

AAO HNS Tinnitus Miniseminar “Tinnitus Lessons Learned from Combat and Service”. Summary 2015

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INTRODUCTION

The theme of the AAO-HNS Tinnitus Miniseminar, 09/23/2014, was “Tinnitus Lessons Learned from Combat and Service.”

The speakers discussed their clinical experiences as well as lessons learned from combat and service for translation to tinnitus theory, basic science and clinical research, and tinnitus patient diagnosis and treatment.

The program chairman and moderator was:

- Michael E. Hoffer, M.D., F.A.C.S., Professor of Otolaryngology, Department Otolaryngology HNS, University of Miami

The invited speakers included:

- U.S. Air Force Col. Mark Packer, MD, Director, Hearing Center of Excellence, San Antonio Military Health System, Lackland AFB, TX.
- Jeffrey D. Lewine, PhD Professor of Translational Neuroscience and Director of Business Development, Mind Research Network, Albuquerque, NM
- Lynn W. Henselman, PhD., Deputy Director, Defense Hearing Center of Excellence, Department of Veterans Affairs, Washington, DC.
- James A. Henry, PhD, Research Career Scientist at VA Portland Health Care System, Portland, OR.
- Abraham Shulman, M.D., Prof. Emeritus Clinical Otolaryngology, Dept. Otolaryngology HNS, SUNY Downstate, Brooklyn, N.Y.

Michael E. Hoffer, M.D. introduced the program with an outline of the goals, and order of presentations of the tinnitus Miniseminar.

The military is a noise rich environment where hearing is both always vital and frequently at risk. Hearing loss can threaten mission accomplishment, careers, and enjoyment in life. Equally as impactful and common is tinnitus. While this tinnitus often accompanies noise induced hearing loss, it can be present without significant hearing impairment and is the number one most frequent disability for military veterans. Like hearing loss, the presence of tinnitus threatens mission accomplishment and has a profound effect on individuals outside the workplace. The constant noise and lack of hope for a

solution can become a life consuming issue for active duty and veterans alike.

The DoD/VA Hearing Center of Excellence (HCE) is a congressionally established organization whose goal it is to address hearing and balance disorders in active duty individuals and military veterans. Tinnitus, as a disorder related to hearing, falls under the Umbrella of the HCE. In today's Miniseminar the Martha Entenmann Tinnitus Research Foundation is please to sponsor a symposium on tinnitus in the military provided by members of the HCE. In this miniseminar we will examine the epidemiology of tinnitus, emerging concepts of tinnitus assessment and management, as well as novel/on-the-horizon strategies for tinnitus management in military, veteran, and civilian populations.

Adequate time was provided for questions and answers.

The goals included attempts by the presenters to provide answers to the following questions:

- What's new and old in lessons learned from this cohort of tinnitus patients?
- What concepts have evolved and been translated for tinnitus diagnosis and treatment?
- Role Functional brain imaging -- EEG Based.
 - Quantitative electroencephalography (QEEG).
 - Low frequency resolution electromagnetic tomographic analysis (LORETA).
- What are the effects of military service on hearing issues for veterans including tinnitus?

U.S. Air Force Col. Mark D. Packer, MD, reviewed information the military has gathered about the effects of “work that involves weapons with a lot of noise.”

Briefly, the history of development of a hearing center of excellence of the Department of Defense program of centers of excellence was reviewed.

The Department of Defense (DOD) established the Hearing Center of Excellence (HCE) to focus on the prevention, diagnosis, mitigation, treatment and rehabilitation of hearing loss and auditory injury. The HCE was legislated by Congress in the FY 2009 National Defense Authorization Act (NDAA) and directed to partner with the Department of Veterans Affairs (VA), institutions of higher education and other appropriate public and private entities. The HCE's primary responsibilities include:

¹ Martha Entenman Tinitus Research Center

- Developing a data registry to track hearing loss and auditory injuries across the armed forces, and sharing such registry data with the VA.
- Encouraging and facilitating the conduct of research.
- Developing best practices and clinical education.
- Ensuring the coordination and delivery of VA rehabilitation benefits and services to former service members.

Department of Defense (DOD) Hearing Center of Excellence: History of the Hearing Center of Excellence¹.

The centers of excellence were described as an outstanding example of how the military health system strives to achieve “the quadruple name”. This is a new relationship which provides care to beneficiaries of the military by focusing on readiness, population health, and a positive patient experience. The center of excellence plan is to meet these goals through focused research, and training in education.

