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Fundamentals Of Human Physiology Of Hearing.

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ABSTRACT

The hearing aid consists of an outer, middle and inner ear. The auricle serves as a collector of sound waves and a determinant of the direction of the sound source. The ear canal is a conductor of sounds, and a resonator in the range of speech frequencies from 2000 to 2500 Hertz. The middle ear is a three-core sound-transmitting system, which includes a hammer, anvil and stirrup, connected on one side with the eardrum, and on the other with the vestibule window (oval window) of the inner ear. It contains auditory receptors that perceive sound vibrations and transmit information about them along the nerve to the brain. Deaf and hearing impaired people are distinguished by somatic weakness, insufficient mobility, lagging in physical and motor development. Hearing impaired people find difficulties in the formation of movements in connection with a violation of the auditory analyzer, which plays a leading role in controlling accuracy, rhythm, and speed of movements. Sharply reduced or completely missing functional activity of the auditory analyzer causes inhibition of the center of the motor analyzer. The external signs of this process are a sharp limitation of the motor activity of people with hearing impairments and their constant control over their every movement. In addition, the slowness of the formation of kinesthetic perceptions arising in connection with the violation of the auditory analyzer, often leads to difficulties in the implementation of work.

Keywords: ear, hearing, physiology, analyzers, deafness, hearing loss.

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INTRODUCTION

A person perceives information from the outside world with the help of five senses - sight, hearing, touch, taste and smell, which not only inform him about any changes in the external environment, but also warn about possible danger. As a result, a person gains a certain life experience. Based on this experience, a certain human behavior is formed [1, 2].

Hearing is an important element of human feelings. Through hearing, we maintain a close relationship with the outside world. Unlike other organs of the senses, hearing acts continuously, even in sleep. It is impossible to "turn off". This is the first feeling that is formed in a child. Even in the womb he begins to hear and recognize the surrounding sounds [3]. Hearing is the most acute human feeling. The intensity of the sound that causes the ear to have the weakest sense of hearing is billions of times less than the equivalent intensity of light. The most perfect feeling. He can not only distinguish a huge range of sounds, but also accurately determine the spatial location of their source, allowing us to feel safe. Only he gives the opportunity to hear the noise of the car approaching from behind and react in time. The sharpest and most perfect feeling. The number of sound vibrations perceived by the organ of hearing is millions of times less than the number of molecules to which the human sense of smell reacts. As a result, a person can distinguish a huge range of a wide variety of sounds and, most importantly, very accurately determine the distance to their source. The human organ of hearing has such a complex structure that none of the most modern technical devices can replace it. Hearing is more important for the fundamental characteristics of a person, as a social being, as compared to any other feeling. It serves as a warning about danger, for receiving information, for mastering knowledge, for social communication, and can cause very strong emotions [4]. In this regard, the aim of the work is to summarize the available information on the physiology of hearing and the mechanisms of its violation in humans.

BASICS OF THE PHYSIOLOGY OF HEARING

Hearing is a subjective perception of the mechanical energy of air oscillations. The perception of this form of energy is a special organ of hearing. The organ of hearing is located inside the cochlea, which is located in the pyramid of the temporal bone. The organ of hearing consists of three sections: the outer, middle and inner ear [5].

The external ear includes the auricle and the external auditory canal. The auricle is a fold of skin protruding freely on the surface of the head, which is based on a plate of elastic cartilage. The shape of the cartilage basically corresponds to the external shape of the auricle. In the area of the lower end of the auricle, there is no cartilage and there is a well-developed layer of fatty tissue that forms, together with the skin covering it, the earlobe. The free edge of the auricle, curving in the form of a groove, forms a curl. At the upper edge of the shell, the curl bears the inconstant tubercle of the auricle. Along the edge of the curl is located in the form of a groove a fossa — a rook, which is bounded in front by an 8 roller anti-backing. The counterwave goes up, bent, divided into two legs, between which there is a triangular fossa. The external auditory foramen in the front is bounded by a small overhang, the tragus. The external auditory canal is a direct continuation of the auricle, which is a curved tube. The inner surface of the external auditory canal is lined with leather, a feature of which is the presence of sebaceous glands, as well as glands that produce earwax. At the border between the outer and middle ear, a tympanic membrane is stretched. The tympanic membrane is a connective tissue plate, tilted forward and down, oval. Most of the eardrum is more stressed and is called the stretched part. At the top, over a short distance, the eardrum is less tense, forming a loose part. The outer surface of the eardrum is somewhat concave inside the middle ear and has the appearance of a funnel, since the central part is fixed at the handle of the malleus and is called the navel of the eardrum. The membrane has elasticity, resisting a wave of pressure that spreads through the ear canal. Due to the fact that the resistance of the eardrum is smallest at a frequency of 800 - 900 oscillations per second, and due to the fact that the vibrations of the eardrum very quickly fade out, it is an excellent pressure transmitter and almost does not distort the shape of the sound wave [6].

