TOPICS IN VESTIBULAR PHYSICAL THERAPY

VESTIBULAR REHABILITATION SIG

Academy of Neurologic Physical Therapy

CENTRAL VESTIBULAR DISORDERS

IN THIS ISSUE PAGE

CLINICAL CASE STUDIES

EXPANDED ABSTRACT

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Message from the Chair

Rachel Wellons, PT, DPT*
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It was great seeing everyone in Boston at the Combined Sections Meeting (CSM). CSM provides a wonderful opportunity to recap our major accomplishments, recognize individuals who go above and beyond, learn, and collaborate. While vestibular rehabilitation programming is typically very strong, this year's programming exceeded my lofty expectations.

I'd first like to recognize the Vestibular SIG Service and Research Awards winners. The Service Award goes to **April Hodge, PT, PhD***. April initiated the Vestibular SIG efforts in social media and was our social media chair for over ten years. The Research Award goes to **Linda D'Silva, PT, PhD***. Linda is the director of the STABILITI lab at the University of Kansas. She has over 20 peer-reviewed publications in the area of Vestibular Rehabilitation, Neurologic Rehabilitation, Balance and Falls, and Diabetes. She currently has over $435,000 in grant funding from the NIH investigating vestibular and neck muscle contributions to head control in balance-impaired older adults. **Iwona Kedzierska, PT, DPT***, **Laura Cialino, PT, DPT***, and **Erin Garcia, PT, DPT*** won the award for best article in this publication for her article entitled "Vestibular Physical Therapy Management of Patients with Idiopathic Peripheral Neuropathy and Chemotherapy Induced Peripheral Neuropathy: A case series". The Vestibular SIG also thanked **James Chia-Cheng, PT, DHS**, for his service on the Nominating Committee over the past three years.

There were 36 posters and two platform presentations in the area of Vestibular Rehabilitation at CSM. Two posters tied for Best Case Study Poster: **Zachary Knox, PT, DPT*** with his poster entitled "Management of Central Vestibular and Oculomotor Impairments in an Individual with Chronic Stroke" and **Jessica Jacobs, PT, DPT, PhD*** for her poster "Central Vestibular and Oculomotor Rehabilitation Following Acute Pontine Stroke." The two case studies are included in this July edition of the TVPT. **Colin Grove, PT, DPT, MS, PhD**, along with **Brian James Loyd**, **Sophia Petrino**, **Leland Dibble**, and **Michael Schubert**, won the award for the Best Research Poster for their poster entitled "Comparison of Vertical and Horizontal Gaze Stabilization Mechanisms in People with Multiple Sclerosis." Thank you to **James Chia-Cheng** for organizing poster judges and to **Jake McPherson**, **Holly Roberts**, **Lisa Brekke**, **Lynn Johnson**, and **Shellie Hodge Zsoldos** for judging the posters.

I encourage all members to actively engage with our SIG by attending an online networking session, participating on social media, or joining one of our many educational offerings. Your insights, expertise, and passion are invaluable assets to our community, and I am deeply grateful for your ongoing dedication and support.

I would like to express my sincere appreciation to the members of the Vestibular SIG leadership team for their tireless efforts in advancing the mission of the Vestibular SIG. The 1,903 members of the Vestibular SIG continue to positively impact the lives of our patients with vestibular dysfunction.

Introduction to the Topic

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Peripheral vestibular pathology welcomes a wealth of evidence to guide the physical therapist during vestibular rehabilitation clinical practice, including clinical practice guidelines for both benign positional vertigo and vestibular hypofunction.(1,2) Unfortunately, these guidelines are specific to peripheral dysfunction and "may not apply to individuals with central vestibular disorders".(2) When it comes to the examination of a client with suspected vestibular dysfunction, the skilled, vestibular-trained physical therapist will perform a thorough oculomotor, postural control, gait and positional examination to not only identify and confirm any vestibular dysfunction, but also distinguish between peripheral and central causes. These skills have become essential components of the physical therapist examination across settings; from the side of the athletic field to the emergency room setting to the outpatient clinic.

If central vestibular findings are determined without clear identification of an underlying pathology or diagnosis, then the client is referred to neurology for further work up. What if central vestibular findings are consistent with a known pathology? Recommendations for physical therapy management based upon evidence-guided decision-making for clients with central vestibular dysfunction is comparatively sparse to peripheral vestibular dysfunction. This is likely related to the fact that central vestibular dysfunction should by no means be considered a homogenous group. Central vestibular pathology may result from a myriad of origins, both mechanical and organic, which may lead to disruption at various levels along vestibular pathways anywhere from the brainstem to the cortex. The spectrum of central vestibular disorders results in clients experiencing a wide array of symptoms of dizziness, gaze instability, gait and postural instability, and even disorders of cognition, including spatial awareness, emotion, and memory.(3)

Lesions along vestibular pathways at the level of the brainstem and cerebellum, including the vestibular nuclei, vestibulospinal tracts and vestibulocerebellar pathways, would impair reflexive control of gaze, head and body position in space. The client with a PICA stroke of the lateral medulla would likely present with utter chaos of symptoms consistent with a vestibular crisis. Symptoms of severe vertigo and gait instability would likely be coupled with profound disorientation to postural vertical with possible ipsiversive lateropulsion and possible brainstem findings, such as Horner's Syndrome.(4) Focal lesions at the subcortical/cortical level, including ascending vestibulothalamo-cortical pathways, would result in inaccurate perceptions of self-motion and postural vertical with impaired integration of reflexive and voluntary movements for balance. These clients may demonstrate deficits in postural vertigo of contraversive lateropulsion, consistent with "Pusher's Syndrome," as well as likely profound motor deficits if related to stroke.(4) Focal lesions to the cerebellum can result in clients with deficits in VOR cancellation, oculomotor deficits, and varying degrees of appendicular or truncal ataxia. As the cerebellum, or the brain's great comparator and error correcting mechanism, is impaired, prognosis tends to be guarded. While clients may show improvement, a retrospective review of clients with central vestibular dysfunction by Brown and colleagues found that those with cerebellar disease improved the least.(5) Finally, focal lesions to vestibular integration through the limbic system affecting areas mainly in the cerebral cortex would result in deficits related to spatial memory, learning and navigation.(6) Clients with global or non-focal lesions can present with a spectrum of deficits across those already mentioned.

Considerations for the examination and treatment of children with central vestibular dysfunction were offered by Dr. Jennifer Christy, PT, PhD.(7) Dr. Christy cited evidence of the efficacy of vestibular rehabilitation in children with as many questions as answers across numerous populations that likely present with vestibular dysfunction. Zhang and colleagues (8) offer expert opinion on the use of vestibular rehabilitation as "safe and effective treatment options" for individuals with central vestibular dysfunction citing limited but growing evidence to support the use of vestibular rehabilitation as an intervention for those with migraine, PPPD, Multiple Sclerosis and cerebellar stroke.

This issue of the vestibular newsletter will share case reports that further our sources of evidence for the use of vestibular physical therapy to promote gaze, postural and gait stability in clients with central vestibular dysfunction. Cases range from a client with a lesion in the brainstem (a pontine stroke), a client post cerebellar hemorrhage due to a rare venous anomaly, a client post cerebellar infarcts following an aortic dissection, and a client post cortical stroke (MCA stroke). Additionally, despite the high incidence of peripheral, central or mixed peripheral and central dysfunction following global traumatic brain injury, a study by Witt et al, shares insights to the limited number of extensive vestibular testing being performed in this population. The highly variable nature of the pathologies and locations of lesions in these clients presented furthers the understanding of the challenges of any study that views clients with "central vestibular dysfunction" in the aggregate as a homogenous group. As these cases and study further contribute to the body of evidence, we continue to move beyond expert opinion regarding the indication for vestibular physical therapy in clients with central vestibular pathology!

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ARE YOU INTERESTED IN WRITING A LITERATURE REVIEW? DO YOU HAVE AN INTERESTING CLINICAL CASE?

The TVPT Editors are interested in sharing your clinical experience and can provide mentorship to help you contribute.

Contact: Jasmine Edwards at jjacksondpt@gmail.com

Vestibular Physical Therapy Following Acute Pontine Stroke: A Case Report

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ABSTRACT

Introduction: Those who experience a pontine cerebrovascular accident (CVA) frequently have unrecognized oculomotor and central vestibular pathologies. The vestibular system is often neglected when addressing postural instability in individuals with central neurological disorders, potentially due to the paucity of evidence on the rehabilitation of central vestibular disorders. The purpose of this case study is to explore the effects of vestibular rehabilitation in an individual with a central neurological disorder and postural instability. The case added the additional complications of cardiovascular comorbidities and lower health literacy. **Case Description:** A 69-year-old female presents with balance and gait deficits following a pontine CVA. Further examination revealed decreased speed of smooth pursuits, undershooting with saccades, impaired vestibulo-ocular reflex (VOR), impaired VOR cancellation, and impaired postural stability. **Intervention & Outcomes:** The patient participated in physical therapy (PT), focusing on ocular and vestibular retraining. Interventions included gaze stability exercises, VORx1, gait training with head turns and visual tracking exercises, and postural interventions on various surfaces. Balance, vestibular, and ocular performance were enhanced over a six-week timeframe. The patient's symptom provocation decreased with oculomotor and vestibular testing. Her Functional Gait Assessment (FGA), Timed Up & Go (TUG), and TUG Cognitive improved, exceeding the minimal detectable change. She continued to experience slight dizziness with VORx1 exercises. Interventions were limited due to adverse blood pressure responses to exercise and cardiac complications. **Conclusion:** While considerable amounts of research are available for treating individuals with peripheral vestibular disorders, there is currently limited research available for individuals with central vestibular pathologies, especially those with additional medical complications. The patient made meaningful and measurable improvements in postural stability following vestibular retraining. Further research into central vestibular pathology following a CVA would be meaningful and beneficial.

INTRODUCTION

Central vestibular pathologies can be found with dysfunction within the temporoparietal cortex, thalamus, brainstem, and cerebellum.(1) Connections from the vestibular nuclear complex, cerebellum, ocular motor nuclei, and the brainstem reticular activating system are required for effective vestibular ocular reflexes, vestibular spinal reflexes, and timing and appropriate orientation of extraocular and skeletal muscles.(2) Vestibular function plays an important role in postural control and gait performance. Research on central vestibular pathologies is lacking compared to peripheral vestibular pathologies. However, 7%-45% of individuals seeking vestibular care have some form of central vestibulopathy.(3) Common findings associated with central vestibular pathology include perceptual and ocular motor manifestations and impaired posture and gait. Central vestibular disorders are more likely to cause imbalance than peripheral vestibular disorders.(4) Migraines, trauma, cerebellar degeneration, and ischemic disease, including vertebrobasilar insufficiency and brainstem stroke, are common central vestibular disorders.(4)

Those who experience a posterior circulation cerebrovascular accident (CVA) can have unrecognized oculomotor and central vestibular

pathologies. These pathologies can contribute to gait and balance deficits seen after a CVA. Due to other deficits following a CVA, the central vestibular system may not be examined unless a patient reports dizziness. Previous research has shown that VOR function is significantly related to gait performance. (5) Therefore, if an individual presents with gait and balance deficits following a CVA, examination of the central vestibular system is essential.

Researchers report vestibular rehabilitation can positively influence gait and balance deficits following a CVA. Mitsutake et al. reported that vestibular rehabilitation may improve gait performance by improving VOR in patients post-stroke.(6) Tramontano et al. found that vestibular rehabilitation can improve gait and dynamic balance in individuals following a subacute stroke.(7) Vestibular rehabilitation in post-stroke rehabilitation may improve balance and gait recovery.

Research shows that health literacy is lower in patients with a stroke compared to healthy controls. (7) The U.S. Department of Health and Human Services defines personal health literacy in its 2030 Healthy People report as "the degree to which individuals have the ability to find, understand, and use information and services to inform health-related decisions and actions for themselves and others."(8) The deficits following a stroke can be complex and variable; therefore the ability to understand the deficits following a stroke and use that knowledge to take the next steps to support their health needs can be even more limited in someone with lower health literacy. Health literacy among patients is important for their overall health outcome. Low health literacy is associated with worse health and poorer health outcomes.(9)

The vestibular system is often neglected when addressing postural instability deficits and gait deficits in individuals with central neurological disorders, potentially due to the paucity of evidence on the rehabilitation of central vestibular disorders. This case study aims to explore the effects of delayed vestibular and oculomotor retraining in an individual with a central neurological disorder and medical complications that led to gait deficits and postural instability. The case also explores the impact of health literacy on patient care following a stroke.

