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The Trials of Transverse Myelitis: A Case Study

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THE TRIALS OF TRANSVERSE MYELITIS: A CASE STUDY

by

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A Scholarly Project Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

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in partial fulfillment of the requirements for the degree of

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This Scholarly Project, submitted by Catherine Heggie 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 Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.


(Graduate School Advisor)


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ABSTRACT

Background and Purpose: Idiopathic acute transverse myelitis (ATM) is an inflammation in the spinal cord that develops suddenly. In the span of a day, an individual can lose all motor control. Most of the time the motor impairment is not permanent and strength can return as the inflammation dies down. However the physical rehabilitation component of recovery is remarkably unstudied. **Case Description:** This case report details the hospital stay of a young man with ATM from the perspective of his physical therapists. When evaluated, the patient had only trace (1/5) muscle strength in some of his extremities. **Intervention:** Physical therapy intervention included passive range of motion progressing to resisted range of motion, postural muscle strengthening, and patient education. **Outcomes:** As the patient participated in physical therapy, motor control and strength improved. After two weeks of therapy, he was medically stable enough to discharge to an intensive rehabilitation facility. At discharge he had at least 3/5 strength in all of his extremities. **Discussion:** Following up on the improvement that was seen in this patient as he received physical therapy, the case report suggests future directions for researching physical therapy and acute transverse myelitis

CHAPTER I

BACKGROUND AND PURPOSE

Transverse myelitis (TM) is an inflammation in the spinal cord that destroys the myelin in the central nervous system (CNS), according to the National Institute of Neurological Disorders and Strokes (NINDS).¹ In most cases, researchers do not know what initiates the inflammation response. It can develop in correlation with diseases such as syphilis, measles, and Lyme disease and viral infections such as chicken pox, herpes, cytomegalovirus, influenza, human immunodeficiency virus, hepatitis A, and rubella. Further complicating the matter, transverse myelitis can develop after receiving some vaccinations including the one for chicken pox. When the initiating agent is unknown, it is considered "idiopathic" transverse myelitis. Even when TM is associated with an infection, the damage to the nerves does not come from the infecting agent but rather the immune system itself.

Over a span of hours or days from the initiation of the immune response, the patient loses motor control of the extremities. Depending on where the inflammation is, the individual may also lose bowel and bladder control and even diaphragm control. While the symptoms normally begin to dissipate within a few weeks to months of appearing, the individual may never fully recover. Medical treatments for ATM is not standardized and includes plasmapheresis, corticosteroids, intravenous immunoglobulin, and chemotherapy.² With plasmapheresis, that patient's blood is removed and the red blood cells filtered out, leaving behind the plasma and problematic antibodies. The patient's red blood cells are then

combined with donor plasma and returned to the body. Research has suggested that plasmapheresis is effective in treating TM.³

As cited in an article by the Transverse Myelitis Consortium Working Group and published in 2002, ATM affects 1 to 4 people per million each year.⁴ According to this article, there are 2 peak age ranges where ATM is seen: 10 to 19 years old and 30 to 39 years old. The NINDS states that the prognosis for about one third of patients with TM is full to good. These individuals likely return to full or near-full functioning. An additional third of patients experience only fair recovery and a final third of patients experience no recovery at all.¹

Physical rehabilitation of patients with TM is remarkably unstudied. A research study published in a 2011 states that it was the first study to examine the efficacy of physical rehabilitation on patients with acute transverse myelitis.⁵ The study, which did not have a control group, did find a significant correlation ($p < 0.05$) between physical therapy and improvement in the patients' spasticity, Functional Independence Measure score, and Functional Ambulatory Scale score. A search for "Physical therapy" and "transverse myelitis" in the PubMed database supported the article's claim to be the first published research article on physical rehabilitation in TM. The purpose of this case report is to explore the journey to recovery that the following patient was on and to shed light on this rare neurological disorder. The focus will be on physical therapy's role in the rehabilitation aspect, specifically.

