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Outcomes of an Inpatient Rehabilitation Program Following Complicated Cardio-Pulmonary Transplantation

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Abstract

The Authors describe the first 118 admissions of inpatient multidisciplinary rehabilitation following heart and/or lung transplantation for 86 patients. Over 20% of all transplantation case at St. vincents Hospital in Sydney required inpatient multidisciplinary rehabilitation. The inpatient program is uniquely designed to provide multidisciplinary rehabilitation to a population who require intense medical and surgical monitoring for rejection and side effects of anti rejection drugs. This is done with close cooperation with the transplant surgical and medical teams. Outcomes including FIM change, FIM efficiency, discharge destination, mortality, interruption to therapy and length of stay are presented together with physical therapy outcome measures such as the 6 minute walk test.

Complexities in managing these patients are described, such as the up skilling of nursing staff to manage cardiac and respiratory assistive devices, the management of chronotopic incompetence of the denervated heart and the psychological sequelae of transplantation are discussed. To our knowledge this is the first Australian and international descriptive study of inpatient multidisciplinary rehabilitation for heart and lung transplantation.

Keywords: Heart transplant; Lung transplant; Multidisciplinary rehabilitation; Inpatient rehabilitation; Activity limitation; Rehabilitation outcomes

Introduction

Heart and lung transplantation is now a realistic management option for patients with end stage cardiac or pulmonary disease, with more than 7000 new transplant procedures reported annually worldwide [1,2]. The past four decades has seen steady improvements in survival due to advances in organ salvage, surgical technique, immunosuppression, and management of complications. The median survival is now more than 10 years following heart transplant and more than 5 years following lung transplant, and more than one third of heart recipients now survive more than 20 years [3]. This improved survival has led to a shift in scientific interest to now include physical function and quality of life [4-9]. Physical therapy is now an integral part of the management [10,11].

Heart and lung transplantation is performed for end stage disease. Prior to transplant the patient is generally deconditioned due to the effects of end stage cardiac or respiratory failure. The combined effects of the surgery, anti-rejection medication, and post operative complications can contribute to activity limitation. Anti-rejection medication regimes predispose to infection and immunosupression. Other medication side effects include myopathy, tremor, osteoporosis, and fat gain. These factors all contribute to reduced aerobic capacity, peripheral neuropathy and proximal muscle weakness [12-14].

The roles of structured exercise programs following uncomplicated transplantation have been well established [15-17]. However, less data is available regarding the role of multidisciplinary inpatient rehabilitation for those patients with complications and significant functional impairment. A German study showed no significant benefit between a day only inpatient program and an outpatient program of "exercise only" rehabilitation for lung transplant patients when considering quality of life and exercise capacity at one year [18]. However, a systematic review of exercise training following lung transplantation indicated that more research is required and high quality studies have been lacking [19]. This is echoed in heart transplant literature by a Cochrane review of exercise only based rehabilitation following cardiac transplantation [20]. Multidisciplinary inpatient rehabilitation comprises of an exercise based program as well as medical, functional, psychological, nursing, social work and nutritional therapy interventions which can be easily distinguished from "exercise only" rehabilitation. "Exercise only" rehabilitation, referred to in the medical literature signifies that only the physical therapy component of rehabilitation is offered to patients, in other words physical therapy alone.

The aim of this paper is to describe the processes and outcomes of multidisciplinary inpatient rehabilitation following complicated heart and lung transplantation, and to outline critical aspects of an inpatient rehabilitation program which can lead to functional improvement. We aim to describe activity limitation (as defined by the International Classification of Functioning, Disability and Health) [21] and functional improvement as measured by the Functional Independence Measure.

