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Symptoms of imbalance associated with cervical spine pathology

Catherine Clara Rieke

SYMPTOMS OF IMBALANCE ASSOCIATED WITH CERVICAL SPINAL PATHOLOGY

by

Catherine Clara Rieke

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Approved by:
Timothy Hullar, M.D., FACS, Capstone Project Advisor
David Dickman, Ph.D., Secondary Reader

Abstract: The goals of the present study are: to determine the prevalence of dizziness or imbalance in a population of patients with cervical-spine pathology as compared to that in the general population; to determine correlations between cervical spinal pathology and symptoms of dizziness or imbalance.

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ABBREVIATIONS

BPPV	Benign paroxysmal positional vertigo
C[#]	A specific vertebrae of the cervical spine (e.g., C3 is the third cervical vertebrae)
CCR	Cervicocollic Reflex
COR	Cervico-ocular Reflex
SNRI	Selective Nerve Root Injection
VCR	Vestibulocollic Reflex
VOR	Vestibulo-ocular Reflex
VSR	Vestibulospinal Reflex
WAD	Whiplash Associated Disorders

INTRODUCTION AND REVIEW OF THE LITERATURE

Many patients complain of dizziness or feelings of imbalance, with dizziness being the chief complaint in 2.5% of all primary care visits, or roughly eight million visits per year (Sloane, 1989). Due to the somewhat equivocal and subjective nature of dizziness, the exact prevalence of dizziness has been difficult to ascertain. However, existing studies have examined prevalence within specific populations, and national surveys have been conducted to determine annual and lifetime prevalence of dizziness. A national survey carried out in the United Kingdom revealed that in a 12-month period eight out of every one thousand individuals would visit their general practitioner because of dizziness. (Jayarajan, 2003). Sloane et al (2001) determined that the prevalence of dizziness ranges from 1.8% in young adults to more than 30% in the elderly population. Dizziness is especially common in the elderly, with prevalence of over 30% at age 70, and over 45% in those ages 88-90 years (Johnsson et al, 2004; Sloane et al, 2001). As such, in this particular population it can lead to significant morbidity such as isolation, depression, and physical injury from falls.

Dizziness can manifest in many ways. Patients with dizziness report avoidance of daily activities such as driving, walking in open areas, being in crowded or sensory-rich environments, and head movement in general, in an effort to evade disorientation (Solomon, 2005). While loss of sight is relatively easy to recognize and describe, many patients with imbalance are at a loss to describe their symptoms. Agreeing on a common nomenclature is critical for thorough study of imbalance. Common terms used to describe dizziness include the following: vertigo, presyncope, and disequilibrium. Sloane (2001) describes “dizziness” as various abnormal sensations relating to the perception of the body’s relationship to space. Typically, the term

"vertigo" refers to the false sensation that oneself or one's surroundings are moving or spinning. Episodic vertigo can last seconds to days, while continuous vertigo is characterized by a constant sensation lasting at least a week. Patients may have experienced "presyncope" when describing their dizziness as a sense of lightheadedness or faintness, with the feeling that one is about to lose consciousness. "Disequilibrium," referring to the sensation of postural instability mainly felt in the lower extremities, is most prominent when standing or walking and can be relieved by sitting or lying down. (Sloane, 2001).

Good balance is generally thought to require normal functioning of the visual, proprioceptive, and vestibular systems. Problems in these systems can be peripheral in origin, related to disorders of the eyes and optic nerves, proprioceptive nerve endings and nerve bundles from the extremities, or the vestibular labyrinth and nerve. Alternatively, they can be central in origin if localized to either the spinal cord pathways or cortical regions regulating the three systems.

Disease states affecting any of the peripheral pathways or central circuits can lead to imbalance. Diseases affecting the peripheral systems include ocular motor disorders, which affect vision; ataxia, hypotonia, and sensory polyneuropathy, which affect proprioception; and lesions of the labyrinth, benign paroxysmal position vertigo (BPPV), Ménière's disease, vestibular schwannomas, and labyrinthitis, which affect the vestibular system. Conditions such as cerebellar degeneration, multiple sclerosis, head trauma, stroke, and vertebrobasilar insufficiency can cause central imbalance. The mechanism by which some pathologic states affect balance is not well known. Pathology of the cervical spine has been linked to imbalance termed "cervical vertigo", although the exact mechanism is not known. This study is designed to

learn more about vertigo related to the cervical spine by studying patients' clinical histories in the context of known cervical spinal diagnoses.

Visual system

Normally functioning eyesight contributes to one's balance in providing information regarding spatial orientation, self-motion perception, and postural balance. A dysfunctional visual system can cause dizziness or imbalance in one of two ways. First, imbalance could be induced by unusual visual stimulation, as in height vertigo. Alternatively, it could be caused by ocular motor disorders, such as acquired ocular oscillations, infranuclear eye muscle paresis, and decrements in visual performance. While the vestibulo-ocular reflex (VOR), in which head movements lead to compensatory eye movements via input from the labyrinth, has been well described and understood. However, it is yet unknown which visual pathways convey optokinetic information to the central vestibular system.

Certain conditions exist which can affect both the visual and the vestibular systems, such as Usher's and Wallenberg's syndromes, and oscillopsia. Usher's Syndrome is a rare genetic disorders. Type I Usher's syndrome is characterized by profound sensorineural hearing loss and decreased vestibular function from birth, as well as a progressive loss of vision due to retinitis pigmentosa. The decreased hearing and balance function is due to mutations in the genes responsible for production of the actin and cadherins in stereocilia. There is also a mutation of the gene responsible for the development of the retinal pigmented epithelium, which results in retinitis pigmentosa and progressive vision loss beginning in early adolescence.

