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# Critical Illness Polyneuropathy, Complications

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by

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(Graduate School Advisor)

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## ABSTRACT

**Study Design:** Case report.

**Background and Purpose:** Critical Illness Polyneuropathy/Myopathy results from the presence of sepsis, multi-organ or respiratory failure, septic inflammatory response syndrome, or difficulty weaning from the ventilator. Decreased amplitudes of compound muscle and sensory action potentials, and widespread denervation potentials in muscle are the primary cause for the resultant muscle weakness. The purpose of this paper is to report on the rehabilitation progress in a woman who developed CIP following surgical complications.

**Case Description:** A 63-year-old woman suffered from critical illness polyneuropathy following a complicated recovery following a sigmoidectomy secondary to diverticular disease. Multiple surgeries, inability to wean from the ventilator, and co-morbidities of obesity and smoking complicated her rehabilitation. Physical therapy rehabilitation included general strengthening, gait, balance and proprioceptive training, and activity modification education.

**Outcome:** The patient returned home with assistance from family in three weeks. She was discharged with a single point cane and education on activity modification. Improvement, manifested in her AM-PAC and Tinetti functional outcome assessments, supported her discharge home.

**Discussion:** Following three weeks of intensive physical therapy, the patient was ready for discharge and given the tools to further her rehabilitation to be functionally independent. She returned home with an assistive device and required minimal assistance from her family.

**Conclusion:** Aggressive physical therapy that targets lower extremity and trunk strengthening, as well as balance and proprioception, and activity modification, is effective treatment for critical illness polyneuropathy.


**Key Words:** *Critical Illness Polyneuropathy, Critical Illness Myopathy, Diverticular Disease, Colovesicular Fistula, Sigmoidectomy*

# CHAPTER I

# BACKGROUND AND PURPOSE

## INTRODUCTION

The patient in this case study presented to the medical community with diverticular disease and multiple co-morbidities. She developed multiple post-surgical complications following a sigmoidectomy related to her diverticular disease and resulted in a prolonged recovery. She was evaluated and treated by physical therapy for assistance in functional outcomes. The diagnosis for her post-surgical physical therapy plan of care was Critical Illness Polyneuropathy (CIP)/Critical Illness Myopathy (CIM).

An overview of diverticular disease, and its co-morbidities and complications will be presented in Chapter 1. The typical presentation and outcomes of CIP/CIM will then be addressed. The specifics of this patient's clinical case will begin in Chapter 2.

### *Diverticular Disease*

Diverticular disease (DD) is caused by inflammation of diverticula; small, bulging pouches that form in the lining of the digestive system, specifically the lower part of the large intestine (colon). Development of diverticula occurs due to structural abnormalities of the colonic wall, disordered intestinal motility, or as the result of diets low in fiber. DD is one of the most common colonic disorders in Western societies. [14]

The prevalence of DD increases with age, and affects over 60% of individuals 50 years or older. Up to 20% of symptomatic diverticular disease patients require surgical

intervention. [14] Twenty-five percent of individuals with diverticular disease develop complications such as an abscess, blockage, fistula, or peritonitis. [14] Surgery is indicated for recurrent episodes and serious DD complications such as abscesses, perforation, bleeding, obstruction, and fistula formation; colovesicular fistula (CVF) is the formation of a connection between the colon and urinary bladder due to chronic inflammatory disease process. [4, 22, 29, 32, 35, 36] The formation of a connection between the colon and urinary bladder may cause changes in the bowel to be present with urination.

***Co-morbidities and Effects Related to Surgical Intervention for Diverticular Disease***

Smoking has been shown to contribute to adverse post-operative outcomes regardless of the presence of smoking-related disease (i.e. cardiovascular disease, chronic obstructive pulmonary disease, and cancer).[26] The study established that cessation of smoking at least one year prior to surgery will not increase risk of postoperative mortality, and lowers risks of arterial and respiratory events when compared to current smokers.

Patients with increased visceral abdominal fat are more likely to develop complications after sigmoid resection for diverticulitis, leading to extended stays in the Intensive Care Unit (ICU) and Transitional Care Unit (TCU) or Progressive Care Unit (PCU). [36] Obesity, with or without co-morbidities, increases the risk for wound dehiscence, surgical site infection (SSI), increased failure to wean from ventilator and risk of developing pulmonary embolism (PE). Obesity is also associated with increased operative time and work of breathing. [15] However, another study refutes that body mass index (BMI) is not associated with development of pulmonary complications. [38]

***Surgical Complications***

Anastomotic leakage (AL) is a common and lethal complication of gastrointestinal surgery, especially with colonic resection. An anastomosis is a surgical connection between two structures, such as two ends of intestine attached during gastrointestinal surgery. AL occurs when the anastomosis is not secure and leakage of digestive system fluid and air enters the abdominal cavity causing peritonitis or sepsis. [38] Authors Lin X et al[21] found that patients with DM have a 2.17 times higher risk of colon perforation following stomach surgery. [21] In relation to the presence of DM; hyperglycemia has also been identified as a risk factor for developing CIP/CIM. [39, 40]

Studies have found that 30.49% of patients who developed septic shock also experienced postoperative pulmonary complications (PPC), such as ARDS; a buildup of fluid in the alveoli of the lungs that can occur as a complication following surgery or in those who are critically ill. [24, 26, 38] ARDS patients have been shown to have an increased risk of developing CIP/CIM which increases the prolongation of mechanical ventilation and ICU- Length of Stay (LOS). [5] Authors Baldwin and Bercker et al [2, 5] found that 74% of patients, severe infections were the underlying cause of ARDS. Sepsis was also a major risk factor for developing CIP/CIM. Up to 90% of patients with severe sepsis, hypotension, and multi-organ dysfunction syndrome, presented clinical signs of muscular weakness. [2, 5]

***Critical Illness Polyneuropathy/Myopathy***

Critical illness polyneuropathy (CIP) and critical illness myopathy (CIM) are now the most common acquired neuromuscular conditions in the ICU setting. [9, 39] CIM can occur

in conjunction or separately from CIP. Typically, CIM occurs in patients from the ICU treated with multiple drugs, who present with diffuse weakness and a failure to wean from mechanical ventilation. [32]

The pathogenesis of CIP is still poorly understood, and the true etiology is yet to be determined. CIP frequency has been found to correlate with the length of severe illness, and diagnosis is typically preceded by acute respiratory distress syndrome (ARDS), sepsis, multi-organ failure, respiratory failure, or septic inflammatory response syndrome (SIRS). Studies have shown that onset of CIP may occur as early as 3 days following onset of sepsis or SIRS. [9] Early signs of CIP/CIM are difficulty weaning from mechanical ventilation and limb weakness. [8, 40]

The presence of severe illness increases the risk of CIP/CIM due to decreased amplitudes of compound muscle and sensory action potentials, widespread denervation potentials in muscles, and normal or mildly increased levels of blood creatine phosphokinase (CPK) levels; elevated CPK levels indicate injury or stress to muscle, heart, or brain tissue.[8, 13, 17, 37, 40] Sepsis and multi-organ dysfunction increase the risk of CIP due to elevated levels of serum glucose and albumin which also impact nerve function. [17]

More than 50% of patients mechanically ventilated for more than 7 days will develop electrophysiological abnormalities. Of those patients more than 25% will develop overt clinical weakness. Acquired neuromuscular dysfunction is associated with difficulty weaning from mechanical ventilation, increased hospital costs and mortality rates. [17]

There is no direct treatment for CIP and CIM. Possible preventions include treating underlying sepsis/SIRS, glycemic control with insulin, and minimizing steroid use.

