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Abstract

Purpose: The purpose of this case is to illustrate the best available evidence to provide early therapeutic intervention for a critically ill patient presenting with cardiovascular and pulmonary complications due to multi-system compromise. Case Description: A 19-year-old male was admitted to the hospital with the diagnosis of necrotizing fasciitis and necrotizing pneumonia. He experienced numerous additional medical complications ultimately leading to tracheostomy, delirium, critical illness myopathy, and quadrilateral amputation secondary to necrotizing fasciitis and critical limb ischemia following prolonged veno-venous extracorporeal membrane oxygenation (VV-ECMO). Outcomes: Patient was discharged to an outside rehabilitation hospital after 103 days in the acute setting (56 days in the ICU) and was able to tolerate 40 minutes sitting edge of bed with supervision, perform bed mobility with supervision, and propel a standard wheelchair up to 50 feet independently. At 10 months' post-discharge from the acute setting, the patient was ambulating independently up to 150 feet without assistive device using bilateral lower extremity prosthetics, able to propel a lightweight wheelchair community distances, independent in all transfers, and returned to school and work. Discussion: These findings suggest that clinicians may want to consider examining and combining the best available evidence of multiple medical conditions to provide a well-rounded therapeutic approach including but not limited to, close monitoring of vitals and early mobilization, to managing complex patients in the intensive care setting.

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ABSTRACT

Purpose: The purpose of this case is to illustrate the best available evidence to provide early therapeutic intervention for a critically ill patient presenting with cardiovascular and pulmonary complications due to multi-system compromise. **Case Description:** A 19-year-old male was admitted to the hospital with the diagnosis of necrotizing fasciitis and necrotizing pneumonia. He experienced numerous additional medical complications ultimately leading to tracheostomy, delirium, critical illness myopathy, and quadrilateral amputation secondary to necrotizing fasciitis and critical limb ischemia following prolonged veno-venous extracorporeal membrane oxygenation (VV-ECMO). **Outcomes:** Patient was discharged to an outside rehabilitation hospital after 103 days in the acute setting (56 days in the ICU) and was able to tolerate 40 minutes sitting edge of bed with supervision, perform bed mobility with supervision, and propel a standard wheelchair up to 50 feet independently. At 10 months' post-discharge from the acute setting, the patient was ambulating independently up to 150 feet without assistive device using bilateral lower extremity prosthetics, able to propel a lightweight wheelchair community distances, independent in all transfers, and returned to school and work. **Discussion:** These findings suggest that clinicians may want to consider examining and combining the best available evidence of multiple medical conditions to provide a well-rounded therapeutic approach including but not limited to, close monitoring of vitals and early mobilization, to managing complex patients in the intensive care setting.

Keywords: critical illness myopathy, necrotizing fasciitis, physical therapy, necrotizing pneumonia, intensive care setting

INTRODUCTION

There is a very limited body of evidence to guide physical therapists' strategy in those with multiple and complex conditions within intensive care unit (ICU) settings.[1] Case reports within healthcare settings have been proven to be beneficial for a variety of reasons, including the presentation of rare diseases.[2] This particular case report highlights the importance and clinical significance of individualized and personalized physical therapy intervention for a patient with the rare diagnosis of necrotizing fasciitis complicated by necrotizing pneumonia.[3] Furthermore, this case report offers a structure for case-based learning within intensive care settings for a patient experiencing compromise of the cardiovascular and pulmonary systems and may facilitate improvements in the delivery of physical and occupational therapy interventions for patients with a similar presentation.

CASE REPORT

A 19-year-old, right-handed male was admitted to the hospital and referred for physical therapy consult with the primary medical diagnoses of necrotizing pneumonia and necrotizing fasciitis. Prior to onset of symptoms, the patient had an unremarkable past medical history and was independent in all functional activities. Patient resided with roommates while attending college but lived with family when in Arizona. At time of physical therapy initial evaluation, the patient had been decannulated from VV-ECMO, and undergone right below knee amputation, left above knee amputation, left transmetacarpal amputation, and right thumb interphalangeal and digits 2-5 metacarpal amputation.

