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Tinnitus, Heart Rate Variability, and Some Biochemical Indicators

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Abstract: Twenty-three tinnitus patients between the ages of 25 and 66 years (mean age, 47.6) were examined completely in the neurootological clinic of the Medical University, Sofia. Heart rate variability measurements were obtained to reveal the relationship between tinnitus and the autonomic equilibrium. Some biochemical indicators (serotonin and the colored sedimentary uric reaction of Kimbarovski [CSURK]) also were followed up. For 19 patients with transitional disturbances in the vertebrobasilar blood circulation, the sympathetic portion of the autonomic nervous system predominates, and heart rate variability is suppressed. The higher suppression of heart rate variability and higher values of the health risk in four occupationally exposed patients are attributable to the higher expressed level of stress connected with the adverse work conditions. Changes in the health risk, CSURK, and serotonin blood values in four tinnitus patients also are discussed.

Keywords: colored sedimentary uric reaction of Kimbarovski (CSURK); heart rate variability; serotonin; tinnitus

Tinnitus is a medical audiologic complaint and a symptom of neurootological disease occurring either alone or in combination with hearing loss, vertigo, or ear blockage [1–3]. It has multiple etiologies and involves primarily the cochleovestibular system, either its peripheral or central part [4]. The factor of stress is significant for all tinnitus patients, particularly tinnitus of the severe disabling type [4,5].

Significant correlation was found to exist between tinnitus and such systemic diseases as cardiovascular disease (particularly fluctuating hypertension), metabolic disease (hyperlipidemias, thyroid disease, elevated blood glucose), and neuropsychiatric disorders [4].

The dopamine-serotonin system, as modulator for affective behavior, is considered to play a significant role in tinnitus production, with involvement of the autonomic nervous system (ANS) [4]. Some of the chronic drifts in ANS can be followed up by computer analysis of heart rate variability (HRV), which reflects the vagal-to-sympathetic equilibrium. Sympathetic predominance is reflected by a suppression of HRV, mimicking the pattern during mental or physical load, with increased gestational age, in the presence of acute myocardial infarction, essential hypertension, or diabetes mellitus, and in persons exposed to different kinds of long-term work-related stress factors [6–10].

The main purpose of the study was to reveal the relationship between tinnitus and the autonomic equilibrium as reflected by HRV. Some biochemical indicators also were followed up.

MATERIALS AND METHODS

HRV Analysis, Kimbarovski Test, and Blood Serotonin Level

The method for HRV analysis created by us [11–13], includes a mathematical algorithm that computes the actual level of physical or mental stress according to its influence on heart function. Both values (physical and

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mental) are used for prediction of HRV-associated health risk (HR). The coloured sedimentary uric reaction of Kimbarovski (CSURK), based on protein metabolism, was used as a measure of a nonspecific reaction to stress. The CSURK provides information about the content of nitrate products from protein disintegration, chlorides, and ammonia. Darker sediments correspond to greater content of toxic products and organic complex compounds and to reduced silver content. The increased amount of nonoxidized products and ammonium nitrogen in urine provokes intense coloring of the sediments at different dilutions. The sediment color intensity at different dilutions is particularly important for interpretating the results.

The blood level of serotonin was measured spectrofluorometrically by the method of Snyder, as modified by Kulinskii-Kostyukovskaya and Sachanska-Vangelova.

Subjects

Twenty-three tinnitus patients, ages 25–66 years (mean age, 47.6 years) were studied. The obtained mean values of HRV parameters were compared with the patients' age-related values, collected as a result of a long-term investigation that included 8,106 healthy persons from Bulgaria (3,852 men and 4,254 women, ages 20–70 years). Data on this population were used as the control values.

Procedure

To exclude circadian biorhythm, the HRV measurements were obtained in a quiet room between 9 and 12 AM, with patients at rest without movement or talking for 10 minutes.

RESULTS

The complete neurootological examination of the 23 tinnitus patients revealed vessel genesis of the neurootological syndrome (central, peripheral, or both) in 19 patients. Also, in four occupationally exposed patients, the following diagnoses were determined: autonomic polyneuropathy of the upper extremities; Hashimoto's thyroiditis; Obs. carcinoma of the thyroid gland; silicosis grade 1; vibration disease; pulmonary emphysema; and chronic occupational bronchitis.

The mean values (plus or minus the standard deviation) of physical stress (in arbitrary units), mental stress (in arbitrary units), and health risk (in percentages) in our 23 tinnitus patients are shown in Table 1. The mean values of physical and mental stress exceed zero, which means that in 23 tinnitus patients, HRV is suppressed and the activity of the sympathetic branch of the ANS predominates. In the group of four occupationally exposed patients, HRV is suppressed more markedly and the level of health risk is higher than in the group of 19 patients with central, peripheral, or combined neurootological syndrome. In these four patients, the predominance of the sympathetic activity is expressed more appreciably.

