Electronystagmographic and Caloric Investigation Data About Vascular-Vestibular Dysfunction Among Patients with Vertebrobasilar Insufficiency

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Abstract: Audiovestibular symptoms are the first and often the only clinical signs of vertebrobasilar insufficiency. The aim of our investigation was to analyze the results of caloric and electronystagmographic investigation of vascular-vestibular disorders among patients with vertebrobasilar insufficiency. We examined a total of 55 men (mean age, 51.8 ± 8.2 years)—a primary group of 35 men with proven vascular-vestibular dysfunction and vertebrobasilar insufficiency and a control group of 20 clinically healthy men. Standard and electronystagmographic ("Tönnies" type) caloric tests were used to evaluate the human vestibular analyzer. Our data from this investigation show that in both rotatory and caloric tests, the slow-phase speed is the most important index about function of the vestibular analyzer.

Key Words: amplitude; caloric test; electronystagmographic parameters; duration; frequency; slow-phase speed; vascular-vestibular disorders; vertebrobasilar insufficiency

Audiovestibular symptoms are the first and often the only clinical signs of vertebrobasilar insufficiency (VBI). The complicated perception of position of the body and its parts in space is a result of analyzed and synthesized impulses by the vestibular analyzer, by superficial and deep proprioception, and by the ocular analyzer, as the vestibular receptors play the main part in this system [1–4].

Anatomical and physiological investigations of blood supply of the vestibular analyzer and vestibular receptors show that these structures are found in most dysfunctional circulatory situations, as anastomotic links are absent and ischemic damage is possible [5–8]. With the exception of arterial hypertonia or atherosclerosis (or both), pathological changes in the cervical spine (cervical osteoporosis) may lead to disturbances in blood supply of the labyrinth and brainstem. According to various authors [2,3,5,9–14], chronic irritation of the sympathetic nerve plexus around the vertebral and basilar arteries provokes reflex changes in blood supply of the inner ear, which leads to vertigo, noise in the ears, and a feeling of hearing loss. Our aim in this investigation was to analyze the results of caloric and electronystagmographic (ENG) investigation of vascular-vestibular disorders among patients with VBI.

SUBJECTS AND METHODS

In the department of neurology and neurootology at the National Transport Hospital *Tzar Boris III* in Sofia, Bulgaria, we examined a total of 55 men (mean age, 51.8 ± 8.2 years), whom we divided into two groups: a primary group of 35 men with proved vascular-vestibular dysfunction and VBI and a control group of 20 clinically healthy men. All examined patients were divided into two groups according to their age: 40–49 years and 50–59 years.

Above-threshold vestibular provocation was registered by ENG, and asymmetrical reactions for duration, amplitude, frequency, and establishment of the slow-phase

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speed (SPS) were evaluated, assuming as asymmetry differences of more than 20% between the two labyrinths. The above-threshold reaction was achieved using an apparatus (Tönnies type) executing the following program: a starting angle-speed enforcement of 6 degrees/sec^2, steady rotation for 30 seconds, acceleration to a speed of 90 degrees/sec, and sudden stop-stimulation. The signal is valid for the following parameters: a 10-mm graphic view of the fast site of the nystagmus in a 10-degree angle diversity of the eyes, for left or right to center. The tape speed used was 5 mm/sec. The horizontal semicircular channel was examined with the head of the subject bent forward 30 degrees, thus rendering the level of the examined channel and that of the chair rotation in one and the same position (i.e., horizontal). Rotational strokes have not been registered in this method.

Evaluation of the ENG according to duration (in seconds) is made by stop-stimulation until nystagmus strokes having an amplitude of 2 mm are registered or until the direction of nystagmus converts. The average amplitude (in degrees) and frequency (in Hertz) have been calculated at a definite part of the ENG, wherein the nystagmus strokes are maximally expressive, coinciding according to time and distance in the left and right labyrinth. This average usually is noted in the first two-thirds of the nystagmus path.

The evaluation of SPS is made as follows: The amplitude of each nystagmus stroke is measured in millimeters; the calibration is provided such that 10 mm of diversity corresponds to 10 degrees; the amplitude is easily read in degrees; the distance between the point at which diversity of the eyes first is noted and the projection of the motion line on the paper is measured; and the received value is recalculated (in seconds) by the formula: $A/B = X$ sec, where A is the distance measured in millimeters, and B is the velocity of the paper in millimeters per second (velocity [V] = A/X [degrees per second]).

