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Outpatient Physical Therapy Management of Symptoms Associated with a Brainstem Arteriovenous Malformation: A Case Report

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OUTPATIENT PHYSICAL THERAPY MANAGEMENT OF SYMPTOMS ASSOCIATED WITH A BRAINSTEM ARTERIOVENOUS MALFORMATION: A CASE REPORT

by

Mitchell Hall

A Scholarly Project

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine and Health Sciences

University of North Dakota

in partial fulfillment of the requirements for the degree of

Doctor of Physical Therapy

Grand Forks, North Dakota

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This Scholarly Project, submitted by Mitchell Hall in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Faculty Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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Title	Outpatient Physical Therapy Management of Symptoms Associated with a Brainstem Arteriovenous Malformation: A Case Report
Department	Physical Therapy
Degree	Doctor of Physical Therapy

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ABSTRACT

BACKGROUND AND PURPOSE: Arteriovenous malformations are irregular connections between arteries and veins, while they can occur anywhere in the body, they are the most common in the brain and the spinal cord. The purpose of this case study is to describe the interventions, treatments, and results of conservative physical therapy for a patient diagnosed with an arteriovenous malformation located in the brainstem. CASE DESCRIPTION: Descriptive case study of a patient scheduled two times a week for a 6-week episode of care. Conservative physical therapy interventions and treatments included lower extremity strengthening, static and dynamic balance training, gait training on stairs, even, and uneven surfaces, patient education, and emotional support. OUTCOMES: The patient demonstrated improved safety and independence with functional mobility, improved measurable balance testing results, improved coping and mood, and was able to teach back home exercises and verbalize aspects of the progression of the exercises to maintain long-term mobility goals. DISCUSSION: Most people with Arteriovenous malformations live long and full lives. Conservative physical management can provide valuable interventions.

KEYWORDS: Arteriovenous malformation, conservative management, invasive, hemorrhage, anxiety, dynamic balance, static balance.

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CHAPTER I

BACKGROUND AND PURPOSE

According to the Mayo Clinic, an arteriovenous malformation (AVM) is an abnormal tangle of blood vessels connecting arteries and veins which disrupts normal blood flow and oxygen circulation.[1] It is estimated that 1.34 per 100,000 people in the United States are diagnosed each year but the actual numbers are not known as it is estimated that only 12% of AVMs become symptomatic. While AVMs can occur anywhere, brain AVMs are of particular concern due to the potential for neurological damage or death. (Refer to Figure 1 and 2.)

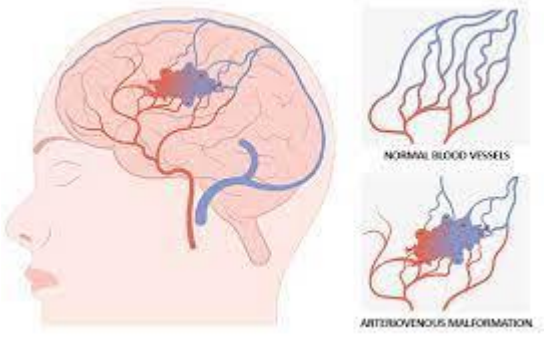

Figure 1. Drawing of AVM.[2]

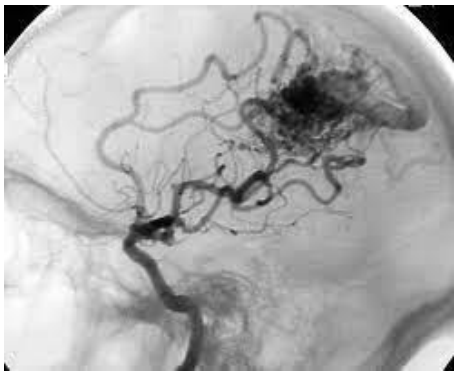

Figure 2. Image of AVM.[3]

Brain AVMs cause pathophysiology through three main mechanisms. AVMs can hemorrhage in areas such as the subarachnoid space or, most commonly, brain parenchyma. If they do not hemorrhage, AVM's can cause mass consequences within the brain through diffuse seizures. The third pathophysiological effect of AVMs is known as the "steal phenomenon." This phenomenon is described by the Journal of the American Medical Association as neurological

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damage to normal brain tissue when it is bypassed, and therefore deprived of nutrients and oxygen, as blood moves through the malformed blood vessels.[4]

Arteriovenous malformations are thought to be either genetic or angiogenic. The conglomerate of arteries and veins do not have an intervening capillary bed and the veins become distended and tangled due to the high arterial pressure.[5] The morbidity rate may be as high as 30-50%. The mortality rate of patients who have a hemorrhage is 10-15%. While sex is not a predilection, most clinical presentations occur in young adults.