Data for the HR and CSURK in four tinnitus patients are summarized in Figure 1.

DISCUSSION

A vasomotor center in the medulla oblongata coordinates and integrates the activity of the sympathetic neurons (disposed in the thoracic and waist part of the spinal cord) and sends to the periphery the vessels' constricted impulses. This vasomotor center and the neurons of vagus nerve nuclei (depressing the heart activity) are always in a tonic state. As a result, the arteries and arterioles are lightly constricted, and heart activity is delayed. The front part of the cortex contains the supreme centers of the ANS. From these centers, impulses spread on the descending pathways and enter the formation reticularis, hypothalamus, and hypophysis. It is well-known that irritation of the cochleovestibular system causes reflex reaction of the organs innervated by the ANS, because the impulses arising in the receptors of the cochleovestibular system spread on the ANS centers, provoking a complex of vestibulor-autonomic reflexes—heart rhythm changes, vessel constriction or dilatation, blood pressure decrease, and the like.

As mentioned earlier, in 19 patients, vessel genesis of the tinnitus syndrome occurred. Transitional disturbances were noted in the vertebrobasilar blood circula-

Table 1: Mean Values (±SD) of Physical Stress, Mental Stress, and Health Risk in 23 Tinnitus Patients

HRV Analysis Parameters	Patients with Vessel Neurootological Syndrome (n = 19)	Age-Related or Normal Values	Occupationally Exposed Patients (n = 4)
Physical stress (arbitrary units)	1.73 ± 0.11	<0	9.24 ± 0.31
Mental stress (arbitrary units)	1.25 ± 0.07	<0	7.30 ± 0.08
Health risk (%)	56.8 ± 14.3	<50	77.3 ± 18.1

SD = standard deviation; HRV = heart rate variability.

