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Functional improvements of patients admitted to an inpatient rehabilitation facility after bilateral lung transplant due to severe COVID-19 pulmonary disease

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Abstract

Background: Coronavirus disease (COVID-19) has introduced a new subset of patients with acute end-stage lung damage for which lung transplantation has been successfully performed.

Objective: To describe the inpatient rehabilitation course of patients who underwent bilateral lung transplant due to severe COVID-19 pulmonary disease.

Design: Retrospective chart review.

Setting: Free-standing, academic, urban inpatient rehabilitation hospital.

Participants: Seventeen patients aged 28–67 years old (mean 53.9 ± 10.7) who developed COVID-19 respiratory failure and underwent bilateral lung transplant.

Interventions: Patients participated in a comprehensive inpatient rehabilitation program including physical, occupational, and speech therapy tailored to the unique functional needs of each individual.

Main Outcome Measures: Primary outcome measures of functional improvements, include mobility and self-care scores on section GG of the Functional Abilities and Goals of the Improving Post-Acute Care Transformation Act, as defined as quality measures by the Centers for Medicare and Medicaid Services. Other functional measures included 6 minute walk test, Berg balance scale, Mann Assessment of Swallowing Ability (MASA), and Cognition and Memory Functional Independence Measure (FIM) scores. Wilcoxon signed rank sum test was used to evaluate statistical significance of change between admission and discharge scores.

Results: Fourteen patients completed inpatient rehabilitation. Self-care (GG0130) mean score improved from 20.9 to 36.1. Mobility (GG0170) mean score improved from 30.7 to 70.7. Mean 6-minute walk distance improved from 174.1 to 467.6 feet. Mean Berg balance scores improved from 18.6/56 to 36.3/56. MASA scores improved from 171.3 to 182.3. All functional measures demonstrated statistically significant improvements with p value ≤ .008, except for cognition and memory FIM scores, which did not show a statistically significant difference. A majority (76%) of patients discharged home.

Conclusion: This new and unique patient population can successfully participate in a comprehensive inpatient rehabilitation program and achieve functional improvements despite medical complications.

INTRODUCTION

Coronavirus disease (COVID-19) has introduced a new subset of patients with acute end-stage lung damage refractory to medical management. Similar to other end-stage pulmonary diagnoses, lung transplantation has now been performed for patients experiencing severe effects of COVID-19.[1,2] As of September 30, 2021, lung transplantations have been successfully performed in the United States for 214 patients with end-stage pulmonary fibrosis or acute respiratory distress syndrome due to COVID-19, a vast majority of which (197) were bilateral lung transplantation.[3]

Lung transplantation is an established treatment option for the management of end-stage pulmonary disease. The indications and criteria for lung transplant have been revised over time to include a variety of medical conditions including respiratory failure due to interstitial lung disease and chronic obstructive pulmonary disease. The U.S. Department of Health and Human Services reported 2597 lung transplants were performed in 2020, which represents an increase greater than 50% over the annual number of transplants performed a decade earlier.[4,5] Advances in medical technology have increased the number of people with severe respiratory failure who have been able to survive on mechanical ventilation and extracorporeal membrane oxygenation (ECMO), which has allowed for the liberalization of restrictions for the types of patients qualifying for transplantation, including irreversible lung damage secondary to COVID-19 infection.[6]

Patients who have undergone lung transplantation face unique and complex challenges and many lung transplant recipients demonstrate functional impairments that require rehabilitation in a post-acute care setting.[7–9] Inpatient rehabilitation (IPR) provides individualized and collaborative care in the postacute care phase and has been shown to improve the functional status of posttransplant patients as well as managing their complex medical needs.[8–10] Reports have also been published describing successful IPR for patients recovering from COVID-19, but there are limited data on the rehabilitation outcomes for patients who underwent bilateral orthotopic lung transplant (BOLT) secondary to COVID-19 related end-stage pulmonary disease.[11–15]

The recent emergence of COVID-19 led to the creation of this patient population that is unique in multiple respects, including having atypical pretransplant circumstances. In the past, patients who qualified for BOLT had chronic respiratory failure and often underwent presurgical rehabilitation to increase functional status and improve outcomes post transplantation.[4,10] Rather than having been prepared for transplantation, patients acutely hospitalized for severe COVID-19 were in critical condition in the intensive care unit and were poor candidates for BOLT based on classic criteria. These patients were selected as candidates for transplantation because they were functionally independent prior to COVID-19 associated illness, lung transplantation may have been the only option for their survival, and they had a greater likelihood of recovery with intensive postoperative rehabilitation related to the relatively short period of preoperative morbidity (as compared with patients with chronic lung disease).[16]

