Rehabilitation of a Patient with Symptoms of Brown- Séquard-Plus Syndrome after Removal of a Benign Thoracic Tumor: A Case Report

A Capstone Project for PTY 768
Presented to the Faculty of the Department of Physical Therapy
Sage Graduate School

In Partial Fulfillment
of the Requirements for the Degree of
Doctor of Physical Therapy

Geanna N. Granger
May, 2010

Approved:

_____
Laura Z Gras PT, DSc, GCS
Research Advisor

_____
Marjane Selleck, PT, DPT, MS, PCS
Program Director, Doctor of Physical Therapy Program

SAGE GRADUATE SCHOOL

I hereby give permission to Sage Graduate School to use my work,
Rehabilitation of a Patient with Symptoms of Brown- Séquard-Plus Syndrome after Removal of a Benign Thoracic Tumor: A Case Report

For the following purposes:

- Place in the Sage Colleges Library collection and reproduce for Interlibrary Loan.
- Keep in the Program office or library for use by students, faculty, or staff.
- Reproduce for distribution to other students, faculty, or staff.
- Show to other students, faculty or outside individuals, such as accreditors or licensing agencies, as an example of student work.
- Use as a resource for professional or academic work by faculty or staff.

Geanna N. Granger Date

I represent to The Sage Colleges that this project and abstract are the original work of the author, and do not infringe on the copyright or other rights of others.

Rehabilitation of a Patient with Symptoms of Brown- Séquard-Plus Syndrome after Removal of a Benign Thoracic Tumor: A Case Report

_____

Geanna N. Granger Date

Rehabilitation of a Patient with Symptoms of Brown- Séquard-Plus Syndrome after Removal of a Benign Thoracic Tumor: A Case Report

Geanna N. Granger, SPT

Abstract:

Background and Purpose: This case report describes a comprehensive outpatient rehabilitation program that focused on the impairments as well as activity and participation restrictions of a patient presenting with Brown-Séquard-Plus syndrome. **Case Description:** After undergoing surgical removal of a benign thoracic tumor, a 64-year-old woman presented with symptoms similar to that of Brown- Séquard-Plus syndrome. **Outcomes:** The patient showed a decreased risk for falls; Timed Up and Go score decreased from 17.7 seconds to 13.5 seconds and the Performance-Oriented Assessment of Mobility score increased from a 21/28 to 24/28. The patient had gains in strength and improved endurance. She went from using both a wheelchair and a wheeled walker to ambulating independently in the community with a quad cane. **Discussion:** Results from this comprehensive rehabilitation program showed outcomes similar to that of patients with spinal cord injury or stroke that used body weight support treadmill training as an intervention. Further research with experimental designs and greater amount of participants will facilitate concrete use of these interventions for patients with similar symptoms of Brown-Séquard-Plus syndrome.

Introduction

Tumors on the spinal cord are rare, occurring in approximately 1.1 cases per 100,000 persons. These tumors can be benign or malignant and can leave patients neurologically and functionally impaired.[1,2] Whether the tumor is located intradural-extramedullary, intramedullary, or extradural, in one of these small areas of the central nervous system can lead to compression of the delicate structures of the spinal cord and associated nerves thereby causing neurological problems that can sometimes be life threatening.

Primary and secondary spinal cord tumors are found most frequently in the thoracic cord (70%) and less frequently in the lumbosacral (20%) and cervical spine (10%).[3,4] About 90% of all primary spinal tumors originate in the cells next to the spinal cord, such as the nerve roots and are benign.[4] Most of these tumors can be "cured" surgically so often this is the first step in treatment. Once diagnosed and surgery is indicated, the goal is to remove (surgical debulking, resecting) as much tumor as safely as possible while preserving and often impeding neurological function the patient had prior to surgery. The long term goal of tumor resection is to control the tumor with minimum morbidity.[5] It is advised, that even with successful outcomes from surgical removal there is still a possibility of a recurrence, which usually requires long term monitoring with magnetic resonance imaging.[6]

While surgery is the primary treatment option for most spinal tumors, it of course comes with high risk of neurological deficits that may not be recoverable. These complications may include paralysis of the lower extremities, loss of bowel, bladder and sexual function, increased sensory deficit possibly due to edema from surgical manipulation or an alteration in blood flow, progressive or delayed neurologic deficit.[6] Sometimes the surgery may not alleviate symptoms

for which the procedure was performed. A study by Sandalcioglu and colleagues looked at functional outcomes after surgical treatment of intramedullary spinal cord tumors in 78 patients. One main conclusion they came to was that thoracically located intramedullary spinal cord tumors proved to harbor an increased risk of postoperative surgical morbidity.[7] In the retrospective study done in 2008 by Manzano et al, they concluded that the most significant postoperative morbidity experienced following aggressive microsurgical resection of intramedullary spinal tumors in adult patients was dorsal column dysfunction.[6] Any damage to the dorsal column could result in the loss of proprioception, kinesthesia, and vibratory sense.[8]

