12-4-2015

A Progressive Physical Therapy Plan Of Care For A Patient With Charcot-Marie-Tooth Disease Following Myocardial Infarction: A Case Report

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

The author acknowledges Kirsten Buchanan, PhD, PT, ATC for assistance with case report conceptualization, Betsy Ross, DPT for supervision and assistance as clinical instructor, and Justin Hsu, SPT and Katie Edminston, DPT for assistance with patient management.

ABSTRACT

Background and Purpose: Charcot-Marie-Tooth disease (CMT) is a neuromuscular disease that leads to distal muscle atrophy, weakness, and sensory loss.[1-3] Myocardial infarction (MI) is often a result of coronary artery disease, which has an incidence rate of 34.6% in men over 80.[4] While rehabilitation practices for CMT and MI have been described separately, there is a paucity of research investigating physical therapy (PT) interventions for patients who have both health conditions. The purpose of this case report was to investigate the PT management of a patient with CMT following an acute MI in the acute and sub-acute care settings.

Case Description: The patient was an 80-year-old male with CMT who was admitted to the hospital with an MI. His hospital course was further complicated by respiratory failure, which necessitated prolonged bed rest. After 6 days in the ICU, he received 30 minutes/day of acute care PT for four days, followed by two daily one-hour sessions of inpatient rehab PT for five days. Interventions included progressive balance, functional mobility, and advanced gait training.

Outcomes: The Physical Function in ICU Test (PFIT) score improved from 8/12 to 12/12 during his acute care stay.[5] In inpatient rehab, his Functional Independence Measure (FIM) scores for mobility and all transfers improved by at least one point, his Two-Minute Walk Test (2MWT) distance improved from 80.8 to 99.1 meters, and he was successfully discharged home.

Discussion: CMT and MI in combination can be especially debilitating. An aggressive rehabilitation course that promoted balance, functional mobility and progressive gait training appeared to substantially benefit an 80-year-old patient's physical function and contribute to his potential for independent living in the community.

Manuscript Word Count: 3,497

BACKGROUND and PURPOSE

Charcot-Marie-Tooth disease (CMT) is a progressive neuromuscular disease that affects the peripheral sensory and motor nerves.[1] The disease is caused by mutations in genes that produce proteins involved in the structure and function of the myelin sheath or the peripheral nerve axon. The degeneration of the nerves results in decreased ability to communicate with their distant targets leading to symmetric distal muscle atrophy and weakness, hand and foot deformities, and sensory loss.[2,3] Common lower extremity (LE) impairments include foot drop, pes cavus, and hammer toes.[3] The upper extremities are usually involved later in the disease progression and are often less severely affected. The intrinsic muscles in the hands are primarily affected resulting in a mild clawing of the fingers, loss of opposition and a weak pinch.[6]

There is currently no treatment that reverses or stops the natural progression of CMT, but some help to reduce the level of disability in individuals with CMT, including: orthopedic shoes or orthotics, surgery to correct deformities, prescription of an assistive device (AD), medication for both musculoskeletal and neuropathic pain, and exercise. Research has shown that interval and resistance exercise can improve functional capacity, strength and activities of daily living (ADLs) in people with CMT.[7-9]

Myocardial infarction (MI) is the irreversible necrosis of the heart muscle as a result of prolonged ischemia, often occurring as a result of coronary artery disease (CAD). CAD occurs when there is a build up of plaque in the coronary arteries and has an incidence rate of 34.6% in men over 80.[4] MI is the leading cause of morbidity and mortality worldwide and six primary risk factors have been identified, including: hyperlipidemia, diabetes mellitus, hypertension, tobacco use, male gender, and a family history of artherosclerotic arterial disease. The recovery process varies widely among individuals and the location and size of the infarct, timeliness of medical

intervention and the individual's conditioning level often determine outcomes. Additionally, secondary complications can cause lengthy hospitalizations following an acute MI.[10] Exercise intervention in the acute care setting following an MI have shown to positively impact a patient's functional capacity and quality of life (QOL).[11]

Bed rest remains a common treatment for managing acute illness even while its efficacy is not supported.[12] It is well documented that prolonged bed rest causes profound deconditioning of multiple body systems in a short period of time. Muscles begin to atrophy and weaken, with muscle mass decreasing by approximately 1.5-2.0% per day.[13] Joint range of motion (ROM), soft tissue extensibility and bone density all significantly deteriorate as the body is not subjected to normal antigravity activity.[14] Maximal oxygen consumption and cardiac output decline and there is increased risk for deep vein thrombosis and orthostatic hypotension.[15]

While rehabilitation practices for CMT and MI have been described separately, there is a paucity of research investigating the optimal PT interventions for patients who have both health conditions concurrently. The purpose of this case report is to describe the PT management of a patient with CMT following an acute MI and a period of prolonged bed rest. Research has suggested that physical exercise and early mobilization may help reduce the consequences of bed rest and improve long-term outcomes. An immediate and progressive PT plan of care for a person with CMT following a complicated MI was hypothesized to improve this patient's function and long-term outcomes.