Charles B Green, Air Force Surgeon General April 13, 2010, before the House committee on and on armed services, subcommittee on military personnel².

At present the Hearing Center of Excellence (HCE) hopes to reduce the tangible and intangible costs of hearing loss and auditory injury, enhance readiness and improve the quality of life of American military personnel and veterans.

The HCE’s mission is to focus on improving outcomes in five key areas, including prevention and surveillance; clinical care, rehabilitation and restoration; research; information collection, sharing and re-use; and outreach. These priorities roughly correspond to the HCE’s five directorates. These directorate groups will work together to prevent injury, care for the hearing impaired, educate the armed forces about tinnitus causes and treatments (treatment options) and improve the operational effectiveness of the military through enhanced diagnosis, assessment and hearing protection. Department of Defense (DOD) Hearing Center of Excellence: Mission and Overview at HCE³.

The demographics of the population were presented:

- More than 350,000 service members who have reported tinnitus following redeployment from the Gulf War conflicts, and over 250,000 who have reported hearing loss during this period of time.
- Unique claims in 2010 alone show 92,260 tinnitus claims and 65,583 hearing loss claims. Using a simple direct calculation of current compensation rates applied to all individual claims of hearing loss and tinnitus by degree of

injury, 2009 figures for Department of Veterans Affairs (VA) compensation benefits would be \$976M for hearing loss and \$920M for tinnitus.

- Considering only major disability for hearing loss, calculated compensations for the disabled would be \$1.063 billion for hearing loss and \$336.66 million for tinnitus, totaling \$1.4 billion for major auditory disabilities in FY 2010³.

Actual compensation for these disabilities is impossible to assess, as many/most veterans’ benefits are based on percentage calculations associated with various other disabilities. That said, hearing loss and tinnitus are highly prevalent and represent a significant issue. Current trends suggest that the incidence of tinnitus and hearing loss is increasing 13 to 18 percent annually. Although the military services teach the importance of hearing protection, provide the means for hearing protection and monitor risk through conservation programs, the need for hearing during battle often overrides the expediency of hearing protective devices. Military personnel equate hearing protection with increased vulnerability, widening the gap between, and decreasing the potential impact of, preventive efforts and hearing preservation. The scope and magnitude of the impacts of war and military service on the auditory system reaffirm the requirements put forth by the National Defense Authorization Act to address these injuries and warrant a vigilant, focused effort to combat them. Department of Defense (DOD) Hearing Center of Excellence: Mission and Overview at HCE³.

Clinically, the neurotologic physical examination was reviewed for tinnitus which included a focus on the history, physical examination, audiologic screening hearing test and the tinnitus evaluation. Attempts for tinnitus treatment included a focus on instrumentation and counseling. Reference to research into hearing-related injuries, including tinnitus, was reported to have expanded to the cellular level. He said, “We want to look at what is going on under the surface.”, i.e. a neurobiology for tinnitus.

James A. Henry, PhD, and Lynn W. Henselman, PhD, discussed the development of evidence-based management of tinnitus as developed at VA institutions. That management is based on the AAO-HNSF tinnitus guideline and guidelines based on Cochrane Reviews which was published in October 2014⁴.

In a review of the guideline Dr. Henry said “The AAO-HNSF guideline for tinnitus should be the standard for management”. It is the first multidisciplinary, evidence-based clinical practice guideline to improve the diagnosis and management of tinnitus. To read the guideline and access related resources, attendees were recommended to visit www.entnet.org/TinnitusCPG⁴.

The VA's principles of tinnitus management, were reported by James A. Henry, PhD to be based on research over the last 20 years and included the following:

- Clinical services for tinnitus should be progressive
- Use an interdisciplinary approach
- Clinicians need training in tinnitus management
- All patients reporting tinnitus need audiologic evaluation
- Determine if the tinnitus problem is clinically significant
- Questionnaires are the best way to determine tinnitus severity
- Make sure the tinnitus problem is not a hearing problem
- Intervention should start with patient education
- Address the problem of low health literacy

Dr. Henselman, Deputy Director, Defense Hearing Center of Excellence, Department of Veterans Affairs, Washington, DC. Dr. Henselman discussed the five hierarchy levels the VA follows in determining the level of treatment needed. It starts at level one with a referral, then moves on to audiologic evaluation, skills education for self-management, interdisciplinary treatment, and individualized support⁴.