Recovery after spinal surgery most frequently includes an aggressive course of physical therapy in order to regain function lost due to tumor and possibly surgical complications. The severity of spinal cord compromise secondary to a tumor spans a wide range. The person may experience weakness and numbness in the arms or legs, sciatica, partial paralysis, clumsiness, spasticity, bowel or bladder problems, spinal deformity or the tumor may cause complete or incomplete injuries such as Brown-Séquard like syndrome.[1,6,9] The true and rarely seen Brown-Séquard syndrome is defined as a complete lesion to a hemisection of the spinal cord resulting in ipsilateral upper motor neuron paralysis and decreased proprioception and contralateral loss of pain and temperature sensation.[8,9,10]

Brown-Séquard-Plus syndrome (BSPS) is a term that is sometimes used to describe the less pure forms of the syndrome. Partial lesions and asymmetrical clinical symptoms are more common with BSPS and in the literature have been shown to typically occur secondary to traumatic injury such as penetration wounds (gunshot, stab, pen assault) or motor vehicle accidents.[2, 9, 10] Some non-traumatic causes that have been reported but with less research include

primary or metastatic tumor, multiple sclerosis, Type II decompression sickness, disk herniation and tuberculosis.[10-12]

Due to the rare occurrence of Brown-Séquard syndrome, most of the descriptions from the literature are in the form of case studies. There is especially very limited research on the rehabilitation of a patient presenting with BSPS. The National Institute of Health and National Institute of Neurological Disorders and Stroke conclude that treatment of Brown-Séquard Syndrome is based on underlying cause of the disorder and is symptomatic and supportive.[3] One specific study was found in a PubMed search using the MeSH terms of Brown-Séquard Syndrome and Physical Therapy Modalities and Rehabilitation. It looked at robotic-assisted body weighted support treadmill training in a person that had spinal decompression sickness presenting as partial Brown-Séquard Syndrome.[13] After 3 months of rehabilitation the patient's American Spinal Cord Association score improved from C to D, Spinal Cord Independence Measurement improved from 50 to 90 out of 100. Berg Balance Test improved from 35 to 43 out of 56 and Walking Index for Spinal Cord Injury improved from 1 to 15 out of 20. Upon discharge the patient could walk with one crutch for more than 1 km (0.62 mi), which he was unable to do previously. The authors concluded that robotic-assisted body weighted support treadmill training for this type of sickness may be beneficial.[13]

The purpose of this retrospective case report is to add to the limited body of knowledge that there is on the rehabilitative management of a patient with lack of coordination presenting like BSPS after removal of a benign thoracic tumor.

Case Description

Patient

Information concerning the patient's outpatient physical therapy was obtained from medical chart review in a manner that complied with the Health Insurance Portability and Accountability Act for disclosure of protected health information. This retrospective case report has been approved by The Sage Colleges Institutional Review Board.

The patient was a 64-year-old woman; 4 feet 11 inches tall, 126 pounds, who had complaints of severe right leg weakness and lack of proprioception after undergoing surgical debulking of a benign thoracic tumor. She came to the outpatient orthopedic clinic after being hospitalized for one week and having three weeks at an inpatient rehabilitation facility for gait training and exercise. She presented wearing a hinged ankle-foot orthosis (AFO) on the right foot during the day and wearing dorsiflexion splints at night. She also used a wheelchair when she was too tired and weak to walk. The patient noted difficulty with gait and mobility due to weakness and lack of control of her right leg and a decrease in sensation of the left leg. Her medications included Neurontin, Paxil and Coumadin. Her past medical history was remarkable for surgery twenty-two years ago to remove a thoracic tumor with residual right flank pain. Relevant familial history included ovarian and breast cancer, rheumatoid arthritis and heart attack. She lived at home with her husband and handicapped daughter and because of this she reports her house being handicap accessible. She noted being able to use a shower wheelchair for safety. She was unable to drive and reported working part time as a land-lady. The patient's stated goals included being able to ambulate without the use of a wheelchair or walker, increasing her strength and endurance to be able to walk in the community and being able to drive again.

Examination

The initial outpatient physical therapist examination occurred two days after discharge from the inpatient rehabilitation facility by a physical therapist that had been practicing for 12 years. Upon examination the patient came into the clinic using a wheeled walker with the AFO on the right foot and had bilateral compression stockings to control for deep vein thrombosis. Upon gait observation, the patient had intermittent circumduction of the right leg with hip hike during swing phase, decreased knee flexion during swing, and lack of lower extremity control at swing phase and heel strike. Observation of posture revealed forward head, increased thoracic kyphosis, and a well healed incision extending the length of the thoracic spine.