CASE DESCRIPTION

The patient signed an informed consent and agreed to participate as the subject of a case report for educational purposes. He was an 80-year-old retired male physician. He lived with his wife out of state and reported prior independence with all ADLs and with functional mobility

using ankle-foot orthoses and trekking poles for long-distance ambulation. He was relatively active prior to hospital admission and enjoyed trout fishing, biking, and photography. His past medical history was significant for CAD status post three-vessel coronary artery bypass grafting surgery ten years prior, hypertension, hypothyroidism, dyslipidemia, CMT, and right total knee arthroplasty. Table 1 lists his daily home medications and their indication.

While traveling, the patient developed chest pain, shortness of breath (SOB), jaw pain, and diaphoresis. In the emergency room, he abruptly developed ventricular fibrillation and required defibrillation. He became responsive shortly after, but continued to have chest pain. At this point, he also developed third-degree atrioventricular block and junctional escape rhythm. He underwent emergent left heart catheterization for severe two-vessel CAD and acute occlusion of the saphenous vein graft. During the procedure, he went into acute respiratory failure and required respiratory support by intubation. Two days later, extubation was attempted, but the patient developed severe stridor. He was unable to successfully maintain his oxygen saturation and required emergent reintubation. After another two days, an extubation attempt was successful without complications. The patient developed pulmonary edema the day following, but this resolved within a few days following treatment with an antidiuretic medication. PT was initiated the day following successful extubation.

During his hospital stay, the patient received PT, occupational therapy (OT) and speech therapy (SLP). The systems review revealed impairments of the cardiovascular and pulmonary systems, musculoskeletal system, and neuromuscular system (*Table 2*). The patient was referred to inpatient rehab for additional therapy intervention to increase his safety and independence.

CLINICAL IMPRESSION 1

Based on the information gathered in the history and systems review, the patient's primary problem was an acute MI. His impairments included deficits in strength, activity tolerance, ROM and balance. These impairments limited his ability to perform transfers, ADLs and independent ambulation. The weakness and impaired mobility he demonstrated could have been a result of prolonged immobilization, an exacerbation of his CMT disease, a result of cardiorespiratory induced fatigue, or the normal aging process.

The patient had been intubated and immobile for the six days prior to the initial PT examination, so the goal of the examination was to determine his assistance needs with bed mobility, transfers, and ambulation. Additionally, limitations in activity tolerance, strength, balance, and sitting posture would be evaluated. Further examination using the PFIT was planned to obtain an objective value for the patient's mobility level in order to track his progress during his acute care stay.[5]

The patient was an excellent candidate for a case report due to the rarity of CMT disease and lack of research on management in this population following an acute MI.

EXAMINATION

Tests and measures were performed during the initial evaluation and discharge from acute care PT and inpatient rehab in order to get an objective picture of the patient's progress across his treatment stay. In acute care, the PFIT was used as a measure of the patient's progress. The PFIT can be used to measure the effectiveness of selected treatments and to objectively compare the functional physical capacity of patients during their ICU stay. This test assesses four items including assistance needed for sit to stand from a chair, marching in place, shoulder flexion strength, and knee extension strength (*Appendix 1*). According to Denehy et al, the PFIT

demonstrated moderate convergent validity when compared with the Timed Up and Go (TUG; *r*=-.60) the Six Minute Walk Test (6MWT; *r*=.41) and the Medical Research Council (MRC) muscle test (rho=.49). Discriminant validity of the PFIT was demonstrated between the Body Mass Index scores (*r*=-.011).[5] According to Skinner et al, the PFIT was responsive to change and had good interrater reliability (IRR) in ICU patients with a tracheostomy for items marching on the spot (ICC=0.999-1.000) and shoulder flexion (ICC=0.996-1.000).[16]

Manual muscle testing (MMT) grades were given to specific muscle groups to objectively document strength. According to Fan et al, MMT has excellent IRR (ICC=.98) in trained examiners and is a reliable method to determine muscle strength in ICU survivors.[17] Cuthbert et al also reported evidence for good reliability and validity with MMT based on a literature review of more than 100 studies.[18]

The FIM was administered upon admission, discharge and intermittently throughout the patient's inpatient rehab stay in order to monitor his progress. The FIM is an 18-item measure of disability used to assess the amount of assistance a person requires when performing basic life activities. The results of a meta-analysis that looked at the reliability of the FIM across a variety of patient populations, setting and clinicians, demonstrated good IRR (median=.95), test-retest reliability (TRR; median=.95), and equivalence reliability (median=.92).[19] Similarly, Pollak et al demonstrated very high TRR for the motor subscale (ICC=.9), good TRR for the cognitive subscale (ICC=.8) and evidence for the construct validity of the motor and cognitive subscales as a functional assessment for patients who are 80 years or older.[20]

The 2MWT was administered to document the patient's functional endurance. This test, as opposed to the longer 6MWT, was chosen because of the suspected poor endurance of the patient and possible inability to successfully complete six minutes of ambulation. The 2MWT

has been tested on a variety of patient populations and shows evidence for high TRR (ICC ranging from 0.82 to 0.99).[21] Furthermore, the 2MWT has shown excellent concurrent validity with the TUG (r=.95), Berg Balance Scale (r=.95), and the 6MWT (r=.95).[22]

A functional task analysis of the patient's functional mobility was performed to understand the patient's assistance level needs and to document any deficits in movement strategies. Functional balance was assessed and graded based on observations using the Functional Balance Grades by O'Sullivan, Schmitz and Fulk (*Appendix 2*).[23]

CLINICAL IMPRESSION 2

Evaluation

The examination revealed muscle weakness, decreased endurance, impaired respiratory function, decreased activity tolerance, poor standing balance and chronically impaired hand and foot function. These impairments caused difficulty with functional activities including bed mobility, transfers and ambulation. These impairments and activity limitations were to be expected due to the extended period of time the patient was effectively immobile following an acute cardiac event, coupled with the patient's comorbidities.

