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Physical Therapy Management and Treatment of a Patient with Post-traumatic Syringomyelia

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Abstract:

Background: Symptomatic post-traumatic syringomyelia (PTS) is a relatively uncommon but potentially serious result of trauma to the spinal cord. PTS can have a significant long-term impact on function and mobility even with surgical management. The purpose of this case report is to describe an outpatient physical therapy management of an individual following surgical management of recurrent spinal cysts associated with PTS. **Case Description:** The patient was a 39-year-old male who presented to physical therapy after the most recent of several shunting procedures to prevent the development of a syrinx in the spinal cord. The patient had a history of recurrent post-traumatic spinal arachnoid cysts and syringomyelia secondary to a past motor vehicle accident. The interventions for the patient included robotic assisted gait training via the Lokomat, functional electric stimulation cycling, stretching, and overground gait training. **Outcomes:** From the initial evaluation, the patient demonstrated improvement in the Kansas University Acute Care Functional Outcomes Tool score (11/28 to 19/28) and the Tinetti (1/28 to 12/28). The patient also required less assistance with transfers and standing, as well as progressing from being non-ambulatory to ambulating with an assistive device and minimal assistance from the physical therapist. The patient also demonstrated improvements in functional ambulation outcome measures. **Discussion:** There is currently limited research describing the use of physical therapy in patients with PTS, which can have a significant impact on the long-term function of patients. This 39-year-old patient with PTS demonstrated positive outcomes in terms of improved independence, function, and ability to ambulate over the course of his care. Further research evaluating the effectiveness and potential benefit of physical therapy interventions is needed in individuals with PTS.

Background:

Syringomyelia is a disease characterized by a development of a fluid filled cyst or syrinx in the spinal cord. The development of syringomyelia has been linked to several pathologies including Chiari malformation, inflammation to the spinal cord from cases such as arachnoiditis, a trauma to the spinal cord, or it can be idiopathic. The term post-traumatic syringomyelia (PTS) is the development of a cyst or cavity formation secondary to a trauma to the spinal cord. The syrinx tends to develop from the center of the spinal cord outwards. The development of neurological symptoms such as new motor deficits or a new type of pain are the primary initial symptoms in PTS. Other deficits commonly include sensory impairments, dysesthesias, and gait abnormalities[1].The overall incidence of symptomatic PTS is approximately 4% in individuals with spinal cord injuries (SCI)[2]. However, the occurrence of a syrinx may be up to 28% when including asymptomatic individuals[3].The time between the trauma and onset of PTS is widely variable ranging 1 month to 46 years[1].

Currently, the etiology of PTS is not well understood, and several theories exist for the development of PTS. One potential theory focuses on the obstruction of cerebral spinal fluid(CSF). Trauma to the spinal cord may lead to a development of arachnoid scarring, which can alter the flow and pressure of the CSF into the subarachnoid space[4]. Additionally, arachnoiditis may in part explain the development of PTS. Arachnoiditis can occur with insult to the spinal cord, and in animals, arachnoiditis leads to an increase in inflammation and scarring in the parenchyma. This additional damage to the parenchyma may alter the flow of CSF resulting in the development of a cyst[5]. A different theory, the intramedullary pulse pressure theory, states that the syrinx may consist of extracellular fluid not CSF. Adhesions or fractures from trauma to the spinal cord may cause an obstruction in the subarachnoid space creating a relative increase of pressure in the spinal cord compared to the subarachnoid space distal to the obstruction. The increase in pressure may cause distension of the spinal cord where extracellular fluid accumulates, and the development of the syrinx occurs[6].

Surgical management is a common intervention strategy for individuals with PTS. Indications for surgery include deteriorating neurological function, increase in pain, and autonomic dysreflexia. The surgical management of PTS primarily focuses on restoring the normal flow of CSF. Several methods of surgeries exist including shunting, laminar decompression, and cordectomy. PTS can have a significant impact on a patient’s overall function and neurological status with variable response after surgical intervention. A retrospective study by Karam et al. found that 52% had improvement in symptoms, 37% had no change, while the neurological symptoms in 22% patients worsened[7]. Along with variable neurological response, PTS can have a high recurrence rate, especially in incomplete SCI. individuals with incomplete spinal cord injuries (AIS C or AIS D) had the worse rates following decompression with reoccurrence in 38% and 74% at 5 and 10 years respectively[1].

