

EDITORIAL

Few tips for management of tinnitus

Abdollah Moossavi* 

Department of Otolaryngology, School of Medicine, Iran University of Medical Sciences, Tehran, Iran

Citation: Moossavi A. Few tips for management of tinnitus. *Aud Vestib Res.* 2020;29(4):186-9.

Tinnitus or the sensation of hearing the sound or the noise without any corresponding external stimulus, can be defined as a dysfunction in coding of silence in the cerebral cortex. From an audiological point of view, tinnitus usually has a limited intensity level (5–15 dB HL), mostly reported with increasing hearing threshold, mainly in the mid-to-high frequencies and sometimes at octave intervals, but it can also occur without any apparent disturbance in the hearing thresholds. The quality of speech comprehension is usually not related to tinnitus. Although tinnitus occurs in a significant percent of people in the world, the degree of annoyance is not the same in all people and not justified by the psycho-acoustic features, but is more related to the cognitive and emotional aspects of patients. Attention and focus on tinnitus causes maintaining and increment of its related distress [1].

The perception of tinnitus is not just a simple hearing phenomenon since in addition to hearing sound(s) from somewhere inside the head or ear(s), the sufferer also is aware of lack of its external origin and does not find a history of similar states and sounds in his/her memory and thus may face emotional symptoms. Tinnitus probably is not the result of limited abnormal

activity in the auditory cortex, but rather several independent neural networks contribute to its creation simultaneously [2], because sole hearing loss cannot justify all the symptoms and complications of tinnitus such as distress in sufferers and abnormal activity in areas such as the frontal cortex and limbic system seems to be the main cause of tinnitus-related discomfort or distress [3]. Therefore, it can be assumed that the network(s) consisting the pathways in the auditory, frontal, and limbic areas make the sufferers to be aware of, and reactive to tinnitus [2].

Tinnitus with hearing loss usually begins as a peripheral lesion at the cochlear level, and leads to persistent dysfunction of central auditory/non-auditory nervous system in some patients over time. Numerous physiopathological explanations have been suggested for the occurrence of tinnitus, but none of them is comprehensive. The simplest justification is that cochlear impairment, especially in areas receiving high frequencies, and its consequent bottom-up auditory deafferentation leads to a change in the regular pattern of dorsal cochlear nucleus inputs and uncontrolled hyperactivity [2], thus increasing automatic activity and neural discharge, which leads to abnormal neural synchronization and cortical reorganization [4,5]. Another theory based on the mechanism of noise detection and inhibition at the thalamus level suggests that under normal conditions the unwanted additional (surrounding) activity in the auditory pathway is removed by an inhibitory feedback loops, and the dysfunction of this loop (disinhibition) can lead to tinnitus due to different reasons [6]. Another mechanism in the development of tinnitus is the Thalamo-

* **Corresponding author:** Department of Otolaryngology, School of Medicine, Iran University of Medical Sciences, Shahid Hemmat Highway, Tehran, 1449614535, Iran. Tel: 009821-86701, E-mail: amoossavi@gmail.com

cortical dysrhythmia (TCD) framework. The basis of this theory is the existence of a natural rhythm of electrical activity in the human brain due to the proper functioning of the subcortical areas and their sensory inputs. If any of the sensory inputs, including hearing inputs, are abnormally reduced and the subcortical areas have poor function, a change in this rhythm leads to the perception of tinnitus and its psychological consequences, in addition to affecting overall brain function [7,8]. Each of the mentioned theories has its strengths, weaknesses, and limitations, and often justifies specific cases. A more comprehensive view based on the overall function of the central nervous system has been proposed as the Global Workspace Hyperactivity (GWH). In this theory, unconscious and conscious processing patterns act in parallel, and information from different sources are integrated and then perceived. This means that although the overall output of brain processing is manifested as a phenomenon, multiple and often overlooked elements are involved and act as an integrated network(s). In this theory, some network(s) is (are) proposed that causes tinnitus due to dysfunction of auditory afferent and its effects on the central auditory system [9], almost a combination of two theories of noise inhibition and TCD. These defects probably trigger cognitive networks and consequently focusing on the tinnitus phenomenon. So, deafferentation alone by itself is not sufficient to perceive tinnitus, and it is only perceived when deafferentation is accompanied by a defect in top-down auditory processing. Thus, dysfunction of the central auditory system (as a part of proposed network) prevents the normal activity of other brain regions that must control the activity of this system [8,10,11].

Based on above-mentioned mechanism, one can say that tinnitus is a unique feeling of sound(s) based on auditory memory, perception of sound and cognition with different aspects in terms of loudness, duration, situation, and excitement (such as distress). Each of these features is related to a separate network connected by some hubs. Further justification for this theory has been based on fMRI findings, indicating the changes in the amygdala, anterior insula, cingulate

gyrus, and prefrontal cortex in various cases of tinnitus [12].

