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Impaired Postural Function in Stroke Patients

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Abstract Impaired postural function is a common consequence of stroke, leading to significant disability and reduced quality of life. This paper explores the various factors contributing to postural balance disorders (PBD) in stroke patients, including ischemic stroke etiology, muscle spasticity, lesion localization, and cognitive and emotional impairments. The study highlights the role of stabilometric assessment in evaluating postural instability and discusses the influence of different brain lesion sites on motor and sensory functions. Furthermore, the relationship between post-stroke depression, cognitive decline, and rehabilitation outcomes is examined. The findings emphasize the importance of early rehabilitation interventions to improve postural control, prevent falls, and enhance the overall recovery process.

Keywords Stroke, Ischemic stroke, Postural balance disorders, Motor function, Stabilometric assessment, Cognitive impairment, Post-stroke depression, Rehabilitation, Gait disorders, Cerebrovascular accidents

1. Introduction

Acute cerebrovascular accidents (ACVA) are one of the leading causes of disability in the population. More than 450 thousand strokes occur in Russia annually, of which 80-85% are cerebral. About 80% of patients become disabled to varying degrees of severity, at least 200 thousand strokes end fatally [1].

The diversity of etiology and pathogenetic mechanisms of stroke development determines its heterogeneity. According to the TOAST classification, ischemic strokes are divided into the following subtypes by etiological factor: atherothrombotic - 34%, cardioembolic - 22%, lacunar - 20%, hemodynamic - 15%, hemorheological - 9% [3].

Ischemic **stroke** (IS) occurs in the carotid basin (CB) 5 times more often than in the vertebrobasilar basin [2]. The most common symptom of stroke in the CB is hemiparesis, which is detected in 80-90% of cases [3]. In addition, among the common symptoms of stroke are upper or lower monoparesis, sensory and speech disorders.

According to the literature, the degree of post-stroke muscle spasticity can affect the patient's movement in different ways. Mild spasticity can impair walking and reduce the distance the patient can walk without stopping, while moderate spasticity often benefits the patient, allowing the paretic limb to be used as a support. Severe spasticity significantly complicates and impairs walking, leading to the formation of contractures and pain syndrome [4].

According to the latest literature data, the side of the brain lesion has an unequal effect on statolocomotor functions. Thus, ischemia in the right hemisphere leads to disturbances in the perception of the longitudinal axis of the body and to more severe postural disturbances than infarction in the left hemisphere of the brain [5].

The discussion continues about the influence of the size of the ischemic focus on the severity of motor disorders [7], and in particular, about the direct dependence of the degree of motor deficit on the volume of the lesion [8]. At the same time, there are also opposite data on the decrease in the dependence of paresis and tone disorders in the lower extremities on the volume of the lesion. This is apparently associated with the presence of duplicate conduction tracts (corticospinal, reticulospinal, rubrospinal, vestibulospinal) of centrifugal fibers [9].

When the ischemic focus is localized in different areas of the brain, one or another level of movement construction responsible for the performance of a specific function suffers. In this case, the brain is deprived of part of the afferent information from the periphery and cannot centrifugally coordinate the function of walking and balance. The situation is complicated by a violation of the sensory correction of initial effector commands, as well as direct damage to the motor structures of the central nervous system - nuclei and conduction pathways, manifested by central hemiparesis of varying severity with changes in muscle tone, apraxia of walking [10].

Stabilometric assessment helps to detail the motor defect. In hemispheric strokes, asymmetry of the vertical posture often occurs, caused by the displacement of the body's center of pressure towards the non-paretic leg, which leads to instability of patients when standing and walking, reducing the quality of gait, the speed of movement of the center of pressure, and also increasing the risk of falls [11]. On the

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other hand, there is a hypothesis [12], according to which the asymmetry of the posture is not associated with the degree of paresis, but may be due to impaired perception or deprivation of sensory information, which in turn lead to the formation of a stereotype of "non-use" of the paretic leg and partially disorient it in space [13].

2. Result and Discussion

As a result of a stroke, various movement disorders can develop [14], among which are pyramidal, extrapyramidal, cerebellar syndromes, balance and gait disorders [15], united by the general term - postural balance disorders (PBD).