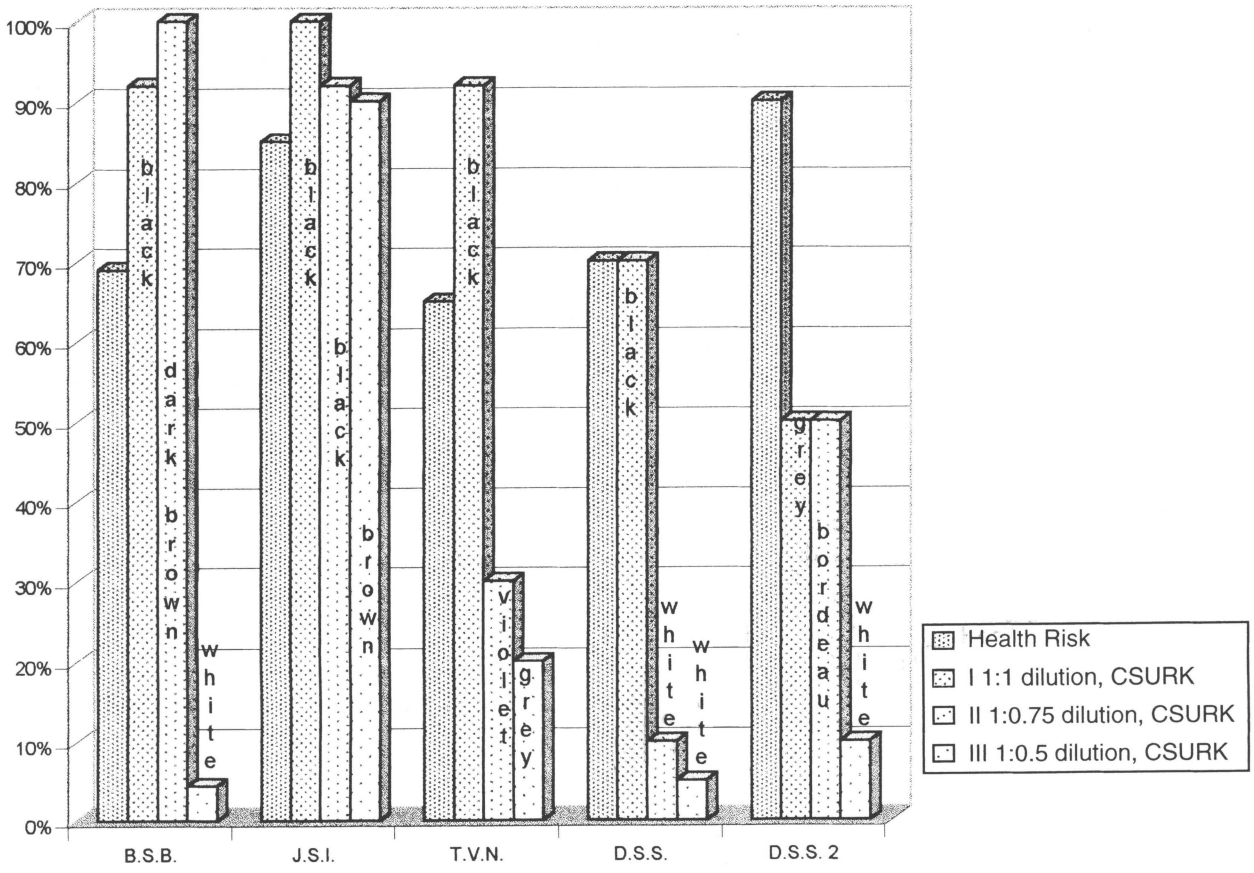

Figure 1. Data on the health risk and colored sedimentary uric reaction of Kimbarovski (CSURK) in four tinnitus patients.

tion. The cochleovestibular system, as a terminal area, was the most ill-affected. The afferent impulses from this area reach and irritate the vasomotor center in the medullar oblongata. As a result, the activity of the sympathetic part of the ANS predominates, and the HRV is suppressed.

The higher suppression of the HRV and the higher values of the HR in four patients with an occupational etiology of tinnitus are due to the higher expressed level of stress connected with the adverse work conditions.

According to the HR data from our study, the general functional state of patient BSB is not satisfactory, with a continual record of changes in protein metabolism and oxidation-reduction processes (see Fig. 1). The relationship between HR and CSURK for patient TVN is similar to that for patient BSB but, in this case, the oxidation-reduction processes are not that altered (see Fig. 1).

In another patient (DSS) in whom HR was 77%, the changes in CSURK demonstrate an unstable functional state and different color intensities of the sediments at the three dilutions observed. This patient was hospitalized after some time due to an aggravated state. The same indicators were examined in the hospital where elevated HR values are found (90%). The urine tests show similar CSURK values at both dilutions I and II, which shows that the morbid process is maintained. These combined data for CSURK with elevated HR (90%) suggest that the physician should concentrate on this patient's state (see Fig. 1).

Patient JSI shows elevated HR (85%) and significantly increased CSURK values, the color of the sediments at the three dilutions being similar (black and dark brown), which indicates serious disturbances in metabolism and increased severity of the disease process. In this case, the tinnitus is accompanied by Hashimoto's thyroiditis (see Fig. 1).

It should be noted that all listed patients have high serotonin values—in most cases, higher than the reference values: BSB, 1,107 nmol/liter; JSI, 810 nmol/liter; TVN, 760 nmol/liter; and DSS, 582 nmol/liter.

Our study shows that the complex examination of HRV, CSURK, and blood serotonin level in patients with tinnitus provides objective information about the changes in autonomic and biochemical equilibrium.

REFERENCES

1. Shulman A: Tinnitus: diagnosis–treatment. *Hearing Aid J* 32–34, 1979.
2. Shulman A: Medical audiologic evaluation of a tinnitus patient. *Semin Hear* 1:7–14, 1987.
3. Shulman A: Subjective idiopathic tinnitus: a unified plan of management. *Am J Otolarynol* 13(2): 63–74, 1992.
4. Shulman A, Goldstein B: Medical significance of tinnitus. *Int Tinnitus J* 3(1):45–50, 1997.
5. Shulman A: A final common pathway for tinnitus—the medial temporal lobe system. *Int Tinnitus J* 2(1):115–126, 1995.
6. Danev S, Datzov E, Svetoslavov S: Pharmacologically induced sympathetic or parasympathetic influence upon heart rate variability in man. *Acta Med Bulgarica* 23(2):64–71, 1996.
7. Kienzle MG, Ferguson DW, Birkett CL, et al.: Clinical, hemodynamic and sympathetic neural correlates of heart rate variability in congestive heart failure. *Am J Cardiol* 69:761–76, 1992.
8. Kleiger RE, Bigger JT, Bosner MS, et al.: Stability over time of variables measuring heart rate variability in normal subjects. *Am J Cardiol* 68:626–630, 1991.
9. Ravenswaaij van C, et al.: Heart rate variability. *Ann Intern Med* 118:436–447, 1993.
10. Rothschild M, Rothschild A, Pfeifer M: Temporary decrease in cardiac parasympathetic tone after acute myocardial infarction. *Am J Cardiol* 18:637–639, 1988
11. Danev Sv, Wartna GF, Bink B, et al.: Psychophysiological assessment of informational load. *Ned Tds vd Psych* 26(1):29–39, 1971.
12. Danev Sv, Winter CR: Heart rate deceleration after erroneous responses—a phenomenon complicating the use of heart rate variability for assessing mental load. *Psychol Fortschr* 35:27–34, 1971.
13. Danev Sv: Informativeness of Heart Rate Variability in Work—Physiological Aspect. Doctoral dissertation, Sofia, NIHPZ-MA, 1989.