It was noticed that the patient had contractures in his interphalangeal joints of both of his hands and had significant difficulty with fine motor tasks. The patient reported that he previously had difficulty with such tasks but it had become increasingly more difficult since admission to the hospital. These impairments and activity limitations warranted referral to OT for further evaluation of the patient's difficulties with fine motor skills and ADLs.

The next plan of action was to proceed with PT interventions to address the impairments and activity limitations. The patient continued to be appropriate for the case because of his unique medical history. His recovery following the MI was complicated by his diagnosis of

CMT as a result of the patient's preexisting impairments that worsened during hospitalization and the period of bed rest. It was anticipated that the patient would benefit from PT to minimize his impairments and improve his independence with functional mobility.

Physical Therapy Diagnosis

Based on the Guide to PT Practice, the practice patterns most applicable to this patient were 4C: Impaired Muscle Performance and 6D: Impaired Aerobic Capacity/Endurance Associated with Cardiovascular Pump Dysfunction or Failure. Pattern 4C is applicable because the patient had a chronic neuromuscular disease that resulted in weakness and impaired muscle function in his distal extremities. Pattern 6D is appropriate because the patient suffered an MI and had impairments including SOB, decreased endurance, and decreased activity tolerance. The ICD-9 code that is most applicable is 410.4, acute MI of other inferior wall.[24]

Prognosis

The patient had good awareness of his impairments, had strong family support, was motivated to participate and was very knowledgeable about medical recommendations. In addition, he had a reasonably high prior level of function before admission to the hospital, as demonstrated by his independence with all functional mobility and ADLs. Based on previous research by Peixoto et al, early exercise intervention in the inpatient setting followed by unsupervised exercise on discharge had a positive impact on a person's health-related QOL and functional capacity in patients who recently had an acute MI.[11] Research has not yet been done regarding rehabilitation following an acute coronary event of persons with CMT; however, research does show that functional gains can be made in this population following PT intervention. Mhandi et al found that persons with CMT who participated in a 24-week interval training experienced significant improvements in cardiorespiratory capacities, isokinetic

concentric strength, and functional ability measurements. These individuals also experienced an improvement in their self-rated feelings of fatigue and pain during activity.[8] Similarly, Chetlin et al reported that a progressive resistance-training program improved strength and performance with ADLs for men and women alike with CMT.[7]

CMT is a progressive and incurable disease at this time, so the patient was likely to continue to have chronic hand and foot dysfunction as a result of peripheral nerve conduction issues. While participation in PT was unlikely to address the patient's more chronic impairments, his prognosis to return to his prior level of function was good following patient compliance and intervention to address the more acute consequences of MI.

Plan of Care

The plan of care (POC) was set for the patient to receive PT services 5-7 times per week for the length of the acute care hospitalization. The POC for inpatient rehab was to receive two hours of PT per day, split between a morning and afternoon session. PT short-term goals (STG) and long-term goals (LTG) were discussed with the patient and his family in both settings. The primary goal of PT was for a safe return home and to gain independence with all functional mobility.

INTERVENTIONS

In acute care, the patient received approximately 30 minutes of PT intervention daily for four days. Interventions were aimed at improving the patient's ability to perform bed mobility, transfers and ambulation with the least amount of assistance possible. During his five-day stay in inpatient rehab, the patient received two one-hour sessions of PT daily. The goal was to further increase his independence and safety with functional mobility and activity tolerance in order to

return home. The patient demonstrated high compliance with PT intervention and was very motivated to participate.

Coordination, Communication and Documentation

PT coordinated treatment with OT, SLP, nursing staff and physicians, including a hospitalist and a cardiologist, while the patient was in the acute care setting. Nursing staff was educated on safe patient handling techniques and the patient's required level of assistance for mobility. Communication with the patient, family, nursing staff, physicians, OT, SLP, dietician, pharmacist and case manager occurred daily in acute care to report on the patient's progress and discharge plans. Additional communication with the patient and family occurred during several treatment sessions regarding education about the recommendation for the patient to be discharged to the hospital's inpatient rehabilitation unit prior to discharge home. Documentation of each treatment session was completed outlining the daily interventions, patient's progression toward short and long-term goals, and discharge recommendations.

In inpatient rehab, coordination and communication occurred between the patient and his family, PT, OT, SLP, nursing staff, a case manager and physiatrist. In addition, a weekly interdisciplinary team conference was held to further discuss patient progress and overall plan of care. Continued daily documentation of each treatment session occurred to keep track of the patient's progress and update the plan of care as needed.

