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LATENT HEARING LOSS: A REVIEW OF THE LITERATURE

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Abstract
Hearing loss affects approximately 18% of the world's population. One possible cause of latent hearing loss is coclear synapopathy — the loss of synapses between the inner hair cells and the fibers of the auditory nerve. These synapses are the most vulnerable structures in the cochlea of the ear when exposed to noise or aging. The loss of synapses causes auditory deafferentation, that is, the loss of auditory afferent information, which in turn leads to the loss of information that is transmitted to higher levels of auditory processing. Understanding the physiological and perceptual effects of this early auditory deafferentation could inform the development of interventions aimed at preventing more severe hearing loss in the future.
Over the past decade, a large number of studies have been conducted to better understand latent hearing loss, including the causes of latent hearing loss, their impact on the auditory pathway, and the use of auditory physiology for the clinical diagnosis of auditory deafferentation. This review synthesizes the results of human and animal studies to answer some of the key questions in the field, and also points to gaps in knowledge that require further research. In particular, recent studies suggest that some electrophysiological indicators have the potential to be indicators of latent hearing loss in humans, but more research is needed to make these indicators part of a clinical trial.

Keywords: Hearing loss, conduction hearing loss, sensorineural hearing loss.

INTRODUCTION

The gold standard for diagnosing hearing loss in the clinic is audiometry. Audiometry determines the quietest audible stimulus, such as pure tone, variable tone, or narrowband noise, in a quiet environment depending on the frequency (typically between 125 and 8000 Hz). The intensity of this sound at the level of its detection is called the "hearing threshold". This threshold is compared to the reference threshold, which is set as the expected median threshold for an 18-year-old person of the same sex, as defined by the International Organization for Standardization (2017). If the hearing threshold is less than 25 dB relative to the reference threshold at this frequency, it is considered normal hearing; if the threshold is 25 dB or more higher than the reference threshold, it is considered clinical hearing loss. It is worth noting that according to this definition, a wide range of audiometric thresholds falls within the normal range of hearing. The types of hearing loss and their causes vary. "Conductive" hearing loss blocks sounds from reaching the inner ear and is usually caused by any kind of obstruction in the outer or middle ear, as well as other structural abnormalities (e.g., perforation of the eardrum). It can often be reversible. "Sensorineural" hearing loss is permanent, describes neurological defects in the inner ear and/or auditory pathway, and is

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usually caused by certain genes, aging, or noise exposure (Smith et al., 2005). Of these, aging and noise exposure are the most common causes of acquired sensorineural hearing loss (Tanna et al., 2024).

1.2. Latent hearing loss

About 1–10% of patients tested at an audiology clinic report hearing problems but have clinically normal audiometric thresholds (Zhao and Stephens, 2007). These patients often describe their hearing problems, especially in noisy environments, with phrases such as "I can hear, but I don't understand" (Lopez-Poveda, 2014; Zeng, 2000). This perceptual anomaly is often referred to as latent hearing loss (TRS), reflecting a combination of hearing problems in the absence of clinically abnormal audiometric thresholds (Liberman and Kujawa, 2014). Although the term SPS may have some uncertainties in the literature, in this review we define SPS as perceptual difficulties in the perception of sounds that cannot be explained by audiometric results. SPS can occur for a variety of reasons. The exact physiological causes of SPS remain unknown in humans. However, recent animal studies have suggested that symptoms resembling SPS may be the result of audience deafferentation. Auditory deafferentation is the loss of early afferent signals, such as the loss of internal hair cells (IHCs) or the loss of synapses between the IHC and the auditory nerve fibers (ANFs). Importantly, these studies have shown that deficits associated with auditory deafferentation, in both physiological and behavioral measures of auditory function, are not always accompanied by detectable deficits in the audiometric threshold (Chambers et al., 2016; Kujawa and Liberman, 2009; Lobarinas et al., 2016; Resnik and Polley, 2021; Sergeyenko et al., 2013; Wu et al., 2019).

2. Why is hidden hearing loss important?

2.1. Hearing Loss Matters

Hearing loss is a major health problem due to its high prevalence and impact on a person's quality of life. Hearing loss is expected to affect about 18% of the world's population (Wilson et al., 2019). There are more than one billion cases of mild to profound hearing loss worldwide, and in almost half of these cases, patients complain of disabling effects on their lives due to hearing problems (Wilson et al., 2019). Hearing loss is most common among older adults, with more than 40% of people aged 60–69 suffering from hearing impairment (Hoffman et al., 2017) and more than half of those over 70 years old (World Health Organization, 2018). It is important to note that although hearing loss is a sensory deficit in itself, its effects extend far beyond the sensory domain, affecting mental well-being, cognitive function, and increasing the risk of dementia (Liang et al., 2021; Thomson et al., 2017). Moreover, hearing loss also creates stigma (Hétu and Getty, 1996), threatens identity (Gagné et al., 2009; Southall et al., 2010), lowers self-esteem (Lash and Helme, 2020) and induces feelings of loneliness (Ellis et al., 2021; Shukla et al., 2020).

