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AUDIOMETRIC CHANGES IN PATIENTS WITH TYPE 1 DIABETES MELLITUS

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Abstract:

One of the important problems of modern otorhinolaryngology in medical and social aspects is the diagnosis and treatment of sensorineural hearing loss and vestibular disorders. Every year in Russia, thousands of children are identified with damage to the auditory system, and this trend has a clearly progressive nature (Daikhes N.A. et al., 2018; Tavartkiladze G.A. 2016). Hearing loss is of particular importance, since hearing pathology causes disturbances in the child's mental and speech development, as well as in the child's further socialization. The most pronounced cochleo-vestibular syndrome appears with a combined pathology of the inner ear and etiopathogenetically similar diseases with pronounced pathogenetic processes. One of these diseases is type 1 diabetes. In the pathogenesis of sensorineural disorders, equally as in diabetes mellitus, the main link is a violation of microcirculation, tissue hypoxia, an imbalance of redox processes, etc. Ischemic processes can manifest themselves at the level of the receptor apparatus of the inner ear, conduction tracts, auditory and vestibular nuclei medulla oblongata and cortical structures.

Keywords: sensorineural hearing loss, vestibular disorders, audiometry, type 1 diabetes mellitus, cochleo-vestibular syndrome

RELEVANCE. One of the important problems of modern otorhinolaryngology in medical and social aspects is the diagnosis and treatment of sensorineural hearing loss and vestibular disorders. Every year in Russia, thousands of children are identified with damage to the auditory system, and this trend has a clearly progressive nature (Daikhes N.A. et al., 2018; Tavartkiladze G.A. 2016). Hearing loss is of particular importance, since hearing pathology causes disturbances in the child's mental and speech development, as well as in the child's further socialization. Cochleovestibular syndrome appears most clearly with a combined pathology of the inner ear and etiopathogenetically similar diseases with pronounced pathogenetic processes. One of these diseases is type 1 diabetes. In the pathogenesis of sensorineural disorders, equally as in diabetes mellitus, the main link is a violation of microcirculation, tissue hypoxia, an imbalance of redox processes, etc. Ischemic processes can manifest themselves at the level of the receptor apparatus of the inner ear, conduction tracts, auditory and vestibular nuclei medulla oblongata and cortical structures. Detailing the level of pathomorphological changes allows you to speed up the process of diagnosing such disorders and timely prevent their occurrence.

Diabetes mellitus (DM) is one of the most common endocrinological diseases worldwide [8]. Studies devoted to the study of neurological disorders in endocrine diseases have shown that in type 1 diabetes, disorders in the nervous system progress, despite the usefulness of replacement therapy [4,5]. At the present stage of development of society, little attention is paid to the prevention of complications of the initial stages of development of nervous system disorders, in particular, those characteristic of dysfunction of the auditory and vestibular analyzer [6,9]. At the same time, a course of treatment and preventive measures in the early stages of development is the most effective [1,2,5]. The analysis of data characterizing the peripheral and central parts of the auditory analyzer in children and adolescents with type I diabetes mellitus was based on the criterion of the duration of the underlying disease. In addition, we took into account the presence of correctional therapy in patients during their hospital stay, which made it possible to determine the influence of therapeutic interventions on indicators of sound perception and evaluate their impact on the sensory structures of the auditory analyzer.

At the initial stage of the study, complaints of hearing loss, noise in the head or ears, or impaired speech intelligibility were not identified in children and adolescents with type 1 diabetes. The dominance of the main pathology, namely polydipsia, thirst, polyuria, weakness, etc., did not allow patients to focus on the unexpressed manifestations of pathology in other organs. Subsequently, an analysis of the patients'

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sensations and anamnestic information allowed us to assume the presence of sensory disorders and substantiated the need for a detailed study of auditory function.
Analysis of acoustic indicators, which included a speech study and tuning fork tests, did not demonstrate significant values, allowing us to present the problem as a whole in any of the selected groups of patients.
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A more detailed examination of changes in the auditory analyzer made it possible to analyze the changes in accordance with the selected groups according to the duration of type 1 diabetes and the age of the patients.

