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Trunk Control And Standing Tolerance Of A Patient With Paraparesis As A Result Of Transverse Myelitis And Mycotic Aneurysm Rupture: A Case Report

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The patient signed an informed consent allowing the use of medical information and photographs for this case report and received information on the institution's policies regarding the Health Insurance Portability and Accountability Act.

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Abstract

Background and Purpose: Transverse myelitis (TM) is a rare condition in which the spinal cord becomes inflamed resulting in pain, paraparesis or paraplegia, impaired sensation, and/or impaired autonomic function. Approximately two-thirds recover with mild to moderate symptoms, but one-third are left with severe and disabling symptoms. Cerebral mycotic aneurysm (CMA) rupture is a brain injury due to a burst artery resulting in diminished blood supply to the brain. There is literature on beneficial physical therapy (PT) intervention progressions following brain injury, such as bed mobility strategies and pre-gait activities, but there is little published on PT for impairments as a result of concurrent TM and CMA ruptures. The purpose of this case report was to describe the PT interventions provided to a patient with paraparesis as a result of TM and multiple CMA ruptures to progress toward achieving his goals of standing and ambulating with a standard walker and bilateral knee-ankle-foot-orthoses (KAFOs).

Case Description: The 28-year-old male patient had been seen for two years at an outpatient clinic with an accredited brain injury program. The patient encountered several barriers throughout his rehabilitation, such as repairs to his KAFOs and low bone mineral density, which resulted in a decrease in standing tolerance over time.

Outcomes: The Brain Injury Assessment Tool (BIAT) and manual muscle testing were used to document changes throughout the patient's period of care. No significant changes were observed.

Discussion: This patient, despite minimal improvements over a two-year period, may have the potential to increase his trunk control and standing tolerance if he has an extended period of time with no barriers to his rehabilitation.

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Background and Purpose

Transverse myelitis (TM), also known as pan myelitis, is a condition where a segment of the spinal cord becomes inflamed and causes a variety of symptoms such as paraplegia, paraparesis, pain, diminished sensation, and urinary and bowel incontinence below the level of the inflamed segment.[1] It can occur insidiously, or following a viral or bacterial infection, and most commonly occurs in the mid-thoracic region in adults.[1,2] The peak incidence, regardless of gender or race, is 10-19 and 30-39 years old with approximately 1,400 new cases diagnosed in the United States each year.[1] Though there is currently no cure for TM, it is commonly treated with steroidal anti-inflammatory medications to decrease the inflammation in the spinal cord.[3] Only one-third of patients achieve a full recovery, which may take at least two years. Incomplete recovery, or no recovery, is more likely if there is no improvement within the first three to six months.[1]

A cerebral mycotic aneurysm (CMA), a form of stroke, occurs when a bacterial infection of a cerebral artery causes it to dilate, forming an aneurysm.[4] This added pressure on the arterial wall increases the risk that it will rupture, which would create an intracranial bleed and deplete the brain of oxygen. Mycotic aneurysms can occur in any artery throughout the body and are very rare, occurring only in 0.7% to 4.0% of people who have a cerebral aneurysm.[5] In those with a non-mycotic cerebral aneurysm, 46.5% to 76% reported decreased physical capacity.[6,7] Treatment ranges from intravenous antibiotics for small, intact aneurysms, to surgery and vascular repair for large or ruptured aneurysms.[5] Recovery and residual deficits range from no impairments to death and are dependent on the patient, location of the aneurysm, and the portion(s) of the brain affected.

There are many interventions available to help patients with deficits related to stroke. Schmitz[8] and O'Sullivan[9] describe interventions and progressions to improve trunk control, bed mobility, and sitting balance in *Improving Functional Outcomes in Physical Rehabilitation*. They state that these exercises and progressions are appropriate for patients who have spasticity or rigidity, spinal cord injury, and for those who are recovering from a stroke or traumatic brain injury to assist in maximizing their independence with activities of daily living and prepare for more complex skills.[8]

This patient was selected as the subject for this case report because of his rare combination of TM with subsequent multiple CMAs and multiple CMA ruptures. Though there have been studies published on the medical management of TM[3] and CMAs,[5] little has been published on the physical therapy (PT) management of the resulting chronic impairments of these conditions. Thus, the purpose of this case report is to describe the PT management of a patient with paraparesis secondary to TM and multiple CMAs.

Case Description: Patient History and Systems Review

The patient signed a consent form to allow this author to participate in his treatment, as well as a consent form to allow for his medical information and photographs to be used for this case report. This patient was a 28-year-old male with a history of TM, aseptic meningitis, and mycotic aneurysms of the right middle cerebral artery, distal left middle cerebral artery, lenticulostriate artery, right posterior cerebral artery, right superior cerebellar artery affecting the right caudate head, anterior right putamen and anterior limb, and right internal capsule. The patient's co-morbidities included obesity and osteoporosis, theorized to be associated with long-term prescribed corticosteroid use and prolonged periods of non-weight bearing. The patient had

been seen for the previous six years at an outpatient rehabilitation facility and was then referred to Maine Center for Integrated Rehabilitation (MCIR) to receive services through the Acquired Brain Injury (ABI) program for continued PT services to improve standing tolerance, increase strength and range of motion (ROM), and pain management. The patient's chief complaints were low back pain, right knee pain, and difficulty standing and ambulating with bilateral locking knee-ankle-foot orthoses[*] (KAFOs). The patient's goals were to stand and ambulate with a standard walker with bilateral locking KAFOs donned. The patient also received speech therapy (ST), occupational therapy (OT), and recreation therapy (RT) at MCIR. This author first met the patient approximately a year and a half into his treatment at MCIR. See Appendices 1 and 2 for information gathered from the patient history and systems review performed at the initial evaluation and at the final session with this author.

Clinical Impression 1

The patient presented eight years post-onset of impairments related to TM and multiple CMAs and CMA ruptures. There were no other differential diagnoses secondary to the chronicity of his condition. Following a patient history and systems review by this author, it was expected that the patient would present with deficits in bilateral lower extremity (BLE) ROM, strength, coordination, sensation, proprioception, difficulty with transfers and gait, and pain. Additional tests and measures to assess these areas included goniometric measurements, manual muscle testing (MMT), coordination assessment, light touch sensation, dynamic sitting balance, the numeric pain scale, and the Brain Injury Assessment Tool (BIAT).