Currently, there is limited literature of the effectiveness and impact of physical therapy (PT) on PTS. One small retrospective study compared surgery versus conservative rehabilitation and found individuals who were not suitable for surgery and only had rehabilitation had better neurological function than those treated with a syringo-subarachnoid shunt[8]. The database Pubmed does not contain literature for post-surgical rehabilitation of PTS. With the significant impact of PTS on a person’s neurological system, PT following surgery may be beneficial to promote independence, mobility, and function. The purpose of this paper is to describe the overall outpatient PT management following surgical management of recurrent spinal cysts in a patient with PTS.

Case description:

The patient is a 39-year-old male who had a medical diagnosis of spastic paraplegia (T11 AIS D) resulting from PTS. The patient was initially diagnosed with a traumatic brain injury resulting from a motor vehicle accident nine years prior to the most recent surgery. Nine months following the accident the patient required T2-T4 laminectomies and fenestration of an intradural arachnoid cyst due to tethering of the spinal cord resulting from the accident. Through rehabilitation, the patient became independent with all mobility and activities of daily living (ADL) until two years ago where an additional spinal cyst was discovered. He was initially treated with a syringopleural shunt and fenestration at the T-10 spinal level. Over the next 15 months, additional spinal cysts formed, and the patient required three additional surgeries. The surgeries were performed to resect the cyst and convert and revise the shunt to a syringo-subaracnoid pleural shunt. The most recent procedure was an additional syringo-subarachnoid shunt procedure to attempt to reduce the cyst.

Following the most recent surgery, he was admitted into acute care for eight days, where he was then transferred to inpatient therapy. The patient stayed at inpatient therapy where he received both PT and occupational therapy (OT) for three hours a day for ten days. The patient was discharged home and was referred to outpatient PT, which he began three days later.

Following the surgery two years ago, the patient returned to ambulation with bilateral Lofstrand crutches and an ankle foot orthotic (AFO) on his right leg due to persistent right foot drop. The patient was still independent with ADLs and self-care. The patient's functional status had declined throughout the multiple surgeries with him requiring minimal assistance for transfers and bed mobility prior to the most recent surgery. The patient was primarily using a manual wheelchair for mobility and did ambulate with a rolling walker, a posterior leaf spring orthotic on his right lower extremity, and moderate assistance prior to the most recent surgery.

The patient's primary goal from physical therapy was to be able to walk again with Lofstrand crutches and his right AFO, similar to what he was doing prior to the most recent round of surgeries. In addition, the patient wanted to become as independent as possible with his transfers, mobility, and other ADLs.

Clinical impression I:

Based on the patient's diagnosis, it was expected that he would present with numerous neurological deficits associated with PTS. From the history and systematic review, the patient was expected to have impairments of bilateral upper extremity and lower extremity strength, decreased range of motion (ROM), spasticity and clonus, and impaired sensation. These impairments are associated with functional limitations, such as limiting the patient's ability to ambulate, transfer, stand, and perform ADLs. The following examination set a baseline measurement for the listed impairments including assessing strength, ROM, sensation, and spasticity. Additionally, other tests assessing function would be used including assist with mobility, the Kansas Functional Outcome Measurement Tool (KUFO), and the Tinetti.

The patient was a good candidate for the case report due to the limited literature on PT interventions for individuals with PTS. Currently, no guidelines exist for the management of PTS in the American Physical Therapy Association. Additionally, the patient had a significant decline in neurological function following the multiple surgeries to resect the cysts and place and revise the shunts. The patient was also highly motivated to return to his prior level of walking and become as independent as possible.

Examination:

The PT examination was conducted approximately three weeks after the patient's surgery. The patient exhibited significant strength deficits bilaterally, however, they were difficult to accurately assess secondary to spasticity and clonus. There was high spasticity present in his knee extensors and hip adductors in both lower extremities. The patient also had clonus in both of his lower extremities during ankle dorsiflexion. The patient's passive ROM was significantly limited due to the spasticty and clonus. Sensation and proprioception was absent throughout his right lower extremity and decreased in his left lower extremity, abdomen, and chest. The patient had some sense of proprioception with left knee flexion and extension.

Functionally, the patient was modified independent for all bed mobility requiring increased time and bilateral upper extremity assistance to manipulate his lower extremities. The patient required supervision for lateral scoot transfers to and from the wheelchair to the mat without the use of a sliding board. He exhibited fair sitting balance without upper extremity support and the patient was able to stand with moderate assistance and with the use of a standard walker. The patient was unable to ambulate or take any steps during the examination and used a manual wheelchair for all mobility.