The Spetzler-Martin grading scale is the most common classification system to describe brain AVMs.[6] The grading system is used as a guide to treatment recommendations for intracranial AVMs. Features considered are size, eloquent location, and venous drainage. Eloquent locations include sensory, motor, language, or visual cortex, hypothalamus or thalamus, internal capsule, brainstem, cerebellar peduncles, and the deep cerebellar nuclei. The cumulative score is between 1 and 5. The lower the number, the lower the surgical risk. A Grade 1 AVM (S1V0E0 or S0V1E0) would be considered small, superficial, and located in non-eloquent areas of the brain, and a low surgery risk. A Grade 6 AVM is a special classification and is considered not operable. Supplemental grading is used to predict neurological outcomes. Scores < or equal to 6 have a low risk for postoperative neurological decline while scores greater than 6 have a strong correlation to worsening neurological outcomes. (Refer to Figure 3.)

Various invasive interventions are considered for hemorrhaging AVMs which score less than or equal to 6 on the Spetzler-Martin Supplemental Scale.[7] Neurosurgical excision, stereotactic radiation, and endovascular embolization versus natural course risks are evaluated. Staged combinations of these invasive interventions may also be performed. Conservative

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management of unruptured AVMs resulted in a lower death rate and lower Modified Rankin Scale dependency scores. (Refer to Figure 4.)

Spetzler-Martin Grading	Points	Supplementary Grading
Size, cm		Age, y
<3	1	<20
3-6	2	20-40
>6	3	>40
Venous drainage		Bleeding
Superficial	0	Yes
Deep	1	No
Eloquence		Compactness
No	0	Yes
Yes	1	No
Total	5	

Figure 3. Spetzler-Martin Grading Scale with Supplemental Grading for brain AVMs.[7]

Modified Rankin Scale	
0	No symptoms
1	No significant disability. Able to carry out all usual activities, despite some symptoms.
2	Slight disability. Able to look after own affairs without assistance, but unable to carry out all previous activities.
3	Moderate disability. Requires some help, but able to walk unassisted.
4	Moderate severe disability. Unable to attend to own bodily needs without assistance, and unable to walk unassisted.
5	Severe disability. Requires constant nursing care and attention, bedridden, incontinent.
6	Dead

Figure 4. Dependency assessment using Modified Rankin Scale.[8]

Many people experience no signs or symptoms from their brain AVM until they hemorrhage or rupture. Other signs and symptoms include: seizure, muscle weakness, headache, unsteadiness, changes in vision, changes in sensation, and changes in cognition. Signs and symptoms usually occur between the ages of 10-40. Indications can emerge slowly over time or can be sudden, severe, and life-threatening. Immediate medical attention should be sought if any neurological signs or symptoms occur.

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Conservative management can include physical therapy. Physical therapy focuses on patient safety, energy conservation, improving quality of life, and achieving the highest level of patient independence. Treatment may include muscle strength training, muscle stretching, endurance training, gait balance, and coordination training. Physical therapists provide ongoing assessments to adapt interventions to meet the patient's needs when performing daily tasks and work closely with the patient and their family to advise for use of adaptive equipment.

This case study describes the 6-week outpatient physical therapy care of a 49-year-old female who had been recently diagnosed with an arteriovenous malformation. The location of the client's AVM was in the brainstem. Due to the location of the AVM, there was a high associated risk of hemorrhage with current invasive procedure techniques. The patient had a career background in the medical field and was aware of the risks and benefits of various interventions. The patient elected to proceed with conservative management. The purpose of this case study as to describe the interventions and treatments used for this patient and the results of these interventions and treatments. The interventions and treatments included lower extremity strengthening, static and dynamic balance training, gait training on stairs, even, and uneven surfaces, patient education, and emotional support.

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CHAPTER II

CASE DESCRIPTION

A career nurse noticed a gradual onset of balance and coordination deficits. Normal activities were progressively more difficult as the patient found themselves leaning to the right. This interfered with managing their full-time job duties and walking recreationally. The 49-year-old female sought guidance from the primary care provider and received a referral to outpatient physical therapy due to the rapid onset of altered balance and coordination. Initial outpatient therapy assessments revealed a diffuse change in coordination and balance and the patient was referred back for medical care and work-up of these unique symptoms. The patient was seen for consultation at Rochester-Mayo and had a confirmed diagnosis of an AVM located in the brainstem. Conservative care was recommended and the patient was referred back for outpatient physical therapy for gait and balance training and to optimize independence and function. The patient was to have follow-up with Rochester-Mayo three months later to assess the effectiveness of conservative management. The need for surgical intervention was to be re-evaluated.