MATERIALS AND METHODS OF RESEARCH. The material for the study was obtained as a result of the examination and treatment of 226 patients with type 1 diabetes mellitus who were treated in the endocrinology department. A functional study of the auditory and vestibular analyzers was carried out at the training base of the Department of ENT Diseases of Samarkand State Medical University.
The study included patients from the endocrinology department with episodes of newly diagnosed type 1 diabetes mellitus, as well as patients with type 1 diabetes mellitus from 1 to 10 years or more. The patients received therapy appropriate to the underlying disease; the study analysis included data from the medical history of the inpatient. To complete the statistical analysis, clinical and functional data for each patient were entered into an individual chart. The information block of patients with type 1 diabetes included anamnestic data on the underlying disease, complaints made during hospitalization, concomitant pathology and complications of diabetes (if any), laboratory data (blood glucose level, etc.), objective status of examination of ENT organs, results of a functional study auditory and vestibular analyzers at the time of admission to the hospital. The dynamics of functional studies were assessed in correlation with the timing of relief of glycemia and glycosuria.
For all patients, it was mandatory to fill out an individual consent for the functional study of the auditory and vestibular analyzers in accordance with the requirements of the ethics of medical and biological research.
The criteria for inclusion of patients in the study were: patients with type I diabetes mellitus with a labile course or severe insulin resistance with informed consent to conduct research.

The exclusion criteria for the study were:

- the presence of acute or chronic inflammatory processes in the upper respiratory tract and ear;
- difficulty in nasal breathing caused by adenoid vegetations in the nasopharynx;
- decompensated condition of the patient associated with the underlying disease (type 1 diabetes) or with a pronounced clinical picture of concomitant pathology;
- the presence of a genetic pathology in the child or an immunodeficiency condition;
- disagreement of the patient (or parents) to conduct a functional study of the auditory and vestibular analyzers.
- age of patients from 5 to 9 years (childhood);
- patients from 10 to 14 years of age (prepubertal and pubertal age);
- children over 14 years of age (senior adolescence).

Since a preliminary analysis of the main functional indicators revealed a dependence on the duration of type 1 diabetes in children and adolescents, the main groups were identified according to this criterion:
Group A – newly diagnosed type 1 diabetes (72 patients);
Group B – duration of the underlying disease from 1 to 5 years (50 patients);
Group C – duration of type 1 diabetes from 5 to 10 years (45 patients); Group D – duration of type 1 diabetes more than 10 years (59 patients).
At the initial stage of the study, no complaints of hearing loss, noise in the head or ears, or impaired speech intelligibility were identified in patients with type 1 diabetes. The dominance of the main pathology, namely polydipsia, thirst, polyuria, weakness, etc., did not allow patients to focus on the unexpressed manifestations of pathology in other organs. Subsequently, an analysis of the patients' sensations and anamnestic information allowed us to assume the presence of sensory disorders and substantiated the need for a detailed study of auditory function.
Analysis of acoustic indicators, which included a speech study and tuning fork tests, did not demonstrate significant values, allowing us to present the problem as a whole in any of the selected groups of patients.

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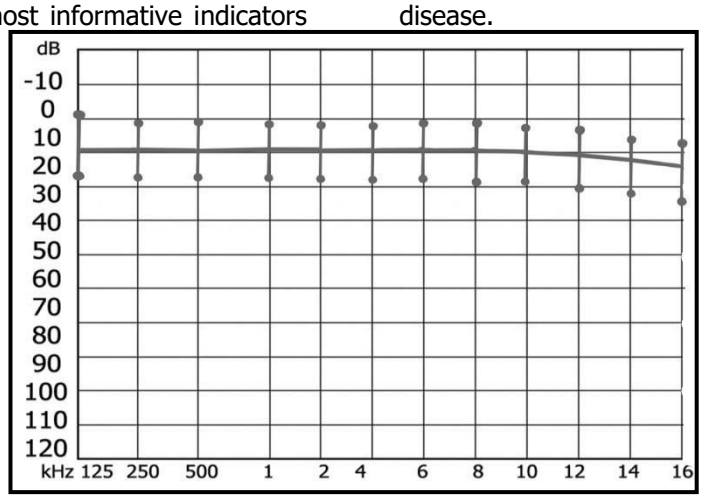
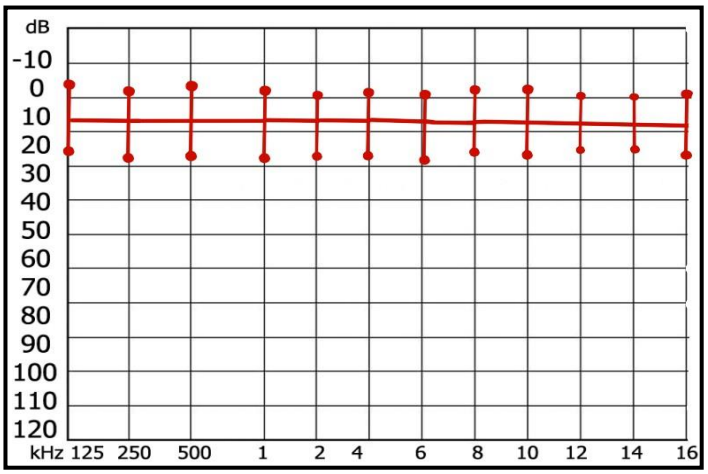
A more detailed examination of changes in the auditory analyzer made it possible to analyze the changes in accordance with the selected groups according to the duration of type 1 diabetes and the age of the patients.

