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Changes in Blood Serotonin in Patients with Tinnitus and Other Vestibular Disturbances

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Abstract: The role of serotonin as a mediator and stress hormone and its function in vessel tonus regulation is proved. The aim of the work is to study the concentration of serotonin in blood in patients with vestibular disturbances before and after vestibular provocation and in patients with tinnitus.

The study was performed on 134 persons distributed among three groups: group I, 35 patients with vestibular disturbances; group II, 75 healthy persons; group III, 24 patients with tinnitus. Serotonin was examined twice in patients with vestibular disturbances (group I) and in healthy persons (group II), before and 15 minutes after vestibular provocation realized by a cold caloric test, and once in patients with tinnitus (group III). Vestibular loading provokes changes in blood serotonin: In vestibularly stable persons, serotonin decreases and comparatively weaker vestibular vegetative reactions develop.

The role of serotonin in the compensatory mechanisms of the organism related to vestibular crisis is discussed. We recommend its inclusion with routine neurootological examinations for selecting candidates for work in conditions that overload the vestibular analyzer. Patients with tinnitus have serotonin blood values that significantly exceed the referent ones.

Keywords: cold caloric test; professional selection; serotonin; tinnitus; vestibular disturbances; vestibular provocation

The role of serotonin in the pathogenesis of a number of diseases is an important issue of modern biochemistry. Its significance for vestibular disturbances has not been studied sufficiently [1,2]. The interest in this biogenic amine has been increasing since its 1947 discovery by Rapport and Green in their search for vasoconstrictors.

Serotonin (5-hydroxytryptamine) has the most common indole structure, but it is a biologically active substance with a very complex physiological effect. It is found in greater concentrations mainly in the chromaffin cells of the gastrointestinal tract, in the spleen, in the skin labrocytes, and in the platelets, where its function is predominantly hormonal.

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Serotonin is a mediator in the peripheral and central nervous system. It is localized partly in the neuron cell and, to a greater degree, in the nerve ends of the axon, the vesicles. There, it can be found in both free and bound forms.

The majority of serotoninergic neurons are situated in the middle portion of the brainstem, in the dorsal nuclei and Raffe's medial nuclei, in the myelencephalon and mesencephalon, in the pons, and the like. Seven serotonin receptors are known by now and are situated in different structures of the brain [3].

Serotonin has an important role in the activity of the limbic and reticular brain structures participating in the central regulation of vessel tonus [4]. Its vasoconstricting effect on large blood vessels and vasodilation of pial vessels has been proved. Serotonin influences heart activity via the hypothalamus [5] and is one of the regulators of arterial blood pressure [6]. Thus, the aim of this survey is to study the concentration of serotonin in blood in patients with vestibular disturbances before and after vestibular provocation and in patients with tinnitus.

MATERIAL AND METHODS

The study was performed on 134 persons distributed among three groups: group I, 35 patients with vestibular disturbances; group II, 75 healthy persons; and group III, 24 patients with tinnitus. Serotonin was examined twice in patients with vestibular disturbances (group I) and in healthy persons (group II) before and 15 minutes after vestibular provocation (VP) realized by a cold caloric test, and once in patients with tinnitus (group III).

Serotonin (free and bound) is studied in whole blood by the Snyder method as modified by Kulinskii Kostyukovskaya and Sachanska Vangelova. The vestibular reactivity is read after Chilov's scheme [7] and the dynamics of nystagmic reaction (ENyG). The vestibular vegetative reactivity (VVR) is read by electrocardiography, computer analysis of heart variability, breathing, and rheoencephalography.

RESULTS AND DISCUSSION

The study showed that after VP, both healthy persons and patients with vestibular disturbances (groups I and II) show significant changes in blood serotonin concentration. The changes in serotonin concentration, expressed as increased percentage and decreased percentage after VP by cold caloric test, are shown in Table 1.

Notably, in healthy persons, the increased serotonin concentrations after vestibular loading are prevalent (43 increases and 32 decreases), whereas sick persons show a greater number of decreases. An interesting result is found if the studied persons are distributed according to the degree of manifestation of vestibular vegetative changes after the cold caloric test (Table 2).

All persons who develop strongly marked VVR (grade III) after the VP—nausea, vomiting, paleness, perspiration, vertigo—increase serotonin values. The rheographic studies show a decreased rheographic index, an indication of disturbed pulse blood supply. Obviously, the percentage of persons with increased serotonin concentration grows in conjunction with the growth of VVR manifestation grade (grades I–III). Table 3 presents changed serotonin values in drivers with severe vestibular disturbances manifesting VVR grade III after VP. Obviously, all drivers increase serotonin values after vestibular loading. This is an indication for decreased vestibular vegetative stability of the organism.

