



Pre and Post Operative Rehabilitation in Lung Transplantation

A la Woo,
Clinical assistant professor,
Division of Pulmonology, Department of Internal Medicine,
Severance Hospital,
Yonsei University College of Medicine

Severance

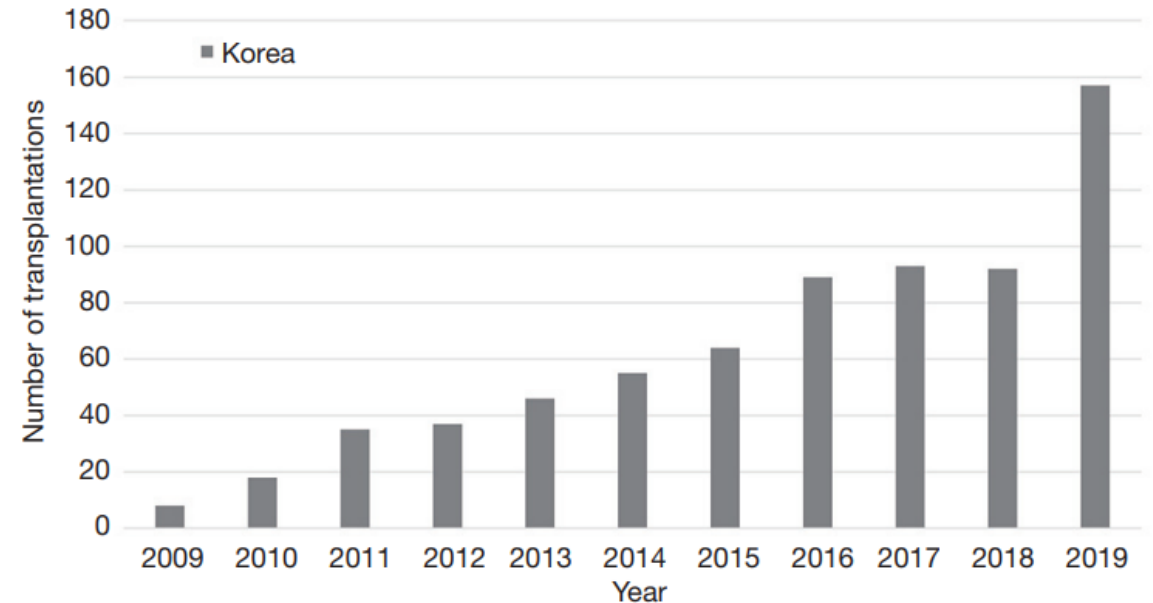
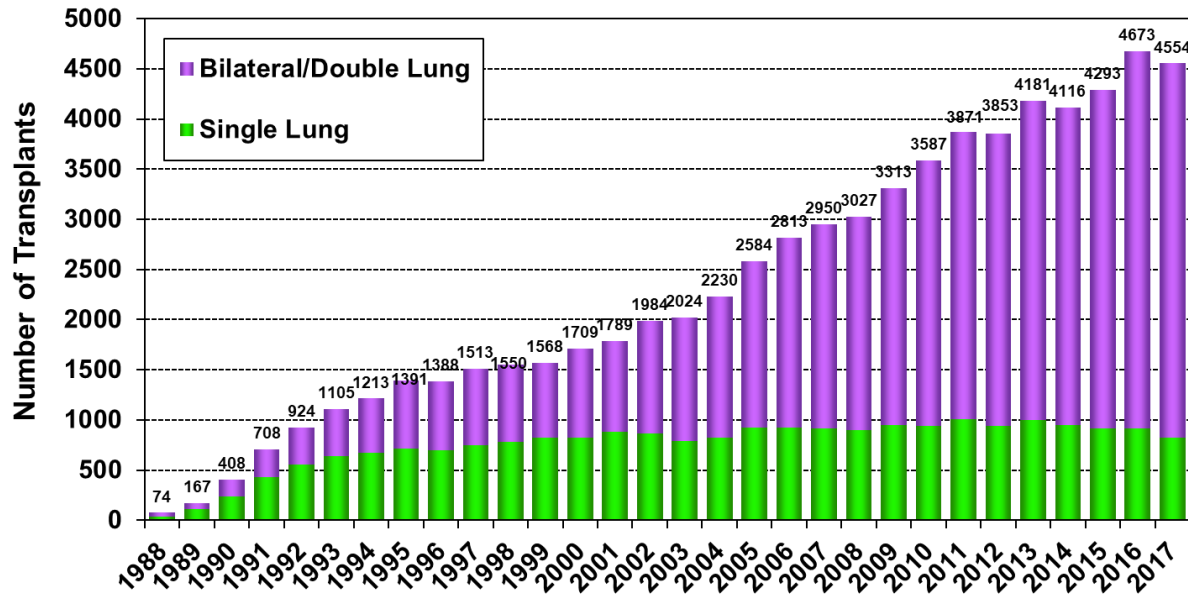


Contents

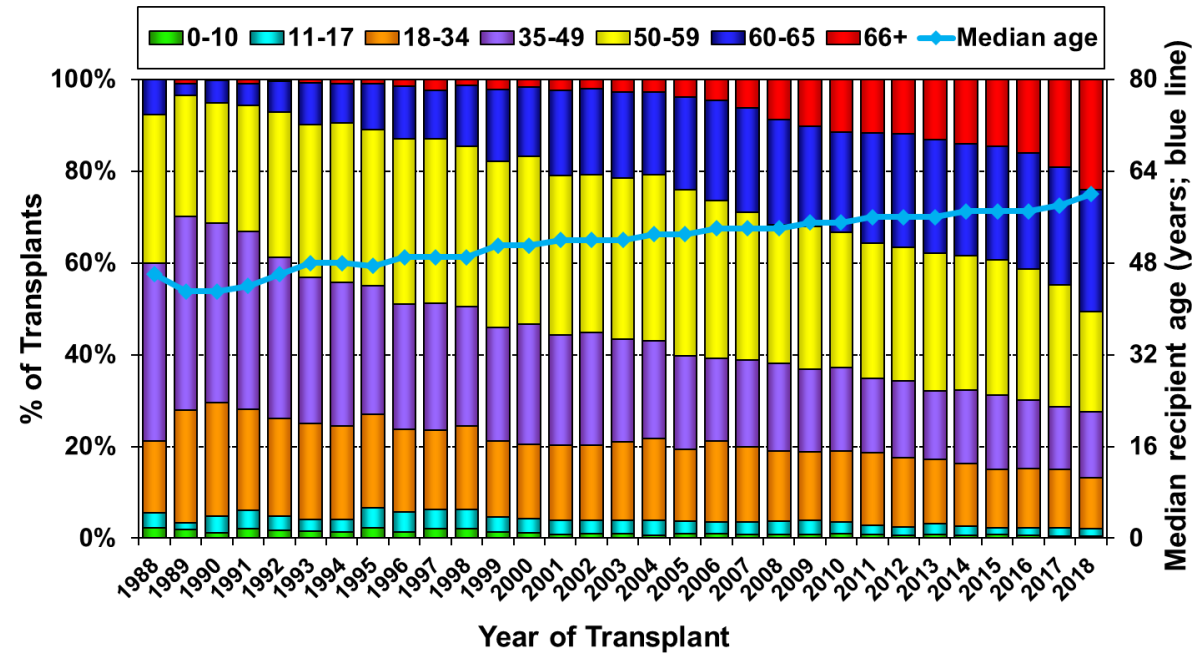
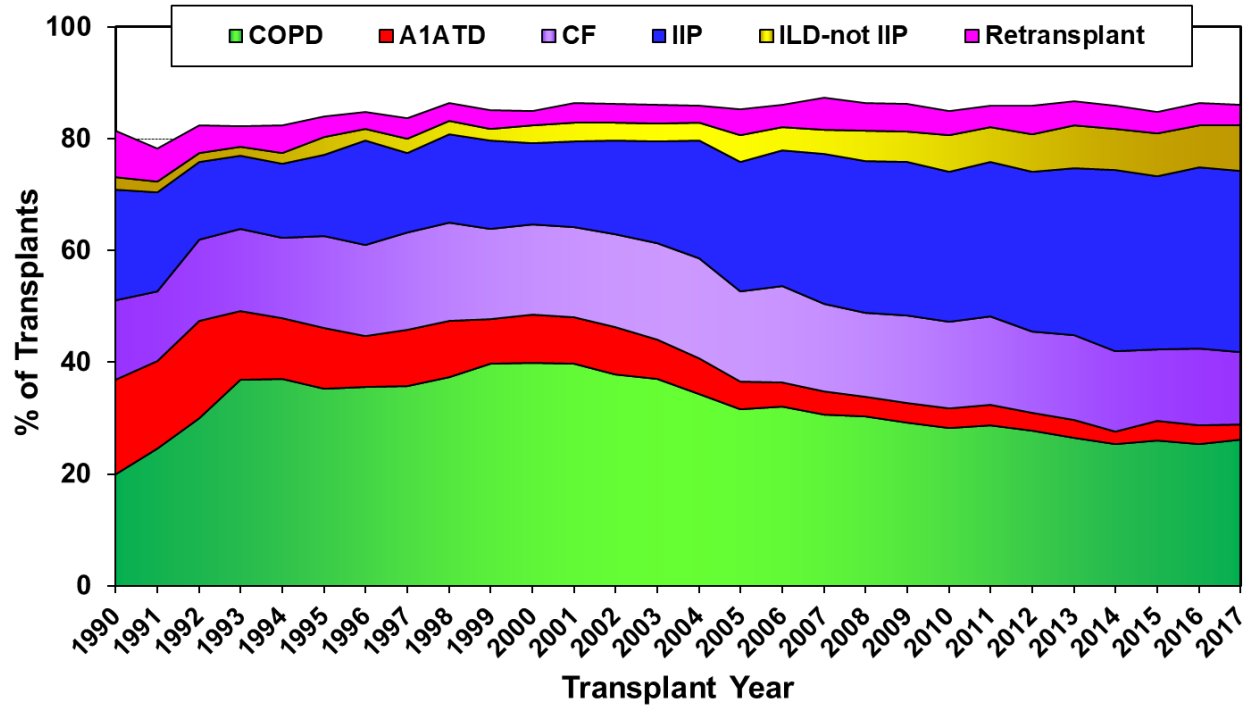
- **Current of lung transplantation**
- **Pulmonary rehabilitation in lung transplantation**
- **Future directions**

