Article

Features of vestibular function in patients with sensorineural deafness of vascular origin

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Abstract: *Objective*: to study the features of vestibular dysfunction in patients with sensorineural hearing loss of vascular origin, depending on the degree of discirculation in the main vessels of the head.

Metods. We examined 60 patients with various degrees of sensorineural hearing loss with circulatory disorders in the vertebrobasilar system (VBS), including 36 (60%) women and 24 (40%) men. The average age of the surveyed was 49.9±1.89 years. All patients underwent audiometry in an extended frequency range up to 20 kHz, the study of acoustic stem evoked potentials, acoustic reflexometry. A caloric test was used to study experimental vestibular reactions, and the results were recorded using computerized electronystagmography. *Results*. According to the otoneurological examination, the patients were divided into 3 subgroups. Peripheral cochleovestibular syndrome (PCVS) was diagnosed in 14 (23%) patients, central cochleovestibular syndrome (CCVS) in 19 (32%), and combined cochleovestibular syndrome (CVS) was diagnosed in 27 (45%) patients. In the analysis of complaints presented by patients with SHD of vascular origin, the combined complaints of hearing deafness, tinnitus and neurological symptoms (headaches, amnesia, paresthesia, fatigue, etc.), as well as dizziness and neurological symptoms, significantly prevailed compared with individual complaints of hearing loss or dizziness ($p < 0.05$). An analysis of the asymmetry of the pathological process on the right or left side did not reveal significant differences, however, the proportion of patients with bilateral lesions in the subgroup with CCVS was significantly higher. If vestibular nystagmus is an unconditioned stem reflex, then optokinetic nystagmus is a product of the activity of the cerebral cortex and occurs with the active participation of the patient himself in the process of research.

Conclusion. The obtained data were compared with the structural changes and hemodynamic parameters in the blood of vertebral arteries (VA) and internal carotid arteries (ICA), as well as magnetic resonance imaging of the brain (MRI).

Keywords: vertebral-basilar insufficiency, computer electronystagmography, cochleovestibular syndromes.

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1. Introduction

According to both domestic and foreign authors, more than 70% of all auditory and vestibular disorders are vascular origin [1, 2, 3]. Vestibular disorders can be the first manifestation of circulatory insufficiency in the vertebrobasilar system (VBS), therefore it is important to identify early auditory and vestibular symptoms characteristic of vertebrobasilar insufficiency (VBI).

The main clinical manifestations of VBI are coordination disorders, dizziness, and hearing disorders, which significantly limit the ability to work and hinder social adaptation [4, 5].

The frequency of dizziness in patients with VBI, according to various data, ranges from 50-90%, and 88.4% of dizziness is non-systemic [6, 7, 8]. Pathological changes in horizontal optokinetic nystagmus are also among the most common symptoms in patients with vertebrobasilar insufficiency [10].

Objective: to study the features of vestibular dysfunction in patients with sensorineural hearing loss of vascular origin, depending on the degree of discirculation in the main vessels of the head.

2. Patients and Methods

We examined 60 patients with various degrees of sensorineural hearing loss with circulatory disorders in the vertebrobasilar system (VBS), including 36 (60%) women and 24 (40%) men. The average age of the surveyed was 49.9±1.89 years. The duration of the disease averaged 12.8±1.75 years. The control group included 18 otologically healthy individuals, 10 (58.8%) women and 7 (41.2%) men. The average age of the surveyed in the control group was 24.33±1.86 years. Due to the presence of inter-age difference between the main and control groups, a correction was made for the involutionary process (the presence of such a range of age differences makes the results of the study incomparable). Age-related hearing loss - presbycusis and static disorders - presbyastasis, characteristic of the elderly, are due to involutional processes in the auditory and vestibular analyzers, general age-related changes in the body corresponds to the average age of the control group presented in the study[11].

All patients underwent audiometry in an extended frequency range up to 20 kHz, the study of acoustic stem evoked potentials, acoustic reflexometry. A caloric test was used to study experimental vestibular reactions, and the results were recorded using computerized electronystagmography (ENG).

The data obtained were compared with structural changes and hemodynamic parameters of blood flow in the vertebral (VA), internal carotid arteries (ICA) recorded using ultrasound methods for studying blood flow (doppler ultrasound, ect), as well as with the brain magnetic resonance imaging (MRI).