Wallenberg's syndrome, or lateral medullary syndrome, causes severe balance and vision dysfunction, including vertigo, nystagmus, and diplopia. In this syndrome, patients will perceive

a tilt of the subjective visual vertical plane. (Brandt, 1999). Wallenberg's syndrome is caused by a dorsolateral medullary infarction with involvement of the vestibular nuclei, and results in a lateropulsion of the eyes and the body. This in turn causes severe dysfunction of the balance and vision systems. (Brandt, 1999).

Oscillopsia can be a severely disabling symptom that contributes to ocular dizziness. The visual vertigo will be a secondary symptom to involuntary eye movements that cause apparent movement in the visual field. Rarely a patient may experience ocular dizziness due to changes in rarefaction, but this will typically resolve spontaneously. (Baloh & Honrubia, 2001).

Somatosensory system

Normally functioning proprioception contributes to balance by providing kinesthetic feedback of the extent of head and limb movements through somatosensory signals from musculo-tendinous receptors in the neck and joints. The signals then converge with vestibular and visual input on multimodal neurons in the vestibular nuclei and in the thalamus, which project to multisensory areas in the cortex. Insufficient transmission of somatosensory input can lead to feelings of dizziness or imbalance.

Although there is paucity in the literature examining causes of dizziness associated with proprioceptive dysfunction, disorders such as sensory polyneuropathies, syphilitic myelopathy and cervical vertigo can affect one's balance. Peripheral neuropathies can cause sensory deficits, which affect the somatosensory system. Without proprioceptive input, one will have limited information regarding the position of the body in space. Diabetes is one of the most common causes of peripheral neuropathy, and can lead to severe disturbances in postural control. A recent study found that diabetic patients with neuropathy were significantly less stable than both normal

subjects and diabetic patients without neuropathy, as assessed through functional balance platform testing (Oppenheim et al, 1999).

Somatosensory imbalance can also be caused by syphilitic myelopathy, which occurs in tertiary syphilis. This can result in tabes dorsalis, characterized by degeneration of nerve fibers in the dorsal columns of the spinal cord. This condition causes muscle weakness and disturbed sensations that lead to loss of coordination. (Fauci et al, 2008).

Cervical vertigo, dizziness which accompanies neck movement, will be described in more detail in following sections. Possible etiologies include cervical spondylosis, vascular compression due to certain neck movements, and cervical muscle spasms which could lead to ischemia. However, it may be appropriate to categorize cervical vertigo as dizziness of proprioceptive etiology. One theory of a possible cause of cervical vertigo is that there is abnormal, unreliable, or absent sensory input from neck proprioceptors. (Ryan and Cope, 1955).

Vestibular system

Finally, bilateral normally functioning vestibular systems are a necessary contribution to one's balance, in that they are the primary organs involved in balance. It is generally agreed upon that the peripheral vestibular system provides the most crucial information in the maintenance of balance. Vestibular input helps to regulate both eye movements and muscle activity in the body. Without this input, the body would rely on visual and somatosensory input alone, interfering with balance, control of eye movements, and one's sense of spatial orientation.

The etiology of dizziness can be understood in terms of the basic anatomy and physiology of the system. For example, in the case of benign paroxysmal positional vertigo, a relatively common pathology of the semi-circular canals, otoconia within the ampullae become

dislodged, resulting in brief, violent episodes of true vertigo occurring following a change in head position. The organs of the otolith, the utricle and saccule, are responsible for providing the sensations of gravity and linear acceleration in the horizontal and vertical planes, respectively. Utricular or saccular dysfunction, then, would result in disorientation and/or sensations of tilting, but perhaps not true vertigo. The membranous labyrinth, which houses the organs of the vestibular system, contains endolymph. If dysfunction occurs in the production of endolymph within the endolymphatic sac, the endolymphatic duct, or the stria vascularis in the cochlea, it could result in an increase in pressure known as endolymphatic hydrops. Endolymphatic hydrops is widely believed to be the cause of Ménière's disease, a vestibular disorder with characteristic symptoms: episodic vertigo, tinnitus, aural fullness, and a fluctuating, low frequency hearing loss.

Anatomy. A review of the anatomy and physiology of the vestibular system is pertinent to a discussion of cervical spine pathology relating to symptoms of dizziness. Each vestibular labyrinth consists of five distinct end organs: three semicircular canals and two organs , the utricle and saccule, within the otolithic apparatus, which are sensitive to angular and linear acceleration, respectively. The three semicircular canals are positioned orthogonally, thereby providing sensation of angular movement in all planes. The posterior and anterior semicircular canals approximate the vertical plane, while the lateral (horizontal) semicircular canal is approximately 30° upward from the horizontal plane. The six semicircular canals work together in a push-pull fashion to provide perception of directional movement.

Each semicircular duct has one bulbous, dilated portion called the ampulla, which contains the neuroepithelium responsible for translating mechanical stimuli into electrical neural stimuli. Within the ampullae is a bow-shaped organ called the crista, which supports

mechanoreceptors (hair cells). The stereocilia of the hair cells will deflect toward or away from a single kinocilium, and determine the direction of polarization. The utricle and saccule within the vestibule allow for the perception of linear acceleration, as well the sensation of the position of the head in space. These structures contain sensory cell regions called static maculae. With the head in an upright position, the macula of the utricle is oriented horizontally, while the macula of the saccule is oriented vertically, placing these maculae at approximate right angles to each other.

The labyrinths contain two separate extracellular fluids: endolymph and perilymph, which have very different compositions. Endolymph is contained in the scala media and is similar to intracellular fluid. It has relatively high potassium concentration, and relatively low sodium concentration compared to perilymph. The stria vascular allows for endolymph secretion and the potassium cycle. Perilymph is similar to other extracellular fluids, in that it is characterized by a high sodium concentration relative to the endolymph. The presence of the two fluids in the cochlea allow for endocochlear potential. The electric potential between endolymph and perilymph is +80-90 mV, which is essential for normal functioning of hair cells.