CHAPTER II

CASE DESCRIPTION

Examination, Evaluation, and Diagnosis

Joseph (name changed) was a patient admitted into a hospital in a large city on the West Coast and subsequently diagnosed with acute transverse myelitis (ATM). The patient was a 34-year-old Korean man without a remarkable previous medical history. Prior to the development of the ATM, he was healthy and active. His primary language was Korean, but he spoke near-fluent English. His family included his wife and 2 children, a 2-year-old and a 4-year-old. His immediate and extended family and friends were obviously very supportive. While his education level is unknown, he worked as the main financial supporter of his family as a software engineer for an international software company. According to the patient's report, the nature of his work allowed him to sit down for most of his workday. He described himself as a fairly active young man. He lived in a home in a large West Coast city with his family.

According to Joseph, he traced his symptoms back to doing yard work on one fall evening. He said his back and shoulders started hurting while he was working. Three days later, in the early evening, his pain was increasing and he went to see an acupuncturist. Following the acupuncturist session, he felt lightheaded and began to develop weakness throughout his body. His wife brought him to the ER where he reported numbness in all

extremities when he arrived. Then, when he was trying to transfer from a wheelchair to a bed in the ER, he briefly passed out. This spurred his hospital admittance for observation and diagnosis.

For the first 2 days in the hospital, Joseph's condition remained undiagnosed. A doctor even noted that the imaging looked "reassuring" because there was no indication of "an anomaly such as transverse myelitis." However, on his third day in the hospital, the diagnosis of idiopathic acute TM was finally made based on a subtle cord-enhancing lesion seen in his cervical spine. He began 10 days of plasmapheresis to facilitate his improvement. After two weeks, he was stable enough that he was discharged to an intensive rehabilitation facility to concentrate more fully on recovering his functional mobility.

His initial review of systems, done in the ER, was clear other than weakness and loss of some sensation in all extremities. According to his admission notes, he originally developed bradycardia and hypotension while in the ER. This was treated by administering 3 L of saline bolus. He continued to struggle with low blood pressure throughout his time in the hospital. His physical therapists kept a careful eye on his vitals. At times he would complain of dizziness with a change in position. He was consistently able to maintain O₂ saturation above 92%. He weighed 68.04 kg on admission and was 1.7 m tall, giving him a BMI of 22.81 kg/m.

On admission, the patient was not on any medication. Once the TM diagnosis was made, he was administered 1 000 mg of Medrol (methylprednisolone) every 24 hours intravenously. This steroid was used to limit the inflammation in his spinal cord. The only potential side effect directly related to therapy is the possibility of mild muscle pain. Other side effects related to short-term (less than 3 weeks) steroid use include mood changes,

sodium retention, and gastrointestinal and blood sugar problems.⁶ He also went through 5 treatments of plasmapheresis in 10 days. That treatment often left him completely exhausted and he missed a couple of therapy sessions due to that.

Throughout this process, the patient's cognition was unaffected. He was always fully oriented. He showed consistent effort in therapy, fighting so hard for each movement. He listened well and would request handouts with exercises that he could show his family so that they could work with him between therapy sessions. Every once in a while, the language difference would become apparent when a therapist would use a term with which he was unfamiliar. As he improved, the therapist gave him more control of each treatment, encouraging him to choose what he wanted to work on.

The sudden loss of all independence was obviously very hard on Joseph. However, during his hospital stay, he remained remarkably calm and friendly. He showed no signs of clinical anxiety or depression. His concern over the disease and what function he would gain back was all within what was expected. He seemed very well supported socially and spiritually. Throughout his hospital stay, his friends and family members kept him supplied with his favorite healthy foods that he did not need any hospital food. His wife and his extended family even asked to be instructed in active assisted range of motion (AAROM) so that they could work with him when he was not working with therapy. It was normal for the physical therapist to arrive to work with him and to find 6 family members in the room with him. Despite his close relationship with his friends and family, he always put time with his physical and occupational therapists first. His family medical history is unremarkable.