Although there are similarities between the rehabilitation of patients who undergo lung transplants due to COVID-19 compared to those with chronic lung disease, there are factors related to patients' pretransplant attributes that differentiate the rehabilitation approaches used for these two distinct patient populations. For patients with chronic lung disease, pretransplant rehabilitation focuses on aerobic and anaerobic training, nutritional counseling, psychosocial optimization, and extensive education. Conversely, patients acutely ill due to COVID-19 did not undergo the physical or mental preparation for lung transplant due to the greater acuity and severity of their disease. The highly complex medical course experienced by these patients compounded by strict isolation protocols, presence of medical devices, medical interventions and procedures, sedating or paralytic medications, as well as prone positioning served as barriers to the various educational and physical training incorporated in conventional preparation for lung transplantation. In addition, the complexity of the transplant surgery itself may be greater for the patients with COVID-19 related lung disease as most patients underwent bilateral lung transplant whereas some patients with chronic lung disease may undergo single lung transplant. Further, the procedure for bilateral lung transplant requires a greater level of postacute care medical monitoring, including larger surgical incisions that are at risk of complications, increased need for pain management and medication titrations, and greater activity restrictions. The combination of these elements suggests that the severity of patients' functional impairments, educational needs, and need for psychosocial support is greater for those who underwent BOLT due to COVID-19 lung disease.[3,4,10,15]

There remains a relative gap in our knowledge of the course of this novel group of patients admitted to IPR and there are only published case reports of patients with COVID-19 related pulmonary disease who underwent IPR following lung transplant.[15,17] The objective in reporting this retrospective review is to describe the IPR course of this patient population, identify common and potential medical complications in the postoperative period that affect functional progress, and present the outcomes of comprehensive, coordinated, interdisciplinary rehabilitation care for the management of these noteworthy patients.

METHODS

This study received Northwestern University Institutional Review Board approval (IRB STU00212585) as a substudy of a larger cohort of patients admitted to IPR for COVID-19 related functional impairments, which includes patients who did not undergo lung transplantation. Additional studies of the patients in the larger cohort of patients are in varied stages of investigation or publication.[18,19] Patients did not require consent given the retrospective nature of the study according to IRB guidelines and data were deidentified.

Case identification/population

The present study is a retrospective review of 17 patients who underwent bilateral lung transplantation due to severe COVID-19 respiratory failure and were admitted to a freestanding academic inpatient rehabilitation facility (IRF) in a large metropolitan city. Patients admitted between September 29, 2020 and November 19, 2021 were included in this review. Criteria for admission to IRF were such that patients had the need for regular visits by a physiatrist, need for rehabilitation nursing care, need for at least 3 hours of therapy per day from at least two therapy modalities (physical therapy, occupational therapy, and/or speech therapy), and need for a coordinated team of providers with the expectation of functional improvement.[8,20,21] Patients were discharged from the acute care setting, and the care of each patient was transferred from the transplant surgery team to the care of an attending physiatrist upon admission to IPR. Under the supervision of a physiatrist, patients who were admitted to the IRF received all components of a comprehensive interdisciplinary rehabilitation program that was adapted to meet the specific needs of patients who underwent lung transplant[7–9] as well as those recovering from COVID-19.[12,13]

Inpatient rehabilitation treatment

The IPR program included a minimum of 15 hours per week of skilled therapy, including physical, occupational, and speech therapy, and was modified to meet the unique functional and medical needs of each patient. Physical therapy goals focused on improving strength, endurance, and functional mobility. Additional pulmonary specific interventions included diaphragmatic breath retraining, inspiratory muscle training, and instruction on pursed-lip breathing. Occupational therapy goals included promoting independence related to activities of daily living (ADLs) such as dressing, hygiene, bathing, and toileting. Within these occupational therapy sessions, additional emphasis was placed on energy conservation techniques, due to the limited activity tolerance of these patients. Speech therapy goals focused on addressing impairments related to dysphagia, voice, and expiratory muscle strength training. Instrumental swallow evaluations (video fluoroscopic swallow studies or fiber optic endoscopic evaluation of swallowing) were used as indicated.