The patient was able to perform single leg stance on the right foot for approximately 3 seconds while holding the walker before losing her balance to the right. Her static stance balance was fair with eyes open and she immediately fell to the right with eyes closed, demonstrating a positive Romberg test. Her deep tendon reflexes measured 3+ for bilateral quadriceps and 2+ for bilateral Achilles. Sensory testing using a light brushing motion through the right and left L2 through S2 dermatomes revealed decreased light touch sensation throughout the left lower extremity. Kinesthetic and proprioceptive awareness of bilateral toes, ankles, and knees was assessed passively sitting in a chair with a straight back. The testing revealed decreased proprioceptive awareness in the right ankle and lower leg. Initially she was able to walk without the wheeled walker approximately 40 feet with contact guard to close supervision and reported fatigue following this activity.

A gross assessment of active range of motion measurements of bilateral lower extremities with the patient in supine position was essentially all within normal limits except for ankle dorsiflexion. Using a standard goniometer the range of motion of right ankle dorsiflexion was -10° and left dorsiflexion measured 3°.[14] Manual muscle testing was performed using the “break

test" against the therapist resistance.[15] The results from this test are in Table 1 and show the progress from initial visit to discharge. Overall testing though revealed muscle weakness of the right lower extremity was greater than that of the left.

Evaluation

It is clear from the examination findings that the patient's pattern of motor and sensory loss were consistent with an incomplete spinal cord injury, specifically BSPS.[10-13] This syndrome, as mentioned previously is defined as ipsilateral upper motor neuron paralysis and decreased proprioception and contralateral loss of sensation. The clinical presentation of this may range from mild to severe neurologic deficit; this patient appeared to have a moderate deficit. The patient presented with decreased proprioception of the right lower extremity and muscle weakness of the right lower extremity and right foot drop and also decreased light touch sensation throughout the left lower extremity. She required contact guard with all standing activities when she was not using her walker and close supervision when she was ambulating with the walker.

Diagnosis

According to the *Guide to Physical Therapist Practice* the preferred practice pattern this patient falls into would be neuromuscular 5H: Impaired Motor Function, Peripheral Nerve Integrity, and Sensory Integrity Associated With Nonprogressive Disorders of the Spinal Cord.[16]

Prognosis

Its been suggested that older individuals with spinal cord injury do well, but have less favorable outcome in regards to walking, among other things, than younger patients.[17] It has been shown that out of the various types of spinal cord injury syndromes, Brown-Sequard syndrome has the best prognosis for independent ambulation at discharge of rehabilitation.[18]

Overall it was determined that her prognosis was fair to good due to the extent and type of neurological loss and her age.

Plan of Care

The plan of care was designed as indicated in the Guide, along with evidence in spinal cord rehabilitation in adults, the primary therapist's clinical experience and the patient's personal goals. The expected range of number of visits per episode of care according to the Guide for this diagnosis is between 4 and 150 visits.[16] This patient was initially seen 3 times a week for 6 weeks for 45 to 60 minutes; it was then reduced to 2 times a week for 3 weeks for 30 to 45 minutes then once a week for 5 weeks for 30 to 45 minutes. The patient's rehabilitation was focused on her impairments as listed previously and limitations due to these impairments which include; decreased mobility, balance, endurance and safety awareness and her participation restrictions, such as being able to drive again and ambulate independently in the community. Therapy sessions therefore consisted of lower extremity stretching and strengthening exercises, balance and proprioceptive training, gait training, endurance training and a home exercise program. Goals for this patient included;

<u>Short Term Goals</u>:

Patient will increase her Tinetti Performance Oriented Mobility Assessment (POMA) score by 2 points in 2 weeks.

Patient will decrease her time on the Timed "Up & Go" (TUG) by 2 seconds in 2 weeks.

Patient will safely ambulate with appropriate assistive device and close supervision at least 500 feet with 2 or less rest breaks in 4 weeks.

Patient will increase strength of right lower extremity musculature by ½ muscle grade in 4 weeks.

<u>Long Term Goals</u>:

Patient will have an increase in her POMA score to 25/28 or greater, signifying a low risk for falls, by discharge.

Patient will decrease her time on the TUG to at least 13 seconds or less indicating increased independence and decreased risk for a fall by discharge.

Patient will be able to safely and independently ambulate in the community with appropriate assistive device ≥ 750 feet without a rest break by discharge.

Patient will increase strength of right lower extremity musculature equalling 1 whole increase in muscle grade to aid in her ability to walk in the community by discharge.