CASE DESCRIPTION

History

The patient was a 69-year-old female with a past medical history significant for hyperlipidemia, hypertension, and diabetes. The patient experienced a pontine CVA and was admitted to acute care. The patient was discharged home after a 6-day stay. The patient did not receive home health therapy or immediate outpatient care following discharge. A friend of the family reached out to a local physical therapy program for possible pro-bono care related to the patient's persistent deficits one month following her CVA.

During her initial visit, she reported blurry vision, slurred speech, and slowed movements, with complaints of the right side feeling heavy. The patient stated she fatigued quickly, reported a sense of imbalance, and had difficulty with word finding. She had been unable to return to work or her apartment, where she lived alone before the CVA. She was living with her daughter and grandson in a second-floor apartment. The patient ambulated with a rolling walker in the community and occasionally with no assistive device in the home. The patient and daughter were concerned about the patient ascending and descending stairs alone to reach the second-floor apartment.

The patient and the daughter stated that the patient had not received any follow-up care after discharge from the hospital. At discharge from acute care, the daughter stated that home health therapy was recommended. The daughter and patient were informed that someone with a home health company would contact them to set up home care.

However, the daughter stated that no one called, and they did not know who to contact. The patient

and daughter demonstrated a decreased ability to use health information provided during their hospital stay to advocate for follow-up services needed to return to her prior level of function.

Examination

On the initial examination, she presented with full range of motion in all joints. Manual muscle testing revealed mild weakness in her right lower extremity (Grade 4+/5). Sensation and proprioception were intact bilaterally. The finger-to-nose test revealed overshooting in her upper extremities bilaterally. The patient demonstrated slow movement when asked to perform rapid alternating movements including pronation and supination of her upper extremities and alternating foot tapping. She required supervision to stand with a narrow base of support and eyes closed. The patient was unable to maintain her balance in tandem stance or single-leg stance.

The patient's score on the Functional Gait Assessment (FGA) was 8/30, which was much lower than average for her age group.(10) The patient scored 44/56 on the Berg Balance test, indicating she was at risk for falls.(11) The patient performed a Timed Up and Go (TUG) in 17.67 seconds without an assistive device and a TUG cognitive score of 33.5 seconds. Both times were significantly longer than average for her age group.(12)

Due to the location of the CVA and the presentation of postural instability and gait deficits, oculomotor and vestibular function was assessed. Oculomotor examination revealed that the patient had full extraocular range of motion with no spontaneous nystagmus or gaze-evoked nystagmus. Smooth pursuit testing showed decreased speed of movement and undershooting with corrective saccades. She exhibited difficulty with cancellations of the horizontal VOR and impaired VOR function. Deficits in her smooth pursuit testing and impaired VOR functioning suggested a vestibular dysfunction of central origin contributing to the postural instability and gait deficits.

Diagnosis

Based on all the examination results, the physical therapy diagnosis for the patient was central vestibular dysfunction following a pontine CVA. The involvement of central vestibular structures caused her to have problems utilizing visual and vestibular cues to maintain balance and may have contributed to her gait impairments. The patient also had lower health literacy and cardiovascular comorbidities, which delayed the timing of her treatment and influenced the decision-making when selecting interventions.

Intervention

A customized vestibular rehabilitation program was designed for ocular and vestibular retraining to improve gaze stability and the ability to utilize visual and vestibular cues in maintaining balance. Gait training and balance exercises were incorporated. The patient participated in 60 minutes of PT twice weekly for six weeks.

The vestibular rehabilitation consisted of gaze stability exercises and visual tracking during activities. Vestibular adaptation exercises were prescribed to promote VOR gain. Initially, VOR x 1 exercises in the horizontal and vertical planes were performed on firm surfaces. Exercises were completed for 60 seconds for three repetitions in horizontal and vertical planes with rest breaks as needed following each repetition. The patient was asked to perform the head movement as fast as possible while maintaining focus on the target. The patient reported dizziness with fast head movements but demonstrated no balance deficits on stable surfaces. Therefore, the exercises were performed on unsteady surfaces at the next visit. The patient continued to report minimal dizziness with head movements but demonstrated no loss of balance. Due to the patient not having any loss of balance and mild symptoms, the patient progressed to performing gaze stability exercises while walking forward, backward, and sideways following the first

week of therapy.

Environmental scanning exercises were initiated. The patient scanned her environment for random alternating visual targets while performing functional mobility tasks, including sit-to-stands, pivoting, and cross-body reach. These exercises progressed in difficulty by adding a weighted ball, creating a multi-task activity, and progressing from a two-step command to a five-step command. With the addition of the weight ball, fatigue became a limiting factor. Once the patient reached a five-step command consistently, the activity progressed to random target practice and timed trials to improve reaction time and decision-making.

Balance and gait training exercises were also included. These exercises included tandem ambulation, obstacle negotiation, stair negotiation, and walking on uneven surfaces. The patient completed various gait training exercises with head turns and visual tracking, dual-task cognitive activities such as serials 3s or categories while ambulating were also incorporated. For balance exercises, the patient was asked to maintain balance with a narrow base of support, single leg stance, and on unstable surfaces. The patient progressed to eyes-closed conditions with a narrow base of support and unstable surfaces once she could maintain balance on a stable surface.

Throughout the six weeks, the patient had many cardiovascular complications, including fluctuating episodes of hypertension. During one session, the patient reported her blood pressure was “105 over something one morning, and I was feeling kind of lightheaded. Another morning it was “209 over something.” The patient stated she was inconsistent with taking her blood pressure medication due to being late for appointments or forgetting. Throughout the plan of care, the patient’s systolic blood pressure averaged between 170-180 mmHg at the start of treatment sessions.

The patient was encouraged multiple times to follow up with the cardiologist before the scheduled appointment, which was a month away. Throughout the treatment sessions, the patient had significant drops in blood pressure with activities that increased her heart rate, such as obstacle negotiation, stair training, and functional mobility tasks. Hypertensive episodes were a barrier to treatment sessions, resulting in many sessions being terminated early. In one instance, the patient had a 54 mmHg drop in systolic blood pressure with activity. During this time, the patient reported no other symptoms.

Ongoing education was provided to the patient and daughter about stroke risk factors, the implications of hypertension, and the adverse blood pressure response to exercise. The patient lacked the health literacy to understand and use this information to make appropriate health decisions. The patient was finally seen by her cardiologist. The information about the drop in blood pressure during exercise was sent to the physician. Following this appointment, the patient was scheduled for a nuclear stress test and used a Holter monitor.

Outcomes

The pre-treatment and post-treatment outcome measure results are summarized in Table 1. The patient exceeded the minimal detectable change for the FGA and TUG outcome measures at the 8-week reassessments.(14,15) She also demonstrated a significant decrease in symptom provocation during oculomotor and vestibular testing. She continued to experience slight dizziness with VORx1 exercises in the horizontal direction.

At the six-week point of treatment, the patient was hospitalized due to a medication reaction and did not receive therapy during this time. She returned to the clinic two weeks later and was reassessed on FGA, TUG, TUG Cognitive, oculomotor, and VOR testing. During the reassessment, the patient notified the therapist of a scheduled heart procedure; the patient could not provide any further details about the type of procedure. The patient was discharged

Table 1: Pre-treatment and Post-treatment Outcome Measure Results

	Pre-Treatment	4-weeks	8-weeks	MDC
FGA	8/30	18/30	22/30	5 point change[15]
TUG	17.67 seconds	14 seconds	11.59 seconds	2.9 seconds[14]
TUG Cognitive	33.5 seconds	20.33 seconds	12.59 seconds	NA

Abbreviations: FGA, Functional Gait Assessment; TUG, Timed Up and Go; MDC, Minimal Detectable Change; NA, not available

from therapy. After following up with the patient's daughter, it was found that the patient had a surgical procedure performed to treat atrial fibrillation.

At the six-week point of treatment, the patient was hospitalized due to a medication reaction and did not receive therapy during this time. She returned to the clinic two weeks later and was reassessed on FGA, TUG, TUG Cognitive, oculomotor, and VOR testing. During the reassessment, the patient notified the therapist of a scheduled heart procedure; the patient could not provide any further details about the type of procedure. The patient was discharged from therapy. After following up with the patient's daughter, it was found that the patient had a surgical procedure performed to treat atrial fibrillation.

DISCUSSION

The patient in this case presented with signs consistent with central vestibular dysfunction. Several findings in the oculomotor examination indicated central vestibular dysfunction, including corrective saccades during smooth pursuit testing, impaired VOR, and impaired VOR cancellation. The results of the FGA and the TUG tests identified the presence of postural instability during gait. Throughout the six-week intervention, the patient had multiple cardiovascular complications that limited intervention selection and length of therapy sessions. Abnormal cardiovascular response led to the decision to decrease the intensity of mobility and gait training interventions.

The patient was delayed in receiving outpatient physical therapy following discharge from the acute care setting. The delay in therapy may have been related to the patient's and her daughter's poor health literacy. Health literacy levels are generally lower in patients with a stroke.(7,16,17) However, despite a one-month delay in therapy and medical complications, the patient improved her outcome measures and subjective symptom report significantly.

A systematic review of the effects of vestibular rehabilitation by Tramontano et al. found that vestibular rehabilitation is safe and effective for individuals with neurological disorders that impact balance and gait.(18) Patient populations included in the systematic review were diagnosed with multiple sclerosis, stroke, traumatic brain injury, or Parkinson's disease. Vestibular rehabilitation in combination with other neurorehabilitation programs had positive effects on balance, with reported improvements persisting over time. The patient in the case demonstrated an improvement in postural stability and gait following vestibular retraining after a pontine stroke.

The case study results show significant improvements in FGA scores and TUG time. Similar improvements to postural stability and gait have been found in the literature. Tramontano et al. conducted a randomized controlled trial investigating vestibular rehabilitation training in patients with a diagnosis of subacute stroke.(10) A group receiving vestibular rehabilitation interventions, including gaze stability exercises and

upright postural control, was compared to a control group receiving balance exercises focused on trunk stabilization and weight shifts. Improvement in the Tinetti Balance Gait scores was found in patients receiving vestibular rehabilitation, but no difference was found in trunk stability compared to the control group. Researchers concluded that incorporating vestibular rehabilitation into post-stroke care can improve dynamic balance and walking recovery. The results of the case study expanded on these findings. The case study shows that a patient with cardiac comorbidities, which would have excluded her from the randomized control trial, can also significantly improve their postural stability and gait.

Research has shown that VOR function is related to gait performance.(5) Gaze stabilization exercises to help adapt the VOR function can impact gait performance. However, research is lacking on vestibular rehabilitation protocols regarding duration, frequency, and types of exercises for individuals diagnosed with neurological disorders that can impact the vestibular system. With six weeks of vestibular rehabilitation focusing on gaze stabilization, balance, and gait, the patient in this case study improved her FGA and TUG scores significantly. The patient demonstrated minimal balance deficits with static gaze stability exercises. Due to minimal impairments in static stance, the patient quickly progressed to performing gaze stabilization exercises with ambulation. She also progressed to visual-tracking activities with functional mobility tasks. These results support the importance of VOR training in someone with gait deficits and postural instability following posterior circulation CVA.

This case report shows that a customized vestibular rehabilitation program may help improve postural stability and gait of a patient with a central vestibular dysfunction following a CVA. These findings are in agreement with previous studies, which have shown that vestibular rehabilitation can improve balance and gait in patients post-stroke. (3,6,10,19)

With the delayed treatment and medical complications, the patient still showed significant improvements in her postural stability. The vestibular system and cardiovascular system have complex interactions. The vestibular spinal reflex is thought to play a role in preventing a drop in blood pressure related to movement.(20) However, there is a gap in the literature related to cardiovascular responses to vestibular rehabilitation. This case demonstrates that vestibular rehabilitation for a patient with a posterior circulation CVA is beneficial, even after a delay in care. The case also highlights the importance of increasing health literacy of patients with a stroke. Improvements in health literacy would help to increase the understanding of treatment strategies, self-care, risk factors, and overall quality of life.