The composition of the middle ear of the middle ear includes the tympanic cavity, the auditory ossicles and the auditory tube. The middle ear communicates with the nasopharynx through the musculo-tubal canal and with the cells of the mastoid process. The tympanic cavity is located in the pyramid of the temporal bone. It is lined with mucous membranes, has 6 walls and the auditory ossicles are located in it [7].

The auditory tube connects the pharyngeal cavity with the middle ear cavity. It begins on the side wall of the pharynx by the pharyngeal opening of the auditory tube. During the act of swallowing, the pharyngeal opening opens, which leads to pressure equalization in the middle ear with external atmospheric pressure. This provides equal air pressure on both sides of the eardrum. In the auditory tube, there are two parts: the cartilaginous - the larger, occupying 2/3 of the tube and the bone - the smaller, occupying 1/3 of the tube. The cartilaginous part of the tube is formed by hyaline cartilage and has the shape of a gutter. There is no cartilage on the underside, and instead there is fibrous tissue forming the membranous plate. In the area of the pharyngeal opening of the tube, the width of the cartilaginous part is 1 cm, and its thickness is 2.5 mm. At the border of the transition of the cartilaginous part into the bone cavity of the tube is narrowed. The lumen of the bone part gradually expands toward the tympanic cavity. The bony part of the auditory tube has a lumen of a trihedral shape, its walls are formed by the bone tissue of the pyramid of the temporal bone. The inner surface of the auditory tube is lined with mucous membranes [8].

Inside the tympanic cavity is a chain consisting of three bones: the malleus, the incus and the stirrup. The bones are interconnected movably. There is a joint between the head of the malleus and the incus. The anvil and the stirrup are connected using synchondrosis. The malleus directly fuses with the eardrum with the help of the lower end of the handle. There are hammer head, hammer neck, hammer handle and processes. The anvil has a body, long and short legs. The stirrup consists of the stirrup head, the base of the stirrup, the front and rear legs. The base of the stapes with the help of connective tissue closes the oval hole [9].

The inner ear lies in the pyramid of the temporal bone and consists of two parts: the outer bone labyrinth and the inner webbed labyrinth. Webbed labyrinth is located inside the bone and repeats its outlines. Between the bone and membranous labyrinths there is a liquid - perilymph, which flows into the subarachnoid space. Inside the webbed labyrinth is the endolymph. The vestibule is an oval cavity, located between the tympanic cavity and the internal auditory canal. On the outer wall of the vestibule facing the tympanic cavity, there is an oval window, covered with the base of the stirrup, and a round window closed by the so-called secondary eardrum [10].

Three semicircular canals lie in three mutually perpendicular planes. The bony semicircular canals have the form of arcuate curved tubes. In each semicircular canal, two bony legs are distinguished: one extended - ampullary, the other unexpanded - simple. The bone snail has a conical shape. In the center of the bone snail is a rod, which consists of spongy bone tissue. The top of the rod does not reach the dome of the snail. Around it is a bone spiral plate. The spiral plate, rising to the dome of the cochlea, ends with a curved edge. The core and the bone spiral plate are closed by the cochlea's bone channel, which is attached to the rod, spirals bent and forms 2.5 turns, therefore it is called the cochlear spiral channel. The bone spiral plate, being in the center of the bone canal, divides the cavity of the spiral channel into two parts: the upper one, called the vestibule ladder, and the lower one, called the drum ladder. The staircase of the vestibule begins with an oval window, rises along the upper surface of the spiral plate to the cochlea dome, where in the area of the hook of the spiral plate it passes into the drum ladder [11].