Once again the patient's stated goals included being able to ambulate without the use of a wheelchair or walker, increasing her strength and endurance to be able to walk in the community and being able to drive again.

Intervention

The initial visit consisted of a review of bed mobility and exercises that were performed at the inpatient rehabilitation center. Sit to stand transfers were worked on for the first 2 weeks of therapy, first allowing her to push up from the chair then progressing to standing without the use of her hands. The subsequent therapy sessions consisted of therapeutic exercise in sitting and standing, ROM exercises and stretching, balance and proprioceptive activities in sitting and standing, gait training and endurance training on a stationary bicycle and she was given a home program. Table 2 gives an overview of the progression of all interventions for the patient's entire episode of care over 14 weeks (29 visits) of physical therapy. All exercises were progressed in difficulty as tolerated by the patient. For all standing and walking exercises the patient wore a gait belt and required minimum assistance when using a wheeled walker. She was given a rest in between most exercises and monitored throughout sessions due to her decreased endurance and ease of becoming fatigued. For all gait and standing exercises she wore her AFO, except during

the last 2 weeks of therapy during functional electrical stimulation (FES) with heel switch training.

Various strengthening exercises were implemented throughout the course of therapy to increase her lower extremity and core strength, and consequently improve her overall balance and endurance as well. The strengthening exercises included; bridging, straight leg raises in all planes on a mat and progression to standing, seated long arch quads, seated marching, small squats, standing knee flexion while practicing eccentric lowering, bilateral hip adduction exercise using a medium sized air filled ball, quadruped rocking, quadruped rocking with rhythmic stabilization at shoulder and hips, alternate shoulder flexion progressed to alternate shoulder flexion and hip extension in quadruped, resisted knee to chest exercise in supine, prone knee flexion, small lunges in all planes, seated shoulder flexion with 3 lb free weight, leg press on a weight machine initially 75 lbs and increased to 90 lbs 5 weeks later. Therapy ball exercises were implemented by week 5 and included long arch quads, marching, bicep curls with 3 lb weight, alternating shoulder flexion with 3 lb weight and D2 flexion/extension with 3 lb weight. Red Thera-Band was used for right ankle strengthening and done in plantar flexion, inversion and eversion. Initially all these exercises were done by one set of ten reps, then increased at approximately week 5 in accordance to a typical strengthening program.[8,19] Neuromuscular electrical stimulation (NMES) with the portable Empi 300 PV was implemented at week 13 for strengthening of the right quadricep and hamstring muscle. The device was set with a 30 seconds on 20 seconds off time at 80 pulses per second. These exercises included one set of fifteen reps of straight leg raises of hip flexion in supine, long-arch quads in sitting, mini squats and knee flexion in standing. This intervention was applied because there is consensus in the literature that neuromuscular strengthening does occur following the electrical stimulation of innervated

skeletal muscle in both healthy and impaired patient populations.[8, 20, 21] The lack of consensus in the literature is in determining what are the "best" parameters to select in order to achieve optimal muscular strength. It was noted that by week 9 the patient reported feeling that her right hip had gotten much stronger and upon muscle testing it was confirmed that she had some improvements in her strength (Table 1).

To maintain range of motion and keep the patient's musculature at proper flexibility, stretching and range of motion exercises were implemented. These exercises included; supine passive dorsiflexion stretch and standing dorsiflexion stretch using the Pro-Stretch device, knees to chest stretch on the right, passive hamstring stretching in supine, passive range of motion for hip flexion, active-assistive and passive range of motion of right ankle in all planes, as this was necessary due to the patient having to wear the AFO.

Static and dynamic balance are key components when it comes to being able to perform regular activities of daily living and during ambulation.[8,20] As consistent with the locomotor training interventions described by Schmitz [22(p524)] and Shumway-Cook [20(p432)] these balance activities included; static balance with eyes open and eyes closed, single leg stance, standing with weight shifts from left to right, tandem walking, walking backward, side stepping and sidestepping with high knees. The difficulty of these walking activities was increased in varies ways, these included; increasing the distance, decreasing her level of support (contact guard to close supervision), varying the surface the activity was performed on, having the patient perform activities with eyes closed and also applying perturbations. By week 5 of therapy the patient stated feeling that her balanced had improved in that she felt less fearful of falling while walking.

To work on proprioception as well, she performed toe taps with her right foot to a target (a sticky note or a small cup) placed on the floor in different planes and she was asked to vary

between light taps and heavy taps, toe taps on a BOSU dome then progressing to lunges on BOSU dome. Other modes to work on proprioception included having the patient sit and with eyes closed and name the position of where her right ankle/foot was in space and also in supine flexing her right knee and holding it in position. These proprioceptive exercises were performed at least once a week throughout her episode of care.

