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REVIEW ARTICLE

Aging of Vestibular System

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ABSTRACT

Background: While a lot has been discovered about the auditory changes that occur with aging in the inner ear, relatively little is known about the vestibular changes that occur with aging. Here, we review the prevalence of vestibular dysfunction and vestibular anatomical and functional changes in aging. As people get older, vestibular impairment becomes more common. Functionally, vestibular evoked myogenic potentials (VEMP) amplitude decreases with age, VEMP threshold increases and head impulse test's vestibulo-ocular reflex gain diminishes. The results of the VEMP latency and caloric tests are contradictory because of the intricacy of the vestibular system, changes in subject age, and measuring methods. A direct assessment of the peripheral vestibular system should be used to address this. Age-related structural changes in the vestibular ganglia and otoconia have been observed; alterations in the hair cell structure are less clear and subcellular changes have not yet been fully investigated. In this study we aim to understand the relationship between the mechanisms driving vestibular aging and both vestibular dysfunction and structural degeneration. **Conclusion:** There is a clear association between aging and a decline in vestibular sensitivity and reduced responses.

Keywords: Aging, Vestibular, VEMP.

INTRODUCTION

Morbidity, mortality, and the availability of medical resources are all significantly impacted by vestibular dysfunction brought on by aging and the imbalance it creates. According to the National Institute of Deafness and Other Communication Disorders of the National Institutes of Health, falls are to blame for more than 50% of all accidental deaths among the elderly [1]. In the United States of America (USA), 69 million adults over 40 have vestibular impairmentor 35.4% of the population [2]. Falls are substantially more likely to occur in people with vestibular impairment (odds ratio 12.3 for patients with concomitant dizziness) [3]. Despite that smoking, diabetes and hypertension are risk factors for a decline in vestibular function, the impact of aging is still much more noticeable [4].

An unstable state and an elevated risk of falling are symptoms of the complex, multifaceted illness known as progressive disequilibrium of age [5], with vestibular dysfunction being a major contributor to imbalance [6, 7], even when combined with other variables (such as musculoskeletal and visual impairment). The strength of peripheral vestibular transmission may change with age, which could be a contributing factor to balance impairment [8]. A study indicated that older people preferred to employ proprioceptive signals for postural motor control over visual and vestibular cues. This suggests that another significant aspect might be modifications in the way brain circuits process sensory information [9]. Overall, Aging causes a decline in peripheral vestibular sensing and the cerebral synthesis of many sensory data for balance.

THE PERIPHERAL VESTIBULAR SYSTEM

Vestibular hair cells are sensory receptors in the inner ear that detect head motion and thereby enable humans to orient their bodies and coordinate movements (Figure 1). The two most important effects of aging on the peripheral vestibular system are the loss of neurons and hair cells, which affect both the otolith organs and the semicircular canals. According to numerous studies, aging decreases the vestibular end organs' sensory hair cell count [6,10]. Several studies have shown the vestibular ganglion (Scarpa's ganglion) and nerve degeneration. The vestibular nerve has two divisions, receiving conveying afferents from both the semicircular canals and the otolith organs via the superior and inferior vestibular nerves, respectively [8,11].

Otolith Organs

In addition to specific degenerative effects on the ultrastructure of the otolith organ, the loss of vestibular hair cells and ganglion cell degeneration also have an impact on the otolith organs. Vestibular-evoked myogenic potentials (VEMPs) have been used to examine how aging affects otolith function. Slow brainstem signal processing may be associated with increased VEMP delay, whereas decreased VEMP amplitude indicates diminished otolith organ function [12].

According to postmortem investigations, the otoconia found in the utricle and saccule also exhibit morphological alterations and degradation over the course of an individual's lifetime. In both humans and animals, aging has been linked to fracture and fragment production as well as a decrease in otoconia mass. In contrast, it has been previously stated that while hair loss develops with advancing age in all of the peripheral vestibular organs, the utricle is comparatively unaffected [13].

Although the effects of otoconia degeneration on otolith organ function are still unknown, it is thought that these otoconial alterations contribute to the emergence of peripheral vestibular diseases including benign paroxysmal positional vertigo (BPPV) [14]. One of the most frequent causes of vertigo, particularly in the elderly, with an increase in prevalence that peaks at age 60, is BPPV. It is a condition where particular positional head motions trigger vertigo. Otoconia debris, which travels through the endolymph or cupula of the semicircular canals, is what causes BPPV [15]. It is believed that the morphological changes that can occur to the otoconia with aging cause the otoconia to get dislodged from the utricular macula. Repositioning techniques, however, can be used to treat BPPV effectively [16].

Semicircular Canals

The semicircular canals transduce head angular acceleration via the anterior, posterior and horizontal semicircular canals. The total aging-related deterioration in the vestibular system includes a considerable component involving the semicircular canals [17].

The angular vestibulo-ocular reflex (VOR) (Figure 2), for instance, can be used to assess semicircular canal decline. The caloric testing depends on this approach to assess the horizontal semicircular canals. A few years back, before caloric ear stimulation, rotatory chair tests were the only method available to evaluate the VOR [18]. More recently, the video head impulse test has been used to identify the overt and covert saccades and study the gain of VOR of each semicircular canal individually [19]. It can be seen that age-related vestibular system degradation significantly includes a decline in semicircular canal function [20]. Given that the main function of the semicircular canals is to record angular acceleration; nevertheless, it is feasible that their deterioration may be more thoroughly monitored related to dizziness reported by patients, which significantly raises their risk of falling in people with vestibular dysfunction [21].