Current of lung transplantation

Current of lung transplantation: Increase in number

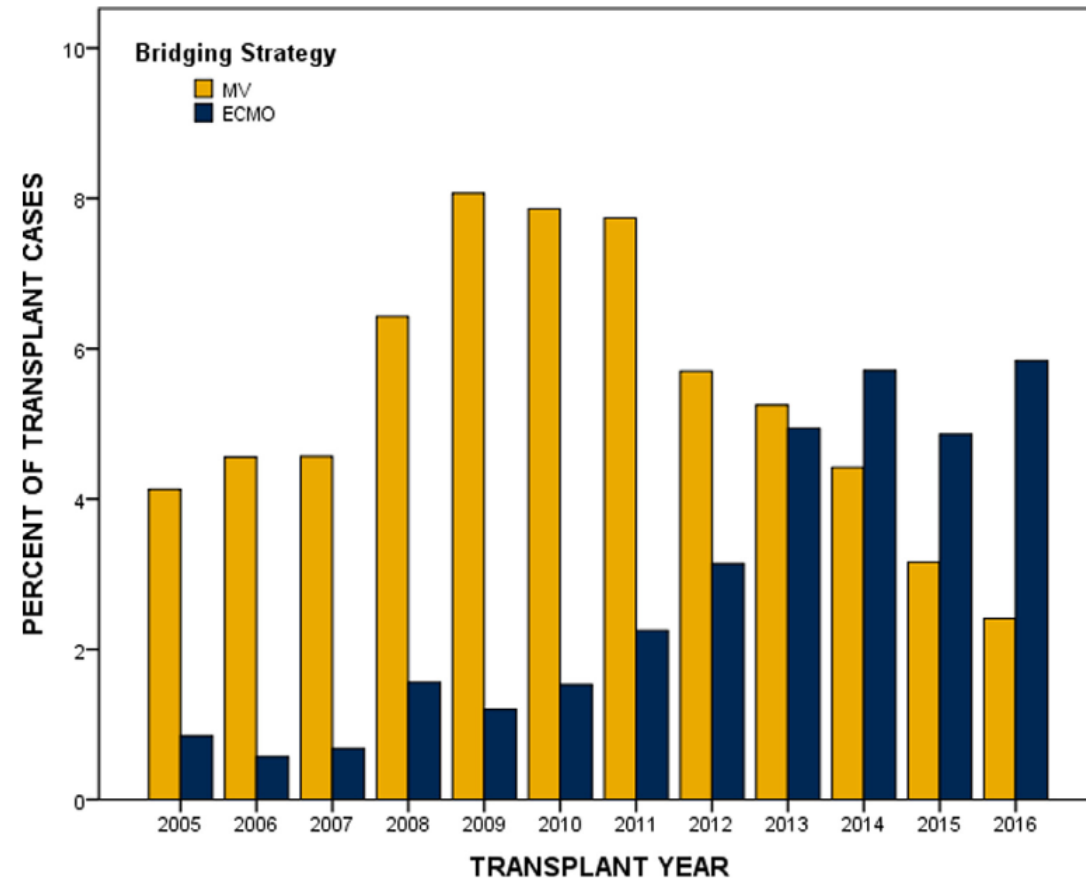


Current of lung transplantation: Recipient



Current of lung transplantation: ECMO bridge

- UNOS data, for 12 years LT patients
- Total, n=21,576
- No Bridge, n=19,783
- MV, n=1,129
- ECMO, n=664



Current of lung transplantation: Korea, Recipient

Age(years)

1-5	8 (1.5)
6-10	5 (1.0)
11-17	15 (2.8)
18-34	52 (9.7)
35-49	126 (23.5)
50-64	275 (51.2)
65-74	55 (10.2)
75+	1 (0.2)

Diagnosis

IPF	268 (49.9)
Post-transplant BO	34 (6.3)
Bronchiectasis	28 (5.2)
Primary pulmonary hypertension	18 (3.4)
Lymphangioleiomyomatosis	14 (2.6)
Emphysema	5 (1.0)
Eisenmenger syndrome	3 (0.6)
Asbestosis	3 (0.6)
Cystic fibrosis	2 (0.4)
Others	189 (35.2)

Current of lung transplantation: Korea

Korean LAS

Status 0	Patient is connected to a ventilator or ECMO
Status 1	One of the following: <ul style="list-style-type: none"> • NYHA stage IV patients with average pulmonary artery pressure >65 mmHg, NYHA stage IV patients with average right atrial pressure of >15 mmHg • NYHA stage IV patients with PaO₂ of <55 mmHg on room air • Cardiac index <2 L/min/m²
Status 2	One of the following: <ul style="list-style-type: none"> • Forced expiratory volume in 1 second <25% • PaO₂ <60 mmHg in room air • Average right atrial pressure: 10–15 mmHg • Average pulmonary artery pressure: 55–65 mmHg • Cardiac index: 2–2.5 L/min/m² • Previous LT • Previous lung volume reduction surgery • Lung cancer
Status 3	Patient requiring a LT with none of the above conditions

Status on transplantation

Status	
0	248 (46.2)
1	205 (38.2)
2	43 (8.0)
3	40 (7.4)
Others	1 (0.2)

Current of lung transplantation: Summary

- 절대적인 시행 건 수 증가
- 고령 이식 증가 추세
- 가교치료로의 ECMO 비율 증가
- **Korea**
 - 반 수 이상이 Idiopathic Pulmonary fibrosis, 50세 이상
 - 중증도를 우선하는 lung allocation
 - 많은 환자가 status 0 상태에서 이식을 받음

Risk factors for poor post-transplant outcomes

CONSENSUS STATEMENT

Consensus document for the selection of lung transplant candidates: An update from the International Society for Heart and Lung Transplantation

- **ABSOLUTE CONTRAINDICATIONS:**

13. Limited functional status (e.g. non-ambulatory) with poor potential for post-transplant rehabilitation

- **RISK FACTORS WITH HIGH OR SUBSTANTIALLY INCREASED RISK:**

9. Limited functional status with potential for post-transplant rehabilitation

- **RISK FACTORS**

15. Frailty

Pulmonary Rehabilitation in Lung transplantation: WHY?