The physical therapy examination was on his third day in the hospital and began with a review of his electronic medical records. Throughout his stay in the hospital, he was

seen primarily by me (a physical therapy student) and my clinical instructor. His disease had been diagnosed earlier in the day. His diagnosis was noted, as was his hypotension. Earlier in the day, a hospitalist had noted that on the left side he lost cold sensation at C4 and sharp sensation at C6; all sensation below that was lost. On his right side, he lost cold sensation at T1 and sharp sensation at T2. All sensation below that was absent except for the ability to sense noxious stimuli in the right lower extremity. Additional sensory testing was not performed by the PT. No range of motion (ROM) deficits were noted.

The physical therapy examination revealed profound weakness. Table 1 contains the results of general manual muscle testing. Manual muscle testing has been shown to correlate significantly with myometer strength assessment (r ranged from 0.59 to 0.94 depending on muscle being tested. $P < .001$).⁷ Manual muscle testing has been found to have excellent interrater reliability (0.88, 95% CI [0.75-0.94]).⁸ While his trunk muscles were not directly assessed, he was able to sit on the side of the bed only if he had maximum assistance. Even with full support, he was able to sit for only 8 minutes before exhausting. He was nearly completely dependent in bed mobility. When a therapist rolled him onto his right side, though, he would hook his left arm through the bed rail and could hold himself there. Balance could not be tested, as strength was the limiting factor; he was unable to hold himself up in sitting.

Table 1. Manual muscle testing initial examination results.

(L) Side	Initial Exam Grade	(R) Side	Initial Exam Grade
Shoulder:	3/5	Shoulder:	1-/5
Elbow flex/ext.:	3-/5	Elbow flex/ext.:	2+/5
Wrist flex/ext.:	2/5	Wrist flex/ext.:	2/5
Fingers:	1/5	Fingers:	0/5
Lower Extremity:	0/5 throughout	Lower extremity	0/5 throughout

Joseph's medical diagnosis of acute transverse myelitis had finally been made. The PT examination findings supported the medical diagnosis and most of the symptoms of his pathology manifested in his musculoskeletal system. The physical therapy evaluation concluded that the patient had quadriplegia as a result of his TM. His ROM was all within normal limits but he was unable to move any of his limbs except his left arm. He had a small amount of control over his left shoulder musculature and elbow extensors.

From a functional perspective, he was initially dependent in all activities of daily living (ADLs). He was unable to take care of himself or move independently. Playing with his children, helping around the house, or working was currently out of the question. Finally, due to his decreased sensation and the insult to his spinal cord, he was at risk for autonomic dysreflexia and also orthostatic hypotension.⁹

Joseph's functional mobility was quantified using Boston University's 6-Clicks Activity Measure-Post Acute Care (AM-PAC) Inpatient Basic Mobility Short Form¹⁰ (Table 2). The minimal detectable change for the AM-PAC has been established as 4.28 for the

Basic Mobility section and 3.70 for the Daily Activity section¹¹. Andres et al found the test-retest reliability to be excellent (0.91 to 0.95) for multiple settings.^{12,13} His problem list was: 1) severe generalized weakness, 2) dependence for mobility, 3) dependence in ADLs, 4) sensory loss, and 5) fatigue.

Table 2. Results of Joseph's 6-Clicks AM-APAC at his initial evaluation.

Basic Mobility How much difficulty would the patient have...	Unable (1 point)	A lot (2 points)	A little (3 points)	None (4 points)
1. Rolling in bed	X			
2. Moving from supine to sitting	X			
3. Moving from sit to stand	X			
Daily Activities				
How much help does the patient currently need...				
4. Transferring from a bed to chair	X			
5. Walking in the hospital room.	X			
6. Walking up 3-5 steps	X			
Score	6/24			

Prognosis and Plan of Care

Originally, Joseph's prognosis was guarded. Only a third of individuals that are diagnosed with TM make a good or full recovery¹. The hope was that he would be one of those. If not, he may need ongoing help with ADLs. As therapy progressed, his strength appeared to be returning to his proximal muscle more quickly than to his distal muscles. If

he did not regain full use of his hands, he may not be able to return to his job as a software engineer.