Most people cope with tinnitus only with sufficient justification, but in some patients, individual reactions may occur, from feeling of its existence to insomnia, depression or severe degrees of restlessness and social disability, which need to be managed. For this reason, efforts have been made to deal with this problem and its complications from a long time [12].

It should be noted that tinnitus will not be eliminated in term of “cure” except in limited and specific cases (e.g. salicylate poisoning or early stages of Meniere's disease with no sensorineural hearing loss). If a person has tinnitus, s/he has to accept that this phenomenon is part of his/her life and must somehow cope with it. Therefore, the first step in dealing with a patient with tinnitus of unknown origin, after excluding any known specific medical and surgical factors and probable treatments, is to clearly explain and justify that currently there is no cure for tinnitus with medication or rehabilitation measures, and one should try to accept the presence of tinnitus during the life and ignore it. Rehabilitation or medication only make tinnitus tolerable to help person to return to his/her normal life. This is why the word “management” is used instead of the word “treatment” for tinnitus. There is a spectrum of different management methods for tinnitus starting from “sound therapy” as the simplest method to transcranial magnetic and electrical stimulations as advanced methods and a wide range of management methods including the use of hearing aids to cover the sound (tinnitus masker), tinnitus retraining therapy, cognitive behavioral therapy, and neurofeedback has been suggested and used between them. The main context of these measures, regardless of their form, is entering the circle of the physiological function of neural networks trying to change them through biological methods i.e. “neuromodulation”. In some cases, medications and supplements have been used to manage tinnitus and especially its complications [13].

Due to limited effectiveness, long duration, lack of significant effect on improving quality of life, failure in complete treatment, exacerbation of

tinnitus and side effects after using some medications, each of these methods has its own advantages and limitations, and are not considered a definitive option for management of tinnitus [13].

Regarding neuromodulation method, several points should be considered. Neuromodulation is based on multi-synaptic plasticity and differs from single neuronal potentiation and augmentation. It is an essential and inherently non-destructive, within biological range, reversible tool for regulating the neural information processing, and a limited part of the plasticity of the nervous system changing the current state of neuronal function to some degree. It reconfigures neuronal communication through changing the properties of neurons and synapses and enabling a wider variety of sensory and motor patterns [14].

The basis of neuromodulation is the change in the inherent physiological processes of synapses and neurons by the neurons themselves or the substances released from them, affecting the type of neuronal communication within the nervous system. The range of action of neuromodulation is limited, and the structure and biological basis and internal stability of neurons/homeostasis/determine its practical and temporal range [15]. Neuromodulation is beyond simple neuronal stimulation and can change the range of neuronal excitability or synaptic power and alter their function. The mechanism of neuromodulation is mostly based on the activation of G-protein-coupled receptors in cell membrane and affects intracellular signaling pathways with the help of cell wall proteins [15]. Neuromodulation may use other mechanisms, including ligand-gated ion channels related to calcium ions and others. One of its functions include activation of G protein and intracellular signaling cascade, which is usually prolonged process so, the final function in this case can be achieved long after the presence of the modulator and depends on the change in the overall function of the neurons at the appropriate time. It can be said that neuromodulation is a very dynamic phenomenon and can last from milliseconds to several day and may provoke multiple reactions during different

periods depending on type of mechanism of action [14]. If modulatory stimulation becomes permanent, the neuron is capable to return to its previous status of homeostasis due to its inherent structure.

Considering the above notes and the limitations of the results of all types of tinnitus management methods, they should be proposed and started from the simplest type and be changed if needed. Patient satisfaction with the effect of the intervention and reaching the desired conditions is a sign of the adequacy of the type and duration of intervention. The patient should be prepared in advance for the possibility of ineffectiveness of management or low likelihood of exacerbation of tinnitus. In the current situation since both the therapist and the patient may want to use machine methods such as transcranial magnetic and electrical stimulations, it should be remembered that these two methods are among the final and third priority options with low success rate and can be used in some cases where first and second priority options have not successful results. Although the success rate of transcranial magnetic and electrical stimulations have been reported to be about 30% at best, they are still promising for patients with failed results with first and second priority methods.

The therapist avoiding false hopes should clearly inform the client in advance, even with written consent, about the possible success and failure of the procedure, and the possibility of the return of tinnitus after a period of relative recovery or even exacerbation of it. In cases of using two different methods simultaneously (such as acoustic therapy and electrical stimulation), which gradually has become widespread due to the failure of single methods, the therapist should be aware of the duration of effectiveness of both methods and set the treatment plan in a way that the start of the second method be within the impact range of the first method so that neuromodulation may become more effective. The last point to be mentioned is that duration and physical strength of stimulation, the frequency and total trials should be planned strictly on scientific bases and to avoid from useless over-treatment in the hope of better results

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