3. Results

According to the otoneurological examination, the patients were divided into 3 subgroups. Peripheral cochleovestibular syndrome (PCVS) was diagnosed in 14 (23%) patients, central cochleovestibular syndrome (CCVS) in 19 (32%), and combined cochleovestibular syndrome (CVS) was diagnosed in 27 (45%) patients.

In the analysis of complaints presented by patients with SHD of vascular origin, the combined complaints of hearing deafness, tinnitus and neurological symptoms (headaches, amnesia, paresthesia, fatigue, etc.), as well as dizziness and neurological symptoms, significantly prevailed compared with individual complaints of hearing loss or dizziness ($p < 0.05$). (Fig.1)

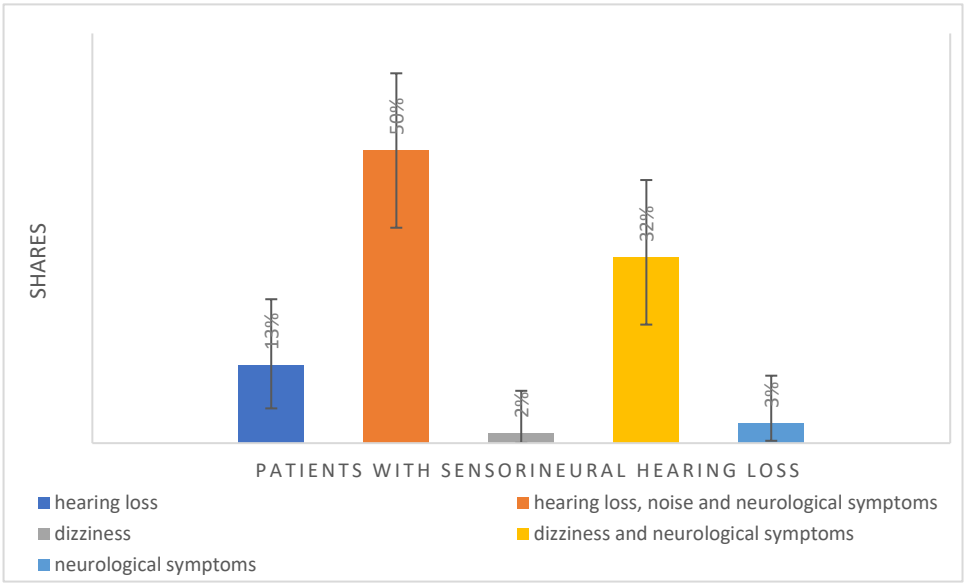

Figure 1. Distribution of complaints in patients with sensorineural hearing deafness. p<0.05

An analysis of the asymmetry of the pathological process on the right or left side did not reveal significant differences, however, the proportion of patients with bilateral lesions in the subgroup with CCVS was significantly higher (Fig. 2)

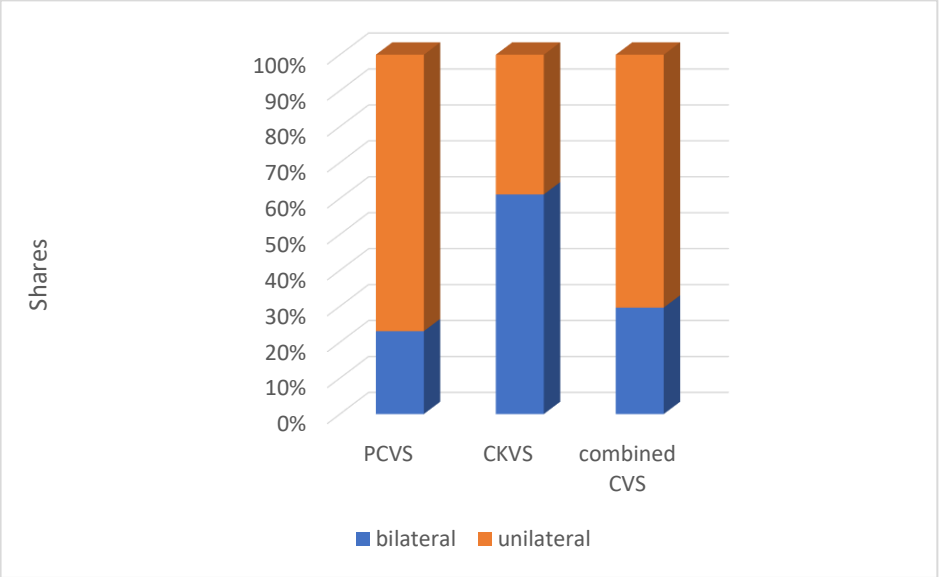

Figure 2. Distribution of patients with sensorineural hearing deafness depending on the side of the lesion and the type of CVS. p<0.05

In our study, dizziness was noted in 47 (78.3%) patients, in 32 (53.3%) patients it was non-systemic and in 15 (25%) - systemic. In 13 (21.7%) cases, dizziness was absent.