The goal for the hospital therapists was to facilitate as much progress as possible in the time that he was in the hospital. His hospital stay was intended to be short. The immediate objective was more about getting him medically stable and limiting the extent of the inflammation than physical rehabilitation. As muscle control began to return, qualifying for an intensive rehabilitation facility became the long term goal of the therapy team. Joseph also had the goal of standing with only minimal assistance. Initially, the short-term goal was to see each muscle group show trace strength within 7 days of initiating therapy. Another short-term goal was to facilitate standing with a standing and raising (SARA) lift so that he could begin weight bearing again. Physical therapy was planned as hour-long sessions 7 days a week.

At the beginning of each physical therapy session, we did a quick re-evaluation by asking Joseph how he was feeling and if he had seen any improvement in the last day. We then ran through a quick assessment of movements at each joint of the extremities by seeing what Joseph could move voluntarily.

Specific interventions were limited by his weakness and decreased endurance. Sitting on the edge of bed with progressively decreasing support was used to strength his trunk muscles. Extremity strengthening started out with passive range of motion (PROM) in proprioceptive neuromuscular facilitation (PNF) patterns. As he regained muscle control, this progressed to active assisted range of motion (AAROM). Intervention also included patient education and provision of 3 orthotic devices: Pressure Relief Ankle Foot Orthosis (PRAFO) boots, abdominal binder, and right hand splint.

CHAPTER III

INTERVENTION

Physical therapy treatment started with bed mobility exercises. We would help the patient roll in bed, encouraging him to think about each movement the therapist was doing with him. As he gained more control, this progressed to him managing his upper body and the physical therapists helping him with his legs. Most days, we led Joseph through side-to-side rolling 4 times each session. The permanence of his quadriparesis was unknown. The objective of doing bed mobility exercises was twofold: it was an unthreatening place to start and it began restrengthening the muscles that Joseph needed to prevent bedsores.

Postural control exercises were also a primary focus from the initiation of rehabilitation. One therapist would kneel on the bed behind Joseph to support him as he was sitting on the edge of the bed. The second therapist stood in front of him as a safety precaution. The therapist on the bed would gradually lessen her support and allow Joseph to slump over to one side. As his torso leaned over, the therapist encouraged him to use his torso muscles to control his progression. When his ipsilateral elbow touched the bed, the therapist then moved him back to neutral while encouraging him to use his contralateral trunk muscles to do as much of the work himself as he could. The patient did 8 repetitions on each side for 2 sets, initially.

As Joseph regained some upper extremity control, we progressed him to reaching movements. The therapist that was standing in front of him held a hand up in front of him

that was far enough away that he had to move his torso to reach it. The therapist behind him provided most of the torso support but Joseph progressed to initiating the lean and reach independently. The therapist in front of him randomly repositioned her hand each time to encourage reaching both left and right and up and down. Joseph was able to reach about 6 times with each arm before fatigue limited him. This increased as he improved. Postural stability was an important objective in rehabilitation because for Joseph to return to his job, he would need to sit up at a computer and be able to move his arms to work his computer.

As the patient began regaining proximal muscle control, we progressed him to sitting without assistance and then to resisting forces applied by the therapist. Once again, there was a therapist in front of him for safety and a second therapist behind him. The therapist alternated between applying force to either humerus, his sternum, or his upper back. Joseph was instructed to isometrically resist the force. The therapist applied each force for about 3 seconds. As these were tiring for Joseph, they were often done in sets of 5 to 7 repetitions. There was the possibility that the patient would be wheelchair bound and so sitting endurance was also encouraged by transferring him to a chair with a mechanical lift and requesting that he sit there for 20 minutes before he asked nursing to transfer him back to bed.