THE CENTRAL VESTIBULAR SYSTEM

The Brainstem and Cerebellum

The vestibular nuclear complex, which spans the Ponto-medullary junction, is the primary part of the brainstem vestibular system. This group of nuclei connects to a number of tissues, including the cerebellum and the vestibular nerve sends primary vestibular afferents to it [22]. The four principal vestibular nuclei are the descending or inferior (DVN), lateral (LVN), superior (SVN) and medial (MVN) vestibular nuclei [23].

The vestibular system depends on the cerebellum, which also recognizes the vestibular nuclei as a source of efferent signals. Purkinje cell density and white matter in the floccular nodular lobe of the cerebellum have been reported to decline with age [24].

THE VESTIBULAR-THALAMIC PROJECTIONS AND THE VESTIBULAR-CORTICAL SYSTEM

In everyday life, spatial orientation plays a crucial role. Spatial disorientation is a complaint made by up to one-third of dementia patients who have just received a diagnosis [25], and it significantly disrupts daily life. The hippocampus is a crucial brain region associated with spatial orientation and memory [26].

Poor vestibular function with aging is associated with significantly reduced volumes of the thalamus, basal ganglia and left hippocampus. As vestibular function declines with aging, less vestibular information is distributed throughout the brain, leading to a loss of neurons in areas that receive those inputs. In support of this putative mechanism in older adults, recent discoveries underscore the association of vestibular impairment with spatial cognitive declines and with volume loss of brain areas that support spatial cognitive ability; the hippocampus and entorhinal cortex [27].

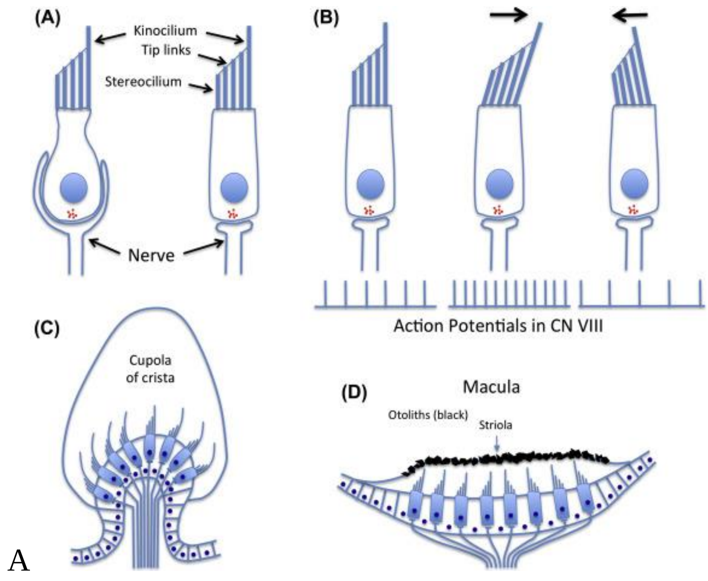

Figure (1): Vestibularhair cell structure, function, and organization [12].

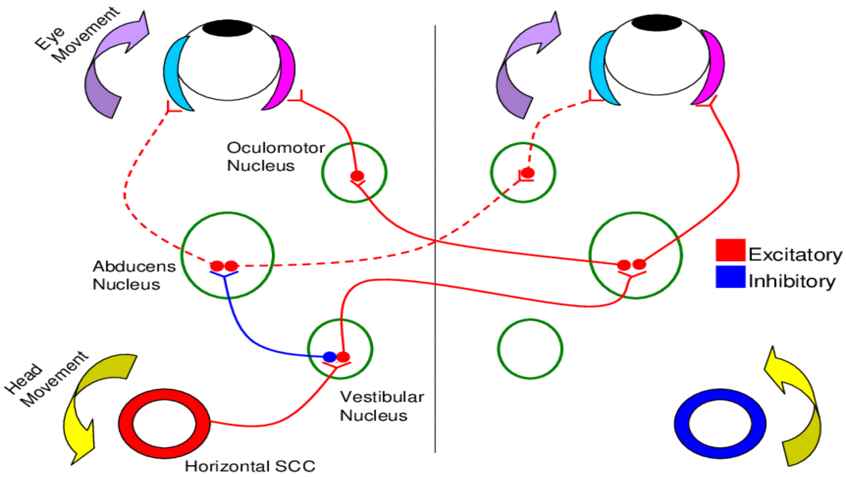

Figure (2): The vestibulo-ocular reflex [18].

CONCLUSIONS

Aging has a degenerative effect on the vestibular system, affecting both the peripheral organ and central circuits, including the peripheral end-organ, brainstem, cerebellum and cerebral cortex. It follows those diseases that affect any one of these areas will disrupt one or more facets of vestibular functioning. Recent studies utilizing VEMP and VOR testing have shown that specific peripheral vestibular organs exhibit a quantifiable reduction in function with aging, which potentially aligns with the previously observed histological and microscopic changes. As evidenced by the review findings, the importance of assessment and management of age-related vestibular dysfunction has been raised. Moreover, it is recommended to develop targeted rehabilitation and training programs for individuals with age-related vestibular dysfunction that can help improve their functional outcomes.

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