Prior to physical therapy evaluation, the patient had experienced many medical setbacks and complications throughout the 2 weeks required to stabilize his condition. In addition to quadrilateral amputations, he experienced sepsis, multiple blood transfusions, necrotizing pneumonia requiring mechanical ventilation with subsequent delirium and critical illness myopathy. During initial physical examination, the patient was lethargic secondary to a ketamine drip utilized for pain management but able to participate in therapy. His Functional Independence Measure (FIM) score was a 25 overall, indicating low functional independence. His Functional Status Score for Intensive Care Unit Settings (FSS-ICU) was 1, as he was limited in ability to participate in functional movements at the time of evaluation due to sedatives, pain medication, and reported pain and anxiety surrounding fear of movement. Refer to Table 1 for a complete list of the patient's medications at time of physical therapy evaluation.

Table 1: Medication List

Medication	Dosage
Scheduled Medications	
Nitroglycerin	0.4% topical ointment, BID
Zinc sulfate	5 mL, TID
Protonix	10 mL, daily
Solu-cortef	0.5 mL, Q6H
Gabapentin	6 mL, daily
Cancidas	50 mg, Q24H interval
Cleocin	50 mL, Q8H
Bacitracin	Topical ointment, TID
Vitamin B1	2 mL, daily
Ergocalciferol	6.25 mL, Q7days
Vancocin	200 mL, daily
Continuous Drip Medications	
Fentanyl	250 mL, 10 mL/hour continuous
Dexmedetomidine	200 mcg, continuous
Ketamine in sodium chloride solution	250 mL, continuous
Medications Delivered as Needed	
Potassium chloride	100 mL, Q1H
Albuminar	100 mL, Q1H
Versed	2 mL, Q2H
Insulin	0-7 units, as directed
Ketamine	5 mL, as directed
Fentanyl	1.5 mL, Q1H
Diasylate	As directed
Sodium phosphate	5 mL, as directed

Note: BID = twice daily, mL = milliliters, TID = three times daily, QxH = every x hours

The patient presented with notable deficits across multiple systems. Refer to Table 2 for an overview of the systems review results. The systems review guided the initial selection of tests and measures performed. Using information obtained from the chart review and the patient and family, assessment of cognition, vital signs, subjective pain rating, skin integrity and incision assessments, functional mobility and endurance, muscle strength and range of motion, it was determined that this patient had complex therapeutic deficits. The patient was an excellent candidate for this case study due to the complexity of comorbid conditions and the limited research on therapeutic approach for patients with these medical complexities.

Table 2: Systems Review and Examination Findings

Systems Review	**Initial Evaluation Findings**
Cardiovascular/pulmonary	Impaired. Medications were utilized to maintain control of cardiovascular and pulmonary function. Vital signs Heart Rate: 81 beats per minute (bpm) Blood Pressure: 129/66 mmHg (millimeters of mercury) Respiratory Rate: 8 breaths per minute Oxygen Saturation: 95% via tracheostomy collar at FiO2 40% and 30L
Integumentary	Impaired. Surgical incisions were present under wound dressings. Wound Vac on left lower extremity.
Musculoskeletal	Impaired. See Table 3.
Neuromuscular	Impaired. Light touch sensation intact at bilateral upper extremities from shoulder to mid-forearm and bilateral lower extremities from left groin to mid-thigh and right groin to mid-shin. Unable to test distally secondary to wound dressings.
Genitourinary	Impaired. Continuous renal replacement therapy (CRRT) utilized to maintain kidney function.
Gastrointestinal	Impaired. Parenteral nutrition and left colostomy bag were utilized to maintain adequate nutrition and excretion.
Cognition, Communication, Affect, Learning Style	Impaired. The patient was oriented to person, place, and time however therapists were unable to determine if he was oriented to the situation. His communication was limited to head nodding and mouthing yes/no responses. The patient's learning style was unable to be assessed.
Tests and Measures	**Initial Evaluation Findings**
Upper Extremity Range of Motion (ROM)	Intact. Patient demonstrates full ROM for passive and active assist shoulder and elbow motions. Motions at the wrist/hands were not assessed.
Lower Extremity Passive Range of Motion (PROM)	Left lower extremity • Hip extension to neutral, limited by pain (sidelying) • Hip abduction to 5 degrees (sidelying) Right lower extremity • Hip extension to -5 degrees, limited by pain (sidelying) • Hip abduction to neutral, limited by pain (sidelying) • Knee flexion to 40 degrees (supine) Knee extension to -10 degrees (supine)
Lower Extremity Active Assist Range of Motion (AAROM)	Left lower extremity • Hip extension to -5 degrees (sideyling) • Hip abduction to neutral (sidelying) Right lower extremity • Hip extension to -5 degrees, limited by pain (sidelying) • Hip abduction to neutral, limited by pain (sidelying) • Knee flexion to 40 degrees (supine) Knee extension to -15 degrees (supine)