Jeffrey D. Lewine, PhD., presented the highlights of the state of the art advances in tinnitus research from the perspective of neuroscience. "We have very little that actually changes the tinnitus percept. Most of our therapies are focusing on the distress and the psychological consequences of tinnitus rather than trying to actually alter the perception of tinnitus. But there is at least a group of us who believe that if we truly understand the neurobiology of tinnitus, we might be able to develop therapeutic interventions that go after that neurobiology and actually alter the tinnitus percept and alter the brain dysfunction that has given rise to the distress we see in tinnitus"⁴.

The highlights included discussions of research that shows that tinnitus distress involves different networks of the brain regions, such as the attention network and the memory network. "The good news is that we potentially have target areas to think about in terms of intervention," he said. "What this has led to over the last 10 years is a movement to look at neuromodulatory strategies that target different nodes of these networks to try to do therapeutic interventions"⁵.

Two such interventions were reported to include transcranial direct current stimulation and transcranial magnetic stimulation, both of which send pulses into targeted brain regions. Other promising areas are vagus nerve stimulation that could reorganize the auditory cortex and tinnitus reorganization training to reduce tinnitus distress.

A device including Tinnitus Re-Organization Training (TROT), an algorithm behind Auditory Processing training (APT) was presented for attempting control of hyperacusis and/or tinnitus relief. Both symptoms are considered central processing disorders. The patient listens to TROT modulated music, combined with transcutaneous stimulation of the Vagus Nerve at the ear. The detailed profile of modulation is based upon current understanding of the neurobiology of tinnitus, the vagus nerve is stimulated externally. The TROT music is directed to increase the efficiency of the plastic changes induced by the transcutaneous stimulation of the Vagus Nerve. The novel music modulation algorithm targets the inherent ability of the brain to change in response to external stimulation. The process of reorganization, i.e. neural plasticity, provides a mechanism for rewiring the brain resulting in reduction in hypersensitivity and improvement in information processing. The device is not yet commercially available but is presently undergoing rigorous clinical and research testing to look at safety and efficacy.

"Ultimately, we want to be doing all of these within the global picture of associating them with cognitive behavioral therapy," Dr. Lewine said. "This is going after the percept. We still need to go after the distress, and it is going to be a combination of the two that is going to be most effective"⁵.

Abraham Shulman, MD, Professor Emeritus of Clinical Otolaryngology at SUNY/Downstate, New York, NY, discussed advances in the study of tinnitus. In particular, he emphasized that there are different types of tinnitus, with medical trauma tinnitus (MTT) identified as a new type.

MTT is a mental health condition that is clinically manifested predominantly with a recurring and increasing anxiety. MTT is the emotional traumatic event clinically considered a mental health disorder, he said⁴.

Clinical issues were presented that have been learned since 1979 for tinnitus from the military experience of combat and retired personnel:

- Comorbidities in single or multiple organ systems in both active and retired personnel significantly influence the severity of the clinical course of tinnitus, eg cardiovascular disease (hypertension); metabolic disease (alcohol); preexistent sensorineural hearing loss particularly in the ultrahigh frequencies 10-20 kHz; cerebrovascular disease; neuropsychiatric disease (depression/anxiety).
- Clinical significance of Post-traumatic stress disorder and tinnitus in mild traumatic brain injury.

