The Vulnerable Neck: What Forensic Audiologists Should Know

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The neck is a complex and delicate mechanism. It transmits motor signals and receives sensory signals for the entire body, carries arterial blood supply and drainage for the brain, and has visceral responsibilities for respiration—the endocrine system and the gastrointestinal tract. In particular, the neck architecture and cervical spine are responsible for supporting the weight of the head and controlling its movements. It also innervates upper body and limb muscles; receives dermatomes for heat, pressure, and pain; protects the spinal cord; and facilitates speech, breathing, and swallowing.

The neck structures are a mechanical wonder but susceptible to injury, degeneration, aging, and disease. The most common injuries come from motor vehicle accidents, sports, falls, lifting of heavy objects, diving into shallow water, or being hit by a falling object. Additionally, aging is a primary cause of neck-related complaints in seniors since arthritis, disc degeneration, and normal wear and tear affect cervical joints, collapsing intervertebral space causing compression and inflammation. Neck, shoulder, and back pain also result from repetitive activities such as excessive computer use or poor posture. A repetitive forward head position has been shown to be responsible for neck pain in adults and older individuals.[1] In fact, a forward head position has been reported as the most frequent physical deformity, reducing motion and affecting static and dynamic balance control.[2]

To the audiologist, neck injury, especially from blunt force trauma, may result in disorders of auditory processing, hearing loss, tinnitus, hyperacusis, and balance, including benign paroxysmal positional vertigo.[3] Audiologists should include questions on neck injury in any clinical or forensic evaluation since these can have long-lasting effects on quality of life, especially for seniors. For forensic audiologists, a clear understanding of the physiology and mechanics of the neck is critical in understanding the merits of the case and the audio-vestibular complaints.

Injuries to the neck can result in a variety of motor and sensory symptoms and frequently pain. For example, damage to the cervical vertebra and discs can result in spinal cord compression (myelopathy) or spinal nerve compression (radiculopathy). For aging patients, the risk of falls increases as weakness, clumsiness, and motor dysfunctions ensue, frequently including neck and shoulder pain. In the case of a whiplash injury, soft tissue damage such as strain or sprain of muscles, ligaments, and tendons may result in a decreased range of motion, headaches at the base of the skull, pain of the neck, shoulders, back, and arms, and insomnia. In all cases, a brief understanding of the functional neck anatomy can be helpful when evaluating these patients, especially for balance complaints.

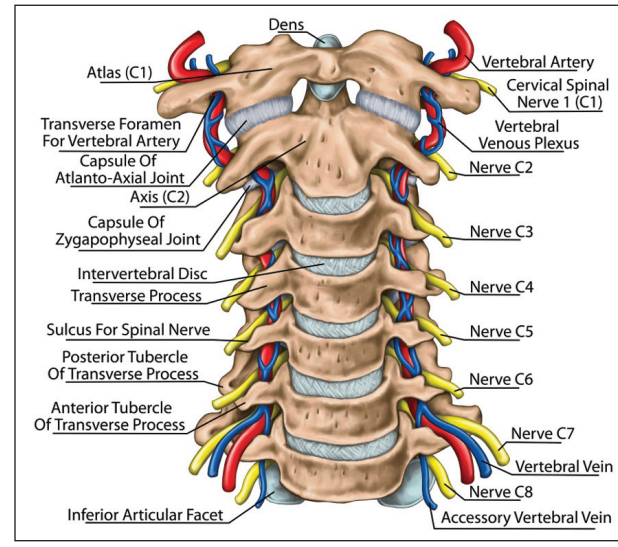
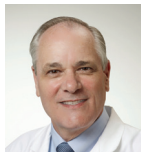


Figure 1. The cervical spine.