Materials and methods

The Sacred Heart Rehabilitation Unit provides multidisciplinary rehabilitation services for St. Vincent's Hospital in Sydney. The St. Vincent's Hospital heart lung transplant unit is the largest and longest running program in Australia [18]. Data are collected by the Transplant team prior to surgery for the purposes of tracking patients' cardiac or pulmonary status for suitability to obtain a transplant. Patients can be contacted any time by the transplant coordinator and called to come into the hospital to be prepared for surgery, within 90-120 minutes. This data have been regularly provided to the Australian and New Zealand Cardiothoracic Organ Transplantation Registry (ANZCOTR) since 1984 [22].

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The rehabilitation team assesses patients in the acute transplant ward on request from the transplant team, this usually occurs when the patient's surgical and medical condition remains stable for several days but the patient is having difficulty mobilizing and/or requires nursing assistance for personal activities of daily living (ADL). The rehabilitation consultation team accepts patients for rehabilitation according to clinical need. Most patients require reconditioning as they have been immobile for a prolonged period and many are severely deconditioned prior to surgery. Other patients may have suffered neurological complications including stroke, neuropathy of critical illness or hypoxic brain damage [23-25]. The exclusion criteria for admission to rehabilitation are active infection or acute rejection usually associated with organ failure or inadequate blood levels of anti-rejection medications.

Once the patient is accepted for rehabilitation they move from a monitored bed on the acute cardiorespiratory ward to an unmonitored bed on the rehabilitation ward which is in a neighboring building within the hospital grounds. The patient is managed by the rehabilitation team with the transplant team consulting on a second or third daily basis. The patient is usually sent for heart or lung biopsy on a second weekly or monthly basis to assess rejection status which involves the patient going to a procedure room for an angiogram or bronchoscopy. The transplant team are available for urgent consultation should the need arise and the rehabilitation medical team assesses daily blood levels of immunosuppressant medication and all other haematological and biochemical parameters. . The rehabilitation team design an inpatient program for transplant patients which includes functional retraining, muscle strengthening, psychological support, nutritional review and cardiopulmonary reconditioning. The program is individualized depending on degree of deconditioning, neurological impairment and stability of co morbidities. In general the goal is to build up muscle strength and cardiovascular reserveso that the patient cantolerate upto 30 minutes of cycle ergometer training per day [16]. Nursing staff have been trained to manage battery changes of cardiopulmonary Assistive Devices and to care for patients with severe cardiorespiratory impairment. This includes the use of pulse oxymetry during dressing toileting and transferring, the recording or respiratory rate and sputum production and the counseling of family members. Dietetics were upskilled to manage nutritional requirements of many patients who often suffered from cardiac cachexia, drug induced nausea and vitamin deficiencies associated with some anti-rejection drugs. Occupational therapists focused on energy conservation techniques and ADL training while psychologists focused on adjustment disorder, anxiety management and any depression that may have been present. The rehabilitation program is designed during the first of the weekly case conferences attended by the whole team and is based on a number of assessment measures including the Berg Balance Score, the 6 minute walk test, the Depression Anxiety and Stress Scale, the Functional Independence Measure (FIM), the Borg Scale, The Timed Up and Go test, pulse oxymetry readings on and off oxygen, a social work interview and nursing assessments of skin condition and continence. Patients are given therapy timetables and a family conference is undertaken when the patient approaches discharge. Patients are deemed to have an interruption in therapy when their physical condition has been judged by the treating doctors to prevent capacity for any exercise or when the patient requires transferring back to the acute cardiorespiratory ward or intensive care for monitoring, unstable neurological observation or vital signs, unresponsiveness to standard medical treatments for infections or rejection or when urgent surgery is required.

The primary outcome measures of this descriptive study of the impact of an inpatient rehabilitation program for heart and/or lung transplantation patients are the Functional Independence Measure, length of stay and discharge destination. FIM efficiency has been used to define the efficiency of the program.

A retrospective audit of data was performed for first 118 admissions of heart and/or-lung transplant patients to the Sacred Heart Rehabilitation Unit between January 2002 and June 2009.

The files were audited for demographic details, Functional Independence Measure data [19,20], length of stay, program interruption, and medical complications. The independent t-test was applied for comparison of the mean FIM item scores, and $p < 0.05$ was considered significant.