The labyrinthine artery provides the vascular supply to the membranous labyrinth. There are three branches: the anterior vestibular artery, the cochlear artery, and the vestibulocochlear artery. The anterior vestibular artery supplies the utricle, superior and lateral ampullae and a small portion of the saccule. The cochlear artery supplies the cochlea, and the vestibulocochlear artery supplies the posterior ampulla, most of the saccule, part of the utricle, and the superior and lateral ampullae.

Vestibular ganglia are bipolar neurons located in the distal one-third of the internal auditory canal. Individual neurons consist of an inferior and superior cell group, which

correspond to the inferior and superior branches of the vestibular nerve. The inferior cell groups innervate the cristae of the posterior canal and the maculae of the saccule, while the superior cell goups innervate the cristae of the superior and horizontal canals, the macula of the utricle, and the anterosuperior portion of the saccular maculae. The bundles of fibers exit the internal auditory canal and terminate in the four vestibular nuclei (superior, lateral, medial, and inferior), which are situated at the floor of the fourth ventricle, and in the cerebellum. (Lee et al, 2003; Probst et al, 2006)

Vestibular reflexes

The vestibular system is constantly interacting with the visual and proprioceptive systems. In discussing dizziness relating to the cervical spine, several reflexes should be addressed, including the vestibulo-ocular reflex, the vestibulocollic reflex, the cervicocollic reflex, the cervico-ocular reflex, and the vestibulospinal reflex.

The vestibulo-ocular reflex (VOR) can be defined as reflexive eye movement in response to head movement (Desmond, 2004). It allows stabilization of images on the retina during changes in head position. The VOR is driven by a three-neuron arc, which includes the primary afferent neuron, whose cell body resides in the vestibular ganglion; a vestibular interneuron, located in the vestibular nuclei; and the neurons supplying the extraocular muscles – the lateral and medial recti. Each receptor end organ simultaneously activates both an excitatory and an inhibitory pathway to respective agonist and antagonist muscles, creating a push-pull system during head movement and resulting in eye movement that is equal and opposite to head movement. If there is damage to one or both peripheral vestibular systems, the VOR will be compromised.

The vestibulocollic reflex (VCR), which serves to stabilize the head position in space, is also driven by a three-neuron arc involving vestibular afferents, a vestibulocollic interneuron, and neck motor neurons. Muscles of the neck respond to input from the vestibular systems to provide a reflexive head movement. Wilson et al (1999) describe the VCR as a compensatory response of neck muscles to rotation of the head in space, whether due to rotation of the entire body or of the head on the neck. Thus, the function of the VCR is to stabilize head position, thereby stabilizing gaze direction in space.

Another reflex involved in maintaining head stabilization is the cervicocollic reflex (CCR), which allows the neck to stabilize the head in space. It is dependent upon the input of the upper two or three cervical nerves. The CCR is evoked by activity of neck receptors and occurs when the head rotates in relation to the body. (Brandt, 1999).

The cervico-ocular reflex (COR), a tonic oculomotor neck reflex, refers to those reflexive eye movements driven by neck proprioceptors and elicited by rotation of the neck. The proprioception of muscles and the facet joints of the cervical spine form the receptor part of this reflex. The purpose of the COR is to prevent visual slip over the retina during self-motion. (Kelders et al, 2003).

The vestibulospinal reflexes (VSR) are phasic and tonic reflexes that stabilize the head and upright posture in relation to gravity through the mediation of lateral vestibulospinal, medial vestibulospinal, and reticulospinal tracts. The VSR serves to maintain and regain posture and stability during movement. (Brandt, 1999; Baloh & Honrubia, 2001).

Causes of dizziness related to the cervical spine

It is possible that some less common etiologies, those not directly relating to the visual,

proprioceptive, or vestibular system, have not been adequately characterized. This study focuses on vertigo that is related to the cervical spine. Reker (1983) proposed that the vestibular nuclei could be affected by dysfunction of the cervical spine in two ways: through either ischemia of the vertebral arteries or functional disturbances of neck proprioception. Strong connections have been established between cervical dorsal roots and the vestibular nuclei, with neck proprioceptors and joint receptors contributing to both hand-eye coordination balance perception (Wrisley et al, 2000). Several disorders of the cervical spine have been known to be correlated with dizziness or imbalance, including whiplash, cervical spondylosis, disturbances of the vertebral artery, selective nerve root injections (SNRI), Barre-Lieou syndrome, and the controversial "cervicogenic dizziness" diagnosis.

Cervicogenic dizziness is considered a diagnosis of exclusion. This diagnosis is made when, in the absence of another identifiable cause, neck pain coincides with reported dizziness. Generally, cervical vertigo has been characterized by a to-and-fro vertigo and an unsteadiness of gait that can be induced by lesions in neck afferents. (Brandt, 1999). First described by Ryan and Cope (1955), cervicogenic dizziness was theorized to be a result of abnormal afferent input to vestibular nuclei from damaged receptors in the cervical spine. Schenk et al (2006) implicated three mechanisms in the cause of cervicogenic dizziness: irritation of the cervical sympathetic nervous system, mechanical compression or stenosis of the vertebral artery, and functional disorders in C0 through C3 involving proprioceptors. Dysfunctions occurring below the level of C3 motion segment are not likely to cause vertigo in patients (Galm et al, 1998).

Evans (1992) suggested that whiplash has an incidence of one million per year in the United States. It is believed that about 10% of patients involved in rear-end motor vehicle collisions will suffer from whiplash, 18% to 40% will have chronic pain in the upper cervical

spine region, and 25% to 50% will complain of vertigo and dizziness. (Sjostrom et al, 2002, Endo, 2006). Although sometimes difficult to accurately examine due to its litigious nature, whiplash can cause dizziness or disequilibrium. Dizziness and unsteadiness are frequent complaints in patients who experienced whiplash-associated disorders (WAD). Many etiologies have been suggested for dizziness caused by whiplash. Some have attributed the imbalance to side effects of pain medications prescribed to patients following trauma, or to anxiety caused by the trauma. Although the relief of neck pain is often associated with the relief of dizziness, (Wrisley et al, 2000), it is unlikely that lesions involving only soft tissues of the neck could produce vertigo or disequilibrium, as the skin and superficial muscles do not provide input to the vestibular system (Brandt, 1999). Research has also suggested that whiplash can affect vestibular receptors, neck receptors, or the central nervous systems' modulation of proprioceptive afferent information. As cervical afferent input allows for control of posture, spatial orientation, and head and eye coordination, many believe that in the absence of traumatic brain injury, cervical mechanoreceptor dysfunction is the cause of whiplash-related dizziness (Treleaven et al, 2005).