Social work and psychological services were provided for all patients. Social work provided coordination of postdischarge services. Psychology supported patient, family, and caregiver emotional needs. Rehabilitation nursing services provided patient and family education regarding medication management, wound/skin care and other patient safety measures. The transplant surgical teams were available via phone for urgent issues on a consulting basis 24 h/day and 7 days/week. In addition, there was regular communication between the rehabilitation and transplant teams for review of management and progress. Rehabilitation physicians collaborated with transplant pharmacists from the referring facilities to ensure accurate immunosuppressant titration. The rehabilitation team also collaborated with the transplant team to coordinate complex patient care, education, and medication needs for discharge. Criteria for discharge from IRF were unique to each patient and were determined via a combination of functional status, home structure, availability of caregivers, and insurance constraints. Patients were discharged home when they reached modified independent level or had caregivers trained to confidently assist with mobility and self-care activities. Patients who were discharged home were deemed medically stable to live in the community by an attending physiatrist. Patients who did not meet these criteria for home discharge were discharged to a skilled nursing facility. Patients that developed acute medical conditions that could not be managed in the IRF were transferred back to the acute care hospital. Some patients transferred to acute care were readmitted to IPR after medical stabilization if they continued to meet IPR admission criteria. The total length of stay for patients readmitted to IPR was summated based on the actual days of admission to IPR excluding days in acute care.

Patient chart review and outcomes

Medical documentation was reviewed for basic demographics, premorbid functional status, acute care medical course, medical complications during IPR, functional status on admission to IRF, and functional status on discharge from IRF—including Quality Measures (primary outcome), Functional Independence Measures (FIM), 6-minute walk test, Berg balance testing, Mann Assessment of Swallowing Ability (MASA), and severity of dysphagia. These measures were determined a priori and each medical chart was

reviewed by at least two different authors. Some functional measures were not obtained for every patient due to a variety of reasons, including transfers to acute care or testing that was inappropriate for patient care or safety. Discharge measures were not obtained for three patients who required unplanned transfer to acute care and who were not readmitted to the IRF because the final discharge measures are acquired in the days leading up to a planned discharge. Admission Berg balance scores and 6-minute walk test measures were not available for nonambulatory patients and admission MASA scores were not available for patients with severe dysphagia.

Quality measures

Quality Measures are defined by the Centers for Medicare and Medicaid Services (CMS) as tools to help measure patient outcomes to ensure high-quality health care and/or that relate to one or more quality goals for health care.[21,22] For IPR, these are further broken down into individual Quality Indicators as mandated by section GG: Functional Abilities and Goals of the Improving Post-Acute Care Transformation Act. These GG scores, which have undergone reliability and validity testing, reflect the patient's functional abilities based on the type and amount of assistance provided by a helper and are assessed at IPR admission, throughout the rehabilitation course, and at discharge.[23–25] Qualified clinicians code each self-care and mobility activity based on a 6-level rating scale ranging from 1 (dependent) to 6 (independent) and the respective self-care and mobility items are combined for a composite score for each category.[23–25] In some cases, a self-care or mobility task was not attempted or deemed unsafe to perform and was not scored with a numerical 1–6 value, but was recoded to a 1 in accordance with CMS guidelines to signify the lowest level of function.[21,24] The most common self-care tasks that could not be attempted on admission were bathing ($n = 3$) and eating ($n = 3$). The most common mobility tasks that could not be attempted on admission were climbing 12 steps ($n = 17$), walking 150 feet ($n = 15$), and walking 10 feet on uneven ground ($n = 15$). Additionally, the admission wheelchair-related GG measurements were excluded for two patients who did not require use of a wheelchair on discharge to most accurately reflect the increase in functional mobility. Both patients scored a 4 on the GG scale for propelling a wheelchair 50 feet on admission, but wheelchair mobility "did not occur" on discharge as both patients were ambulatory and would be recorded as a 1 on discharge. The exclusion of these wheelchair measures prevents this misleading 3-point reduction for functional mobility. FIM scores were obtained for speech therapy outcome measures including comprehension, expression, social interaction, and problem solving as there are no GG measurements for these functional outcomes.[26] There is overlap in the activity measures for FIM and GG scores, though FIM scores use a rating scale of 1 to 7 to signify the level of assistance a patient requires ranging from dependent to independent and have been replaced by GG scores for reporting function in self-care and mobility.[24,25]

