Case Report

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The importance of pulmonary rehabilitation in lung transplantation

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Abstract:

Lung transplantation is now the standard of care for nonreversible end-stage lung disease and leads to dramatic improvements in pulmonary function, quality of life, and survival. Pretransplant pulmonary rehabilitation (PR) can optimize potential recipients and widen or open a "transplant window" period. Given the potential for long wait times in our country, ongoing PR is crucial to ensure recipient fitness. Postoperative rehabilitation is an integral part of care of the recipient and may extend beyond hospital discharge. We present the case of a 42-year-old female who underwent bilateral lung transplantation for advanced interstitial lung disease and discuss the challenges and our approach to PR in this setting.

Keywords:

Interstitial lung disease, lung transplantation, pulmonary rehabilitation

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Introduction

Lung transplantation is now the standard of care for nonreversible end-stage lung disease and leads to dramatic improvements in pulmonary function, quality of life, and survival. Worldwide, more than 4000 lung transplants are performed annually.[1] The outcome of lung transplantation depends upon the underlying disease, recipient selection, donor factors, surgical approach, and center volume. Center volume affects outcome by affecting surgical approaches, optimum immunosuppressant, and effective use of pulmonary rehabilitation (PR). Pretransplant PR can optimize potential recipients and widen or open a "transplant window" period. Given the potential for long wait times in our country, ongoing PR is crucial to ensure recipient fitness. Postoperative rehabilitation is an integral part of care of the recipient and may extend beyond hospital discharge. While much has been published about the other aspects affecting transplantation outcome, very little emphasis has been placed on PR in this setting. We present a patient who underwent bilateral lung transplantation for advanced interstitial lung disease and discuss the challenges and our approach to PR in this setting.

Case Report

A 42-year-old female with chronic respiratory failure related to interstitial lung disease associated with autoimmune features on long-term oxygen therapy was referred for lung transplantation during an acute exacerbation. Transplant assessment

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was deferred, and the acute exacerbation [Figure 1] was managed with high-flow nasal oxygen and steroids. When she improved and oxygen requirements stabilized, the core team members, including the pulmonologist, transplant surgeon, anesthetist, PR therapist, dietician, and psychiatrist completed a multidisciplinary meeting and decided to initiate her listing. She was listed in the hospital and state registry for lung transplantation on completion of her assessment with the infectious disease specialist, nephrologists, cardiologist, dentist, and other ancillary specialists. She was started on regular PR program after obtaining informed consent to maintain and improve exercise tolerance, lung mechanics, and peripheral and respiratory muscle function, with an aim of reducing the risk of perioperative complications. Prerehabilitation assessment was undertaken by a dedicated PR therapist (First author), and it included a 6-min walk test[2] performed according to the American Thoracic Society guidelines with 5 L/min of oxygen support [Table 1]. The protocol initiated and continued up to the day of lung transplantation is summarized in Table 2.

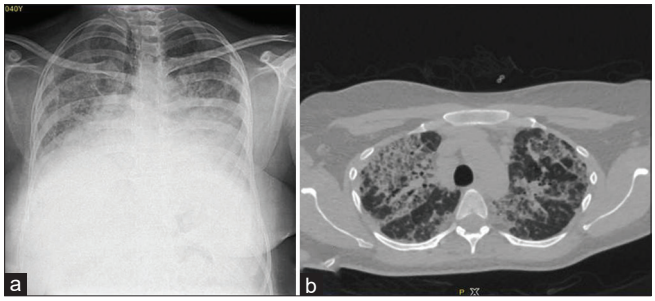

Figure 1: (a) Preoperative chest radiograph. (b) Preoperative high-resolution computed tomography scan

She received bilateral lung transplants at 1 year of listing. Transplantation was performed sequentially under cardiopulmonary bypass through a clamshell incision; the donor was a 14-year-old with brain death due to status epilepticus. The postoperative period was uneventful without the need for extracorporeal membranous oxygenation or nitric oxide. Steroids, cyclosporine, mycophenolate (mofoetil), and analgesia were initiated and titrated according to protocol.