The drum ladder goes along the lower surface of the spiral plate to the base of the cochlea, where it communicates with a round window covered with a so-called secondary eardrum. Thus, the drum stairs and the stairs of the vestibule are communicated on the dome of the cochlea. Inside the core there are gaps (channels) in which nerve bipolar cells are located (I neurons of the auditory analyzer). The membranous labyrinth has the same parts as the bone maze. The membranous snail is the distribution site of the peripheral apparatus of the cochlear nerve. It belongs to the organ of hearing and forms a spiral organ. The webbed snail is located inside the spiral channel of the bone snail and also forms 2.5 turns. It is a triangular channel. On the main membrane is the Corti, or spiral, organ. This is the peripheral part of the auditory analyzer. It includes two types of receptor cells: one row of internal and three or four rows of outer hair cells. Each receptor cell is crowned with a bundle of stereocilia. Stereocilia are attached to the lower surface of the integumentary membrane. The hair cells are located on the supporting cells, which are subdivided into cells — poles, Hensen cells, external supporting and external phalangeal cells. In the organ of Corti 24,000 such cells that stretch in rows along the snail curls along its entire length. Each neuroepithelial cell is fixed at one end to the main membrane, its second pole is in the cavity of the membranous canal. At the end of the pole of the neuroepithelial cell are hairs, from 30 to 120 for each cell, which are washed by the endolymph. The bipolar dendrite fits into each cell and forms a synapse. The axon of the bipolar cell forms the auditory nerve. Sound waves, falling into the outer ear, hit the eardrum. This oscillation drives the auditory ossicles. From the

bottom of the stirrup, oscillation is transmitted to the perilymph of the vestibule, and at the top of the cochlea - to the perilymph of the drum stairs. The wave of vibrations reaches the round hole closed by the secondary eardrum, hits and rolls back. The main membrane oscillates. The hair cells are in contact with the integumentary membrane, mechanical stimulation occurs, which causes excitation, which is transmitted through the dendrites to the body 1 of the neuron [12].

The auricle serves as a collector of sound waves and a determinant of the direction of the sound source. The ear canal is a conductor of sounds, and a resonator in the range of speech frequencies from 2000 to 2500 Hertz. The sound is amplified at these frequencies from 5 to 10 decibels [13].

The middle ear is a three-core sound-transmitting system, including the hammer, the anvil and the stirrup, connected on one side to the eardrum, and on the other to the vestibule window (oval window) of the inner ear. The cavity of the middle ear is filled with air. The auditory ossicles perform a dual role. Their first function is that they form a system of levers, with the help of which the transfer of vibrational energy from the air of the ear canal to the perilymph of the inner ear is improved. Due to the fact that the area of the base of the stirrup reinforced in the vestibule window is significantly less than the area of the eardrum, and also thanks to a special way of joining the bones acting like levers, the pressure on the membrane of the oval window is about 20 times greater than on the eardrum. This pressure increase mechanism is an extremely expedient device aimed at ensuring the efficient transfer of acoustic energy from air to liquid. The second function is the ability of the ossicles system to change the nature of movement at high sound intensities. When sound pressure approaches 120 dB (above the threshold of hearing), the person begins to feel tingling in the ears. At such intensities of the sound stimulus, the nature of the movement of the bones changes significantly, which sharply reduces the function of the middle ear [14].

In the middle ear, there is also a special mechanism that protects the hearing aid from prolonged acoustic overloads. This is achieved by reducing the muscles of the middle ear, which are two: the muscle that strains the eardrum, and the stirrup muscle. Reflex contraction of these muscles under the action of high-intensity sound leads to a decrease in the amplitude of vibrations of the eardrum, middle ear pits, respectively, to a decrease in sound pressure transmitted to the cochlea. The role of the eardrum and the auditory ossicles is reduced to the transformation of high-amplitude air oscillations and a relatively small force through an oval window into the vibrations of an ear lymph with a relatively small amplitude, but high pressure. This is due to the fact that the area of the bottom plate of the stirrup is about 20 to 25 times smaller than the area of the eardrum, and all the energy that falls on the eardrum is concentrated on the smaller surface of the base of the stirrup. Moreover, thanks to the lever mechanism of the functioning of the auditory ossicles, the force transmitted to the perilymph is increased approximately 2 times more. Therefore, the transformation ratio, according to the latest data, is 20 - 25, since only a part of the eardrum is actively involved in vibrations. Thus, under normal conditions, the auditory ossicles enhance the delivery of sounds to the window of the vestibule, and, with excessively strong sounds, they perform a protective function with the help of auditory muscles attached to the ossicles. In addition, the auditory ossicles perform an accommodative function, providing the most favorable tension of individual elements of the sound-conducting system of the middle ear. One of the important conditions for the normal transmission of sounds is the absence of a difference in pressure on both sides of the eardrum, which is ensured by the ventilation capacity of the auditory tube [15].