Possible treatments include intensive psychological care and reassurance, intensive physical therapy and supportive care, or an intensive rehabilitation program. [17]

Prognosis is favorable once the patient leaves the acute care hospital. However, in the short-term there is a high mortality rate associated with sepsis/SIRS and prolonged ventilator support. In the long term, patients have a 50% chance of making a complete recovery; this is dependent on the initial severity. Further research into the causes and treatments of CIP and CIM are needed to improve diagnosis and intervention timing. [17]

Recovery from CIP/CIM can take weeks to months, and currently there is no medication therapy. CIP/CIM is managed conservatively through services such as Physical Therapy. Approximately 50% of individuals with CIP/CIM experience complete recovery. [8, 25] One study suggests that most patients benefit from transitioning to an inpatient rehabilitation unit once clinically stable, with the goal of returning home to independent living. [9]

The patient in this case study was selected due to the high occurrence rates of diverticular disease in society, and the lack of research into effective physical therapy treatment for CIP/CIM.

**PURPOSE**

The purpose of this case study is to describe the rehabilitative physical therapy course in a 63 year old woman who developed critical illness polyneuropathy/critical illness myopathy following a sigmoidectomy for diverticular disease with subsequent complications.

# CHAPTER II

# CASE DESCRIPTION

*This chapter will detail the specifics of this patient's presentation to physical therapy. It will include the subject history, presentation, examination and evaluation findings, interventions, and outcomes. This patient was successfully discharged home following physical therapy intervention.*

## *Subject History*

The patient was a 63-year-old female who presented to physical therapy with Chronic Illness Polyneuropathy/Myopathy following multiple complications from diverticular disease surgery. Her multiple co-morbidities may have exacerbated the pre- and post-surgical course, and contributed to the development of the CIP and CIM. Patient was transferred for swing bed rehabilitative care, 3 months status post initial surgery.

The patient's past medical history was significant for cholecystectomy, laparoscopic tubal ligation, tonsillectomy and adenoidectomy, sinus surgery, left ankle ORIF, and back surgery. Patient's past medical history is non-significant for cancer, diabetes, or hypertension. However, it is significant for a history of smoking, morbid obesity (BMI: 40), sedentary lifestyle, post-menopause, and age greater than 55-years-old, stratifying her into the high risk level for cardiovascular involvement. Family history was reported to be unremarkable.

Patient was transferred from major medical center to swing bed location near her home following a 3 month recovery period, status post complications from sigmoidectomy and take-down surgery for diverticular disease. Patient's symptoms began in spring 2014 with the presence of dietary changes in her urine output. Patient was seen by her primary care physician and misdiagnosed with a urinary tract infection (UTI) that was treated with 2 courses of antibiotics. The antibiotics did not have an effect, and further review of her medical history revealed a scan showing an adnexal mass in 2002. No further medical intervention was initiated at that time.

New scans were completed in summer 2014, and it was determined that the patient had a colovesicular fistula which was identified as the cause of the dietary changes in the patient's urine output. Patient underwent sigmoidectomy and take-down surgery in late summer of 2014, had an unremarkable hospital recovery, and was discharged home after 3 days. Patient experienced pain, abdominal distention, and inability to have a bowel movement in the week following surgery. After presenting to the local emergency room, she was transferred via life flight to undergo urgent surgery for an anastomotic leak.

A referral for inpatient rehabilitation services was initiated following her second surgery. During inpatient rehabilitation, she developed severe shortness of breath and fever. She was readmitted to the hospital for a thoracentesis and a subsequent third surgery to address respiratory complications. After surgical intervention for respiratory complications, the patient was unable to wean from the ventilator. A transfer was initiated secondary to familial concerns to a major medical center in early fall 2014. During her time at the major medical center, she was weaned from the ventilator and

began the process of regaining her strength. After one month, she had regained enough strength to transfer to a more local swing bed location via medical transport van.

The patient was initially evaluated in swingbed rehabilitation approximately three months after her initial surgery. Patient presented with complaints of general weakness and diminished activity tolerance. She rated her pain as 0 on a 10-point visual analog pain scale. Multiple abdominal surgeries caused a loss of sensation across the entirety of her abdomen. She did not experience any abdominal pain. Nursing managed post-surgical abdominal wound care with precautions for protection and maintained integrity of the incisions. Patient presented with an ileostomy that she had started emptying independently with supervision from nursing. Patient required the use of a front wheeled walker (FWW) to complete transfers and for ambulation. Her goals were to regain her independence with activities of daily living (ADLs), improve her strength and endurance, and return home.

Patient had been widowed for 2 years and lives alone in a one-level home with basement. She stated that all ADLs can be completed on the main level with the exception of laundry which is located in the basement. To enter the home, patient has 5 stairs with bilateral railings. She reports that she retired in spring 2014 from a 30-year career in personal banking. She continued to hold the position of treasurer for her church, with assistance from her daughter. Patient had a strong connection with her personal faith and excellent family support. She had one daughter who lived locally and assisted as needed.

***Review of Systems***

Patient presented with overall deconditioning evident with muscular disuse atrophy and diminished functional mobility. She exhibited decreased strength bilaterally in lower and upper extremities. It was noted that the left lower extremity had greater weakness and atrophy present, versus the right lower extremity. Cardiovascular review showed patient's oxygen saturation levels remained stable with room air, but shortness of breath apparent with activity. Integumentary concerns included decreased healing of abdominal incision and right forearm radial aspect ulcer with thrombosed vessel from faulty IV line. Additional concern expressed regarding development of stage I pressure ulcer to patient's sacrum. Neuromuscular involvement found to be unremarkable upon examination.

***Clinical Impression***

Patient was an acceptable candidate for intervention due to referral from primary care provider, availability of the appropriate equipment, skills, and intervention techniques to positively impact patient's health status. Patient had a strong desire to return to independent living, as well as, strong family and friend support systems.

***Examination Plan***

Patient examination assessed for differential diagnosis of spinal cord dysfunction, critical illness myopathy, Guillain-Barre syndrome, motor neuron disease, porphyria, pre-existing neuropathy, and myasthenia gravis. [8, 40] Examination included strength and functional mobility assessments to determine limitations and areas that needed

improvement. Prognosis was dependent on results of examination and review of medical record. Interventions were targeted to improve muscular strength and endurance of trunk and lower extremities, balance and neuromuscular re-education, gait training, and patient education.