CONCLUSION

The patient made meaningful and measurable improvements in postural stability and gait following vestibular retraining. Further research into central vestibular deficits following posterior circulation CVA would be meaningful and beneficial. This case report highlights the importance of including vestibular and oculomotor testing in people presenting with postural instability and gait deficits following posterior circulation pathologies. Therapists should be aware of and monitor for possible adverse responses in individuals with central vestibular dysfunction. By identifying the presence of vestibular and oculomotor dysfunction, physical therapists are better equipped to treat the patient effectively. Low health literacy and poor recognition of vestibular impairments after stroke may delay patients receiving care.

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Recognition from CSM VRSIG Meeting

Vestibular SIG Service Award

April Hodge, PT, PhD*

- Initiated Vestibular SIG efforts in social media
- Social Media Chair

Vestibular Physical Therapy after Cerebellar Stroke. Going Beyond Functional Mobility Training to Optimize Outcomes in the Inpatient Setting: A Case Report

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ABSTRACT

Introduction: Of ischemic strokes, about 2-3% are isolated to the cerebellum, with common findings including impaired postural control, ataxic gait, incoordination of the extremities, dizziness, and various oculomotor deficits, including impaired smooth pursuits, saccades, and vestibular-ocular reflex (VOR) function.(1) It is well known that patients after a cerebellar stroke should be recommended for specialized vestibular rehabilitation due to their unique needs and presentation. Unfortunately, the research surrounding the therapeutic management of cerebellar stroke is limited and of low-to-moderate quality. To drive clinical practice and further research, this case report aims to highlight the specific assessment and intervention-level details of a patient post-cerebellar stroke plus an aortic dissection and repair. **Case Description:** The patient is a 53-year-old male who was admitted to the inpatient rehabilitation facility (IRF) 25 days following an aortic dissection and repair with multiple acute/subacute ischemic strokes within the right posterior cerebral artery (PCA) and superior cerebellar artery (SCA) distributions, along with ischemic infarct to the left frontal lobe. Notable examination findings included significantly impaired static and dynamic standing balance, head motion intolerance, right-sided incoordination, impaired oculomotor function, reduced activity tolerance, and altered communication and cognition, all resulting in increased dependence for mobility and activities of daily living (ADLs), with increased risk for falls from baseline. **Intervention:** After thorough examination and evaluation, the physical therapist provided a challenge-point framework for sensory organization, coordination, habituation, gaze stability, and activity tolerance training to improve safety and independence with mobility, reduce risk of future falls, and ensure successful discharge to home. **Outcomes:** By discharge from IRF at day 17, the patient demonstrated significant improvement, progressing to independence with mobility and ADLs without a device, as well as demonstrating clinically meaningful improvement in his Berg Balance Scale, Timed Up and Go, Four Square Step Test, and Functional Gait Assessment outcome measures. **Conclusion:** Physical therapists have an integral role in the treatment of patients post-cerebellar stroke. Although further high-quality studies, systematic reviews, and clinical practice guidelines are needed to supply adequate dosing recommendations, it is clear that a thorough examination and assessment by a vestibular-trained specialist can outline the relevant impairments and functional limitations to drive accelerated return to their salient home environment.

INTRODUCTION

Aortic dissection is a serious medical condition with high morbidity and mortality rates. Type A aortic dissection is considered a true surgical emergency with a mortality rate as high as 1% per hour in the first several days if left untreated, with an incidence of 3.0 per 100,000 individuals per year and an in-hospital mortality rate of 37.5%.(2) Incidence of stroke related to aortic aneurysm has been difficult to determine thus far; however, 18-30% of patients

with an aortic dissection present with neurological symptoms, with the most common cause being stroke.(3) This may be related to extension of the dissection into the common carotid arteries, thromboembolism, and cerebral hypoperfusion.(3)

Only about 2-3% of ischemic strokes are isolated to the cerebellum.(1) Common findings include impaired postural control, ataxic gait, incoordination of the extremities, dizziness, and various oculomotor deficits, including impaired smooth pursuits, saccades, and vestibular-ocular reflex (VOR) function. It is well known that patients after a cerebellar stroke should be recommended for specialized vestibular rehabilitation due to their unique needs and presentation. It is also well known that when compared to their peripheral vestibular dysfunction counterparts, these patients generally have a slower progression with more guarded outcomes. This is due to the cerebellum's important role in motor learning, which results in significantly reduced adaptability when damaged.(4) Furthermore, research has demonstrated that patients with damage to the superior cerebellar artery (SCA) tend to have worse outcomes in motor function than those with posterior inferior cerebellar artery (PICA) damage. While both will result in postural instability, damage within the SCA will tend to produce more pronounced gait and limb ataxia and dysarthria, as compared to vertigo and nystagmus within the PICA distribution.(1)

Unfortunately, the research surrounding the therapeutic management of cerebellar stroke is limited and of low-to-moderate quality. To date, no clinical practice guidelines specific to this population exist. Two systematic reviews examined the effectiveness of physical therapy for those with cerebellar disorders. Both reviews recommend that results be interpreted with caution due to lower levels of evidence and high heterogeneity for included studies.(4,5) Despite this, the research does show promising effects for physical therapy, particularly positive effects on balance, gait, and function, especially when prescribed in a customized, patient-centered approach. Martin and colleagues noted the most frequently reported interventions included vestibular habituation exercises, proprioceptive neuromuscular facilitation (PNF), Frenkel exercises, and a range of activities aimed at retraining balance.(5) Unfortunately, most of the studies included in this systematic review lacked detail regarding the specific details of their intervention, making it difficult to extrapolate appropriate dosing and progression recommendations. The systematic review by Marquer et al, found moderate-level evidence that rehabilitation is effective in improving postural stability in those with cerebellar ataxia, particularly in those with degenerative ataxia or multiple sclerosis (MS) as these were the populations most commonly studied. Their recommendation includes use of the Scale for the Assessment and Rating of Ataxia (SARA), and treatment with a focus on intense balance and coordination exercise training. They note this to be accomplished through various methods, including virtual reality, biofeedback, and treadmill training, but again, with limited evidence to provide prescriptive dosing.(4)

This case report highlights a patient who presented with vestibular deficits following a cerebellar stroke post-aortic dissection and repair. After thorough examination and evaluation, the physical therapist provided a challenge-point framework for sensory organization, coordination, habituation, gaze stability, and activity tolerance training to improve safety and independence with mobility, reduce risk of future falls, and ensure successful discharge to home. This case report aimed to provide greater assessment and intervention-level detail to aid and facilitate relevant research and clinical practice.

CASE DESCRIPTION

History

The patient is a 53-year-old male with no significant past medical history admitted to an

inpatient rehabilitation facility (IRF) 25 days after his stroke. Originally from out of state, he was visiting the area for a job interview when he developed acute chest pain, presented to the emergency department, and was found to have a Type A aortic dissection. The patient underwent repair, but once off sedation, he was found to have new neurological deficits, including aphasia, ataxia, right-sided facial droop, and dysphagia. The patient was found to have developed multiple acute/subacute ischemic strokes within the right posterior cerebral artery (PCA) and superior cerebellar artery (SCA) distributions, deemed likely as a complication of the original dissection versus intraoperatively. Specific areas of involvement included bilateral thalami, left corpus striatum, medial right temporal lobe, right midbrain and pons, and more notably, the left frontal lobe and right more than left cerebellar hemisphere. His course was further complicated by hemorrhagic conversion of the above left frontal lobe stroke, as well as stress-induced hyperglycemia, acute blood loss anemia, and acute thrombocytopenia.

Examination

Review of the chart showed that prior to his hospital admission, the patient was independent with all mobility, ADLs, and instrumental ADLs (IADLs), including driving and working in construction. His examination, completed on day 2 of his IRF stay or 26 days after his initial stroke, was challenging due to moderate expressive and moderate-to-severe receptive language deficits, along with mild dysarthria. Due to language impairments, his cognition was not formally evaluated, but deficits in attention, reasoning, and memory were suspected by speech-language pathology. As a result, the physical therapist deemed a movement analysis approach per Shumway-Cook and Wollacott to be most effective for examination, moving to impairment-based assessment when the patient could successfully follow directions.(6)

Functionally, moderate-to-severe safety deficits were noted, with the patient demonstrating poor awareness and compliance with sternal precautions despite consistent cueing. Lower extremity sensation and strength were not formally tested, but the patient could move all four extremities against gravity through informal observation. The patient was able to complete bed mobility, including rolling left and right along with supine to/from sit with supervision only, primarily to ensure adherence to sternal precautions. Transfer performance required variable contact-guard to minimal assist (CGA-Min A), requiring consistent cues for safe hand placement. The patient's ambulation abilities were first assessed without a device, with him requiring moderate assist (Mod A) due to ataxic gait, while also requiring consistent cueing for pathfinding and object avoidance. The greatest imbalance was noted with head and body turns in both static and dynamic standing, consistent with an altered vestibulospinal reflex (VSR). A front-wheeled walker (FWW) was trialed, with the level of assist improved to Min A, which was deemed safer for use with the unit's nursing staff. On stairs, the patient was able to step-to ascend and descend 12, 6-inch stairs with bilateral handrails and Min A. Consistent cueing was required from the physical therapist for safe lower extremity sequencing due to right lower extremity weakness, likely related to the patient's left frontal lobe stroke. The patient was also able to complete picking up an object from the ground while standing with Min A due to instability, as well as transferring in and out of the car with a FWW and Min A. Considering the patient's status and expected prognosis, wheelchair mobility was not trialed nor assessed.

In an attempt to gather further information, through demonstration by the physical therapist, the patient completed formal coordination testing, demonstrating moderate incoordination on the right lower extremity, as assessed through simultaneous and alternate toe-tapping. Moderate incoordination was also noted on the right upper extremity, as assessed with rapid alternating

pronation/supination, finger-to-nose, and finger-to-thumb opposition, as well as with functional activities, for example, reaching and manipulating toilet paper when using the bathroom.

Throughout the examination, the patient was often self-selecting to close one eye, the left more than the right. While he was unable to verbalize symptoms of diplopia, it is not uncommon to observe impairments in subjective visual vertical (SVV) in patients with unilateral cerebellar damage.(4) Cross-cover testing was completed, which revealed a positive vertical skew deviation, confirming apparent diplopia. Oculomotor testing was completed in room light, with negative spontaneous or gaze-evoked nystagmus. Saccadic intrusions were present with smooth pursuit testing in all directions, and multiple undershoots and overshoots were noted with saccade testing. The patient also demonstrated saccadic intrusions with VOR cancellation testing. These findings are all consistent with cerebellar dysfunction. Due to time limitations on the date of the initial examination, outcome measures were collected the following day, including the Berg Balance Scale (BBS), scoring 22/56; a Timed Up and Go (TUG), scoring 23.7 seconds with a FWW and Min A for stability; and the Four Square Step Test, scoring 17.5 seconds without a device. These outcome measures were chosen based on the Academy of Neurologic Physical Therapy's (ANPT) Vestibular Evidence Database to Guide Effectiveness (EDGE) document published in 2013, considering the patient's acuity and central diagnostic category.(7) All the above indicated significantly impaired static and dynamic standing balance with a high risk for future falls. Outcome measure scores are noted in Table 1.

Assessment

A thorough physical therapy assessment revealed impaired static and dynamic standing balance with an altered VSR, impaired right-sided coordination, impaired communication and cognition, reduced activity tolerance compounded by concurrent sternal precautions, and impaired oculomotor function, notably with smooth pursuits, saccades, VOR cancellation, gaze stabilization, and apparent

Table 1: Physical Therapy Standardized Outcome Measures

Outcome Measure	Initial - IRF Day 3	Reassessment - IRF Day 10	Reassessment - IRF Day 14	Discharge - IRF Day 16
Berg Balance Scale	22/56	37/56		50/56
Timed Up and Go	23.7 sec with FWW and Min A for stability	11.0 sec without a device		9.5 sec without a device
Four Square Step Test	17.5 sec without a device	15.0 sec without a device		12.5 sec without a device
Functional Gait Assessment		6/30		21/30
Dynamic Visual Acuity			4 line loss	
6 Minute Walk Test				394.7 m without a device

Abbreviations: FWW = front-wheeled walker, IRF = inpatient rehabilitation facility, sec = seconds, m = meters

diplopia. Based on the movement system diagnoses for neuromuscular conditions from Scheets et al, 2014, it was determined he most closely fit patterns for sensory selection and weighting deficit, as well as dysmetria.(8) As a result, he required increased assistance for mobility and was at a significantly increased risk for falls from baseline.

