REHABILITATION APPROACH IN PATIENTS AFTER STROKE IN THE VERTEBROBASILAR SYSTEM

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Abstract: Strokes in the vertebrobasilar system often damage structures important for balance control (vestibular nuclei, brainstem, cerebellum) and lead to vertigo, nystagmus, nausea, vomiting and ataxia. Vestibular function senses rotational and linear acceleration of the head, assists in spatial orientation, and stabilizes eye movements during postural control. This function is critical for maintaining balance, walking speed, and reducing the risk of falls. Central vestibular disorders have different mechanisms than peripheral ones and require a specific rehabilitation approach. **The purpose** of the report is to present contemporary approaches for vestibular rehabilitation and to investigate the effect of personalized vestibular rehabilitation treatment in patients after vertebrobasilar stroke. **Materials and methods:** Three patients after a stroke in the VBS were studied, with a mean age of 80.7 years. The patients were treated for 6 days in the Neurology Department, and rehabilitation program began on average 11 days after the stroke. They underwent a 7-day rehabilitation course, twice a day, combining gaze stabilization exercises (VOR exercises), balance and equilibrium exercises, as well as different types of walking with active head movement. **Results:** The results of Berg balance scale demonstrate a significant improvement in the patients' condition – from an average of 5/56 points at admission to 50.3/56 at discharge. Subjectively, symptoms such as vertigo and dizziness have almost completely disappeared. At first, these symptoms appeared when turning over in bed and sitting up. At the end, they only occurred with quick and sudden head movements, and in one of the patients, with loud sound stimuli and bright lights. The patients gained confidence and absolute independence in their mobility, including going up and down stairs. **Conclusion:** Vestibular rehabilitation is an effective intervention in patients after vertebrobasilar stroke. Individualization, early initiation (when clinically safe) and integration into a multidisciplinary rehabilitation program improve clinical outcomes. Vestibular rehabilitation appears to be a promising therapeutic approach for many post-stroke patients and deserves further research as a potential standard treatment method.
Keywords: vestibular rehabilitation, strokes in the vertebrobasilar system, vertigo

1. INTRODUCTION

The vertebrobasilar system (VBS) plays an essential role in the blood supply to vital structures of the nervous system. As part of the circle of Willis, it contributes to the large compensatory capabilities of the cerebral circulation in some hemodynamic disorders. On the other hand, certain pathological processes affecting the VBS can be fatal or lead to severe damage and functional deficits in the patient. The clinical picture of patients with vertebrobasilar vascular insufficiency (VBSI) includes numerous symptoms and syndromes. The most common of them are vertigo, dizziness, weakness, headache, ataxia, impaired postural control, unsteady gait, nausea, vomiting, impaired vision, and diplopia. Often these symptoms are a manifestation of acute ischemic stroke (AIS) or transient ischemic attack (TIA) (Ivanov, 2023). In recent years, diagnostic criteria for vascular vertigo and dizziness have been unified, emphasizing the close link between vascular pathology and acute vestibular symptoms (Kim et al., 2022). A stroke in the vertebrobasilar system affects the brainstem, cerebellum, and vestibular nuclei, resulting in impaired processing of visual, somatosensory, and vestibular information. Sensory information from the periphery is transmitted to the vestibular nucleus in the medulla oblongata and pons, then to the interstitial nucleus of Cajal in the midbrain and to the vestibular cortex via the thalamus. Damage to any of these pathways results in vestibular vertigo (Fan et al., 2025). New neuroanatomical findings suggest that lesions in the posterior insular cortex also contribute to impaired vestibular compensation after stroke (Zhang et al., 2021). Vestibular function senses rotational and linear acceleration of the head, assists in spatial orientation, and stabilizes eye movements during postural control. The vestibulo-ocular reflex (VOR) is crucial for sustaining visual stability when the head rotates quickly by inducing an opposite rotation of the eyes. Injuries to the VOR can result in retinal image slip in response to rapid head movements, consequently impacting visual perception (Schubert & Migliaccio, 2019). The vestibular system plays an essential role in preserving balance and spatial orientation in everyday life (Cronin et al., 2017). Improving vestibular function through rehabilitation is important for restoring balance and improving quality of life. Repeated walking exercises facilitate muscle strength and promote brain plasticity and motor retraining. Vestibular rehabilitation (VR) is a method that aims to centrally compensate for vestibular dysfunction, and its origins date

back more than 70 years (Cawthorne & Cawthorne, 1944). VR has proven effective in unilateral peripheral vestibular disorders (Hall et al., 2022). Recent systematic reviews show that VR also improves balance and gait in patients after stroke, although the rehabilitation duration is often longer compared with peripheral disorders (BMC Medicine, 2023). Clinical studies highlight that symptoms in stroke patients—such as deviations of perceived vertical, nystagmus, fall direction, and vertigo—depend on the specific location of the lesion within the vestibular pathways (Fan et al., 2025). Case reports demonstrate that even isolated pontine infarctions within the VBS can present solely with acute vertigo and nystagmus (Kwon et al., 2023), while chronic bilateral vertebral artery stenosis may mimic long-standing dizziness (Severe Bilateral Vertebral Arterial Disease, 2023). In central vestibular lesions, nuclei (such as nucleus vestibularis), their connections, and cerebellar structures (flocculus, nodulus) are affected, which impairs VOR, postural reflex modulation, and sensory integration.