[*] Townsend Design Custom Knee Ankle Foot Orthoses: Townsend Design, 4615 Shepard St, Bakersfield, CA 93313

The patient was a good candidate for this case report because of the paucity of literature on the PT management of individuals with chronic impairments related to TM and multiple CMAs.

Examination: Tests and Measures

Following a thorough patient history, an objective examination was performed as outlined by White[10] in *Physical Rehabilitation*. See Table 1 for the results of all tests and measures at admission and at the final session documented in this case report.

ROM values were obtained using a universal goniometer and adhering to methods as described by Norkin and White.[11] The bilateral upper extremities (BUE) were grossly within functional limits. Measurements were taken for the patient's bilateral passive hip straight leg raise and bilateral passive ankle dorsiflexion, plantarflexion, inversion, and eversion. Research has shown that goniometric measurements at the hip and at the ankle have fair to excellent intrarater and interrater reliability and validity.[12-14]

Muscle strength was assessed through MMT as described by Kendall et al[15] with grades from zero, no movement or muscle contraction, to five, the patient can hold the test position against strong pressure and against gravity.[15] MMT has been found to have good to excellent intrarater and interrater reliability as well as good validity.[16]

Coordination was assessed via rapid alternating movements (RAMs) of pronation and supination, and finger to nose coordination, as described by Gutman et al.[17] The coordination of the lower extremity (LE) was not assessed secondary to paraparesis. Scoring finger to nose coordination has been reported to have fair intrarater reliability and poor interrater reliability in the presence of tremor or dysmetria, although it has high reliability when clinicians report the

time it takes the patient to complete the test.[18] A study by Dittiger et al[19] found larger amplitude RAMs to be a reliable and valid measure of coordination. This case report used small amplitude RAMs of forearm pronation and supination, but the results of Dittiger's study may be applicable to this case report.

Light touch sensation was assessed as described by Schmitz[20] in *Physical Rehabilitation*. Schmitz states that there is little evidence to support the use of sensory tests in clinical practice secondary to the inability to correctly measure the test results.[20] Utilizing consistent methods and having the same skilled clinician perform the assessment each time will improve the reliability and validity of this assessment tool.[20]

Proprioception was examined through assessing the patient's dynamic sitting balance as described by O'Sullivan[21] in *Physical Rehabilitation*. The patient did not have his bilateral KAFOs with him on the initial examination, so standing balance was unable to be assessed. Dynamic sitting balance was assessed with the patient unsupported at the edge of the mat and he was asked to weight shift and reach outside of his base of support. This author was unable to locate studies reporting on the reliability and validity of this assessment method.

The numeric pain scale, where zero indicates no pain and ten indicates the most severe pain possible, was used as a means for the patient to quantify his pain from session to session. In healthy populations, it has been shown to have 100% interrater reliability and excellent concurrent validity when compared to the numeric pain rating scale (NPRS). [22]

The Brain Injury Assessment Tool (BIAT) is the standard outcome measure used for ABI programs under MaineCare insurance.[23] It is adapted from the Mayo-Portland Adaptability Inventory-4 (MPAI-4) and has six sections, each with three to ten subsections.[23] Each subsection is rated on a five point scale where zero indicates no problem and four indicates a severe

problem that interferes with activity more than 75% of the time. No research was found on the reliability or validity of the BIAT.[24] See Table 2 for the patient's BIAT scores at the initial evaluation and the final session of this case report.

Clinical Impression 2

The examination revealed decreased BLE active ROM, strength, and impaired light touch discrimination with left deficits greater than right. This was consistent with the initial impression of paraparesis secondary to TM with subsequent CMAs and CMA ruptures. The patient continued to be seen for PT intervention as there was no need for further testing or referral at that time. The patient continued to be appropriate for this case report as he continued to demonstrate a need for PT services. The plan for intervention included BLE strengthening, standing and ambulation within the parallel bars with bilateral locking KAFOs donned, and improving trunk control, balance, and coordination. The patient was routinely re-evaluated every six months to assess progress towards goals and achievement of outcomes.

The patient's medical diagnoses and associated ICD-9 codes were stroke, 436.0, idiopathic transverse myelitis, 341.22, and mycotic brain aneurysm, 421.0. The patient's PT diagnosis was paraplegia, 344.1. The patient's prognosis for improvement with PT was guarded due to the time since initial injury, co-morbidities, and the mechanism of injury that resulted in his impairments. The majority of motor recovery occurs up to two years post injury and this patient was eight years post injury.[1] His obesity was a barrier to the patient achieving his goals and outcomes secondary to the amount of stress that was placed on his cardiovascular and pulmonary systems, as well as the additional weight he had to manage when performing

transfers, bed mobility, and standing and ambulation tasks. Appropriate short and long term goals were established (see Appendix 3) and updated every six months.

Interventions

The patient received PT, RT, OT, and ST at MCIR where all four disciplines communicated regularly to address the patient's impulsivity, safety awareness, and ability to toilet and transfer independently. The patient communicated with PT in regards to his regular appointments with his primary care physician to assess his bone mineral density. PT coordinated with a local wheelchair provider about modifications and repairs the patient needed on his wheelchair, as well as with the patient's orthotist about repairs to his KAFOs. Daily therapy sessions were documented at the end of each day. The patient's case was reviewed with the therapy team once a month to reassess progress towards goals and any changes in the patient's status. Goals were updated at least every six months.

The patient related instruction included verbal instructions from PT regarding his impulsivity, safety awareness, and written instructions on his home exercise program. Once the patient received his KAFOs, he was instructed to continue standing at home in his body weight support system within the parallel bars to improve his standing tolerance.

Procedural interventions and a plan of care were developed following a thorough initial examination. Decisions were based on clinical judgment and evidence-based research to address his impairments and improve both his activity limitations and participation restrictions. Unfortunately, at the time of his initial evaluation, he was six years post-onset of symptoms and, at the time of this case report, he was almost eight years post-onset. The chronicity of his symptoms, in addition to many barriers throughout his rehabilitation at MCIR, proved to be

significant in regards to his minimal improvements and subsequent lack of exercise progression since his start of care (SOC). Tables 3 and 4 describe the exercises he participated in throughout his PT sessions during this case report period and the description and parameters for each exercise. Appendix 4 provides the exercises the patient has participated in with PT since his SOC at MCIR.