Lower extremity rehabilitation initially focused on passive range of motion (PROM). When Joseph was supine in bed, one of us moved Joseph's leg from neutral to flexion at his hip and knee and dorsiflexion at his ankle before moving it back to neutral again. Throughout each movement, we encouraged Joseph to think about the movements and contribute as much as he could. We performed 2 sets of 10 repetitions on each leg in most sessions.

As Joseph regained more and more muscle control in his lower extremities, we progressed to active assisted range of motion (AAROM) in all movements of the hip, knee, and ankle. Joseph slowly progressed to do more and more of each movement on his own. Once he could do most of the movement on his own, one of the therapists began applying resistance as he moved through the motion.

A goal that Joseph had set for himself was to be able to stand. The hospital had a SARA lift that helped someone stand up from a sitting position by doing 75% of the work and providing a steady source of support. On Day 13, we had planned to attempt using the lift with Joseph to see if he could stand up with assistance. However, he was too fatigued at the end of the session to safely attempt it. On Day 14, when he was hours away from being discharged to the intensive rehabilitation facility (IRF), he asked try standing up again. With the assistance of only one physical therapist and the lift, he was able to stand up. Using a standing assistive device has been shown to correlate with a decrease in the complications for individuals with spinal cord injuries.¹⁴

Three orthotic devices were provided to Joseph by his physical therapists during his time in the hospital: Pressure Relief Ankle Foot Orthosis (PRAFO) boots, an abdominal binder, and a right hand splint. The PRAFO boots were to prevent pressure ulcers on his heels and to prevent a plantarflexion contracture. The therapists wrote a schedule for him that included 6 hours in the PRAFO boots, time for his calf sequential compression devices (as prescribed by the hospitalist), and time for his skin to rest. The objective of the abdominal binder was to provide assistance to his weak abdominal muscles and therefore make breathing easier. Finally, his right hand was taking longer to recover muscle control; the hand brace was to prevent a contracture.

In keeping with the driven personality that Joseph had displayed, on his 3rd day of therapy he asked for a list of exercises that his family members could do with him when he was not working with his therapists. A print off of PROM movements was provided to him. The movements included basic flexion and extension movements for both his upper and lower extremities. His family was instructed that they could do each movement with him in repetitions of 7 with sets of 3 up to 3 times a day.

Joseph was very attentive to any education from the physical therapists. Prior to his initial examination, we educated him on the role of physical therapy and the specific role that we were taking for his situation, namely, that we could not change what was happening in his spinal cord but that we were going to do our best to build up his strength and mobility as the inflammation decreased. Patient education also included the objective of the PRAFO boots, abdominal binder, and hand splint and instructions for wearing each of them. Any patient education that happened was documented in the daily note each session.

Communication between the patient's caregivers happened both in person and through his electronic medical record. Communication between his physical and occupational therapists was particularly intentional as both disciplines tried to time and coordinate each sessions. Joseph need a few hours to rest between physical therapy and occupational therapy so one discipline normally worked with him in the morning and the other in the afternoon. The case managers handled his application to the IRF.

CHAPTER IV

OUTCOMES

Joseph's hospital caregivers were not able to witness the full progression of Joseph's disease. After 14 days in the hospital, he was stable enough to discharge to an IRF. When he left the hospital, he was showing at least 3/5 muscle strength in all movements. His hip flexors, knee extensors, and dorsiflexors were all 4/5 strength on discharge (see Table 3 for more). He was also able to sit on the edge of the bed independently and stand up with the assistance of the SARA lift. He was not able to walk at that point but it looked like a realistic goal for the future.

Table 3. Comparison of MMT from initial and final examination.