It was clear from the literature that compensation after central vestibular injury requires a greater time than peripheral causes, much beyond the average 2–3-week length of stay allotted in an IRF.(4) Considering the patient's medical diagnosis, current functional status, and concurrent communication and cognitive impairments, the physical therapist and interdisciplinary team set goals for supervision-level mobility and ADLs with a walker at discharge. The development of a home exercise program to address relevant impairments and reduce fall risk was also deemed important, as the patient was anticipating discharge back to his home state, where there would likely be a delay until he was able to visit with his primary care provider and obtain a referral.

Intervention

The patient was admitted to the IRF 25 days post-cerebellar stroke and was seen daily for therapies for 17 subsequent days before discharging home. After initial examination on day 2 of his stay, or 26 days after his stroke, even though the patient did not appear to demonstrate any considerable nausea or dizziness related to his visual deficits, an eye patch was ordered through internal supplies, with the physical therapist able to trial patching on day 3 to address apparent diplopia. In-depth education was provided on the pros and cons of patch use, namely that therapies will work to reduce patch needs over time to help facilitate central vestibular compensation. Ultimately, no significant change in the level of assist with mobility was noted when compared with and without patching. Still, the patient did demonstrate greater ease with reaching and grasping tasks when in place and, therefore, was encouraged to use during various activities such as meals and toileting if he preferred.

As his goals in physical therapy primarily related to safety with mobility for accelerated discharge to home as quickly and as safely as possible, the initial treatment focus was on deficits in static and dynamic standing balance and lower extremity coordination, while at the same time beginning to include central vestibular habituation for his head motion intolerance. This was based on assessment of his performance with VSR and VOR cancellation testing. Initially, the patient needed consistent cueing for safe hand placement with all transfers, indicating likely impaired memory from his stroke. With sit-to-stand transfers, he was found to do best when the walker was placed several feet in front of him, forcing him to push up with his upper extremities from the chair or mat instead of the walker, in an effort to maintain safety and his sternal precautions.

Therapies utilized various functional interventions including the Dynavision (Dynavision International, Cincinnati OH), card wall matching, alternate step tapping and reduced height stair progressions, sit to/from stands, multi-directional gait and stepping reaction training (such as sidestepping, retro ambulation, marches forward, gait with horizontal and vertical head turns, forward and lateral Figure 8 patterns), obstacle navigation, cone finding, and ball catch and toss activities. Working within the challenge-point framework, (6) the physical therapist worked to reduce upper extremity support when able to further up-train the patient's sensory organization processing. When visual targets and tracking were incorporated into the activity, the patient required his eye patch due to diplopia, and the physical therapist ensured the patch was alternated between left and right eyes to avoid unilateral disuse atrophy. When the patient was notably fatigued but still agreeable to physical therapy, the NuStep bike (NuStep LLC, Plymouth MI), without the use of arms to maintain sternal precautions, was utilized to help

address activity tolerance impairments.

By day 8 of his rehab stay, the patient's expressive and receptive language improved fairly considerably, allowing for a more complex set-up of tasks and activities. He was able to progress to step-to ascending and descending 8-inch stairs. Still, as he continued to struggle with memory and 2-3 step directions, he did require ongoing cueing to descend retrograde due to fair right lower extremity control and ongoing diplopia, causing buckling and requiring increased assist if descending forwards. He had also progressed to more consistent CGA-Stand by Assist (SBA) for transfers and ambulation with a FWW, CGA-Mod A without a device. On day 9 of his rehab stay, the patient participated in outdoor training, including uneven surfaces and up/down curbs and ramps with CGA-Mod A. Aside from improved patient engagement, this was done to challenge further the patient's visual sampling abilities, which has been demonstrated to increase during negotiation of complex or uneven terrain and with turning.(9) Crowdy, 2000, demonstrated that a greater number of saccades with testing correlated with higher step errors and a slower gait velocity.(10) Thus, it is reasonable that training visual sampling, or our functional use of smooth pursuits and saccades to orient to the environment and bring areas of interest into visual focus, should be incorporated into the plan of care to improve stability and reduce risk of future falls.

With standardized reassessment on day 10 of his rehab stay, the patient demonstrated significant static and dynamic standing balance improvements. Although he continued to demonstrate instability with head and body turns, he was demonstrating improving insight into his abilities, electing to slow down with challenging tasks as a mode of compensation. In collaboration with the interdisciplinary team, he was deemed safe for a trial of independence in the room on day 11 and fortunately experienced no falls for the remainder of the stay.

By day 13, he was ambulating up and down a steep ramp in various directions, weaving around obstacles while on uneven outdoor terrain, reciprocally ascending and descending outdoor stairs without rails, walking with horizontal head turns to cross the street safely, and going up and down grassy inclines, using rate of perceived exertion monitoring to gauge appropriate intensity recommended after stroke.(11) Variable SBA to Min A was required throughout to maintain balance, but overall, his performance was significantly improved from several days prior, requiring only periodic seated rest breaks due to fatigue and mild shortness of breath.

On day 14, repeat oculomotor testing was completed. The patient continued to demonstrate abnormal, central findings with smooth pursuits, saccade, and VOR cancellation testing; however, this time, he was able to verbalize dizziness with VOR cancellation. Head impulse testing showed corrective saccades bilaterally. As the physical therapist was questioning possible inattention from the patient and felt this contradictory to typical central pathology findings, it was decided to complete more objective Dynamic Visual Acuity (DVA) testing. Performed in standing with alternate eye patching to allow for a clear target, the patient demonstrated a four-line loss above the three or more line difference to be considered abnormal.(12) Considering the positive head impulse test and DVA findings, gaze stability training was deemed appropriate and initiated with this patient, acknowledging any possible improvement would be through the patient's ability to substitute with corrective saccades, compared to true adaptation.(13) Working from the theoretical framework of ensuring a clear target with gaze stabilization training, the physical therapist decided to alternate eye patching with VORx1, extending this same principle to VOR cancellation training as well.

As language continued to improve, a home exercise program was initiated with written instructions, pictures, and video links for each exercise. Table 2

Table 2: Functional Tests Initial and Discharges Result

Exercise	Dosing	Impairment Focus
Alternating standing marches	Upper extremity support as needed through countertop x15 reps bilateral. 1-2x/day.	Sensory organization, Dynamic balance, LE coordination
Alternating hip abduction	Upper extremity support as needed through countertop x15 reps bilateral. 1-2x/day.	Sensory organization, Dynamic balance, LE coordination
Horizontal and Vertical Head Turns	x10 reps each, standing with narrow base of support. 1-2x/day.	Habituation
VOR Cancellation	x30 sec with alternating eyes covered, standing with normal base of support. 1-2x/day.	Habituation
VOR x1 horizontal and vertical	x40-60 sec as tolerated in each direction with alternating eyes covered, standing with normal base of support. 1-2x/day.	Gaze Stabilization

Abbreviations: LE = lower extremities, VOR = vestibulo-ocular reflex

provides details of this patient's home exercise program, including the relative dosing and rationale for each exercise.

Day 15 and 16 of his rehab stay allowed a review of his home exercise program per above. The physical therapist felt it to be especially important that the patient could complete as accurately and with as little cueing as possible, considering the patient's plan to discharge back home out of state, where a delay in therapies could reasonably be anticipated. With reassessment of standardized outcome measures on day 16, the physical therapist recommended using a walking stick for community mobility, which the patient verbalized understanding, agreement, and fortunately had available at home. In addition, after initial instructions and demonstration, the patient demonstrated independence with a floor transfer as part of fall recovery training.

Day 17, the last day of his IRF stay, the patient's brother had flown in to complete family training. The interdisciplinary team took the opportunity to educate about diagnosis, prognosis, and relevant implications for safety. The brother was educated about the patient's improving but ongoing imbalance, diplopia, and right-sided incoordination. Although typically coordinated as part of discharge, the physical therapist stressed the importance of obtaining appropriate follow-up care with a vestibular-trained physical therapist. To ensure carryover and proper performance, the physical therapist also had the patient complete his home exercise program with his brother present.

Outcomes

The patient demonstrated significant improvements in his outcome measures, as noted in Table 1, as well as his functional mobility. The minimal detectable change on the BBS for patients post-stroke is 7 points.(14) The patient demonstrated a remarkable 28-point improvement (from 22/56 to 50/56) from admission to discharge and landing above the falls cut-off score of 45/56. (15) Similarly, for the TUG, the minimal detectable change is 2.9 seconds for patients post-stroke, (16)

with the patient demonstrating a considerable 14.2 second improvement (from 23.7 to 9.5 seconds), including the ability to transition from performance with a FWW to without a device. This also lands under the established falls cut-off of 13.5 seconds.(17) Regarding the Four Square Step Test, the patient also demonstrated meaningful change from 17.5 to 12.5 seconds, well above the established 2.0 second minimal detectable change.(18) While his discharge score of 12.5 seconds lands under the falls cut-off of 15 seconds established for stroke, it does not surpass the 12 second cut-off established for vestibular dysfunction.(19,20) While deemed unsafe at initial evaluation, the FGA was performed on day 10 and repeated on day 16, with the patient demonstrating a considerable 15 point improvement from 6/30 to 21/30, well above the 4.2 point and 6 point minimal detectable change for stroke and vestibular dysfunction, respectively.(21,22) However, it should be noted that scores < 22/30 do still indicate increased risk for falling.(23) Functionally, the patient progressed from Min A with a FWW to independent without a device for household mobility and ADLs. The physical therapist recommended family assistance for IADLs and a walking pole for support with community mobility. This considers the patient's ongoing imbalance with head and body turns, especially on uneven terrain, which is more likely to be encountered in the community versus within his household.

DISCUSSION

This case report aimed to provide a greater level of detail of the physical therapy assessment and intervention of a patient post-cerebellar stroke. It highlights the unique contributions of vestibular rehabilitation to facilitate enhanced recovery for this patient population beyond what may be considered the standard of care for stroke rehabilitation. While the evidence remains limited and non-specific, several systematic reviews provide at least moderate evidence for intense rehabilitation, specifically focused on balance and coordination training when provided in a customized, patient-centered approach.(4,5) Incorporation of findings from the Clinical Practice Guideline to Improve Locomotor Function Following Chronic Stroke, Incomplete Spinal Cord Injury, and Brain Injury was also done to ensure adequate intensity of multi-directional gait training.(11) For this patient, the initial emphasis was on sensory organization and habituation training, as this was deemed most relevant to improving his safety and independence with functional mobility and successful return to home. As communication and cognition impairments continued to improve during his stay, the physical therapist was able to incorporate gaze stability and multi-step task training. The patient demonstrated significant improvements in functional outcomes and greater independence with all mobility, including ADLs, during his episode of care. These outcomes are consistent with previous research related to recovery after cerebellar stroke.(4,5)

There are several limitations, primarily this being a single-subject case report with no control to compare standard versus vestibular-based training after cerebellar stroke. Although the author served as the primary physical therapist for this patient, several other physical therapists were also involved in the treatment of this patient, increasing the variability in prescriptive dosing. A recent retrospective study showed that more physical therapy providers seen by a patient were negatively correlated to functional mobility improvement at discharge from an IRF.(24) Thus, provider consistency correlates with improved outcomes. Lastly, while outcome measures were chosen based on the Vestibular EDGE documents, more thorough assessment including the use of the ANPT's Core Set of Outcome Measures for Adults with Neurologic Conditions, would help to reduce variability in outcome measurement across studies, allowing for greater ease with future systematic reviews.(25) The use of the SARA would also be recommended for

this patient case to provide a more objective measure of his changes in coordination and ataxia.(4)

CONCLUSION

Physical therapists have an integral role in the treatment of patients post-cerebellar stroke. Although further high-quality studies, systematic reviews, and clinical practice guidelines are needed to supply adequate dosing recommendations, it is clear that a thorough examination and assessment by a vestibular-trained specialist can outline the relevant balance, coordination, and oculomotor abnormalities commonly affecting these patients' safety and independence with mobility, ADLs, and IADLs. This should facilitate a more customized, patient-centered plan of care that theoretically, enhances recovery and drives successful return to home and previous lifestyle.