Patient-Related Instruction

While in the hospital, the patient was educated regarding bed mobility techniques, safety with the front-wheeled walker (FWW) during transfers and ambulation, and recommended assistance or supervision from nursing or therapy staff until deemed safe and appropriate with all functional mobility. In inpatient rehab, the patient was educated about Borg's Scale of Perceived

Exertion, including how to use the scale to monitor exertion during exercise and how to progress exercise (*Appendix 3*).[25] Furthermore, he was educated about safety with the wheelchair, ambulation with trekking poles, ambulation on uneven surfaces and a home exercise program (*Appendix 4*).

Procedural Interventions

The procedural interventions that were provided during the patient's acute care hospitalization included: therapeutic activities, therapeutic exercise and gait training (*Table 3*)**.** Therapeutic activities consisted of bed mobility training (supine-to-sit, sit-to-supine, rolling right/left, and repositioning in bed) and transfer training (sit-to-stand, stand-to-sit). Verbal and tactile cues were provided to improve his technique with all functional mobility. The patient improved with all functional mobility as demonstrated by the decreasing amount of assistance from the therapist to complete these tasks each day. Therapeutic exercise included strengthening to improve LE strength deficits and activity tolerance to be able to complete ADLs and functional mobility tasks. The focus of gait training was to educate the patient about safe FWW management, improve endurance and activity tolerance, increase gait speed and improve gait quality. Gait training was advanced by increasing the distance the patient ambulated and by providing verbal and tactile cues to improve posture and gait quality. Activity tolerance was addressed by slowly increasing the amount of out of bed activity each day.

The procedural interventions provided in inpatient rehab included: therapeutic activities, therapeutic exercise, gait and locomotion training, and balance training (*Table 4*). In order to safely return home, the patient needed to safely ascend and descend stairs to enter his home, perform a variety of transfers and bed mobility independently, and ambulate on a variety of surfaces. Interventions in this setting were designed to meet these goals and progressed as the

patient demonstrated safety and increased independence. Therapeutic activities included additional bed mobility and transfer training (including stand-pivot transfers and car transfers). Therapeutic exercise included an exercise program for strengthening and using the NuStep® Cross Trainer* with resistance to increase the patient's endurance and strength. Exercises for strengthening were advanced by increasing the number of exercises and by adding resistance once the patient demonstrated ability to successfully complete the exercises with proper form. Gait and locomotion training included wheelchair mobility training, gait training on a variety of surfaces with the FWW and later advancing to bilateral trekking poles and stair training. Once the patient required only supervision using the trekking poles, stair training with trekking poles was introduced and advanced by increasing the number of sets and reducing the level of assistance.

OUTCOMES

Upon discharge from acute care, the patient required supervision for all functional mobility. His PFIT scores improved from 8/12 to 12/12 during his acute care stay, demonstrating a positive change in functional capacity (*Table 5*). He met two of the STG for transfers and activity tolerance and made significant progress towards the bed mobility and ambulation goals (*Table 6*). He was discharged to inpatient rehab for further multidisciplinary rehabilitation.

In inpatient rehab, the patient's FIM scores for mobility and all transfers improved by at least one point and his 2MWT distance improved from 80.8 to 99.1 meters (*Table 5*). He met all STG and LTG and was successfully discharged home using bilateral trekking poles as an AD (*Table 6*).

The patient spent a total of nine days receiving PT and increased his strength, activity tolerance, balance, and independence with functional mobility. Gait improvements included

more upright posture, increased step length, increased gait speed and improved stability, as demonstrated by graduation from FWW to bilateral trekking poles.

DISCUSSION

This case outlined the PT management of a patient with CMT following an MI. Despite the patient's complicated hospital stay and comorbidities, he made significant functional gains and improvements in endurance. An immediate and aggressive rehabilitation course that promoted balance, functional mobility and progressive gait training seemed to substantially improve this patient's physical function and contribute to his potential for independent living in the community.

Prolonged periods of bed rest results in profound deconditioning of the entire body; however, research suggests that early mobilization and physical exercise may help reduce the consequences of bed rest and improve long-term outcomes. Early PT and OT for critically ill patients have resulted in better functional outcomes at hospital discharge.[26] Early mobilization and rehabilitation is also associated with shorter hospital stays and improved outcomes after hospital discharge.[27] Similarly, literature suggests that early progressive exercises in the inpatient setting followed by unsupervised exercise training at discharge have a positive impact on health-related QOL and functional capacity in patients following an acute MI. For this patient, PT exercise intervention was initiated as soon as he was medically stable to prevent further functional decline due to immobility. Our findings corroborated research findings as the patient had good outcomes following early rehabilitation.

In patients with CMT, both interval training and resistance training have had physiological benefits and resulted in improved function and activity performance.[7,8] These findings were also supported in this case study. Throughout his therapy course, the patient was

progressively challenged with therapeutic exercise and gait training to enhance his ability to independently perform functional mobility and ADLs. The patient made significant functional and strength gains throughout his stay as demonstrated by his ability to perform all mobility safely and independently upon discharge.

While there is literature that documents the benefits of early mobilization, PT following an acute MI, and the positive effects of exercise in the CMT population, there is a paucity of research documenting therapy recommendations for patients with both CMT and MI. Future research is needed to understand the profound effect of MI and its sequelae, particularly prolonged immobilization, on patients with CMT and on the most effective treatment options for this population.