According to the results of the studies, NPB were detected in 85% of patients in the acute period of the disease. The most frequent localization of the lesion was associated with the thalamus, internal capsule, occipital lobe, and with the expansion of the cerebellar sulci. It was found that any localization of cerebral infarction was associated with one or another NPB. According to brain MRI data, the value of the volumetric subarachnoid-parieto-occipital index of more than 0.06 in patients in the acute period of stroke constituted a high risk of developing balance disorders [16]. NPB had four main mechanisms of formation, which corresponded to 4 groups of patients with the most pronounced concomitant clinical symptoms [17].

According to I.P. Yastrebtseva (2012), in variant I (20.6%) - afferent, in addition to the predominant sensory disorders, moderate or mild cognitive impairment, minor ataxia and dynamic paralysis were observed. At the same time, hemiparesis and static paralysis were not typical. As a result, daily activity suffered slightly or moderately. In variant I, pathomorphological changes in the brainstem dominated.

In variant II (43.3%) - efferent, in addition to the dominant pyramidal and cerebellar symptoms, moderate cognitive and dynamic NPB, mild static balance disorders with the development of moderate or severe limitations of daily activity were observed. At the same time, sensory and affective disorders are not typical, but possible. In variant II - foci of atrophy are localized in the cerebellum, in the internal capsule and caudate nucleus, in the temporal lobe.

In variant III (10.6%) - integrative, in addition to prevailing cognitive disorders, severe static and dynamic NBP, moderate static ataxia, with pronounced limitations of daily activity were noted. Affective dysfunctions are not characteristic. In variant III, lesions were more often found in the occipital lobe, thalamus, and internal capsule.

In variant IV (7.2%) - psychogenic, in addition to the predominant affective disorders, mild cognitive and dynamic NPB were noted, with moderate limitation of daily activity. Other neurological symptoms are not characteristic. In variant IV - atrophy zones in the frontal lobes and leukoaraiosis of 1-2 degrees were observed.

The severity of the PBP in patients who had a stroke correlated more stably with stabilometric indices, namely, with the average speed of the center of pressure (CP) movement, the length of the CP trajectory in the sagittal plane, and the shift in the spectrum power in the high-frequency range along the sagittal plane [19]. This clinical and stabilometric interdependence contributed to the widespread introduction of the stabilometry method in clinical practice. However, most authors conducted a stabilometric examination in patients with ischemic stroke once, without considering changes in stabilometric indices over time, which did not allow tracking the entire process of PBP restoration. At the same time, postural balance disorders (PBD) led to a significant deterioration in the quality of life of patients, the inability to lead a normal life and perform their professional duties, caused a limitation of the motor regime and dependence on outside help.

It has been proven that severe forms of walking difficulties are 10 times more common in people with decreased strength and impaired balance, which is also due to changes in the biomechanical parameters of walking with age. This includes a decrease in the strength of plantar flexion during push-off, heel strike, a decrease in the length, level, and speed of the step, an increase in the width of the walk, the duration of the support phase, and the time with double support [20].

Impaired balance in patients after a stroke is the most significant risk factor for falls, which often worsen the patient's condition - leading to persistent disability of the patient and death [21]. Also, constant functional dependence on others and reduced social activity of patients determined their tendency to depression [22].

It has been proven that post-stroke depression occurs in almost half of patients with stroke, and is more common in the acute stage of stroke and early recovery period, as well as in the first 7-10 days from the onset of vascular accident [15]. In 20-40% of patients with stroke, apathy developed [90], leading to aspontaneity, lethargy and lack of critical thinking. Emotional disorders associated with the abrupt, sudden onset of the disease, the severity of neurological disorders, and limited self-care led to the development of depression, which further aggravated the clinical picture of the disease and reduced the life potential of patients [23]. This prevented patients from actively participating in the rehabilitation process and reduced patient survival. According to follow-up data, the mortality rate of patients with post-stroke depression was 5% higher than in its absence [24]. It has been proven that early initiation of rehabilitation measures reduces the incidence of post-stroke depression [25]. Currently, special methods for assessing emotional disorders for their timely correction have been developed, based on patient surveys - the Beck Depression Scale, the Spielberg and Yu. L. Khanin test, the Tsung and T. I. Balashova test. However, the literature does not sufficiently cover the dynamics of depressive disorders during long-term observation of post-stroke patients, including the use of modern rehabilitation methods, including stabilometric training, the relationship of depression with other clinical and neurological disorders.