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Low to Moderate Intensity Vestibular Physical Therapy Improves Outcomes in Active Cerebellar Hematoma Caused by Rare Venous Anomaly: A Case Study Report

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ABSTRACT

Introduction: Cerebral cavernous malformations (CCM) are abnormal capillary clusters characterized by slowed blood flow and low pressure. If previous history includes hemorrhage with this condition, neurosurgery is highly recommended. This case report describes the role of a physical therapist in appropriately screening for central vestibular conditions, referring to neurology thus leading to a diagnosis of CCM, and providing preoperative physical therapy. **Case Description:** A 70-year-old female presents to PT with acute onset diplopia, weakness, and coordination deficits, restricting mobility and function. Following a PT bedside examination, the patient was referred to neurology, where an MRI confirmed a CCM with subsequent right cerebellar hematoma. Neurosurgery requested physical therapy with hemodynamic precautions for four weeks prior to repeat MRI. The patient underwent 16 sessions of therapy, was discharged from PT, and received neurosurgical intervention. Following surgery, the patient was re-evaluated by PT to compare post-PT discharge to post-surgical function. **Outcomes:** Balance confidence (ABC), gait capacity (6MWT), gait speed (10MWT), and balance (FGA, mCTSIB, backwards gait speed) were measured at baseline. Low to moderate intensity gait, balance, tennis specific activity, central and peripheral vestibular rehabilitation, and therapy with sensory reweighting were performed. To keep the patient safe, a heart rate monitor was always worn, and exercise was stopped once heart rate exceeded medical parameters. A daily home exercise program was established, and the patient demonstrated compliance. Clinically significant improvements were noted following therapy and these changes were maintained. **Conclusion:** Although patients with CCM and hemorrhage initially undergo surgical intervention to stabilize their condition, clinically significant improvements in gait speed, gait capacity, and balance were made with conservative physical therapy management first. Future studies may wish to examine the efficacy of physical therapy as a precursor to surgical intervention.

INTRODUCTION

Cerebral cavernoma or cerebral cavernous malformation (CCM), is an abnormal capillary cluster characterized by slowed blood flow and low pressure without intervening brain parenchyma.(1) This low pressure state coupled with dysmorphic vascular walls leads most commonly to repeated microhemorrhage, a characteristic identified by hemosiderosis on MRI.(1) CCM is the most common vascular abnormality, comprising between 10% and 25% of all vascular malformations.(2) The per annum risk of clinically significant hemorrhage is 0.25% to 6%.(1) However, the average annual hemorrhage rate for patients without a previous history of hemorrhage is between 0.7%-1.1%.(2) Rates of re-hemorrhage vary widely in the literature due to several factors, including discrepancies in the definition of re-hemorrhage, classification of microhemorrhage as a hemorrhaging event, and potential differences in the prevalence of recurrent hemorrhage in CCMs located in superficial versus deep brain structures.(3)

Cerebellar hemorrhage is characterized by bleeding

in the posterior fossa or cerebellum, causing symptoms consistent with central cerebellar dysfunction, including vertigo, ataxia, headache, nausea, and vomiting.(4) In severe cases, changes in consciousness, hemimotor and hemisensory deficits, and downward displacement of conjugate gaze can occur.(4) These symptoms typically have a sudden onset. Cerebellar hematoma accounts for 9-10% of all intracranial hemorrhages.(4) The most common cause of non-traumatic intracranial hemorrhage is hypertensive vasculopathy, causing microaneurysms and rupture.(5)

A joint guideline from the American Heart Association and American Stroke Association published in 2015 recognizes early hematoma evacuation is not clearly beneficial compared to delayed hematoma evacuation once patients experience functional deterioration. Both decompressive craniotomy and minimally invasive clot evacuation have mixed evidence, with the former being level C evidence for use in patients with large hematoma and significant midline shift, and the latter being identified as uncertain benefit both with and without aspiration or thrombolytic usage.(6) Additionally, the primary inciting causes of intracerebral and cerebellar hemorrhage are hypertension, anticoagulation therapy, and amyloid angiopathy.(7) Older adults have an increased frequency of hemorrhage due partially to the increase in amyloid angiopathy with aging, as well as the increased likelihood of conditions of aging requiring anticoagulation therapies.(7)

Recent literature has explored conservative management of hemorrhage; a 2019 meta-analysis found patients with cerebellar intracerebral hemorrhage had no difference in functional status at three months compared between surgical evacuation and conservative treatment.(8) As hypertension is the strongest risk factor for hemorrhage in most populations, studies have focused on hypertension management for prophylactic risk mitigation. Several studies have found lower incidence of hemorrhage in patients who achieve hemodynamic targets, particularly lower resting systolic and diastolic blood pressure.(9,10) Joseph and colleagues in 2019 found aerobic exercise and non-contact sports did not increase CCM hemorrhage risk. They suggest patients should not be limited in pursuing non-contact activities that may improve physical health.(11) This finding creates an opportunity for physical therapists to provide precisely structured exercise for patients with CCM to improve presurgical health and conservatively managed outcomes. The purpose of this case report is two-fold. First, we aim to discuss the differential performed to distinguish inconsistency between referring diagnosis and signs and symptoms associated with a likely central nervous system problem. Second, we describe the functional outcomes and tailored physical therapy management in a patient with cerebellar hematoma caused by CCM.

CASE DESCRIPTION

History

The patient is a 70-year-old female with acute onset of imbalance and dizziness after a plane ride. After seeking medical attention, her physician prescribed PT and reported that her symptoms were consistent with Meniere's disease. Two weeks prior to the onset of these changes, the patient reported a mild runny nose with persistent 1/10 dizziness and imbalance on the visual analogue scale (VAS) but full ability to complete all activities of daily living and recreational activities without aides and assistance. She denied changes in aural fluctuations, endorsed occasional headaches, and reported that her dizziness felt like lightheadedness. Following the plane ride, she declined in her independence, reporting she was unable to walk without a single point cane (SPC) and physical assistance from her husband in the household or community or drive herself anywhere. Although she reported double vision and occasional dizziness, she emphasized that as an active recreational tennis player, NIH medical researcher, and grandmother, the drastic reduction

in her gait and balance was more impactful to her quality of life. Past medical history includes a midbrain hemorrhage which occurred seven years prior.

Examination

The initial outpatient physical therapy examination was completed roughly one month from onset of initial dizziness and 15 days following the acute worsening of symptoms. Vitals were taken in seated revealing stage 2 hypertension at rest: 154/84mmHg and 75bpm. The therapist proceeded with outcome measures spanning the participation, activity and impairment levels of The International Classification of Functioning, Disability and Health (ICF).

Participation: Knowing that increased fear of falling and reduced balance confidence can increase fall risk, the therapist provided an Activities Balance Confidence Scale (ABC-16).(12,13) The patient reported a 78% confidence, surpassing cut-off scores (<67%) for increased fall risk in adults 65 or over, contradicting her previous reports in the subjective examination.(14)

Activity: Due to the abrupt change in ambulatory function, the therapist performed a 6 Minute Walk Test (6MWT) to assess walking capacity. The patient ambulated 424 meters or 90% of age predicted norm (471m for 70-year-old women), using a SPC with Minimal Assistance (MinA) for postural stability. (15) During testing, the therapist observed excess right drift, right trunk lean, and inconsistent right step length, width, and foot placement. There was also a more pronounced error with fatigue onset.

Impairment: Suspecting a coordination deficit, the therapist tested heel shin glides in supine and rapid alternating movements (RAM) in sitting. A noted reduction in both tasks' accuracy, smoothness, and velocity was seen on the right side, which was greater than the left side for both the upper and lower extremities. The therapist proceeded with an oculomotor and vestibular function examination in room light to investigate the lesser complaints of double vision and dizziness (Table 1). Deep tendon reflexes (DTR) revealed asymmetry (Table 2) between the right and left side.

Table 1: Initial Evaluation Oculomotor and Vestibular Examination

Test	Result	Clinical Notes
Spontaneous Nystagmus	Negative	WNL
Gaze Evoked Nystagmus	Upwards, left gaze	Direction Changing
Smooth Pursuits	Saccadic Pursuit during downward and leftward gaze	Reduced speed, accuracy during upwards and rightward gaze
Horizontal Saccades	+	Hypermetria in rightward direction, hypometria in leftwards direction
Vertical Saccades	+	Hypermetria in downwards direction, hypometria in upwards direction
Convergence	9 centimeters	Abnormal
Head Impulse Test	Bilaterally	Abnormal
VOR Cancellation	Right	Abnormal
Skew Deviation	Negative	WNL
Cover/ Uncover Test	Negative	WNL

Table 2: Deep Tendon Reflex Testing

	RIGHT	LEFT
C5	2+	1+
C6	2+	1+
C7	2+	1+
L4	2+	1+
S1	2+	0

Diagnosis - PT

The patient's prior history of midbrain hemorrhage and current clinical presentation, vertical orientation and balance deficits during ambulation, right-sided coordination deficits, and positive central oculomotor and vestibular findings led the therapist to conclude that a neurological consult and neuroimaging were indicated to investigate suspicion of an acute cerebellar lesion. Although the patient accepted the therapist's concerns, the patient and her husband asked the therapist to explain clinical findings and differentials in detail. The therapist explained that they began trying to differentiate between mechanical, peripheral, or central causes of dizziness and imbalance. Based on the subjective, a mechanical issue like BPPV was ruled out. The patient's history of recent illness preceding the onset brought concerns for peripheral conditions such as labyrinthitis, vestibular neuritis, hypofunction, or Meniere's Disease into question. Labyrinthitis and Meniere's Disease were also ruled out in the absence of aural symptoms and symptom fluctuations over time. At the time of the subjective examination, the clinician did not rule out vestibular neuritis or hypofunction. In addition, previous history of hemorrhage distinguished central pathology as a plausible cause as well. The clinician also considered the potential for a functional movement disorder. The clinician explained to the family why each test was selected and summarized clinical findings, including ataxia of the right upper extremity, right lower extremity, and trunk. The patient was educated that if this were a cerebellar lesion, the lesion would be right-sided, as impairments often appear on the ipsilateral side of involvement. Additional tests to support this hypothesis included hyperreflexia and central signs like direction-changing nystagmus in room light, dysmetria during smooth pursuits and saccades, and positive right-sided VOR cancellation.

Diagnosis - Medical

Neurology performed an MRI 3 days following physical therapy evaluation and after reviewing it, provided the patient with a consult to neurosurgery. The MRI confirmed the presence of a right-sided subacute cerebellar hematoma caused by CCM. See Image 1 for more details.

Neurosurgery requested immediate surgical intervention, but the patient refused and asked for six weeks of conservative management with physical therapy instead. Neurosurgery and neurology obliged the patient's request and wrote a script with hemodynamic precautions: Blood pressure (BP) and heart rate (HR) were not to exceed 170/100mmHg and 100 bpm, respectively. The medical plan was to perform therapy for several weeks, have a repeat MRI, and determine the appropriate next steps.

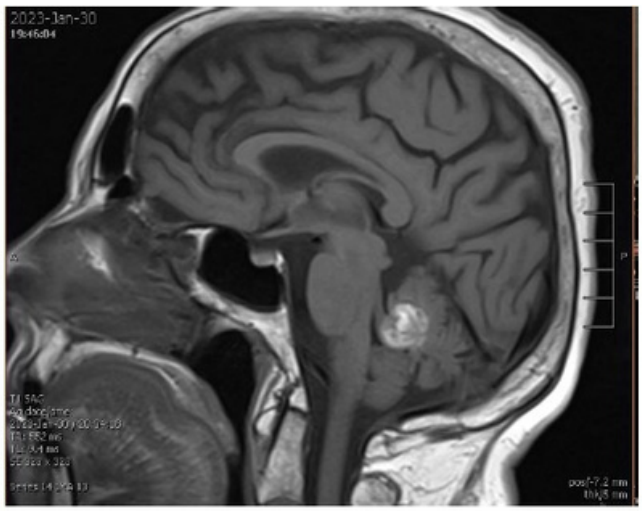

Image 1: On January 30th, 2023, MRI with contrast reveals hematoma in right paramedian central cerebellum/vermis, abutting the margins of the fourth ventricle and partially compressing it. The hematoma measures approximately 2.0 x 1.7 cm in size.