The patient presented with no communication barriers and they were alert and oriented to person, place, time, and situation. She was able to give an accurate work, social, and medical history. The patient had family and community support. The patient's prior level of function was independent in all daily activities. She was motivated to participate in their plan of care and to attain the highest functional level possible. Medically, the prognosis was guarded due to the location and severity of the AVM. The patient expressed anxiety about an unknown future and was frequently concerned about the risks from invasive interventions along with concerns if

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conservative measures were going to be effective. The patient's mental well-being was addressed with open-ended questions and support was offered each visit.

Physical therapy goals focused on mobility for employment and functional independence. These goals were aligned with the patient's goals. The patient wanted to be able to safely resume walking on the community trail with her husband. The patient was also concerned about safety when ambulating on stairs so special attention was taken on each visit to address aspects of stair climbing. The patient needed endurance and coordination to perform their duties in their now part-time job. The rationale for treatment and education was based on textbook information, article review, coordination of care with medical professionals as well as treating the patient's symptoms. Treatment was progressed or changed when appropriate based on the patient's response. Examples of two goals reflecting S.M.A.R.T. goal components of specific, measurable, attainable, relevant, and time-bound are listed here:

- Following PT intervention, the patient will be able to ascend/descend two flights of stairs to be able to access all floors of the hospital to meet job requirements. (6 weeks)
- Following PT intervention, the patient will be able to ambulate community distances for greater than 30 minutes without external cueing to return to recreational activities. (6 weeks)

Precautions and activity restrictions from Rochester-Mayo referral were vague. Generalized precautions were having the patient avoid heavy lifting, straining, excessive fatigue, or any activity that would raise blood pressure and put a strain on the AVM. Guidance from Rochester-Mayo was to attempt anything that the patient thought possible and felt safe doing. The patient had a high baseline functional level but their diagnosis was complicated and had an uncertain progression. The patient is a nurse and had been the Nursing manager at her local

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hospital.-With increased risk of falls and decreased endurance when ambulating community distances and on uneven surfaces, the patient was no longer able to manage the full-time nursing job requirements and changed their status to part-time which allowed for increased focus on health.

The patient rated pain 0 on a 0-10 scale. Vitals were normal for age and gender. The patient's balance was assessed using the 30-Second Chair Stand and Four Stage Balance Test. The 30-Second Chair Stand score was 15 repetitions without the use of upper extremities on a firm surface to push to stand. This puts her in the normal range for age and gender. The purpose of the test was to assess leg strength and endurance. (Refer to Table 1.)

Table 1. 30-second Chair Stand[9]

30-Second Chair Stand	Age	Males	Females
Purpose: To test leg strength and endurance Equipment: A chair with a straight back without arms rests, (seat 17" high), and a stopwatch. Instruct patient: 1. Sit in the middle of the chair. 2. Place your hands on the opposite shoulder crossed, at the wrists. 3. Keep your feet flat on the floor. 4. Keep your back straight, and keep your arms against your chest. 5. On "Go," rise to a full standing position, then sit back down again. 6. Repeat this for 30 seconds.	20-29	24	23
	30-39	22	21
	40-49	20	19
	50-59	18	17
	60-69	16	15
	70-79	14	13
	80+	10	10
	A below average score indicates a risk for falls.		

Four Stage Balance Testing revealed that the patient was unable to hold tandem or single-leg stance for the normal time of 10 seconds. The patient was only able to hold a tandem stance for 4 seconds and single leg stance for 3 seconds. (Refer to Table 2.)

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Table 2. Four Stage Balance Testing for Assessment of Static Balance.[10]

	Initial Results	**Normal Values**
Normal Stance	60 seconds (Stopped by PT)	>10 seconds
Narrow Stance	42 seconds	> 10 seconds
Tandem Stance (Sharpened Romberg eyes open)	4 seconds	>10 seconds
Single-leg Stance	3 seconds	>10 seconds

Active and passive range of motion was evaluated by having the patient demonstrate active motion. Range of motion was within normal limits for all extremities. Gross manual muscle testing was performed for all extremities in sitting with 5/5 for all extremities.