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TABLES, FIGURES & APPENDICES

Table 1: Medications

Home Medications	Indication
Aspirin	Antiplatelet for blood clot formation prevention
Nitroglycerin	Preventative for angina as a result of coronary artery disease
Atorvastatin	High cholesterol
Protonix	Acid reflux
Levothyronine	Hypothyroidism
Gabapentin	Neuralgia
Metoprolol	Hypertension
Prasugrel	Platelet inhibitor for acute coronary syndromes
Inpatient Medications	**Indication**
Lovenox	DVT prophylaxis
Metoprolol	Hypertension
Lisinopril	Hypertension
Effient (prasugrel)	Platelet inhibitor for acute coronary syndromes
Albuterol	As needed for shortness of breath or wheezing
Nitroglycerin	As needed for treatment of chest pain
Lasix	Mild pulmonary edema
Subcutaneous Insulin	Glucose intolerance as a result of stress
Lipitor (atorvastatin)	High cholesterol and coronary artery disease

Table 2: Systems Review

Cardiovascular/Pulmonary	*Impaired:* patient required oxygen supplementation via nasal cannula to maintain O2 saturation; vital signs measured at rest in supine and after sitting edge of bed with a drop in systolic blood pressure from 146 in supine to 112 in sitting, at rest peripheral pulse rate was 100 bpm and oxygen saturation on 3 L/min of O2 was 93%; shortness of breath and patient reporting fatigue with light activity
Musculoskeletal	*Impaired:* Gross range of motion (ROM) impairments of bilateral PIP and DIP joints; Gross strength impairments of bilateral upper extremities, including decreased grip strength; Gross strength impairments of bilateral lower extremities; right sided thoracic scoliosis; High medial longitudinal arches bilaterally, over-supination on left foot; impaired gait due to bilateral drop foot
Neuromuscular	*Impaired:* diminished sensation on bilateral distal extremities; impaired sitting and standing balance without AD
Integumentary	*Intact:* Right internal jugular central line, Left radial artery arterial line
Communication	*Intact*
Affect, Cognition, Language, Learning Style	*Intact:* alert and oriented x 4; basic command following, safety/judgment, and problem solving all within normal limits
Other	Foley catheter, GI prophylaxis

Table 3: Acute Care Interventions

		Day 1: Evaluation	Day 2		Day 3	Day 4
Therapeutic Activities	**Bed Mobility**	- Supine→sit with Min A - Rolling right and left - Repositioning in bed	- Supine→sit with S	- Sit→supine with Min A - Repositioning in bed performed I	- Supine→sit with S - Sit→supine with S	- Supine→sit with S
	Transfers	- Sit→stand from hospital bed using FWW with Max A - Stand→sit in armchair using FWW with Max A	- Sit→stand from hospital bed using FWW with Mod A with VC's for technique and correct hand placement on FWW - Stand→sit in armchair using FWW with Min A with VC's for safe technique	- Sit→stand from armchair using FWW with Mod A - Stand→sit in bed with Min A	- Sit→stand from bed using FWW with S for safety - Stand→sit in bed using FWW with S	- Sit→stand from bed using FWW with S - Stand→sit in armchair using FWW with S
Gait Training	**Ambulation**	- Ambulation using FWW 2' with Max A	- Ambulation using FWW 5' with Min A for safety and VC's for FWW management backing up to chair	- Ambulation using FWW 6' with Min A	- Ambulation using FWW 20' with CGA	- Ambulation using FWW 100' with S
Therapeutic Exercise	**Strengthening**					- Sitting B LE exercises including LAQ, marching, armchair push-ups and heel/toe raises x 10 reps x 1 set
	Balance Exercise	- Sitting balance EOB with S and B UE support - Standing balance maintained using FWW and Max A	- Sitting EOB x 3 minutes with S and B UE support		- Static standing for 2 minutes using FWW for support as needed	
	Patient Education	- Proper hand placement and management of FWW - Use of call bell to alert nursing staff for assistance	- Patient and family educated about discharge planning and recommendations	- Patient's spouse educated about IRU placement		- Patient educated about proper completion of LE exercises
	Other	- Patient was on 3 L/min O2 via nasal cannula - Vitals continuously monitored at rest and with activity	- Vitals continuously monitored at rest and with activity	- Patient was on 5 L/min O2 via nasal cannula - Patient set-up on portable telemetry unit to prepare for unit transfer - Patient became moderately fatigued and tachypneic during activity	- Per nursing staff, patient had a hypotensive episode earlier in the morning - Vitals and symptoms monitored for orthostatic hypotension during position changes - Patient was on room air and vitals were monitored by telemetry	- Patient was on room air and vitals were monitored by telemetry

I: Independent; **S:** Supervision; **CGA:** Contact Guard Assistance; **Min A:** Minimum Assistance; **Mod A:** Moderate Assistance; **Max A:** Maximum Assistance; **FWW:** Front-Wheeled Walker; **EOB:** Edge of Bed; **B:** Bilateral; **UE:** Upper Extremity; **LE:** Lower Extremity; **O2:** Oxygen; **VC:** Verbal cues; **IRU:** Inpatient Rehab Unit; **LAQ:** Long arch quads; **→:** to; **<>:** to/from; **Pt:** patient