Sound waves, falling into the outer ear, hit the eardrum. This oscillation drives the auditory ossicles. From the bottom of the stirrup, oscillation is transmitted to the perilymph of the vestibule, and at the top of the cochlea - to the perilymph of the drum stairs. The wave of vibrations reaches the round hole closed by the secondary eardrum, hits and rolls back. The main membrane oscillates. The hair cells are in contact with the integumentary membrane, mechanical stimulation occurs, which causes excitation, which is transmitted through the dendrites to the body 1 of the neuron. In the basal part of the spiral organ, receptor cells are located, which perceive higher frequencies, and in the apical part (at the top of the cochlea), cells that perceive only low frequencies. This spatial method of frequency analysis is called the principle of location. However, the understanding of the mechanism on which this encoding method is based has undergone significant changes in the last hundred years [16].

A poorly hearing person can recognize a word by looking at the movement of the lips of the speaker. But most of the emotional nuances remain inaccessible to him. Communication is reduced to a simple exchange of information, so people will unwittingly try to avoid talking with a poorly hearing interlocutor.

People with hearing impairments will confirm that hearing loss is perceived and experienced by a person very hard. This is because each of us is part of the auditory world. Therefore, a deaf person is isolated [17].

Persons with hearing impairments are divided into the deaf and hearing impaired. Deaf - persons whose hearing is completely absent or there is residual hearing, on the basis of which independent formation of speech is impossible. Hearing impaired - persons who have hearing loss of varying degrees, on the basis of which independent development of speech is possible. This group of people is also divided into two subgroups: people with a slight decrease in hearing and better speech development and people with a significant decrease in hearing and severe speech underdevelopment [18]. Hearing impaired people hear speech, but they hardly perceive individual complex phrases. Independently, speech is not fully formed, which can be expressed in poor vocabulary, loss of individual syllables, disturbances in sound pronunciation, features of constructing phrases. The conclusion is obvious - the better the hearing, the better the speech. However, let's not forget that the loss or hearing loss of a child should be treated differently than that of an adult. It is easier for an adult to keep an existing speech, while in children its independent formation is extremely difficult or impossible, but even an adult who has lost hearing can be threatened by the risk of disintegration of already existing speech due to the lack of auditory control [19].

The presence of those or other remnants of hearing gives deaf people the opportunity to directly perceive some sounds of the surrounding world, which is of great importance in the development of their cognitive activity. With minimal hearing residues (I and partially group II), people are able to perceive only very intense sounds that occur at close distances from them (locomotive horn, shout) [20,21].

Special experiments have shown that the presence of hearing residues greatly helps deaf people to master words denoting sound objects and sound phenomena, and to use these words correctly. Playing a well-known cognitive role, auditory perception has for the deaf and purely practical significance, facilitates its orientation in the environment [22].

FUNCTIONAL FEATURES OF HEARING IMPAIRED PEOPLE

Impairment of the function of the auditory analyzer leads to a delay in speech, motor and mental development. As you know, speech is an activity of communication, expression, influence, communication through language, speech is the language in action. Speech is a form of existence of consciousness (thoughts, feelings, experiences) for another, serving as a means of communicating with it, and a form of generalized reflection of reality, or a form of existence of thinking. Speech is a language that functions in the context of individual consciousness. Speech, being a unique ability inherent only to a person, is associated with the processes of thinking and provides communication through one or another language. When the peripheral parts of the auditory analyzer are damaged, the perception of oral speech suffers, which is the cause of sensory aphasia (or alalia), and the phonemic hearing is disturbed [23].

Mental development of people with impaired hearing is subject to patterns that are found in the development of normal hearing. However, they manifest patterns that are common to all types of abnormal development. Thus, for all types of violations, there is a decrease in the ability to receive, process, store and use information. Note that in persons with impaired hearing, a decrease in some indicators is characteristic only for a certain period of ontogenesis. For example, the slower speed of information processing with visual perception, less accurate and long-term storage of visual material (visual images of familiar objects) is noted at the preschool and primary school age (up to 12 years). As a result of insufficient development of speech, a smaller amount of knowledge that a child who does not hear has in comparison with hearing peers, as well as limited communication with others, a slower pace of the formation of a deaf person is revealed. This is manifested in the relative narrowness of cognitive interests, in the lack of awareness of various areas of society [24].