Phase I PR was initiated 24 h postsurgery; the treatments administered initially were positioning, airway clearance and bronchial hygiene, chest wall mobility exercises, and limb exercises. On the 5th postoperative day, her respiratory function, cough, hemodynamics, and neurological status were deemed adequate, and a spontaneous breathing trial (SBT) with pressure support (PS) of 8 cm H_2O was performed for 30 min. She failed SBT, and a decision on slow PS decrements was taken. Chest X-ray was taken and assessed for airway clearance [Figure 2]. She was continued on PS mode with chair mobilization for 15–30 min twice daily. Active upper limb exercises were initiated with ergo meter. Lower limb strengthening exercises were performed with weight cuffs and thera band tubes. Endurance training was given with portable mini-leg cycle. While intubated and with intensivist oversight and adequate endotracheal tube protection, she was mobilized to standing position and marching exercises were performed. Commode privileges were instituted. She could be extubated to 3 L/min of oxygen and shifted to room by day 10 with the above protocol. Her subsequent hospital course was uneventful, and she was discharged at 30 days posttransplantation on stable immunosuppressant with a plan for the second phase of PR lasting for 3 months.

Table 1: Outcome measures

Outcome measures	Initial assessment pretransplant status	Status of posttransplant (%)				
		2nd week	4th week	12th week	6th month	1 year
6MWD (m)	120 (22.23)*	285 (53.55%)*	342 (64.57%)*	410 (78.76%)*	430 (83.42%)	445 (86.63%)
SpO_2% desaturation	−13 (98-85) (5 L/min O_2)	−9 (96-87) (room air)	−9 (96-87) (room air)	−9 (98-89) (room air)	−6 (98-92) (room air)	−9 (98-89) (room air)
Δ Heart rate, beats (beats/min)	25 (120-154)	11 (111-122)	21 (97-118)	24 (99-123)	44 (96-140)	48 (94-142)
Modified Borg scale	7/10	5/10	4/10	3/10	3/10	3/10
FIM scale (self-care domain)	23/42 (54) (moderate assistance)	33/42 (78.5%) (minimal assistance)	37/42 (88%) (supervision)	42/42 (completely independent)	42/42 (completely independent)	42/42 (completely independent)
PAI	18 (sedentary)	48 (fair, acceptable)	64 (very good, active and healthy)	80 (very good, active and healthy)	80 (very active lifestyle)	100 (very active life style)
PFT						
FVC	0.66 (L), 24	0.85 (L), 28%	0.91 (L), 31%	1.00 (L), 34%	1.35 (L), 44%	1.45 (L), 48%
FEV1	0.61 (L), 29	0.8 (L), 31%	0.88 (L), 35%	0.91 (L), 35%	1.00 (L), 47%	1.34 (L), 51%
FEV1/FVC (%)	91.27	94.6%	97%	90.9%	115%	114%
PEFR	2.34 (L) 45	4.28 (L), 68%	4.25 (L), 65%	4.69 (L), 75%	5.30 (L), 84%	6.07 (L), 96%

*Prediction value: Ramanathan *et al*.[2] (2014). 6MWD: 6 min walk distance, FIM score: Functional independence measure score, PAI: Physical activity index, PFT: Pulmonary function testing, FVC: Forced-vital capacity, FEV1: Forced expiratory volume in 1 s, PEFR: Peak expiratory flow rate

Table 2: Protocol of pulmonary rehabilitation programme (pretransplant)

Component	Description
Protocol of pulmonary rehabilitation programme	
Frequency of PRP	3-5 days/weekly (rehabilitation centre as a inpatient)
	for 1 year (waiting period) up to transplantation (213 visits)
Intensity of exercise program	
Flexibility training	10-15 times of each targeted muscle
Endurance training	60%-85% of age predicted maximal heart rate or 4-6 score of modified Borg's scale
Strength training	10 repetitions per set for 2 sets of each targeted muscles (weight selected based on 10 repetition maximum)
Breathing exercises	10-15 times of pursed lib breathing, 10-15 times of diaphragmatic and thoracic expansion exercise with manual resistance, along with active airway clearance techniques given on need
Time	Initially started with 45 min per session according to patient's tolerance to all the exercise program enlisted above then it is progressed up to 2 h per session finally. The duration of exercise includes with warm up and cool down period
Type or mode of exercise	
Flexibility training	Stretching exercises to neck, shoulder, trapezius, biceps, triceps, back muscles, quadriceps, hamstring, gluteus, and calf muscles
Endurance training	Upper limb: Arm ergo meter training (10-25 min, with intensity mentioned above)
	Lower limb: Treadmill walking (10-25 min, according to patients walking speed or with 6 MWT distance or intensity reached above mentioned)
Strength training	Target muscles trained with dumbbells, medicine balls, weight cuffs and thera bands
	Upper limb: Biceps, triceps, deltoid, pectorals, trapezius. Lower limb: quadriceps, hamstrings, gluteus muscles, calf and Dorsi flexors)
Breathing exercises	Diaphragm and intercostals with weights and therabands and incentive spirometry
Oxygen titration	At rest 4-5 l/min, during rehab activities titrated up to 6-8 lit/min (nasal prongs and facemask) to maintain SpO_2 above 85%-90%
Patient education	Familiarization with the surgical procedure, preparation for the perioperative period, secretion management, controlled coughing techniques, incentive spirometry, chest tubes, wound and pain management, importance of early mobilization, disease-specific educational topics, anatomic and physiologic basis of symptoms, importance and proper use of supplemental oxygen therapy, management of daily activities: pacing, energy conservation and when to stop exercise