Disturbances of the vertebral artery can also lead to symptoms of disequilibrium. Strek et al (1998) found that a pathological decrease of vertebral arterial flow will coincide with degenerative changes in the cervical spine. Olszewski et al (2006) described associations between vertebral and basilar arterial lesions and the prevalence of vertigo. They explained that the close anatomical associations between the vertebral arteries and the cervical spine could be responsible for a range of central and peripheral vestibular syndromes like vertigo, dizziness, nystagmus, and disequilibrium. Typically, a rotation and hyperextension of the neck will compress the vertebral artery and cause such symptoms of imbalance. (Olszewski et al, 2006).

Although its very existence has been debated, Barre-Lieou syndrome is worth mentioning

in a discussion of dizziness of cervical etiology. It is a rare syndrome of the posterior cervical spine, which combines three very common symptoms: head or neck pain, dizziness, and tinnitus. The syndrome has been attributed to ischemia caused by cervical sympathetic nerve compression. Due to the reputedly flawed basis of this entity, the legitimacy of this diagnosis has been questioned (Foster et al, 2007).

While it has been established that dysfunction in the cervical spine can lead to symptoms of dizziness, it has also been found that the treatment of cervical radicular pain may also cause feelings of imbalance, including lightheadedness, nausea, and vasovagal symptoms. Huston et al (2005) determined that cervical selective nerve root injections (SNRIs) caused feelings of lightheadedness and nausea in 13.6% and 3.4% of their subjects, respectively.

The goals of the present study are as follows: to determine the prevalence of dizziness or imbalance in a population of patients with cervical-spinal pathology as compared to that in the general population; to determine correlations between cervical spinal pathology and symptoms of vertigo, dizziness or feelings of imbalance; to determine correlations between symptoms of imbalance and presenting symptoms, recent history of trauma, recent history of smoking, medications, age, and gender. It is anticipated that the prevalence of dizziness, vertigo, or a sense of imbalance may be greater in cervical spinal patients than in the general population.

MATERIALS AND METHODS

The Institutional Review Board and the Human Studies Committee at Washington University School of Medicine reviewed and approved the research protocol and informed consent used for the present study.

Procedure

Medical histories of fifty consecutive patients seen in the Department of Neurosurgery at Washington University School of Medicine from January 2, 2008 to March 19, 2008, were collected and reviewed. A database was established in this chart review study, which focused on patient answers to a routinely distributed dizziness questionnaire and on pertinent medical history (including age, gender, smoking history, recent trauma, medications, presenting symptoms, and final diagnosis). The prevalence of dizziness was assessed by an affirmative answer to the initial question on the dizziness questionnaire, "Do you have complaints of dizziness, vertigo, or a feeling of imbalance?"

The characteristics of patients' dizziness were further analyzed in the questionnaire, which included questions regarding a description of the sensation, the duration of the imbalance, the occurrence of falls due to imbalance, associated audiologic symptoms, and precipitating factors. Patients could answer one or more possible responses to a description of the sensation: nausea, lightheadedness, spinning sensation, and/or pulling sensations (with option to specify whether the pulling sensation is to the left, to the right, or varying). Patients were asked to indicate the duration of the dizziness by choosing one of the following responses: one to five seconds, ten to sixty seconds, less than two hours, more than two hours, or constant. The

questionnaire also asked patients with dizziness to check whether or not they experienced falls, hearing loss, or ringing in the ears. Finally, in describing what makes the imbalance worse, they were asked to choose from the following: change in the weather, allergy attack, lying down, rolling over in bed, getting up too quickly, looking up, and/or neck movement (with option to specify the direction of neck movement).

Data Analysis

The purpose of this study was to compare the prevalence of dizziness, vertigo, or a sense of imbalance in patients with cervical spine pathologies in the Department of Neurosurgery at Washington University School of Medicine and the prevalence of imbalance in the general population. An additional goal was to determine correlations between symptoms of imbalance (dependent variable) and presenting symptoms, diagnosis, recent history of trauma, recent history of smoking, medications, age, and gender (independent variables). The prevalence of imbalance in the study population was compared to the prevalence of imbalance determined through various epidemiological studies. To determine whether or not age had an effect upon patients' complaints of dizziness, a two-tailed unpaired t-test was performed. Chi-square tests were used to determine correlations between symptoms of imbalance and all other independent variables. P-values less than 0.05 were considered statistically significant. All statistical analyses were completed using Microsoft Excel software.

RESULTS

Subjects

Fifty consecutive patients (21 females and 29 males; ages 20 to 79 years; mean age = 53.2 ± 13.2 years) with diagnoses of cervical spinal pathology presenting to the Department of Neurology at the Washington University School of Medicine during the period of January to March 2008 were included in the study. Twenty-three patients complained of dizziness, vertigo, or a feeling of imbalance. Twenty-seven reported no complaints of imbalance.

Figure 1: Numbers of patients according to age and gender

AGE (years)*	Men	Women	Total
20-43	7	6	13
44-51	9	4	13
52-60	6	7	13
61-79	7	4	11
Total	29	21	50

*quartiles

Population Characteristics

Of the 50 consecutive patients seen in the Department of Neurosurgery at Washington University School of Medicine during this study period, 46% had complaints of dizziness, vertigo, or a feeling of imbalance.

