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ORIGINAL ARTICLE

VESTIBULAR DYSFUNCTIONS IN CHRONIC BRAIN ISCHEMIA IN THE POST COVID PERIOD

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ABSTRACT

The aim: The aim of the study is the clinical-pathogenetic reasoning of vestibular dysfunctions (VD) development against the background of chronic brain ischemia in the presence of degenerative changes in the cervical spine (CS) in the post COVID period.

Materials and methods: 82 patients, in the conditions of the clinical base of the Odessa National Medical University in 2019-2021 were examined. Group I with VD against the background of chronic brain ischemia (CBI) at the compensated phase; Group II with VD against the background of CBI at the subcompensated phase (33 men; 49 women), aged from 18 to 55 years. The control group (CG) consisted of 20 patients of the corresponding gender and age. The condition of the state of the autonomic nervous system, vestibular functions, cervical spine, cerebral arteries and emotional condition were examined.

Results: Vestibulo-ataxic disorders were higher compared to CG and increased along with the degree of brain damage. An important aspect of the development of VD is autonomic dysfunction against the background of pathological autonomic characteristics with predominant parasympathetic orientation of autonomic tone, especially in the case of insufficiency of autonomic recativity (AR) and pathological autonomic support of activity. Such changes significantly increased in the presence of subcompensation of CBI. The correlation between psychoemotional disorders and changes in autonomic characteristics with VD against the background of CBI with initial regularities depending on the degree of brain damage was defined. The progression of CBI is facilitated by coronavirus infection and manifested in autonomic and psychoemotional dysfunctions. A characteristic hemodynamic feature in groups with compensated and subcompensated CBI is the presence of reduced perfusion in basilar (BA) and vertebral (VA) arteries. Changes in cerebral vascular reactivity with a decrease in cerebrovascular reactivity indicators were characteristic of the subcompensated phase of CBI. Hyperactivity to rotational functional loads in both clinical groups has a high correlation with the presence of stair descent and, to a lesser extent, isolated instability in CS.

Conclusions: 1. The occurrence of VD is facilitated by the presence of autonomic dysfunction and degenerative-dystrophic changes in the CS, especially in case of subcompensation of CBI. 2. Psychoemotional changes were a characteristic feature of patients with VD against the background of CBI and had certain regularities depending on the phase of CBI. 3. Suffered coronavirus infection contributes to the progression of VD and further decompensation of CBI due to direct damage to the autonomic and vascular systems of the brain. 4. Changes in cerebral hemodynamics in the form of reduced perfusion in BA and VA, a decrease in cerebrovascular reactivity, and an increase in reactivity to rotational functional load were determined in patients with VD against the background of subcompensated CBI.

KEY WORDS: chronic brain ischemia, autonomic dysfunctions, degenerative-dystrophic damage, cervical spine, cerebrovascular reactivity

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INTRODUCTION

Chronic brain ischemia (CBI) in the structure of cerebrovascular pathology occurs much more often than acute conditions and leads to a long-term disability. It is the risk factor for the development of cerebral strokes. Prevention of the development of significant organic vascular changes in the brain is the most urgent problem of modern medicine and neurology [1-4]. The presence of vestibular dysfunctions (VD) in the clinical picture of vascular cerebral dyshemia correlates with the degree of brain damage [5,6]. VD is the most common syndrome in ischemic brain damage. The clinical variety of dizziness occurs against the background of a decrease in the compensatory capabilities of the central mechanisms of balance, the sensory system, especially in case of CBI with a predominant lesion of the vertebral-basilar basin against the background of the cervical spine (CS) pathology [7]. The important indicator of VD occurrence is the change in vegetative and vascular reactivity, which complicates the examination and differential diagnosis

of dizziness. The progression of ischemic brain damage is advanced by the development of the coronavirus infection, which negatively impacts the process of neurological rehabilitation [8-14]. The penetration of SARS-CoV-2 virus into the central nervous system (CNS) causes its damage and can activate some degenerative nervous system diseases [15]. Hypercoagulation due to systemic inflammation, cytokine storm, endotheliitis and other factors lead to infectious vascular lesions of the CNS [16,17]. Inflammatory damage of the vestibular apparatus reduces blood flow, causes vasospasm, leads to thrombosis as well as other vascular problems that may occur during the coronavirus infection.