Statistical analysis was performed using SAS (v 9.4). Data for all groups demonstrated a small sample size and normal distribution was not assumed such that the Wilcoxon signed rank sum test was used to compare the unpaired admission and discharge values for all functional measures. Statistical significance was set to a value of $p < .05$. Statistical outlier testing for length of stay was performed using the interquartile range (IQR) techique.[27] This method defines as outlier as being any point of data that lies 1.5 times the IQR below the first quartile or 1.5 times the IQR above the third quartile. Clinically meaningful improvements for secondary outcomes were 177 feet for 6 minute walk test,[28] 12.5 points for Berg balance score,[29] and 10 points for MASA.[30]

RESULTS

Demographics

Seventeen patients who developed COVID-19 respiratory failure, underwent bilateral orthotopic lung transplantation, and subsequently participated in IPR were included (Table 1). Sixteen patients (94%) were admitted to the IRF from one of two urban acute care hospitals, and one patient was initially discharged from acute care to a long-term acute care hospital before IRF admission. Twelve of the patients (71%) were male and five (29%) were female. The ages of the patients in the study were 28–67 years with a mean age of 53.9 (± 10.7) years. All of the patients in this study were independent for ADLs and mobility prior to hospitalization with COVID-19.

Acute care course

There was a large variety of complications that occurred during the acute hospitalization prior to admission to IRF (Table 1). Many of the patients in this study were hospitalized in the intensive care unit (ICU) for an extended period of time. The average length of stay (LOS) in acute care was 129 days with the range being 67–311. The average number of days requiring mechanical ventilation was 93 days (maximum 175 days) for the 14 patients who required mechanical ventilation and ECMO was 95 days (maximum 163 days) for the 13 patients who required ECMO. See Table 1 for major reported

TABLE 1 Patient characteristics, demographics, and acute care details ($n = 17$)

Demographics		
Age, mean years (range)	53.9 (28–67)	
Male gender, *n* (%)	12 (71%)	
Weight, mean kg (range)	79.9 (61–116)	
Body mass index, mean kg/m^2 (range)	24.2 (16.1–35.6)	
Tracheostomy at time of IPR admission, *n* (%)	0 (0%)	
Gastrostomy at time of IPR admission, *n* (%)	5 (29%)	
Hemodialysis at time of IPR admission, *n* (%)	2 (12%)	
Premorbid reported medical history, *n* (%)		
Hypertension	9 (53%)	
Diabetes mellitus	7 (41%)	
Coronary artery disease	3 (18%)	
Asthma	3 (18%)	
Obesity	3 (18%)	
Thyroid dysfunction	2 (12%)	
Neuromyelitis optica	1 (6%)	
Rheumatoid arthritis	1 (6%)	
Castleman's disease	1 (6%)	
Hepatitis C	1 (6%)	
Acute care treatment duration, mean days (range)		
Length of stay in acute care (all patients, $n = 17$)	129 (67–311)	
Time on mechanical ventilator (all patients, $n = 17$)	76.6 (0–175)	
Time on ventilator (only ventilator patients; $n = 14$)	93.1 (4–175)	
Time on ECMO (all patients, $n = 17$)	72.8 (0–163)	
Time on ECMO (only ECMO patients; $n = 13$)	95.2 (41–163)	
Major reported complications in acute care, *n* (%)	**Pre-BOLT**	**Post-BOLT**
Lung infection (bacterial PNA/VAP/abscess/empyema/tracheitis)	9 (53%)	6 (35%)
Pleural space complications (pneumothorax/hemothorax/effusion)	8 (47%)	5 (29%)
Bacteremia	6 (35%)	2 (12%)
Acute kidney injury/renal failure	5 (29%)	5 (29%)
Vascular (deep vein thrombosus/arterial/pulmonary embolism/digit ischemia)	11 (65%)	2 (12%)
Anemia	0 (0%)	4 (24%)
Acute cardiac injury/heart failure/pericarditis	5 (29%)	0 (0%)
Neurological (encephalopathy/delirium/stroke)	4 (24%)	0 (0%)
Hematologic (thrombocytopenia/neutropenia)	3 (18%)	0 (0%)
Gastrointestinal (bleed/*C. difficile*/hepatitis C)	1 (6%)	3 (18%)
Urologic (recto-prostatic-urethral fistula/urinary tract infection)	2 (12%)	0 (0%)
Adrenal insufficiency	1 (6%)	0 (0%)
Serotonin syndrome	0 (0%)	1 (6%)

Abbreviations: BOLT, bilateral orthotopic lung transplant; ECMO, extracorporeal membrane oxygenation; IPR, inpatient rehabilitation; PNA/VAP, pneumonia/ventilator-associated pneumonia.

complications in acute care that are separated relative to their timing before or after transplant. The most common organ complications pre- and post-BOLT were pulmonary complications (pneumonia, empyema, abscess, pneumothorax, and hemothorax), hemovascular complications (deep vein thrombosis, pulmonary embolism, arterial thrombosis, and digital ischemia), bacteremia, and acute kidney injury. Data on patient positioning, such as frequency of turning or information about prone positioning, were not available.