Pre-operative rehabilitation: Why?

- Exercise capacity is predictor of mortality in patients awaiting transplantation

The Journal of Heart and Lung Transplantation 27, 729–734
American Journal of Respiratory and Critical Care Medicine 174, 659–664

- Pulmonary rehabilitation in lung transplantation candidates

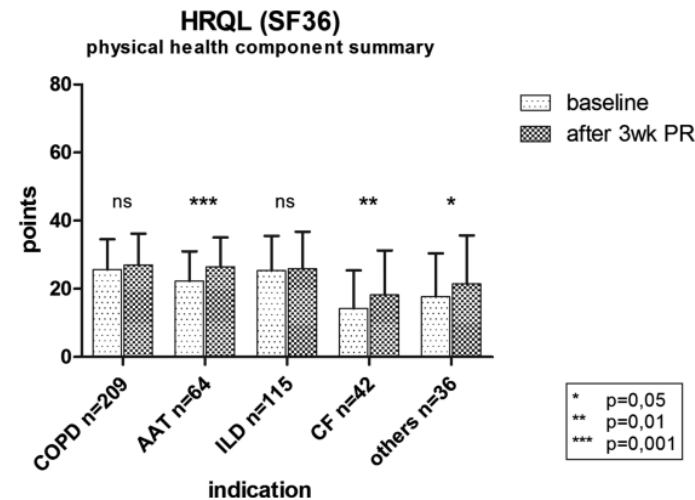
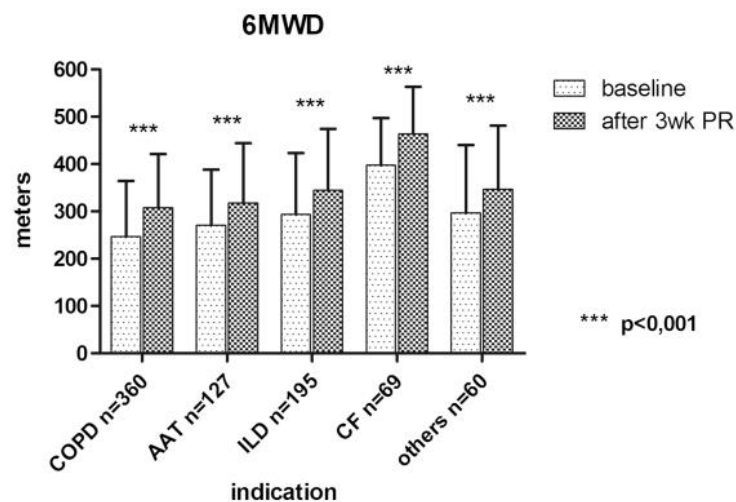
- Exercise capacity ↑

J Heart Lung Transplant 2013; 32: 626-632

J Heart Lung Transplant. 2012 Sep;31(9):934-41

- Quality of life ↑

J Bras Pneumol. 2013 May-Jun;39(3):349-56



Post-operative rehabilitation: Why?

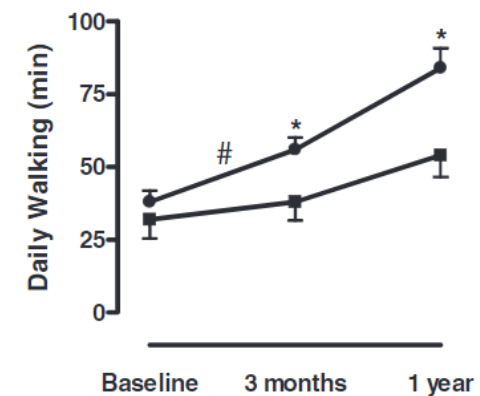
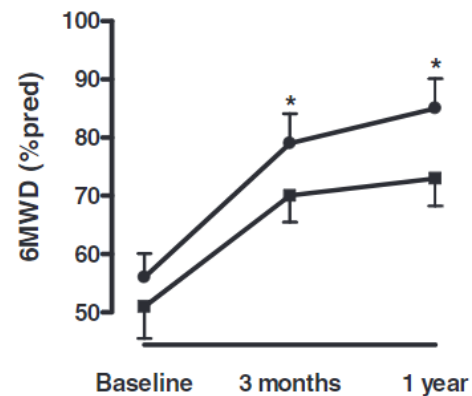
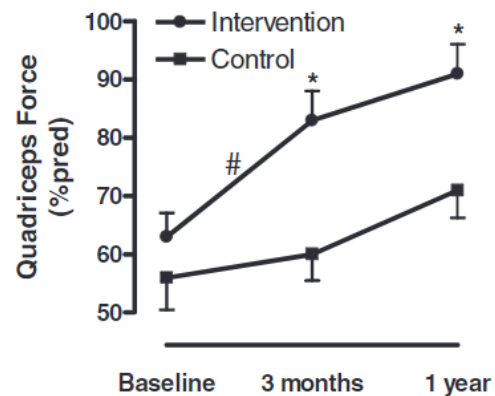
- Exercise tolerance ↑
- Quality of life ↑
- Independence, physical function ↑
- Pulmonary function ↑

- J Heart Lung Transplant 2011;30:912–9
 - Respiration. 2017;94(2):178-185

- J Cardiopulm Rehabil Prev. 2019 Jul;39(4):E7-E12
- Transplantation Proceedings 41, 292–295.. doi:10.1016/j.transproceed.2008.10.043