Ambulation was the main focus during all therapy sessions, as the patient's goal was to be able to get around without a walker and ultimately no assistive if possible. Another goal was to improve her endurance so that she could walk longer distances and get about the community, as sometimes even though she was using a walker she also had a wheel chair to get around when she was too fatigued. The first two weeks ambulation was practiced with the wheeled walker up and down the hallway of the facility and up and down a standard 25 foot long ramp. Emphasis was placed on proper placement of the right foot, as this was the leg that would intermittently circumduct with a slight hip hike during swing phase, had decreased knee flexion during swing, and overall she had a lack of control of the right lower extremity at swing phase and heel strike. The patient required a few rest breaks in order to complete these ambulation tasks. At her eleventh visit she informed the therapist that she had a quad based cane and wanted to progress to walking with it, so the session incorporated practice of walking with a quad cane that was owned by the clinic. Practice with the quad cane was on the flat carpeted floor of the clinic and also down the carpeted hallways of the office building and down the carpeted ramp. At the end of week 4 the patient was allowed to use her quad cane at home as the therapist felt that she was able to use it safely. At week 5, ambulation was progressed to the patient walking without an assistive device with contact guard for a distance of 40 feet. She also walked a distance of 240 feet up and down the hallway and ramp without a rest break. By week 6, the patient practiced

walking up and down one standard flight of stairs with the cane and contact guard. This was continued in subsequent sessions as well as walking the whole distance of the hall and ramp without rest breaks. At week 7 the patient reported she went to church and used the cane without difficulty.

During the last 2 to 3 weeks the patient was issued an Empi 300PV unit with a heel switch (Empi) to work on the right tibialis anterior muscle for her foot drop and also the NMES component to work on quadricep strengthening. The Empi 300PV is portable NMES device that is a multi-function electrotherapy system, with the ability to function as a FES, transcutaneous electrical nerve stimulation (TENS), and High Volt device. The effects of FES include increased muscle mass and oxidative capacity of the muscle, increased power output, increased ROM of the joint, decreased risk of osteoporosis and increased functional ability to ambulate.[23,24] The patient was educated in proper use of the device and electrode placement and to ensure safety she was asked to demonstrate this skill back to the therapist in clinic before going home. She was able to perform this skill safely and accurately with little to no verbal cuing before using for her first home treatment.

Besides all the walking in therapy that helped to increase her endurance, the patient also began riding an upright stationary bicycle to work on this. The patient began pedaling for 3 minutes the first week, increased to 4 minutes at week 2, and subsequently increased the time by one minute each week starting at week 6 and going through to week 9, eventually working up to 7 minutes total. The resistance was not increased as the patient had a difficult time keeping her right foot in the pedal due to the decreased active motion and strength in her right ankle. To accommodate for this the therapist would hold the foot in the pedal and also Dycem non-slip pads were used, but with little success.

Outcome Measures

The patient made significant progress during treatments and reported improved overall gait, balance, and endurance since beginning treatments. She was able to discontinue use of the wheeled walker to use of a small based quad cane with fair to good standing balance. She only continued to note some difficulty with proprioception of the right leg and decreased sensation in the left leg.

At the patient's twenty-second visit (week 8) to the clinic and then again at discharge (week 14), functional tests of balance and walking performance were administered. It was at this point that I made the decision to start documenting the rehabilitation of this patient for further study for this case report. The Tinetti Performance Oriented Mobility Assessment (POMA) and Timed "Up & Go" (TUG) test were administered.[25-27] The POMA is a simple test to measure a patient's gait and balance and is scored on the patient's ability to perform specific tasks. It focuses on maintenance of position, postural response to voluntary movement, postural response to perturbation and gait mobility.[8] The maximum total score is 28 points. In general, patients who score below 19 are at a high risk for falls and in the range of 19-24 indicate the patient has a moderate risk for falls.[25] This test has good interrater reliability at .85 and concurrent validity in correlation with the Berg is .91. It was chosen in this case because it allows the patient to use an assistive device, unlike the Berg Balance Scale. All directions were followed as explained for the POMA, the patient used a quad cane and was wearing the AFO on her right foot. A gait belt was also used for patient safety and close supervision was used. At the end of the test the patient had a score of 12/16 on the balance section and a 9/12 on the gait section. Her total score was a

21/28, indicating that she is at a moderate risk for a fall. At her last visit during week 14 the test was re-administered and she scored as follows; 14/16 on balance, 10/12 on gait, total score of 24/28 indicating she is still at a moderate risk but at the upper limit of the range.