Length of stay and transfers to acute care

The average length of stay at IRF for all patients was 29.2 (± 23.3) days (median 22 days) with the range 6–

94 days. Eight of the 17 patients (47%) admitted to the IRF had an interrupted rehabilitation stay due to acute complications requiring re-admission to acute care. One of the patients was transferred to acute care twice for respiratory distress/failure and one patient required readmission to acute care four times: three times for gastrostomy tube complications and once for pneumonia. These two patients also exhibited the longest length of stays of 78 days and 94 days, respectively, both of which are statistical and clinical outliers (Figure 1). The other six patients transferred to acute care for acute kidney injury, mucus plugging, pericardial effusion, pneumonia, abdominal pain, and respiratory distress.

Discharge destination

Of the 17 patients admitted to the IRF, 13 (76%) were discharged directly to home and only one patient (6%) was discharged to a skilled nursing facility. Three patients were discharged to an acute care hospital without readmission to IRF. Of these three patients, two were discharged to home from acute care and the third transferred to an acute hospital closer to their residence at which point no further information was obtainable. These three patients were admitted to the IRF for 78 (between two IPR admissions), 15, and 6 days, respectively, prior to final transfer to acute care.

Functional outcomes

After completing a course of IPR, the patients who underwent post-COVID BOLT demonstrated statistically significant improvements across multiple functional domains including self-care, mobility, 6-minute walk test distance, balance, and dysphagia (Table 2). Self-care (GG0130) mean score improved from 20.9 to 36.1, mobility (GG0170) mean score improved from

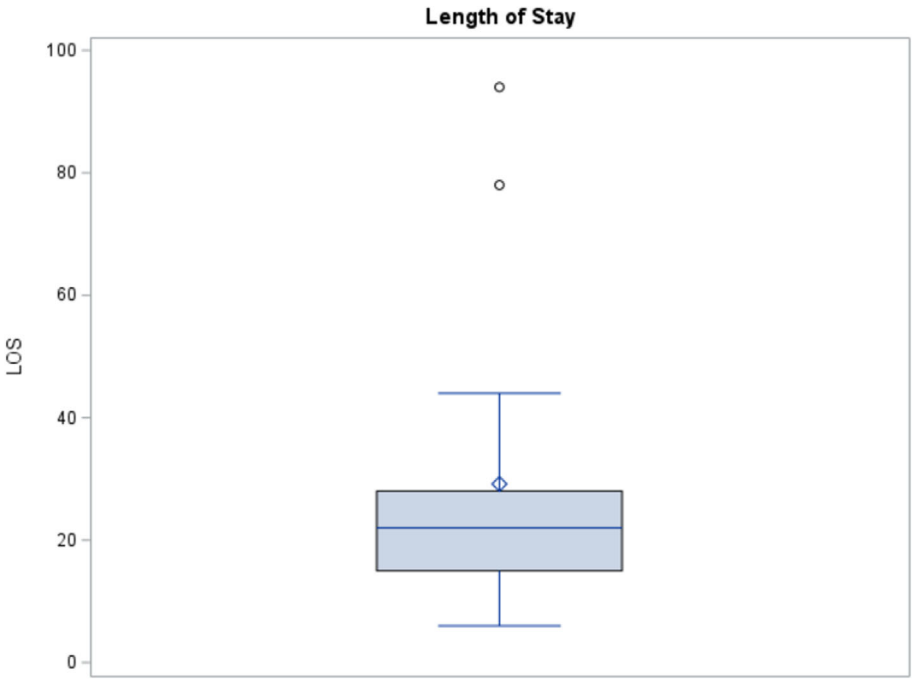

FIGURE 1 Quartile box plot for length of stay (in days). Box plot shows first to third quartile as the upper and lower edges of the box in days. The plot shows a median of 22 represented by the horizontal line near the center of the box and a mean of 29 represented by a blue diamond. The two black circles represent two separate statistical outliers of 78 and 94 days.