More informative at the present stage is the analysis of audiological indicators that characterize not only the mechanism of damage, but also the level (central or peripheral).

RESULTS. When analyzing audiological indicators reflecting changes in the peripheral part of the auditory analyzer in our study, the most informative indicators were pure-tone audiometry performed in an extended frequency range (12-16 kHz), suprathreshold tests and delayed evoked otoacoustic emissions, examined as a result of control studies upon admission and at Day 7 of therapy for the underlying disease. Since pure tone threshold audiometry data have some age-related aspects, in Figure 1 one can trace a certain trend in dynamics, especially manifested in the high frequency range at the initial stage and upon achieving certain positive data on the correction of blood glucose levels, i.e. normalization of both general condition and achievement of certain results of the underlying disease.



at the initial stage



on the 7th day

Figure 1 Pure-tone audiometry data in the extended frequency range 125-16000 Hz in children with type 1 diabetes upon admission to the hospital and on the 7th day of therapy

Although the obtained TA data reflected in Fig. 1 look more negative, we are not inclined to associate this fact with age. Since this group included patients with type 1 diabetes who have more experience with the underlying disease, it is quite natural to consider this fact in relation to the duration of the disease and the severity of existing complications in the form of polyneuropathy.

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Tables 1 and 2 present TA data in an extended frequency range in interpretation to selected groups according to the duration of the underlying disease (A – first diagnosed type 1 DM, B – duration of type 1 DM from 1 year to 5 years, C – from 5 to 10 years and D – more than 10 years).

As can be observed from the data in Table 1, differences with the group controls were observed in all studied groups of type 1 diabetes.

Table 1 - Analysis of air conduction during pure tone threshold audiometry in an extended frequency range with type 1 diabetes mellitus at the initial period of the study (before glycemic correction

Patient groups	Airborne thresholds			
	0.5 kHz	1 kHz	1.5 kHz	2 kHz
GroupA (n=72)	**15 (10;30)** pAB= 0.872291587 pAC= 0.782794117 pAD= 0.921988525 **pAK=0.02742371**	**15 (10;30)** pAB= 0.926798888 pAC= 0.247500897 pAD=0.442062852 pAK=0.033986027	**15 (10;30)**pAB=0.891763826 pAC=0.46573606 pAD= 0.539610188 pAK= 0.07687752	**15(10;25)** pAB= 0.90821578 pAC= 0.307363524 pAD= 0.384844002 **pAK= 0.026169084**
Group B (n=50)	**15 (10;30)**pBC=0.509394849 pBD=0.807533324 **pBK=0.004213795**	**15 (0;40)**pBC=0.145604216 pBD=0.431078771 **pBK=0.027196218**	**15 (10;50)**pBC=0.512301994pBD=0.62490796 pBK=0.114251	**15 (10;60)**pBC=0.38733943 pBD=0.614763007 pBK=0.143179282
GroupC (n=45)	**15(10; 20)** pCD=0.930066963 **pCK=0.003997885**	**15 (10;25)** pCD=0.786654803 **PCK=0.04157226**	**15 (10;30)** pCD=0.75227498 PCK=0.085422778	**15 (10;35)** pCD=0.837914124 PCK=0.161011669
Group D (n=59)	**15 (10;15) pDK=0.002546279**	**15 (10;15)** pDK=0.190611978	**15 (10;15)** pDK=0.223695348	**15 (10;15)** pDK=0.223695348
Group K(n=30)	5(5;15)	5(5;15)	5(5;15)	5(5;15)
	3kHz	**4kHz**	**8kHz**	**10 kHz**
GroupA (n=72)	**15 (10;20)**pAB=0.67241218 pAC= 0.858873135 pAD= 0.734644561 pAK= 0.085304013	**15 (10;30)** pAB= 0.935428921 pAC= 0.597260091 pAD= 1 **pAK=0.051398531**	**15(10;35)** pAB= 0.655367569 pAC= 0.959150558 pAD= 0.53046841 pAK=0.084408589	**15 (10;40)** pAB= 0.375583951 pAC= 0.08339907 pAD=0.519187869 pAK=0.085587026
Group B (n=50)	**15 (10;45)** pBC= 0.41652891 pBD= 0.63177502 pBK= 0.121280776	**15 (5;50)** pBC=0.482936391 pBD=0.954832473 pBK=0.104867538	**20 (10;50)**pBC=0.435458866 pBD=0.807704824 **pBK=0.047274806**	**20 (10;60)**pBC=0.488143291 pBD=0.961179937 **pBK=0.007950082**
GroupC (n=45)	**15 (10;40)** pCD=7.02384E-05 PCK=0.406446166	**15(10;30)** pCD=0.672607801 PCK=0.06386784	**15 (10;30)** pCD=0.294305836 **PCK=0.009925219**	**20 (10;35)** pCD=0.69107214 PCK=0.00004758
Group D (n=59)	**15 (10;15)** pDK=0.223695348	**15 (10;20) pDK=0.00584358**	**20 (15;25) pDK=0.000130652**	**20 (10;30) pDK=0.001662533**
Group K (n=30)	5(5;15)	5(5;15)	5(5;15)	10(5;15)
	12kHz	**14kHz**	**16kHz**	