- The etiology of noise exposure and tinnitus accompanied by symptomatology of dysfunction in both ear and brain.
 - Subclinical tinnitus - presence of tinnitus not manifest to the patient. Its clinical characteristics highlighted both by variability in latency, and episodic intermittency of becoming clinically manifest to the patient.
 - Secondary endolymphatic hydrops -clinically high incidence of occurrence; presumed association (IIH/aka benign intracranial hypertension (BIH) or pseudo tumor cerebra (PTC),
 - Idiopathic intracranial hypertension - presumptive diagnosis based on subjective report by tinnitus patient of associated symptoms of increase in tinnitus intensity with Ear blockage with normal tympanometry/head pressure/ Position change, fluctuation tinnitus intensity.
 - Ear blockage- site of lesion Ext ear/middle ear/ inner ear/intracranial pressure - SUBJECTIVELY THE SAME.
 - Cognitive complaints - significant incidence association, e.g. memory, speech expression.
 - Medical trauma tinnitus(MTT-PTSD/tinnitus) - a special clinical type of tinnitus, a medical trauma, a mental health condition, clinically manifested predominantly with a recurring and increasing anxiety, which follows the clinical course paradigm of a post-traumatic stress disorder. Its clinical significance to be determined by its clinical course, short, long term, and chronicity.
 - Tinnitus Treatment Paradigm PTSD (TTPP) is a combined therapy for attempting relief of MTT with a focus predominantly on behavioral therapy, and EEG-based neurofeedback-not medication - in combination with instrumentation.
 - Concepts that have evolved for translation for tinnitus theory, diagnosis and treatment were presented:
 - The dilemma for tinnitus patients, and tinnitus professionals is how a sensation becomes transformed into one of affect and vice versa⁵.
 - Principle of sensory physiology - all sensations, normal/abnormal have functional components, i.e. sensory, affect, Memory, (chronicity)⁶⁻⁸.
 - Sensorineural/Sensory Neuroscience (SNSN) Ear Brain Tinnitus Model a model for tinnitus theory diagnosis and treatment based on what is known of the basic sciences of ear and brain function, and sensations -- translated for all clinical types and subtypes of tinnitus.
 - Functional brain imaging - Functional brain Imaging-structure function correlation (s); provides a visual display of the phenotype for the tinnitus reflected in images of multiple brain functions in auditory and non-auditory regions of interest (ROIs) in the presence of the tinnitus signal.
 - Nuclear medicine -Single photon emission computerized tomography (1989); Positron emission tomography (PET) - functional MRI (fMRI); diffusion tensor imaging;
 - Magnetoencephalography (MEG)
 - EEG based Electroencephalography - Qualitative electroencephalography (QEEG) Low frequency Brain Electromagnetic Tomography (LORETA)-sensitivity/ Resolution high; validation with SPECT/PET⁹.
 - The pathophysiologies in this cohort of tinnitus patients include inflammation^{10,11}.
 - increased intracranial¹².
 - and chronic traumatic encephalopathy - concern for present and future¹³.
- The sequential data of EEG based Electrophysiology- QEEG/LORETA, separated by 6 months in a MTT patient, was demonstrated. In both examinations, statistically significant activation with a probability of $p < 0.05$ was identified in only non-auditory ROIs in source localization of the maximal abnormality in the very narrow band frequency spectra 24.21Hz and in the table of Z scores of statistically significant ROIs.
- Both evaluations showed a tendency toward low power in all frequency bands. Initially, this was most noted in delta and theta, while the last evaluation found this to be maximal in the alpha and theta bands, suggesting a shift in the frequency spectrum. The excess power in the beta frequency band seen in the prior evaluation was also seen in this evaluation although more posterior. Power relationships between and within hemispheres were maximal in the beta frequency band and involving midline central regions i.e. mid-cingulate, bilateral precuneus, cingulate and the bilateral caudate nucleus.
- The significant disturbances previously reported in coherence and cortical connectivity (coherence relationships between regions), were found to be largely normalized in this evaluation. Narrow band abnormalities and maximal peak in the LORETA spectra were found in both evaluations to be in the high beta frequency band with most probable underlying sources of the scalp recorded data to be greatest in similar regions with the current evaluation showing more involvement of the precuneus and less involvement of the Thalamus compared with the prior exam.
- The caudate nucleus has been identified to contribute to emotional trauma. Of interest is that in a MTT patient, the brain function of affect, emotion, behavior predominates in non-auditory pattern of activation in brain¹⁴⁻¹⁶.

Clinically, this data finds support for 1) the clinical history of comorbidity of head trauma; 2) a monitor function of the clinical course of the tinnitus highlighted by the affect emotional component; and 3) objective electrophysiologic data in support of a tinnitus diagnosis of MTT and a tinnitus treatment plan to focus on behavior modification.

He concluded by adding that electroencephalography (EEG) aka electroencephalotinnitography (ETG) is analogous to the EKG in the 1930s⁴.

Functional brain imaging technologies provide a visual display of brain wave oscillations, reflecting multiple brain functions in the presence of the tinnitus signal. Statistical analyses of the data obtained to be used as an adjunct to the clinical evaluation of the tinnitus patient and reduce the clinical dilemma presented by tinnitus to the patient, basic scientist and clinician.

Functional brain imaging EEG based electroencephalography was recommended for Medical trauma tinnitus (MTT), a special clinical type of a predominantly central type subjective idiopathic tinnitus of the severe disabling type.

CONCLUSIONS

Tinnitus was reported to be a persistent problem for which there is no cure, but new neurobiology research shows the promise of developing effective treatments. In addition, an AAO-HNSF guideline and the research of Veterans Administration (VA) institutions help to direct effective management of the condition⁴.

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