Schmitz[8] describes different methods and exercises to improve rolling in patients who have trunk weakness. One of the approaches included having the patient clasp both arms out in front of him and use the momentum of swinging his arms to either side to initiate a roll. This method was an effective approach for this patient to achieve more independence with bed mobility, though he still required occasional minimal assistance with BLE management. Also discussed were exercises to improve trunk control including prone on elbows and quadruped progressions. According to Schmitz[8], the prone on elbows and quadruped exercises are effective to prepare for sitting and standing through gains in stability and static control of the head, trunk, shoulders, and hips. These exercises and their progressions, such as rhythmic initiation, unilateral reaching, and weight shifting, were beneficial to this patient in increasing his trunk control, upper extremity stability, and control of his bilateral hips.

O'Sullivan[9] provides a progression of sitting balance exercises to improve static and dynamic sitting balance for patients who have impairments in postural control, such as sitting unsupported at the edge of a mat, reaching outside of the base of support, and altering the sitting surface. This patient presented with impaired dynamic sitting balance and poor posture in sitting at the edge of the mat, which indicated that these exercises and their progressions may be beneficial in improving those impairments.

The patient utilized Russian electrical stimulation (e-stim) in order to improve bilateral quadriceps strength. Vitenzon et al[25] discusses the use of neuromuscular e-stim, which includes Russian e-stim, with different neurological patient populations to improve muscle strength. The authors found that the amount of improvement in muscular strength was dependent on the level of the initial injury. Though the patient populations assessed in this study differ from this patient's diagnoses, the clinical implication that there may be limited benefit of using Russian e-stim due to his level of injury was still applicable. See Figure 1A, which depicts the patient set-up with Russian e-stim.

The WalkAide[†] was utilized to help activate the patient's tibialis anterior and peroneal muscle group, as well as to help maintain gastrocnemius and soleus extensibility and ankle ROM. The WalkAide is typically used in ambulating patients with foot drop, but one study found that it improved ankle ROM and strength, as well as decreased gastrocnemius spasticity.[26] Despite this study being performed with ambulatory children with cerebral palsy, the results may still be applicable for this patient given the shared impairments between the two populations.

The patient also performed various core strengthening exercises, such as abdominal curls in supine with a weighted three-kilogram ball, and quadriceps strengthening exercises, such as short arc and long arc quads. These exercises were chosen based on clinical judgment and experience to maintain and improve core and quadriceps strength. Unfortunately, the patient's reliance on bilateral KAFOs and BUE support to stand and his impaired dynamic sitting balance, in addition to the patient's limited improvement throughout his care at MCIR, were limitations in progressing his strengthening exercises. See Table 3 for a list of the interventions provided

[†] WalkAide®: 3600 N. Capital of Texas Highway, Suite B150, Austin, TX 78746

throughout this case report period and Appendix 4 for a list of the interventions provided since his SOC at MCIR.

The PT or physical therapist assistant (PTA) also performed BLE passive stretching for the patient's hamstrings, quadriceps, piriformis, adductors, and gastrocnemius at the start of each session. These stretches were the most feasible with the patient in supine on the therapy mat and each stretch was held for 30 seconds. These stretches were chosen based on clinical judgment to preserve ROM, reduce spasticity, and help prevent contracture.

The patient was instructed in and given a paper copy of his home exercise program. His mother assisted him with passive stretching of his BLEs at home. The patient had a body weight support system and parallel bars at home, which allowed him to improve his standing and ambulation tolerance while home with his bilateral locking KAFOs donned. Previous treatment included interferential e-stim, pre-modulated e-stim, cold packs, and moist hot packs to address the patient's knee and low back pain. These interventions, however, were not necessary during the duration of this case report due to adequate pain control.

The patient encountered many barriers throughout his rehabilitation at MCIR that created delays in his interventions. He was reliant on locking bilateral KAFOs to stand and ambulate within the parallel bars. His orthotics broke several times which resulted in a hold on standing for weeks at a time while they were being repaired. He also fractured his left ankle due to osteoporosis, which resulted in a hold on weight bearing on BLEs for four months until his fracture healed and his bone mineral density improved (see Table 5 for full timeline of barriers). These barriers did not change the plan of care, but required a hold on several interventions throughout his rehabilitation and delayed his progress towards his standing and ambulation

goals. Despite these barriers, the patient was compliant with PT and only canceled appointments for unexpected hospital stays or when he was ill.

Outcomes

The patient received approximately 200 PT treatment sessions since his SOC at MCIR two years prior to this report. He was seen three times a week for one-hour sessions. This case report highlights approximately 36 of those treatment sessions over a period of 12 weeks. Since his SOC, his BIAT score had increased by three points, which indicated a slight decrease in function over time, specifically in the areas of language/cognition and emotional adjustment. There had been no change in his mobility BIAT score since his SOC, which indicated that there had been no improvement or regression (see Table 2). There were slight improvements in his muscle strength (see Table 1), including hip flexion, adduction, and abduction, and knee extension. With the exception of knee extension, he was unable to move his BLEs against gravity at the conclusion of this case report. The patient had improvements in ankle eversion and hip straight leg raise passive ROM, but had decreases in his ankle dorsiflexion passive ROM.

Discussion

This case report describes the PT management of a patient with paraparesis secondary to TM and multiple CMAs and CMA ruptures. The patient's progress had been fairly stagnant since his SOC at MCIR two years prior, secondary to many barriers throughout his rehabilitation. The patient's obesity was a significant co-morbidity that likely resulted in his bilateral KAFOs breaking several times. This impaired his ability to improve his standing tolerance since he was unable to stand in the parallel bars without his orthoses. These periods of extended non-weight

bearing and prolonged corticosteroid use likely contributed to decreased bone mineral density. After his orthoses were repaired and he was able to stand again, he sustained a left ankle fracture secondary to osteoporosis. His ankle fracture and decreased bone mineral density resulted in a four month hold on standing until his fracture healed and his bone mineral density improved with bisphosphonate medications.