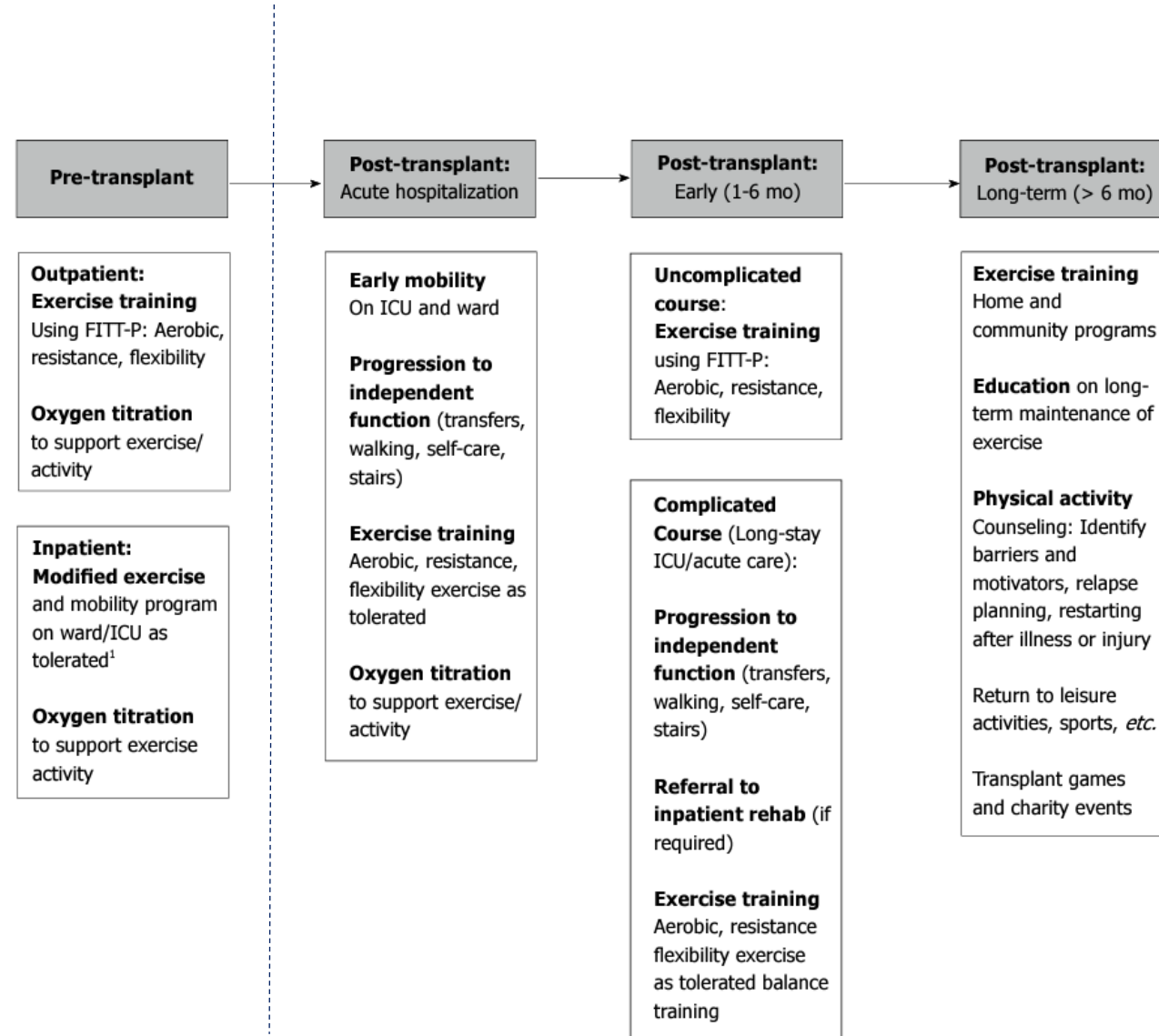
- PM&R 11, 849–857.. doi:10.1002/pmrj.12057

- Annals of Palliative Medicine 10, 3906–3915.. doi:10.21037/apm-20-1783



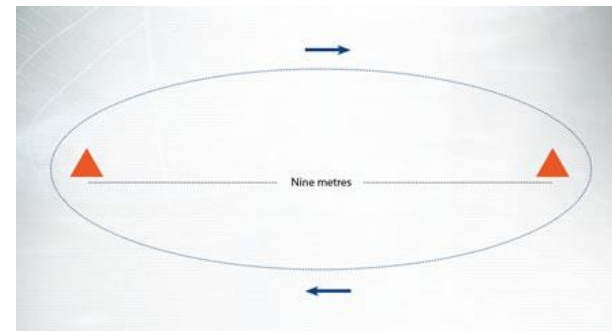
Pulmonary Rehabilitation in Lung transplantation: How?

Pulmonary rehabilitation in lung T: University of Toronto



Pulmonary rehabilitation in lung T: University of Toronto

- **Physical assessment of lung transplant candidates and recipients**
 - Exercise capacity
 - Cardiopulmonary exercise test, 6MWT, ISWT, UULEX
 - Muscle function
 - Peripheral muscles : Manual muscle testing or hand held dynamometry Handgrip force1-repetition maximum
 - Respiratory muscles : MIP/MEP
 - Physical performance and mobility
 - Gait speed, Sit-stand tests
 - Short Physical Performance Battery
 - Balance tests
 - Tests specifically for ICU/inpatients : Egress test
 - Physical activity : Physical Activity questionnaires



https://www.researchgate.net/figure/Performing-the-Unsupported-Upper-Limb-Exercise-Test_fig1_340324887
[accessed 1 Apr, 2022]

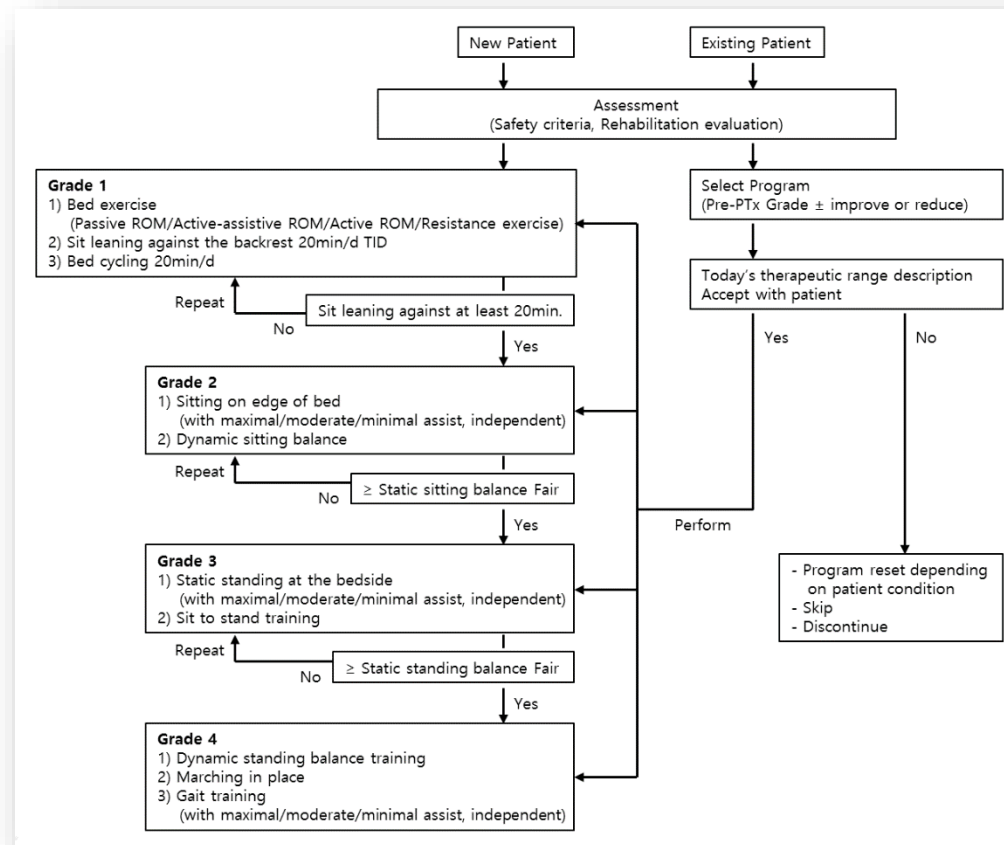
<https://pulmonaryrehab.com.au/patient-assessment/assessing-exercise-capacity/incremental-shuttle-walking-test/>

Pulmonary rehabilitation in lung T: University of Toronto

- **Pre-transplant Exercise prescription in stable outpatient**
 - Aerobic/Resistance/Flexibility
 - Frequency : 2-5 day/week
 - Intensity
 - HR reserve 50-80%, SpO₂ > 85-90%
 - 60%-80% 6MWT speed for walking
 - 60% peak workload for cycling
 - Type
 - Aerobic: Walking, cycling
 - Resistance: Free weights/dumbbells, Elastic bands, Pulleys, Gym equipment, Body weight (stairs, squats, heel raises, wall push-ups)