Acute cerebrovascular accidents were also the cause of cognitive disorders. Their frequency varied from 10 to 60% in different cohorts of patients [14]. Prerequisites for their development were considered to be chronic cerebral

hypoperfusion, subcortical white matter damage with damage to perforating vessels, multiple lacunar strokes located in "strategic" areas of the brain and responsible for higher mental functions (anterior thalamus, caudate nucleus, mediobasal areas of the temporal, frontal and occipital lobes) [11]. Risk factors were old age, female gender, low level of education [19]. Among the frequent manifestations of cognitive disorders there were decreased short-term memory, attention, thinking, apraxia, agnosia, aphasia, decreased speed of psychomotor processes [11]. Cognitive impairments complicated rehabilitation activities in patients with ischemic stroke due to a lack of understanding of the tasks and their participation in a specific rehabilitation procedure [10]. Various tests and scales were used to assess cognitive impairment, the most well-known of which are: the Montreal Cognitive Assessment (MoCa) [6]; the Mini-Mental Examination (MMSE) [3]; the Frontal Assessment Battery (FAB) [5]; FAB) [12]; MINI-COG method: "clock drawing" test and "five words" test [6]; intelligence test and memory test of D. Wechsler (Wechler Aduit Intelligence Scale - WAIS; Wechler Memory Scale - WMS).

The relationship between cognitive disorders and the features of social and clinical-neurological characteristics of patients with stroke, confirmed by instrumental methods, is of considerable interest, especially in relation to the ability of cognitive disorders to influence the rehabilitation process.

Thus, stroke is one of the most frequent vascular catastrophes with a high degree of mortality and disability of patients. The heterogeneity of stroke determines a wide variety of clinical disorders in the motor, proprioceptive, cerebellar, vestibular, visual and other systems. The layering of depressive and cognitive disorders aggravates the existing picture of the disease, complicates the rehabilitation of patients. One of the priority areas of therapy is the restoration of lost functions and, as a result, improving the quality of life of patients with ischemic stroke.

3. Conclusions

Stroke remains one of the most common and severe vascular pathologies, leading to a high mortality rate and significant disability among patients. Postural balance disorders (PBD) are among the most frequent complications following a stroke, affecting motor function, stability, and overall quality of life. The heterogeneity of stroke etiology and its impact on different brain structures contribute to a variety of movement impairments, including hemiparesis, sensory deficits, and coordination disorders.

The study highlights that the severity of postural dysfunction is influenced by multiple factors, including the location and size of the ischemic lesion, muscle spasticity, and impaired sensory perception. The asymmetry of posture observed in stroke patients is often associated with disruptions in the central nervous system's ability to coordinate movement and maintain balance. This imbalance increases the risk of falls, further worsening patient outcomes.

Additionally, post-stroke depression and cognitive impairments are identified as major factors that hinder rehabilitation efforts. Emotional disturbances, including depression and apathy, significantly reduce patient motivation and participation in recovery programs. Cognitive deficits, such as memory loss, attention difficulties, and executive dysfunctions, further complicate the rehabilitation process by limiting the patient's ability to follow instructions and actively engage in therapy.

Stabilometric assessment has proven to be a valuable tool in diagnosing and monitoring postural instability in stroke patients. However, most studies have assessed stabilometric indices at a single time point, lacking long-term monitoring to track recovery progress. This gap in research highlights the need for continuous assessment and tailored rehabilitation strategies that adapt to the patient's evolving needs.

Given the complexity of post-stroke complications, an integrated rehabilitation approach is crucial. Early and intensive rehabilitation, including stabilometric training, physiotherapy, and cognitive-behavioral therapy, plays a key role in improving motor function, reducing the risk of falls, and enhancing overall recovery. The findings of this study emphasize the importance of a multidisciplinary approach to stroke rehabilitation, addressing both physical and psychological aspects to ensure a better quality of life for patients.

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