His obesity also impaired his ability to stand for prolonged periods of time because he relied heavily on his BUEs to hold himself upright in the parallel bars. The series of complications related to his obesity diminished his prognosis as his gains in PT were not consistent and he was subject to regression when he was unable to weight bear and stand. This postponed his ability to achieve standing and ambulation goals and prolonged his plan of care. Despite these barriers, the patient's family support as well as his positive attitude and motivation helped prevent the patient from further regressions, especially during the weeks where he was non-weight bearing.

In the case of this patient, it is unclear and we are unable to definitively determine whether or not the typical approaches used to address common stroke-related impairments, such as trunk control and sitting balance activities, are effective to address the impairments related to TM with subsequent multiple CMAs.[8, 9] The chronicity of the patient's condition, as well as the inconsistent opportunity to build standing and ambulation tolerance with his KAFOs, may also contribute to his lack of improvements throughout his care at MCIR. Further research is needed to determine options for effective PT treatment approaches for a patient with impairments related to TM and multiple CMAs and CMA ruptures.

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Table 1. Tests and measures at admission and at the final session for this case report

Test & Measure		Admission		Final Session*	
		Left	**Right**	**Left**	**Right**
Manual Muscle Testing	Hip SLR	1/5	1/5	1/5	1/5
	Hip Flexion	1/5	1/5	2/5	2+/5
	Hip Extension	Not Tested	Not Tested	1/5	1/5
	Hip Adduction	2/5	2/5	2+/5	2+/5
	Hip Abduction	2/5	2/5	2+/5	2+/5
	Knee Flexion	2-/5	2-/5	1/5	1/5
	Knee Extension	2+/5	3-/5	3/5	3/5
	Ankle Dorsiflexion	2/5	2/5	2-/5	2-/5
	Ankle Plantarflexion	2/5	2/5	2-/5	2-/5
	Ankle Inversion	2/5	2/5	2-/5	2-/5
	Ankle Eversion	2/5	2/5	1/5	1/5
Goniometry	Hip SLR	80°	86°	90°	90°
	Ankle Dorsiflexion	5° from neutral	0°	0°	0°
	Ankle Plantarflexion	60°	60°	40°	40°
	Ankle Inversion	WFL	WFL	12°	12°
	Ankle Eversion	0°	5°	14°	14°
Coordination	Rapid alternating movements: pronation & supination	Slow	Slow	Slow	Slow
	Finger to nose	Slow	Slow	Slow	Slow

Sensation	Light touch sensation	Diminished T6 and distally with left deficits greater than right	Diminished T6 and distally	Diminished T6 and distally with left deficits greater than right	Diminished T6 and distally
Proprioception	Dynamic seated balance at edge of mat	Impaired with reaching to each side outside of base of support		Impaired with reaching to each side outside of base of support	

SLR = straight leg raise; WFL = within functional limits

*Final session for this case report.

Table 2. Brain Injury Assessment Tool (BIAT) at admission and at the final session for this case report.

Brain Injury Assessment Tool (BIAT)	Admission	Final Session*
Physical Function: Mobility, Use of Hands, Dizziness, Vision, Audition	8/20	8/20
Language/Cognition: Attention/Concentration, Motor Speech, Verbal Communication, Nonverbal Communication, Visuospatial Abilities, Memory, Novel Problem-Solving, Executive Function/Prospective Memory, Initiation, Impaired Self-Awareness	21/40	22/40
Emotional Adjustment: Anxiety, Depression, Inappropriate Social Interaction, Irritability/Anger/Aggression, Sensitivity to Mild Symptoms, Psychotic Symptoms, Law Violations, Problem Behaviors, Danger to Self or Others	4/36	7/36
Independence: Self-Care including Eating, Dressing, Bathing, Hygiene, and Toileting; Information Management and Self-Advocacy, Residence, Transportation, Constructive Roles, Managing Money and Finances	26/40	25/40
Medical: Pain and Headache, Fatigue, Sleep Disturbance, Additional Medical/Psychological/Neurological Problems, Medical Self-Care, Medication Management and Compliance	14/24	14/24
Substance Use: Alcohol Use, Drug Use, Nicotine Use	0/12	0/12
TOTAL:	73/172	76/172

Footnote: Each item within each domain is scored from 0-4 with a score of 0 indicating no problem and a score of 4 indicating a severe problem that interferes greater than 75% of the time. The total score is the sum of all subsections within each domain.

404 **Table 3.** Exercises by week for the duration of this case report

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Weeks	1	2	3	4	5	6	7	8	9	10	11	12
Sessions	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36
Exercise												
Stretching BLEs	X	X	X	X	X	X	X	X	X	X	X	X
Russian e-stim to Quadriceps with Short Arc Quad	X	X		X	X	X		X	X	X	X	X
3-Way Medicine Ball Crunch	X	X	X	X	X	X	X	X	X	X		X
Active Assist ROM	X						X	X		X		
Bed Mobility	X		X			X	X		X	X		
Prone & Quadruped Weight Shifting & Reaching	X	X		X	X				X			
WalkAide Exercise Mode		X								X		
Seated Trunk Stability at EOM		X						X	X	X	X	
Stand and Amb. in Parallel Bars		X	X			X						X

406 BLEs = bilateral lower extremities; e-stim = electrical stimulation; ROM = range of motion; EOM = edge of mat; amb. = ambulation

407

408 **Table 4.** Exercise Descriptions and Parameters

Exercise	Description	Parameters
Stretching bilateral lower extremities	Targeted muscle groups included hamstrings, quadriceps, piriformis, adductors, and gastrocnemius	A stretch to each muscle group was held for 30 seconds, 1-2 times each
Russian electrical stimulation[‡] to bilateral quadriceps with short arc quad	Electrodes[§] were placed on the vastus medialis and rectus femoris of the bilateral quadriceps. The Russian electrical stimulation setting was set to a tolerable intensity that elicited a muscle contraction. The patient contracted his quadriceps and performed a short arc quad exercise over a bolster[**] in conjunction with the electrical stimulation.	• 10-15 minute treatment time • Duty cycle: 10 seconds on to 20 seconds off, alternating LEs • Russian electrical stimulation setting on electrical stimulation machine with preset parameters • Intensity between 40mA and 55mA depending on patient tolerance
3-Way Medicine Ball Crunch	With the patient in supine and a bolster under his knees, the patient held a medicine ball and crunched to the left, center, and right.	• 15-20 reps in each direction • 3-5 kg medicine ball
Active Assist Range of Motion	Active assistance with contraction of quadriceps, hip adductors, and hip abductors.	• 3x10 bilaterally
Bed Mobility	Activities included rolling to each side, and resisted and alternating isometrics in sidelying at the hip and shoulder. The patient required min. assistance for bilateral LE management.	• Roll to each side x10 • Resisted isometrics at hip and/or shoulder x15 each side • Alternating isometrics at hip and/or shoulder x15 each side
Prone & Quadruped Weight Shifting & Reaching	Activities in prone included protraction push-ups, maintaining scapular protraction bilaterally and unilaterally when reaching with	• Protraction push-ups 3x10 • Maintained protraction 3x30 sec