Upper Extremity Manual Muscle Testing (MMT)	Left upper extremity • Shoulder flexion: 1/5 • Shoulder extension: 1/5 • Shoulder abduction: 1/5 • Shoulder adduction 2/5 • Elbow flexion: 2/5 • Elbow extension: 2/5 • Wrist/hand not assessed secondary to recent amputation at manual contact points. Right upper extremity • Shoulder flexion: 1/5 • Shoulder extension: 1/5 • Shoulder abduction: 1/5 • Shoulder adduction: 1/5 • Elbow flexion: 3-/5 • Elbow extension: 3-/5 Wrist/hand not assessed secondary to recent amputation at manual contact points.
Lower Extremity MMT	Left lower extremity • Left hip extension 0/5 (supine) • Left hip abduction to 1/5 (supine) Right lower extremity • Right hip extension 1/5 (supine) • Right hip abduction 1/5 (supine) • Right knee flexion/extension not assessed secondary to recent amputation at manual contact points. Patient was able to move against gravity into flexion and extension, will assess in future for formal MMT
Cough Assessment	Patient was able to produce a weak, ineffective cough with head of bed at 45 degrees. He had decreased middle and lower chest wall expansion and required tracheal suction to clear secretions.
Sputum Analysis	Sputum was thick, milky white/pale green which was consistent for presentation of consolidation of the left posterior upper lobe.
Functional Mobility: Rolling	Dependent: required maximum assistance of 2 therapists in either direction. Physiologic response Patients heart rate increased to 98 bpm, and returned to 83 bpm within 30 seconds of return to head of bed at 45 degrees
Functional Mobility: Supine to Sit Transfer	Unable to attempt secondary to anxiety expressed by patient regarding early mobility
Functional Mobility: Wheelchair Propulsion	Unable to attempt secondary to positional restrictions set by plastic surgery team
Numeric Pain Rating Scale	3/10 at quadrilateral surgical sites
AM-PAC 6-clicks^	8/24 (basic mobility domain), 6/24 (daily activity domain) (indicates high level of physical assistance needed)
FSS-ICU*	1/35 (indicates lower physical functioning)
FIM#	12 cognition/ADLs, 13 motor Total 25/126 (indicates low level of function)

As the examination progressed, tests and measures were selected and utilized to determine the patient's overall functional ability and cardiovascular endurance to provide an appropriate discharge recommendation for when he was determined to be ready to progress to the next level of care. The results of these tests are provided in Table 3. The primary problem at the time of initial evaluation was a significant decline in his baseline function, and therefore a battery of function-based outcome measures was selected to track progress. The Activity Measure for Post-Acute Care Inpatient Short Form (AM-PAC 6-clicks) was utilized as it

was a standardized measure utilized in the medical facility, but also has high test-retest and interrater reliability as well as internal consistency.[4-5] The AM-PAC 6-clicks was taken at initial visit and every subsequent visit until discharge. Additionally, the Functional Status Score for the ICU (FSS-ICU) and Functional Independence Measure (FIM) were both utilized at time of initial evaluation to aide in decision-making related to overall functional performance within the acute care setting. The FSS-ICU has good internal consistency and is considered a valid and responsive measure of physical function for patients within the ICU setting, specifically.[6] The FIM was selected, as the therapists were not certain of the patient's cognitive deficits from prolonged VV-ECMO and the tool offers both motor and cognitive scores. Also, the patient's age and expressed motivation to recover made him a strong candidate to consider for acute inpatient rehabilitation where the FIM is more widely used. The FIM has excellent interrater consistency among neurological disorders.[7] The FSS-ICU and FIM were taken at initial visit and at ICU discharge date. The patient's scoring on outcome measures at initial visit and ICU discharge are shown in Table 3.