Non-systemic vertigo significantly prevailed in the subgroup of patients with combined and central CVS, and systemic vertigo in patients with PCVS (Table 1).

Table 1. Distribution of patients with sensorineural hearing deafness of vascular origin depending on the type of dizziness. (The table should provide statistical indicators - n (P ± m) (*p< 0,001).

Cochleovestibular syndromes	Dizziness			Total
	no	non-systemic	systemic	
Peripheral cochleovestibular syndrome (n=14)	5(36%)*	-	9 (64%)*	14
Central cochleovestibular syndrome (n=19)	4(21%)*	15 (69%)*	-	19
Combined cochleovestibular syndrome (n=27)	4 (16%)*	17 (63%)*	6 (22%)*	27
Total	13 (22%)	32 (53%)	15(25%)	60

Spontaneous nystagmus was recorded in 42 (70%) patients, of which in 29 (48.3%) cases it was unilateral and in 13 (21.7%) cases it was bilateral. (Table 1).

Table 2. Distribution of patients with sensorineural hearing deafness of vascular origin depending on the type of dizziness. (The table should provide statistical indicators - n (P ± m) (p<0, 01*).

nystagmus	PCVS	CKVS	Combined
Absent	5 (35,7)	7 (36,8%)	6 (22,2%)
Unilateral	8 (57,1%)	7 (36,8%)	14 (51,9%)*
Bilateral	1 (7,1%)	5 (26,3%)	7 (25,9%)

With PCVS, unilateral nystagmus was diagnosed in most cases, which indicates the interest of one of the labyrinths. In patients with CCVS and PCVS, spontaneous nystagmus had both one and two-sided direction, which indicates the involvement in the pathological process of the vestibular nuclei of the IV ventricle bottom and vestibulo-oculomotor connections in the posterior longitudinal bundle[9].

If vestibular nystagmus is an unconditioned stem reflex, then optokinetic nystagmus is a product of the activity of the cerebral cortex and occurs with the active participation of the patient himself in the process of research.

In cases of impaired blood supply to the VBI, optokinetic nystagmus can also be subjected to pathological changes.

Violation of optokinetic nystagmus was noted by us in 20 (33.3%) patients.

In the PCVS subgroup, no pathological changes were recorded; in the subgroups with CCVS and combined CVS, disturbances of optokinetic nystagmus were detected, which significantly differed from the subgroup with PCVS. These pathological changes indicate a deep CNS lesion both at the subtentorial and supratentorial levels in the two marked subgroups (Table 3).

Table 3. Distribution of disturbances in optokinetic nystagmus depending on the type of PCVS. (in the table, statistical indicators should be given - n (P ± m) (p‹0,01).

optokinetic nystagmus	PCVS	CKVS	Combined
not violated	14 (100,0%)	10 (52,6%)	16(59,3%)
violated	-	9*(40,7%)	11*(40,7%)

Computed electronystagmography was performed in 51 patients with sensorineural hearing deafness: 13 patients with PCVS, 15 patients with CCVS, and 23 patients with combined CVS. The quantitative and qualitative components of spontaneous and experimental vestibular reactions were analyzed. A bithermal caloric test was used to stimulate the vestibular analyzer.

When studying caloric nystagmus, its frequency (Freq), latency until the onset of the climax (Cul N), slow phase velocity (SPV), amplitude (Ampl), total amplitude (T Ampl) were recorded during calorization on the right (R) and left (L) hot (44°C) and cold water (20°C).

All of the above parameters were evaluated for the main, horizontal component of the experimental caloric nystagmus.

A qualitative assessment was also carried out: the presence of a vertical component, monooculars, and vestibulo-vegetative and somatosensory reactions.

According to the results of the data analysis from the study of the frequency of horizontal spontaneous nystagmus to the right (SNyD) and to the left (SNyS) (where are these frequency indicators?), see Table 4, it can be argued that there are statistically significant differences (p‹0.01) both between the normal group and the group SNHD in general and within the SNHD group with a tendency to increase the frequency of spontaneous nystagmus in patients with CCVS (p‹0.05) (Table 4).