[‡] Chattanooga Group, Inc Forte 400 Stim Electrical Stimulation Unit: Chattanooga Group, Inc, 827 Intermont Rd, Chattanooga, TN 37415
[§] Performa Reusable and Self-Adhering Stimulating Electrodes: Patterson Medical, 28100 Torch Parkway, Suite 700, Warrenville, IL 60555
[**] Skillbuilders Roll 10”x36” Fabrication Enterprises Inc, PO Box 1500, White Plains, NY 10602

	contralateral UE, as well as when weight shifting. Activities in quadruped included weight shifting between UEs and LEs and reaching with one UE.	• Weight shifting 3x30sec • Reaching 2-3x10 bilaterally
WalkAide Exercise Mode	The WalkAide was used on exercise mode as a method to help strengthen his ankle dorsiflexors and evertors, as well as to help stretch his gastrocnemius and soleus and maintain ankle ROM while the patient was in supine on the mat.	• Exercise mode on device • 3x30 unilaterally or bilaterally
Seated Trunk Stability at EOM[††]	Exercises included using the Body Blade[‡‡], crunches with a Swiss ball behind the patient, ball catch, balloon tap, posture activities, D1 and D2 flexion and extension UE patterns, and performing various UE motions with a 5-pound dowel.	• Body Blade and posture activities performed 2-3x30 sec (bilaterally) • Other activities 2x15 • Mirror occasionally used for visual feedback on posture and form • Tactile cues occasionally used for feedback on posture and form
Stand and Ambulate in Parallel Bars[§§]	With bilateral locking KAFOs donned, the patient stood within the parallel bars. The patient required mod. to max. assistance x1 for sit to stand and stand to sit transfers as well as BUE support for transfers and static standing. Min-mod assistance x1 was needed to maintain static standing. Ambulation was done within the parallel bars with BUE support, mod. assistance x1 for weight shifting, and a wheelchair follow.	• Static standing time was per patient tolerance. During this case report period, it ranged from 2 minutes to 7 minutes • Ambulation was always 6 feet due to the length of the parallel bars

[††] Midland Bariatric Mat Platform 5 feet x 7 feet: Patterson Medical, 28100 Torch Parkway, Suite 700, Warrenville, IL 60555
[‡‡] Body Blade® Classic Black: Patterson Medical, 28100 Torch Parkway, Suite 700, Warrenville, IL 60555
[§§] Clinton Kangoo Parallel Bars: Clinton Industries, Inc, 1140 Edison St, York, PA 17403

mA = milliamps; kg = kilogram; reps = repetitions; min. = minimum; LE = lower extremity; UE = upper extremity; BUE = bilateral upper extremity; sec = seconds; KAFOs = knee-ankle-foot orthoses; mod. = moderate; max. = maximum

Table 5. Timeline of Standing since Start of Care at Maine Center for Integrated Rehabilitation (by month)

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
# of sessions	**Sessions prior to this author's start of care with the patient.**																					**2 sessions standing**	**1 session standing**	**3 sessions standing**
Maximum standing and ambulation tolerance	Stand up to 32 minutes, ambulate 6 feet in parallel bars x5					Stand up to 8 minutes, ambulate 6 feet x1	Stand up to 37 minutes, ambulate 6 feet x3										Stand up to 45 minutes, ambulate 6 feet x4					Stand up to 8 minutes, ambulate 6 feet x2	Stand up to 3 minutes	Stand up to 2 minutes
Barrier					**KAFOs broke and needed repair. Eight weeks without standing.**	**KAFOs needed adjust-ment after two sessions. Six weeks without standing.**					**Consecutive holds on weight bearing due to ankle fracture, low bone density, and multiple syncopal events. Waited to begin weight bearing until 1 month without syncopal event. Total 32 weeks without standing**									**KAFOs broke, waited to be eligible to receive new KAFOs. 10 weeks without standing**		**KAFOs needed adjust-ment. Two weeks without standing.**	**KAFOs broke after 1 session. Four weeks without standing.**	