Pulmonary rehabilitation in lung T: University of Toronto

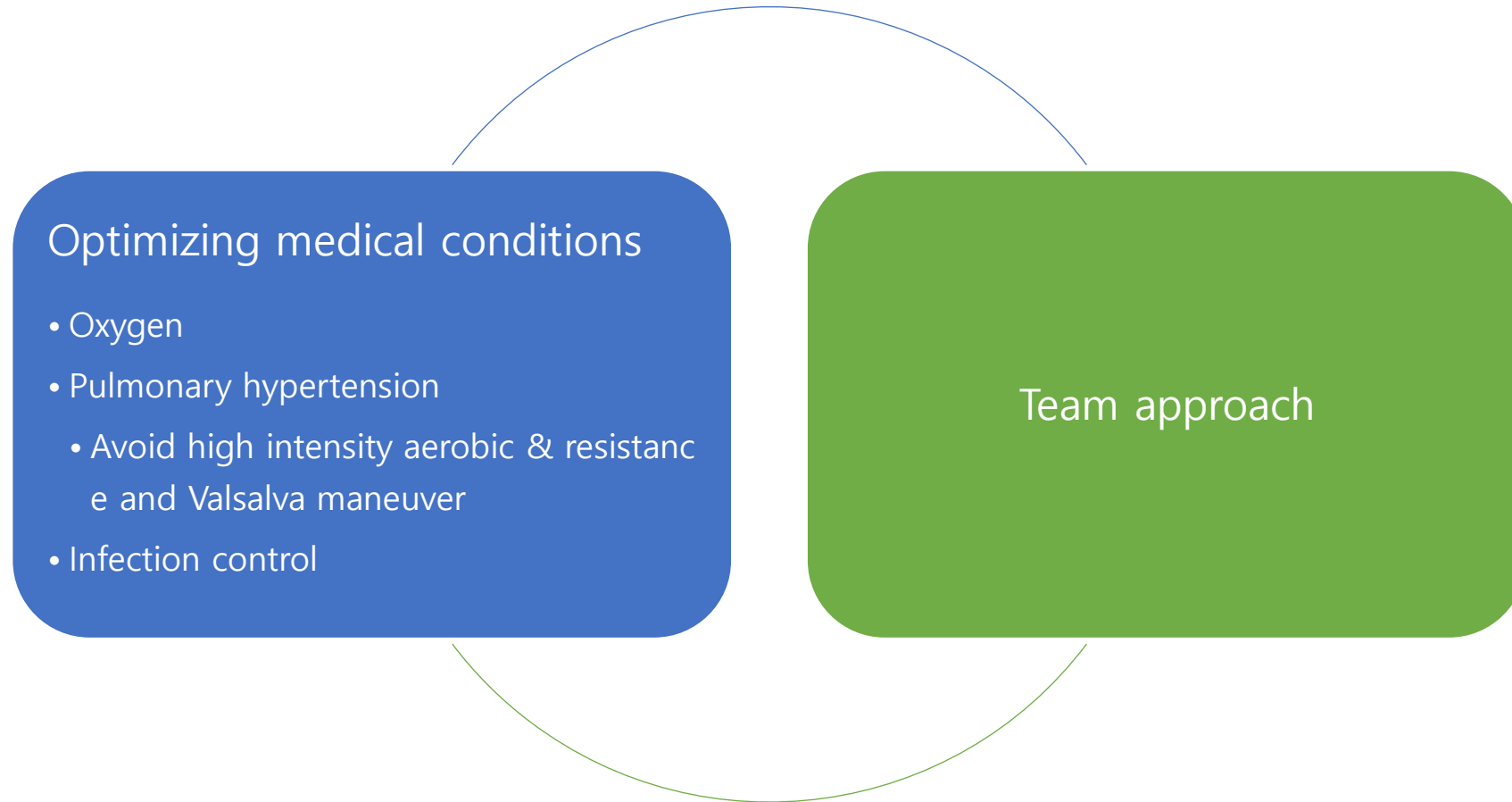
- Hospitalized lung transplant candidates and recipients



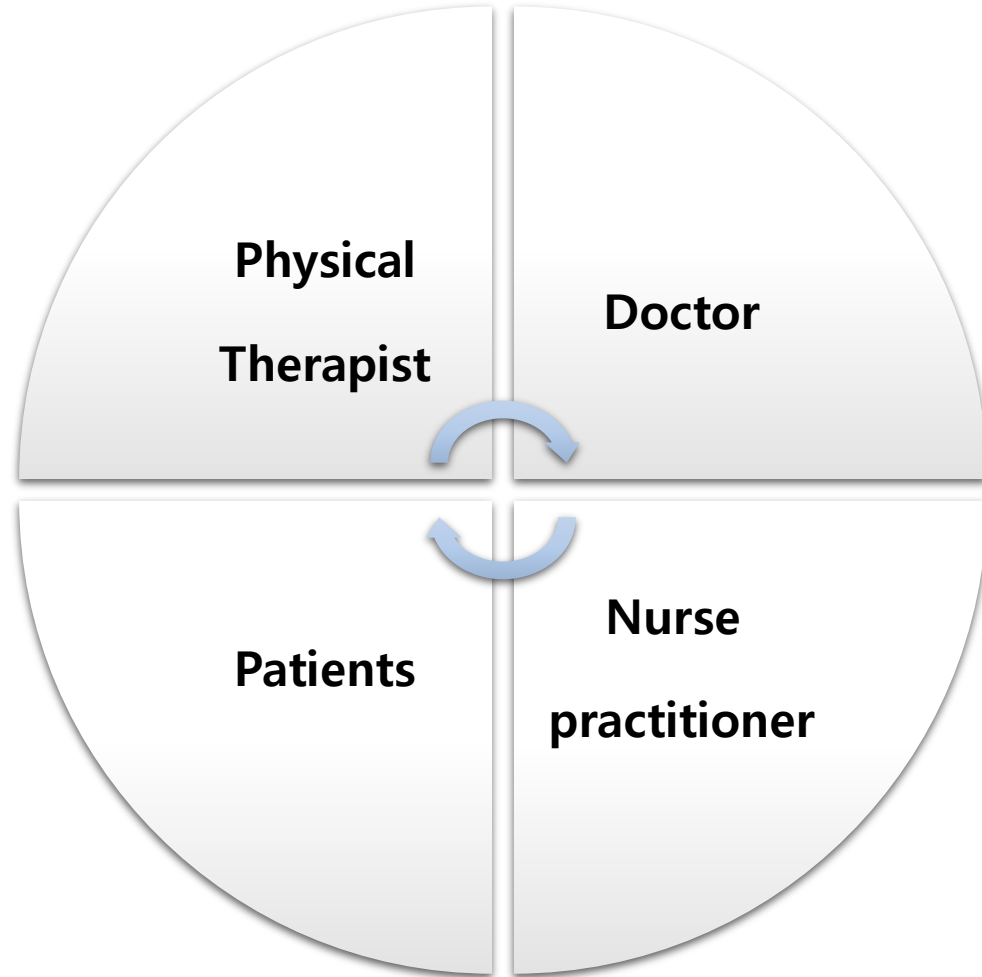
Pulmonary rehabilitation in lung T: University of Toronto

- **Early post-transplant exercise prescription in stable outpatients**
 - Aerobic/Resistance/Flexibility
 - Frequency : 2-5 day/week
 - Intensity
 - HR reserve 50-80%, SpO2 > 88%
 - 75%-100% 6MWT speed for walking
 - 50-80% peak workload for cycling
 - Type
 - Aerobic: Walking, cycling
 - Resistance: Avoid abdominal muscle exercises for first 3 month, No upper extremity lifting/pulling/pushing