PRP: Platelet-rich plasma, 6 MWT: 6-min walk test

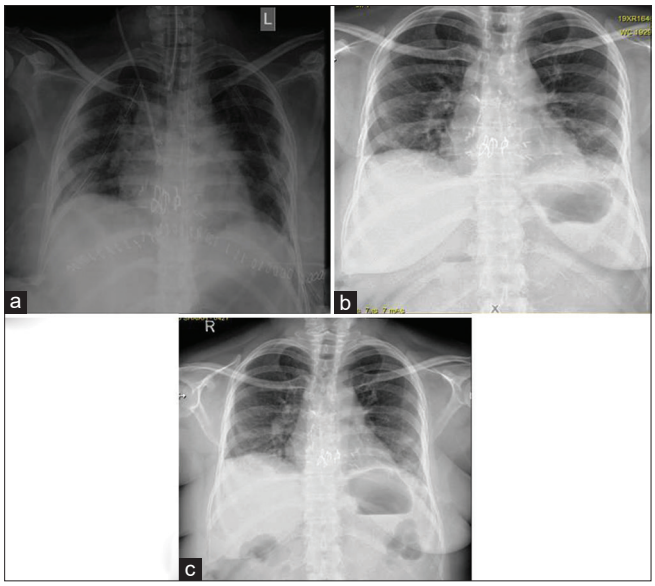

Figure 2: (a) Chest radiograph on the first postoperative (b) Chest radiograph one month after transplantation. (c) Chest radiograph three months after transplantation

The protocol of our Phase II Rehabilitation program is shown in Table 3. The program was initiated thrice weekly for 3 months with a home-based exercise program; regular walking, breathing exercises, resistance exercises with water bottles, and sand bags was also encouraged. Serial outcome measures at the 2nd week, 4th week, 12 week, 6 month, and 1 year are summarized in Table 1. The results show an appreciable increase in clinical variables, functional walk capacity[2] (from 53.5% to 86.63% predicted), and functional independence measure score changes from moderate assistance to completely independence in self-care activities. Physical activity index also changed from "sedentary" to "active healthy."

Discussion

Postoperative rehabilitation is an integral part of care of the posttransplant recipient. It begins when the patient medically stable (Phase-I; acute phase), Phase-II (early outpatient/intensive monitoring phase) begins days after discharge from hospital and lasts up to 6–12 weeks according to the patient's need and followed by Phase-III and Phase-IV can be initiated after the completion of Phase-II.

In our case report, we expressed our PR program with appreciable outcome measures after double-lung transplantation, at present, the patient not having any

Table 3: Protocol of pulmonary rehabilitation programme (posttransplant)