TABLE 2 Functional outcomes

Rehabilitation measure	Mean admission score (± SD)	Mean discharge score (± SD)	Mean score increase (± SD)	*p* value
Self-care (GG0130)	20.9 ± 5.1 (*N* = 17)	36.1 ± 7.3 (*N* = 14)	14.7 ± 5.6 (*N* = 14)	<.001
Mobility (GG0170)	30.7 ± 9.1 (*N* = 17)	70.7 ± 16.7 (*N* = 14)	38.6 ± 12.4 (*N* = 14)	<.001
Cognitive and Memory Score (Functional Independence Measures)	27.8 ± 3.3 (*N* = 17)	28.3 ± 3.8 (*N* = 13)	1.1 ± 3.0 (*N* = 13)	.28
6-min walk test (feet)	174.1 ± 153.9 (*N* = 15)	467.6 ± 308.0 (*N* = 13)	281.0 ± 280.5 (*N* = 13)	<.001
Berg Balance Scale	18.6 ± 14.6 (*N* = 14)	36.3 ± 15.6 (*N* = 12)	15.5 ± 10.0 (*N* = 12)	<.001
Mann Assessment of Swallowing Ability (MASA)	171.3 ± 13.6 (*N* = 13)	182.3 ± 13.7 (*N* = 8)	13.1 ± 16.4 (*N* = 8)	.008

TABLE 3 Dysphagia diet order at admission and discharge

	NPO	Modified diet	Regular diet
Diet level admission ($n = 17$)	17.6%	23.5%	58.8%
Diet level discharge ($n = 14$)	7.1%	7.1%	85.7%

30.7 to 70.7, mean 6-minute walk distance improved from 174.1 to 467.6 feet, mean Berg balance scores improved from 18.6/56 to 36.3/56, and MASA scores improved from 171.3 to 182.3. Clinically meaningful improvements in the secondary outcome measures were observed for the 6-minute walk test, Berg balance score, and MASA. Patients demonstrated an improvement in dysphagia, as 41% of patients were either NPO or on a modified consistency diet on admission to IRF, but 88% of patients were able to consume a regular consistency diet by the time of discharge (Table 3). No statistical or clinical difference was observed in the cognition and memory FIM scores, which showed a nominal change from 27.8 on admission to 28.3 on discharge ($p = .28$). (Table 2).

DISCUSSION

This article describes the IPR course of patients who underwent BOLT due to severe COVID-19 infection. These patients concluded complicated and often protracted acute care hospital courses and many had prolonged ventilator and/or ECMO time. This study provides insight into the functional improvements and medical complications of this patient population during IPR.

IPR is not only suited to managing complex medical and rehabilitation needs but offers the most intensive form of inpatient rehabilitation and also demonstrates higher rates of discharge to the community and lower acute care readmission rates for many diagnoses as compared to skilled nursing facilities.[20,31] IRFs have adapted to the changing COVID-19 medical landscape, both in terms of hospital and logistical modifications to allow for patient isolation as well as rehabilitation program participation.[12,32] It is recognized that an integrative and comprehensive rehabilitation team, as can be provided in IRF, is important for patient recovery after COVID-19, particularly for patients with ICU-related weakness.[12,13,32,33] Close medical monitoring is associated with better outcomes among patients who underwent lung transplantation. The IPR provider's insight into the complex pathophysiology of these posttransplant patients, awareness of possible complications, and medical monitoring experience can help to reduce morbidity and risk of secondary functional decline through early recognition of potential problems, need for intervention, and/or transfer to acute care.[8,34]

Medical complications

Complications reported in acute care were consistent with other reports of patients with COVID-19, including respiratory failure, hematologic complications, rheumatologic complications, weakness, and renal failure.[33,35–37] Postoperative complications were also consistent with reported complications of patients who underwent BOLT for reasons other than COVID-19, including infection, pneumothorax, bleeding, renal failure, and weakness.[8,34,38,39] Acute hospital readmissions from IPR are seen among non-COVID-19 lung transplant patients with variable readmission rates that can range from 19–40%.[8,12] It is not surprising that this patient population had a greater percentage of readmission rates to acute care (47%) given the greater medical complexity of these patients compared to those not infected with COVID-19.

