

# Knowles Hearing Center

## Northwestern University

### *Vestibular dysfunction: research to rehabilitation*

#### **SPEAKER ABSTRACTS**

##### *Vestibular Loss and Cognitive Decline in Aging Adults*

Yuri Agrawal, M.D.

Associate Professor, Division of Otolaryngology, Neurotology and Skull Base Surgery  
Department of Otolaryngology-Head & Neck Surgery  
Johns Hopkins University School of Medicine

Vestibular function declines with normal aging. Numerous lines of evidence suggest that vestibular loss leads to cognitive decline, particularly of spatial cognition, which encompasses spatial orientation and navigation skills. This talk will review recent epidemiologic studies from our group which have found that vestibular loss in aging adults is specifically associated with reduced spatial cognitive skills, such as the ability to mentally rotate images or recall spatial relationships. Moreover, we will also review studies from our group showing that vestibular loss is related to poorer spatial cognition among patients with Alzheimer's disease, which manifests as difficulty driving and wandering behaviors. An overarching hypothesis regarding the contribution of vestibular loss in aging adults to age-related cognitive decline and dementia will be presented.

##### *Balance and Hearing: What Cochlear Implants Have Taught Us about The Developing Vestibular System*

Sharon Cushing, M.D.

Associate Professor University of Toronto  
Staff Otolaryngologist and Director of the Cochlear Implant Program  
Hospital for Sick Children

Objective measures have been integral in assessing and monitoring auditory function and overall performance in children with sensorineural hearing loss who receive cochlear implants. However, we have long known that over a third of these children with cochlear implants will have a concurrent severe vestibular deficit which translates into poor balance. These children's desire and need to maintain an upright posture and move through the world around them without injury will compete for its share of the child's cognitive load and at times finds itself in direct competition with their auditory needs and demands. The evaluation of children with sensorineural hearing loss and cochlear implants with objective measures of vestibular end-organ and balance function is essential in understanding their overall performance. This is particularly relevant as we begin to target therapies to reduce the impact of these multisensory deficits.

### *Gaze and Vestibular Afferent Recovery during Regeneration following Ototoxic Insult*

J. David Dickman, Ph.D.

Professor and Vivian L. Smith Endowed Chair in Neuroscience  
Department of Neuroscience  
Baylor College of Medicine

Motion related behaviors, such as gaze stabilization and orientation depend upon a properly functioning vestibular system. Vestibular insult often results in compromised function, but can improve during regeneration of vestibular receptors and afferents. Here, we characterize gaze stability and afferent dynamic recovery in response to motion during vestibular regenerative recovery in pigeons. Ototoxic antibiotics were used to produce a complete vestibular receptor loss and afferent denervation. Immediate post-lesion effects included severe postural ataxia, lack of gaze control, and loss of afferent responsiveness. We found that these abnormal responses improved during regeneration over a period that lasted several months. We also found that the dynamic recovery of gaze and afferent responses was not homogeneous for all types of motion. Instead, high frequency motion responses for both gaze and afferent dynamics were first achieved, followed much later by slow movement responses. Initial gaze stability was established using large head movement components, with little contribution from eye movements. During later regeneration, the trend reversed as recovery progressed. Spontaneous afferent discharge was initially regular after lesion, but increased in sensitivity and irregularity as regeneration progressed. Recovery of gaze and afferent responses correlated with the morphologic regeneration of hair cell and terminal innervation.

## *Ion Channels in Development, Function, and Regeneration of Vestibular Hair Cells and Afferent Neurons*

Ruth Anne Eatock, Ph.D.

Professor

Department of Neurobiology

University of Chicago

Sensory hair cells and afferent neurons of the inner ear express diverse ion channels that make the electrical signals that are transmitted to the brain. In mammalian vestibular organs, which detect head motions, the complement of ion channels in each hair cell includes mechanosensitive channels that detect head motion and voltage-gated ion channels that shape the receptor potential and are involved in both quantal and non-quantal forms of synaptic transmission. In afferent neurons, ligand- and voltage-gated ion channels initiate and shape the postsynaptic response to the hair cell signals and the timing of action potentials that carry the signal into the brain.

The specific ion channels expressed by each hair cell and afferent neuron change with development in ways that vary systematically with cell type, age, organ and epithelial location. As a result, characterization of the ion channels provides insight into the functions of recognized hair cell and afferent classes and can sensitively indicate the differentiated status of individual hair cells or neurons in developing or regenerating vestibular epithelia. For example, all hair cells and afferents have large numbers of potassium-selective channels that open in response to an excitatory stimulus and repolarize the cell membrane – a form of adaptation. In mammalian vestibular epithelia, differences in the types of potassium channels present distinguish immature hair cells and neurons from their mature forms, type I hair cells from type II hair cells, and central-zone adapting neurons from peripheral-zone non-adapting neurons. Some of these differences contribute to known functional differences among hair cell and afferent classes. In a mouse model system of damage-evoked regeneration, regenerating hair cells fail to ever acquire the mature diversity of potassium channels, a failure that may help explain the lack of recovery of vestibular reflexes. We are interested in understanding what drives normal differentiation of ion channel expression and whether it is possible to recapitulate those mechanisms in regenerating mammalian vestibular organs.

## *Assessment and Management of Persistent Postural-Perceptual Dizziness (PPPD)*

Devin L. McCaslin, Ph.D.

Director, Vestibular and Balance Laboratory

Mayo Clinic – Rochester

Persistent Postural-Perceptual Dizziness (PPPD) is a relatively new term for a disorder that has been described as far back as the 1800s. The International Classification of Vestibular Disorders (ICVD) group of the Barany society recently worked to come to a consensus on the presentation and symptoms of this disorder which was formally referred to as Chronic Subjective Dizziness (CSD). New research on brain function using fMRI and personality types as well as the postural stability and gait performance of patients with PPPD is assisting clinicians and researchers alike to better understand this disorder. Based on emerging data it has been possible to develop a neurophysiological model proposing that there is an association between the threat assessment of the patient and anxiety which is important to understanding the development of PPPD. This presentation will review these concepts as well as discuss how chronic co-morbid disorders such as migraine and Meniere's disease should be factored into the treatment of this disorder

## *Meniere's Disease and Migraine: One Disease or Two?*

Steven D. Rauch, M.D.

Dept of Otolaryngology

Harvard Medical School

Massachusetts Eye and Ear

Meniere's disease is the name applied when patients present with a clinical scenario of fluctuating, progressive sensorineural hearing loss and episodic vertigo lasting minutes to hours. The symptoms are believed due to a failure of inner ear homeostasis. There is no definitive diagnostic test for this condition. Diagnosis is based upon clinical presentation and exclusion of alternative explanations. Migraine is a disorder of brain chemistry causing intensification and distortion of sensory phenomena. The cardinal symptom is headache but a high proportion of migraineurs have vision disturbance and 25-30% have vestibular symptoms. And, like Meniere's disease, there is no definitive diagnostic test. Because of its high prevalence in the general population, migraine is 10-15 times more common than Meniere's disease as a cause of episodic vertigo. A significant subset of patients with vestibular migraine actually lose hearing in one ear, meeting all the diagnostic criteria for Meniere's disease. The

prevalence of migraine in patients with Meniere's disease is approximately four fold greater than in the general population, and the vast majority of Meniere patients, even those without definite migraine, exhibit so-called "migraine indicators". Shared clinical features between these two conditions, and growing evidence of possible shared pathophysiology, are presenting clinicians with both greater diagnostic challenges and greater opportunities for effective treatment. This presentation will review the clinical features and current understanding of pathophysiology in these two common and vexing clinical entities, and offer a management approach.