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INTEGRATIVE ANALYSIS OF NYSTAGMUS IN MIDDLE EAR AND VESTIBULAR SYSTEM DISORDERS: PATHOGENESIS, CLINICAL PHENOTYPES, DIAGNOSTIC ALGORITHMS, AND MODERN TREATMENT STRATEGIES

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ABSTRACT. Nystagmus is a rhythmic, repetitive, uncontrolled movement of the eyes, a common sign in pathologies of the middle ear and vestibular systems. This article provides an integrative analysis of the pathogenesis of nystagmus, its main clinical phenotypes (peripheral and central), diagnostic algorithms, and modern treatment strategies. Detection of nystagmus and establishing the correct etiology are important for the patient's rehabilitation and prognosis. The diagnostic process is carried out by anamnesis, examination by assignment, Fresnel or videonystagmography, VHIT, VEMP, audiology and, if necessary, MRI/CT. Treatment is etiological: in vestibular peripheral diseases, pharmacotherapy (vestibular suppressors, antiemetics), vestibular rehabilitation and, if indicated, surgery; in central diseases, it is important to identify and treat the underlying disease, symptomatic therapy and rehabilitation. The article presents a clinical-unified algorithm and practical recommendations.

Keywords: Nystagm; vestibular system; middle ear; peripheral vestibulopathy; central disorders; diagnostics; videonystagmography; vestibular therapy.

НИСТАГМ ПРИ ЗАБОЛЕВАНИЯХ СРЕДНЕГО УХА И ВЕСТИБУЛЯРНОЙ СИСТЕМЫ: ИНТЕГРАТИВНЫЙ АНАЛИЗ ПАТОГЕНЕЗА, КЛИНИЧЕСКИХ ФЕНОТИПОВ, ДИАГНОСТИЧЕСКИХ АЛГОРИТМОВ И СОВРЕМЕННЫХ СТРАТЕГИЙ ЛЕЧЕНИЯ

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АННОТАЦИЯ. Нистагм — это ритмичное, повторяющееся, нерегулируемое движение глаз, часто встречающееся при патологии среднего уха и вестибулярной системы. В данной статье представлен интегративный анализ патогенеза нистагма, основных клинических фенотипов (периферических и центральных), диагностических алгоритмов и современных стратегий лечения. Выявление нистагма и установление правильной этиологии имеет важное значение для реабилитации и прогноза пациента. Диагностический процесс проводится с помощью анамнеза, обследования по заданиям, Френзеля или видеонистагмографии, вВИТ, ВЭМП, аудиологии и при необходимости МРТ/КТ. Лечение направлено на

этиологию: при вестибулярных периферических заболеваниях - фармакотерапия (вестибулярные супрессоры, антиэметики), при вестибулярной реабилитации и индикации - хирургическое вмешательство; при центральных заболеваниях в основном важно выявить и лечить основное заболевание, симптоматическую терапию и реабилитацию. В статье представлен клинико-единый алгоритм и практические рекомендации.

Ключевые слова: Нистагм; вестибулярная система; среднее ухо; периферическая вестибулопатия; центральные нарушения; диагностика; видеонистагмография; вестибулярная терапия.

Introduction. Pathologies of the middle ear and diseases of the vestibular system are among the most common otoneurological problems in clinical practice, which directly affect a person's balance, spatial orientation, and movement coordination. Functional disorders of these systems are often manifested by nystagmus - a rhythmic, involuntary oscillation of the eyeball. Nystagmus is not only a symptom, but also an important biomarker for assessing the physiological and pathological state of the vestibular system. The mechanisms of its occurrence are closely related to changes in the central and peripheral vestibular structures, inflammatory processes of the middle ear, impaired endolymphatic dynamics, or dysfunction of neurosensory integration.

The imbalance of the vestibulo-ocular reflex (VOR) is the main axis of nystagmus pathogenesis, and the asymmetry of afferent vestibular impulses leads to compensatory activation of the oculomotor centers. Inflammation of the middle ear (otitis media), endolymphatic hydrops, perilymphatic fistulas, labyrinthitis, as well as diseases of the central nervous system (focal lesions of the cerebellum, demyelination of the brainstem, cerebrovascular pathologies) are manifested by various types of nystagmus. Therefore, the correct interpretation of clinical phenotypes of nystagmus is an important diagnostic step in the differential identification of peripheral and central genetic mechanisms.