Results

St. Vincent's Hospital, Sydney performs more heart and lung transplant than any other transplant hospital in Australia with 843 transplantations performed from 1984-2012 compared to 2298 for Australia and New Zealand in the same time period [26]. At St. Vincent's Hospital between 1 January 2002 and 30 June 2009 a total of 156 heart transplants were competed and a total of 258 lung transplants were completed. Average waiting times, sex distribution and average ages are presented in Tables. Of interest 75% of those awaiting heart transplantation were living e with moderate to severe dyspnea on exertion or at rest (NYHA grades 3 – 4) while the average number of meters walked in 6 minutes by those awaiting lung transplant was 311 metres (0.86m/s) [27-32].

A total of 86 post operative transplant patients were admitted for inpatient rehabilitation over 118 separate admissions. This represents 20.77% of all patients admitted for transplantation surgery to St. Vincent's Hospital. These 86 patients included 31 heart, 37 bilateral lung, 13 single lung and 5 combined heart/lung transplants. The mean age was 52. In each case the patient had suffered medical complications resulting in a prolonged acute hospital stay. The primary medical complications leading to need for rehabilitation are summarized in tables 1 and 2.

Interruptions to the rehabilitation programs due to medical complications occurred for 47 patient admissions (40% of admissions). The patients were transferred back to the acute ward on each occasion. The reasons for interruption to rehabilitation are summarized in table 3. Often rejection is diagnosed based on the histopathological features of a heart or lung biopsy rather than on clinical findings and patients will be transferred to the acute hospital for further monitoring as a precautionary measure.

Overall mean admission Functional Independence Measure (AFIM) was 92, and the mean discharge Functional Independence

Deconditioning post transplant	28
Pneumonia	25
Orthopaedic / injury	4
Rejection	4
Stroke	3
Pleural effusion	2
Lobectomy	1
Myocardial infarction	1
Overdose	1
Stevens Johnson syndrome	1
Diarrhoea	1

Table 1: Triggers for rehabilitation admission of Lung Transplant patients (n = 71).

Measure (DFIM) was 102. The mean length of stay was 21.1 days. The mean itemized AFIM and DFIM scores are summarized in table 4. For admissions not resulting in interruption to rehabilitation, the mean AFIM was 96 and the discharge FIM was 116, with a mean length of stay of 24 days. The mean FIM change was 0.8 per day. Functional improvement was noted in the areas of bathing, lower body dressing, bed/chair transfer, toilet transfer, tub transfer, walking, and stair climbing.

All transplant patients on admission are fully assessed by physiotherapy staff (Physical Therapists) including- functional assessments, manual muscle testing, respiratory assessment (Rated Perceived Exertion Scale and BORG scales), 6 minute walk test , 10m walk, Timed up and go test (TUAG) and a Berg Balance Score is measured. During initial assessments these patients commonly have significant problems with: muscle weakness compounded by steroid induced myopathy, decreased balance (average admission Berg Balance score = 15.3/56), poor cardio vascular fitness (average admission 6 minute walk test 67.7m of those able to walk for 6 minutes) and altered patterns of breathing.

A convenience sample of patients demonstrates what is generally found on physiotherapy outcome measures on admission and discharge and is presented in tables 5-7.

Out of the 86 patients, 77 returned home and 9 died in hospital. One patient suffered sudden death on the rehabilitation ward (massive haemoptysis from broncho-arterial fistula). The other 8 patients died following transfer to the acute ward due to graft rejection (3), infection (2), cholecystitis (1), arrhythmia (1), and tracheal stenosis (1). No patients were discharged to institutional care.

Deconditioning post transplant	22
Stroke	4
Pneumonia	3
Amputation	1
Atrial flutter	1
Acute renal failure	1
Laminectomy	1
Rejection	1
Small bowel obstruction	1
Myocardial infarction	1
Psychosis	1
Hypercalcaemia	1
Demyelinating polyneuropathy	1
Orthopaedic	1

Table 2: Tiggers for rehabilitation admission of Heart transplant patients (n = 40).