Table 4. Frequency of spontaneous horizontal nystagmus in groups of patients with sensorineural hearing loss of vascular origin and in the control group (p‹0,01).

The frequency of spontaneous horizontal nystagmus	I.Control group (n=18)	II.Group of patients with sensorineural hearing loss in general (n=51)	Group of patients with sensorineural hearing loss depending on the type KVS.		
			III. PCVS (n=13)	IV. CKVS (n=15)	V. Combined KVS. (n=23)
SNyD	8±1,7	16,6±1,6 I-II	16,9±2,0 I-III	15,7±3,7 I-II	16,8±2,5 I-V
SNyS	9,2±2,3	16,9±1,7 I-II	14,0±2,5 I-III	21,0±3,5 I-II, III-IV	16,3±2,7 I-V

Hidden vertical spontaneous nystagmus was detected in 7 patients, including: 3 patients with CCVD and 4 patients with combined CVD.

In all cases, vertical nystagmus was combined with horizontal nystagmus. Isolated vertical nystagmus was not recorded.

In the analysis of experimental vestibular reactions in the group of patients with SNHD as a whole, compared with the normal group, there is a significant increase in the frequency of caloric nystagmus (no data), as well as in the total amplitude during stimulation with hot and cold water

(p<0.01). There was an increase in the latent period and the rate of the slow phase of the experimental nystagmus (no data), see Table 5 with cold water stimulation (p<0.05) (Table 5).

In the subgroup of patients with PCVS, there was a significant increase in the frequency (no data) of experimental nystagmus during stimulation with hot water on both sides and cold water on the right (p<0.05), as well as an increase in the latent period during calorization with cold water against the ba CKVS CKVSground of a decrease in the amplitude of nystagmus (no see tab. 6 for data). Other CENG parameters did not significantly differ from the normal group or were less (Table 6).

Table 5. Comparative characteristics of CENG indicators in patients with sensorineural hearing loss of vascular origin and in the control group (p<0,05, ** p<0,01, *** p<0,001).

Indicators of computer electronystagmography	Control group (n=18)		Vascular Genesis Group (n=51)	
	AD	AS	AD	AS
Freq 44°C, N/30 sec.	37,6±2,9	39,7±3,4**	37,0±2,5	44,5±3,2**
Cul N 44°C, sec.	29,7±5,8	21,1±4,1	30,5±3,6	25,6±3,2
Ampl 44°C, uV	138,4±8,6***	145,3±12,9***	82,1±7,4***	82,0±6,5***
SPV 44°C,º/ sec.	7,45±0,61	11,6±1,6	9,3±0,8	10,2±1,2
T Ampl 44°C, °	321,0±58,1*	449,1±90,2	341,1±40,8*	531,4±67,6
Freq 20°C, N/30 sec.	43,2±3,1**	43,4±3,8*	54,7±3,1**	50,9±3,1*
Cul N 20°C, sec.	12,8±3,8*	23,7±6,3	21,0±3,3*	23,8±2,6
Ampl 20°C, uV	167,2±10,5	176,6±12,6*	114,1±10,6	96,4±6,5*
SPV 20° C,º/ sec.	13,4±2,1	15,4±2,4	15,1±2,0	12,2±1,1
T Ampl 20°C,°	681,6±149,2	616,0±146,2**	670,0±73,7	622,0±75,5**

Table 6. Comparative characteristics of CENG indicators in patients with sensorineural hearing loss of vascular origin with PCVS and the control group (* p<0,05, ** p<0,01,*** p<0,001)

Indicators of computer electronystagmography	Control group (n=18)		PCVS (n=13)	
	AD	AS	AD	AS
Freq 44°C, N/30 sec.	37,6±2,9*	39,7±3,4*	42,2±11,7*	43,5±4,6*
Cul N 44°C, sec.	29,7±5,8	21,1±4,1	32,1±7,4	22,1±4,6
Ampl 44°C, uV	138,4±8,6	145,3±12,9***	78,5±11,7	83,9±14,6***
SPV 44°C,º/ sec.	7,45±0,61	11,6±1,6	7,4±0,8	10,2±2,1
T Ampl 44°C, °	321,0±58,1	449,1±90,2	323,9±66,9	430,1±105,2
Freq 20°C, N/30 sec.	43,2±3,1*	43,4±3,8	50,1±4,4*	45,9±5,2
Cul N 20°C, sec.	12,8±3,8*	23,7±6,3	22,0±5,8*	25,5±6,7
Ampl 20°C, uV	167,2±10,5	176,6±12,6**	133,6±36,7	104,8±15,9**
SPV 20° C,º/ sec.	13,4±2,1	15,4±2,4	14,6±5,7	10,8±1,7
T Ampl 20°C,°	681,6±149,2*	616,0±146,2*	419,3±85,9*	440,5±117,0*

An increase in the latent period during calorization with cold water, which is a more powerful stimulus of the vestibular analyzer than hot water, indicates a violation of the functional state of the vestibular analyzer and the presence of the "vestibular recruitment" phenomenon.