Table 4: Inpatient Rehab Interventions

		Day 1: Evaluation	Day 2		Day 3		Day 4		Day 5	
Therapeutic Activities	**Bed Mobility**	- Supine<>sit with Mod I using bedrails	- Supine<>sit with Mod I using bedrails	- Supine<>sit with Mod I using bedrails	- Supine<>sit with I without bedrails	- Supine<>sit with I without bedrails	- Supine<>sit with I without bedrails	- Supine<>sit with I without bedrails	- Supine<>sit with I without bedrails	- Supine<>sit with I without bedrails
	Transfers	- Squat-pivot transfer with Mod I with I w/c locking - Stand-pivot transfer using FWW with S	- Stand-pivot transfer w/c<>NuStep using FWW with S	- Stand-pivot transfers with FWW with Mod I-S	- Stand-pivot transfers with FWW with Mod I	- Stand-pivot transfers with FWW with Mod I	- Stand-pivot transfers with B trekking poles and FWW with Mod I	- Stand-pivot transfers with B trekking poles and FWW with Mod I	- Stand-pivot transfers with B trekking poles and FWW with Mod I	- Stand-pivot transfers with B trekking poles and FWW with Mod I - Car transfers x 2 into passenger seat of SUV with S
Gait and Locomotion Training	**Ambulation**	- 2MWT performed using FWW and B AFOs 265' and 40' (cool down) with S	- Walking circuit 6x150' with 15-20 s seated rest between laps with S using FWW and B AFOs	- 6MWT performed with patient ambulating 781' using FWW with S and B AFOs	- Ambulation using FWW and B AFOs 150' on level surfaces with Mod I - Ambulation using FWW and B AFOs 150' on uneven dirt surfaces with CGA for safety	- Ambulation on level surfaces using B trekking poles and B AFOs 150' with S - Ambulation on uneven dirt surface using B trekking poles and B AFOs 100' with CGA for balance/safety	- Ambulation on level surfaces using B trekking poles and B AFOs 150' with S	- Ambulation on uneven dirt surface using B trekking poles and B AFOs with S and occasional VC's for safety	- 2MWT performed using FWW and B AFOs 325' with S - Ambulation on level surfaces using B trekking poles 150' Mod I	- Ambulation 200' x 2 with B AFOs using FWW for 1st lap and B trekking poles for 2nd lap with Mod I
	Stair Training						- Up/Down 4 6" stairs x 3 sets with B handrails using reciprocal gait pattern with S - Up/Down 4 6" stairs x 4 sets with B trekking poles using step-to gait pattern with VC's for placement of trekking poles with Min A to recover balance x 2	- Up/Down 4 6" stairs x 6 sets with rest breaks between every two sets - Up/down single 6" curb step using FWW x 4 sets with S - Up/down single 6" curb step using B trekking poles x 4 sets with S	- Up/Down 4 6" stairs with B AFOs using single hand rail, reciprocal gait ascending and sideways step-to gait descending with Mod I	- Up/Down 4 6" stairs with B AFOs using single hand rail with Mod I - Up/Down 4 6" stairs with B AFOs using B trekking poles with Mod I
	Wheelchair Mobility	- Propelled w/c 50' with S. Difficulty with turns due to impaired grip strength/fine motor control bilaterally	-Propelled w/c 50' with Mod I with B UE	- Propelled w/c 150' with Mod I with B UE	- Propelled w/c 150' with Mod I with B UE	- Propelled w/c 150' with Mod I with B UE	- Propelled w/c 150' with Mod I with B UE	- Propelled w/c 150' with Mod I with B UE	- Propelled w/c 150' with Mod I with B UE	- Propelled w/c 150' with Mod I with B UE
Therapeutic Exercise	**Strengthening**	- Slow seated marches x 20 reps -Static/dynamic sitting balance (perturbations, eyes open/closed) with S - Standing balance (30 s unsupported with S, 15 s Romberg stance with S, 15 s semi-tandem stance with Min A to assume position and S once set)	- Standing LE exercises in parallel bars including marching 10 reps x 3 sets, hip extension 10 reps x 1 set	- Sit<>stands without UE from 23.5" seat 10 reps x 3 sets - SLR 10 reps x 2 sets each side - Glute bridges 10 reps x 3 sets - Clamshells 10 reps x 1 set each side - Supine hip abduction 10 reps x 2 sets each side	- Sit<>stands without UE from 22" seat 10 reps x 4 sets	- SLR 10 reps x 2 sets each side - Glute bridges 10 reps x 1 set - Clamshells 10 reps x 1 set each side - Supine hip abduction 10 reps x 1 set each side		- Glute bridges 10 reps x 1 set - Clamshells 10 reps x 1 set each side - SLR 10 reps x 1 set each side - Standing hip flexion, hip extension, and hip abduction with B UE support 10 reps x 1 set	- Pt educated about and performed HEP including glute bridges 10 reps x 1 set, clamshells with red resistance band 10 reps x 2 sets, SLR 10 reps x 2 sets each side, standing hip flexion 10 reps x 1 set each side, standing hip abduction 10 reps x 1 set each side, standing hip extension 10 reps x 1 set each side and sit<>stands with UE support 10 reps x 3 sets	- Sit<>stands from progressively lower mat height starting at 22", lowering 1" per successive attempt x 10 reps. Pt able to successfully perform sit<>stands to 19" mat height
	Activity Tolerance		- NuStep 8 min, level 1 resistance (RPE below 11)		- NuStep 8 min, level 2 resistance (RPE below 11)		- NuStep 10 min, level 3 resistance (RPE 11-12)		- NuStep 5 min, level 1 resistance for warm-up	