(L) Side	Initial Exam Grade	Discharge Exam Grade	(R) Side	Initial Exam Grade	Discharge Exam Grade
Shoulder:	3/5	3/5	Shoulder:	1-/5	3/5
Elbow flex/ext.:	3-/5	3/5	Elbow flex/ext.:	2+/5	3/5
Wrist flex/ext.:	2/5	3/5	Wrist flex/ext.:	2/5	3/5
Fingers:	1/5	3/5	Fingers:	0/5	3/5
Lower Extremity:	0/5 throughout	4/5 throughout	Lower extremity	0/5 throughout	4/5 throughout

When Joseph's functional mobility was reassessed with the AM-PAC, he showed improvement but not enough for a clinically detectable change in either section (Table 4). He improved from 3/12 in Basic Mobility to 6/12 on discharge. This was a change of 3 points while the minimal detectable change has been established as 4.28.¹¹ He improved from 3/12 in Daily Activities to 4/12 on discharge. This was a change of 1 point while the minimal detectable change has been established as 3.7.¹¹

Table 4. Results of Joseph's 6-Clicks AM-APAC at his discharge.				
Basic Mobility	Unable	A lot	A little	None
How much difficulty	(1 point)	(2 points)	(3 points)	(4 points)
would the patient have...				
1. Rolling in bed		X		
2. Moving from supine to sitting		X		
3. Moving from sit to stand		X		
Daily Activities				
How much help does the patient currently need...				
4. Transferring from a bed to chair		X		
5. Walking in the hospital room.	X			
6. Walking up 3-5 steps	X			
			Score	10/24

Joseph was very satisfied with the progress that he saw in his time at the hospital and was prepared for the difficult work of an IRF. Standing with the SARA lift was a huge accomplishment in his mind and served as proof of how far he had come. However, seeing

how hard the simple act of standing up was also acted as a reminder of how far he still was from his baseline. He had demonstrated full compliance throughout his time in the hospital and it seemed likely that could be expected in the IRF, as well.

Due to the amount of improvement that was seen in such a short time I suspect that he will be in the one third of people with ATM who recover well. The hope for him is that he will be able to return to his work and all of his ADLs independently. However, in a study by Kalita and colleagues,¹⁵ severity of initial weakness when someone has ATM was significantly correlated with worse outcomes. While studies have shown that ATM correlates with the eventual development of multiple sclerosis, it is specifically partial acute transverse myelitis, not what this patient had.¹⁶

A formal quality of life (QOL) analysis was not administered to Joseph while he was in the hospital. However, an applicable option would have been the World Health Organization's Quality of Life - BREF. It is self-reported but Joseph would have needed assistance, as he was not able to hold a pen. The test is 26 questions and addresses physical, psychological, social, and emotional health.¹⁷ Construct validity, test-retest reliability, and normative data has been established (Table 5)

Table 5. Assessment of WHO-QOL-BREF

Construct Validity	<i>Significant</i>
Test-retest reliability	<i>Adequate to Excellent</i>
Normative Data	<i>Established</i>
Minimal Detectable Change	<i>Not established</i>
Standard Error of Measurement	<i>Not established</i>

CHAPTER V

DISCUSSION

The improvement that Joseph showed over 2 weeks was impressive. He progressed from barely having trace strength in a few of his muscles to conscious control over all movements and even being able to take resistance in some areas. However, it is unknown how much of that improvement was due strictly to the decreasing inflammation in his spinal cord. This was the same uncertainty that was seen in the only published research article on physical rehabilitation in patients with ATM. While the participants all showed significant improvement, there was no control group to distinguish the direct effect of physical therapy from the effect of steroid medication and plasmapheresis.

However, in a preliminary study of 4 people with multiple sclerosis, another central nervous system inflammation pathology, bicycling correlated with decreased inflammation markers in the patients' cerebrospinal fluid. These patients bicycled using functional electrical stimulation (FES) to stimulate the leg muscles that they did not have control over any more. The participants were asked to cycle for at least an hour 3 times a week. The study was too small to draw any definite conclusions but the patients did see a decrease in inflammatory marks in their CSF over 6 months.¹⁸ As research develops, this may be a way for physical rehabilitation to play a role in decreasing CNS inflammation.