VR aims to improve function through three mechanisms:

- VOR (vestibulo-ocular reflex) structural and functional adaptation; (Schmid & Jeannerod, 1985)
- Compensation (reorganization of central circuits), use of other sensory systems for compensation;(Curthoys, 2000)
- Habituation – reduction in sensitivity /symptomatic reactions/ to repeated, provoking stimuli. (Gresty et al., 1977)

These mechanisms have been observed in both peripheral and central lesions, although the speed and extent of recovery vary.

- Principles of vestibular intervention:
- Individualization: consider the localization of the stroke, cognitive status, coordination, cardiorespiratory tolerance.
- Gradual increase in load and provocation (progressive challenge).
- Combining gaze-stability + balance and functional tasks - this gives the best clinical results according to systematic reviews.

The aim of the report is to present contemporary approaches for vestibular rehabilitation and to investigate the effect of personalized vestibular rehabilitation treatment in patients after vertebrobasilar stroke.

2. MATERIALS AND METHODS

Three patients after a stroke in the VBS were studied, with a mean age of 80.7 years. The patients were treated for 6 days in the Neurology Department, and rehabilitation program began on average 11 days after the stroke. They underwent a 7-day rehabilitation course, twice a day, combining gaze stabilization exercises (VOR exercises), balance and equilibrium exercises, as well as different types of walking with active head movement.

The vestibular rehabilitation intervention consisted of a personalized program tailored to each patient's impairments and functional limitations related to vertigo, dizziness, oculomotor function, and balance and gait disorders. The exercise categories that were implemented included gaze stabilization exercises (VOR - in which the individual maintained a fixed gaze position while turning the head from side to side in a sitting and standing position), moving object tracking exercises, standing balance (e.g., standing with legs apart and together on a stable surface - with eyes open and closed), walking with a balance challenge (e.g., walking with head rotation, tandem walking, and avoiding obstacles), bending and picking up exercises, body rotation, toe lifting, etc.

Specific exercises

- Exercises for stabilizing the gaze (VOR adaptation)

• The patient fixes a small, contrasting target (at eye level, at a distance of 1–2 m).
• Keeping the gaze on the target, gradually turning the head horizontally 20–40° /left-right/, vertically /up-down/ and diagonally.
• Dosage: 2 times/day; each series 30–60 s;
• Progression: sitting → standing (wide support) → standing (narrow support) → standing on an unstable surface → walking (with head movement).
• Adaptation: movement of both the head and the target in opposite directions.
If severe nausea/disorientation occurs — decrease the speed/duration and then gradually increase.

- Balance exercises (static and dynamic)

Static: normal standing → tandem standing → single-support standing; on stable and unstable surfaces; eyes closed.
Dynamic: weight transfer, steps (lateral/front/back), zigzag walking, figure eight, overcoming and avoiding obstacles

- Ocular-motor exercises

• Tracking movements: following a moving object /simultaneous movement of the head and eyes in one direction/.

• Saccades: rapid transfer of gaze fixation between two points.

- Dual tasks

Integrating cognitive tasks (counting down, speaking) during walking/balance.

• Start with easy tasks and increase complexity.

- Strength training and stability

• Mini squats, climbing stairs, toe lifts.

3. RESULTS

At the beginning, the most frequently described symptoms in all patients were dizziness (100%), loss of balance (100%), followed by nausea (66.6%) and headache (33.3%).

Dizziness initially occurred when turning over in bed and when sitting. At the end, it subjectively almost completely disappeared. It appeared only with rapid and abrupt head movements, and in one of the patients also with strong auditory stimuli and bright lights. One of the patients complained of a headache at the beginning, which gradually resolved.

The results of the Berg balance scale demonstrate a significant improvement in the patients' condition - from an average of 5/56 points at admission to 50.3/56 points at discharge.

After the 7-day rehabilitation program, two of the patients gained complete independence in their mobility, including climbing and descending stairs. One of them did not feel confident enough and needed supervision and emotional support.

4. DISCUSSIONS

A review of the available literature and a growing body of scientific evidence support the positive effects of VR in post-stroke patients who present with vestibular symptoms such as vertigo, balance disorders and/or gait difficulties. There is a lack of complete homogeneity in the available protocols (various exercises, dosage, starting point), which limits the determination of the optimal dosage.

Although most evidence comes from peripheral cases, there is accumulating evidence that adaptive exercises have applicability also in central lesions; the rate of improvement may be slower and requires a more individualized approach.

A systematic review and meta-analysis (Meng et al., BMC Medicine 2023) summarized data from controlled studies and concluded that VR improves balance and gait in post-stroke patients, with better results in programs that combine gaze-stability and head movement exercises; the effects are more pronounced in programs ≥4 weeks.

Since the manifestations in patients after stroke are very diverse, rehabilitation exercises must be individually adapted according to the diagnosis and the patient's response to recovery.

5. CONCLUSIONS

Vestibular rehabilitation is an effective method in patients after vertebrobasilar stroke, and its early inclusion can accelerate rehabilitation and improve outcomes.

VR is most effective when personalized to the specific deficits of the patient, for which it is important to better understand the mechanisms by which different approaches in VR lead to improvement in patients after stroke in order to develop more effective rehabilitation strategies.

Vestibular rehabilitation appears to be a promising therapeutic approach for many patients after stroke and deserves further investigation as a potential standard treatment method.

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