Patient Diagnoses and Symptoms of Imbalance

The most common diagnoses were degenerative disc disease (24 patients) and herniated nucleus propulsus (14 patients). A Chi-square test revealed that a diagnosis of these two pathologies did not correlate with patient complaints of dizziness ($p=0.123$). Other common

diagnoses included cervical spondylosis, myelopathy, foramen magnum tumor, cervicalgia, neck sprain, and stenosis. Again, no statistically significant correlations were seen between these diagnoses and complaints of vertigo, dizziness, or feelings of imbalance.

Figure 2
Patients' baseline characteristics

	Study Group (n=50)
Age (years), mean ± SD	53.2 ± 13.2
Gender	
male	58.0%
female	42.0%
Dizziness, vertigo, or imbalance	46.0%
Diagnosis	
Tumor	4.0%
Cervicalgia	4.0%
Spondylosis	8.0%
HNP	28.0%
DDD	48.0%
Myelopathy	6.0%
Other	20.0%

As a part of their regular evaluation of patients with cervical spine problems, neurosurgeons at Washington University School of Medicine ask their patients to complete a dizziness questionnaire. The form asks the subjects to describe precipitating factors inducing the dizziness, sensations associated with their imbalance, and the duration of the sensations. Precipitating factors of balance symptoms are described in Table 3. More common precipitating factors include getting up too quickly (65%), some sort of neck movement (57%), lying down (26%), and rolling over in bed (26%). Of the patients who had complaints of dizziness, vertigo, or a feeling of imbalance, 30% (7) reported nausea, 65% (15) reported lightheadedness, 17% (4) reported a spinning sensation, 22% (5) reported a pulling sensation to the right, 22% (5) reported

a pulling sensation to the left, and 17% (4) reported a varying pulling sensation (Table 4). Additionally, seven of the 23 patients (30%) who had symptoms of dizziness reported falls associated with their dizziness (Table 5).

Figure 3
Precipitating factors of balance symptoms reported by subjects

Age	20-42	43-49	50-57	58-77
Allergy attack	0	1	1	0
Change in the weather	0	1	1	0
Lying down	1	1	1	1
Rolling over in bed	0	2	1	2
Getting up too quickly	2	2	3	5
Looking up	0	2	2	2
Neck movement				
Bending neck forward	1	3	3	1
Bending neck backwards	1	3	2	1
Turning head to the right	1	2	2	0
Turning head to the left	0	2	2	0
Any neck movement	1	4	3	2

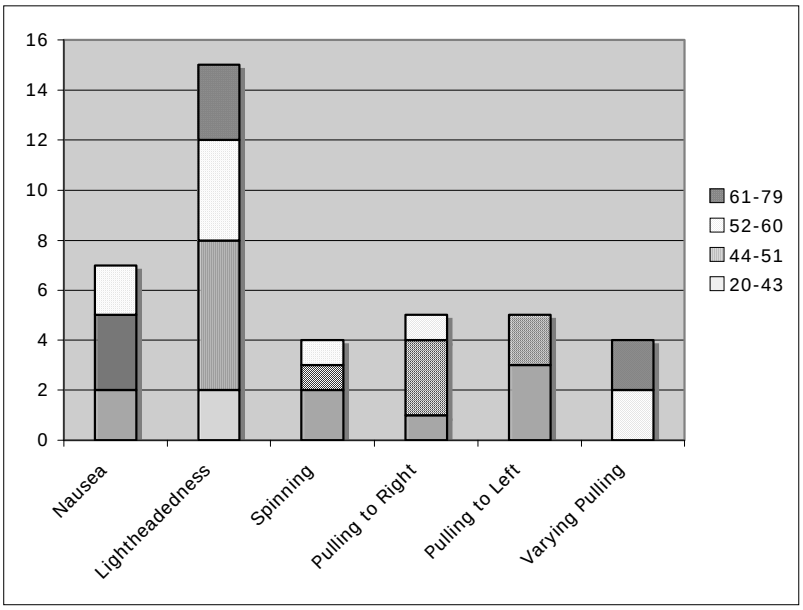

Figure 4: Character of balance symptoms by age

Falls due to dizziness are a common source of morbidity and mortality, especially in the

elderly. In the elderly 5-10% of falls are due to dizziness, including orthostatic hypotension, arrhythmia, and vertigo. (Rubenstein et al, 1988). The risk of falls increases with age above 60 years. In this patient population, the mean age (± standard deviation) of patients who fell due to symptoms of imbalance was only 54.3 (±11.8) years. (Table 5).

Table 5
The occurrence of falls concurrent with balance symptoms

Age	20-43	44-51	52-60	61-79	Total
Falls	1	3	1	2	7
No Falls	3	4	6	3	16

Correlations between patient characteristics and medical histories, and complaints of vertigo, dizziness, or feelings of imbalance

An additional goal of this study was to determine correlations between symptoms of imbalance with age, gender, a recent history of trauma, presenting symptoms, medications, and a recent history of smoking.

In this study, the mean ages of patients with and without symptoms of dizziness or imbalance were 54.5 years (±11.5 years) and 50.6 years (±15.4 years), respectively. A two-tailed unpaired t-test, revealed no statistical significance in age between subjects with and without complaints of dizziness.

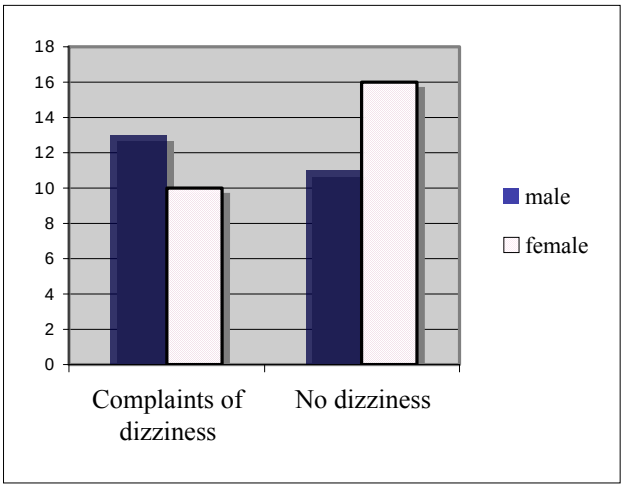

Figure 6: Prevalence of dizziness by gender

Thirteen out of 24 male subjects and 10 out of 26 female subjects in this study reported complaints of dizziness. A Chi-square test indicated that gender is not a significant factor in terms of complaints of dizziness or imbalance.