First Follow Up PT Session/Goal Setting

Roughly two weeks later, the patient returned to physical therapy, and the therapist tested balance to gain a better clinical picture. The Modified Clinical Test for Sensory Integration of Balance (mCTSIB) was performed to assess sensory contributions to balance function. The findings were as follows: Condition 1: 30/30, Condition 2: 8.62/30, Condition 3: 30/30, Condition 4: 1/30, totaling 69.62/120 seconds. Based on these findings, the therapist concluded that the patient was visually dependent and had significant vestibular involvement due to poor performance on conditions 2 and 4.

Because the patient mentioned that walking tasks in the community were challenging for her balance, the Functional Gait Assessment (FGA) was also chosen. The patient scored a 12/30, indicating an increased risk for falls (<22/30 effective in predicting falls in community-dwelling older adults).(16) From item 1 on the FGA, a baseline gait speed was established at 1.15m/s (greater than the normative gait speed for 70-year-old females 1.13m/s).(17) Item 9 on the FGA helped the clinician establish a baseline backwards walking speed of 0.14m/s. Although backwards walking speed is not a validated test for this population, the clinician compared forwards gait speed and backwards gait speed to better highlight a discrepancy between a reflexive movement pattern (forward walking) and a highly coordinated movement pattern (backwards walking).

At this time, goals for therapy were to maintain hemodynamic precautions, improve static and dynamic balance, reduce reliance on SPC, and assist with safe community reintegration.

The patient was seen 2x weekly at an outpatient neurologic therapy clinic for four weeks (7 visits) before repeat imaging. A second MRI was then performed. The patient was again cleared to participate in therapy for another four weeks (9 visits) prior to discharge for medical management of the condition. See Figure 1 below for more details.

Intervention

Due to strict guidelines provided by neurology for hemodynamic management (170/100mmHg and 100 bpm), a polar H10 heart rate monitor was worn during all sessions. Using the Taneka formula (HR MAX= 208-(.7x AGE)), it was calculated that 159 bpm was the patient's age referenced HR maximum.(18) In addition, the precautions provided by the provider (100 bpm) would roughly equate to 62% of HR maximum or low to moderate-intensity aerobic intensity.

Therapy interventions were varied to engage the

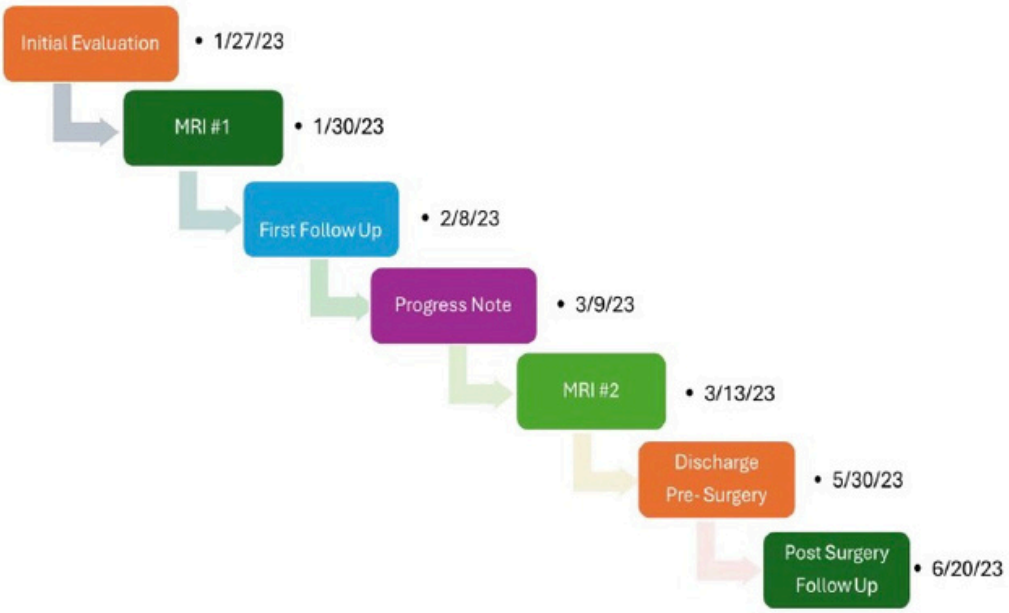

Figure 1: Patient Timeline

patient during all sessions. They included static and dynamic balance training, tennis-specific training, variable stepping/plyometrics, gait training overground and on the treadmill, central and peripheral vestibular exercise, sensory reweighting using a weighted vest, and dual-task. Because of the cerebellum's role in sequencing and coordination, motor learning strategies through error augmentation were selected. For example, when walking backwards on the treadmill with a weighted vest while the therapist altered treadmill speed, the patient was forced to make errors and correct them in real-time.

External focus of attention was also emphasized during this plan of care to improve posture and balance control.(19) An example of this strategy included the therapist giving the patient different targets to aim for when using a tennis racquet to hit a balloon.

In addition, a daily HEP including VORx1, VOR cancellation, static balance training on foam, and walking with a weighted vest and HR monitor was prescribed and consistently performed.

Outcome

Initial Evaluation to Progress Note:

The changes made can be found in Table 3. During this time, the patient demonstrated a decline in balance confidence (ABC-16 from 78% to 58%) due to her return to ambulation without a SPC in the community. Improvements in walking capacity (6MWT from 424m to 540m), static balance (mCTSIB from 69.62 to 120 seconds), and dynamic balance occurred (FGA from 12 to 22). Because the patient made significant improvements on the FGA, the treating clinician felt it was safe to include a more challenging balance assessment called the High-Level Mobility Assessment Tool (HiMAT) during this progress note. Although this test is typically performed for individuals with traumatic brain injury, the items on this test most closely resembled activities the patient would need to perform to return to recreational tennis.

Despite all the improvements in function, repeat MRI imaging revealed mild expansion of the hematoma, as seen in Image 2. The physician cleared the patient for continued skilled rehabilitation for four additional weeks prior to surgical intervention.

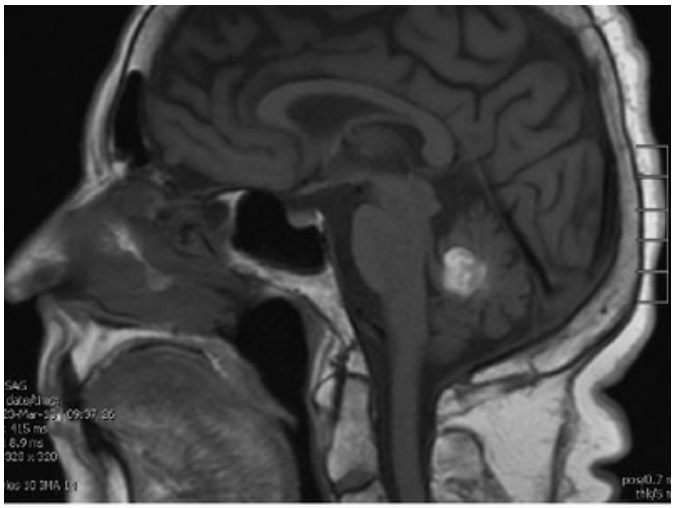

Image 2: March 13th, 2023, a repeat MRI was performed revealing an increase in hematoma size measuring approximately 2.2 x 1.7 cm, previously 2.0 x 1.7 cm.

Progress Note to Discharge Pre-Surgery:

Improvements in balance confidence (ABC-16 from 58% to 96%), gait capacity (6MWT from 540m to 589m), dynamic balance (FGA from 22 to 27), and backwards gait speed or functional coordination (.14m/s to 1.2m/s) are noted in Table 3. The patient was then discharged for Laser Interstitial Thermal Therapy (LITT) to ablate the venous anomaly causing the hematoma.

Post- Surgery Follow Up:

Following neurosurgical intervention, function post-physical therapy was comparable to discharge from conservative PT management (Table 3).

DISCUSSION

This case report outlines the differential diagnosis of an individual presenting with central nervous system findings consistent with cerebellar pathology and presents the opportunity to discuss several unique decisions made by the treating therapist. When presented with a complex clinical case, the

Table 3: Physical Therapy Testing Through 2 Plans of Care

	Initial Evaluation 1/27	First Follow Up 2/8	Progress Note 3/9	Discharge Pre-Surgery 5/30	Post- Surgery Follow Up 6/20
ABC-16	78%	X	58%	96%	94%
6MWT	424m SPC, minA	X	540m No AD, I	589m No AD, I	542m No AD, I
10MWTSelf Selected	X	1.15m/s	1.58m/s	1.47m/s	1.47m/s
FGA	X	12	22	27	28
HiMAT	X	X	29	29	23
mCTSIB	X	69.62 sec	120 sec	120 sec	120 sec
Retro Gait Speed	X	.14m/s	.14m/s	1.2m/s	1.07m/s

Abbreviations: SPC= single point cane, no AD= no assistive device, minA= minimal assistance, I = Independent

treating therapist returned to their vestibular drawing board and pinpointed that a mechanical issue was unlikely in this case. After listening to the patient's primary complaints, the therapist carefully selected tests from the core set of outcome measures for adults with neurologic conditions and supplemented them with impairment-based testing to create a comprehensive clinical picture.(20) Once the evaluation was completed, the therapist applied neuroanatomical rationale to consolidate their differential diagnoses and concluded that cerebellar dysfunction was a likely primary differential.

By choosing the appropriate tests and measures, the therapist was able to refer to neurology, who formally diagnosed the patient with a right-sided subacute cerebellar hematoma as a consequence of CCM. Although consulting neurologists and neurosurgeons recommended surgical intervention, as patients with hematoma are often managed either surgically or through watchful waiting, the patient requested conservative management with PT.(6) Therapy over eight weeks following hemodynamic restrictions resulted in improved balance and function prior to neurosurgical intervention despite expansion of hematoma on repeat neuroimaging.

Clinicians may benefit from knowing that the treating therapist explicitly requested hemodynamic precautions and guidelines to understand if this patient could safely be enrolled in a high-intensity training program to improve gait and balance. Based on the maximum HR allowed by the medical team (100bpm), the therapist understood that training would be classified as low to moderate aerobic intensity considering age calculated HR max for 70-year-old adults.

Backwards walking speed was tracked throughout this clinical case as it is an indicator of falls risk in community-dwelling populations. A 2017 study found that in the healthy older adult population without neurologic insult, a cutoff score of less than 3 seconds on a 3-meter backwards walk test (translating to at least 1.0 m/s) was correlated with fewer falls.(21) Those scoring greater than 4.5 seconds (translating to slower than 0.67 m/s) were likely to report falls in the same time frame.(21) This test, which was administered concurrently with item 9 of the Functional Gait Assessment, could provide additional insight into falls risk for individuals with coordination deficits as a result of cerebellar pathology. This patient demonstrated a clinically significant improvement in backwards walking speed

during the presurgical intervention period, scoring above the falls risk cutoff established by Carter and colleagues.(21) Most importantly, we believe backwards walking speed and maintaining this improvement post-operatively was a better indicator of her actual balance deficits because at baseline, this patient ambulated at an appropriate forward walking speed for her age.

While research regarding dose and response of exercise for this population is sparse, we would like to emphasize the potential benefit physical activity offered our patient in this case. As has been extensively established, consistent physical activity can improve physical capacity and quality of life in healthy and comorbid populations.(22) Although patients, families, and care team members may understandably hesitate to allow participation in structured exercise prior to surgical stabilization, this case presents an opportunity to share the outcomes of a patient managed conservatively prior to radiosurgical intervention.