THE AIM

The aim is the clinical-pathogenetic reasoning of VD development against the background of chronic brain ischemia in the presence of degenerative changes in the cervical spine (CS) in the post COVID period.

MATERIALS AND METHODS

82 patients were examined, Group I with VD against the background of CBI at the compensated phase (n =24); Group II with VD against the background of CBI at the subcompensated (n=38) phase (33 men; 49 women), aged from 18 to 55 years, the average age was 38.6 ± 1.6 years. All patients had a history of COVID 19. Control group (CG), n=20 – relatively healthy people who underwent professional screening. During the examination of the state of the autonomic nervous system (ANS) according to the questionnaire [8] all patients reported the dysfunction availability. In order to objectify statics and balance, an original electrical contact device was designed and used for ataxia assessment [18] with the calculation of the integrative index of ataxia (IIA). Emotional layers were examined using the hospital anxiety and depression scale [19], the cognitive sphere – according to the test of A.R. Luria [18]. All patients had an X-ray examination of the cervical spine with functional loads. X-rays of the cervical spine were performed using a digital radio-fluoroscopy system OPERA T90cex GMM (Italy). X-rays were executed in standard modes, in direct and lateral projections with functional load (flexion – extension).

Cerebral arteries were examined in triplex mode on an Ultima-PA ultrasound scanner (RADMYR, Ukraine). The parameters of time-averaged maximum blood flow velocity (TAMX) and resistance index (RI) in the anterior (ACA), middle (MCA), posterior (PCA) cerebral, vertebral (VA) and basilar (BA) arteries were studied. The state of cerebrovascular reactivity was assessed using the following functional loads: hypercapnic reactivity (reactivity coefficient to hypercapnic (CrCO2)), and hyperventilation reactivity (CrO2) test, functional nitroglycerin (CrFNT) tests, functional probes with rotation (RIRP), index of the vasomotor reactivity (IVMR). Statistics 8.0 was used for statistical processing with the assessment of the Wilcoxon test, as well as the Mann-Whitney U test. Differences at $p<0.05$ were considered statistically significant.

RESULTS

In the main groups, all patients complained of dizziness (predominantly non-systemic – 51.6%, systemic – 48.4%), caused by physical exertion (25.8%), head movements (38.7%), orthostatic changes (14.5 %), blood pressure increase (9.7%).

The main symptoms of the launch of accompanying pathological mechanisms of vestibulopathy have been revealed. Headache (75.8%) had vascular and/or autonomic components: vasomotor (24.2%), ischemic-hypoxic (48.4%), venous (27.4%) cephalalgia. Localization: diffuse (40.3%), in the occipital (33.9%), parietal (14.5%), frontal (11.3%) regions. The algic syndrome was manifested by pain in the neck (69.3%), including the ones with irradiation to the shoulder and corresponding hand (37.1%); back pain (56.4%); cardialgias (37.1%) and other pain phenomena. Muscle tension of shoulder girdle and neck had reflex-tonic or generalized character in 48.4% of cases. In addition, the most significant symptoms were: increased blood pressure (59.8%), noise in the head (38.7%), decreased hearing (30.6%), orthostatic hypotension (19.3%), asthenia (41.9%), emotional lability (58.1%), cognitive disorders (70.9%), dyssomnias (40.3%). In the objective, vestibulo-ataxic disorders of mild or moderate severity prevailed [9, 13]. The average values of IIA were increased in patients with CBI compared to healthy subjects (Group I – 2.7±0.09 relative units, Group II – 3.6±1.10 relative units, CG – 1 .8±0.08 relative units, $p<0.05$). High rates of IIA were accompanied by the presence of vagotonia (3.0±0.12 relative units versus 2.3±0.14 relative units in patients with eytonia, $p<0.05$). Manifestations of cervical osteochondrosis were diagnosed in all patients. Instability of the cervical spine was noted in half of the examined patients, more often in segments $C_4 – C_5$ (77.4%, $p<0.05$), less often – $C_3 – C_4$ and $C_5 – C_6$. Uncovertebral arthrosis was defined in 41.9% of studies. Pathological autonomic tone (AT) was manufested in 96.7% of patients, mostly shifted towards the vagal direction (53.2%); pathological autonomic reactivity (AR) – 83.9% of patients mainly had autonomic insufficiency (52.4%), which increased along with ischemic brain damage increase; changes in