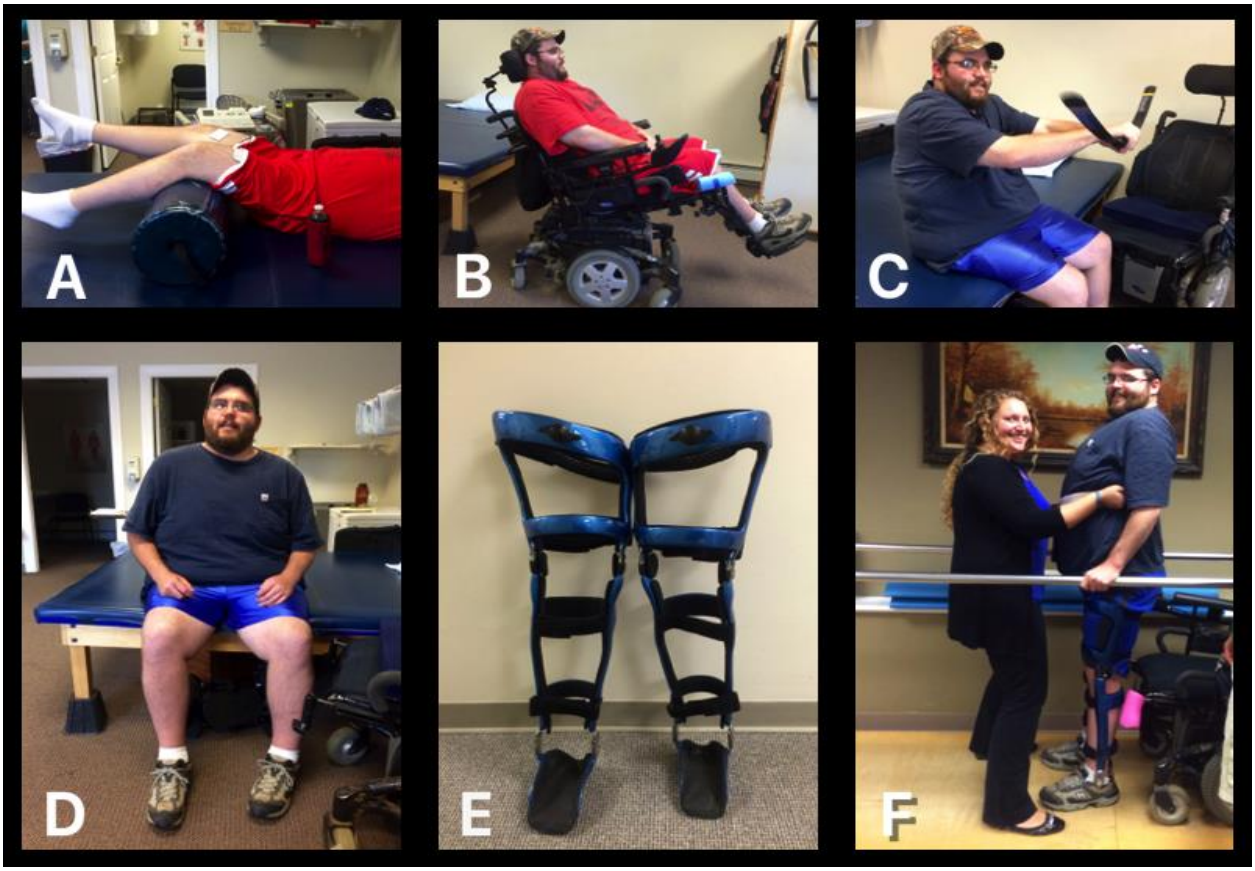
KAFOs = knee-ankle-foot orthoses

Legend:

Green	Barriers causing periods of time without standing	**Blue**	Periods of standing and ambulation

Footnote: All standing required moderate to maximum assistance of one person to assist the patient from sitting to standing and minimum to moderate assistance of one person to maintain a standing position. The patient required bilateral upper extremity support with the parallel bars for all standing and ambulating. The patient required minimum to moderate assistance of one person to assist with weight shifting when ambulating within the parallel bars and required a second person to perform a wheelchair follow.

Figure 1. Patient Related Clinical Interventions



Footnote:

A. The patient performing a short arc quadriceps exercise with Russian e-stim.

B. The patient in his wheelchair,*** which is slightly tilted.

C. The patient performing small amplitude shoulders flexion and extension at the edge of the mat with the Body Blade.

D. The patient maintaining a proper upright posture at the edge of the mat.

E. The patient's custom knee-ankle-foot orthoses (KAFOs).

F. The patient standing in the parallel bars with a student physical therapist/manuscript author with bilateral KAFOs donned.

*** Invacare TDX SP Power Tilt-In-Space Wheelchair: 1 Invacare Way, Elyria, OH 44035

Appendix 1. Patient History

Social History	The patient worked as a crane operator at a chip plant until the age of 20 when he experienced an insidious onset of transverse myelitis. The patient was not able to return to work since the initial onset of symptoms. He denied smoking, alcohol consumption, or illicit drug use.
Living Environment	The patient lived with both of his parents in a one-story home with a ramp. The patient had a set of parallel bars with a standing harness in his home.
General Health Status	The patient was obese and was dependent on a power wheelchair for mobility.
Social/Health Habits	The patient had a poor diet and did not comply with diet recommendations. The patient socialized with other clients during his time in MCIR's ABI day program and was interested in obtaining a job or participating in volunteer work in the future.
Family History	No family history of immune deficiency, prior episodes of transverse myelitis, or aneurysm rupture.
Patient's Medical/Surgical History	Past surgical history included mediastinal lymph node biopsy, right frontal exploratory craniotomy and open brain biopsy, right-sided ventricular drain placement, video-assisted thoracoscopic surgery (VATS), bronchoscopy, and lumbar puncture.
Clinical Tests	MRI of the whole spine and brain, CT angiogram of the brain, chest CT, and conventional angiography of the head.
Functional Status/Activity Level	The patient was independent in his power wheelchair for mobility. He required min. assistance during sliding board transfers with BLE management. He required min. to mod. assistance for LE management with bed mobility. The patient required mod. to max. assistance times one for sit to stand transfers with bilateral locking KAFOs in the parallel bars. The patient was able to ambulate six feet in the parallel bars with bilateral KAFOs, BUE support, and min. to mod. assistance times one for weight shifting.
Patient Goals	To stand and ambulate with bilateral locking KAFOs and a standard walker. To increase independence with ADLs and IADLs.

MCIR = Maine Center for Integrated Rehabilitation; ABI = acquired brain injury; MRI = magnetic resonance imaging; CT = computed tomography; min. = minimum; mod. = moderate; max. = maximum; BLE = bilateral lower extremity; LE = lower extremity; KAFO = knee-ankle-foot orthoses; BUE = bilateral upper extremities; ADLs = activities of daily living; IADLs = instrumental activities of daily living

Appendix 2. Systems Review

Cardiovascular/Pulmonary System	
Unimpaired	At risk for impairment due to obesity. Respiratory rate, heart rate, and blood pressure within normal limits.
Musculoskeletal System	
Impaired	Weak bilateral lower extremities distal more than proximal. History of left ankle fracture.
Neuromuscular System	
Impaired	Paraparesis left more impaired than right. History of multiple aneurysm ruptures resulting in cerebral vascular accident. Decreased sensation in bilateral lower extremities left more impaired than right.
Integumentary System	
Unimpaired	At risk for skin breakdown due to use of power wheelchair as primary means of mobility.
Communication	
Unimpaired	Able to communicate clearly with physical therapy staff and peers.
Affect, Cognition, Language, Learning Style	
Impaired	Impaired safety awareness.