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GroupA (n=72)	**15 (10;30)** pAB= 0.392847501 pAC= 0.621218403 pAD= 0.229801735 **pAK=0.018387244**	**15 (10;30)** pAB= 0.851760214 pAC= 0.839452745 pAD= 0.311556219 **pAK=0.019489795**	**22 (10;40)** pAB= 0.390395748 pAC= 0.417196709 pAD= 0.086678649 **pAK=0.007820386**	
Group B (n=50)	***20 (10;50)***pBC=0.386253616 pBD=0.800356427 **pBK=0.011922265**	***20 (10;60)***pBC=0.596250827 pBD=0.464723657 **pBK=0.033213889**	***20 (10;40)***pBC=0.910916116**pBD= 0.00129524** **pBK=0.003157636**	
GroupC (n=45)	***15 (10;30)*** *pCD=0.255722017* **PCK=0.000807005**	***15 (10;45)*** *pCD=0.210612233* **PCK=0.025608683**	***20 (10;40)*** **pCD=0.003688753** **PCK=0.009889239**	
Group D (n=59)	**20 (15;25)** *pDK=0.00001065*	**20 (15;25)** *pDK=***0.00000976**	***35 (30;40)*** pDK=0.000000001	
Group K(n=30)	10(5;15)	10(5;15)	10(5;15)	

Noteworthy is the presence of differences between group A with newly diagnosed type 1 diabetes and the control group, even at frequencies of 0.5 Hz, 1 kHz, 2 kHz, 4 kHz and at high frequencies.

In the group with diabetes duration from 1 to 5 years, statistically significant differences are observed at frequencies of 0.5 Hz, 1 kHz, 8-16 kHz. There are also intergroup differences with group D at frequencies of 16 kHz.

Groups C and D according to table. 1 in the study showed differences similar to group B with a small difference only at frequencies of 10 and 12 kHz.

Table 2. - Analysis of air conduction in the extended frequency zone during pure tone threshold audiometry with type 1 diabetes mellitus after treatment (7-10 days of the study)

Groups patients	Airborne thresholds			
	0.5 kHz	**1 kHz**	**1.5 kHz**	**2 kHz**
Group A (n=72)	15 (10;30)	15 (10;30)	15 (10;30)	15 (10;25)
Group B (n=50)	15 (10;30)	15 (0;40)	15 (10;50)	15 (10;60)
Group C (n=45)	15 (10;20)	15 (10;25)	15 (10;30)	15 (10;35)
Group D (n=59)	15 (10;15)	15 (10;15)	15 (10;15)	15 (10;15)
Group K (n=30)	5(5;15)	5(5;15)	5(5;15)	5(5;15)
	3kHz	**4kHz**	**8kHz**	**10 kHz**
Group A (n=72)	15 (10;20)	15 (10;30)	15 (10;35)	15 (10;40)
Group B (n=50)	15 (10;45)	15 (5;50)	20 (10;55)	20 (10;60)
Group C (n=45)	15 (10;40)	15 (10;30)	15 (10;30)	20 (10;35)
Group D (n=59)	15 (10;15)	15 (10;20)	20 (15;25)	20 (10;30)

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Group K (n=30)	5(5;15)	5(5;15)	5(5;15)	10(5;15)
	12kHz	**14kHz**	**16kHz**	
Group A (n=72)	15 (10;30)	15 (10;25) ***pAK=0.299239813***	18 (10;35) ***pAK=0.04616524***	
Group B (n=50)	*20 (10;60)*	*20 (10;55)*	*20 (10;35)*	
Group C (n=45)	15 (10;30)	15 (10;45)	20 (10;40)	
Group D (n=59)	20 (15;25)	20 (15;25)	*35(30;40)*	
Group K (n=30)	10(5;15)	10(5;15)	10(5;15)	
Note: The threshold values in the table indicate the average values, in brackets - the maximum and minimum values found among those studied in groups.				