When analyzing qualitative indicators, the vertical component was detected only in one patient of the subgroup, and the monoocularity of the experimental vestibular reaction was not recorded.

Vestibulo-vegetative reactions and sensory reactions were expressed moderately and proceeded harmoniously in 11 (84.6%) patients with normoreflexia of vestibular reactions. In two cases of hyperreflexia (15.4%), vestibulo-vegetative reactions and sensory reactions proceeded rapidly, but harmoniously.

Thus, in patients with PCVS, all components of the experimental vestibular reaction proceeded in the same direction, which is typical for damage to the peripheral part of the vestibular analyzer.

Considering the asymmetry of vestibular reactions, it can be noted that a significant predominance of asymmetry in the labyrinth was revealed compared to the predominance in the direction in 9 (69.2)% of 13 cases, more pronounced than in the normal group.

According to the brain MRI, focal lesions of the brainstem and subcortical regions were visualized only in 3 (21%) cases.

In the study of blood flow, the greatest changes were obtained in the VA system in the form of obstruction of blood flow in 8 (57.1%) cases, hypoplasia and non-linearity of the course - in 9 (64.3%). Violation was also detected in the ICA system, but only in 2 (14.3%) cases. Obstruction of venous outflow was recorded in 13 (-93%) patients.

Table 7. Comparative characteristics of CENG indicators in patients with sensorineural hearing deafness of vascular origin with CVD and the control group (* p<0,05)

Indicators of computer electronystagmography	Control group (n=18)		CKVS (n=15)	
	AD	AS	AD	AS
Freq 44°C, N/30 sec.	37,6±2,9	39,7±3,4*	35,6±6,2	54,4±4,8*
Cul N 44°C, sec.	29,7±5,8	21,1±4,1	43,4±8,1	27,6±7,1
Ampl 44°C, uV	138,4±8,6*	145,3±12,9	94,7±21,8*	90,2±14,3
SPV 44°C,º/ sec.	7,45±0,61*	11,6±1,6	9,1±1,6*	11,7±1,8
T Ampl 44°C, °	321,0±58,1	449,1±90,2	281,3±71,2	708,8±123,6*
Freq 20°C, N/30 sec.	43,2±3,1*	43,4±3,8	58,3±6,5*	56,0±7,5
Cul N 20°C, sec.	12,8±3,8*	23,7±6,3	24,2±7,9*	14,5±3,6*
Ampl 20°C, uV	167,2±10,5	176,6±12,6	115,5±12,4	103,6±12,8*
SPV 20° C,º/ sec.	13,4±2,1	15,4±2,4	16,0±3,1	12,0±2,0
T Ampl 20°C,°	681,6±149,2	616,0±146,2	724,4±130,0	583,7±143,7

When analyzing CENG data in patients with CCVS, a significant (p<0.05) increase in the amplitude, slow phase velocity and total amplitude on the right and the frequency of experimental nystagmus on the left (no data) during calorization with hot water, as well as the frequency of experimental nystagmus on the right and latency of the vestibular reactions on both sides during calorization with cold water (no data). The results obtained indicate an increase in vestibular excitability and involvement in the pathological process of the central parts of the vestibular analyzer (Table 7).

When analyzing qualitative indicators, the vertical component of the experimental nystagmus was recorded in 11 (73.3%) patients, monoocularity - in 6 (40%). Hyperreflexia of the vestibular experimental reaction was detected in 10 (66.7%) patients, normoreflexia - in 5 (33.3%) cases.

Vestibulovegetative reactions and sensory reactions proceeded disharmoniously, and mainly according to the subtentorial type in 12 (80%) cases and according to the supratentorial type in 3 cases (20%).

When analyzing the asymmetries of vestibular reactions in 75% of cases, a predominance in direction was revealed.

4. Discussion

Thus, in the subgroup of patients with CCVS, the central lesion of the vestibular analyzer with hyperreflexia and subtentorial nature of the experimental vestibular reactions prevailed.