The TUG test is a single task test that requires the patient to stand up from an armchair, walk 3 meters (10 feet), turn around, and return to a seated position all while being timed. The focus of this test is to look at functional mobility and is predictive of falls in the elderly. The patient is allowed one practice test and then the average of three trials is used for the final score. A score of less then or equal to 10 seconds the patient is independent, less then or equal to 20-29 seconds is normal for frail elderly or disabled patients and 30 seconds or more indicates the patient is dependent in mobility skills and most ADLs. It has been shown that a score of greater than or equal to 14 seconds may indicate a high risk of falls.[26,27] This test has strong interrater reliability=.99 and intrarater reliability= .98. In correlation with the Berg is has concurrent validity= .81. The patient is also allowed to use an assistive device with this test. We followed the precise directions as described for the TUG. The patient once again used her quad cane and had the AFO on the right foot. She was given the directions and allowed one practice trial. She proceeded to perform three trials and the average time of the trials was 17.69 seconds. This indicates that she may have good mobility but could be at risk for a fall. When reassessed 6 weeks later at her last visit her scored improved to 13.5 seconds, taking her out of the high risk for falls bracket. It should be noted however that the patient reported having a fall at about 4 weeks before discharge. She stated that she "caught her foot getting out of the van" and hit her knee. This was an isolated incident though and she reported not having any other falls.

She continues to use an AFO on the right due to the weakness in the right ankle and decreased proprioception but overall there was still an increase in strength of bilateral lower

extremities by discharge as shown in Table 1. She was issued the 300PV stimulation unit to help facilitate muscle strengthening and gait, but the patient reported not using the unit as often as suggested due to a busy schedule. She required fewer rest breaks between exercises and during gait. She began ambulating independently during her normal daily activities with the quad cane and the hinged AFO brace. She was able to go 500 feet with increased stride length, widened base of support, and minimal circumduction without rest. She was able to ambulate without the cane 50 feet plus with contact guard of one. However, it was noted that she had a narrowed base of support and shortened stride length with a mild loss of balance. With the AFO removed and using the 300PV on the right tibialis anterior muscle with the heel switch, she was able to ambulate with the cane with mild ankle inversion on heel strike. She was able to perform single leg stance for about 25 seconds bilaterally with occasional fingertip touch to regain balance. While this is not the true test of ability to stand on one leg to determine balance due to the occasional finger tip touch, she was unable to perform this task previously at this level. Dynamic balance was good as she moved her feet to regain balance during different movements and perturbations. Static balance with feet together, eyes closed, and brace removed is fair to good with mild increased sway.

Overall the patient met her short and long term goals of increasing her POMA score and decreasing the TUG score, increasing her lower extremity strength and ambulating with the appropriate assistive device (quad cane) safely and independently with a decrease in the amount of rest breaks taken. She was also able to ambulate safely in the community, but by time of discharge she was still unable to drive. There was talk about possibly getting adaptive driving equipment but this was something the patient was not ready to look into by the time of her discharge.

Discussion

The patient's symptoms were consistent with a partial spinal cord injury that presented like BSPS after the surgical removal of a benign thoracic tumor. This case report described the outcomes of outpatient physical therapy and home based rehabilitation programs over a course of 14 weeks.

There is little known about the optimal training program in spinal cord injury and more specifically in BSPS. There is also very limited research on training to regain proprioception back. All rehabilitation for this patient was done in an outpatient clinic that did not have access to special equipment such as a treadmill, body weight support system, or an FES bike, which are all widely being used today and are said to provide the most beneficial outcomes in regards to gait training in patients with spinal cord injury.[19,20,22-24] While this might be true and a possible limitation of this study, in this case the contraindication to body weight support might have restricted the patient from even being able to use it. According to assistant professor Gabriele Moriello PT, MS, GCS (Body Weight Support lecture, April 2008, The Sage Colleges) the contraindications and precautions to use of body weight support that would be relevant in this case would include metastatic disease and any skin integrity issues in the region of the harness. The incision along her thoracic spine would have to be completely healed before applying the harness near the area. Due to her age, is it likely that the skin integrity is not as strong, so the healing process would take longer and it would be more likely that damage could occur to the area. Also the pressure from the harness might cause pain in the area, so this would have to be taken into consideration. This patient would also have to be ruled out for having any metastatic

disease in her ribs before the use of this device as well. A conversation with the patient's physician would also be crucial before any decision about use of this intervention could be made.