## EXAMINATION AND EVALUATION

### *Tests and Measures*

Baseline data was collected for range of motion, strength, and functional mobility. Upper and lower extremity range of motion in all motions was found to be within normal limits. A slight limitation was noted with bilateral hip flexion in short sitting, secondary to muscle weakness. Manual muscle testing (MMT), using the isometric technique, was used to determine gross strength of hip, knee, and ankle (Table 1). Upper extremity testing was deferred to occupational therapy. Patient strength assessment resulted in 3- out of 5 in bilateral hip flexion, extension, and abduction and 4- out of 5 in bilateral knee flexion and extension. Functional mobility was assessed with the Activity Measure for Post-Acute Care (AM-PAC); a copy of the scale is presented in Appendix 1. The reliability of the AM-PAC is addressed in Table 2. Authors Coster et al [11] compared the AM-PAC to the Functional Independence Measure (FIM) which showed the AM-PAC scales are more sensitive measures of change in functional activity performance over time in the general population of persons who receive inpatient rehabilitation services when compared to the FIM. Patient initial score on the AM-PAC was 13, indicating a sixty-five percent degree of functional impairment. [18, 19] The patient's level of endurance was extremely low. She was fatigued from the trip to swingbed, and she was unable to

physically complete the AM-PAC. Clinical judgement was utilized to complete the AM-PAC form.

At the time of evaluation in fall 2014, the patient's consent was given to proceed with physical therapy evaluation. Patient's wound and ileostomy cares were followed by nursing and are not included in this case study. Patient was seated in a straight-backed, low bedside chair with no supplemental oxygen. Patient's posture was observed to be "slouched" with rounded shoulders and forward head. Deconditioning of the abdominal walls and shoulder girdle were suspected to contribute to the patient's posture. The bedside chair was too narrow and low for the patient to achieve optimal positioning. Patient denied any pain or discomfort prior to initiation of evaluation. Difficulty was noted when completing transfers from sit-to-stand, stand-to-sit, and sit-to-supine. She required the use of a FWW and assistance from therapist for functional mobility. Even with minimal activity, the patient became short of breath and fatigued.

She was able to ambulate the two feet from the bedside chair to sit edge of bed (EOB). It was noted that the patient pushed heavily through her upper extremities into the FWW, was flexed forward at the hip, and shuffled her feet. The distance ambulated did not allow a full understanding of patient's gait pattern. Patient's posture and gait mechanics supports the hypothesis of overall deconditioning, especially in large muscle groups.

Patient was encouraged to slow her breathing with verbal cueing, and supervision was given at bedside to assure patient safety. Bed mobility took significant effort and multiple attempts for the patient to complete. Therapist assistance was needed to position

patient safely in bed. Patient was informed of physical therapy's intention to see her twice daily in the physical therapy department, which was agreeable to her.

During later evaluation, the patient was unable to maintain correct posture in sitting or standing, due to weakness and deconditioning. Patient was also unable to lift her feet during ambulation and relied heavily on her assistive device. She was also easily fatigued and short of breath during the evaluation, indicating diminished aerobic capacity and intolerance for functional activity.

Patient did not have a previous history of cardiovascular or pulmonary involvement, had not experienced unexpected weight gain, and did not have signs of bilateral ankle edema, ruling out an underlying heart condition. Presence spinal cord dysfunction was ruled out due to lack of trauma. Guillain-Barre syndrome, motor neuron disease, porphyria, pre-existing neuropathy, or myasthenia gravis were also ruled out due to patient history of surgical intervention, sepsis, difficulty weaning from the ventilator, obesity, and smoking history that are all risk factors for the development for CIP/CIM.

Patient problem list was determined to include: decreased strength, decreased AROM, decreased balance, decreased postural control, and decreased endurance. Patient impairments have created limitations in patient functional mobility, and she currently requires the use of an assistive device to complete transfers and ambulation. She is also currently unable to ascend/descend stairs.

Prior to her hospitalization, the patient was independent in all areas of functional mobility. At the time of the initial evaluation, the patient was able to watch television, talk on her phone, visit with friends, and sit up to eat supper. She was unable to move independently within her room to complete ADLs or for leisure. She was also unable to

participate in social activities such as attending church or going out in the community alone or in a group. The patient was very motivated to participate in physical therapy, and had a positive attitude regarding her recovery. She also had very supportive friends and family in the community, as well as, the support from her insurance company to cover the length of her swing bed rehabilitation.

**Table 1: Manual Muscle Test Reliability[30]**

| | *Test-Retest* | | | *Interrater/Intrarater* | | |
|---|---|---|---|---|---|---|
| | ***Strength*** | ***ICC*** | | | ***Strength*** | ***ICC*** |
| **Left** | Excellent | 0.98 | | **ICU Survivors** | Adequate | 0.66 |
| **Right** | Excellent | 0.97 | | | Excellent | 1.00 |

| ***Sensitivity*** | ***Specificity*** | ***Likelihood Ratio (+)*** |
|---|---|---|
| 0.35 | 0.90 | 3.5 |

**Table 2: AM-PAC Reliability[11, 18, 19]**

| | *Test-Retest* | | | *Interrater/Intrarater* | | |
|---|---|---|---|---|---|---|
| | ***Strength*** | ***ICC*** | ***95% CI*** | ***Strength*** | ***ICC*** | ***95% CI*** |
| **Personal & Instrumental** | Excellent | 0.96 | 0.92-0.98 | Excellent | 0.90 | 0.73-0.94 |
| **Movement & Physical** | Excellent | 0.97 | 0.92-0.98 | Excellent | 0.86 | 0.68-0.96 |
| **Applied Cognition** | Excellent | 0.91 | 0.70-0.96 | Adequate | 0.68 | 0.55-0.89 |

## DIAGNOSIS

Following review of the patient chart, patient history, and evaluation, it was determined that the patient had developed critical illness myopathy, secondary to a prolonged hospital stay, secondary to multiple surgeries from complications due to diverticular disease. It was initially determined that she fell under the musculoskeletal practice pattern, 4I: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Body or Soft Tissue Surgery, due to her surgery for diverticular disease. After reviewing the literature, it seems more likely that the patient was experiencing critical illness polyneuropathy (CIP) or a combination of CIM and CIP. A diagnosis of CIM or CIP would include this patient under the neuromuscular practice pattern, 5G: Impaired Motor Function and Sensory Integrity Associated with Acute or Chronic Polyneuropathies. The cardiovascular/pulmonary practice pattern, 6B: Impaired Aerobic Capacity/Endurance Associated with Deconditioning could also be applied.