Pulmonary rehabilitation in lung T: University of Toronto



Severance: Pulmonary rehabilitation



Severance: Pulmonary rehabilitation

- 호흡재활의 대상

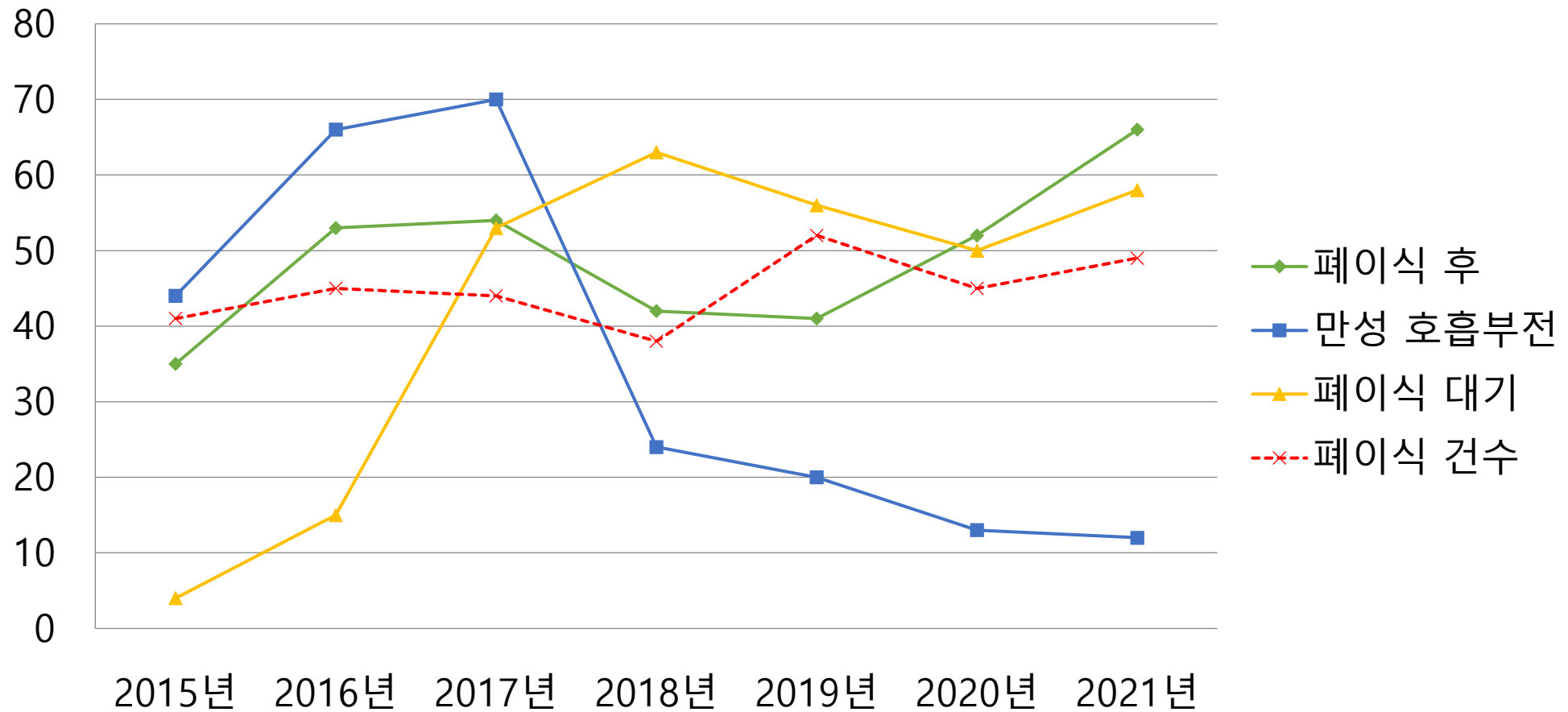
- 폐 이식 수술 전 / 후 환자
- 장기간 인공 호흡기 의존 중인 환자
- 만성 호흡기 질환자
- 폐암 수술 전 / 후
- 척추 측/후만증 포함, 제한성 폐질환 일으킬 수 있는 흉곽 병변

수가코드	한글명칭	보험수가	종별가산 수가
MM440	폐질환 운동재활치료	47,050	61,165

- 전담 업무 : 폐질환 운동 재활치료 전담 물리치료사 / 전담 간호사/ 호흡기내과 전담 간호사
- 횟수 : 주 3회 이상
- 장소 : 내·외과 중환자실 / 병동