Due to the ease of administration and the inclusion of bed mobility and transfers, the Kansas University Acute Care Functional Outcome Tool (KUFO) was initially used to examine functional mobility where the patient scored a 11/28. The Tinetti was also used to assess balance and with the goal of eventually assessing gait. The patient also had performed the Tinetti from rehabilitation just prior to the most recent surgery for a comparison to prior level of function. At baseline, the patient scored a 1/28. Additional functional outcome measures such as the Timed Up and Go (TUG), 10 Meter Walk Test (10 MWT), and Spinal Cord Injury Functional Ambulatory Inventory (SCI-FAI) were not performed at this time due to the patient's inability to ambulate.

Clinical impression II:

After the examination, the initial impressions were consistent with the expected neurological deterioration as the patient presented with impairments in strength, sensation, spasticity, transfers, and gait. The patient was appropriate for physical therapy to address those deficits and progress towards the patient's own goals of improving his ability to walk on his own with Lofstrand crutches and become more independent. The plan of care included gait training with both robotic assisted gait, and once able to, overground training. Additionally, task specific training with transfers, FES cycling, and passive stretching were included to improve function and reduce spasticity. As the patient progressed, gait specific outcome measures to quantify walking speed and functional mobility were included such as the TUG, 10 MWT, and SCI-FAI. The patient was an appropriate candidate for this case report because of his high motivation and expected neurological impairments from PTS and the resulting surgery.

Intervention:

The patient was seen for PT three times a week for an hour each session. The patient also received OT twice a week for an hour each session. The interventions primarily focused on improving the patient's ambulation and overall mobility to promote independence, which were consistent with the patient's primary goals. The procedural interventions included, gait training (both robotic assisted and overground), FES cycling, task specific training (including standing and transfers), and stretching. With this patient, one treatment session was focused on robotic assisted gait training, one on PROM and FES cycling, and one that included a more traditional physical therapy such as overground gait training, task specific training, and PROM. At this facility, the occupational therapists focused primarily on the rehabilitation of the patient's upper extremity and sitting balance. Communication and documentation of the patient's care was discussed between PT and OT both daily through notes and interdisciplinary discussion, and at weekly team meetings.

Gait training was a large focus of our intervention to promote functional independence. The gait training was initially performed only using robotic assistance from the Hocoma Lokomat (Fig.1) one treatment session a week. The patient had begun use of the Lokomat during his inpatient stay, and it was continued during his outpatient rehabilitation. Parameters of the gait training that were adjusted per patient tolerance included body weight support, guidance force, and speed. The patient had some fluctuation in parameters secondary to activity tolerance and changes in spasticity throughout his

Figure 1. Hocoma Lokomat device. https://www.hocoma.com/us/solutions/lokomat/

treatment. The patient was on the Lokomat between 17-30 minutes depending on his tolerance. As the patient progressed, the speed of the Lokomat was increased with guidance force and body weight support being reduced as the patient tolerated. The patient required verbal cueing for ankle dorsiflexion on bilateral swing phase. The patient occasionally triggered the Lokomat emergency switch secondary to increased clonus and spasticity.

The patient began over-ground gait training at week 3 in the parallel bars. Starting at week 8, the patient was able to tolerate gait training outside of the parallel bars. The patient began ambulation on smooth indoor surfaces with a rolling walker, bilateral metal upright orthotics, right foot slider, and moderate assistance of two to help with limb advancement and foot clearance. The bilateral metal upright orthotics were used to help reduce clonus and right toe drag. Level of assistance was decreased throughout the treatment sessions as the patient was able to progress to minimal assistance of one. As the patient progressed, his parents were educated on how to assist the patient with ambulation. He began to ambulate at home two times a day.

One treatment day generally focused on the reduction of spasticity. The patient began treatment with passive ROM to the patient's adductors, hamstrings, ankle plantar flexors to help reduce spasticity, improve lower extremity range of motion, and prevent contractures. The stretches were performed bilaterally for 3 sets of 30 seconds. Following passive ROM, FES cycling was primarily used once a week during his plan of care to help address spasticity and promote functional endurance. The patient was strapped onto the RT300-SLSA FES cycle. Electrodes were placed on the patient's quadriceps, hamstrings, and glutes with stimulation intensity increased to a strong motor contraction within the patient's tolerance. The patient performed the FES cycle one time a week for 30-40 minutes.

Task specific training was also included throughout the patient's plan of care to promote independence. The patient was modified independent with bed mobility at the initial evaluation, so the primary focus was on transfers and standing. At the beginning of his treatment, the patient was educated on and practiced scooting to and from his wheelchair without use of a sliding board. As the patient increased his tolerance, the patient progressed his standing balance from moderate assistance to contact guard assistance from therapist.