The results from neurootological studies also show decreased vestibular vegetative resistance in those persons. They develop VVR grade III after Chilov's scheme. This fact is particularly important in assessing health risk and ensuring safety in the workplace. Prolonged driving presents a real danger of emergencies, owing to overloading of the vestibular analyzer. Increased blood serotonin concentration can provoke spasms of the main vessels, with all sequences of labyrinth and brain ischemia potentially causing accidents. No similar data were found in the available literature.

VP provokes changes in blood serotonin values. In persons with more marked vestibular resistance, serotonin concentration is decreased after vestibular loading, and the individuals develop significantly lighter VVR. Probably the decreases in blood serotonin in these patients are a genuine form of engaging the compensatory mechanisms of the organism to overcome the vestibular crisis. In persons with severe VVR, increased blood se-

Table 1. Changes in Blood Serotonin Concentrations After Cold Caloric Test

	Increase %					Decrease %				
	n	$\bar{x}$	$S\bar{x}$	*t*	*p*	n	$\bar{x}$	$S\bar{x}$	*t*	*p*
Healthy persons	43					32				
Drivers	18	30	7.35	4.14	.001	15	29	3.83	4.21	.002
Divers	6	26	8.81	2.97	.05	6	15	4.96	3.08	.025
Young persons	19	41	12.43	3.30	.01	11	28	5.90	4.82	.001
Patients	12	27	7.03	3.86	.01	23	27	13.50	2.08	.002

n = number; $\bar{x}$ = mean; $S\bar{x}$ = standard error of the mean; *t* = Student's *t* test; *p* = probability.

Table 2. Degree of Manifestation of VVR and Percentage Change in Blood Serotonin After Cold Caloric Test

	Serotonin change (% of subjects)		
	VVR Grade I	VVR Grade II	VVR Grade III
Healthy persons			
Increase	40	82	100
Decrease	60	18	0
Patients			
Increase	5	57	100
Decrease	95	43	0

VVR = vestibular-vegetative reactivity.

Table 3. Serotonin Values in Drivers Before and After VP

	Serotonin (nmol/liter)		
	Before VP	After VP	Increase (%)
IKB	885	1,829	114
GDK	743	1,265	70
ACD	250	431	73
PCM	980	1,532	62
IAI	624	932	50
IBR	970	1,106	14
TVN	1,175	1,248	6

VP = vestibular provocation.
Note: Referent blood serotonin values: 393–576 nmol/liter.

Table 4. Blood Serotonin Levels in Patients with Tinnitus

	n	$\bar{x}$	$S\bar{x}$	*t*	*p*
Group I: 582–910 nmol/liter	9	721	85	2.75	.025
Group II: 390–576 nmol/liter	8	457	61	2.63	.025
Group III: 911–1,235 nmol/liter	7	1,111	71	3.60	.010

n = number; $\bar{x}$ = mean; $S\bar{x}$ = standard error of the mean; *t* = Student's *t* test; *p* = probability.
Note: Referent serotonin values: 393–576 nmol/liter.

rotonin is related to disturbances of the compensatory mechanisms, owing to which vasoconstriction cannot be overcome.

The data from these analyses should be considered in defining treatment of a given vestibular disorder and a work and recreation regimen for a patient. They also should be considered in the professional selection of workers in conditions of vestibular analyzer overloading. The study shows that serotonin plays a significant role in the adaptation of an organism to various extreme conditions [2,8,9]. Its concentration in blood undergoes significant changes, which creates an impact on the specific nervous structures and blood flow and reflects on the activity of the cardiovascular, neurovegetative, endocrine, and excretion systems and on psychic activity. Consequently, the decreased VVR of the organism could be associated with increased blood serotonin values after VP.

Table 4 presents the results of studies on blood serotonin in patients with tinnitus. The data in the table reveal that patients with tinnitus have significantly higher values of blood serotonin as compared with referent values. Seven of the patients (29.17%) had a mean serotonin value of 1,111 nmol liter; 9 (37.50%) had a value of 660 nmol liter; and 8 (32. 80%) had standard serotonin values (459 nmol-liter).

CONCLUSIONS

These studies demonstrated that 67% of examined patients with tinnitus blood serotonin concentrations that are significantly increased above the referent values. Owing to the insufficient number of patients with tinnitus in the study, particular conclusions about the role of blood serotonin in the etiology and pathogenesis of tinnitus cannot be drawn. However, what should be emphasized is that patients with tinnitus have higher blood serotonin values.

Follow-up of the dynamics of change in serotonin levels at vestibular loading shows that serotonin concentration could be used as an indicator for determining vestibular stability: Serotonin data from this study correspond to data from neurootological tests and Chilov's criteria for degree of vestibular stability. On the basis of the presented results, we recommend that blood serotonin studies be included with routine neurootological examinations for choosing candidates to work in conditions that overload the vestibular analyser.

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