THE CERVICAL SPINE

The cervical spine supports the head and articulations, protects the spinal cord, provides motor and sensory information, and delivers blood flow to the brain via the vertebral arteries. As seen in Figure 1, the vertebral arteries pass through foramina on either side of the vertebral bodies. These supply blood flow to the inner ears via the anterior cerebellar arteries or basilar artery. Blood flow to the brain is also accomplished via the internal carotid arteries arising from the common carotid arteries of the lateral neck. Seven vertebrae (C1-C7) are connected dorsally by a series of paired facet joints supported by muscles, tendons, and ligaments allowing for forward, backward tilting and rotational mobility. The cervical spine forms a normal lordotic curve, gradually curving toward the front of the body and then back. Notably, a radiological sign of a neck injury is a straight neck that lacks curve—a condition called kyphosis, which may be seen in forensic cases of whiplash.

As seen in Figure 1, the first cervical vertebra (C1) is a unique ring-like structure called the atlas, which connects to the occipital skull by membranes and ligaments. The atlas articulates with the skull by paired facets and rounded condyles found on the underside of the occipital bone, allowing the head to nod up and down. Below the atlas is the second vertebra



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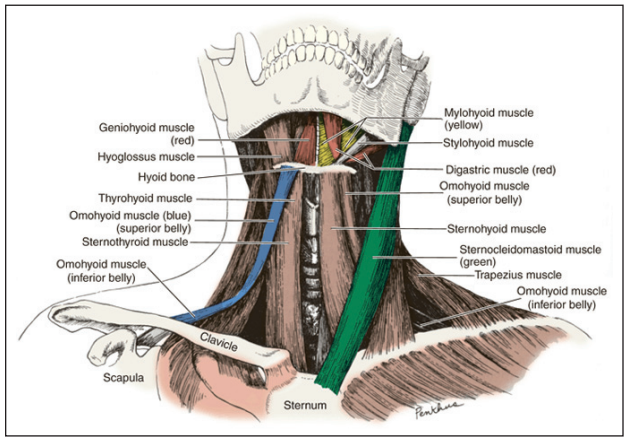

Figure 2. Muscles of the neck (reproduced from Clemente CD, ed. *Gray's anatomy of the human body*. 30th ed. Philadelphia, PA: Lea & Febiger, 1985:451, with permission).

(C2), known as the axis, which permits the head to pivot side to side about a peg-like structure inserted into the atlas called the dens. Unlike other vertebrae with a single disc, these attachments have no discs but have cartilaginous membranes between the vertebra allowing for a gliding motion and maximum rotation. The remaining five vertebrae are aligned to articulate with discs, softening the impact of motion and compression.

The intervertebral discs are fibrocartilaginous cushions fused in place on the surface of the vertebrae. Each disc has a tough outer surface called the annulus fibrosis, which encapsulates fibers and a gel-like substance found in the central structure called the nucleus pulposus. These are susceptible to injury from blunt force trauma, physical overuse, aging, and disease. When herniated, they can lose fluid, reduce in size, or release proteins, thereby inflaming nearby spinal nerves and causing pain and malfunctions.

HEAD & NECK SYNERGY

The muscles of the neck have multiple attachments to the skull, hyoid bone, clavicles, and sternum (Fig. 2). These provide substantial protection of intrinsic structures and control over fine and gross motor coordination, which are needed in speaking, swallowing, breathing, and maintaining balance and head position. Two large muscle groups cover the outer neck—the superficial platysma ventrally and the trapezius muscle dorsally attached at the occipital skull down to the shoulders and mid-back. In all, the neck has 26 muscles divided into 10 pairs and two sets with three muscles. They control head movements such as bending forward and backward, which puts considerable weight on the neck, thus requiring the musculature to be robust just to make daily activities possible. The average 11-12-pound head is supported on the body by the neck, softening the force of gravity by distributing the weight on the cervical spine and collateral physiology. However, this changes precipitously with motion, such as bending forward or backward. The head's static weight can be up to 27 pounds at a 15-degree angle, and up to 60 pounds at 60 degrees.[4]

In accidents such as whiplash, g-force can reach seven to eight times gravity in seconds as the head is forced backward in hyperflexion and then forward to hyperextend. Similar mechanical actions can occur in a fall as the body or head strikes a surface and rebounds. This can result in ruptured discs and misaligned vertebrae, and strain the delicate muscles, ligaments, and tendons of the neck.