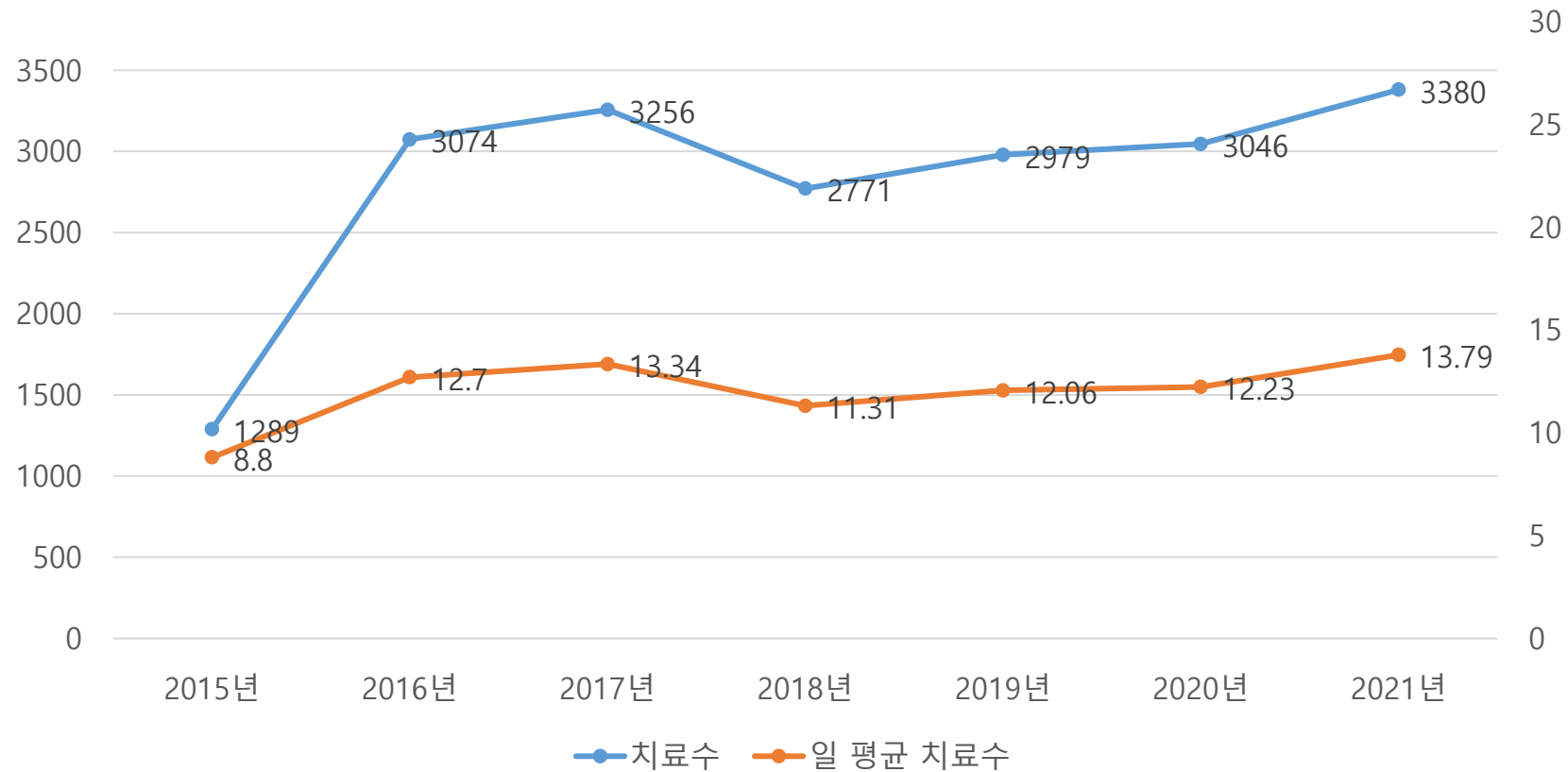
Severance: Pulmonary rehabilitation

폐질환 운동재활치료 건수

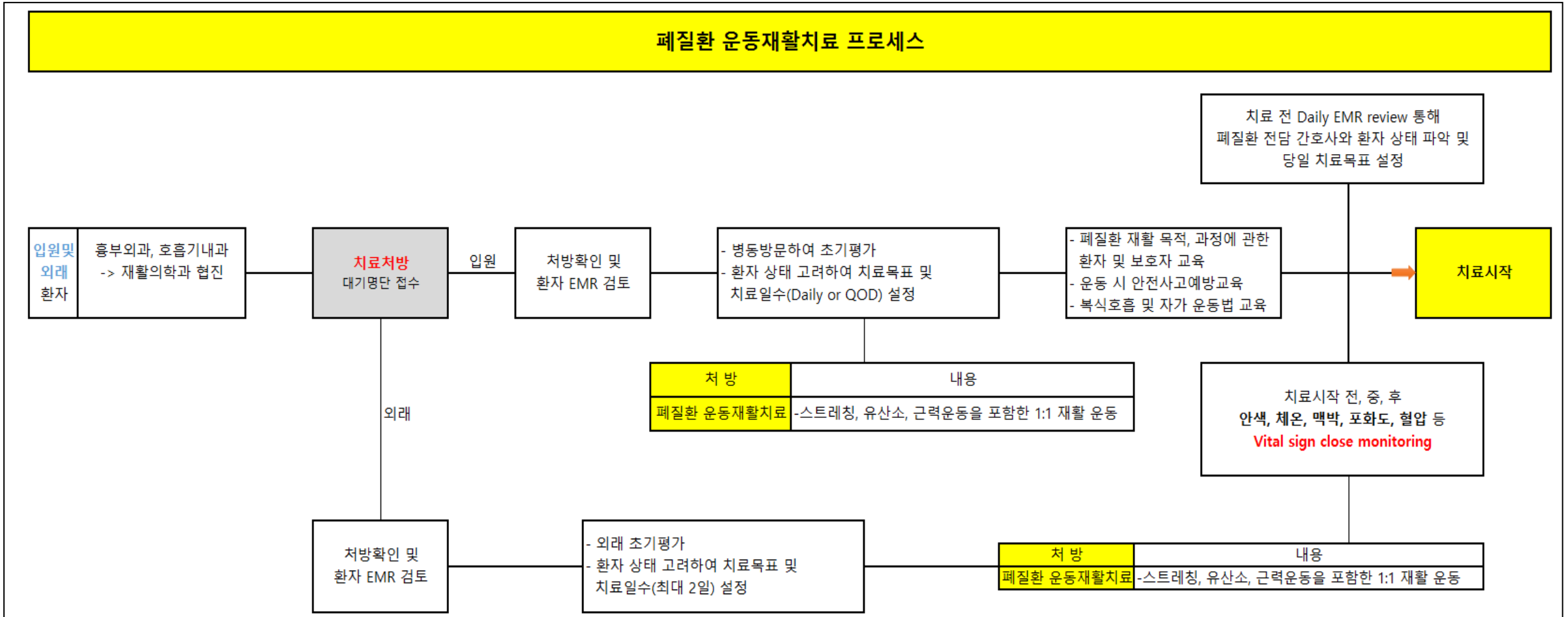


Severance: Pulmonary rehabilitation

폐이식 운동 재활



Severance: Pulmonary rehabilitation



Severance: Pulmonary rehabilitation

- 재활 전 평가

- 통증평가

Pain 평가 ○ 통증없음 ○ Pain(NPIS) ○ Pain(FLACC scale : Face, Legs, Activity, Cry, Consolability)

- 안전성 평가

Safety criteria

- 1) $FiO_2 < 0.6$ Yes No
- 2) $SpO_2 > 88\%$ Yes No
- 3) $RR < 40$ Yes No
- 4) $HR < 130$ Yes No
- 5) $MBP > 60$ Yes No

Severance: Pulmonary rehabilitation

- 재활 전 평가
 - 목표설정

Main problem	<input type="text"/>
patient's goals	<input type="text"/>
Therapist's goals	<input type="text"/>
Patient's agreements	
1. 치료내용에 대한 충분한 설명 후 환자 및 보호자가 이에 동의하였습니까? <input type="radio"/> 예 <input type="radio"/> 아니오	

Severance: Pulmonary rehabilitation

- 재활 전 평가
 - 의식/관절/근력/기능

Evaluation Lists

Mental Status

X Set Mental Status

Mental Status Alert Confuse Drowsy Stupor Semi-coma Coma

관절가동범위검사 Range of Motion Evaluation

X Set ROM evaluation

Rt. side → Full ROM Lt. side → Full ROM

Comment 서술문선택

근력검사 Manual Muscle Test

X Set 물리치료-MMT

Comment 서술문선택

기능적 균형능력 평가 Functional Balance Grades

X Set Balance

기능적 균형능력 평가 Functional Balance Grades		1	2	추가 삭제
검사일				
Sitting	Static			
	Dynamic			
Standing	Static			
	Dynamic			
치료목표				

Comment 서술문선택

Functional level

X Set Functional level 3

Functional level

Side rolling to Rt. side :

Side rolling to Lt. side :

Come to sit :

Sit to stand :

Standing unsupported :

Gait : ,

W/C transfer :

Severance: Pulmonary rehabilitation

- 재활 전/후 평가
 - 활동범위/호흡/활력징후

Activities

X Set Activities

Activities	1	2
검사일		
Time Up and go Go test (초)		
6-minute walking distance(6MWD) (m)		
Gait device & AFO 사용		

추가 삭제

참고 편집

(참고) - Timed Up and Go test

10s 이하	Normal mobility
11s - 20s	노인 및 장애가 있는 환자인 경우, within normal limits
20s 초과	Needs assistance outside
30s 초과	Fall risk 증가

호흡요법

X Set 호흡요법

호흡요법 Ventilator T-mask T cannular Nasal cannular Room air

서울문선택

Vital Sign

X Set Vital Sign

Vital Sign	안정 시	운동 시
SpO2 (%)		
Blood pressure (S/D)		
Heart rate		

Modified Borg Scale

X Set Modified Borg Scale

Modified Borg Scale (안정시와 운동시의 호흡곤란정도 점수 매김)

Shortness of breath	At rest	During activity
Nothing at all	<input type="radio"/> 0	<input type="radio"/> 0
Very very slight	<input type="radio"/> 0.5	<input type="radio"/> 0.5
Very slight	<input type="radio"/> 1	<input type="radio"/> 1
Slight	<input type="radio"/> 2	<input type="radio"/> 2
Moderate	<input type="radio"/> 3	<input type="radio"/> 3
Somewhat severe	<input type="radio"/> 4	<input type="radio"/> 4
Severe	<input type="radio"/> 5	<input type="radio"/> 5
	<input type="radio"/> 6	<input type="radio"/> 6
Very severe	<input type="radio"/> 7	<input type="radio"/> 7
	<input type="radio"/> 8	<input type="radio"/> 8
Very very severe	<input type="radio"/> 9	<input type="radio"/> 9
Maximal	<input type="radio"/> 10	<input type="radio"/> 10