Infection	23
Rejection	7
Pleural effusion	6
Arrhythmia	4
Acute renal failure	1
Small bowel obstruction	1
Myocardial infarction	1
Hypercalcemia	1
Cholecystitis	1
Stevens-Johnson syndrome	1
Sternum dehiscence	1
TOTAL	**47**

Table 3: Causes for Interruption of heart and lung transplant rehabilitation programs (118 admissions).

Discussion

Heart and lung transplantations are complex surgical and medical procedures that are performed in patients with end stage cardiopulmonary disease. Postoperatively, the general aim is to discharge the patient home from the acute surgical wards and to provide a structured ambulatory exercise program. However, this is not always possible for patients with significant premorbid disability or postoperative complications. Further a significant proportion (in some papers over 11%) of transplant patients will be associated with neurological [22] or musculoskeletal complications so that there is likely to be a need for multidisciplinary inpatient rehabilitation in a significant number of cases. In our cohort 20.77% of patients required admission for multidisciplinary rehabilitation.

Further, the patients in this sample had a mean admission FIM 92, (motor FIM of 59) which indicates a need for assistance with most activities of daily living such bathing, dressing, transferring from bed/chair to chair, walking and stair climbing. These activities are most affected by proximal muscle weakness, peripheral neuropathy and limited cardiorespiratory endurance which are commonly suffered by patients with deconditioning due to prolonged hospitalization and immobility.

Interruptions to rehabilitation are commonplace in our experience, occurring in 40% of admissions. Complications were more prevalent in the lung transplantation patients. The most common complications were infections (particularly pneumonia) [23,24] and graft rejection. Rehabilitation related complications such as falls, anxiety and fatigue did not cause interruptions to therapy. Close monitoring of medical status during rehabilitation is critical for this patient population. Immunosuppression requires close observations and active management, with timely use of antibiotics, antifungals and antiviral medications, monitoring of therapeutic blood levels of immunosuppressants, regular biopsies and imaging for graft rejection and regular blood and microbiological tests for infective complications.

The model of care for transplant rehabilitation pioneered in Australia at St. Vincent's Hospital, Sydney is based on seamless transfer of the patient from rehabilitation to acute medical wards and back when appropriate. This has been managed through close liaison between the transplant medical team and the /transplant rehabilitation team. Members of the rehabilitation team have required upskilling to become familiar with the nursing needs for these patients, emergency responses to subtle changes in medical condition and the patient's altered physiological responses to exercise and activity. As procedures are in place for rapid response and management of complications, together with efficient transition between rehabilitation and acute care wards, transplant patients can receive the benefit of intensive multidisciplinary rehabilitation without any decrement in their acute medical attention. This allows the transplant team to observe the manner in which the patient and his/her transplant function when put under the cardiorespiratory demands associated with community living. It also allows the patient to obtain intensive psychosocial and physical rehabilitation in preparation for community living independent of highly sophisticated medical service. For many patients discharge to the community represents, the first time in many months or years that they have not had to attend the hospital 2 – 3 times per week.

Further, a relationship is built up between the patient and the rehabilitation service so that outpatient services, readmission and ambulatory rehabilitation services can be offered with ease.