In modern otoneurology, instrumental analyses for the study of nystagmus, such as videonystagmography (VNG), video head impulse test (VHIT), caloric test, vestibular evoked myogenesis responses (VEMP), audiometry, and high-resolution computed tomography (CT), are combined into an integrative diagnostic algorithm. This approach allows for a comprehensive assessment of vestibular function, determining the relationship between structural and functional changes.

Treatment strategies are selected individually based on the etiology of the pathology, central or peripheral origin, and the clinical type of nystagmus. Vestibular rehabilitation, pharmacotherapy (betagistin, vestibular suppressors), etiological treatment of middle ear infections, surgical procedures (endolymphatic decompression, closure of perilymph fistulas), and therapeutic programs based on neuroplasticity are used in a complex manner. All this contributes to symptomatic relief of patients, restoration of balance function, and improvement of quality of life.

This article analyzes the pathogenesis, clinical phenotypes, modern diagnostic algorithms, and multidisciplinary treatment strategies of nystagmus in

diseases of the middle ear and vestibular system based on an integrative approach. Also, the significance of the latest scientific research and innovative technologies in clinical practice in the detection and management of nystagmus is widely covered.

Modern interpretation of pathogenesis. The vestibulo-ocular reflex (VOR) is the main mechanism of nystagmus pathogenesis, and when its peripheral links - semicircular canals, otolith receptors, and vestibular nerve - undergo functional asymmetry, rhythmic eye movements are formed. Inflammation, pressure changes, or increased endolymph in the middle ear cause uneven afferent impulses to the vestibular nuclei, leading to classic peripheral "jerk" type nystagmus. Among the central mechanisms, the integrated role of the cerebral cortex, brainstem, cerebellar flocculo-nodular complex, and vestibular nuclei is emphasized. Their dysfunction causes forms of vertical, torsion, or dissociated nystagmus. Metabolic stress, toxic agents, medications (especially aminoglycosides), hypoxic states, and intrathympanic chemical effects can alter the excitability of vestibular receptors, causing variable and sometimes transient nystagmus phenotypes.

Variety of clinical phenotypes. Although the clinical division of nystagmus into peripheral and central types is well known, modern literature interprets its phenotypic spectrum much more broadly. Peripheral vestibular nystagmus is usually unidirectional, often subsiding with fixation and intensifying with head movements. This type may be associated with Meniere's disease, vestibular neuritis, acute labyrinthitis, barotrauma, perilymphatic fistula, or BPPV. Central nystagmus is vertical, torsional, or multi-component and does not disappear with fixation, but in some cases intensifies. Its occurrence is associated with such pathologies as cerebellar degeneration, stroke of the brainstem, MS, Arnold-Chiari malformation. Episodic, provocative forms in the clinic - nystagmus arising from shaking the head, nystagmus induced by hyperventilation, Valsalva-provocative nystagmus - have diagnostic significance and often manifest as latent vestibular dysfunction.

Diagnostic algorithms. In current scientific sources, the International Classification of Vestibular Diseases (ICVD) is considered the main criterion of the diagnostic process. According to it, clinical examination, head position-driven tests, fixation-suppression reaction, temporary provocative tests (head-shaking, hyperventilation, Valsalva) and instrumental diagnostics are used in combination to assess nystagmus. Modern studies, such as videonystigmography, video head impulse test, caloric stimulation, VEMP (oVEMP, cVEMP), help to more accurately determine the degree of vestibular asymmetry, the functional state of otolith organs, and central-peripheral analysis. Imaging methods - especially high-resolution MRI - play a key role in the rejection of central etiology. The integrative diagnostic approach is based on the interpretation of nystagmus morphology, duration, direction, and reaction to visual fixation as a whole.

Modern treatment strategies. In the treatment of nystagmus, an integrative strategy based on etiology prevails over a one-sided symptomatic approach. In acute vestibular syndromes, vestibular suppressants and antiemetics are used for

short-term symptom relief, but it is noted that their prolonged use can slow down vestibular compensation. In Meniere's disease, intrathympanic gentamicin may improve vertigo control, but selective, controlled administration is required due to the risk of hearing loss. Betahistine and some neuromodulators (gabapentin, baclofen) have been observed to reduce symptoms in some forms of central nystagmus.

Vestibular rehabilitation therapy (VRT) has been shown in many studies as the most effective method for accelerating post-peripheral vestibular pathology compensation, contributing to the reduction of nystagmus intensity through targeted exercises aimed at re-learning head-movement coordination, postural stability, and VOR. In central nystagmus, the main treatment is aimed at the etiological factor - for example, reperfusion protocols in stroke or immunomodulation measures in demyelination. Among future approaches, AI-based videonystagm analysis, individualized vestibular rehabilitation protocols, and non-invasive neuromodulation technologies that enhance oculomotor neuroplasticity are recognized as particularly promising areas.