The physical therapy interventions, as described here, appear to have contributed to the regaining of balance and improved gait of this patient in the 4 months since her surgery. The repetitive use of certain walking and strengthening exercises and the increasing of intensity over time could have been key to the gains this patient had. The practice of using functional activities in therapy has been shown to increase carry over in patients' own environment.[8,9,19,22] In this case the patient walked in varying circumstances that closely mimicked situations she might come across while out in the community, making it likely that these activities could also be a reason the patient's ability to ambulate improved. In addition, the patient had a high level of motivation to improve her condition and become more independent. While it is very likely these physical therapy interventions and the patient's motivation facilitated recovery, we can not be 100 percent sure of this. It is likely that some recovery came from the spontaneous neural recovery and reorganization in the region of injury on the spinal cord and it should be noted that most gains do happen within the first 2 months after injury to the spinal cord. [8-10,19]

Change over time would have been better detected if the POMA and TUG were performed at, or closer to, the patient's initial visit. I chose the POMA due to my familiarity with it, the ability of the patient to use their regular assistive device and because it focused on performance of gait, which was a concern to the patient. The Berg Balance Scale is considered the gold standard in measuring balance but it does not measure gait performance, thereby this being a reason it was not chosen for this report.[8]

The patient's goals of being able to drive and to not have to wear the AFO were not met. The patient's participation restriction of not being able to drive was limited by her inability to

control ankle dorsiflexion. I suspect that it might have improved if we were able to spend more time with her and using the FES unit in combination with more gait training in the clinic. Recommendation of getting a driving evaluation and adapters for her vehicle were suggested towards the end of therapy but not acted on in this clinic due to her continued limitations with walking and also the patient's disinterest in learning about the adaptations at that time.

It is also my suggestion that more outpatient clinics use outcome measures when working with patients with incomplete spinal cord injury in order to contribute to the limited research there is on outpatient rehabilitation. Further research with experimental designs and greater amount of participants will facilitate concrete use of these interventions and determine appropriate outcome measures for patients with similar symptoms of BSPS.

Conclusion

There is limited literature on functional outcomes after outpatient rehabilitation for patients with BSPS. This case demonstrates how a physical therapist designed rehabilitation program, that focused on the patient's impairments and activity restrictions, may have contributed to improvements in general strength, endurance, balance, and improved ambulation. The above described intervention program shows to be a practical means of rehabilitation for a patient presenting with symptoms of BSPS.

REFERENCES:

1. Ogden AT, Wetjen N, Francavilla TL. Intramedullary Spinal Cord Tumors. eMedicine/Medscape Articles Web site. http://emedicine.medscape.com/article/251133-overview. April 2009. Accessed September 17, 2009.
2. Kirshblum S. Neurorehabilitation in spinal cord cancer. *Rehabil Oncol*. 1999;17(3):29-31.
3. Brain and Spinal Tumors- Hope Through Research. National Institute of Neurological Disorders and Stroke Web site. http://www.ninds.nih.gov/disorders/brainandspinaltumors/detail_brainandspinaltumors.htm#138553060. December 1, 2009. Accessed December 1, 2009.
4. Shapiro WR. Spinal Cord Tumors. In: Porter RS, Kaplan JL, Homeier JP, eds. *The Merck Manuals Online Medical Library*. Whitehouse Station, NJ: Merck Research Laboratories; 2008. http://www.merck.com/mmhe/sec06/ch088/ch088c.html. Accessed October 3, 2009.
5. Kadi E. Spinal Tumor. Spinal Tumor.org Web site. http://www.spinetumor.org/. September 18, 2007. Accessed October 3, 2009.
6. Manzano G, Green BA, Vanni S, Levi AD. Contemporary management of adult intramedullary spinal tumors-pathology and neurological outcomes related to surgical resection. *Spinal Cord*. 2008;46(8):540-546.
7. Sandalcioglu IE, Gasser T, Asgari S, et al. Functional outcome after surgical treatment of intramedullary spinal cord tumors: experience with 78 patients. *Spinal Cord.* 2005;43(1):34-41.
8. Fulk GD, Schmitz TJ, Behrman AL. Traumatic spinal cord injury. In: O'Sullivan SB, Schmitz TJ, eds. *Physical Rehabilitation*. 5th ed. Philadelphia, PA:F.A. Davis; 2007. 941.
9. Lundy-Ekman L. Spinal region. In: Lundy-Ekman L, ed. *Neuroscience-Fundamentals for Rehabilitation*. 3rd ed. St. Louis, MO:Saunders Elsevier; 2007:322-323.
10. Koehler PJ, Endtz LJ. The Brown Sequard syndrome-true or false? *Arch Neurol*. 1986;43:921-924.
11. Vandenakker-Albanese C, Zhao H. Brown-Sequard Syndrome. eMedicine Web site. http://emedicine.medscape.com/article/321652-overview. July 31, 2008. Accessed October 6, 2009.
12. Gupta A, Taly AB, Srivastava A, Murali T. Non-traumatic spinal cord lesions: epidemiology, complications, neurological and functional outcome of rehabilitation. *Spinal Cord.* 2009;47(4):307-311.
13. Moreh E, Meiner Z, Neeb M, Hiller N, Schwartz I. Spinal decompression sickness presenting as partial Brown-Sequard syndrome and treated with robotic-assisted body-weight support treadmill training. *J Rehabil Med*. 2009;41(1):88-90.
14. Reese NB, Bandy WD. *Joint Range of Motion and Muscle Length Testing*. 2nd ed. St. Louis, MO:Saunders; 2010.
15. Kendal F, McCreary E, Provance P. *Muscles: Testing and Function*. 4th ed. Baltimore, MD:Williams & Wilkins; 1993.