In spite of medical complications, functional gains were achievable

FIM item	Admission	*Mean (sd)*	Discharge	*Mean (sd)*	*P**	*95% CI*
Eating	6.12	(1.50)	6.38	(1.21)	0.0712	-0.55 to 0.02
Grooming	5.47	(1.56)	6.03	(1.53)	0.0002	-0.84 to -0.27
Bathing	4.57	(1.65)	5.36	(1.86)	0.0001	-1.11 to -0.49
Dressing upper	5.03	(1.83)	5.68	(1.85)	0.0004	-1.00 to -0.30
Dressing lower	4.30	(2.06)	5.29	(1.89)	0.0001	-1.38 to -0.60
Toileting	5.05	(1.84)	5.66	(1.86)	0.0007	-0.95 to -0.26
Bladder	5.88	(1.72)	6.00	(1.71)	0.4452	-0.43 to 0.19
Bowel	5.76	(1.68)	5.88	(1.59)	0.4595	-0.45 to 0.20
Transfer bed/chair	4.55	(2.05)	5.48	(1.88)	0.0001	-1.38 to -0.50
Transfer toilet	4.32	(2.01)	5.41	(1.87)	0.0001	-1.53 to -0.66
Transfer Tub	4.29	(2.05)	5.35	(1.92)	0.0001	-1.50 to -0.62
Walk	3.49	(2.23)	5.23	(2.00)	<0.0001	-2.23 to -1.24
Stair	1.53	(1.57)	4.38	(2.26)	<0.0001	-3.33 to -2.39
Comprehension	6.72	(0.86)	6.76	(0.69)	0.6081	-0.20 to 0.12
Expression	6.61	(0.95)	6.63	(0.84)	0.7745	-0.16 to 0.12
Social	6.68	(0.87)	6.65	(0.85)	0.7199	-0.14 to 0.20
Problem solving	6.41	(1.19)	6.40	(1.16)	0.9133	-0.17 to 0.19
Memory	6.60	(1.00)	6.66	(0.80)	0.3892	-0.20 to 0.08

Table 4: Functional Independence Measure of patients admitted for inpatient rehabilitation following heart or lung transplantation (n=118 admissions).

Pre-morbid
- Functional status, device use, Oxygen
- Home and family situation
- Comorbidities, renal function, vascular disease, core pulmonale

Complications of surgery
- Infection
- Rejection
- Prolonged intensive care stay – illness of critical care
- Hypoxic brain injury, stroke, renal function

Medication effects
- Osteoporosis and fractures
- Proximal myopathy
- Peripheral neuropathy
- Tremor
- Nausea
- Poor Wound healing
- Hypertension, renal impairment, blood glucose abnormalities
- Opportunistic infections

Psychosocial
- Depression, anxiety
- Dependence
- Cognitive impairment
- Motivation
- Kinesiophobia

Table 5: Factors to consider in selecting patients for heart and lung transplantation rehabilitation.

	Heart	**Lung**
St. Vincent's transplant numbers between 2004-2009	156	258
Average age in yrs	47.73	43.27
gender	44 female (28.2%)	121 female (46.9%)
Average days spend on waiting list	229.5	196.7
Premorbid use of 0xygen	N/A	157 (71.7%) *
Premorbid use of cardiac assistive device or inotropic meds	32 LVAD, balloon, bivent assist 5 inotropic meds (23.7% in total using assistive devices) #	N/A
Premorbid NYHA dyspnoea grade 3 and 4	118 (75.6%)	N/A
Premorbid 6min Walk test average numbers of metres	N/A	311.4m
Three Most common causes of transplantation	Idiopathic Dilated cardiomyopathy (47.4%), Ischaemic cardiomyopathy (26.9%), Miscellaneous heart conditions(18.5%)	Cystic fibrosis (25.6%), Emphysyma (12.7%), Alpha antitrypsin deficiency (8.5%)

39 subject's Oxygen use unknown*
LVAD= Left Ventricular Assistive Device; Bivent Assist = Biventricular Assistive Device; Ionotropic Meds = The Permanent Use of an Infusion of Dobutamine and Other Drugs an Order to Maintain Blood Pressure #

Table 6: Demographics and pre-transplant data on patients transplanted with either heart or lung transplants at St. Vincent's Hospital Sydney from January 2002 to June 2009.