Table 3: Functional Outcome Measures at Evaluation and Discharge

Outcome Measure	ICU Evaluation Score	ICU Discharge Score
Functional Status Score for the ICU (FSS-ICU)*	1	10
Functional Independent Measure (FIM)#	13 motor 12 cognition 25 overall	18 motor 28 cognition 46 overall
Activity Measure for Post-Acute Care (AM-PAC) – 6 Clicks^	8 mobility 6 activity	12 mobility 17 activity
* = MDC 2-5; # = MDC 22 overall, 17 motor, 3 cognition; ^=MDC 4.28 mobility, 3.70 activity		

This patient's history and examination findings were consistent with the medical diagnosis of necrotizing pneumonia with residual consolidation of the left upper lobe, as well as quadrilateral amputations. In addition, prolonged time on mechanical ventilation, VV-ECMO, and CRRT contributed to delirium and critical illness myopathy, which in combination with conditions previously mentioned, resulted in significant functional decline from baseline. The patient presented with impaired muscle performance; range of motion; gait, locomotion, and balance; and ventilation/gas exchange. He was functionally limited in self-care, home management, and work, community, and leisure activities. At time of evaluation, he was on mechanical ventilation. The primary physical therapy diagnosis was consistent with impaired ventilation and respiration/gas exchange associated with respiratory failure and impaired motor function, muscle performance, range of motion, gait, locomotion, and balance associated with amputation. Additionally, based on his exam, the additional deficits related to impaired ventilation, respiration/gas exchange, and aerobic functional capacity associated with airway clearance dysfunction and deconditioning.

At the time of initial evaluation, the patient had experienced several medical setbacks and complex conditions that contributed to the therapists anticipating a prolonged course of care. The patient's predicted level of functional improvement was not known, as he had experienced several medical setbacks during his course of care. It is well documented that those who are experience prolonged mechanical ventilation, VV-ECMO, and other life-saving interventions in the ICU settings also experience long-term effects such as critical illness myopathy and post-intensive care syndrome (PICS).[8-9] The therapists considered and anticipated the unfavorable prognostic indicators related to prolonged ICU stays, such as emotional and psychological effects, and collaborated with other medical professionals on a holistic plan of care. Both the patient and the patient's family had experienced significant trauma leading up to the therapeutic evaluation, and expressed anxiety and apprehension surrounding the therapeutic process, mostly related to early mobility. This led the therapists to advocate for a psychology consult and other mental health resources for the patient and his family.

These additional resources included recreational therapy, music therapy, and increased outdoor privileges (as medically able), which did provide a positive experience for the patient and family. Despite the many adverse events that patient encountered during this length of stay, he had a strong social support system willing to participate in the therapeutic process. He expressed strong motivation and participated actively in the intended outcomes of therapy. Both the patient's support system and motivation were considered favorable prognostic indicators for functional improvements. Based on mutually agreed upon goals, the patient was seen daily over the course of 56 days in the ICU in order to produce measurable improvements in aerobic capacity/endurance, functional status in activities of daily living (ADLs), locomotion/balance, muscle performance, ROM, airway clearance, functional cough, and physical and psychological state. To achieve these outcomes, the therapists used a targeted, evidence-based plan of care that focused on patient and family education and instruction, therapeutic exercise, functional training in self-care, functional training in locomotion, prescription, fabrication, and application of orthotic equipment, and airway clearance techniques.

Therapeutic interventions were implemented to target the patient's impairments within the cardiovascular/pulmonary, musculoskeletal, neuromuscular, and cognition/communication/affect systems. Impairments noted within the integumentary system were managed by the nursing staff and plastic surgeon, however maintenance of surgical site integrity was targeted within physical therapy through patient and family education within each visit. Evidence-based therapeutic interventions and delivery method can be found in the Appendix.