But a completely different picture based on pure tone threshold audiometry data in an extended frequency range was presented as a result of a statistical analysis of the data after correction of blood glucose in the studied groups (Table 2).

According to the table. 2 we can conclude that almost all identified deviations from the norm in the studied groups were stopped, with the exception of thresholds of 14-16 kHz in group A.

This fact gives grounds to conclude not only about the presence of initial changes in the peripheral part of the auditory analyzer in children and adolescents with diabetes, but also to consider pathological changes in the body with this disease as an etiopathogenetic factor contributing to the formation of changes in the inner ear.

In addition, a decrease in TPA thresholds when correcting the glycemic level against the background of adapting the insulin dose allows us to conclude that pathomorphological processes in the peripheral part of the auditory analyzer are reversible.

Considering the selection criteria for this study and the fact that among the studied children with type 1 diabetes there were no patients with severe hypo- or hyperglycemic comas (their presence was assessed only in anamnestic data), the timeliness factor

Correction of glycemia can be considered as preventive measures against sensorineural disorders.

The study of suprathreshold tests in children is a rather controversial research method. The works of M.R. Bogomilsky (2008,2014) indicate that this research method is uninformative due to a number of completely objective aspects, which include the physiological features of the child's body, decreased sensitivity to rapidly changing sound signals. But M.R. Bogomilsky considers the main thing in this aspect to be the fact that suprathreshold tests, as markers for assessing central or peripheral disorders in the pathology of the auditory analyzer, in children are not the basis for any conclusions and conclusions, since at the moment objective methods for assessing sensorineural disorders.

Since we initially included suprathreshold tests in the scope of the study of the peripheral part of the auditory analyzer exclusively from a scientific point of view, Table 3 presents the results of the study.

Table 3. - Analysis of values of suprathreshold tests with type 1 diabetes mellitus before and after treatment of the underlying disease

Suprathreshold tests	Groups with type 1 diabetes			
	Group A (n=72)	Group B (n=50)	Group C (n=45)	Group D (n=59)

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	before treatment	by 7 day	before treatment	by 7 day	before treatment	by 7 day	before treatment	by 7 day
SiSi test (%)	22.10±2.4	23.15±1.4	25.61±1.8	26.10±2.1	28.98±1.0	31.57±2.9	32.22±3.1	29.2±2.3
O.Lushera (dB)	1.77±0.2	1.82±0.5	1.83±0.6	1.97±0.1	1.78±0.3	2.43±0.1	1.97±0.2	1.96±0.3
FGD	56.78±3.1	55.38±2.2	65.6±1.9	58.7±3.7	44.98±2.4	34.13±3.2	32.45±2.1	31.61±1.8
R	p≥0.05		p≥0.05		p≥0.05		p≥0.05	

Data in Table 3. allow us to conclude that suprathreshold tests in the study were not informative when considering the entire sample of patients in the selected groups. But in some cases, the data from above-threshold tests were informative at the initial stage of management of type 1 diabetes.

CONCLUSION. Thus, as a result of the study of the peripheral part of the auditory analyzer with type 1 diabetes mellitus, the presence of a relationship between the duration of the presence of the underlying disease and the age of the patients was revealed. At the same time, studies of perception thresholds in the high-frequency zone (10-16 kHz) and recording of PIOAE parameters are the most informative at the early stage of the formation of disorders in the auditory analyzer in this category of patients.
Noteworthy is the fact that most of the indicators characterizing the peripheral part of the auditory analyzer in this category of patients have major differences from the age norm at the peak of type 1 diabetes manifestations and demonstrate positive dynamics with normalization of glycemia.
Of course, the examinations carried out do not reflect the entire problem of impaired auditory system with type 1 diabetes mellitus. But a comprehensive assessment of the state of the peripheral part of the auditory analyzer allows, using available methods, to diagnose disorders at an early stage of their formation and correct them in accordance with existing therapeutic measures.

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