Focal lesions of the brainstem were found in 16 (84.2%) patients with CCVS, and in the white matter of the brain in 8 cases (42.1%).

In the study of blood flow disorders, obstruction of blood flow in the VA was detected in 15 cases (78.9%), in the common carotid artery (CCA) in 5 (26.3%) cases, in the ICA - in 10 (52.6%) cases, and also ICA occlusion in 2 (13%). Difficulty in the venous outflow of their cranial cavity was recorded in 15 (78.9%) patients. Structural changes in the PA system in the form of hypoplasia, asymmetry of diameters and non-linearity of the course were detected in 11 patients (57.9%), in the CCA system in 4 (21.1%) and in the ICA system in 6 (31.6%), t .e. there are more gross changes in the system, not only in the VA system, but also in the CCA and the ICA.

In the case of combined CVS, a significant ($p<0.05$) increase in the amplitude of the experimental nystagmus and the speed of the slow phase was obtained during stimulation with hot water from both sides, as well as an increase in the frequency of experimental nystagmus during stimulation with cold water on the left. The vertical component was detected in 3 (11.5%) patients, monoocularity - in 14 (53.8%), hyperreflexia of vestibular experimental reactions - in 17 (65.4%) patients, which indicates the interest of the central department of the vestibular analyzer. In 6 (26%) cases, normoreflexia was noted.

Vestibulo-vegetative reactions and sensory reactions proceeded disharmoniously in 17 patients (74%), and mainly in the supratentorial type, peripheral type in 6 cases (26%).

According to MRI data, focal lesions of the brainstem were detected in 12 (44.4%) patients, in the white matter of the brain in 18 cases (66.7%), most often in the form of leukoaraiosis[12].

Difficulty in blood circulation in the VA system was detected in 19 (70.4%) patients of this subgroup, with a predominant decrease in blood flow of 50%-60% and unilateral occlusions in 3 patients (11%). In the CCA and ICA systems, stenoses were detected in 3 (11%) and 9 (33.3%) cases, respectively, and occlusions in 2 (7.4%) and 4 (14.8%) cases. Difficulty in venous outflow from the cranial cavity was present in most patents of this subgroup - 25 (92.6%). Path disturbance, hypoplasia, asymmetry of VA diameters were observed in 19 (70.4%) patients, CCA - 2 (7.4%), ICA - 6 (22.2%)[13].

Thus, the pathology of the VA and ICA systems with significant blood flow disturbances, as well as a pronounced obstruction of venous outflow from the cranial cavity, prevailed in patients with SNHD with concomitant CVS, compared with other studied subgroups.

5. Conclusions

Thus, in the subgroup of patients with CCVS, the central lesion of the vestibular analyzer with hyperreflexia and subtentorial nature of the experimental vestibular reactions prevailed.

Focal lesions of the brainstem were found in 16 (84.2%) patients with CCVS, and in the white matter of the brain in 8 cases (42.1%).

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In the case of combined CVS, a significant ($p<0.05$) increase in the amplitude of the experimental nystagmus and the speed of the slow phase was obtained during stimulation with hot water from both sides, as well as an increase in the frequency of experimental nystagmus during stimulation with cold water on the left. The vertical component was detected in 3 (11.5%) patients, monoocularity - in 14 (53.8%), hyperreflexia of vestibular experimental reactions - in 17 (65.4%) patients, which indicates the interest of the central department of the vestibular analyzer. In 6 (26%) cases, normoreflexia was noted[15].

Vestibulo-vegetative reactions and sensory reactions proceeded disharmoniously in 17 patients (74%), and mainly in the supratentorial type, peripheral type in 6 cases (26%).

According to MRI data, focal lesions of the brainstem were detected in 12 (44.4%) patients, in the white matter of the brain in 18 cases (66.7%), most often in the form of leukoaraiosis.

Difficulty in blood circulation in the VA system was detected in 19 (70.4%) patients of this subgroup, with a predominant decrease in blood flow of 50%-60% and unilateral occlusions in 3 patients (11%). In the CCA and ICA systems, stenoses were detected in 3 (11%) and 9 (33.3%) cases, respectively, and occlusions in 2 (7.4%) and 4 (14.8%) cases. Difficulty in venous outflow from the

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Thus, the pathology of the VA and ICA systems with significant blood flow disturbances, as well as a pronounced obstruction of venous outflow from the cranial cavity, prevailed in patients with SNHD with concomitant CVS, compared with other studied subgroups.

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