Outcomes

After both week 17 and week 28 of rehabilitation, the patient demonstrated improvements with balance, independence, and functional mobility. The patient exhibited improvements with the amount of assistance needed to transfer, stand, and ambulate. The patient's balance and endurance associated with sitting and standing also improved. During his initial evaluation the patient was able to stand for two minutes with moderate assistance until he required a rest break. The patient progressed to being able to stand for five minutes with stand by assistance. After 17 weeks the patient was able to ambulate up to 100 feet before requiring a rest break due to fatigue and progressing up to 150 feet at week 28. The qualitative assessments are detailed in Table 1.

Improvements were seen in the functional outcome measures that assessed balance and functional mobility. The patient showed an improvement on the KUFO from 11/28 to 19/28. No reports of validity and reliability of the KUFO could be found for spinal cord population. The patient also demonstrated an improvement on the Tinetti of 1/28 to 11/28 at week 17, progressing to 12/28 at week 28. The Tinetti has not been examined in a spinal cord population, however, it has been found to have moderate to excellent correlation in subjects who had shunt surgery for hydrocephalus (r=.59)[9]. The patient had significant improvements with gait. The patient was unable to take any steps at the initial evaluation. After 17 weeks of therapy, the patient was able to ambulate with the use of walker, a metal upright AFO on both ankles, and minimal assistance. The patient was able to complete the 10 MWT and TUG after 17 weeks. The patient performed the 10 MWT in 60 seconds for an average speed of .167 m/s. The 10 MWT has excellent test-retest reliability and inter-rater reliability (Table 2) in patients with spinal cord injuries[10]. The test has moderate to strong construct validity with the WISCI-II and the TUG (Table 2). At week 28 the patient had improved his 10 WMT score to 47 seconds and .213 m/s. He performed the TUG in 57 seconds at week 17, which indicates that he is a high fall risk and that he has impaired mobility. He improved to 48 seconds at week 28, however was still considered a high fall risk. The TUG also has excellent test-retest and inter-rater reliability in a spinal cord population (Table 2).[10]

Table 1. Assessment of function at admission, week 17, and week 28.

	Admission	Week 17	Week 28
Transfers	- Supervision with lateral scoot	- Modified Independent with lateral scoot	- Modified Independent with lateral scoot
Sitting balance	- Fair static balance - Poor dynamic balance	- Good static balance - Fair dynamic balance	- Good static balance - Good dynamic balance
Standing	- Sit to stand: Moderate assistance - Excessive weight bearing through UE on standard walker with moderate assistance - Standing tolerance: 2 minutes	- Sit to stand: Minimal assistance - Excessive weight bearing through UE on standard walker with minimal assistance - Standing tolerance: 5 minutes	- Sit to stand: contact guard assistance - Excessive weight bearing through UE on standard walker with no assistance - Standing tolerance: 5 minutes
Gait	Unable to ambulate	-Ambulates with bilateral metal uprights and rolling walker. -Bilateral LE foot slide/drag -Increased weightbearing through UE -Max gait distance = 100 ft. -Minimal assistance -Clinic only	-Ambulates with bilateral metal uprights and rolling walker. -Bilateral LE foot slide/drag -Increased weightbearing through UE -Gait distance = 150 feet -Minimal assistance -Clinic and at home
Sensation	- Absent sensation to right LE. - Impaired sensation to abdomen, chest, and left LE. - Absent proprioception on R LE - Impaired proprioception with left knee flexion/extension	- Unchanged	- Unchanged

Table 2. Reliability and Validity of functional measures in the spinal cord injury population.

	Test retest	Inter-observer	MDC	MCID	Construct Validity
10 MWT	r=.983	r=.974	.05 m/s	.13 m/s	WISCI ρ=-.68 TUG r=.89
TUG	r=.979	r=.973	3.9 s	10.8 s	10 MWT r= .89
SCI-FAI	ICC=.850-.956	ICC= 100% agreement on assistive device and temporal distance. ICC =.703-.840 for gait score	.7 points	1.9 points	Gait speed r=-.74 Self-report walking mobility r=.679

The SCI-FAI was included due to its ability to assess multiple components of gait. The SCI-FAI assesses three main categories of gait including gait parameters/symmetry, use of an assistive device, and a temporal distance components of gait. The SCI-FAI gait score has moderate to strong correlation with the gait velocity (Table 2). The SCI-FAI has excellent test-retest reliability (Table 2). The SCI-FAI had 100% agreement for the assistive device use and temporal distance measure and moderate to strong intra-observer reliability for the gait score (Table 2). At 17 weeks the patient received a score of 8/20 on the gait parameters, 8/14 on the assistive device component and 1/5 on the temporal-distance components. The patient improved on 2/3 components at the most recent assessment with scores of 14/20 on the gait parameters and 2/5 on the temporal-distance component with the patient remaining at 8/14 for the assistive device component. The 6-point improvement on the gait score surpassed a clinically significant threshold of 1.9 points[11].