### *Goals*

The patient's goal was to return home independent with all activities within one month. Physical therapy goals were for the patient to tolerate age appropriate functional and community activity, with minimal fatigue and no discomfort with the use of an assistive device, and to return home with assistance from family within three weeks. Short and long term goals were developed to reflect the skills necessary for the patient to return home (Table 3).

| Table 3: Goals |
| --- |
| ***Short Term Goals (to be met in 1 week):*** |
| 1. Patient will logroll independently. |
| 2. Patient will perform bed mobility independently. |
| 3. Patient will go supine to/from sit modified independent with FWW. |
| 4. Patient will go sit to/from stand modified independent with FWW. |
| ***Long Term Goals (to be met in 3 weeks):*** |
| 1. Patient will transfer modified independent with FWW. |
| 2. Patient will ambulate > 200 feet with FWW. |

## PROGNOSIS

Patient had a fair prognosis for recovery as she was extremely motivated to return home independently. She had a positive attitude towards her recovery, a strong network of friends and family, and no pain in her abdomen. Limitations to patient prognosis involved the extent of her surgical intervention and length of hospitalization, level of deconditioning, and presence of co-morbidities. Based on acuity of her condition, age, motivation, and pain level, her expected recovery for return home with assist from family was three weeks.

### *Clinical Impression*

Patient was referred to physical therapy by her primary care provider upon her arrival to swing bed. Following patient examination and evaluation, it was determined that the patient would benefit from skilled physical therapy intervention. The facility had the equipment and skilled therapists necessary to facilitate the completion of patient goals. The patient was followed by a multi-disciplinary team due to the extent of her needs. She desired to be an active participant in the planning and implementation of her care plan.

### *Plan*

Patient was seen in the physical therapy department twice daily, Monday through Friday, and once daily on Saturday, for three weeks. Patient was re-assessed on swing bed day nine, and upon anticipated discharge from the hospital. Continuation of physical therapy through outpatient services was determined at patient's discharge evaluation from swing bed.

## INTERVENTION

Studies show unambiguously that neuromuscular dysfunction, resulting in muscle wasting and weakness is the most persistent and debilitating problem for survivors from the ICU. These symptoms could persist as long as 2 years after hospital discharge due to the multiple systems involved. [20, 40] An additional study states that patients with recent mechanical ventilation have poor long-term survival. Interventions focused on improving function and mobility has the potential to reduce mortality and improve functional status.[3] Due to the potential for long term disability, physical therapy interventions focused on improving musculoskeletal strength, aerobic endurance, balance and proprioception, and activity tolerance, to minimize the long term effects of the disease process. Functional activities such as transfers, ambulation, and stairs were important considerations when developing a plan of care. Therapy sessions were completed twice daily, so interventions needed to be grouped into manageable sections for the patient. It was also important to avoid over-fatigue, especially during the initial days, with this patient.

There are few studies on CIP/CIM, and most do not identify a specific protocol for rehabilitation. One study suggests patients complete 15 minutes of walking, alternating 1 minute fast walking with 1 minute of slow walking. [6] In this specific case, the treadmill was deemed not to be the most appropriate option secondary to safety concerns. The same study advocated 15 minutes of resistance work to include forward and lateral step-ups, bicep curls and shoulder press, and sit-to-stand transfers. [6, 7] Initial intervention did include bicep curls and shoulder press, but occupational therapy assumed primary responsibility for upper extremity conditioning following initial PT intervention.

An additional study supports the use of ROM, progressive resistive exercises (PRE), functional transfers, and ambulation as the foundation to developing an effective intervention program for CIP/CIM. Specific exercises to include were ankle plantar flexion and dorsiflexion, hip and knee flexion and extension, SLR, and sit-to-stand transfers. The treatment group receiving physical therapy intervention made significant gains in comparison to the control group after 6 weeks. The most notable gains were in limb strength and improvements in functional test scores, such as the Functional Independence Measure (FIM). [10]

The current research supports the types of intervention techniques utilized in this patient's rehabilitation. A structured approach to intervention was requested so she could mentally and physically prepare herself. A series of exercises were developed for her to complete in morning and afternoon sessions that would challenge her, yet would not push her past fatigue and into exhaustion.

Morning sessions (Table 4) included gait analysis and ambulation, progressing from 60 feet with assistive device and therapist assistance, to distances greater than 200 feet with the least restrictive assistive device at discharge. Verbal cueing was utilized to increase stride length, develop toe push-off, activate core muscles, and facilitate trunk extension during ambulation. Morning sessions included ambulation at the beginning and end, and were followed by seated exercises: long arc quads (LAQ) with ankle weights; knee flexion and hip abduction with TheraBand; and isometric hip adduction with a medium-sized ball. The patient would then transition to the parallel bars to complete three-way hip exercises; hip extension, abduction, and marching flexion with ankle

weights. Forward and lateral step-ups and toe and heel raises were also completed while the patient was in the parallel bars.

Hip musculature was the primary focus in the morning sessions, to improve gait mechanics and ambulation quality, muscular endurance during aerobic activity, sit-to-stand transfers, and sit-to-supine transfers. Ankle musculature and promotion of ankle strategy were incorporated with exercises in the parallel bars. Due to the extent of the patient's deconditioning, she required multiple rest breaks. During the transitions between activities and associated breaks, the patient would receive verbal and tactile cueing to perform proper sit-to-stand transfers until a proper transfer was achieved.

Afternoon sessions (Table 5) included a five minute warm-up on the Nu-Step with seat and arms adjusted for patient use. Initial workload was set at 1, and she was instructed to use only her lower extremities. Mat exercises, performed in supine, included short arc quads (SAQ) with a five inch diameter bolster placed under the knees, straight leg raises (SLR), hip abduction, posterior pelvic tilts, and bridging. In addition to verbal and tactile cueing for mat exercises, the patient also required assistance completing SLR and bridging activities. Patient was also instructed in rhythmic rotation in hooklying with progression to include resistance at the knee. Patient had a tendency to "squeeze" her knees into hip adduction rather than pushing into the therapist's hand while completing the hip abduction movement. Progress was made with muscle activation, positioning, and quality of movement. The afternoon sessions were concluded with additional ambulation.

The patient and daughter were instructed in proper vehicle transfers, and received further education on completing sit-to-stand transfers, types of surfaces and heights of chairs to sit on, and energy conservation techniques, prior to a trial-run at home. In

preparation for her transition to home, she purchased a bed rail, ankle weights, a cold pack, and a single point cane. She was instructed in proper use of each of these items and proved her understanding through verbalization and demonstration. She was also administered a leg-lifter through occupational therapy, as she continued to have minimal difficulty lifting her left lower extremity onto the bed.