Chi-square test showed that recent trauma was a significant factor in patient complaints of dizziness. ($p = 0.01$).

In this study, no presenting symptom could significantly predict whether or not a patient had complaints of vertigo, dizziness or feelings of imbalance. (Figure 7).

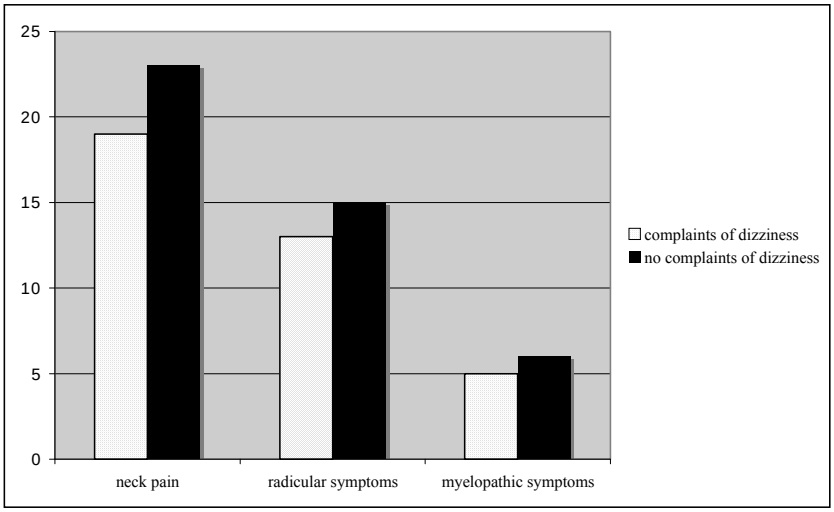

Figure 7: Presenting symptoms

Although anti-convulsants and anti-depressants did not have a significant effect on patient complaints of dizziness, results of this study test indicated that patients who were on anti-hypertensive medications were more likely to complain of dizziness or imbalance than those who were not on those medications. A recent history of smoking did not correlate to patient complaints of dizziness or imbalance. (Figure 8).

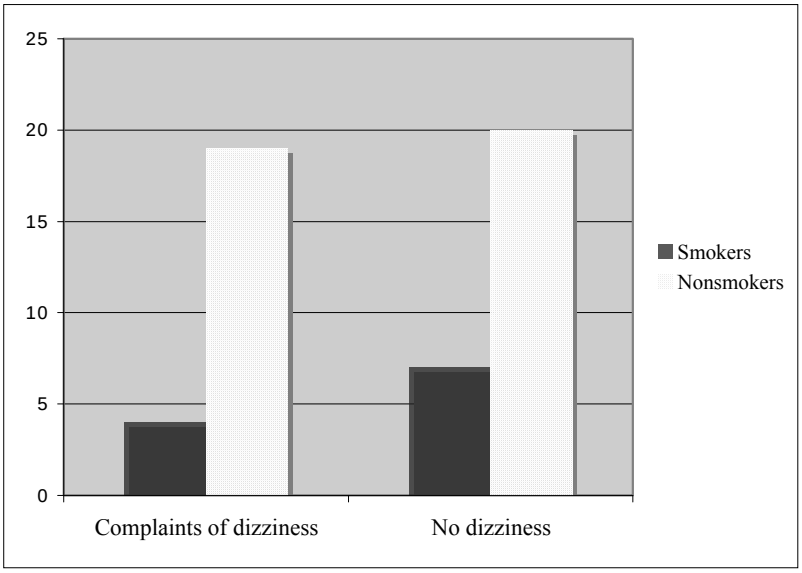

Figure 8: Prevalence of dizziness among smokers and nonsmokers

DISCUSSION

In this retrospective chart-review study, we found the prevalence of vertigo, dizziness, or feelings of imbalance in cervical spinal patients to be greater than that found in the general population. Sloane et al (2001) carried out the most recent thorough review of the prevalence of dizziness in various populations. These researchers admitted the obvious challenge in doing epidemiological studies of the inexact diagnosis of "dizziness". The results of their review indicated a prevalence of 1.8% in young adults to more than 30% in the elderly population. The highest reported prevalence in this review was 36% in women aged 70-74 years. A national survey carried out in the United Kingdom revealed that eight out of every 1,000 individuals are likely to consult their general practitioner with complaints of dizziness or imbalance in a 12-month period. (Jayarajan, 2003). It has also been reported that 4% of patients presenting to primary care practices complain of dizziness (Yardley et al, 1999). However, some believe the actual prevalence to be greater, since not all who suffer from dizziness seek medical assistance. In a study by Yardley et al (1998), researchers performed a survey of a random sample of patients in general practice medical offices with no selection criteria in terms of presenting complaint. Their results revealed that more than 20% (N=480) of the general population experienced dizziness.

The highest prevalence of dizziness reported in epidemiological studies is seen in the elderly, ages 88-90 years, with an overall prevalence of balance problems of 51%-45%. No subject in the present study was in this age range. Given this information, and the mean age of the subjects in the present study (53.2 years), it is likely that the prevalence of balance problems is greater in patients with cervical spine dysfunction than that in the general population. In our

study, the overall prevalence of dizziness was 46% (23 out of 50 patients), indicating that patients with cervical spine pathologies may suffer from dizziness more often than those without cervical spine pathologies.