Appendix 3. Short Term and Long Term Goals

Short Term Goals	Long Term Goals
Within 6 months	**Within 1 year**
Stand in parallel bars times 15 to 20 minutes with contact guard to minimal assistance times one to two in preparation for gait within six months.	Stand times 10 to 15 minutes in parallel bars and perform sit to stand transfer with standard walker with minimal assistance to increase functional lower extremity mobility within one year.
Demonstrate a decrease in right knee pain to four to five out of ten at worst and five out of ten at worst for low back pain to increase ability to perform transfers when standing within six months.	Demonstrate a decrease in right knee pain to three out of ten at worst to increase ability to sleep at night and perform standing activities within one year.

Appendix 4. Exercises by Month

Month	Exercises
1	BLE stretching, stand in parallel bars 1x10 minutes, amb. 6 feet in parallel bars x1, supine BLE exercises x15 each
2	BLE stretching, stand in parallel bars 3x5 minutes, 1x20 minutes 1x32 minutes; amb. 6 feet in parallel bars x3, AAROM for bilateral hip flexion, hip abduction, knee flexion x15 each, supine and seated core exercises
3	BLE stretching, stand x3-4 trials, e-stim IFC right knee times 10 minutes, amb. 6 feet in parallel bars x5
4	BLE stretching, stand in parallel bars 1x13 minutes, 1x7 minutes, IFC R knee, Body Blade seated at edge of mat, e-stim IFC to low back x10 minutes, rolling x10 to each side with min to mod assist for BLE management
5	BLE stretching, quadruped with UE reaching, seated and supine core exercises
6	BLE stretching, stand x8 minutes, amb. in parallel bars x1, e-stim pre-mod to bilateral knees x10 minutes, e-stim IFC to low back x10 minutes, rolling x10 each side, seated and supine core exercises
7	BLE stretching, seated and supine core exercises, rolling x15 to each side, amb. in parallel bars 6 feet x2
8	BLE stretching, seated and supine core exercises, mechanical lumbar traction 60lbs x12 minutes, amb. in parallel bars 6 feet x3, stand in parallel bars x21 minutes, x30 minutes, x37 minutes, e-stim to low back IFC x15 minutes
9	BLE stretching, seated and supine core exercises, short arc quad 2x10 bilaterally, stand in parallel bars up to 8 minutes, amb. 6 feet in parallel bars x4, Russian electrical e-stim to bilateral quadriceps with active knee extension x15 minutes, seated weight-shifting x3 minutes
10	BLE stretching, seated and supine core exercises, amb. 6 feet in parallel bars x2, stand in parallel bars x15 minutes, x10 minutes, Russian e-stim to bilateral quadriceps with active knee extension x10 minutes
11	BLE stretching, seated and supine core exercises, AAROM in supine for hip abduction and adduction 2x10 bilaterally, WalkAide exercise mode x3 in supine to increase right ankle ROM, Russian e-stim to bilateral quadriceps x10 minutes, prone on elbows with UE reach x15 each side
12	BLE stretching, seated and supine core exercises, long arc quadriceps 2x10 bilaterally, rolling x10 each side, bridge 2x15, Russian e-stim bilateral quadriceps x10 minutes, WalkAide exercise mode x3 in supine to increase right ankle ROM
13	BLE stretching, seated and supine core exercises, trunk rotation in sitting x10 bilaterally, WalkAide exercise mode x3 in supine to increase right ankle ROM, long arc quadriceps 2x10 bilaterally, posterior pelvic tilts 2x15, rolling x10 bilaterally

14	BLE stretching, seated and supine core exercises, sidelying pelvic rotation rhythmic initiation with manual resistance 2x10 each side, rolling x10 each side, short arc quadriceps with Russian e-stim bilaterally x10 minutes, isometric contraction for bilateral hamstrings 2x15 and quadriceps 2x15
15	BLE stretching, seated and supine core exercises, pelvic rotation in sidelying 2x15 each side without resistance, 2x15 each side with resistance, Russian e-stim to bilateral quadriceps with short arc quadriceps x15 minutes, isometric contraction for bilateral hamstrings 2x15 and quadriceps 2x15
16	BLE stretching, seated and supine core exercises
17	BLE stretching, seated and supine core exercises, lower trunk rotation x15 each side, bridge 2x15, prone on elbows with reaching, resisted pelvic rotation x15 each side, weight shifting in quadruped, standing in parallel bars x30 minutes, amb. 6 feet in parallel bars x2
18	BLE stretching, seated and supine core exercises, stand x45 minutes, x 23 minutes, x14 minutes in parallel bars, amb. 6 feet in parallel bars x2, resisted pelvic rotation x15 each side, short arc quadriceps 2x10 bilaterally
19	BLE stretching, seated and supine core exercises, rolling x15 each side, stand in parallel bars x20 minutes, amb. 6 feet in parallel bars x1, WalkAide exercise mode x3 in supine to increase right ankle ROM
20	BLE stretching, seated and supine core exercises, Russian e-stim to bilateral quadriceps x10 minutes, pelvic rotations 2x10 bilaterally, quadruped weight shifting and UE reaching x10 bilaterally
21	BLE stretching, seated and supine core exercises, rolling 2x10 each side, quadruped weight shifting 2x10 each side, WalkAide exercise mode x3 in supine to increase right ankle ROM, Russian e-stim to bilateral quadriceps x10 minutes, active hip abduction and adduction in supine x15 bilaterally, prone press up on elbows
22	BLE stretching, seated and supine core exercises, stand in parallel bars x7 minutes, x3 minutes, x8 minutes, amb. 6 feet in parallel bars x2, quadruped weight shifting 2x10 bilaterally, long arc quads x15 bilaterally, wheelchair push-ups x10
23	BLE stretching, seated and supine core exercises, bridge 2x10, Russian e-stim bilateral quadriceps x15minutes with short arc quadriceps, rolling x10 each side
24	BLE stretching, seated and supine core exercises, stand 2x2 minutes

