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Review Article

Pathogenesis and treatment progress in age-related hearing loss: a literature review

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Abstract: Age-related hearing loss (ARHL) is a progressive sensorineural hearing loss caused by age. The pathogenesis of ARHL is not completely clear at present, but it is closely related to auditory nerve degeneration, metabolic disorders, vitamin deficiency, and genetics, especially mitochondrial DNA damage. With the acceleration of industrialization and urbanization in our country, the impact of environmental noise is increasing, and ARHL has become one of the most important factors affecting the quality of life of the elderly in our country. Therefore, hearing intervention for patients with ARHL plays a crucial role in improving their quality of life. At present, the use of hearing aids and cochlear implants are the main means to treat the daily hearing difficulties and communication difficulties of patients with ARHL. However, in China, due to the economy, the concept of not wanting to treat the elderly, and other reasons, the hearing aid wearing rate compared to developed countries has significant differences. Cochlear implant is another option for patients with presbyacusis, and patients can obtain good hearing and speech recognition rate after surgery. At present, there is no definitive conclusion on whether the quality of life of patients after cochlear implantation has been improved, and this study will be reviewed based on previous relevant reports.

Keywords: ARHL, cochlea, treatment effect

Introduction

Age-related hearing loss (ARHL) is a senile disease with progressive hearing loss gradually occurring with age, mainly manifested by binaural symmetry, slowly progressive sensorineural hearing loss, and eventual severe deafness [1, 2]. Generally, the incidence of the disease can be as high as 60% in the elderly aged 65 to 75 years [3]. ARHL usually has a slow progressive increase, often not noticed at first, with the decline in high-frequency hearing, and the ability to distinguish speech. Patients can hear the sound, but can not hear the content, so words often need to be repeated by others. Then, as hearing becomes more impaired, the speaker is asked to raise his or her voice. ARHL is a multi-factorial disease, such as diseases (hypertension, diabetes), noise, drug toxicity and genetic factors, with complex pathologic mechanisms and characteristics. It is often accompanied by a variety of abnormal manifestations, such as dementia, dull eyes, vision loss, and so on [4-7].

With the aging of society, ARHL has become a major national health problem, which seriously affects the quality of life of the elderly. Therefore, improving the hearing of patients with ARHL can improve communication between the elderly and the outside world, thereby improving their quality of life. Because hearing loss in ARHL is irreversible, drug therapy has little effect on these patients [7-9]. The use of hearing aids is currently one of the main ways to improve communication disorders in ARHL patients, and with the improvement of technology, digital hearing aids have significantly improved the effect compared with traditional hearing aids [9]. However, according to statistics, the proportion of ARHL patients using hearing aids in China is only 10%-20%.

In recent years, the application of cochlear implantation in ARHL patients has become more common, but whether it is suitable for the treatment of all ARHL patients is still controversial. Current studies have shown that for patients over 60 years old, age growth has almost no impact on speech discrimination after cochlear implantation. Cochlear implantation in the elderly has similar efficacy to young patients, and the impact of organ degradation is not obvious [10, 11]. Therefore, from the perspective of safety and quality of life, ARHL implantation of cochlear implants is a relatively good choice.

Previous studies on ARHL were mostly limited to one aspect, such as treatment or quality of life, etc. This study conducted a comprehensive and systematic review from the pathogenesis, treatment and improvement of ARHL quality of life.

Pathogenesis of ARHL

The pathogenesis of ARHL is not a single one. It is the result of a variety of physiological and pathological mechanisms. In addition to the effects of aging, noise and drug toxicity, various senile diseases such as hypertension, hyperglycemia, and hyperlipidemia can cause changes in the osmotic pressure of the labyrinthian lymph fluid of the inner ear, resulting in damage to the structure and function of the cochlea. In addition, roles for ototoxicity, estrogen, and free radicals in the pathogenesis of ARHL have been proposed one after another [12-14]. Especially, more attention has been paid to the role of genetic factors in the pathogenesis of ARHL, especially the factors related to mitochondrial genes that have been found [1, 2, 15].