In this study, the two most common cervical spine diagnoses were herniated nucleus pulposus (HNP) and degenerative disc disease (DDD). A diagnosis of HNP refers to a slipped disc on the cervical spinal cord. Spinal cord compression can lead to neck pain, incoordination and gait disturbances. DDD causes a deterioration of spinal discs over time. It can also lead to cervical spondylosis, which will produce intermittent neck pain in middle-aged and elderly adults. In a study by Colledge et al (1996) cervical spondylosis was found to be the second most common cause of dizziness in elderly subjects. Additionally, cervical spondylosis may compress the vertebral artery, which may cause vertigo or disequilibrium. (McCormack et al, 1996; Olszewski, 2006). The most debilitating result of this disease is cervical spondylotic myelopathy, which causes severe pain from compression of the spinal cord. Dizziness could also be a symptom of DDD, especially if a patient remains in one position for an extended period, since the outer layer of discs contain nerve endings. Although dizziness is not typically the primary presenting symptom in these disorders, the conditions can cause arterial compression, which can lead to vertigo. (McCormack et al, 1996; Olszewski, 2006).

Of the 36 patients in this study diagnosed with HNP and/or DDD, 15 (42%) reported symptoms of disequilibrium and 21 (58%) did not. Therefore, our data did not show a stronger prevalence in this subgroup than in the overall study population. In fact, no single diagnosis seemed to be an independently significant prediction of dizziness.

If these results are accurate, it is surprising since some cervical spinal diagnoses are known to be more likely to cause dizziness than others. Those diagnoses include WAD (Humphreys et

al, 2002; Wrisley et al, 2000), vertebrobasilar insufficiency (Strek et al, 1998), and cervical spondylosis (Colledge et al, 1996). The lack of correlation may be due to a number of factors. First, there are a relatively small number of subjects in this study. Second, there were a total of 15 diagnoses given to these 50 subjects, and therefore small numbers of subjects with a given diagnosis. Third, the final diagnose for each patient was made by only one surgeon working with one institution's patient population and therefore could perhaps be inaccurate. Future research in this area should call for a larger, multi-centered study, further controlling through verifying the diagnosis among several surgeons or verifying a diagnosis over time.

Predicting dizziness based on a patient's presenting symptoms might provide neurologists with a better understanding of dizziness in relation to the cervical spine. Clinicians will often use patient descriptions of dizziness in differential diagnosis. Although the description alone cannot dictate etiology, especially in a symptom as vague as dizziness, certain words commonly used to describe different types of dizziness, patient reports of precipitating factors, and duration of symptoms can guide in the diagnostic process. It is generally thought that a "spinning" sensation indicates true vertigo, which occurs in vestibular pathologies. Additionally, patients with vestibular disorders commonly experience episodic dizziness, rather than a constant sensation. Conversely, those who describe lightheadedness or a feeling of continuous "floating" are more likely to suffer from a nonvestibular dizziness. Causes of dizziness or imbalance not of vestibular etiology include traumatic injury, orthostatic hypotension, migraine, medications, cerebellar atrophy, cardiac arrythmia, strokes and transient ischemic attacks. Typically, dizziness associated with these etiologies will be characterized by perceptions of disorientation, lightheadedness, or general imbalance, but not true vertigo.

Our study showed the most commonly described symptom of imbalance was lightheadedness, with a smaller percentage reporting nausea, spinning, and pulling sensations. Of the subjects who had complaints of dizziness, vertigo, or a feeling of imbalance, 15 (65%) reported lightheadedness, seven (30%) reported nausea, four (17%) reported a spinning sensation, five (22%) reported a pulling sensation to the right, five (22%) reported a pulling sensation to the left, and four (17%) reported a varying pulling sensation. Most subjects characterized their dizziness as having more than one of these symptoms. This is consistent with the findings of Sloane et al (2001), who found that most patients could not place their dizziness in just one category, usually describing it with two or more of these descriptors.

Many studies have demonstrated that reported incidence of dizziness increases with age. Koch and Smith (1985) found that dizziness is the most common reason for a physician visit in persons over the age of 75 years. Histologic studies have found a decrease in the number of vestibular hair cells, ganglion cells, and nerve fibers associated with increasing age. Although many studies have demonstrated that complaints of dizziness or imbalance tend to increase with age, in this study, there was no significant age difference between the dizzy and non-dizzy groups. (Schweigart, 2002). In this study, the mean age of patients with symptoms of dizziness or imbalance was 54.5 years (±11.5 years). The mean age of patients without symptoms of dizziness or imbalance was 50.6 years (±15.4 years), with a range of 20-79 years. Using a 2-tailed unpaired t-test, we found no statistical significance in age between subjects with and without complaints of dizziness. Therefore, age was not a significant factor in this study. Additionally, since our study population does not include extremely elderly patients (known to have a much higher dizziness prevalence), age is less likely to confound out results.

Some studies have found that women tend to experience dizziness more often than men. In

the present study, 13 out of 24 males and 10 out of 26 females had complaints of dizziness, indicating that gender seems not to be a significant factor in terms of complaints of dizziness or imbalance. (Chi Square test; p-value = 0.1). This is somewhat surprising since studies have shown women to be relatively more sensitive to imbalance (Sloane, 2001). However, this sensitivity appears often to be hormonally related. Our results can perhaps be explained because this study concerns bone and joint disease and is therefore not generally related to hormonal effects. Although many vestibular disorders occur more commonly in females than in males, it is difficult to ascertain whether or not the prevalence of dizziness is greater in women than in men. The review conducted by Sloane et al (2001) showed that most studies found greater prevalence in women than in men, although no studies found the prevalence to be significantly greater.