Early in the patient's course of care, postural drainage was utilized to provide airway clearance and secretion removal.[10] The most tolerated and successful position for the patient was in right side lying with head of bed elevated to 30 degrees. This position targeted the left posterior segment of the upper lobe. Vibration and percussion were not utilized early in the therapeutic intervention, as patient had expressed anxiety. However, the therapists were able to provide both vibration and percussive techniques coupled with postural drainage as the course of care progressed and the patient found success in airway clearance. Continued patient and family education and instruction was provided for effective cough strategy as well as use of upright positioning for effective airway clearance.

Additionally, the use of upper extremity (UE) adapted cycling and strengthening were utilized to provide both cardiovascular training and range of motion. Vitals were continuously monitored, and the use of Borg Rate of Perceived Exertion (RPE) was utilized so that the cardiovascular system was not overwhelmed in the acute phase of recovery. Sommers et al[11] described the benefits of using UE cycling with interval training sessions when discussing the importance of early physical therapy for patients within the ICU settings. Strengthening protocols with use of TheraBand as well as proprioceptive neuromuscular facilitation (PNF) are well documented in the literature for patients who have experienced an ICU stay and sepsis.[12-13] Graded motor imagery and relaxation techniques were utilized to assist in phantom pain management and anxiety during therapeutic sessions.[14] The patient experienced a positive outcome with these techniques and found them to be helpful in other aspects of his medical stay beyond therapy sessions (debridement, dressing changes, etc.). Bed mobility and transfer training were implemented to enhance the patient's functional independence and increase the likelihood of meeting acute inpatient rehabilitation requirements at time of hospital discharge. The value and benefit of functional mobility retraining in the ICU is well documented for a variety of conditions, including prolonged mechanical ventilation.[12,15-17] The patient had expressed early on in the therapeutic process that his main goal was to return to an independent state, and therefore, coupled with the clinical judgement of the therapists and recommendation in the literature, functional mobility retraining was the main focus of hospital-based physical therapy.[3,15-17] Lastly, the therapists were aware of the patient and family members likelihood of experiencing anxiety, stress, and apprehension given the patient's trauma and long length of stay in an ICU. They followed the recommendations of Falgares et al[18] that guided them to providing resources outside of therapy time to manage stress and anxiety.

Overall, the patient remained adherent and highly motivated. Initially in the ICU, the patient received co-interventions with physical and occupational therapies due to his significant decline in cardiovascular endurance and lethargy. However, over time, he was able to participate in multiple therapeutic sessions daily without the need for co-interventions. Progression of all interventions were based on the patient's performance and as part of a collaborative decision-making process among the therapeutic team.

OUTCOMES

Over the course of 79 physical therapy visits and 103 total days in the acute setting (56 of which were in the ICU), the patient made meaningful improvements in functional mobility and on all functional outcome measures utilized. The patient transitioned from total dependence for all functional movement to supervision only using the bed rail for rolling, supervised sitting at edge of bed for ADLs, and propelling a wheelchair independently up to 50 feet. At ICU discharge, the patient demonstrated meaningful change on the FSS-ICU, and at discharge from the acute care hospital demonstrated meaningful change on the FIM and AM-PAC 6-clicks. Minimal detectable change for the FSS-ICU, FIM, and AM-PAC 6-clicks are 2-5, 22, and 4.28 (motor)/3.70 (activity), respectively (see Table 3). At 10 months' post-discharge from the acute setting, the patient was ambulating up to 150 feet without assistive device using bilateral lower extremity prosthetics, able to propel a lightweight wheelchair community distances, was independent in all transfers, and had returned to school and work.