Caloric tests (for examining each labyrinthine irritation) are conducted 10 minutes after the rotatory tests, as the received nystagmus reactions are registered by the ENG at the same calibration as in the rotatory provocations. (The patient lies supine with the head raised 30 degrees.) The test of Fitzgerald and Hallpike [4] has been used. One hundred cubic centimeters of water at 37 ± 7°C is inserted in the external auditory canal by a syringe for 10 seconds, and the following quantitative indices are measured: latent period (in seconds); duration (in seconds); frequency of nystagmus reactions, measured every 10 seconds; frequency of nystagmus (in Hertz) at culmination (which we defined as maximal intensity, usually occurring 30–60 seconds after the reaction begins, after which the intensity decreases until nystagmus stops); SPS at culmination (degrees per second); labyrinth asymmetry (canal paresis [CP]); and direction asymmetry (directional preponderance [DP]) using Jonkins and Philipson's formula [4] and assuming as asymmetry differences of more than 20%.

RESULTS AND DISCUSSION

Rotatory Tests

On ENG registration, the curve of spontaneous nystagmus shows that the relative share of people with spontaneous nystagmus increases in accordance with increasing age: Among the primary group of patients 40–49 years old, 30% (3 of 10 men) exhibited nystagmus, whereas in the 50- to 59-year-old group, 72% (18 of 25 men) demonstrated nystagmus. Among the control group, 0% of 40- to 49-year-olds and 10% of 50- to 59-year-olds (1 of 10 men) were found to have nystagmus.

The presence of spontaneous nystagmus noted on ENG recordings in patients in the primary group who had no vertigo complaints, however, indicates blood pressure dimensions leading to vestibular dysfunction. The relative share of people in the primary patient group with duration asymmetry of more than 20% is 34.3% (12 of 35 men), much higher than that in the control group (10%, or 2 of 20 men) ($p < .001$).

As regards frequent asymmetry, we found that 31.4% of patients (11 of 35) in the primary group had more than 20% asymmetry, as compared to 5% among men (1 of 20) in the control group ($p < .01$).

Amplitude asymmetry was found in 28.6% of the examined men with vestibular dysfunction, whereas in the control group, the same factor was only 5% ($p < .001$). The SPS data showed that indices up to 20% were met in 54.3% of subjects (19 of 35) in the primary group and 25% of those (5 of 20) in the control group. The difference is rather essential ($p < .001$). The mean SPS index for the main group was 2.3 times higher than that in the control group: 22.11 ± 15.82 degrees/sec and 9.83 ± 8.28 degrees/sec, respectively ($p < .001$). These results show that the most important index is that of SPS, followed by amplitude asymmetry and duration asymmetry.

Caloric Vestibular Tests

In caloric tests, in contrast to rotatory tests, only one labyrinth in each subject was examined. As a whole, the reactions show hyporeflection, which correlates with the data of rotatory tests. We found that 42.8% of patients in the primary group have a latent period between 30 and 40 seconds (in contrast to the control group's 35%) and 37.1% have a latent period between