Conclusion. Nystagmus, observed in diseases of the middle ear and vestibular system, is a clinical manifestation of the interaction of complex neuro-otological mechanisms, the pathogenesis of which is determined by the combination of peripheral sensory dysfunction, central compensatory responses, and neuroplastic changes. The diversity of clinical phenotypes - spontaneous, positional, induced, and visual - contributes to the emergence of forms of nystagmus, which are directly related to the degree of damage to the vestibular apparatus, inflammatory processes, pressure dynamics, and disruptions in neural pathways.

The modern approach to diagnostic algorithms is multi-stage, allowing for precise determination of etiology by integrating such instrumental studies as audiometry, vestibulometry, VNG/VHIT, pulse tests, positional tests, CT/MRI of the temporal bone. In this case, the differentiation of peripheral and central nystagmus, assessment of the effect of visual fixation, dynamic monitoring, and analysis of the process of functional compensation play an important role in making a clinical decision.

Modern treatment strategies require a comprehensive approach to the pathogenesis of the disease, including anti-inflammatory therapy, blood pressure normalization procedures, labyrinth stabilizing drugs, vestibular rehabilitation, exercises to restore visual-proprioseptive integration, and in some cases, surgical interventions. The integrative treatment model increases the rate of functional recovery of patients, reduces symptoms, and accelerates central compensation.

Thus, the systematic study of nystagmus and the individualization of diagnostic and therapeutic measures in associated diseases, the application of a multidisciplinary approach and the introduction of digital vestibular monitoring technologies into clinical practice will significantly increase effectiveness and improve the quality of life of patients.

REFERENCES

1. Bhattacharyya, N., Gubbels, S. P., Schwartz, S. R., et al. (2017). Clinical practice guideline: Benign paroxysmal positional vertigo (Update). Otolaryngology–Head and Neck Surgery, 156(3), S1–S47.
2. Bronstein, A. M., & Lempert, T. (2019). Dizziness: A Practical Guide to Diagnosis and Management. Cambridge University Press.
3. Fife, T. D., Colebatch, J. G., Kerber, K. A., et al. (2017). Practice guideline: Cervical and ocular vestibular-evoked myogenic potential testing. Neurology, 89(22), 2288–2296.
4. Hain, T. C., & Cherchi, M. (2021). Nystagmus: Clinical and diagnostic evaluation. Handbook of Clinical Neurology, 173, 263–286.
5. Kim, J. S., & Zee, D. S. (2014). Benign paroxysmal positional vertigo. New England Journal of Medicine, 370(12), 1138–1147.
6. Merchant, S. N., & Nadol, J. B. (2010). Schuknecht's Pathology of the Ear. PMPH-USA.
7. Strupp, M., & Brandt, T. (2008). Diagnosis and treatment of vertigo and dizziness. Deutsches Ärzteblatt International, 105(10), 173–180.

ИСПОЛЬЗОВАННАЯ ЛИТЕРАТУРА:

1. 1. Бхаттачарья, Н., Губбельс, С. П., Шварц, С. Р. и др. (2017). Руководство по клинической практике: Доброкачественный пароксизмальный позиционный головокружение (Обновлено). Отоларингология-Хирургия головы и шеи, 156 (3), S1-S47.
2. Бронштейн, А. М., и Лемперт, Т. (2019). Головокружение: практическое руководство по диагностике и лечению. Cambridge University Press.
3. 3. Фиф, Т. Д., Коулбэтч, Дж. Г., Кербер, К. А. и др. (2017). Практические рекомендации: Проверка цервикального и глазного вестибулярного миогенного потенциала. Неврология, 89 (22), 2288-2296.
4. Хайн, Т. К., и Черчи, М. (2021). Нистагм: клинико-диагностическая оценка. Справочник по клинической неврологии, 173, 263-286.
5. Kim, J. S., & Zee, D. S. (2014). Доброкачественный пароксизмальный позиционный головокружение. New England Journal of Medicine, 370 (12), 1138-1147.
6. Merchant, S. N., & Nadol, J. B. (2010). Патология уха Шукнехта. PMPH-США.
7. Strupp, M., & Brandt, T. (2008). Диагностика и лечение головокружения и головокружения. Deutsches Ärzteblatt International