Functional impairments

All patients exhibited functional impairments compared to their prior (pre-COVID-19) independent level of function for ADLs and mobility based on history and IRF admission GG scores. The functional impairments for these patients are attributed to multifactorial and overlapping etiologies: immobility and deconditioning related to prolonged acute care hospital length of stay, medical complexity, medication side effects, diaphragm weakness, dysphagia and malnutrition, peripheral neuropathy or plexopathy, and critical illness weakness.

Patients who experience severe illness necessitating prolonged hospitalization and life-saving measures inevitably experience a period of immobilization. Muscle weakness is not an unusual finding among critically ill patients requiring extended periods of immobility and/or bedrest and can be seen in a variety of clinical scenarios including post-lung transplant,[8,39] sepsis, corticosteroid exposure, and long-term ventilator dependence; the patients in this sample experienced one or more of these conditions.[33,40,41] Diaphragmatic weakness, dysfunction, and/or direct phrenic nerve injury are known complications of severe COVID-19 infection itself and post BOLT.[8,42] Peripheral nerve injury, including brachial plexopathy, is also an established complication of critically ill patients requiring prolonged and/or prone positioning as a life-saving measures, including severe COVID-19 associated acute respiratory distress syndrome (ARDS).[18,43] Though no electrodiagnostic testing was performed on these patients to distinguish between generalized deconditioning, peripheral nerve/plexus injury, or myopathy, potential etiologies that contributed

to the functional impairments of the patients evaluated in this study include a combination of malnutrition, deconditioning, and peripheral nerve injury. The ICU syndrome can involve physical, emotional, and/or cognitive symptoms and has been reported 12 months after an ICU admission for patients surviving COVID-19; this may also be an influential factor to the impairments identified in this study.[33,44] Another study compared symptoms between COVID-19 and non-COVID-19 ICU survivors and reported that new disability, severity of disability, reduced health-related quality of life, psychological dysfunction, and cognitive dysfunction were similar at 6 months.[45]

Length of stay

The mean LOS in IRF (27 days; range 6–94 days) was greater than the median LOS of 22 days for this patient sample. Two patients who were clinical and statistical outliers can explain this 5 day difference. These two patients had LOS of 78 and 94 days, had the lowest admission GG scores for self-care and mobility, and were the only patients to require more than one transfer to acute care. An additional factor that contributed to the extended cumulative LOS for these two patients is the expected functional regression that occurs with each interruption in the IPR course such that patients typically do not resume IPR at the same functional level as prior to transfer to acute care.[8] Exclusion of these two outliers reduces the mean LOS to 22.7 days, which improves the alignment between the mean and median LOS and is likely more representative of the expected length of stay of this population. These data are similar to the IPR LOS range reported for non-COVID-19 BOLT patients (7–60 days) and are greater than the reported mean LOS (15.2 days) for COVID-19 patients who did not undergo BOLT.[8,12] This reported LOS is not surprising for this patient population given the higher medical complexity and dual diagnosis and should be considered when evaluating patients for IRF level of care.

Functional improvement

The specific patients in this study were preselected for BOLT based on their medical and functional prognosis, and their progress in IPR suggests this patient population can demonstrate significant functional improvements. Of the total 17 patients evaluated in this study, 76% (13/17) discharged directly from IPR to the community and 88% (15/17) were ultimately able to discharge to the community. Of the 14 patients that completed IPR, approximately 93% (13/14) were able to discharge directly to the community. These numbers are slightly higher or consistent with IRF community discharge rates among patients with COVID-19 without lung transplant (60%–90%) and other lung transplant patients (88%).[8,12,14]

The patients in this study showed significant improvements across multiple functional domains representing mobility (GG0170; 6-minute walk test) and self-care (GG0130) as well as balance (Berg). The functional improvements observed in this study are consistent with prior studies reporting on IPR outcomes for mobility and self-care among COVID-19 patients who did not undergo lung transplant[12] as well as 6-minute walk test distance and Berg balance scores among patients who underwent heart or lung transplant.[8,9] The mean discharge 6-minute walk test distance observed also confers a survival advantage among patients who underwent lung transplant.[8] Although the patients in the current study showed tremendous functional improvement during admission to IRF, balance remained a significant challenge despite mean improvement in Berg balance scores from high fall risk (18.6/56) to moderate fall risk (36.3/56).[46] The LOS in the present study is similar to LOS for other patients who underwent heart or lung transplantation (21.1 days)[8] and is longer than for COVID-19 patients who did not undergo lung transplant (11–19 days).[12]

The lack of statistically significant changes in cognitive and memory FIM scores was attributed to the relatively high values upon admission to IPR, which were consistent with low levels of impairment in these domains. In the absence of cognitive or memory impairments, speech-language pathology providers focused on other meaningful rehabilitation techniques, including dysphagia and expiratory muscle strength training.