Dynamic balance was assessed through observation of gait and exercises and was also impaired by the introduction of dual-tasks, changes in the gait surfaces, or if the patient was fatigued. The patient preferred to not use an assistive device and had a progressive right lean and right deviation of path within the first 50 feet. The patient was not aware and would not correct until they ran into an object on the right. The patient was evaluated ambulating 4 steps in a flight of stairs with a reciprocal pattern with the use of a rail when no distractions were present. If distracted by a cognitive task, the patient then modified her sequencing on stairs to non-reciprocal and demonstrated decreased speed.

Determining frequency and duration of interventions was challenging for this patient. The patient was re-evaluated weekly to determine progress toward goals. Patient self-report, observation of gait, and repeated balance testing was used to measure changes brought about by PT interventions and to facilitate modification of treatment approaches to maximize outcomes.

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CHAPTER III

INTERVENTION AND PLAN OF CARE

A Neurological Clinical Decision-Making Model was used to establish a plan of care for this patient.[11] This model integrates enablement and disablement approaches. This model is patient-centered, supported by evidence-based physical therapy practices, supports developing a hypothesis to establish the plan of care, and allows for the systematic analysis of tasks and movement dysfunction. The interventions and treatments included lower extremity static and dynamic balance training, gait training on stairs, and even and uneven surfaces. Evidence-based practices along with the primary physical therapist's 24 years of experience were utilized to establish interventions.

The patient was scheduled two times a week for 6 weeks. Each session was 45 minutes long. Physical therapy interventions included static standing balance exercises on a foam pad, tandem walking, stair training, gait training with cues for gait with different eye gaze, 4-cone drill, sit-to-stands on foam pad using a medicine ball, and patient education into diagnosis and compensation strategies. The patient performed core and hip exercises to maintain 5/5 level strength.

Although the patient tested within normal limits for strength and range of motion, gait was significantly affected by difficulty attending to dual tasks during ambulation activities. The patient expressed limited awareness of a tendency to veer to the right during gait and rarely self-corrected until they ran into an object or unless cued. A dual-task approach was used for intervention. This approach used motor and cognitive tasks simultaneously. Compensatory

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strategies were the goal of the dual-task approach. Research indicates there is a short-term benefit to this dual task technique as attentional capacity is maximized.[12] Evidence also suggests integration, automatization, and faster information processing are the main components of dual-task training. Long-term benefits from this approach required the patient to continue to incorporate dual-tasks into their activities of daily living. Dual-task activities consisted of having the patient rotate their head side-to-side, look up and down, and answer basic math questions while ambulating down the hallway at the clinic.

The patient had identified stair climbing as the chief concern; therefore, stair training was incorporated into each visit. Research indicates an additional benefit of utilizing proprioceptive neuromuscular facilitation techniques (PNF) during stair training.[13] Resistance was applied by the therapist against the ankle and knee while the patient performed a one step-up exercise with the step-in front and then to the side. This technique was repeated with the other leg.

The patient's balance was affected by the location of her AVM. Static balance was poor with sway outside of her base of support, usually to the right, when vision was obscured, if the base of support was uneven, or with the introduction of cognitive tasks. Examples of static balance exercise interventions used during this episode were narrow stance standing, tandem stance with eyes open and eyes closed, and single leg stance. Examples of dynamic balance exercises included tandem walking, walking backwards, and braiding. (Refer to Figure 5.)

Figure 5. Standing exercises for improved static balance.[14]

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Core strengthening interventions were performed. Evidence has shown that core strengthening improves not only core strength, but it is important for stabilization of the back and pelvis for initiation of limb movement.[15] Core strengthening was determined to be important to help the patient maximize current functional potential. Maximizing core strength was also important for future concerns related to the uncertain nature of the diagnosis with the potential for progression of neurological symptoms. Exercises included yoga poses of bird dogs, dead bugs, and scissor kicks were performed by doing 8-10 repetitions, 2-3 sets with verbal cues for good technique. Modified planks were performed with 15-30 second holds and then a 30-second rest for 3 sets with verbal cues for proper posture. (Refer to Table 3.)