Although the patient was considered medically stable throughout most of his inpatient episode of care, he did experience several medical setbacks during this time, including repeat surgical debridement and removal of necrotic tissue of bilateral lower extremities, difficulty controlling pain and bleeding post-debridement, and depression. After each debridement procedure, the patient was placed on a medical hold per the surgeon for 3-5 days, after which therapy would re-assess and continue per the re-established plan of care. The course of care was further delayed due to the influence of intermittent ketamine use for debridement procedures contributing to delirium and lethargy. The delirious states occurred on days 30-40 and manifested in hallucinations, anxiety, and paranoia. The therapists managed the delirium episode with continued structure therapy, descriptive and succinct

explanation of therapy, and focus on patient obtaining good quality sleep during the nighttime hours.[19] Additionally, the patient was able to successfully wean from strong sedatives during this time which contributed to his return to cognitive baseline by day 40 of hospital stay. Despite the temporary shift in cognitive function during the delirious state, it did not seem to affect the physical therapy plan of care, as the patient continued to progress toward all therapeutic goals.

Despite the stated medical complications and interruptions to therapy, the patient remained highly motivated and participatory in his care. Interventions were well tolerated by the patient and assessed in the ICU by the response of heart rate, blood pressure, and oxygen saturation. Adherence from the patient was rarely considered a negative factor in his progress; however, the therapists did intervene with the patient's family early on. The patient's parents' anxiety and apprehension toward therapeutic progression was apparent throughout the patient's course of care. In response, the therapist's provided each family member a role in the therapeutic process. The use of family members as a participant in a loved one's care is well-supported in the evidence and the patient's mother reported this intervention aided in reducing her anxiety toward early mobility.[20] Additionally, the therapists' worked with the patient directly to establish daily therapeutic goals that were meaningful to him and his recovery. Utilizing this strategy worked to provide the patient some aspect of control in their course of care, improving his adherence to the therapeutic plan.

DISCUSSION

This case study highlights the application of evidence-based rehabilitation to a patient with multiple diagnoses. With limited resources available to guide the clinicians in practice, they were able to combine interventions from numerous resources to provide evidence-based interventions. Research is prevalent when considering mechanically ventilated patients and those carrying a diagnosis of acute respiratory distress syndrome (ARDS).[21-23] However, the patient in this case had the medical complexities of quadrilateral amputation as well as delirium and critical illness myopathy (CIM) compounding the total effects of his time in the intensive care unit. The evidence supports intervening early and often for those who suffer with delirium and CIM within the ICU settings.[24-26] Unfortunately, there remains a lack of evidence-based resources surrounding therapeutic intervention when delirium and CIM are combined with additional complex medical diagnoses.[27]

Limitations

One major limitation of this case study is the high degree of complexity of the medical conditions presented made it difficult to find research describing best practice to guide the therapeutic process. Another limitation to the study is the number and quality of evidence available for the patient's specific comorbid conditions as related to physical therapy. No publications were found specifically discussing the therapeutic role in necrotizing fasciitis or necrotizing pneumonia. Due to the limitations in evidence for this patient's presentation, the therapists utilized the best available evidence to formulate a comprehensive intervention plan. This approach involved searching for high-level evidence (randomized controlled trials and systematic reviews) that focused on the patient's primary diagnoses of ARDS and quadrilateral amputations, followed by secondary diagnoses of critical illness myopathy, prolonged mechanical ventilation, and delirium. This yielded many recent publications that fit the patient diagnoses, but also included the use of one case study[28] and several publications over 10 years old. One randomized controlled trial found that intensive physical therapy did not improve long-term physical functional performance compared with a standard program for mechanically intubated patients.[29] Despite these findings, the therapists were able to find many other publications citing the value and benefits of early and aggressive therapies for patients who are in the ICU and mechanically ventilated.[13-14, 19, 23-27]

Strengths

Although this case had its limitations, one major strength is the functional outcome demonstrated by the patient during his length of stay and post-discharge. The patient was discharged to an outside rehabilitation hospital after 103 days in the acute setting (56 days in the ICU) and was able to sit edge of bed for self-care/ADLs and perform bed mobility with supervision and propel a standard wheelchair independently. At 10 months' post-discharge from the acute setting, the patient was ambulating up to 150 feet without assistive device using bilateral lower extremity prosthetics, able to propel a lightweight wheelchair community distances, independent in all transfers, and returned to meaningful recreation, specifically yoga and weight training. At the time of this manuscript, the patient is living independently, attending school full-time, participates in a part-time job, and volunteers for a non-profit, all with the accommodation of a trained therapy dog.