Table I. Indexes TAMX (cm/s) in cerebral arteries in patients with CBI

	MCA	ACA	PCA	VA (V4)	BA
Group I	57,2±8,4	54,3±7,3	38,6±5,7	37,5±6,1	36,4±4,9
Group II	51,3±9,2	51,6±5,8	36,5±4,7	30,6±5,8	31,4±6,2
CG	62,6±10,1	52,3±6,7	36,5±5,7	34,7±9,1	38,9±8,4

Table II. Indicators of CVR in patients with CBI

	CrCO2	CrO2	IVMR	CrFNT
Group I	1,17±0,04*	0,34±0,04	62,9±7,5*	0,11±0,05
Group II	1,14±0,03*	0,26±0,03*	54,2±8,8*	0,05±0,03*
CG	1,28±0,06	0,36±0,03	81,5±6,9	0,16±0,04

* p <0,05 compared with CG

Table III. Indexes RIRP in patients with SDI, II and KA

	SDI	II	KA
Group I	1,27±0,03*	1,26±0,05*	1,20±0,04
Group II	1,32±0,05*	1,29±0,06*	1,19±0,03
CG	1,18±0,03	1,18±0,03	1,18±0,03

*p <0,05 compared with CG

autonomic support of activity (ASA) were characterized by excess (41.5%) or deficiency (47.1%). In the presence of subcompensated CBI, the latter increased up to 95.8% (p<0.01). A similar trend occurred in the presence of menopausal syndrome in women (59.4%, p <0.05), while ASA was always pathological. Clinically significant depression was registered in 58.1% of cases, and 80.5% of them were women (p < 0.05), and in the presence of menopausal syndrome it reached 94.4% (p < 0.05). With vagotonia, these indicators were 100.0% in men and 59.5% in women. Anxiety was defined in 30.6% without gender differences, more often at the compensated phase of CBI. In case of dyshormonal changes in women, anxiety occurred much more often (72.9%), with a predominance of sympathicotonic background (51.8%). The parameters of hemodynamics in patients of Group I did not differ significantly from the data of CG, only the values of blood flow in the MCA slightly lowered. In patients of Group II, a moderate decrease in blood flow indicators was observed in MCA, VA and BA. Analogous indicators in ACA and PCA did not significantly differ from normative ones. These changes can be explained by the appearance of local stenosing processes in the main arteries affecting cerebral hemodynamics in patients with subcompensated CBI (Table I).

Indicators of RI in VA exceeded the normative values in the direction of angiospasm, the average RI in Group II was more often interpreted as dystonic, and in Group I, persistent cerebral angiospasm was manufeste more frequently, especially against the background of sympathicotonia (up to 0.73±0.09 units, p <0.05), in cases of eytonia these indicators decreased (0.53±0.08 units), and in cases of vagotonia it reached the minimum values (0.46±0.08 units, p <0.05). In patients of Groups I and II, a significant decrease in CrCO2 indicators was observed (Group I – 1.17±0.04, CG – 1.28±0.06, p<0.05; Group II – 1.14±0.03, CG -1.28±0.06, p<0.05). CrO2 values in Group I did not change significantly, in Group II they significantly decreased (Group I – 0.34±0.04, CG – 0.36±0.03, Group II – 0.26±0.03, CG –1.28±0.06, p<0.05). The values of IVMR being an integral indicator of stability of cerebral autoregulation showed sharp decrease in Groups I and II (Group I – 62.9±7.5, CG – 81.5±6.9, p<0.05; Group II – 54.2 ±8.8, CG – 81.5±6.9, p<0.05). These changes were mostly characteristic of the patients of Group II. Also, hyporeactivity to FNT (0.05±0.03, CG – 0.16±0.04, p<0.05) was significantly manufested in Group II, which is the most sensitive indicator of the vasodilation function disorder at various phases of CVP (Table II).