Component	Description
Phase I: Started 24 h after lung transplantation when hemo dynamically stable	
Goals in the ICU	Optimizing lung expansion and secretion clearance
	Breathing pattern retraining, to maintain upper and lower extremity ROM, strength and basic bed mobility and transfers
Exercise program in acute hospitalization phase	
Airway clearance	Gentle chest percussion, vibration and shaking maneuvers, suctioning on need basis, along with manual hyperventilation
Breathing retraining	Synchronizing the breathing with abdomino thoracic movement with ventilator, 15-20 repetition/3-4 times/day
DVT prophylaxis and ROM	Pneumatic compression device applied during night and sleep time, active ankle pump exercise, calf stretching, squeezing, and other ROM exercises when the patient awakes, 15-20 repetition/3-4 times/day
Breathing exercises	After extubation from ventilator, 10-15 times of pursed lib breathing, 10-15 times of diaphragmatic and thoracic expansion exercise with manual resistance, and incentive spirometry
Early mobilization	Initially long sitting, bed side dangled sitting with caution about all tubes and drains 10-30 min/daily, chair sitting after drain removal done up to extubation from ventilator
Cardiopulmonaryendurance training	Leg cycling with mini pedal exerciser 10-20 min once/daily, standing march 10-15 times once/daily up to weaned from the ventilator. Same continued twice daily after weaning
Walking training	Initially 5-10 min with 2-4 L/min oxygen to maintain SpO_2 above 90%, then progressed up to 20 min, twice daily with 1-2 L/min oxygen support through nasal prongs
Phase II: Started after discharge: Up to 12 weeks (3-4 days/week) as out patient	
Flexibility training	Stretching exercises to neck, shoulder, trapezius, biceps, triceps, back muscles, quadriceps, hamstring, gluteus, and calf muscles
Endurance training	Treadmill walking (10-25 min, according to patients walking speed or with 6 MWT distance or intensity reached above mentioned) ground level walking encouraged 15-30 min upto the target distance of 750-1500 m at nearby home
	Leg cycle ergo meter: 10-20 min/thrice weekly. Borg's scale 4-6/10
Strength training	Target muscles trained with dumbbells, medicine balls, weight cuffs and thera bands (up to 12 weeks we avoided upper limb weight lifting)
	Upper limb: Biceps, triceps, deltoid, pectorals, trapezius. Lower limb: quadriceps, hamstrings, gluteus muscles, calf and dorsi flexors with 1-3 kg/10 rep/2 sets/alternate days
Breathing retraining exercises	Breathing control through pursed lib breathing trained with 15-20 rep/2 h once, followed by Diaphragmatic breathing exercise and localized thoracic expansion exercise with 15-20 rep/2 h once, trained breathing exercise in sitting, semi fowler's position and side lying and supine gradually, incentive spirometry encouraged to do regularly

Precautions and advices during rehabilitation: Incisional: Perform bilateral arm movement rather than unilateral arm movement for 6 weeks, avoid driving for 6 weeks, unless physician permission, Upper extremity lifting should be <5-10 lbs, avoid arm ergometry for 6 weeks, avoid significant trunk twisting for 6 weeks. Other considerations: Should start when the patient is medically stable, avoid trendelenburg position during chest physiotherapy, transplanted lung is denervated - direct and assisted cough is needed. 6 MWT: 6-min walk test, DVT: Deep-vein thrombosis

oxygen and Bi-level positive airway pressure support. Here, we presented appreciable outcomes after the Phase-II rehabilitation programs, if it can be continued up to Phase III and Phase IV and regular care, the patient's survival and quality of life will be better. In our knowledge, there is no study related to PR program for lung transplantation in India. We hope that researchers can initiate research toward PR program and outcomes with lung transplantation patient's, morbidity, mortality, increasing the survival years after transplant. This study may guide some information to the rehabilitation professional who involving in organ transplantation.

In India, there are no large studies with outcomes after lung transplantation.[3,4] Prasad *et al*. 2019 reported that "there is an urgent need to initiate a lung transplant registry where all the lung transplant cases and their outcomes should be maintained to identify problems unique to our geographic locale," likewise PR program for lung transplant patients and outcomes also be wanted to document.[5] Three cohort studies demonstrated positive effects of exercise training on muscle function and exercise capacity in the long-term posttransplant phase.[6-8] This study also found similar good outcomes in the patient with lung transplantation.

Conclusion

In our case report, we have taken objective measurements as an outcome which is easier to practice rather than the disease-specific quality of life outcome measures and also able to replicate the outcomes after a year and regular follow-up. Each and every case will differ from treatment program and outcomes, so the researchers and practitioners should go according with patients and current practice guidelines. The team involvement is very essential in the every part of rehabilitation program and patient's education. This may help other researchers

to conduct study with large number of patients and outcomes after transplantation.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the legal guardian has given his consent for images and other clinical information to be reported in the journal. The guardian understands that names and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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