I: Independent; **Mod I:** Modified Independent; **S:** Supervision; **CGA:** Contact Guard Assistance; **Min A:** Minimum Assistance; **FWW:** Front-Wheeled Walker; **B:** Bilateral; **UE:** Upper Extremity; **LE:** Lower Extremity; **VC:** Verbal cues; **w/c:** wheelchair; **2MWT:** 2 Minute Walk Test; **6MWT:** 6 Minute Walk Test; **AFOs:** Ankle-Foot Orthoses; **SLR:** Straight Leg Raise; **HEP:** Home Exercise Program; **RPE:** Rate of Perceived Exertion; **DC:** Discharge; **→:** to; **<>:** to/from; **Pt:** Patient

Table 5: Tests and Measures at Admission and Discharge

		Acute Care Initial Eval	Acute Care Discharge	Inpatient Rehab Initial Eval	Inpatient Rehab Discharge
Bed Mobility	**Sit to Supine**	Min A	S	Mod I with bedrails	I
	Supine to Sit	Min A	S	Mod I with bedrails	I
Transfers	**Sit to Stand**	Max A with FWW	S with FWW	DNT	DNT
	Stand to Sit	Max A with FWW	S with FWW	DNT	DNT
	Stand Pivot	DNT	DNT	S with FWW	Mod I with FWW and B trekking poles
Observational Gait Analysis		Patient sidestepped and pivoted two feet to bedside chair with Max A and FWW. He demonstrated decreased bilateral foot clearance, decreased gait speed and short step length bilaterally. 2' Max A with FWW	Patient demonstrated decreased dorsiflexion on BLE and compensated with increased hip flexion for B foot clearance. He walked with forward flexed trunk, had short step length and decreased heel strike bilaterally. Walked on lateral edge of L foot due to over supination. 100' S with FWW	Patient demonstrated increased hip flexion compensation with decreased control during swing bilaterally. 265' S with FWW and B AFOs	With B trekking poles and B AFOs, patient demonstrated increased fatigue at ~5 minutes ambulation as indicated by mild increased R trendelenberg gait 200' x 2 Mod I with FWW and trekking poles and B AFOs
Manual Muscle Testing	**RLE**	Hip Flexion: 4/5 Knee Extension: 5/5 Ankle DF: 0/5 Knee Flexion: 5/5	DNT	Hip Flexion: 4/5 Knee Extension: 5/5 Ankle DF: 0/5 Hip Abduction: 2+/5	DNT
	LLE	Hip Flexion: 4/5 Knee Extension: 5/5 Ankle DF: 1/5 Knee Flexion: 5/5	DNT	Hip Flexion: 4/5 Knee Extension: 5/5 Ankle DF: 1/5 Hip Abduction: 2+/5	DNT
Balance	**Static Sitting**	Fair	Good	Good	Good
	Dynamic Sitting	Fair	Good	Good, able to withstand perturbations with eyes open/closed	Good
	Static Standing	Poor, required Max A for standing balance	Fair, static standing with FWW with no noted sway	Fair, able to stand unsupported with S x 30 s, Romberg stance S x 15 s, Semi-tandem stance with Min A to assume position and S to maintain x 15 s each side	Fair
	Dynamic Standing	Poor, required Max A and FWW for 2' ambulation to bedside chair	Fair, using FWW	Fair, using FWW	Fair, using FWW or B trekking poles
Physical Function in ICU Test (PFIT)		8/12 Assistance=1 Cadence=1 Shoulder Strength=3 Knee Strength=3	12/12 Assistance=3 Cadence=3 Shoulder Strength=3 Knee Strength=3	DNT	DNT
Functional Independence Measure (FIM)		DNT	DNT	*Transfer In/Out Bed, Chair, Wheelchair* 5-Supervision/Setup *Toilet Transfer* 0- Activity does not occur *Tub/Shower Transfer* 0-Activity does not occur *Ambulation/Level Surface* 5-Supervision/Setup *Stairs* 0-Activity does not occur	*Transfer In/Out Bed, Chair, Wheelchair* 6 Modified Independent *Toilet Transfer* 6-Modified Independent *Tub/Shower Transfer* 5-Supervision/Setup *Ambulation/Level Surface* 6- Modified Independent *Stairs* 5-Supervision/Setup
2 Minute Walk Test (2MWT)		DNT	DNT	80.8m with FWW	90.1m with FWW

I: Independent; **Mod I:** Modified Independent; **S:** Supervision; **Min A:** Minimum Assistance; **Max A:** Maximum Assistance; **FWW:** Front-Wheeled Walker; **DNT:** Did Not Test; **AFOs:** Ankle-Foot Orthoses; **B:** Bilateral; **R:** Right; **L:** Left; **LE:** Lower Extremities; **s:** seconds