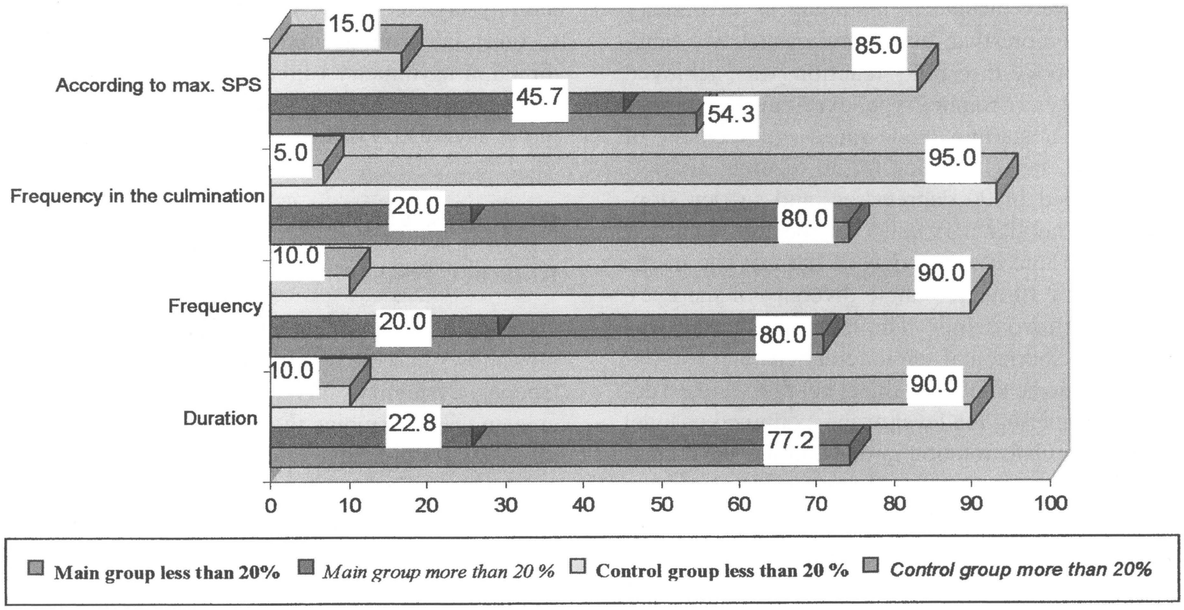

Figure 1. Percentage of subjects according to labyrinth asymmetry (canal paresis).

20 and 30 seconds (in contrast to the control group's 30%). The difference is not statistically significant ($p > .05$). In the primary group, 50- to 59-year-old patients with a longer latent period predominated (52%, as compared to 20% of those in the control group [$p < .01$]), which definitely could be related to hypoxia of the inner ear as a result of insufficient circulation of the blood in the vertebrobasilar system.

Calculating the reaction by Jonkins and Philipson's formula [4] for CP, duration asymmetry of more than 20% was found in 22.8% of patients in the primary group and in 10% of those in the control group ($p > .05$). This finding correlates with increased age. We did not note any significant difference between the primary and control groups in terms of frequent asymmetry (20% and 10%, respectively; $p > .05$).

At culmination, an essential difference ($p < .05$) between the two groups was found as regards frequent

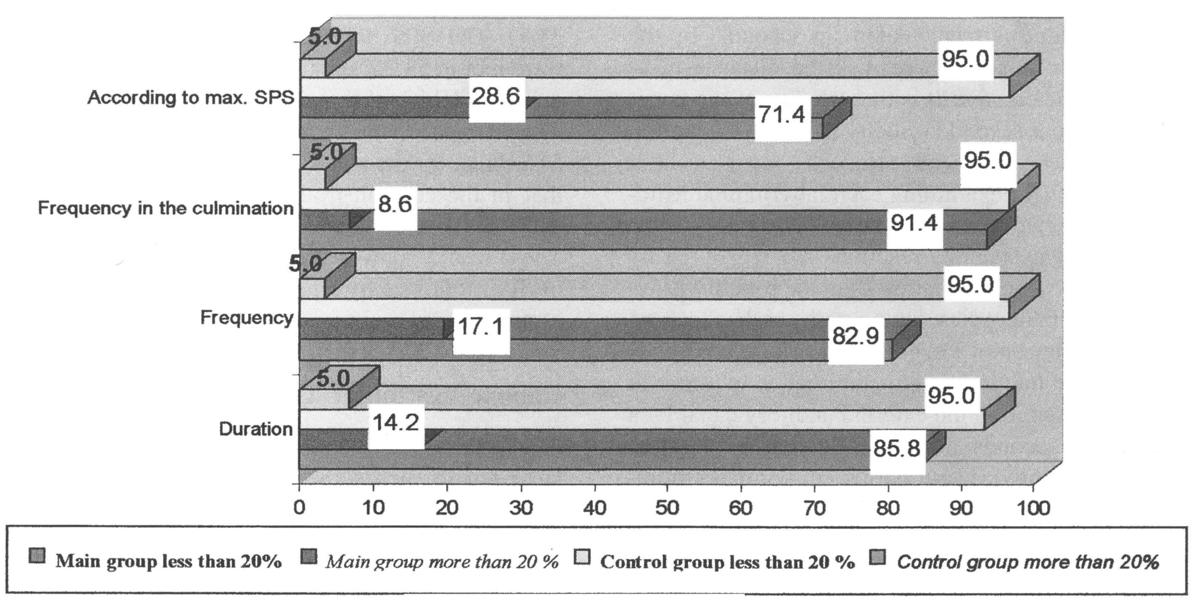

Figure 2. Percentage of subjects according to directional asymmetry (directional preponderance).

asymmetry of more than 20% (CP: 20% of the primary group and 5% of the control group). The SPS indices up to 20% (CP) also showed a statistically significant difference between members of both groups: 45.7% of the primary group and 15% of the control group ($p <$ .05). The relative share of people with asymmetry increases with increasing age.