Future research may wish to establish safe physical activity guidelines for conservative management of unstable hematomas caused by CCM. Furthermore, an expansion of safe activity guidelines may lead to an understanding of the role prehabilitation plays for the CCM population and may improve post-surgical outcomes.

CONCLUSION

Physical therapists can play a crucial part in detecting the presence of centrally mediated dizziness and imbalance. By performing a thorough subjective examination, therapists can select appropriate tests to better differentiate central, peripheral, or mechanical origin of patient complaints. The patient discussed in this study demonstrated clinical signs of central pathology leading to the medical diagnosis of subacute cerebellar hematoma from CCM. Due to the structured and individualized therapy provided for this patient with support from the medical team, improvements in function were made. Since prehabilitation is indicated for select orthopedic and vestibular conditions to improve outcomes, future studies may wish to assess safety and feasibility of this for individuals with cavernous malformations complicated by hemorrhage.

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Recognition from CSM VRSIG Meeting

Vestibular SIG Research Award

Linda D'Silva, PT, PhD*

- Director of the STABILITI lab at the University of Kansas.
- Over 20 peer-reviewed publications in the area of Vestibular Rehabilitation, Neurologic Rehabilitation, Balance and Falls, & Diabetes.
- Over $435,000 in grant funding from the NIH investigating vestibular and neck muscle contributions to head control in balance-impaired older adults

Unexpected Dizziness? Vestibular Physical Therapy Following a Right MCA Stroke: A Case Report

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ABSTRACT

Introduction: Those who experience central nervous system injuries, such as a cerebrovascular accident (CVA), frequently have unrecognized central vestibular and oculomotor pathologies. The vestibular system is often neglected when addressing postural instability in individuals with central neurological disorders, potentially due to insufficient evidence or lack of familiarity regarding the management of central vestibular disorders. The purpose of this case study is to explore the effects of vestibular rehabilitation in an individual with a central neurological disorder with unique vestibular implications. **Case Description:** An 82-year-old female presents with dizziness and impaired postural stability following a right middle cerebral artery (MCA) CVA. Further examination revealed saccadic corrections during smooth pursuits, undershooting with saccades, impaired vestibulo-ocular reflex (VOR), impaired VOR cancellation, impaired vergence, and impaired postural stability. **Outcomes:** The patient participated in physical therapy, focusing on ocular and vestibular retraining. Interventions included gaze stability exercises and VORx1 exercises on various surfaces and during ambulation. Her Timed Up & Go, Dynamic Visual Acuity, and Dizziness Handicap Inventory all improved, exceeding the minimal detectable change. The patient had a significant decrease in symptom provocation with oculomotor and vestibular testing. Her outcome measures also fell within age-matched norms following vestibular physical therapy (VPT). **Conclusion:** While considerable amounts of research are available for treating individuals with peripheral vestibular disorders, there is currently limited research available for individuals with central vestibular pathologies. This case is unique due to her primary diagnosis and area of injury not typically presenting with vestibular involvement. She responded favorably to VPT, which was unexpected considering her initial diagnosis. Further research into unique central vestibular presentations would be meaningful and beneficial.

INTRODUCTION

Vestibular dysfunction is most simply defined as a disruption to the body's balance system.(1) The vestibular system maintains postural stability when performing functional activities. Dysfunction of the vestibular system is typically categorized into peripheral and central causes based on the anatomy involved. Although the symptoms of both peripheral and central vestibular disorders are unique, they can also overlap.(2) The combination of peripheral and central disorders can lead to confusion and difficulty discerning where a patient's symptoms are coming from.

The most common cause of severe central vestibular dysfunction is ischemic stroke of the posterior fossa, which contains the brainstem and cerebellum.(3) While these areas are the most common cause of vestibular dysfunction, injury to other portions of the brain has been associated with dizziness.(3) Acute ischemic stroke accounts for up to 25% of patients who present with central vestibular dysfunction.(1)

Since central vestibular disorders are treated differently from peripheral disorders, it is essential to recognize the signs of central dysfunction when attempting to address specific vestibular symptoms. Frequently, individuals with central vestibulopathy following a CVA present with signs and symptoms such as imbalance, visuospatial

impairments, diplopia, dysmetria, gait disturbances, dizziness, and nausea.(4) While these symptoms can present individually in multiple peripheral vestibular disorders, the presentation of these symptoms as a cluster should raise clinical suspicion for central vestibular dysfunction. This is why a complete history and physical examination is the best way to differentiate peripheral from central vestibular dysfunction. Tests of posture and gait are also used to examine a person with dizziness. The Dynamic Gait Index and the Functional Gait Assessment can identify instability, fall risk, and disability in this patient population.(5)

Those who experience a CVA frequently have central and peripheral vestibular pathologies.(6) However, central vestibular pathologies are not as common or widely understood. Although central vestibular disorders are less common than peripheral, around 10-25% of individuals seeking vestibular care have some form of central vestibulopathy.(7) Tramontano et al. conducted a systematic review of individualized vestibular rehabilitation (VR) for central vestibular pathologies. They reviewed several prospective randomized controlled trial studies, showing that individualized VR was efficacious for the treatment of central vestibular disorders.(6) VR has increasingly become a generally accepted, noninvasive, and safe treatment option for individuals with vestibular impairments.(8) However, the vestibular system is continually neglected when addressing postural instability in individuals with central neurological disorders, potentially due to the paucity of specific parameters of vestibular exercises when considering the rehabilitation of central vestibular disorders.(5) The purpose of this case study is to explore the effects of vestibular and oculomotor retraining in an individual with an atypical vestibular presentation as well as a central neurological disorder and how this affected postural instability.

CASE DESCRIPTION

History

The patient is an 82-year-old female with a past medical history significant for breast cancer and hypertension who experienced a right middle cerebral artery (MCA) CVA in April of 2022. She received acute care skilled treatment for ten days prior to being transferred to 14 days of inpatient rehabilitation. Following her discharge home from inpatient therapy, she declined home health services. Six months later, she requested to be referred to outpatient therapy for management of residual weakness and dizziness.

During her initial visit, she presented with primary complaints of postural instability, blurry vision when moving, decreased gait capacity, and left-sided weakness. The patient stated she is unable to complete her activities of daily living without assistance, reported a sense of imbalance, and had difficulty maintaining upright posture due to weakness. She had been unable to return to work and unable to care for her multiple horses. She lived with her husband in their two-story home. There were also five steps with a unilateral handrail on the right to enter the home that she could not navigate without assistance. The patient utilized a wheelchair for most functional mobility and ambulated with moderate assistance and a large base quad cane limited household distances. The patient and husband were both concerned with the patient ascending and descending stairs alone to reach the primary bedroom on the second floor. Although the patient had received extensive physical therapy, she reported that she felt her greatest limiting factor was her dizziness, visual changes, and postural instability. Previous therapies primarily focused on tolerance to upright posture, bed mobility, and functional mobility with success in allowing her to eventually discharge home. Her symptoms of dizziness and visual blurriness were primarily attributed to the changes to her central nervous system by her physicians and past therapists. VPT

had not been attempted due to her MCA CVA not typically presenting with vestibular symptoms.

Examination

On the initial examination, she presented with significantly limited left upper extremity active range of motion (AROM) and passive range of motion (PROM), largely due to increased tone and spasticity of the limb. Manual muscle testing revealed significant weakness in her left upper and lower extremities (Grade 2+/5). Sensation and proprioception were intact bilaterally. However, there was observable dysdiadochokinesia in the left upper and lower extremities with coordination testing. The finger-to-nose test revealed overshooting in bilateral upper extremities. The patient also had difficulty with rapid alternating movements (supination/pronation and alternating foot tapping), demonstrating slowed movement on the left more so than the right. The patient reported inconsistent diplopia and significant visual and cognitive fatigue. Her reports of vague vestibular and oculomotor symptoms led to a more thorough vestibular and oculomotor examination. The patient required moderate assistance to perform a sit-to-stand transfer and minimal assistance to maintain standing with a wide base of support. The patient's speed on the Timed Up & Go (TUG) was 88.32 seconds with a large-based quad cane and moderate assistance for steadying during gait, which was much slower than compared to age-related norms.(9) The patient's dynamic visual acuity was assessed with the Dynamic Visual Acuity Test (DVA). She presented with a three-line loss of vision during the DVA, further confirming vestibular oculomotor reflex (VOR) deficits.(10) Her oculomotor and vestibular testing symptoms were also recorded using the Vestibular Oculomotor Screening test. Although this assessment is primarily used in mild traumatic brain injury testing, it was utilized with this patient to specifically quantify the symptoms she was having with oculomotor and vestibular testing. This test assesses not only smooth pursuits, saccades, and VOR integrity but also includes an assessment of vergence.(11) She had her most significant symptoms of diplopia when attempting to converge her vision to focus on a target 10 centimeters away from the bridge of her nose. She also reported that converging her eyes most closely reproduced her familiar symptoms during gait and functional mobility.

Oculomotor examination revealed that the patient had full extraocular movements with no spontaneous nystagmus or gaze-evoked nystagmus. During the smooth pursuit test, decreased speed of movement and undershooting with corrective saccades were observed, with horizontal corrective saccades presenting more prominently than vertical. She exhibited difficulty suppressing her horizontal and vertical VOR. The patient complained of dizziness, diplopia, and oscillopsia during testing. Based on the patient's history and clinical examination, a central vestibular pathology was suspected.

Diagnosis/Prognosis

The patient was referred to outpatient physical therapy after receiving a battery of tests and images due to her primary diagnosis of an MCA CVA. Although the primary involved artery was the MCA, her most recent MRI indicated some posterior fossa involvement, which explained her vestibular and oculomotor impairments. Her findings on imaging, combined with the clinical examination results, led to a physical therapy diagnosis of central vestibular dysfunction. Although she did experience a central nervous system injury, she also presented with peripheral vestibular involvement as well. Her central vestibular involvement resulted in difficulty with visual fixation and utilizing visual or vestibular input during gait or functional mobility.(12) Meanwhile, her peripheral vestibular involvement was causing impairments with gaze stability and dizziness with positional changes.(13) Given her unique

presentation, medical complexities, and decreased functional status, a lengthy plan of care was required for this patient in order to achieve her physical therapy goals.

Intervention

The patient participated in 60 minutes of physical therapy (PT) two times a week for twelve weeks and then once a week for six weeks. Primary PT interventions included a customized VPT program of ocular and vestibular retraining. Examples of the interventions included VOR cancellation on firm and unsteady surfaces, VORx1 training, gait training with head turns, convergence and divergence exercises, and various postural interventions on multiple surfaces with vestibular training exercises.

Vestibular adaptation exercises (gaze stabilization exercises) were used to promote VOR gain and improve the symptoms of diplopia with visual fixation. VORx1 exercises were utilized using a simple target (x on a sticky note). The patient was instructed to keep her eyes on the target while moving her head at a self-selected speed in the horizontal and vertical directions. Initial trials consisted of two thirty-second bouts of VORx1 while standing on a firm surface. After the patient could tolerate this activity for 30 seconds, exercises progressed and were completed for 60 seconds for three repetitions in both horizontal and vertical planes with rest breaks as needed following each repetition. The patient was asked to perform the head movement as fast as possible while maintaining focus on the target. Additional progression included performing VORx1 for longer bouts of time (achieving a full two minutes of head shaking by discharge), changing the practice environment, introducing unstable surfaces, and having the patient perform VORx1 while walking forward and backward. These progressions were introduced once the patient was able to tolerate standard VORx1 for one minute at a quick speed with minimal reproduction of dizziness and improved gaze stability.

Vergence was also addressed based on her symptom presentation and the impairments noted in the examination. A “Near/Far” chart was utilized to address her convergence and divergence impairments. This consisted of one large 18-inch chart with 100 letters listed on it. The chart is placed at eye height, and the patient is instructed to stand ten feet away while holding a smaller identical chart in their hand, held at a reading distance of roughly 12-18 inches away from the face. She was instructed to alternate reading the first line on the far chart to the first line on the near chart until she had completed reading through the lines of both charts. Progress was tracked based on the time she took to complete both charts as instructed. She typically performed three rounds of this activity. The dosage was adjusted as needed based on her symptom reporting.