16. *Guide to Physical Therapist Practice*. 2nd ed rev. Alexandria, VA:American Physical Therapy Association, 2003.
17. Scivoletto G, Morganti B, Ditunno P, Ditunno JF, Molinari M. Effects on age on spinal cord lesion patients' rehabilitation. *Spinal Cord*. 2003;41(8):457-464.
18. McKinley W, Santos K, Meade M, Brooke K. Incidence and outcomes of spinal cord injury clinical syndromes. *J Spinal Cord Med*. 2007;30(3):215-224.
19. Harkema SJ. Neural plasticity after human spinal cord injury: application of locomotor training to the rehabilitation of walking. *Neuroscientist*. 2001;7(5):455-468.
20. Shumway-Cook A, Woollacott MH, eds. *Motor Control: Translating Research into Clinical Practice*. 3rd ed. Philadelphia, PA:Lippincott Williams & Wilkins; 2007.
21. Lyons CL, Robb J, Irrgang JJ, Fitzgerald GK. Differences in quadriceps femoris muscle torque when using a clinical electrical stimulator versus a portable electrical stimulator. *Phys Ther*. 2005;85(1):44-51.
22. Schmitz TJ. Locomotor training. In: O'Sullivan SB, Schmitz TJ, eds. *Physical Rehabilitation*. 5th ed. Philadelphia, PA:F.A. Davis; 2007.
23. Krauss JC, Robergs RA, Depaepe JL, et al. Effects of electrical stimulation and upper body training after spinal cord injury. *Med. Sci. Sports Exerc*. 1993;25(9):1054-1061.
24. Thijssen DH, Heesterbeek P, VanKuppevelt DJ, Duysens J, Hopman MT. Local vascular adaptations after hybrid training in spinal cord-injured subjects. *Med. Sci. Sports Exerc*. 2005;37(7):1112-1118.
25. Tinetti ME. Performane-Oriented Assessment of Mobility problems in elderly patients. *J Am Geriatr Soc*. 1986;34(1):119-126.
26. Shumway-Cook A, Brauer S, Woollacott MH. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go test. *Phys Ther*. 2000;80(9):896-903.
27. Podsiadlo D, Rishardson S. The Time "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*. 1991;39(2):142-148.

.

Table 1: **Results of Manual Muscle Testing Over Course of Physical Therapy Treatment**

	Initial Visit		Midterm (12th visit)		Discharge (30th visit)	
	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
Hip Flexion	4-	3-	4+	3- to 3	4+ to 5	3+
Knee Flexion	4 to 4+	3+	5	4 to 4+	5	4 to 4+
Knee Extension	4+	3+ to 4-	5	4	4+ to 5	4+
Ankle Dorsiflexion	4+	3	5	3 to 3+	5	3 to 3+
Ankle Plantarflexion	NT	NT	NT	4	5	4 to 4+
Ankle Eversion	5	3	5	3 to 3+	5	3+
Ankle Inversion	NT	NT	NT	3	5	3+ to 4-

NT= Not test

Table 2: **Progression of Interventions Through Entire Episode of Care (29 visits)**

Intervention	**Week 1** **(3visits/week)**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7-9** **(2visits/week)**	**Week 10-14** **(1 visit/week)**
LE Strengthening	X	→ +	→ +	→	→ ↑ +	→ +	→ +	→ ↑ +
Stretching/ROM	X	+	O	O	O	O	O	+
Transfers	X	↑	O	O	O	O	O	O
Static/Dynamic Balance	X	→ +	→	→	→	→ ↑	→ ↑	→
Ambulation	X	→ +	→ ↑	→	→ ↑	→ +	→	→ ↑ +
Endurance	X	↑	→	→	↑ +	↑	↑	→
Proprioception	X	→ +	↑ +	→	→	→	→	→ ↑

KEY: X: Started interventions
→: Continued exercises
↑ : Increased reps, weight, difficulty, intensity
+ : Added new intervention
O: Did not perform intervention