Table 3. Functional Exercise to Improve Static Balance

Functional Exercise
• Sit-to-stand transfer without arms   ○ 5 repetitions in less than 10-15 seconds
• Walking in hallway/outside   ○ Even and uneven surfaces for 10 minutes
• Ascending/Descending stairs with rail   ○ 2 flights of stairs x3 sets
• Standing balance exercises (narrow stance, EO/EC tandem stance, single leg)   ○ Progress to 30 seconds in each position with contact guard assist

Another focus of physical therapy intervention was on the patient's well-being. During each visit, time was taken to assess the patient's coping mechanisms. The patient expressed a strong support system involving family, co-workers, and friends as a long-term member of the community. The patient would verbalize anxiety and strong emotions about an uncertain future. Support was offered as well as insight into other resources for professional interventions. The

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patient was able to verbalize an understanding of support being offered and would frequently indicate that being able to express concerns at therapy was helpful.

Physical therapy goals focused on keeping the patient employed and attaining the highest functional independence. Physical therapy goals were aligned with the patient's goals. Frequency and duration considerations included the patient living in town, working in the same facility, and having adult children who were supportive and could assist with transportation. (See Table 4.)

Table 4. Home Exercise Program Established Throughout 6 weeks for Discharge

Exercise	Duration
Foam pad balance (Normal stance, narrow stance, head rotations, eyes closed)	5 minutes
Unilateral Stand	3 x 20 seconds each leg
Cone exercises (4 cone, figure 8, backward walking around cones)	2 x each way
Sit to stand on foam pad while holding medicine ball	3 x 10 reps
Ambulating in the hall while rotating head side to side and up and down.	4 x 200 feet
Tandem walking	4 x 20 feet
Walking/sidestep over 6-inch hurdles	4 x 8 hurdles

The patient was given a verbal explanation of exercises along with a demonstration by the therapist. Cuing varied each visit depending on the patient's quality of movement on the day of treatment. The patient was able to perform exercises with consistent verbal and tactile cues for enhanced performance. A written home program was established throughout the 6-week episode for reference with cues specific to patient needs.

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CHAPTER IV

OUTCOMES

The patient was able to state goals of wanting to understand the diagnosis and to be able to achieve the highest functional level. The patient's goals of being able to continue work, to walk community distances with her husband, and to be able to ambulate stairs safely were all met.

- Following PT intervention, the patient was able to ascend/descend two flights of stairs to access all floors of the hospital to meet job requirements.
- Following PT intervention, the patient was able to ambulate community distances for greater than 30 minutes without external cueing and returned to recreational activities including community walking with spouse on trails.

Tolerance to exercise intensity was assessed each visit and was determined in part by using a 0-10 pain scale.[15] The patient denied pain other than transient generalized soreness and denied any other ill effects from exercise. The patient's perceived exertion of exercise was also used throughout each session. The goal during exercises was a 4/10 perceived exertion. This "somewhat heavy" intensity of exercise prompt was used to help the patient internally monitor exercises for optimal outcomes. Vitals were monitored intermittently, and the patient was observed when exercising for shortness of breath or any other signs of intolerance to exercise. Compliance with exercise and home instructions was reportedly good. The patient was able to teach back and demonstrate independently the home exercises at the time of discharge.

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The patient was very motivated but had daily fluctuations in presentation of symptoms and the resultant variation in mood. The patient was very pleasant and reported good tolerance and was pleased with the attention to her needs, recommendations, and education received, and the progression and written home exercise instructions that were provided.

Over the course of the 6 weeks, the patient made measurable progress as evidenced by an increased tandem stance time from 3 seconds to greater than 10 seconds which is considered normal. The patient also demonstrated an improved gait as evidenced by a decrease in their path deviation during ambulation activities. The 30-second chair stand improved from 15 repetitions at first evaluation to a discharge score of 19 repetitions. (Refer to Table 5.) On evaluation, their path deviation of gait was from wall to wall and by discharge, the path deviation of gait was within a 12-inch floor tile. The patient demonstrated an improved stair gait pattern at discharge as they were able to perform two flights of stairs using a reciprocal pattern with rail and their cadence improved but was not timed. The patient noted that they felt safer at work and were having fewer episodes of loss of balance with community ambulation.

Table 5. Initial Results and Final Results

	At Initial Evaluation	At Discharge
Tandem stance	4 seconds	>10 seconds
Single-leg stance	3 seconds	>10 seconds
30-second chair stand	15 repetitions	19 repetitions

The Johari Window is a model to help an individual better understand the relationship with themselves and others.[16] In this case, a Johari Window approach was used to evaluate areas of understanding and misunderstanding between the patient and their medical professionals.