According to X-ray examination, signs of stair descent instability (SDI) in CRS C2-C6 were defined in 19.3% of patients of Group I, in 22.1% of patients of Group II. Isolated instability (II) in CRS C2-C3 was observed in 5.1% of patients of Group I and in 6.3% of patients of Group II , in CRS C3-C4 – in 17.4% of patients of Group I and in 21.7% of patients of Group II , in CRS C4-C5 – in 4.5% of patients of Group I and in 4.3 patients of Group II, in CRS C5-C6 – in 3.2% of patients of Group I and in 5.6% of patients of Group II. Signs of Kimmerli's anomaly (KA) were observed in 8.7% of patients of Group I and 5.1% of patients of Group II. In the clinical group of patients with SDI, pronounced hyperreactivity to functional loads with rotation to the right and left

was defined (Group I – 1.27±0.03, CG – 1.18±0.03, p <0.05; Group II – 1.32±0.05, CG– 1.18±0.03, p<0.05). In patients with II indicators of reactivity index to rotation probes (RIRP) were also significantly increased (Group I – 1.26±0.05, CG -1.18±0.03, p<0.05; Group II – 1.29±0.06, CG – 1.18±0.03, p<0.05). In the group with KA, relative normal reactivity to the right and left rotation was observed (Group I – 1.20±0.04, CG – 1.18±0.03; Group II – 1.19±0.03, CG – 1.18 ±0.03) (Table III).

DISCUSSION

Ischemic damage to the brain due to degenerative-dystrophic changes in the cerebral spine is often accompanied by VD. The presence of the latter correlates with the degree of brain damage. Vestibulo-ataxic disorders were higher compared to CG and increased along with the degree of brain damage. An important aspect of the development of VD is autonomic dysfunction against the background of pathological autonomic characteristics with predominant parasympathetic orientation of AT, especially in the case of insufficiency of autonomic recativity (RA) and pathological ASA. Such changes significantly increased in the presence of subcompensation of CBI. The correlation between psychoemotional disorders and changes in autonomic characteristics with VD against the background of CBI with initial regularities depending on the degree of brain damage was defined. The progression of CBI is facilitated by coronavirus infection, which, in addition to neurotropic, leads to vascular damage, especially in the structures of the vestibular apparatus, which is sensitive to ischemia and manifested in autonomic, psychoemotional dysfunctions, and cognitive deficits. Our studies confirm the conclusions that coronavirus infection affects the vestibular analyzer both in the acute and post COVID periods of the infection [20,21], with changes in functional characteristics of the autonomic system [22], affects cerebral hemodynamics [23]. A characteristic hemodynamic feature in groups with compensated and subcompensated CBI is the presence of reduced perfusion in BA and VA. Changes in cerebral vascular reactivity with a decrease in CrO2 and CrFNT indicators were characteristic of the subcompensated phase of CBI. Hyperactivity to rotational functional loads in both clinical groups has a high correlation with the presence of stair descent and, to a lesser extent, isolated instability in CS.

CONCLUSIONS

1. The occurrence of VD is facilitated by the presence of autonomic dysfunction and degenerative-dystrophic changes in the CS, especially in case of subcompensation of CBI.
2. Psychoemotional changes were a characteristic feature of patients with VD against the background of CBI and had certain regularities depending on the phase of CBI.
3. Suffered coronavirus infection contributes to the progression of VD and further decompensation of CBI due to direct damage to the autonomic and vascular systems of the brain.
4. Changes in cerebral hemodynamics in the form of reduced perfusion in BA and VA, a decrease in cerebrovascular reactivity, and an increase in reactivity to rotational functional load were determined in patients with VD against the background of subcompensated CBI.

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The Authors declare no conflict of interest.

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