Table 6: Physical Therapy Goals in Acute Care and Inpatient Rehab

Acute Care Goals		Time Frame	Status
STG 1	Patient will be independent with bed mobility in order to successfully get into and out of bed.	7 days	Making progress toward goal
STG 2	Patient will be able to transfer from sit to stand and stand to sit using front-wheeled walker (FWW) with only minimum assistance (Min A).	7 days	Goal Met
STG 3	Patient will ambulate 100 feet using FWW with a normal cadence and velocity with Min A for safety.	7 days	Making progress toward goal
STG 4	Patient will ambulate continuously for two minutes without shortness of breath, on supplemental oxygen as needed, in order to increase endurance for functional tasks.	7 days	Goal Met
LTG 1	Patient will be able to transfer from sit to supine and supine to sit using most appropriate assistive device with modified independence.	21 days	Making progress toward goal
LTG 2	Patient will ambulate 300 feet on various surfaces using most appropriate assistive device in order to return home.	21 days	Making progress toward goal
LTG 3	Patient will tolerate 15 minutes of physical activity without shortness of breath in order to complete functional tasks.	21 days	Making progress toward goal
	Inpatient Rehab Goals	**Time Frame**	
STG 1	Patient will perform stand-pivot transfers with modified independence using either front-wheeled walker or bilateral trekking poles.	4 days	Goal Met
STG 2	Patient will ambulate 150 feet with bilateral AFOs using FWW or bilateral trekking poles with modified independence.	4 days	Goal Met
STG 3	Patient will tolerate five minutes of NuStep on level three with Rate of Perceived Exertion <17.	3 days	Goal Met
STG 4	Patient will ambulate 50 feet outdoors using FWW with supervision.	4 days	Goal Met
LTG 1	Patient will ambulate greater than 97 m during Two Minute Walk Test (2MWT) using FWW with modified independence.	7 days	Goal Met
LTG 2	Patient will perform car transfer using FWW with supervision in order to safely get into and out of a car.	7 days	Goal Met
LTG 3	Patient will be able to go up and down two 6” curbs using FWW with supervision in order to safely ambulate in the community.	7 days	Goal Met
LTG 4	Patient will be able to go up and down four 6” steps using right-sided handrail with modified independence in order to safely enter and exit his home.	7 days	Goal Met
LTG 5	Patient will be independent with performing home exercise program using written handout.	7 days	Goal Met

Appendix 1: Physical Function in ICU Test Scoring:

PFIT-s Components			
Assistance	**Cadence (steps/min)**	**Shoulder Strength[a]**	**Knee Strength[b]**
0=unable	0=unable	0=grade 0, 1, or 2	0=grade 0, 1, or 2
1=assist × 2	1=>0–49	1=grade 3	1=grade 3
2=assist × 1	2=50–<80	2=grade 4	2=grade 4
3=no assistance	3=80+	3=grade 5	3=grade 5

[a] Maximum strength of left or right shoulder flexion using the Oxford grading system.
[b] Maximum strength of left or right knee extension using the Oxford grading system.

Appendix 2: Functional Balance Grades:

Normal	**Static:** Patient able to maintain steady balance without handhold support **Dynamic:** Patient accepts maximal challenge and can shift weight easily within full range in all directions
Good	**Static:** Patient able to maintain balance without handhold support, limited postural sway **Dynamic:** Patient accepts moderate challenge; able to maintain balance while picking object off floor
Fair	**Static:** Patient able to maintain balance with handhold support; may require occasional minimal assistance **Dynamic:** Patient accepts minimal challenge; able to maintain balance while turning head/trunk
Poor	**Static:** Patient requires handhold support and moderate to maximal assistance to maintain position **Dynamic:** Patient unable to accept challenge or move without loss of balance

Appendix 3: Borg's Scale of Perceived Exertion

6 No exertion at all
7
8 Extremely light
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion

Appendix 4: Home Exercise Program

Lying on your back with knees bent.

Squeeze your buttocks together and lift your bottom off the floor. Return to starting position.

Repeat 10 times.
Complete 1 set.

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Lie on your side with your knees bent. Place red theraband above both knees.

Tighten your buttocks. Lift your top knee as far as you can, without letting your pelvis rotate forward or back. Keep your feet together and back straight during the exercise.

Repeat 10 times each leg. Complete 2 sets.

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Lying on your back with one leg straight and the other leg bent.

Exercise your straight leg by pulling the toes up, straightening the knee and lifting the leg 20 cm off the bed. Hold approx 5 secs. - slowly relax.

Repeat 10 times with both legs. Complete 2 sets.

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Stand straight.

Lift one leg with your knee straight.

Repeat 10 times.
Complete 1 set.

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Stand straight holding on to a support.

Lift your leg sideways and bring it back keeping your trunk straight throughout the exercise.

Repeat 10 times each leg. Complete 1 set.

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Stand straight holding on to a chair.

Bring your leg backwards keeping your knee straight. Do not lean forwards.

Repeat 10 times each leg. Complete 1 set.

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Sit to stands.

Place your feet on the floor with the stronger foot behind the other. Lean forward and move your weight to your feet. Push down with your hands to stand up. Sit down by lowering yourself slowly back to the surface.

Repeat 10 times.
Complete 1 set.

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