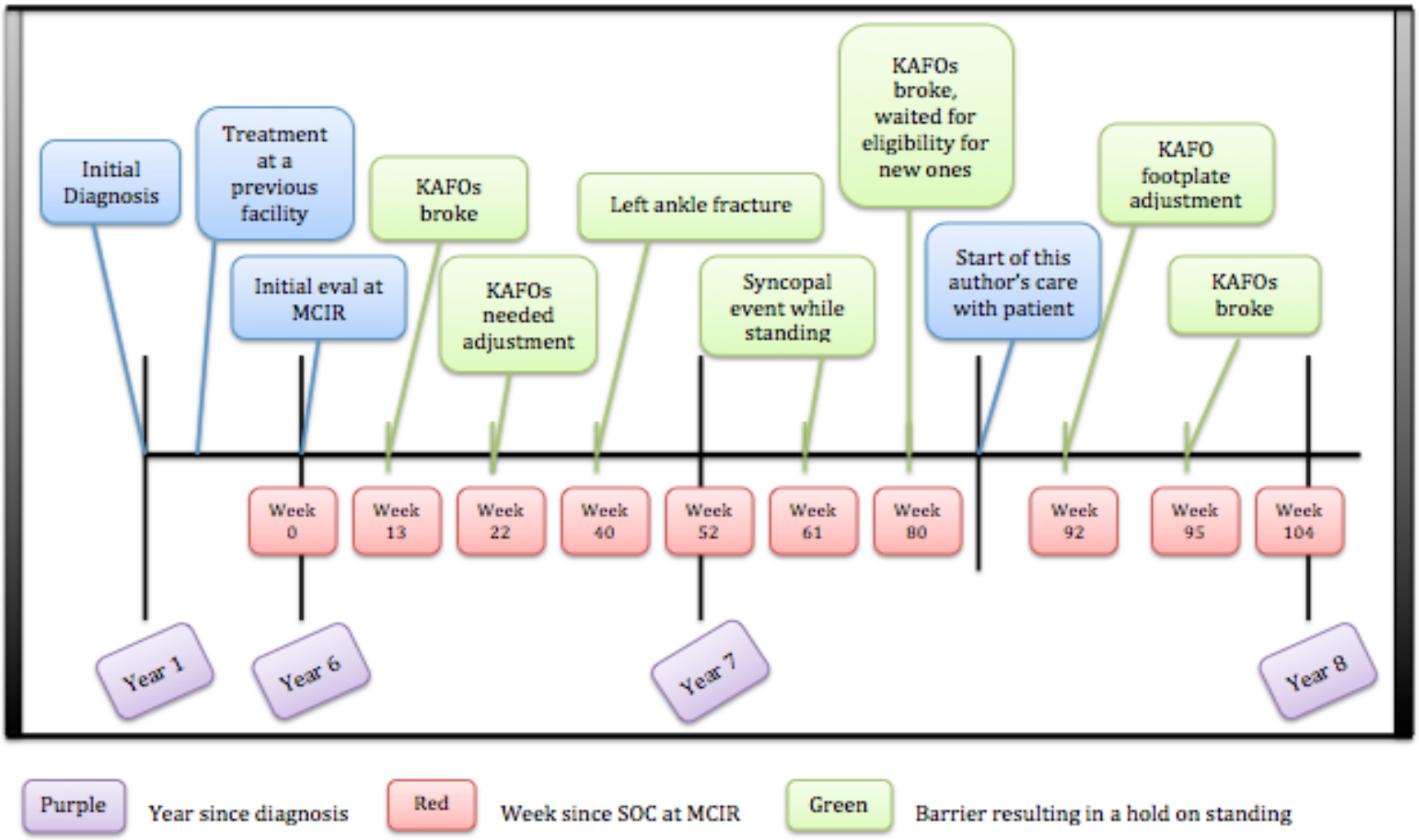
BLE = bilateral lower extremity; UE = upper extremity; AROM = active range of motion; e-stim = electrical stimulation; amb. = ambulation

Footnotes:

- Bilateral lower extremity stretching included hamstrings, quadriceps, piriformis, adductors, and gastrocnemius. Each stretch was held for 30 seconds.

- Seated and supine core exercises included supine crunches to the front and each side with a 3-5 kilogram medicine ball, using a 5 pound dowel in a kayak motion in supine and sitting, partial sit-up with a Swiss ball behind the patient in sitting, seated balance exercises at the edge of the mat, such as reaching across the body, ball catch, balloon tap, and using the Body Blade in D1 and D2 flexion and extension patterns. Each exercise was performed 2x15 (bilaterally, if applicable).
- The patient required maximum assistance of one person for sit to stand and stand to sit transfers in the parallel bars. The patient required minimum to moderate assistance of one person for weight shifting during ambulation within the parallel bars and second person for a wheelchair follow.

Appendix 5. Timeline of Barriers to Standing & Ambulating Encountered since Start of Care at MCIR



Appendix 6. Medications

Medication	Dose	Frequency	Purpose
Nortriptyline	100 mg	1 tab PM	Depression
Potassium citrate	1080 mg	2 tabs AM & PM	Kidney stones; decrease urine acidity
Multivitamin	N/A	1 tab AM	Prevent vitamin deficiency
Doc-Q-Lace	100 mg	1 tab AM & PM	Stool softener
Senna lax	8.6 mg	2 tabs AM & PM	Stimulant laxative
Azathioprine	50 mg	2 tabs AM & PM	Immunosuppressant
Baclofen	20 mg	1 tab 3x daily	Antispasmodic
Oxybutynin	5 mg	1 tab 3x daily	Decrease overactive bladder
Trazodone HCL	50 mg	1-1.5 tabs PM	Antidepressant
Trimethoprim	100 mg	1 tab PM	Urinary tract infection treatment
Folic acid	1 mg	1 tab AM	Improve folate deficiency, lower homocysteine levels (high levels linked to heart disease & stroke)
Jantoven	6-6.5 mg (alternate)	1 tab PM	Anticoagulant
Oxycontin	20 mg	1 tab AM & PM	Narcotic pain reliever
Oxycodone/Acetaminophen	10/325 mg	As needed	Opiod pain reliever
Prednisone	2 mg	Every other AM, tapering dose every 2 months by 1 mg	Corticosteroid; anti-inflammatory

AM = in the morning; PM = in the evening; mg = milligram