

Tinnitus

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Tinnitus is an auditory perception in the absence of an auditory stimulus. It may be associated with acoustic trauma (eg, exposure to loud noise), chronic hearing loss, emotional stressors, or spontaneous occurrence. The psychopathological reaction to the perceived auditory stimulus is an enormous source of distress and disability for many patients with tinnitus. National health surveys estimate that nearly 10 in 100 adults experience some form of tinnitus.¹ Among workers exposed to occupational noise, the prevalence of tinnitus is 15 per 100.² Of these, tinnitus is burdensome and chronic for roughly 20 million and extreme and debilitating tinnitus for 2 million US residents.² Many patients with tinnitus report that the auditory perception impairs sleep, concentration, and cognitive function required for day-to-day functioning. Among the nearly 4.5 million US military veterans receiving service-connected compensation, 42% receive compensation for tinnitus, which makes it the most prevalent service-connected disability. The number of veterans who receive compensation due to tinnitus is nearly 60% greater than the number of veterans who receive compensation for hearing loss, which is the condition with the second most disability claims.³

The evaluation of patients with newly diagnosed tinnitus depends on presumed inciting events (ie, acute acoustic trauma), type of tinnitus (pulsatile or not), and association with other audiological conditions (ie, unilateral sensorineural hearing loss). A complete head and neck physical, neurological examination, and audiogram is recommended. Patients with pulsatile tinnitus (which may be a symptom of increased intracranial pressure, dural arteriovenous fistula, or other vascular lesions), abnormalities on physical examination (draining ear or mass in the middle ear space), or abnormal audiogram (unilateral sensorineural loss) should be referred for specialty evaluation and may require additional diagnostic testing, such as magnetic resonance imaging of the temporal bone with gadolinium to rule out structural or vascular abnormalities.

The prevailing hypothesis for the causes of tinnitus is the top-down or bottom-up auditory attention theory.⁴ Theoretically, tinnitus's auditory perception stems from lost sensory input from the cochlea to the auditory thalamus (*bottom-up* generation) and/or reorganization of key neural networks responsible for attention, emotion, and audition (*top-down* modifiers). Neuroimaging studies⁵ have identified multiple neural systems associated with bothersome tinnitus, including the attention (dorsal and ventral), default mode, limbic, auditory, somatosensory, and visual brain networks.

This overarching theory implies heterogeneity in the biological underpinnings of symptomatic tinnitus. Bothersome tinnitus probably involves abnormal function of different networks for individual patients. These abnormal networks are likely a result of persistent chronic abnormal auditory function for some patients and a preexisting vulnerability for others. The neural network theory posits that individual differences in the pathogenesis of tinnitus require a precision-medicine approach for treatments that are tailored to individual patients. A first step toward precision medicine

will include predicting which patients will respond to a particular tinnitus treatment. A second step emphasizes matching patients to a set of specific, promising treatments.

Tinnitus Retraining Treatment

Tinnitus retraining therapy (TRT) has been used for more than 30 years and is a habituation-based therapy created on a neurophysiological model of tinnitus. The model was 1 of the first to recognize the contributions of both auditory and nonauditory (ie, limbic and autonomic neural mechanisms) processes in the development of tinnitus and its level of disturbance for a patient. TRT involves inducing and facilitating habituation to the tinnitus signal through educational counseling and sound therapy provided by an audiologist using a specific protocol. The efficacy of TRT was recently examined in a randomized, placebo-controlled, multicenter trial of functionally normal-hearing individuals.⁶ The Tinnitus Retraining Therapy Trial randomized 151 active-duty and retired military participants to 1 of 3 groups: (1) tinnitus-specific educational counseling and low-level broadband sound therapy delivered with ear-level sound generators, (2) tinnitus-specific educational counseling and placebo sound generators, or (3) standard care, described as a patient-centered counseling protocol that aligned with current military care and recommended practice. All 3 treatment groups were encouraged to use an enriched sound environment as much as possible. Across the 3 treatment groups, approximately half of the participants showed a clinically meaningful reduction in tinnitus as assessed using the Tinnitus Questionnaire. However, no clinically meaningful differences were observed between the 3 treatment groups in any of the patient-reported outcome measures.

Behavioral Therapies

TRT, implemented either with or without active sound generators, offered benefit no greater than standard counseling with enriched sound. This finding of no benefit with TRT contrasts with evidence of efficacy reported for behavioral therapies that do not rely on the use of sound therapy, including cognitive behavior therapy (CBT),⁷ acceptance and commitment therapy (ACT),⁸ and mindfulness-based stress reduction (MBSR).⁹ Of these treatments, only CBT has strong evidence to support its use.⁷ Each treatment provides patients with multiple ways to cope with the tinnitus sound in a more neutral or relaxed way, such that instead of tinnitus being a source of distress, it can recede into the background and allow patients to continue with their lives. Importantly, CBT, MBSR, and ACT each offer multiple, specific skills, and practices, going beyond education, that allow patients to not be bothered by the tinnitus sound. Even the focused educational experience offered by TRT, which is certainly longer than patients would experience in standard care, may not be enough. Practicing skills over time might be necessary to allow the habituation that TRT seeks.

As to which skills are important, it is worth noting that the most thoroughly researched form of CBT for tinnitus, most recently studied

by Beukes and colleagues,¹⁰ currently incorporates elements of both ACT and MBSR. Thus, these treatments may have more in common than their names would seem to indicate. CBT may thus be an effective treatment partially because it provides several skills, thereby addressing heterogeneity among patients.

One of the primary challenges in finding a single effective tinnitus treatment is heterogeneity in the patients' clinical condition. Indeed, heterogeneity in the etiology and maintenance of tinnitus is widely acknowledged. That is, the condition for some patients might involve cognitive symptoms (eg, distraction) leading to both anxiety and being bothered by tinnitus. For others, their tinnitus bother itself might lead to both cognitive symptoms and anxiety. In addition, the strength of such associations could be widely discrepant across individuals, which must be the case because the majority of individuals who report tinnitus are not debilitated by it.

Getting to Precision Medicine

Getting beyond the currently limited successes of precision medicine in tinnitus will require new methods for capturing patient information. One method is ecological momentary assessment (EMA), which includes intensive longitudinal sampling of a patient's tinnitus experience in their natural environment. The use of EMA facili-

tates development of both tinnitus group and individual profiles, with the expectation that more precise and dynamic measurement will be more useful than typically used predictors (eg, demographics) for patients with tinnitus who often experience changes in reactions to their tinnitus based on their daily life stresses.

Discussion

There is substantial heterogeneity in both the etiology and best-treatment strategy for patients with tinnitus. For many, the onset of tinnitus is associated with an offending noise exposure or other types of acoustic trauma. For others, the onset of tinnitus may have no identifiable environmental acoustic injury. Patients may or may not be able to identify an emotional stressor associated with the onset and worsening of the tinnitus bother. Physicians should be alert to particular symptoms, which indicate referral to a specialist, and additional diagnostic testing may be appropriate. Treatment directed at the auditory percept or tinnitus sound may not be effective because, for most people, the functional and emotional problems associated with tinnitus are based on the patient's reaction to the sound rather than the nature of the sound itself. With this perspective, it is easier to understand why behavioral therapies, such as CBT, may be successful for patients with tinnitus.

ARTICLE INFORMATION

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