Physiotherapy outcome	Average admission assessment score	Average discharge assessment score	% change
10metre walk	33.5 secs	15 secs	55.2% improvement or 19 secs faster
TUAG Timed Up and Go Test*	29.5 secs	13 secs	55.9% improvement or 16 secs faster
6 minute walk	67.7 m	193 m	185% improvement 125m increase
Berg Balance Score	15.3/56	35/56	128.7% improvement 22 point increase

Time taken to stand from a chair , walk three metres, turn around walk back and sit down *

Table 7: physiotherapy outcomes on 39 heart and/or lung transplantation patients in a convenience sample.

in this patient sample. Overall, a mean FIM gain of 0.8 points per day was achieved. This compares favorably with national data on stroke rehabilitation 0.7 point/day [21].

A specialized rehabilitation approach is mandatory for this group as compared with typical cardiothoracic surgical patients. Transplant patients are managed with sternal precautions for a prolonged 3 month period due to reduced bone healing rates secondary to anti rejection medications. Transplant patients are immuno-suppressed so consideration when exercising in open gym areas should be taken to minimize exposure to potential infections and nursing patients in private rooms is a priority. Following heart transplantation, the heart is denervated and relies on circulating catecholamines to change the heart rate in response to exercise. This "chronotropic incompetence" does not normalize for up to 1 year post heart transplantation [33]. In physiotherapy sessions, it is essential for patients to "warm up" and "cool down" for 5-10 minutes at the beginning and end of physiotherapy sessions with low intensity appropriate exercise to allow for heart rate responses to be monitored. Physiotherapy treatment focuses on increasing independence with functional tasks, improving muscle strength with graduated weight training, improving balance and cardiovascular fitness. A convenience sample of 32 of our most recent transplantation patients demonstrated that heart transplant patients have an average of 49 mins of individual physiotherapy per day with an additional 45 minutes of group physiotherapy exercises daily. Lung transplants have an average of 57 mins of individual physiotherapy a day with additional group therapy daily.

Significant improvements were noted in the physical FIM items, with no significant change in the areas of bowel/bladder or cognition. The most significant areas of functional gain were walking, stair climbing and transfer ability. These functional tasks are related to proximal muscle strength. Our findings suggest that a targeted strengthening and conditioning program can significantly improve physical function in this patient population, provided that the patient remains medically stable. This involves regular review of medication particularly steroid use so that the timing of high intensity strength training for proximal muscle strengthening can be optimal [28]. Further training of allied health staff need to take place so that familiarization with the delayed physiological responses to exercise and the impact of anti rejection drugs can take place. The psychologists and social workers need also to be familiar with the impacts on a patient and their families of a dramatic recovery from life threatening chronic disease instigated by a transplant. While nursing staff need to be familiar with immunosuppressant and complex cardiac medications as well as advanced assistive devices such as Left Ventricular Assistive Devices (LVAD), Bi Pap and C-Pap machines.

Patient selection and timing of rehabilitation appear to be critical factors in planning inpatient rehabilitation following transplantation. Medical stability is a most important factor with the patient needing to be afebrile, with a normal routine blood tests and stable radiology for a 48 hour period. Motivation needs to be assessed as well as the identification of achievable rehabilitation goals. Any depression must be treated, fear of movement addressed while cognitive impairments need mapping. The factors to consider when selecting patients for heart and/or lung transplantation rehabilitation are summarized in table 5.

The main limitations of this study are its small numbers and its descriptive quality. The patients in the sample had heterogeneity of medical comorbidities. However the overall purpose of this paper is to describe processes and outcomes of an inpatient multidisciplinary rehabilitation program heart and lung transplantation patients in terms of functional gains that can be achieved.

Conclusions

Cardiopulmonary transplantation is now mainstream therapy for end stage disease, and most patients will survive the initial phase of their treatment. However, the continued medical consequences following transplantation can result in disability. Our paper describes the significant functional gains achievable in this patient population following an inpatient multidisciplinary rehabilitation program. However, the success of the program is based on close liaison with the transplant team and the rehabilitation physician ability to promptly diagnose and manage medical and surgical complications as they arise. To our knowledge this is the first Australian or international paper to describe inpatient multidisciplinary rehabilitation and it's outcomes in a population of heart and lung transplantation patients.

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