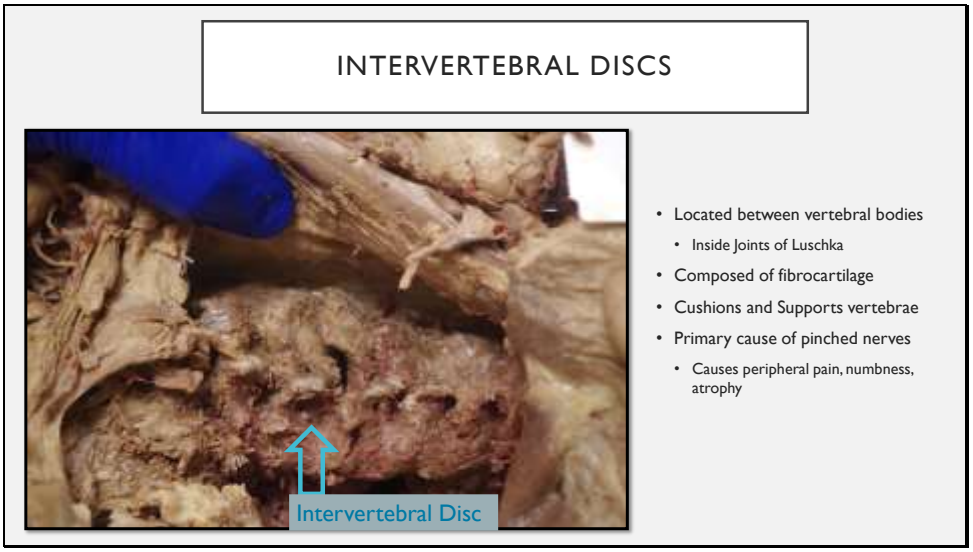

Slide 8: In between each vertebra is an intervertebral disc that is composed of fibrous cartilage. The intervertebral discs are strong elastic structure that acts as a shock absorber between vertebrae. The most common injuries to intervertebral discs are slipped discs or a ruptured disc. When a disc is not properly aligned, it typically projects posteriorly and may pinch or block a nerve and or artery. This may result in numbness, pain, and possible muscle atrophy.

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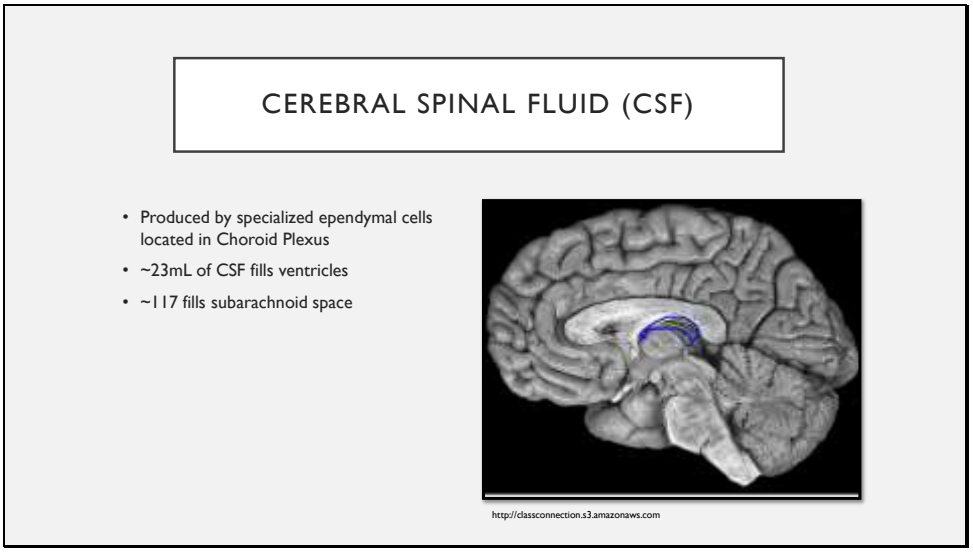
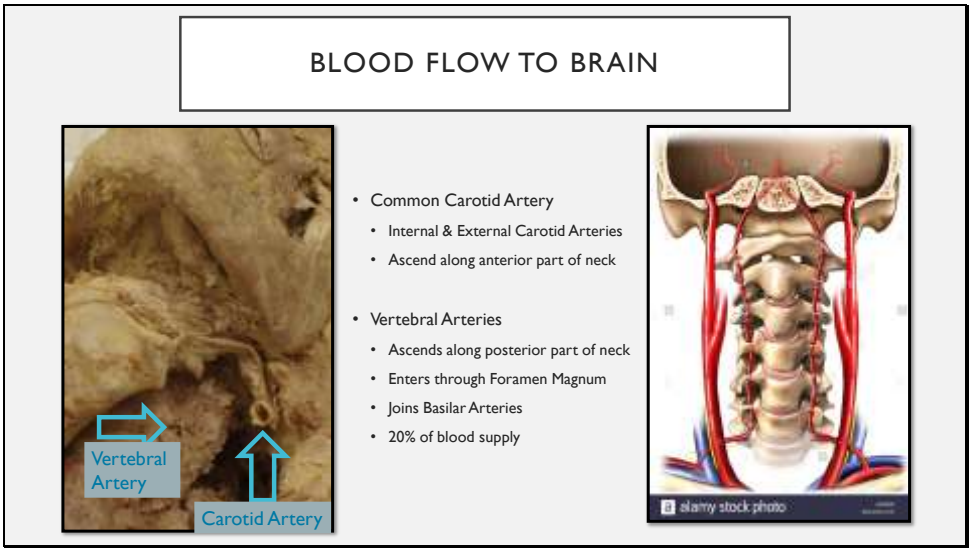