2.2. Latent hearing loss matters

IHC-ANF synapses are usually the first cochlear structures to be affected by aging or noise exposure, and these synapses are lost more rapidly than outer hair cells (OHCs) or IHCs (Sergeyenko et al., 2013; Wu et al., 2019). This suggests that SPS may manifest before the

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appearance of clinically abnormal audiometric thresholds, in which case SPS may be considered as a natural process of normal aging (Wu et al., 2019). Although the impact of SPS is not as severe as that of clinical hearing loss, SPS also affects communication in daily life, as real-life conversations usually take place in noisy environments. It can be assumed that such hearing difficulties in noise may affect cognitive functions (Moore et al., 2014).

Latent hearing loss can also predict later clinical hearing loss. With age, the loss of IHC-ANF synapses occurs faster than the loss of OHC (Wu et al., 2019, 2020), and the loss of IHC-ANF can disrupt the functioning of nearby preserved IHC-ANF synapses (Bullen et al., 2019). It is believed that SPS appears as IHC-ANF synapses are lost, and therefore SPS must manifest earlier than clinical hearing loss (which usually includes OHC loss). In this way, SPS can be used to predict later, more severe hearing loss, making early intervention possible. However, while this hypothesis is attractive, it is only supported so far by the correlation association between the loss of inner and outer hair cells and the loss of IHC-ANF synapses (Wu et al., 2020), and at this point there is no solid evidence in humans that people with SPS are more likely to develop clinical hearing loss in the future (see a recent review in Trevino and Lobarinas 2021).

In terms of systems, researchers can use IHC-ANF synapse loss as an experimental tool to study its effects on the auditory system and its perceptual consequences. The exact level of auditory deafferentation can only be quantified by postmortems in humans or animals. If such measurements are available, they can be correlated with physiological or behavioral data collected at an earlier stage. However, as we discuss in Section 3.2, researchers can induce controlled degrees of auditory deafferentation in animals, allowing for more detailed and causal investigation of central adaptations to the reduction or impairment of peripheral inputs. As we discuss in more detail in Section 4, such adaptations include central gain, unchanged or improved central response after the loss of peripheral signals (Chambers et al., 2016; Harris et al., 2022; Schaette and McAlpine, 2011), and internal noise, hyper-synchronized neural activity in the central auditory system following the loss of peripheral signals (Resnik and Polley, 2021). These maladaptive changes in the central system may also help explain tinnitus and hyperacusis (Auerbach et al., 2014; Plack et al., 2014).

3. What causes hidden hearing loss?

3.1. Innervation of auditory nerve fibers in the cochlea

The cochlea is a bony structure that contains hair cells and synapses between the hair cells and the ANF. Humans have approximately 3,500 IHC, 12,000 OHC, and about 31,000 ANF in the cochlea (Nadol 1988). IHCs encode the location of the displacement on the basilar membrane by releasing neurotransmitters. When neurotransmitters exceed a threshold sufficient to depolarize postsynaptic ANFs, ANFs generate an action potential, which is then transmitted along their axon to the cochlear nucleus (Pickles, 2013). OHCs both enhance and refine basilar membrane displacement (Ashmore, 2008). Both IHC and OHC are innervated by ANFs, but with different types of ANFs: Type I and Type II. For a more detailed overview of the anatomy of hair cells and ANF, see Carricondo and Romero-Gómez (2019) and Eybalin (1993). Note that the characteristics of ANF may vary by species (see Nayagam et al., 2011 for a detailed comparison of ANF between

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species). In humans, the characteristics of ANF are very different, and we will discuss them in detail later in this section.

3.1. Other factors associated with latent hearing loss

3.1.1. Combined effects of aging and noise exposure

The previous section might have given the impression that we now have a relatively detailed understanding of the effects of ANF-IHC synapse loss and hair cell loss associated with age and noise exposure in animals. However, this probably exaggerates our level of knowledge, as aging and noise exposure have a combined effect on the auditory system. CBA/J mice older than 8 weeks showed a decrease in vulnerability to noise with age (Henry 1982). In the "critical period" from 4 to 8 weeks after birth, CBA/CaJ mice are more vulnerable to noise than when exposed at an older age. Exposure to Level 2 noise at frequencies of 8–16 kHz for 2 hours causes temporary hearing loss (TTS) in adult CBA/CaJ mice, but persistent hearing loss (PTS) in CBA/CaJ mice during the critical period (Kujawa and Liberman, 2006). Immediately after exposure to level 3 noise at week 16, CBA/CaJ mice showed more significant loss of IHC-ANF synapses and OHC degeneration compared to controls at frequencies greater than the frequency of exposure (Fernandez et al., 2015, 2020). A year later, the loss of IHC-ANF synapses spread to low-frequency regions (Fernandez et al., 2015; Kujawa and Liberman, 2009). Even areas of the cochlea that appear to be unaffected by synapse damage or OHC (or areas that have fully recovered) show a faster process of hair cell and synapse loss with age after noise exposure than in the case of no-noise aging (Fernandez et al., 2015).