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(Refer to Table 6.) Enhancing the individual's and others' perceptions is a valuable method for establishing a comprehensive plan of care. The individuals that were used for this model were the patient and the medical professionals. The open area is where the situation is known by the patient and the medical professionals, such as her being diagnosed with an AVM. The blind spot would be where the medical professionals know the risks of the patient's diagnosis and surgical interventions and the patient does not. The hidden area is the patient's emotions or own thoughts that they wish to hide from others. The unknown area is where information is unaware to both the patient and medical professionals such as not knowing the outcome.

Table 6. Johari Window[17]

Johari Window	Known to patient	Unknown to patient
Known to others (medical professionals)	Everyone knows the patient has AVM (Open Area)	Medical professionals have understanding of progressive risks to patient (Blind Spot)
Not known to others (medical professionals)	Patient's emotions, coping mechanisms (Hidden Area)	Unknown outcome (Unknown Area)

Tapping into the patient's motivation to improve and be able to keep working at baseline was key for establishing a plan of care and for guiding the progression of interventions during the course of therapy visits. It was difficult to overcome the patient's anxiety and varied neurological presentation. Presentation of symptoms and the patient's mood needed to be assessed each visit in order to modify the approach on that day.

After working with the patient for 6 weeks, the patient was able to teach back home exercises and verbalize aspects of the progression of the exercises. The therapist and the patient started to see a plateau in progress. The patient's 6-week goals were met. The plan was for the

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patient to continue working and to progress with their home exercises. The episode remained open for another 30 days with the physical therapist available for indirect consultation if the patient had questions or for direct consultation if the patient had concerns. The patient verbalized understanding and agreed with the plan of care.

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CHAPTER V

DISCUSSION

Interventions for both functional and mental status were appropriate for patient set goals. Standardized objective measures performed included the 30-Second Chair Stand and the Four Stage Balance tests. The patient developed a greater understanding of her diagnosis and prognosis and strategies to maintain a safe base of support for dynamic mobility on stairs and when ambulating on uneven surfaces. The patient was motivated to continue with home exercises which challenged core strength and dynamic balance strategies. The patient's big-picture goals of being able to stay active in life by continuing to work, walking recreationally in the community with spouse, and being independent in caring for themself at home were met.

The patient was a long-time employee of the medical center and an involved member of the small community. Health Insurance Portability and Accountability Act (HIPAA) concerns about sharing information were an ethical concern. Efforts were made to share information with primary care providers and therapists directly involved in the patient's care. Conversations were in private areas as staff and visitors in the work setting were very familiar and concerned about this patient. The patient's privacy was an individual issue and caution from providers was a moral obligation and ethical issue. Details of this patient's situation and progress were solely hers to share.

Just as the physical presentation varied each visit, so did their mental coping status. At no time was the patient disoriented or showing behavioral changes that affected safety. The

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patient was essentially going through the stages of grief: shock, denial, anger, bargaining, depression, testing, and acceptance. The patient was grieving the loss of former self. The patient needed supportive listening and then were able to set goals each visit to support the final stage of grief which is acceptance. By the end of the therapy episode, the patient verbalized being more accepting of their diagnosis and prognosis.

Most people with AVMs live long and full lives. Symptoms, if any, rarely result in the AVM being detected. For symptomatic AVMs, immediate medical attention is indicated as sometimes the earliest symptoms are associated with hemorrhaging which can be life-threatening. Other early signs can be a seizure, headache in one location, focal muscle weakness, or unsteadiness.[18] Early attention to establishing care and creating a treatment strategy offers the best support and outcome for the patient.

Physical therapy can be a valuable intervention when conservative management of an AVM is appropriate. Evidence-based interventions already exist to support conservative PT management.[19] Physical therapy focuses on the whole person and how they interact in their environment. Professional sharing of anecdotal outcomes from case studies would guide further evidence-based research into the most effective strategies for functional progress with this group who are challenged by the neurological symptoms related to their AVMs.

Upon reflection, a Dynamic Gait Index[20] and Tinetti Balance and Gait Assessment[21] could have been used to provide evidence-based quantifiable testing. This could have been done to show the benefit of skilled physical therapy to third-party payers. While taking history during the evaluation would have been beneficial to ask more measurable questions such as preferred gait speed, terrain in where see ambulates, and what time of day she walks at. The plan of care could have incorporated ambulation activities outside on uneven terrain. A referral for mental

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health services could have been made to address the patient's diagnosis and uncertainty about the future. Using reflective practice is a good ongoing professional skill to guide self-directed learning.

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