**Table 4: Morning Interventions**

| **Aerobic** | **Initial** | **Progression** | **Equipment** |
|---|---|---|---|
| ***Ambulation*** | 60 feet | > 200 feet | FWW → SPC |
| **Musculoskeletal** | | | |
| ***Seated PRE*** ***(Hip & Knee Ext, ABD, Flex)*** | 3 sets of 10 repetitions | 3 sets of 20 repetitions | BW → 5# weight<br>PTB → BTB |
| ***Seated Isometrics*** ***(Hip ADD)*** | 3 sets of 10 repetitions | 3 sets of 20 repetitions | Medium Foam Ball |
| ***Standing PRE*** ***(Hip Ext, Flex, ABD)*** | 3 sets of 10 repetitions | 3 sets of 20 repetitions | BW→ 5# weight |
| **Neuromuscular** | | | |
| ***Standing PRE*** ***(Step-ups; Toe & Heel Raises)*** | 3 sets of 10 repetitions | 3 sets of 20 repetitions | BW → 5# weight<br>2” → 6” block |
| ***Transfers*** ***(Sit-to-Stand, Sit-to-Supine)*** | 5-10 repetitions | 5-10 repetitions | Varying Heights<br>Varying surfaces |

| Table 5: Afternoon Interventions | | | |
|---|---|---|---|
| **Aerobic** | **Initial** | **Progression** | **Equipment** |
| ***Nu-Step*** | WL 1, 5 minutes | WL 5, 10 minutes | --- |
| ***Ambulation*** | 60 feet | > 200 feet | FWW → SPC |
| **Musculoskeletal** | | | |
| ***Supine PRE***<br>***(SAQ, *SLR, Hip ABD)*** | 3 sets of 10 repetitions<br>*1 set of 10 repetitions<br>(*AAROM) | 3 sets of 20 repetitions<br>*1 set of 10 repetitions<br>(*AROM) | 5" Diameter Bolster<br>BW → 4# weight<br>PTB → BTB |
| **Neuromuscular** | | | |
| ***Supine***<br>***(Bridging, Post Pelvic Tilt, RR)*** | 1 set of 10 repetitions | 1 set of 10 repetitions | Manual Input |
| ***Transfers***<br>***(Sit-to-Stand, Sit-to-Supine)*** | 5-10 repetitions | 5-10 repetitions | Varying Heights<br>Varying surfaces |

## OUTCOMES

The patient was extremely satisfied with her progress. She was in the swing bed rehabilitation for twenty-one days, and she received PT care on eighteen of those days. She attended a total of thirty-three therapy sessions which lasted 30-45 minutes, and was one hundred percent compliant during her swing bed stay. The patient tolerated the arrangement of the sessions well, and reported only two instances of muscle soreness following her PT sessions. She had no complaints of abdominal pain with intervention, but did experience low back pain once during her rehabilitation.

The AM-PAC was used during the initial examination. The patient scored a thirteen, indicating an impairment level of sixty-five percent. The AM-PAC identifies the improvement in functional activities following post-acute care stays; bed mobility, transfers, ambulation, and stairs. Due to persistent balance and gait concerns, the Tinetti (Table 6; Appendix 2) exam was performed on swing bed day nine (SB-9) with an initial score of seventeen, indicating an impairment level of 40-59 percent. The Tinetti was chosen, as it addresses balance and gait limitations. At discharge (Table 7), the patient improved her AM-PAC score to twenty-three (11% impairment) and Tinetti score to twenty-six (1-19% impairment). Improvements in both of these functional measures indicate patient gains in musculoskeletal strength, aerobic endurance, functional transfers, balance, and gait, which were the goals of the previously established plan of care. The minimal detectable change (MDC) for basic mobility on the AM-PAC is a 4.28, this patient improved her score by 10 points. [34]

To meet discharge criteria, the patient had to meet all short and long term goals, improve functional test and measure score to 1-19 percent impairment, demonstrate full

understanding and skills necessary to complete home exercise program (HEP), demonstrate safe community and stair ambulation with assistive device, and understand and verbalize the importance of activity modification and assistive device utilization for safety in continuation of age appropriate activities as her strength continues to improve. Patient successfully met all discharge criteria on SB-18.

Patient limitations at discharge included the continued use of an assistive device for transfers, ambulation, and stairs. She also required a bed rail and leg lifter for assistance into her bed at home. Activity modification and energy conservation continued to be factors at discharge, especially in environments involving low or soft surfaces for transfers. Due to these limitations, patient was discharged with a HEP (Appendix 3), given patient education on activity modification, and instructed that her encounter would remain active for six months for the option of continuing with outpatient physical therapy.

**Table 6: Tinetti Reliability[26]**

| | ***Test-Retest*** | | ***Interrater/Intrarater*** | | |
|---|---|---|---|---|---|
| | ***Strength*** | ***ICC*** | | ***Strength*** | ***ICC*** |
| **Older Adults** | Excellent | 0.96 | **Frail Elders** | Excellent | 0.84 |
| | | | | | |
| | ***Sensitivity*** | | | ***Specificity*** | |
| **Older Adults** | 68% | | **Older Adults** | 78% | |

| Table 7: Outcome Measures | | | | |
|---|---|---|---|---|
| **Test** | **Initial** | **Impairment** | **Discharge** | **Impairment** |
| ***AM-PAC*** | 13/24 | 65 % (60-80%) | 23/24 | 11% (1-19%) |
| | | | | |
| ***Tinetti*** | 17/28 | 40-59% | 26/28 | 1-19% |

# CHAPTER III

# DISCUSSION

A meta-analysis by authors Hermans et al [16] stresses the need for debate and consensus on criteria to define CIP/CIM for the purpose of research. In addition, further evaluation of early rehabilitation strategies and optimal timing during critical illness should be pursued. Other studies have noted the limitation in research for the rehabilitation of patients with critical illness polyneuropathy and myopathy. This condition is especially concerning as there is currently no proven pharmaceutical intervention available. Patients who suffer from CIP/CIM develop muscle weakness, decline in endurance, and limitations in functional mobility. This report addresses the physical therapy intervention developed to address the general deconditioning and endurance limitations in a patient who developed CIP/CIM following an extensive hospital stay due to complications from surgical intervention.

Development of CIP/CIM is not uncommon, as it occurs in 70 percent of patients who develop sepsis following surgical interventions. However, the length of time needed for recovery is highly variable and only 50 percent make a full recovery. [8, 25] Current literature is inconsistent concerning the appropriate physical therapy interventions following a diagnosis of CIP/CIM. I found no report that addresses a specific protocol for rehabilitation for patients with CIP/CIM, just suggestions for developing appropriate interventions. The literature does support the involvement of physical therapy for improved functional status with early implementation in the ICU with continuation

through patient discharge home. [12] A study by Mehrholz, suggests stretching, strength training and mobility training (i.e. dressing and transfers, or to improve balance, sit-to-stand, and walking) are appropriate intervention techniques to address the limitations caused by CIP/CIM. [25]

A study published in the APTA journal found physical training 5 days a week for 6 weeks significantly improved respiratory and limb muscle strength. In addition, functional measurement score improved significantly from baseline measurements. [10] The patient in this case study had physical therapy sessions twice daily, Monday through Friday, and once daily on Saturdays. This was an aggressive physical therapy schedule, but the patient was able to return home with minimal assistance from her family after three weeks in our rehabilitation center. Her rehabilitation progress was unhindered due to pain at her abdominal incision sites, and her dedication to completing her therapy sessions. Further studies would need to be completed to determine if this approach would be effective in a larger sample of the CIP/CIM population, or if the absence of incisional pain and her motivation to return home were the key factors to her recovery.