Conclusion

In recent decades, auditory deafferentation, especially cochlear synaptopies, has been identified as a potential cause of latent hearing loss (HHL). Animal studies have significantly contributed to improving the understanding of the physiological consequences of auditory deafferentation, such as reduced amplitude of the first wave of ABR, EFR, and MEMR. Human studies have mainly focused on identifying correlations between behavioral/electrophysiological measures (e.g., speech perception on background noise, EFR, ABR, MEMR) and risk factors for auditory deafferentation (e.g., noise exposure and age). Here, we have attempted to synthesize data from the literature by providing an overview of some of the key questions and relevant answers on the topic of audience deafferentation.

To date, human data remain inconsistent, especially in the case of noise-induced audience deafferentation. A major problem in studies of auditory deafferentation in humans is the lack of a standard diagnostic test. This limits researchers in looking for correlations between risk factors (age and noise exposure), noninvasive measures (e.g., ABR, MEMR, EFR), and predicted outcomes (speech perception difficulties) of auditory deafferentation. Despite considerable efforts in various laboratories, a clear picture has not yet emerged. In order to obtain a reliable indirect diagnosis of auditory deafferentation, other factors such as the reliability of the tests will likely need to be considered (Guest et al., 2019b; Kamerer et al., 2019), exclusion of OHC loss effects (Wu et al., 2020), auditory nerve demyelination (Budak et al., 2021; Wan and Corfas, 2017) or synaptopy of ephemerent hearing pathways (Qian et al., 2021). At the moment, no test satisfies all

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of these requirements. Given the current conflicting data on the diagnosis of auditory deafferentation, a combination of several tests is likely to be required to indicate the likelihood of cochlear synaptopies in humans; for example, a combination of the task of speech perception against background noise (DiNino et al., 2021), EFR recordings (Mepani et al., 2021) and MEMR (Bharadwaj et al., 2022), and measurements of high-frequency audiometric thresholds (Lokwani and Prabhu, 2022) could potentially guide further treatment.

REFERENCES

1. Patel KN. Ossification of the stapedius tendon. J Laryngol Otol 1972; 86:863–5
2. Hara A, Ase Y, Kusakari J, Kurosaki Y. Dominant hereditary conductive hearing loss due to an ossified stapedius tendon. Arch Otolaryngol Head Neck Surg 1997; 123:1133–5Cheng T, Gan RZ. Mechanical properties of stapedial tendon in human middle ear. J Biomech Eng 2007; 129:913–18
3. Schuknecht HF, Trupiano S. Some interesting middle ear problems. Laryngoscope 1957; 67:395–409
4. Hough JV. Congenital malformations of the middle ear. Arch Otolaryngol 1963; 78:335–43
5. Kurosaki Y, Kuramoto K, Matsumoto K, Itai Y, Hara A, Kusakari J. Congenital ossification of the stapedius tendon: diagnosis with CT. Radiology 1995; 195:711–14
6. Improving the treatment of patients with juvenile angiofibroma of the nasopharynx G. Lutfullaev, Sh. Kobilova, F Khamraev, F Asrorova - Stomatology, 2015
7. Clinical and Morphological Characteristics of Benefits of the Nose and Paranasal Sinuses G Lutfullaev, N Safarova, U Nematov, S Kobilova… - Annals of the Romanian Society for Cell Biology, 2021
8. Exudative Otitis Media-Early Symptom of Junior Nasopharyngeal Angiofibroma G Lutfullaev, U Lutfullaev, S Kobilova, N Safarova… - Annals of the Romanian Society for Cell Biology, 2021
9. Lutfullaev, G. U., & Safarova, N. I. (2023). Plant Immunomodulators in the Treatment of Diseases of the Upper Respiratory Tract. INTERNATIONAL JOURNAL OF HEALTH SYSTEMS AND MEDICAL SCIENCES, 2(1), 128-132.
10. Lutfullaev, G. U., Fayzullaev, A. I., & Sh, K. S. (2023). Clinic and Diagnosis of Benign Tumors of the Laryngopharynx. INTERNATIONAL JOURNAL OF HEALTH SYSTEMS AND MEDICAL SCIENCES, 2(1), 115-118.
11. Lutfullaev G. U. Clinic, diagnosis and modern methods of treatment of benign tumors of the nasal cavity and paranasal sinuses. Dis. Doctor of Medical Sciences. Tashkent, 2004, pp. 65-85.
12. Lutfullaev U.L., Safarova N.I., Kim N.A., Mukhtarova D.A. // Microflora of maxillary sinusitis in patients with benign neoplasms of the nasal cavity and maxillary sinus Stomatologia. Tashkent, 2015. № 3-4. Pp. 128-130.
13. Safarova N.I. Diagnosis and treatment of sinusitis in benign neoplasms of the nose and paranasal sinuses. Dis. Doctor of Medical Sciences. Tashkent, 2011, pp. 3-7.

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Licensed under a Creative Commons Attribution 4.0 International License.

14. Lutfullaev, G. U. (2023). Characteristics of Auditory Disfunction in Patients with Benign Neoplasms in Ent Practice. INTERNATIONAL JOURNAL OF HEALTH SYSTEMS AND MEDICAL SCIENCES, 2(6), 132-135.

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