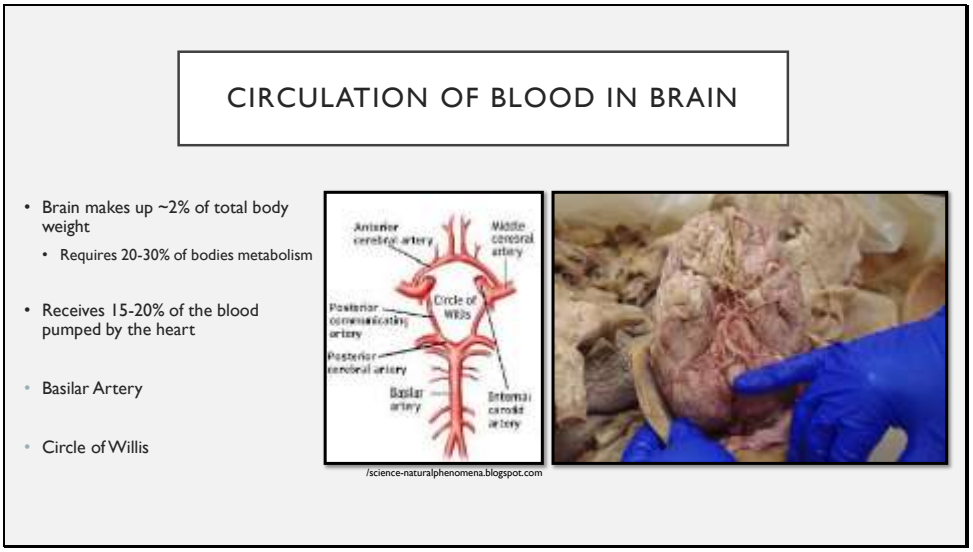
Slide 9: When we talk about blood flow to the brain, we also have to talk about cerebral spinal fluid, CSF, CSF is an uncompressible fluid that bathes the brain and spinal cord. CSF lays in between the brain and the base of the skull and protects the brain from hitting against the hard, rigid structure of the skull. CSF also provides nutrients and removes waste in the brain. Because CSF is an uncompressible fluid it relies on the pulsations of blood through the brain to move efficiently throughout the brain. There is a direct relationship between the pressure and volume of CSF and blood with in the brain. If the volume or pressure changes in CSF then volume and pressure of blood also changes.

Slide 10



Slide 10: Blood flows to the brain via two main vessels, the common carotid artery and the vertebral arteries. The carotid artery branches off from the brachiocephalic artery, which is a branch from the arch of the aorta. If you have ever seen anyone checking someone's pulse on their neck; they are checking the carotid artery. As the common carotid artery ascends to the brain it splits into the external carotid and internal carotid arteries. The external carotid artery begins around the C4 vertebrae and enters the skull behind the neck of the mandible and supplies blood to the face and occipital lobes of the brain. The internal carotid artery most commonly begins in the C3-C5 region of the cervical spine. The internal carotid artery enters the skull through the carotid canal, which is located within the temporal lobe and supplies blood to the anterior portion of the brain. The second main vessels that delivers blood to the brain are the vertebral arteries. They branch off the subclavian artery, which are branches from the brachiocephalic artery. The vertebral arteries enter the transverse foramen at the C6 vertebrae and ascend upwards, where they exit at the C1 vertebrae. The left and right vertebral arteries join as they enter the skull through the foramen magnum and form the basilar artery.