Many conditions are associated with post-traumatic vertigo, including BPPV, post-traumatic Ménière's disease, post-traumatic migraine, cervical vertigo, temporal bone fracture, and perilymph fistula. In this study, Chi-square analysis showed significance (p = 0.01) for recent trauma being a significant predictor of dizziness. Patients who experienced trauma recently are more likely to complain of dizziness or imbalance than those who have not experienced trauma recently. A study by Chamelian et al (2004) found that 138 of their 207 (66.7%) participants with mild to moderate traumatic brain injury had subjective complaints of dizziness. Similarly, Humphreys et al (2002) found in their study that subjects who reported dizziness were significantly more likely to have been involved in an injury. Therefore, it is not surprising that our study found that symptoms of dizziness occurred significantly more in patients with a recent history of trauma.

It would be of great value to neurologists to be able to correlate their patients' specific presenting symptoms with dizziness, in helping to better diagnose and treat patients. It might

also aid in generating new hypotheses regarding the pathophysiology of dizziness in relation to the cervical spine. However, in this study, no presenting symptom could significantly predict whether or not a patient would also experience vertigo, dizziness or feelings of imbalance.

Zingler et al (2007) reported that adverse effects of smoking related to dizziness, such as transient dizziness, nausea, and nicotine-induced nystagmus [NIN], suggest dose-dependent nicotine-induced vestibular dysfunction. In this study, however, smoking did not have a strong correlation with patient reports of dizziness. Of 11 total smokers in the study population, only four (36%) complained of dizziness. (Figure 8).

Several medications are known to affect the balance system, including antidepressants, anticonvulsants, and anti-hypertensives. Gabapentin and pregabalin are commonly prescribed for neuropathic pain. Pregabalin is increasingly being prescribed for fibromyalgia pain. In our study, 12 patients (24%) were on one of these two medicines, seven of whom complained of dizziness, and two directly attributed their dizziness to the medication. This value compares with 28% incidence of dizziness in clinical trials of Gabapentin and 8-29% for pregabalin (dependent upon dosage). Therefore, these medications are likely contributors to dizziness in this subgroup. The results of this study emphasize that this side effect is worth discussing with patients before initiating therapy with these medicines.

Neurologists commonly prescribe anti-depressants for patients with symptoms of anxiety or depression. In our study, 14 patients (28%) were on an antidepressant from the selective serotonin reuptake inhibitor (SSRI) category, eight of whom complained of dizziness. This value compares with about 5% who were found to experience an adverse effect of dizziness in clinical trials of commonly prescribed SSRIs. Therefore, it is unlikely that antidepressants can account for the dizziness prevalence in this subgroup.

All classes of anti-hypertensive medications work to reduce blood pressure. The nature of these drugs makes the possibility of imbalance due to orthostatic hypotension inherently more likely. Classes of antihypertensive medications such as ACE inhibitors, ARB's, beta-blockers, calcium channel blockers, thiazide diuretics, and loop diuretics, are commonly prescribed for hypertension. Dizziness is commonly listed as a side effect in all of these classes of drugs. In our study, 18 patients (36%) were on an anti-hypertensive medication. Of these patients, 11 complained of dizziness, and seven described their dizziness as a feeling of lightheadedness. This may be consistent with orthostatic hypotension. However, other causes of dizziness should be considered in evaluation of patients with cervical spine disorders, rather than simply dismissing dizziness as an adverse effect of medication.

Although anti-convulsants and anti-depressants did not have a significant effect on patient complaints of dizziness, patients who were on anti-hypertensive medications were more likely to complain of dizziness or imbalance than those who were not on those medications ($p=0.02$). These results indicate that physicians should prescribe anti-hypertensives with caution in regard to risk of imbalance

CONCLUSIONS

The goals of this study were as follows: to compare the prevalence of dizziness, vertigo, or a sense imbalance in patients with cervical spine pathologies in the Department of Neurosurgery at Washington University School of Medicine with regard to the prevalence of imbalance in the general population; to determine correlations between symptoms of imbalance and presenting symptoms, diagnosis, recent history of trauma, recent history of smoking, medications, age, and gender.

In terms of the prevalence of symptoms of disequilibrium in patients with cervical spine pathologies as compared to the prevalence of imbalance in the general population, the data presented here show that imbalance is a more common complaint in patients referred to a neurosurgical practice specializing in cervical spinal disease than in the general population.

Addressing correlations between symptoms of imbalance with the various aspects of patients' medical histories, we found that both recent history of trauma and use of antihypertensive medications significantly correlate with patient complaints of dizziness.

Results of this study demonstrate that, because of the high prevalence of dizziness in their patient population, it is important for neurologists and neurosurgeons to closely monitor complaints of dizziness before and after medical or surgical therapy in order to minimize the morbidity of this sometimes debilitating affliction.

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APPENDIX: Dizziness Questionnaire

Do you have complaints of dizziness, vertigo, or a sense of imbalance?

☐ **NO** (Thank you- this is the end of the questionnaire)

☐ **YES** (Please answer the questions below)

1. What is this sensation most like?
(please check all that apply)

- ☐ Nausea sensation
- ☐ Lightheadedness
- ☐ Spinning sensation
- ☐ Pulling sensation
  - ☐ To the left
  - ☐ To the right
  - ☐ Varies

2. How long does this sensation last?
(please check one)

- ☐ 1-5 seconds
- ☐ 10-60 seconds
- ☐ Less than 2 hours
- ☐ More than 2 hours
- ☐ Constant

3. Have you ever fallen due to this imbalance?
(please check one)

- ☐ Yes
- ☐ No

4. Is the sensation associated with:
(please check all that apply)

- ☐ Hearing loss
- ☐ Ringing in the ears

5. What makes the imbalance worse?
(please check all that apply)

- ☐ Change in the weather
- ☐ Allergy attack
- ☐ Lying down
- ☐ Rolling over in bed
- ☐ Getting up too quickly
- ☐ Looking up
- ☐ Neck movement-
  - ☐ Bending neck forward
  - ☐ Bending neck backwards
  - ☐ Turning head to the right
  - ☐ Turning head to the left