Many of the studies promote the use of the Functional Independence Measure (FIM), Short Form- 36 (SF-36), 6-Minute Walk Test (6MWT), and Barthel Index of Activities of Daily Living (BI) to assess the baseline and improvements of patients with CIP/CIM. [1, 10, 27] No other study was found that utilizes the AM-PAC or Tinetti to assess these patients. However, one study compared the AM-PAC to the Functional Independence Measure (FIM) and identified the AM-PAC scales as more sensitive measures of change in functional activity performance for inpatient rehabilitation when compared to the FIM. [11] The Tinetti showed improvement from the mid-point of therapy

to discharge. Future studies would benefit from the use of the MiniBESTest in place of the Tinetti. The MiniBESTest addresses anticipatory, reactive postural control, sensory orientation, and dynamic gait, which would have given a more complete picture of the patient's limitations. The ICC values of the MiniBESTest were 0.99 in older adults in comparison to 0.96 of the Tinetti. [23, 26]

As there is little research on specific interventions or protocols for the rehabilitation of critical illness polyneuropathy and myopathy, this case study can be entered into evidence to support trunk and lower extremity strengthening; gait, balance, and proprioceptive training; activity modification; and patient education for treatment of CIP/CIM. Coordination with specialties such as occupational and respiratory therapy would provide a clearer understanding of their role in patient care. Further studies on interventions should address upper extremity strengthening and ADL training, as well as strengthening of the diaphragm and accessory muscles used for respiration.

Limitations with this case report include the inconsistency in the use of functional measurements and evaluation tools at initial, mid-way, and discharge evaluation. A functional measure, quality of life, and patient survey should be administered at each of these times to determine a baseline and progression for the patient. Also, due to the neurological involvement found with CIP/CIM, myotomes, dermatomes, and deep tendon reflexes should have been assessed to determine presence of strength, sensation, and nerve conductivity. Another potential limitation with the applicability of the interventions is the diminished presence of sensation and pain in the abdomen. Patients that do have pain may have difficulty completing the physical therapy sessions or interventions as laid out in this case study. The cost of the physical therapy sessions could also be a limitation,

for patients who were paying out-of-pocket, or with reluctant third party payers. In this case, the patient had a supportive third party payer, and the out-of-pocket costs incurred were justified by the patient, as she was able to meet her goal of returning home. Further limitations were the shortened time frame and lack of follow-up after the patient's discharge from swingbed. The patient was given a home exercise program and TheraBand at discharge to promote continuation of her strengthening program. The final limitation that could affect this case was the limitation in my experience with managing a high-level case such as this. Further education on the geriatric population and cardiopulmonary techniques would benefit my practice in the future, and better prepare me to work with high-level patients.

***Conclusion***

This case report describes the interventions and functional outcomes measures used to improve general conditioning and functional mobility in a woman who developed critical illness polyneuropathy. The patient made strength and endurance gains similar to those proposed by the limited research, and faster than expected by the multidisciplinary team treating her. An aggressive approach to intervention was encouraged because of her desire to return home independently, and to return to her community and family activities. Her high level of motivation and absence of pain could have played an important role in her rate of improvement. The positive gains of this patient suggest that there is potential value in the approach and research to determine the most effective interventions to treat patients with CIP/CIM.

# Appendix 1: AM-PAC Short Form.

## Appendix 1.

"6-Clicks" Inpatient Basic Mobility Short Form[a]

| Please check the box that reflects your (the patient's) best answer to each question. | Unable | A Lot | A Little | None |
|---|---|---|---|---|
| **How much difficulty does the patient currently have . . . .** | | | | |
| 1. Turning over in bed (including adjusting bedclothes, sheets, and blankets)? | ☐1 | ☐2 | ☐3 | ☐4 |
| 2. Sitting down on and standing up from a chair with arms (eg, wheelchair, bedside commode)? | ☐1 | ☐2 | ☐3 | ☐4 |
| 3. Moving from lying on back to sitting on the side of the bed? | ☐1 | ☐2 | ☐3 | ☐4 |
| **How much help from another person does the patient currently need . . .** | | | | |
| 4. Moving to and from a bed to a chair (including a wheelchair)? | ☐1 | ☐2 | ☐3 | ☐4 |
| 5. To walk in hospital room? | ☐1 | ☐2 | ☐3 | ☐4 |
| 6. Climbing 3–5 steps with a railing? | ☐1 | ☐2 | ☐3 | ☐4 |

Clinicians may find the following helpful in selecting responses:

1. Total/Unable=Total/Dependent Assist
2. A Lot=Maximum/Moderate Assist
3. A Little=Minimum/Contact Guard Assist/Supervision
4. None=Modified Independence/Independent

### "6-Clicks" Inpatient Basic Mobility Short Form Scoring

| Raw Score | Scale Score | Scale Score Standard Error | Approximate Degree of Functional Impairment |
|---|---|---|---|
| 6 | 23.55 | 4.57 | 100% |
| 7 | 26.42 | 4.33 | 92% |
| 8 | 28.58 | 4.04 | 87% |
| 9 | 30.55 | 3.69 | 81% |
| 10 | 32.29 | 3.42 | 77% |
| 11 | 33.86 | 3.22 | 73% |
| 12 | 35.33 | 3.08 | 69% |
| 13 | 36.74 | 2.99 | 65% |
| 14 | 38.10 | 2.95 | 61% |
| 15 | 39.45 | 2.93 | 58% |
| 16 | 40.78 | 2.95 | 54% |
| 17 | 42.13 | 3.03 | 51% |
| 18 | 43.63 | 3.20 | 47% |
| 19 | 45.44 | 3.55 | 42% |
| 20 | 47.67 | 4.06 | 36% |
| 21 | 50.25 | 4.69 | 29% |
| 22 | 53.28 | 5.43 | 21% |
| 23 | 56.93 | 6.22 | 11% |
| 24 | 61.14 | 6.94 | 0% |

[a] The AM-PAC "6-Clicks" forms are copyright protected by The Trustees of Boston University.

# Appendix 2: Tinetti Test.

**Tinetti Balance and Gait Evaluation**

NAME:_____ DATE:_____ ____

BALANCE

**Instructions:** Person is seated in a hard armless chair. The following maneuvers are tested.

**1. Sitting balance**
Leans or slides in chair 0
Steady, safe 1 ____

**2. Rising**
Unable without help 0
Uses arms to help 1
Able without use of arms 2 ____

**3. Attempts to rise**
Unable without help 0
Requires more than one attempt 1
Able to rise with one attempt 2 ____

**4. Immediate standing balance** (first 5 sec)
Unsteady (staggers, moves feet, trunk sways) 0
Steady but uses walker or cane or grabs other objects for support 1
Steady without any support 2 ____

**5. Standing balance**
Unsteady 0
Steady but has wide stance (medial heels more than 4 inches apart) or uses cane or walker or other support 1
Narrow stance without support 2 ____

**6. Nudged** (person stands with feet as close as possible; examiner pushes light on person's sternum with palm of hand three times)
Begins to fall 0
Staggers, grabs, but catches self 1
Steady 2 ____

**7. Eyes closed**
Unsteady 0
Steady 1 ____

**8. Turning 360 degrees**
Discontinuous steps 0
Continuous steps 1
Unsteady (grabs, staggers) 0
Steady 1 ____

**9. Sitting down**
Unsafe (misjudges distance, falls into chair) 0
Uses arms or not a smooth motion 1
Safe, smooth motion 2

**Balance score** _____/16

GAIT

**Instructions:** Person stands with examiner, walks down Hallway or across room, first at usual pace, then back at rapid but safe pace (using usual walking aid such as cane or walker).