This activity progressed by having the patient stand farther than ten feet away, thus increasing the amount of divergence required to focus on the far chart visually and having the patient alternate from near to far chart after each letter rather than each line. The decision to progress this activity was based on the patient’s ability to perform the standard eye chart with minimal reproduction of dizziness or cognitive fatigue.

Balance and gait training exercises were also included throughout this patient’s course of outpatient therapy. These exercises included unassisted ambulation, obstacle negotiation, stair negotiation, and walking over uneven surfaces. The patient completed various gait training exercises with head turns and visual tracking. For balance exercises, the patient was asked to maintain balance with a narrow base of support and on unstable surfaces. Once she could maintain balance on a stable surface, the patient progressed to eyes-closed conditions with a narrow base of support and unstable surfaces.

Outcome

The pre-treatment and post-treatment outcome measure results are summarized in Table 1. Improvements in all outcome measures exceeded the minimal detectable change at the 12-week and 16-week reassessments.(9,10) She also demonstrated a significant decrease in symptom provocation with oculomotor and vestibular testing during the Vestibular Oculomotor Screen.

Throughout the 16-week outpatient therapy period, the patient only missed one scheduled session of physical therapy. She also significantly improved her tolerance for functional mobility and gait. While the primary focus of outpatient physical therapy was addressing suspected central vestibular dysfunction, she also significantly improved her ability to transfer, requiring only supervision assistance at discharge, independence with standing postural stability, and gait with no more than supervision at discharge. She also subjectively reported that independence had drastically improved compared to the initial evaluation.

DISCUSSION

This patient presented a unique opportunity to approach post-stroke rehabilitation in a new and impactful way. Although her primary diagnosis was an MCA CVA that does not typically present with vestibular symptoms, she presented with symptoms consistent with central vestibular impairment following her stroke. This case highlights the importance of clinicians not solely focusing on the referring diagnosis but on the patient's presentation and primary complaints. Using clinical decision-making and active listening, this patient was found to have profound vestibular and oculomotor impairments when arriving in outpatient therapy. The oculomotor examination revealed corrective saccades during smooth pursuits, significantly impaired ability to converge and diverge, impaired VOR cancellation, and decreased adaptability of the VOR. The results of her TUG also identified the presence of significant postural instability during gait.

For individuals post-CVA, symptoms of dizziness may be dismissed or attributed to other factors, such as blood pressure or medications.(15) Therefore, it is important that patients are appropriately assessed and tested for the underlying cause of dizziness and not miss potential vestibular-related impairments.(15) In the case of this patient, her symptoms of dizziness had been largely unaddressed, and she was frequently told that dizziness often occurs post-stroke. It was not until a thorough vestibular examination was performed that the cause of her dizziness and imbalance was determined and addressed. Although MCA CVAs do not typically cause vestibular dysfunction, this patient presented with significant vestibular involvement with both central and peripheral features. This case provides an important example of why clinicians must set aside assumptions based solely on medical diagnoses and provide individualized interventions that address the impairments identified in the examination.

Although research on managing central vestibular impairments is improving, there is still a noted lack of high-quality studies in treating these disorders. An absence of evidence leaves most clinicians with few options for resources when looking at how to

Table 1: Pre- and Post-Outcome Measure Findings

	Initial	12-weeks	16-weeks	MDC
TUG	88.32 seconds	21.76 seconds	12.35 seconds	2.9 seconds[9]
DVA	4 line loss	3 line loss	1 line loss	2 line improvement[10]
DHI	77	54	24	17.18[14]

Abbreviations: TUG=Timed Up and Go, DVA= Dynamic Visual Acuity, DHI=Dizziness Handicap Inventory, MDC = Minimal Detectable Change

manage these patients best.(16) There is one prominent systematic review, as previously mentioned, that addresses central vestibular pathologies and potential management mechanisms, which has helped shine a light on the significant need for more high-quality studies in vestibular rehabilitation.(6) This case report demonstrates the strengths of developing an individualized VPT program for managing central vestibular dysfunction following a CVA. One limitation of this case report is that interventions for both the peripheral and central vestibular systems were utilized based on the patient's symptom reports. Although outcomes were favorable, due to the nature of this VPT program, it is difficult to determine which exercises caused the biggest improvements in this patient's symptoms. Outside of these shortcomings, her progress through VPT is congruent with those reported in the literature, which have shown that it can improve postural stability, functional mobility, and symptom severity.(5-8,16)

CONCLUSION

There is currently limited research available for individuals with central vestibular pathologies, especially compared to the considerable amount of research available for treating individuals with peripheral vestibular disorders. The patient made meaningful and measurable improvements in overall function and activity participation following vestibular retraining. This case report also demonstrates the importance of a comprehensive neurological examination in patients with various central nervous system disorders. Further research into potential vestibular disorders and vestibular involvement following various types of CVA would be meaningful and beneficial. Additionally, additional research into the dosage and type of VR following a CVA would be beneficial to aid in the management of unique vestibular presentations.

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The Importance of Performing Vestibular Assessments on Patients Following Traumatic Brain Injury: A Retrospective Study

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Purpose: There is limited research on the feasibility of completing a standardized vestibular assessment for individuals in an inpatient rehabilitation facility following traumatic brain injury (TBI).(1,2) Approximately 17.6% of individuals who report symptoms of dizziness following TBI experience benign paroxysmal positional vertigo (BPPV).(1) Although the occurrence of BPPV following TBI is recognized, the evidence for clinical care is still growing.(2-8) A brain injury unit of an inpatient rehabilitation facility implemented a standardized vestibular assessment plan for individuals following a TBI to be completed within the first four days of admission to the facility. The objective of this retrospective review was to determine if the vestibular assessment plan was completed. The secondary objective was to determine the incidence rate of vestibular dysfunction when the assessment plan was completed and the overall incidence rate when a vestibular assessment was completed.

Number of Charts Reviewed: 285

Methods: A retrospective review was conducted following implementation of a standardized protocol for vestibular assessments for individuals following TBI at a large inpatient rehabilitation facility with a dedicated unit for individuals recovering from brain injury. The timeline of development, implementation, and review of the standardized vestibular assessment is seen in Figure 1.

During this standardized protocol, individuals would receive a vestibular screen within the first four days

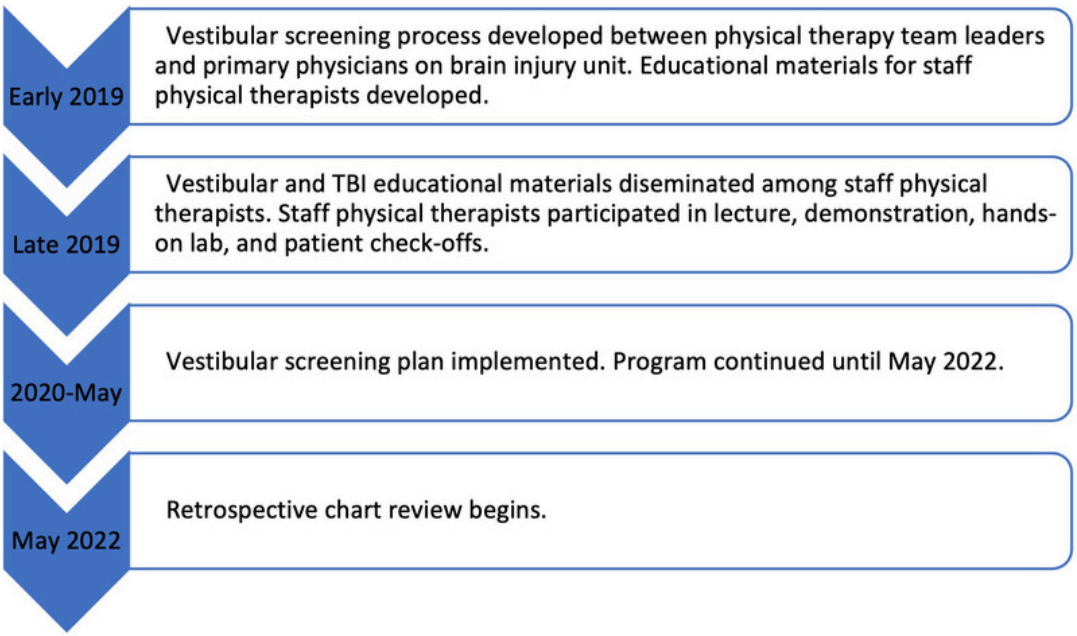

Figure 1: A timeline of the vestibular assessment

of admission to the unit. Physical therapists underwent vestibular training to standardize this assessment process, including didactic education, demonstration, lab, and a patient check-off. They also created an agreed upon documentation process. Information gathered from the chart reviews included (but was not limited to): Date of birth, age at admission, admission date, discharge date, date of vestibular assessment, diagnosis, falls during admission, prior head injury, occupation, central nystagmus, visual tracking, vertical saccades, horizontal saccades, convergence, divergence, VOR head thrust, positional tests, interventions performed, medications.

Chart reviews were completed for admissions from January 1, 2020 to May 1, 2022. Inclusion criteria were diagnosis of moderate to severe TBI and admission to the brain injury unit where therapists had undergone specialized training.

Results: Two hundred eighty-five charts met the inclusion criteria and were reviewed (mean age = 51 years, SD, 26.9). Charts all included a diagnosis of moderate to severe TBI and the admission date was between December 2019 and May 2022. Of the charts reviewed, only 44 charts had vestibular assessments completed that were further analyzed for type and diagnosis. Charts included 23 males and 21 females between the ages of 10 and 92 (mean age = 53.5 years). Of those 44 assessments, only 23 were completed in the appropriate time frame as indicated by the set protocol. The overall completion rate for vestibular assessments within the first four days was 8%.

Diagnoses were divided into BPPV, other (peripheral hypofunction, CNS dysfunction, and any other vestibular diagnoses), or a combination. Eighty-three percent of the vestibular assessments completed following the protocol were positive for vestibular dysfunction. For total vestibular assessments completed, vestibular dysfunction was found in 84% of assessments. Diagnosis categories included 50% BPPV, 20.5% other (peripheral hypofunction, CNS dysfunction, and other vestibular diagnoses), and 13.6% combination.

The most common treatments were canalith repositioning maneuvers for posterior canal and horizontal canal BPPV. Although other vestibular system deficits were noted, not as many interventions were completed for those deficits.

Discussion: There was no significant difference in the percentage of positive findings between those charts that followed the protocol compared to those where the assessment was completed after the first four days of admission. About half of the assessments were completed outside of the first four days after admission. It was anticipated that individuals assessed after the first four days of admission would have higher rates of vestibular dysfunction as they would be evaluated secondary to a therapist's concern for a vestibular issue. These rates were relatively similar, likely due to the unexpected high rates of dysfunction found during the first four days of admission. This correlation would require further study due to the low number of vestibular assessments completed.

Despite standardized education for all physical therapists completing the vestibular assessments, the assessment completion rate was very low. The rate of interventions for vestibular dysfunction other than BPPV was also minimal. This may be due to therapist time, functional goals of the setting, or therapist resources.

Further research is needed to explore the barriers to performing vestibular rehabilitation in the inpatient rehabilitation setting. Due to the nature of retrospective chart reviews, we were unable to determine the barriers to completing vestibular assessments. Further study would include qualitative interviews or focus groups to determine what barriers and facilitators exist to completing vestibular assessments for physical therapists in the inpatient rehabilitation setting. With improved

implementation, it would also be possible to describe the incidence rate of vestibular dysfunction in this setting.

Conclusion: Findings suggest a need for more vestibular assessments in individuals in an inpatient rehabilitation facility following TBI. This retrospective review had a low completion rate overall of vestibular assessments. However, there was a high rate of positive assessments regardless of whether the individual reported symptoms when assessed.

Clinical Relevance: Physical therapists treating individuals following a TBI should consider screening for vestibular dysfunction given the overlap of symptomology. Physical therapists are especially equipped to screen and treat patients with vestibular dysfunctions to diminish symptoms and improve their quality-of-life post-TBI.

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Topics in Vestibular Physical Therapy (TVPT) is the official publication/newsletter of the Vestibular Rehabilitation Special Interest Group (VRSIG) of the Academy of Neurologic Physical Therapy (ANPT). The purpose of the publication is to disseminate clinically relevant information to our members who treat individuals who have vestibular related symptoms.

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