Slide 11



Slide 11: The basilar artery caries oxygenated blood to the cerebellum, brainstem, and the occipital lobes. Because the basilar artery supplies blood to the brainstem and cerebellum, which are vital in many life support processes, any interruption in blood flow can have sever effects. As the basilar artery travels anteriorly towards the mid brain, it joins with the internal carotid arteries and forms the Circle of Willis. The Circle of Willis is a loop of vessels that supplies blood to every region of the brain. The brain is a unique organ in that is receives its blood supply from branches that penetrate different lobes from the outside. For example; the kidney and liver both receive blood with from a single vessel, the renal artery and hepatic artery, respectively. As these arteries enter the organs they branch off inside the organ to supply blood from the inside. The brain has a “net” of vessels that cover the exterior and penetrate to supply blood from the outside.

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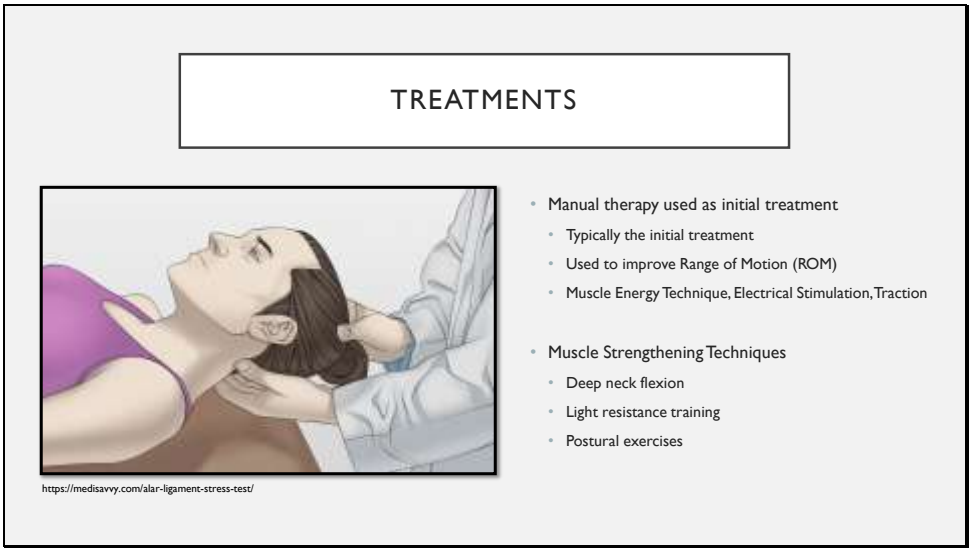

Slide 12: Individuals who experience a whiplash injury are recommended to seek medical treatment as soon as possible. Early diagnosis and treatment are key to a successful recovery. After diagnosis, a healthcare provider may prescribe some physical therapy sessions. Depending on the severity of the injury as well as a number of other factors the physical therapist may use different techniques for treatment. A physical therapist may begin with a manual therapy technique. This technique involves the therapist to manipulate the neck and head of a submissive patient. The physical therapist may apply slight pressure along the patient's spinous processes with one hand and gently rotate the head of the patient to break up any scar tissue and to loosen fascia in the neck. This technique, called the muscle energy technique, can assess the patient's range of motion, muscle activation, and can be used as an assessment technique. Other treatments like electrical stimulation and traction can also be utilized. Long term treatments will often be useful in recovery and prevention of future whiplash injuries. Deep neck flexion exercises can be performed to return a misaligned intervertebral disc to its proper location. The therapist will instruct the patient to tuck their chin in towards their chest and tilt their head back. This fans the anterior side of the vertebrae which allows the disc to move back into place. Resistance training, including chin ups and lateral rows will increase strength in the trapezius muscles and improve posture.