CONCLUSION

This case study highlights the difficulty clinicians can encounter when searching for evidence-based guidelines regarding multiple complex comorbid conditions in a specific patient population. Therefore, it is necessary to consider that if the therapeutic approach of this case solely focused on typical post-amputation intervention, ARDS, or early mobility without the consideration of all contributing medical issues of this patient (necrotizing pneumonia, hemodynamic instability secondary to medications, and

psychological impact, for example), the functional outcome may have been less favorable. Focusing on only one aspect of this patient's medical course would have likely neglected other areas that required aggressive intervention.

For example, had the therapists neglected the use of airway clearance techniques early on, the patient may have had a longer wean time from the mechanical ventilator, and poorer outcomes and longer length of stay.[21] The use of postural drainage positioning was highly effective in assisting in airway clearance early on the therapeutic plan; however, the research supporting its use was typically over 10 years old and often times considered outdated. Currently, there are emerging studies highlighting the therapeutic benefits of positioning in those suffering the negative respiratory effects of coronarvirus disease (COVID-19). Also, if the therapeutic focus was solely on early mobility without considering the need for post-amputation specific interventions, the patient may not have attained enough range of motion and strength to be ambulatory with prostheses. Additionally, the patient was on several medications that had significant impact on multiple systems creating hemodynamic instability, with ketamine being the primary influence.

Ketamine is known to increase blood pressure, heart rate and respiratory rate as well as induce hallucinations[30] and therefore the therapists had to provide continuous and thorough vital monitoring throughout the therapy sessions to ensure that the patient maintained appropriate hemodynamic shifts before, during, and after activity. These findings suggest that clinicians must continually examine and combine the best available evidence of multiple medical conditions to provide a comprehensive therapeutic approach to managing complex patients in the intensive care setting.

Last, considering the psychological impact of a prolonged ICU stay on patients and their family members is critical to a holistic approach to care. An interprofessional relationship including access to psychology professionals, including neuropsychologists within the ICU setting would have a lasting impact on the amount and quality of care the patient receives. With these considerations in place, patients and their families would benefit from high level, interprofessional, and evidence-based care within the ICU and acute care settings.

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Appendix

Intervention	Delivery Method
Passive Range of Motion (PROM)	• 5 times/joint, 1 set, once daily[11]
	• Lying flat to allow passive hip extension[11,15-16] • Side-lying with assisted hip extension/hip flexor stretching[11-12,15-16]
Graded motor imagery, relaxation	• Hand laterality[14] • Breathing and meditation as distraction methods[14] • Visualizing unclenching of phantom fists and ankle range of motion (ROM) at phantom ankles[14]
MotoMed	• Upper extremity (UE) cycling, interval training building to 10 minutes[11,13]
Functional Retraining	• Rolling, supine to sitting, activities of daily living (ADLs) with modifications, prone positioning, sitting balance[12, 15-17]
Strengthening	• Theraband attached to hospital bed, alternating between upper extremity and shoulder girdle, and lower extremities and hip girdle.[12] • Proprioceptive neuromuscular facilitation (PNF) D1/D2 and lower extremity diagonals with assistance progressing to against resistance and reversal-holds.[13]
Psychological Coping Strategies	• Advocating of outdoor time intervals[18] • Patient participation in goal setting and daily therapeutic schedule[18] • Recreational and music therapies consult
Environmental Modifications	• Use of built-up handles • Use of stabilizing, non-slip materials to improve grip

Airway Clearance Techniques	• Active cycle of breathing and huffing techniques provided every 2 hours (RN, OT, and PT collaborative intervention) progressed to manual cough assist[29]
	• Instruction of effective cough technique[29]
	• Positioning[10]
	  • Right side lying with head of bed elevated to 30 degrees, targeting the left posterior segment of the upper lobe.
	  ▪ 4-10 minutes 2x/daily initially
	• Vibration and percussion utilized as patient was able to tolerate positioning[10]
	  • Seated to alter work of breathing