The neck has multiple spaces segregated by the fascia, compartmentalizing bones, muscles, and the vascular and neural processes. As seen in Figure 1, a series of spinal nerves (Nerves C1-C8) exiting both sides of the vertebra, giving rise to peripheral nerves that ensure motor function to the head, neck, upper limbs, and diaphragm, as well as a dermatomal pattern of sensation in the head, neck, shoulders, and upper body.[5] Along with the accessory nerve (XI), which innervates the large muscles of the neck and shoulders (trapezius and sternocleidomastoid), the spinal nerves activate muscles controlling the motion of the head and activities such as swallowing, speech, and respiration. For example, damage to the C4 spinal nerve, which is responsible for innervating the diaphragm, can result in breathing issues and even paralysis.

AUDIO-VESTIBULAR & SPEECH

Depending on the severity of the injury, the incidence of hearing loss, tinnitus, and balance dysfunction after trauma to the neck can be substantial. In a study by Segel, et al., of 83 patients or 166 ears who sustained blunt force neck trauma, such as whiplash, 81.3 percent had an acoustic trauma-like notch and 4.8 percent had hearing loss in the 500 to 2,000 Hz range, with two ears also demonstrating higher-frequency losses.[6] Tinnitus was also reported in 55.4 percent of the subjects. These complications have been reported to result from sudden hemodynamic pressure changes caused by the mechanical action of whiplash. In another study, Nacci, et al., tested two groups of subjects for vestibulopathy: Group A included participants with whiplash only and Group B included those with both whiplash and mTBI.[7] VNG test results taken within 15 days of the injury revealed that 19 percent of Group A and 60 percent of Group B participants had vestibulopathy. In Group A, 11 percent had peripheral findings, five percent with central findings, and three percent had undefined findings. In Group B with the added mTBI, 50 percent had peripheral and 10 percent had central findings. A variety of complaints accompanied the vestibulopathy, including cervical vertigo, benign paroxysmal positional vertigo, or ocular motor system abnormalities. Although a remarkable difference was found between the groups, results showed that whiplash injury alone produced either peripheral or central vestibulopathy.

An injury to the neck may result in a myriad of potential neurological deficits both peripherally and centrally affecting balance, cognition, and communication. In whiplash cases, the associated disorders include headaches, cognitive and psychological symptoms, dizziness, tinnitus, visual impairments, paresthesias, weakness, palsy, and even paralysis. For example, speech can be impaired as neck injuries can cause hypoglossal nerve palsy, which affects articulation and swallowing, or superior laryngeal nerve (branch of the vagus nerve) damage, which causes paralysis, difficulty with pitch and explosive laryngeal sounds.[8]

An injury that takes only seconds to occur may take days, weeks, months, or even years to recover, if at all. The most common types of injuries that cause neck pain are whiplash, repetitive strain, pinched nerves, disc injury, vertebral fractures, and spinal cord damage. All these injuries may result in peripheral and/or central audio-vestibular complaints, and, in some cases, include other communication and cognitive disorders. In older adults, falls not only result in severe hip injuries but also concussion and neck injury—which can all have serious and life-threatening outcomes. In sports, head contact with another player, even with helmets, can result in a neck injury and concussion. Diving injuries can be very severe, causing vertebral, spinal cord, and disc damage resulting in paralysis. It is not uncommon for strain from poor posture or daily physical activities to occur with many of these resolving without long-term consequences, although repetitive forward head position can result in more severe outcomes. Regardless of the causation, audiologists, especially those working in forensics, should pay close attention to the status of the neck, clinical examinations, and the patient's medical records.

References for this article can be found at http://bit.ly/HJcurrent.