Dysphagia

Dysphagia is a known complication following critical illness with ARDS, lung transplant, and COVID-19 and the associated malnutrition has been implicated in prolonged hospitalization, medical comorbidities, and reduced 6-month survival.[8,47,48] Rates of dysphagia for patients recovering from ARDS, critical illness or COVID-19 range from 32%–81%, though an even higher rate of 93% has been observed among patients admitted to IPR after COVID-19 hospitalization.[47–51] The rate of dysphagia observed among this patient population (41%) is consistent with these reports. The percentage of patients able to consume a regular diet increased from 59% to 86% in the current study. This improvement is consistent with other reports of patients admitted to IPR after COVID-19 with improvements from 7% to 88% consuming a regular diet, which also parallels the statistically significant improvement of dysphagia represented by MASA scores for this study.[51]

Limitations

Given the retrospective study design, the measures evaluated herein were limited to data previously collected. For this reason, we observed variability in the amount of data and outcome measures collected for each individual patient. Additionally, the study design relied on information from medical documentation and/or discharge summaries from acute care hospitals and one long-term acute care hospital that were not written in a uniform manner. Further, the total number of medical complications in acute care reported in Table 1 is likely an underrepresentation of the number of complications and more detailed explanations of specific complications experienced by patients who underwent BOLT due to COVID-19 lung disease have been reported.[1,15] Discharge functional data for patients who transferred to acute care and did not return to IRF were not available for analysis; therefore, direct admission and discharge functional comparisons could be performed only for those patients who completed IPR. Comparison of the GG mobility and self-care scores from this study to prior studies that report FIM scores may be difficult due to the different measures reported. We were unable to control this change in measures as the GG scoring methodology was implemented in 2019 by CMS as a replacement for FIM.[21] Respiratory function testing or measures of dysphonia were not documented consistently to allow for comparison. The cardiopulmonary trained physical therapists did perform peak expiratory flow measures to further track expiratory strength if a weak cough or poor airway clearance was identified for specific patients, though the details of these assessments were not consistently reported in the medical charts. There were some patients with voice impairments identified within the MASA under the "voice" item that could qualify as dysphonia, but this specific impairment was not specifically measured with an independent voice instrument. Additionally, a speech therapist may have provided a description of voice quality related to phonation simply based on auditory assessment, but no formal instrument was used and the details of these assessments were not reported consistently. Further evidence of dysphonia from vocal cord paresis or weakness could be directly observed during a fiberoptic endoscopic evaluation of swallowing test but was not specifically noted in medical documentation nor analyzed separately.

Future studies

This new population of patients who underwent BOLT due to severe COVID-19 lung disease provides an opportunity for numerous potential areas of future study. Long-term functional outcomes are not known and could be an area of future study, especially in the context of postacute COVID-19 syndrome.[52] Quality of life is a well-known challenge for patients with chronic lung disease that has been shown to improve after lung transplant[8,10] and could serve as an notable measure for future studies. Nutritional deficiencies are known issues for both patients with chronic lung disease status post BOLT and COVID, and pretransplant weight and nutritional status of patients with end-stage lung disease may affect postoperative outcomes.[8,12,53] Other areas of study include evaluation of psychiatric or psychological manifestations associated with acute illness and prolonged time periods of intubation and immobility in the ICU. Measures of dysphonia and respiratory function testing, such as diaphragm ultrasound and/or direct visualization of vocal folds with fiberoptic evaluation, could provide additional insight into these impairments in future studies. Inclusion of control groups of patients recovering from COVID-19 who did not undergo lung transplant and/or patients who underwent BOLT for other reasons in future studies would serve to further improve the breadth of knowledge in this field.

CONCLUSION

This is the largest study to date to examine the IPR course of individuals with a dual diagnosis of severe COVID-19 pulmonary disease that required BOLT. This retrospective review demonstrates significant functional improvements across mobility, self-care, and dysphagia domains among patients who participated in an inpatient rehabilitation program.

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DISCLOSURE

None.

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