The effect of physical therapy on the speed of the ATM's progression has not been shown in research, yet. Regardless of whether or not the physical rehabilitation portion of Joseph's treatment sped up his disease's progression, it did have a positive psychological effect. This was an intelligent man who was used to working hard and supporting his family and suddenly, he became completely dependent for every movement. Physical therapy gave Joseph a chance to participate in his own recovery. He got to feel like he was helping himself get better instead of just lying in bed as a victim of the disease process.

The results that we saw at discharge suggest that Joseph was, at least, in the top 60% of people with ATM that recover some or most of their function following the resolution of it.¹ The motor control recovery that he showed in the 2 weeks that he was at the hospital demonstrated that he would not be in the percentage of people who would not recover anything after ATM. His motivation and the full effort that he put into every PT session likely contributed to his recovery and would likely continue to contribute to his recovery in the IRF.

Reflective Practice

This was the first time I had ever encountered a patient with anything like ATM. I was a physical therapy student and my clinical instructor had graduated less 2 years ago. While we researched the disease prior to evaluating the patient, neither of us really understood the severity of the disease until we walked into the room. We had to apply our experience with stroke patients and other CNS pathologies to treat Joseph. However, as more research on rehabilitating patients with ATM is completed, therapists will be able to apply more pathology-specific interventions.

Future research could study different aspects of physical therapy that were present in Joseph's treatment. Did the PROM that we did with him have any benefit on him or would he have recovered just as quickly if we only worked on strengthening movements that he had at least trace muscle control over? Walking on a treadmill with body weight support has also been shown to have a positive effect on patients with a spinal cord injury.¹⁹ While the hospital that Joseph was at did not have the capabilities for that intervention, research suggests that it would have been helpful. Maybe the IRF that he was discharged to had the set up.

I also felt like the quality of our treatment was limited by time. Our daily treatment sessions with Joseph were limited to an hour. While that sounded like a long time, initially, it limited the complexity of our interventions. Research has shown the effectiveness of FES for patients with spinal cord injuries.²⁰ However, the time that it would require to transfer Joseph to a wheelchair, bring him to the physical therapy gym, transfer him to a stationary bike, and then apply electrodes to the appropriate muscles would have left us with only a few minutes of treatment time. Our intervention was also limited by Joseph's stamina as he exhausted quickly and needed rest breaks during the session.

In the future, there are things that I will do differently. I wish that we had have incorporated more standardized tests into our evaluation. At the initial evaluation, however, he was simply too weak to be able to move, limiting my applicable test options. Next time I will not limit special tests to just evaluation and discharge; I'll utilize them whenever the patient is strong enough to participate. I also wish that I had have maintained closer communication with Joseph's neurologist. Our knowledge of the inflammation progress

came from reading his notes and researching ATM. However, throughout this hospital stay, the entire focus was to get him medically stable enough to discharge to an IRF.

The full financial ramifications that this ordeal will have on Joseph are unknown. At the time of admission, he had insurance through his employer. However, we did not discuss with him what that covered. Using the online Medicare price calculator, Joseph's 10 days of physical therapy cost around \$1,270. That cost pales, however, in the context of his 14 days at the hospital and unknown length of time in the IRF. Joseph was in a situation where he was not able to debate the "necessity" of his hospital stay. I would judge that the necessity of the care that he received made the costs worth it.

Treating Joseph was originally only about that: treating him and facilitating improvement. However, as he progressed, I realized the fascinating potential he held as a possible case study. We established a professional friendship as his time in the hospital; I was invested enough in him as a person that I knew it would make writing a case study on him engaging. However, it was not until after he had discharged to the IRF and I started looking for research on ATM that I realized how unstudied it was. It was an eye opening experience with a fascinating pathology.

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