The most important index proved to be the SPS index (Fig. 1). Therefore, this index must be applied in routine neurootological practice, especially in vascular-vestibular disorders. The results obtained by Jonkins and Philipson's formula [4] for prevalence in relation to the direction (DP), at the same indices (Fig. 2), show that SPS asymmetry (DP) of more than 20% is again the most important index (main group, 28.6%; control group, 5%; $p < .01$).

Frequent asymmetry (DP) was found in 17.1% of subjects in the primary group and in 5% of control subjects ($p < .05$). We noted no essential difference in regard to duration asymmetry (DP): primary group, 14.2%, and control group, 5%. Frequent asymmetry at culmination was 8.6 % and 5%, respectively ($p > .05$).

It is the opinion of many authors that directional nystagmus is a symptom of vestibular system disturbance and is a sign of this system's central damage. In comparing the results of CP and DP asymmetry, we found that CP asymmetry is predominant in all groups at all indices, as the most significant differences are determined in SPS asymmetry. The results of that objective investigation show that receptor damages of the vestibular analyzer prevail over the central ones in people with vascular-vestibular dysfunction at ages between 40 and 49 years.

CONCLUSIONS

The aforementioned, previously observed asymmetry indices—especially the SPS, duration, and amplitude indices of subjects in the primary group—showed statistically based increases relative to increasing subject age. The differences between the two examined groups—subjects and controls—are statistically important for indices of more than 25% asymmetry, relative to the exaggerated vascular disorders in the vertebrobasilar system and especially in the a. labyrinthica among people with vascular-vestibular disorders.

In caloric tests and rotatory investigations, important differences between the two groups were observed at an SPS asymmetry of more than 20% and frequent asymmetry of more than 20% at culmination. As regards DP results, the most important index was SPS asymmetry (DP) of more than 20%, followed by frequent asymmetry.

In comparing the results of CP and DP asymmetry, we found that CP asymmetry is predominant at all indices, as the most important differences are determined in SPS asymmetry. In both rotatory and caloric tests, this index was shown to provide the most information about functions of the vestibular analyzer.

REFERENCES

1. Blagovestenskaya SN. Otoneurological symptoms and syndromes. *M Med* 430, 1990 (in Russian).
2. Diksa RM, Huda GD. Vertigo. *M Med* 480, 1987 (in Russian).
3. Ivanov I. *Vestibular Dysfunctions* (in Bulgarian). Sofia: Med I Fizk, 1982:180.
4. Kehayov NA, Dimov D, Maximov I, et al. *Manual in Otoneurology* (in Bulgarian). Sofia: Med I Fizk, 1982:325.
5. Kolev O. Audio-Vestibular Examination in Patients with Latent Vascular Insufficiency of the Brain. Doctoral thesis, Sofia, p 164 (in Bulgarian).
6. Bruyn GW. Vertigo and vertebrobasilar insufficiency. *Acta Otolaryngol Suppl (Stockh)* 460:128–134, 1998.
7. Caplan LR. Vertebrobasilar System Syndromes. In PJ Vinken, GW Bruyn, et al. (eds), *Handbook of Clinical Neurology, vol. 531: Vascular Diseases*. Amsterdam: Elsevier Science, 1986:371–408.
8. Pessin MS, Giorelick PB, Kwau ES, Caplan LR. Basilar artery stenosis: Middle and distal segments. *Neurology* 37:1742–1746, 1987.
9. Koltshev H. *Treatment of Vertigo and Disturbance of Balance* (in Bulgarian). Sofia: Med Leader Press, 1997:98.
10. Brandt T. Cervical vertigo—reality or fiction. *Angio Neuro-Otol* 1:187–196, 1996.
11. Kazmierzak H, Zabrowski A. Cervical nystagmus in the diagnosis of vertebrobasilar insufficiency. *Otolaryngol Pol* 42(6):400–406, 1989.
12. Norre ME. Neurophysiology of vertigo with special reference to cervical vertigo. *Rev Med Phys* 9:183–194, 1986.
13. Norre ME. Cervical vertigo. Diagnostic and semiological problem with special emphasis upon cervical nystagmus. *Acta Otorhinolaryngol Belg* 41(3):436–452, 1987.
14. Sasaki S, Zhang H, Kesteloot H. Dietary sodium, potassium saturated fat, alcohol and stroke mortality. *Stroke* 26:783–789, 1995.