Slide 13

Slide 13: Back to Jim McMahon, the inspiration for my research. McMahon was thought to be suffering with chronic traumatic encephalopathy, CTE due to repeated hits to his brain. It turns out that McMahon does not have CTE, he has a misaligned C2 vertebra. His misalignment interrupts the return flow of cerebral spinal fluid, CSF, and blood from his brain back into normal circulation. This blockage of return flow has resulted in a disorder called normal pressure hydrocephalous, NPH. NPH occurs when the CSF is trapped inside the skull and unable to properly drain from his brain back into circulation. CSF is responsible for removing toxins from the brain and providing nutrients. Because of McMahon's misaligned C2 vertebra, the stagnant CSF in his brain is essentially poisoning him. McMahon's NPH is the cause of his dementia and neurodegeneragtion. The segment in the documentary ends with McMahon visiting a chiropractor that realigns his cervical spine to allow his CSF to drain properly. Jim McMahon will never fully recover from his neurodegeneragtion, but his symptoms has been reduced and he has regained some short term memory and motor function.

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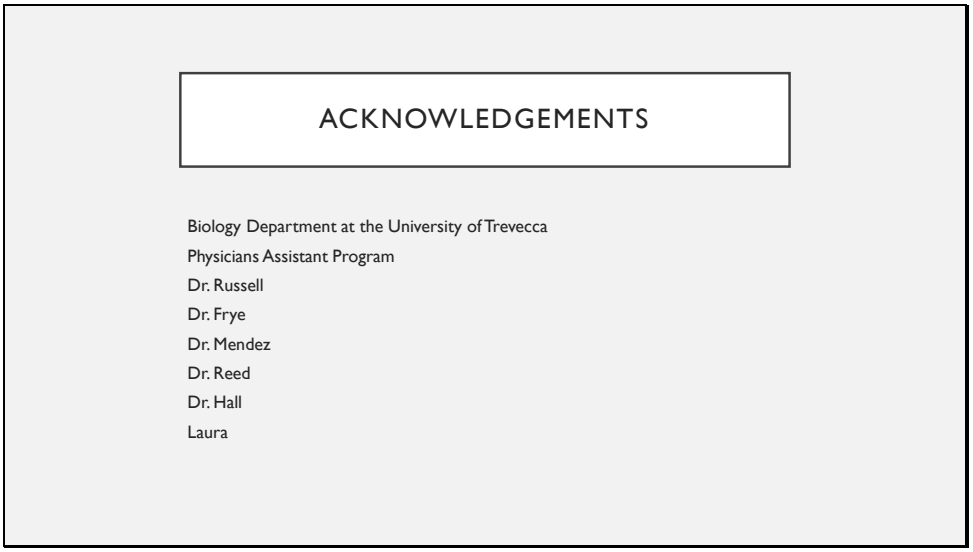

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Physicians Assistant Program
Dr. Russell
Dr. Frye
Dr. Mendez
Dr. Reed
Dr. Hall
Laura

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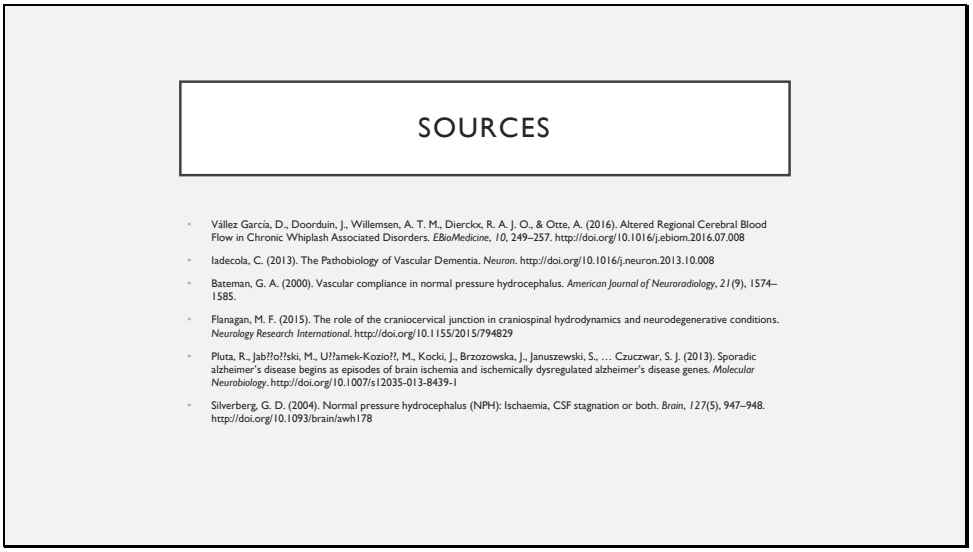

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