Discussion

The purpose of this case report was to describe the PT management for an individual with PTS. The interventions were primarily focused on improving ambulation, independence, and reducing spasticity in conjunction with the patient's own goals and deficits. This author could not find any research or case reports on any specific rehabilitation interventions on PTS, so the results are not easily compared to other individuals. The patient showed significant improvements in function and independence with improvements associated with decreased assistance for transfer, ambulation, and standing. The patient also demonstrated improvement with sitting balance and endurance associated with standing. While improvements were noted in sitting balance and endurance, the associated OT may have been an important driving factor.

Most of the research conducted has been in a more general spinal cord injury population. As he was not able to initially ambulate, all the ambulatory outcome measures were to be zero at initial evaluation for the 10 MWT, TUG, and SCI-FAI. Overall, he showed improvements during his rehabilitation with ambulation as he progressed in the clinic and at home with assistance. While he demonstrated improvements from week 17 to week 28, those improvements were not clinically significant[10]. From a baseline of zero, the change in walking speed the 10 MWT would be clinically significant. This result is similar to a systematic review by Lam. who found that Lokomat training had a significant improvement on gait velocity compared to no interventions[12]. This patient also demonstrated clinically significant improvements with the level of functional mobility and independence with ambulation as determined by his SCI-FAI gait scored. While this patient performed both robotic and overground training, Robotic assisted training has been shown to improve functional mobility and independence compared to gait training alone[13], however this patient received both robotic assisted and overground gait training. While the patient experienced some improvement with gait, the overall functionality of his everyday gait is still limited. The patient still requires assistance with ambulation at home and in the clinic and therefore unable to ambulate on his own.

The patient demonstrated improvements in both the KUFO and the Tinetti. Since his gait was first assessed at week 17, a more appropriate outcome measure than the KUFO or the Tinetti to assess this patient's functional mobility might have been the WISCI-II as it has validity and reliability in a spinal cord injury population. The WISCI-II assesses gait based on assistance devices, bracing, physical assistance, and distance. The index progresses from the patient being unable to ambulate, level 0, to level 20, which indicates they can walk 10m with no bracing, assistance device, or physical assistance. The WISCI-II exhibits excellent inter reliability in the chronic spinal cord population with a ρ =1.0. This tool would have been appropriate for this patient as it would be measurable for his entire plan of care since it captures being unable to ambulate[12].

One focus of this case was to reduce the amount of spasticity to improve function and gait in the patient. FES has been shown by some researchers to reduce spasticity in spinal cord patients. One study looking at chronic incomplete SCI patients found that spasticity was reduced in the rectus and hamstring at sixth months after FES cycling[14]. Additionally, studies by Krause et al. and Reichenfelser et al. found that FES cycling may lead to reduced Modified Ashworth scores in the quadriceps[15,16]. However there is conflicting studies which have found that FES cycling does not reduce spasticity in lower extremity musculature[17,18]. Stretching was also performed in this patient to help prevent contracture, improve range of motion, and reduce spasticity. Stretching has shown to a more immediate effect on contractures and stiffness[19]. While stretching is a commonly used as a therapeutic modality for spasticity currently there is inconclusive evidence on the effectiveness of stretching on spasticity[20]. While FES cycling and stretching are commonly used clinically for spasticity management, further research is needed to accurately determine their effectiveness in the SCI population. A weakness of this case report was the lack of systematic assessment of spasticity, which can have a large impact on gait and function. Modified Ashworth scores should have been included at initial evaluation and future assessment to allow a more accurate assessment of any change in spasticity potentially associated with treatment.

This case report examined an overall outpatient PT management for PTS following a shunting procedure. This patient did demonstrate improvement in terms of function and mobility. At publication of this case report, the patient was still receiving PT but was discharged from OT. Rehabilitation management of PTS has been sparsely described in the literature. Further research addressing the effectiveness of specific interventions for individual with PTS is warranted. Additionally, with the high recurrence rate of syringomyelia following surgeries, further research examining the differences between conservative treatment and surgical management is warranted.

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