ARHL with chronic diseases

ARHL is closely related to chronic diseases such as hypertension, diabetes, arteriosclerosis, and hyperlipidemia. Modern anatomy proves that there is no collateral circulation in the auditory artery of the ear, and vascular spasm and embolism are easy to cause ischemia and hypoxia of the inner ear and deafness. The above factors are important factors in the occurrence of vasospasm and embolism. Frisina et al. found that in the elderly population, the hearing function of patients with diabetes is significantly decreased, and aging may lead to slow or blocked blood flow, resulting in hypoperfusion ischemia, labyrinthine microcirculation disorder, and cochlear and vestibular function abnormalities [16]. Chen Yu et al. found that ARHL patients showed hemorheological abnormalities, mainly reflected in increased whole blood and plasma viscosity, hematocrit, and fibrinogen [17]. Chai Feng et al. analyzed through clinical observation that hypertension and diabetes can cause different degrees of hearing damage, which is an important factor aggravating ARHL [18].

ARHL and mitochondrial genes

Mitochondria are common organelles in eukaryotic cells, the main sites for oxidative phosphorylation to produce energy, and they participate in the synthesis of many bioactive substances in the body. In recent years, it has been reported that ARHL is related to mtDNA mutation. Seidman et al.'s animal experiments and human temporal bone sections both found mtDNA deletion in age-related deafness. It has been confirmed that human mtDNA4977bp deletion and mouse mtDNA4834bp deletion are related to ARHL [18]. In 2002, Zhang et al. found in animal experiments that the absence of mtDNA3867bp in the cochlea might be related to the production of ARH [19]. In 2006, Wei Xuemei et al. found that the absence of mtDNA4586bp in cochlea spiral tissue and auditory nerve tissue was related to ARHL [20]. Deletion results in the fusion of the 5th subunit gene of mitochondrial oxidative phosphorylation complex I with the 8th subunit gene of complex V (ATPase), affecting mitochondrial oxidative phosphorylation and ultimately producing bioenergy-deficient cells. Different types of ARHL have a different molecular basis, and not all ARHL patients have mtDNA deletion. mtDNA deletion may be more related to sensorial and vascular ARHL, because there are more mitochondria in the cochlear hair cells and vascular striae [21, 22]. mtDNA deletion represents only one aspect of ARHL's many genetic factors.

Other pathogenesis of ARHL

ARHL with major histocompatibility complex (MHC) Bern-stein showed an increased percentage of patients with MHC B8/DR3 in 14 patients with vascular ARHL, especially A1/B8/DR3 haploids, suggesting a significantly increased incidence of B8/DR3 antigen in patients with vascular ARHL [7, 23]. It is speculated that the genes related to this disease may be within or associated with MHC. At the same time, it was pointed out that B8 locus and DR3 locus did not cause disease by themselves, and when the two genes were closely linked, they increased susceptibility to ARHL. The B8/DR8 antigen is associated with changes in immune system activity. This immune dysregulation can lead to the production of protein antibodies, circulating immune complexes, decreased immune complex clearance, and suppression of T cell function [5, 15].

ARHL starts earlier in men, (after the age of 30), while in women, it does not start until age 50. This coincides with the menopause transition in most women, when endogenous circulating estrogen levels in the body are declining [14]. R.K. Shepherd et al. used kanamycin (KA) and the diuretic acetic acid (EA) in the kittens' age range from 2 to 16 days after birth (DAB), and they found that animals treated with 2-8 DAB sessions showed severe high-frequency hearing loss, and all animals showed bilateral symmetrical hearing loss [24].

ARHL is the result of both genetic and environmental factors. After years of research, it is believed that ARHL is closely related to noise, smoking, chronic diseases such as hypertension, diabetes, arteriosclerosis, hyperlipidemia, ototoxic drugs, dietary habits, psychosocial factors, and immune function, in addition to the factors mentioned above.

Treatment status of ARHL

Drug therapy

So far, the pathogenesis of ARHL has not been thoroughly studied, so the research on drug treatment is mostly animal experimental research, and clinical research has not made breakthrough progress. Drug therapy mainly includes anti-oxidation, regulation of mitochondrial function and metabolism, inhibition of apoptosis, regulation of NKCC1, protection of hair cells and anti-inflammation. Polanski et al.'s study compared the efficacy of ginkgo biloba extract, alpha-lipoic acid, VC, VE and placebo, and found that there was no statistical difference in hearing threshold between the observation group and the placebo group [25].