**10. Initiation of gait**
Any hesitancy or multiple attempts to start 0
No hesitancy 1 ____

**11. Step length and height**
**(a) Right swing foot**
Does not pass left stance foot with step 0
Passes left stance foot 1
Right foot does not completely clear floor 0
Right foot completely clears floor 1 ____
**(b) Left swing foot**
Does not pass right stance foot with step 0
Passes right stance foot 1
Left foot does not clear floor completely 0
Left foot completely clears floor 1 ____

**12. Step symmetry**
Right & left step length do not appear equal 0
Right & left step appear equal 1 ____

**13. Step continuity**
Stopping or discontinuity between steps 0
Steps appear continuous 1 ____

**14. Path** (estimate in relation to 12-inch floor tiles; observe excursion of 1 ft over about 10 ft of the course.
Marked deviation 0
Mild or moderate deviation or uses walking aid 1
Straight without walking aid 2 ____

**15. Trunk**
Has marked sway or uses walking aid 0
No sway but has flexion of knees or back or spreads arms out while walking 1
No sway, no flexion, no use of arms, and no use of walking aid 2 ____

**16. Walking stance**
Heels apart 0
Heels almost touch while walking 1 ____

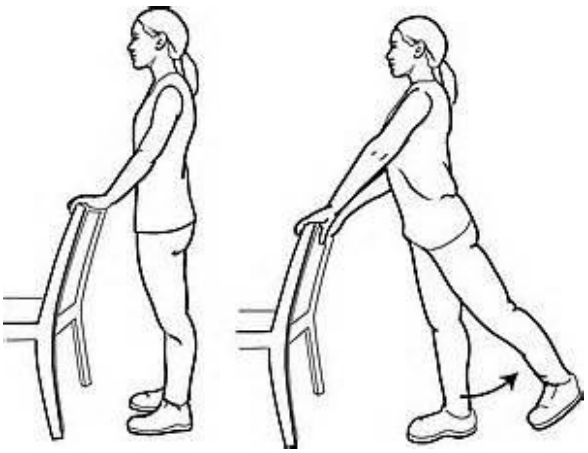
**Gait Score** _____

**Total** _____/28

A score of less than 25 usually indicates a problem. A score of less than 19 indicates a fivefold increased risk of falls.

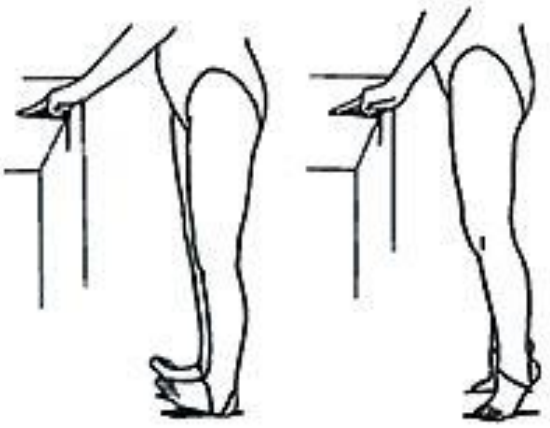
**Appendix 3: Home Exercise Program.**

Standing Hip Flexion



Standing Hip Extension

Standing Hip Abduction



Standing Toe and Heel Raises

Seated Knee Extension

Seated Knee Flexion

## REFERENCES

1. Baker C, Mansfield L. Physical rehabilitation following critical illness. *Journal of the Intensive Care Society*. 2008;9(2):166-169. doi: 10.1177/175114370800900215.

2. Baldwin CE BA. Myopathic characteristics in septic mechanically ventilated patients. *Curr Opin Clin Nutr Metab Care*. 2015;18(3):240-247.

3. Barnato A, Albert S, Angus D, Lave J, Degenholtz H. Disability among elderly survivors of mechanical ventilation. *American Journal of Respiratory & Critical Care Medicine*. 2011;183(8):1037-1042.

4. Basler J, Schwartz Bea. Enterovesicular fistula. Medscape Web site. http://emedicine.medscape.com/article/442000-overview. Updated 2015. Accessed July 1, 2015.

5. Bercker S, Weber-Carstens S, Deja M, et al. Critical illness polyneuropathy and myopathy in patients with acute respiratory distress syndrome. *Crit Care Med*. 2005;33(4):711-715. http://ezproxy.undmedlibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid,cookie&db=c8h&AN=2005089042&site=ehost-live.

6. Berney S, Haines K, Skinner E, Denehy L. Safety and feasibility of an exercise prescription approach to rehabilitation across the continuum of care for survivors of critical illness. *PHYS THER*. 2012(92):1524-1535.

7. Berney S, Skinner E, Denehy L, Warrillow S. Development of a physical function outcome measure (PFIT) and a pilot exercise training protocol for use in intensive care. . 2009.

8. Center for Disease Control. Critical illness polyneuropathy and myopathy. Center for Disease Control Web site. http://www.cdc.gov/nchs/data/icd/icd501a.pdf. Accessed May 10, 2015.

9. Chawla J, Gruener G. Management of critical illness polyneuropathy and myopathy. *Neurologic Clinics*. 2010;28(4):961-977.

10. Chiang L, Wang L, Wu C, Wu H, Wu Y. Effects of physical training on functional status in patients with prolonged mechanical ventilation. *Physical Therapy*. 2006;86(9):1271-1281. doi: 10.2522/ptj.20050036.

11. Coster W, Haley S, Jette A. Measuring patient-reported outcomes after discharge from inpatient rehabilitation settings. *J REHABIL MED (16501977)*. 2006(38):237-242.

12. Doherty N, Steen C. Critical illness polyneuromyopathy (CIPNM); rehabilitation during critical illness. therapeutic options in nursing to promote recovery: A review of the literature. *Intensive Crit Care Nurs*. 2010;26(6):353-362. http://ezproxy.undmedlibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid,cookie&db=c8h&AN=2010868355&site=ehost-live. doi: 10.1016/j.iccn.2010.08.008.

13. Dugdale D. Creatine phosphokinase test. Medline Plus: Trusted Health Information for You Web site. http://www.nlm.nih.gov/medlineplus/ency/article/003503.htm. Updated 2013. Accessed May 10, 2015.