A longer time remains inadequate self-esteem. Self-assessments and evaluations of comrades are often situational, often depend on the teacher’s opinion, there are cases of non-critical self-esteem, and overestimated self-esteem prevails even among high school students [25].

The instability and inadequacy is different and the level of their claims, which often does not correspond to the capabilities of deaf students and is too high. The level of claims of hearing impaired

students in learning activities is characterized by high lability, especially noticeable in the early school years [26].

The moral and ethical views of the deaf, although in general meet the social criteria of the society, nevertheless, are distinguished by a certain one-sidedness, the predominant use of concrete concepts without taking into account intermediate, relative assessments. The use of verbal notation of certain emotions is carried out by hearing impaired students only in well-known life situations. Determining the causes of any emotions makes it very difficult for children, usually referred to as clearly outwardly expressed circumstances [27].

Many emotional states, social and moral feelings remain completely unfamiliar to deaf schoolchildren up to middle school age. The development of the emotional sphere of the deaf person is delayed due to the low availability of the expressive side of speech and music, the great difficulties of familiarizing with literature. However, it should be noted significant opportunities for the expression of emotions in facial expressions and pantomimes used by people with hearing impairments in communication [28].

Deaf and hard of hearing people are different from hearing somatic weakness, lack of mobility, lag in physical and motor development. Sharply reduced or completely absent functional activity of the auditory analyzer causes blockage of the center of the motor analyzer, external signs of this process are a sharp limitation of the motor activity of people with hearing impairments and their constant control over each movement [29,30].

Hearing impaired people find difficulties in the formation of movements in connection with a violation of the auditory analyzer, which plays a leading role in controlling accuracy, rhythm, and speed of movements. In addition, the slowness of the formation of kinesthetic perceptions, arising in connection with the disruption of the interaction of the analyzers (kinesthetic, visual, auditory), and also often caused by a lesion of the vestibular apparatus, leads to difficulties in performing arbitrary actions underlying any activity [31,32].

Coordination of movements is understood as the processes of coordination of activity of the muscles of the body, aimed at the successful implementation of the motor task. Coordination is a necessary function of the body for the normal existence of any person. Correction of coordination abilities is necessary for hearing impaired people [33].

From the point of view of the development of static and locomotor functions, hearing impaired people lag far behind the normally developing ones. Some instability, difficulties in maintaining balance, insufficient coordination of movements persist in many of them for a long time. Many hearing impaired people have a lag in the development of fine motor skills, small movements of fingers and articulatory apparatus are not sufficiently differentiated. Imitation of the movements of the articulation organs causes these people great difficulties over a long period. More pronounced disorders occur in people with the consequences of Rh - conflict [34].

The vestibular analyzer has numerous connections with the cerebellum. Since the vestibular analyzer is in the ear, it affects the coordination of movements, mental development, and physical development in hearing impaired people [35].

The presence of the above-mentioned deviations in hearing impaired people leads to a progressive weakening of their level of development of physical qualities, in particular, in terms of strength development (at the age of eight, the amount of the deaf people lagging behind the hearing was 6–8%, and by the age of seventeen it reached 50.0%).

CONCLUSION

A person perceives information from the outside world with the help of five senses - sight, hearing, touch, taste and smell, which not only inform him about any changes in the external environment, but also warn about possible danger. As a result, a person gains a certain life experience. Based on this experience, the acquired human behavior is formed. Deaf and hard of hearing people are different from hearing somatic weakness, lack of mobility, lag in physical and motor development. Sharply reduced or completely absent

functional activity of the auditory analyzer causes blockage of the center of the motor analyzer, external signs of this process are a sharp limitation of the motor activity of people with hearing impairments and their constant control over each movement. Hearing impaired people find difficulties in the formation of movements in connection with a violation of the auditory analyzer, which plays a leading role in controlling accuracy, rhythm, and speed of movements. In addition, the slowness of the formation of kinesthetic perceptions, arising in connection with the disruption of the interaction of the analyzers (kinesthetic, visual, auditory), as well as often caused by a lesion of the vestibular apparatus, leads to difficulties in performing arbitrary actions underlying.

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