Hearing aids

At present, hearing aids are one of the main means to improve the daily listening difficulties of ARHL patients and reduce communication barriers. In recent years, digital hearing aids have made major improvements in design and significantly improved in effect, making it easier for ARHL patients to accept hearing aids, and therefore gradually replacing the previous analog hearing aids [26-28]. However, compared to the large number of ARHL patients, the proportion of ARHL patients using hearing aids in China is very small. This proportion is about 10% to 20%, and even some scholars think that it is less than 10%. According to previous literature reports, there are four main reasons for the low wearing rate of hearing aids in China's ARHL patients: First, Chinese elderly people believe that deafness is a natural decline without intervention. Second, for economic reasons, nearly one-third of patients refuse to wear hearing aids simply because of the price. Third, a considerable number of elderly people worry that hearing aids will aggravate deafness or affect their image. Fourth, some patients cannnot operate and use hearing aids, which is more common in elderly patients [5, 29].

Cochlear implant

Cochlear implant is an electronic bionic device. Based on the cochlear electrophysiology principle, the sound is converted into a certain encoded electrical signal by the external speech processor, and the auditory nerve is directly excited by the implanted electrode system in the body to restore or rebuild the hearing function of the deaf.

Cochlear implants have been shown to be an effective treatment for patients with severe and very severe sensorineural hearing loss [30]. Common concerns regarding cochlear implants in the elderly are the safety of general anesthesia and the impact of degenerative central and peripheral auditory processing in patients with ARHL on implant effectiveness. In this regard, there have been many foreign literature reports in the past decade, and the overall results suggest that for elderly patients ≥65 years old, aging has almost no effect on the discrimination ability of words after cochlear implant. The effect in elderly patients with cochlear implant is close to that of ordinary young patients, and the impact of organ degradation is not obvious [30, 31]. In recent years, there have been reports of successful cochlear implantation in

ARHL patients ≥60 years old [32-34]. In terms of safety and speech rehabilitation effect, cochlear implants with ARHL have a good prospect.

Cochlear implantation can improve the quality of life of ARHL patients

Although ARHL is not a serious fatal disease, it affects the daily life of elderly patients in their later years. As a special vulnerable group, senile deafness patients have more factors related to their daily life quality and negative emotions. The quality of life and negative mood of patients with senile deafness can be improved by strengthening standardized treatment and improving the disturbances caused by hearing loss and tinnitus.

The study of Zheng Mengmeng et al. showed that the auditory behavior grading, speech intelligibility grading, and speech recognition rate of ARHL patients after cochlear implantation were significantly improved compared with those before surgery [34]. A number of domestic and foreign studies have confirmed the effectiveness of cochlear implant in improving speech recognition, cognitive function, psychological state and quality of life of ARHL, and the safety of the operation. The complications do not increase with age, and age should not be a limiting factor for cochlear implant in the elderly. Studies by Isabel et al. have shown that hearing and quality of life are improved in older cochlear implant users, with similar effects as in younger people [35]. Special attention must be paid to the possibility of age-related diseases in the elderly that may increase the risk of surgery.

Liu Ying et al. evaluated 24 patients with ARHL who underwent cochlear implantation. Their study found that the hearing aid threshold of each frequency after cochlear implantation was significantly improved compared with that before surgery. The scores of CAP (auditory behavior grading evaluation), WRS (word list recognition rate evaluation) and SIR (speech intelligibility grading standard) were significantly improved before and after cochlear implantation [32]. Mosnier et al. compared the cognitive function of 94 patients aged 65-85 years with cochlear implants before, 6 months, and 12 months after surgery, and found that average scores in all cognitive areas improved at 6 months after cochlear implants. The use of cochlear implants can improve the cognitive ability of patients with bi-focused and extremely severe SNHL [36]. Some scholars have confirmed that the neurocognitive ability of elderly patients with cochlear implant can be improved at 6 months and 12 months after surgery, and the score of quality of life assessment (QLA) can be significantly improved [37]. This suggests that cochlear implants can significantly improve the independent living ability of elderly patients, and produce obvious economic benefits. In addition, their study showed that the hearing performance and quality of life QLA of older adults (older than 65, 70, and 75 years) improved after cochlear implantation compared to before implantation. Although young individuals have better postoperative recovery than old individuals, this does not negate the judgment that cochlear implant patients are effective for the elderly, because these individuals also have positive effects.

Of course, there are some limitations to this study. First, this study is a review, only a summary of previous relevant studies, and does not propose different treatment views. In addition, the current research on the pathogenesis of ARHL and the improvement of quality of life is still insufficient, and a large number of follow-up studies are still needed to make up for this gap.

Conclusion

Cochlear implantation with ARHL has good development prospects both in terms of safety and speech rehabilitation effect, and can significantly improve the quality of life of ARHL patients.

Disclosure of conflict of interest

None.

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