14. Epocrates. Diverticular disease. epocrates Web site. https://online.epocrates.com/u/292416/Diverticular+disease/Basics/Etiology. Updated 2015. Accessed June 1, 2015.

15. Esemuede I, Murray A, Lee-Kong S, Feingold D, Kiran R. Obesity, regardless of comorbidity, influences outcomes after colorectal Surgery—Time to rethink the pay-for-performance metrics?. *Journal of Gastrointestinal Surgery*. 2014;18:2672.

16. Hermans G, De Jonghe B, Bruyninckx F, Van den Berghe G. Interventions for preventing critical illness polyneuropathy and critical illness myopathy. *Cochrane Database Syst Rev*. 2014(1). http://ezproxy.undmedlibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid,cookie&db=c8h&AN=2010231121&site=ehost-live. doi: 10.1002/14651858.CD006832.pub2.

17. Jani C. Critical illness neuropathy. *Medincine Update*. 2011:236-241.

18. Jette D, Stilphen M, Ranganathan V, Passek S, Frost F, Jette A. AM-PAC "6-clicks" functional assessment scores predict acute care hospital discharge destination. *Physical Therapy*. 2014;94(9):1252-1261. doi: 10.2522/ptj.20130359.

19. Jette D, Stilphen M, Ranganathan V, Passek S, Frost F, Jette A. Validity of the AM-PAC "6-clicks" inpatient daily activity and basic mobility short forms. *Physical Therapy*. 2014;94(3):379-391. doi: 10.2522/ptj.20130199.

20. Larsson L. Critical illness myopathy in intensive care unit patients: Underyling mechanisms and rehabilitation strategies. *J REHABIL MED (16501977)*. 2011;43(9):827-827. http://ezproxy.undmedlibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid,cookie&db=c8h&AN=2011292894&site=ehost-live.

21. Lin X, Li J, Chen W, et al. Diabetes and risk of anastomotic leakage after gastrointestinal surgery. *J Surg Res*. 2015;196(2):294-301. Accessed 7/8/2015 1:15:06 AM. doi: http://dx.doi.org.ezproxy.undmedlibrary.org/10.1016/j.jss.2015.03.017.

22. Lynn E, Ranasinghe N. Management and outcomes of colovesical fistula repair. *The American Surgeon*. 2012;78(5):514-518.

23. Maia A, Rodriques-de-Paula F, Magalhães L, Teixeira R. Cross-cultural adaptation and analysis of the psychometric properties of the balance evaluation systems test and MiniBESTest in the elderly and individuals with parkinson's disease: Application of the rasch model. *Braz J Phys Ther*. 2013;17(3).

24. Mayo Clinic Staff. Ards. Mayo Clinic Web site. http://www.mayoclinic.org/diseases-conditions/ards/basics/definition/con-20030070. Updated 2014. Accessed July 8, 2015.

25. Mehrholz J, Pohl M, Kugler J, Burridge J, Mückel S, Elsner B. Physical rehabilitation for critical illness myopathy and neuropathy. *Cochrane Database of Systematic Reviews*. 2015(3).

26. Musallam K, Rosendaal F, Zaatari Gea. Smoking and the risk of mortality and vascular and respiratory events in patients undergoing major surgery. *JAMA Surg*. 2013;148(8):755-762.

27. Novak P, Vidmar G, Kuret Z, Bizovicar N. Rehabilitation of critical illness polyneuropathy and myopathy patients: An observational study. *Int J Rehabil Res*. 2011;34(4):336-342. http://ezproxy.undmedlibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid,cookie&db=c8h&AN=2011402845&site=ehost-live.

28. Panella L, Tinelli C, Buizza A, Lombardi R, Ganolfi R. Towards objective evaluation of balance in the elderly: Validity and reliability of a measurement instrument applied to the tinetti test. *Int J Rehabil Res*. 2008;31(1):65-72.

29. Pankaja S, Rrukaj A, Bathula U. Diverticular disease of the colon presenting as pyometra: A case report . *Journal of Medical Case Reports*. 2014;8:135.

30. Parry S, Berney S, Granger C, et al. A new two-tier strength assessment approach to the diagnosis of weakness in intensive care: An observational study. *Critical Care*. 2015;19(1):52.

31. Raad J, Johnson T. Activity measure for post acute care. Rehabilitation Measures Web site. http://www.rehabmeasures.org/Lists/RehabMeasures/PrintView.aspx?ID=978. Updated 2013. Accessed July 7, 2015.

32. Ricks E. Critical illness polyneuropathy and myopathy: A review of evidence and the implications for weaning from mechanical ventilation and rehabilitation. *Physiotherapy*. 2007;93(2):151-156. http://ezproxy.undmedlibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid,cookie&db=c8h&AN=2009625834&site=ehost-live.

33. Romney W. Manual muscle test. Rehabilitation Measures Database Web site. http://www.rehabmeasures.org/Lists/RehabMeasures/PrintView.aspx?ID=1033. Updated 2013. Accessed June 10, 2015.

34. Selig S, Gosling C, Carlson J. A multi-stage step test protocol for people with low exercise capacity. *Clinical Kinesiology*. 2000;54(3):67-71.

35. Sentilhes L, Foulatier O, Verspyck E, Roman H, ScottÃ© M, Marpeau L. Colouterine fistula complicating diverticulitis: A case report and review of the literature. *European Journal of Obstetrics & Gynecology and Reproductive Biology*. 2003;110(1):107-110. Accessed 7/8/2015 1:19:55 AM. doi: http://dx.doi.org.ezproxy.undmedlibrary.org/10.1016/S0301-2115(03)00086-1.

36. Tappouni R, Mathew P, Connelly T, Luke F, Messaris E. Measurement of visceral fat on preoperative computed tomography predicts complications after sigmoid colectomy for diverticular disease. *The American Journal of Surgery*. (0). doi: http://dx.doi.org.ezproxy.undmedlibrary.org/10.1016/j.amjsurg.2014.10.026.

37. Weber-Carstens S, Schneider J, Wollersheim T, et al. Critical illness myopathy and GLUT4: Significance of insulin and muscle contraction. *Am J Respir Crit Care Med*. 2013;187(4):387-396. http://ezproxy.undmedlibrary.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid,cookie&db=c8h&AN=2012009262&site=ehost-live. doi: 10.1164/rccm.201209-1649OC.

38. Yang C, Teng A, Lee D, Rose K. Pulmonary complications after major abdominal surgery: National surgical quality improvement program analysis. *J Surg Res*. (0). Accessed 7/8/2015 1:39:35 AM. doi: http://dx.doi.org.ezproxy.undmedlibrary.org/10.1016/j.jss.2015.03.028.

39. Ydemann M, Shil E, Øberg L. Treatment of critical illness polyneuropathy and/or myopathy- a systematic review. *Dan Med J*. 2012;59(10):A4511.

40. Zhou C, Wu L, Ni F, Ji W, Wu J, Zhang H. Critical illness polyneuropathy and myopathy: A systematic review. *Neural Regen Res*. 2014(9):101-110.