점수 At rest During activity

Severance: Pulmonary rehabilitation

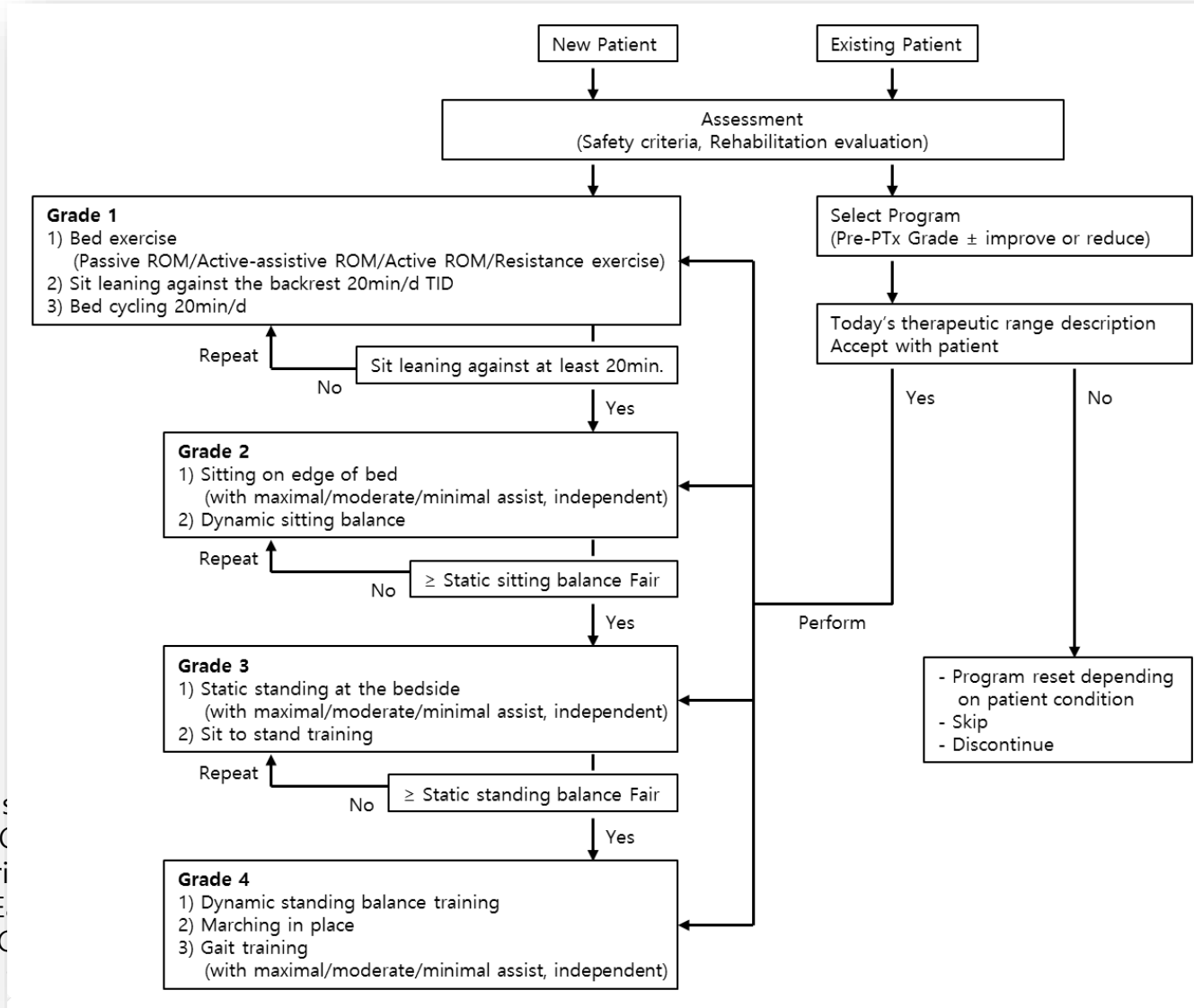
재활의학과 처방

수가 코드	처방 명칭	보험가 (원)	가산수가 (원)	일반가 (원)
EX773	ROM evaluation	18,300	23,790	48,000
E6610	Check MMT_상지, 체간 또는 하지,체간	12,440	16,172	32,500
MM440	폐질환 운동재활치료	47,050	51,165	125,000
MM101	Simple (Exercise)	4,520	5,876	12,000
MM102	Complex (Equipment)	7,070	9,191	18,500

호흡기내과 처방

처방명	처방코드	수가코드	보험수가	일반수가
호흡기내과 폐질환 운동재활치료	MM440_2	MM440	47,050	125,000

Protocol for rehabilitation assessment







[1]D. McWilliams
Journal of C
[2]Peter E. Morri
[3]Heidi J. ICU E
[4]Nathan E. A C
Therapy in

Quality improvement project.

Care Med 2008 Vol. 36, No. 8;
Care Med 2013; 41:S69-S80;
III: The Activity and Cognitive

Protocol for rehabilitation assessment

만성 호흡부전 재활치료 단계

Grade 1		Grade 2	Grade 3			Grade 4		
Bedside PTx		Dangling	Standing			Gait		
G1-1> Bed exercise - Passive ROM - Active-assistive ROM - Active ROM - Resistance exercise	G1-2> Sit leaning against the backrest	G2-1> Sitting on edge of bed	G3-1> <u>Bobath</u> standing (standing 시 무릎, 골반, 상체의 지지가 필요한 경우)	G3-2> Standing with walker	G3-3> Standing without device	G4-1> Marching in place	G4-2> Gait with walker	G4-3> Gait without device
								
G1-1 G1-2		G2-1	G3-1 G3-2 G3-3	G4-2				

Severance: Pulmonary rehabilitation

폐질환 운동 재활치료	스트레칭, 유산소, 근력운동을 포함한 1:1 재활 운동
유산소운동	최대 운동 근력의 60% 이상의 강도로 20~60분 운동. 주 3~5회 시행
근력운동	최대 근력의 60~70%의 강도로 1세트 10회를 2~3세트 운동. 주 2~3회 시행
운동 프로그램	준비 : 5~10분 저강도 (<40% 최대산소섭취량) 또는 중강도(40~60% 최대산소섭취량)의 운동
	스트레칭 : 준비운동 후 10분간 시행
	본운동 : 환자의 운동 능력에 맞추어 20~60분 유산소 운동, 근력운동, 유연성 운동
	정리운동 : 5~10분 저강도 (<40% 최대산소섭취량) 또는 중강도(40~60% 최대산소섭취량)의 심혈관 및 근지구력 운동

Severance: Pulmonary rehabilitation



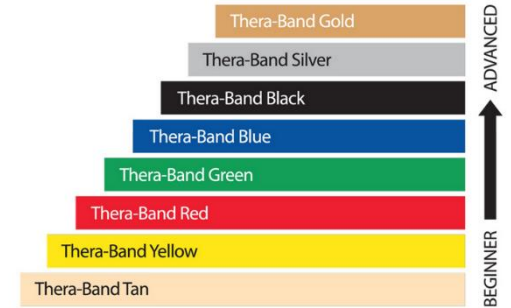
Ergometer(침상 자전거)



Dynamometer(악력계)



Pulse Oximeter



Thera-Band® System of Progressive Exercise



Thera-Band

Severance: Pulmonary rehabilitation



Sara Steady(기립 보조기)



Grillo(보행 보조기)



Standing Frame(전동 기립기)

Severance: Pulmonary rehabilitation



Severance: Pulmonary rehabilitation - Patients education

5. 한발 앞으로 던고 다리 굽히기

양 발을 어깨 넓이로 벌려 바로 선 자세에서 한 발을 앞으로 내딛고 뒷발 발꿈치를 들어준다. 무릎이 지면에 닿는 느낌으로 천천히 굽혀 내려준다.

6. 벽에 등기대어 앉기

벽에 등을 기대고 무릎을 구부려 10초간 유지하고 다시 바로 선다.

12

11

9

7

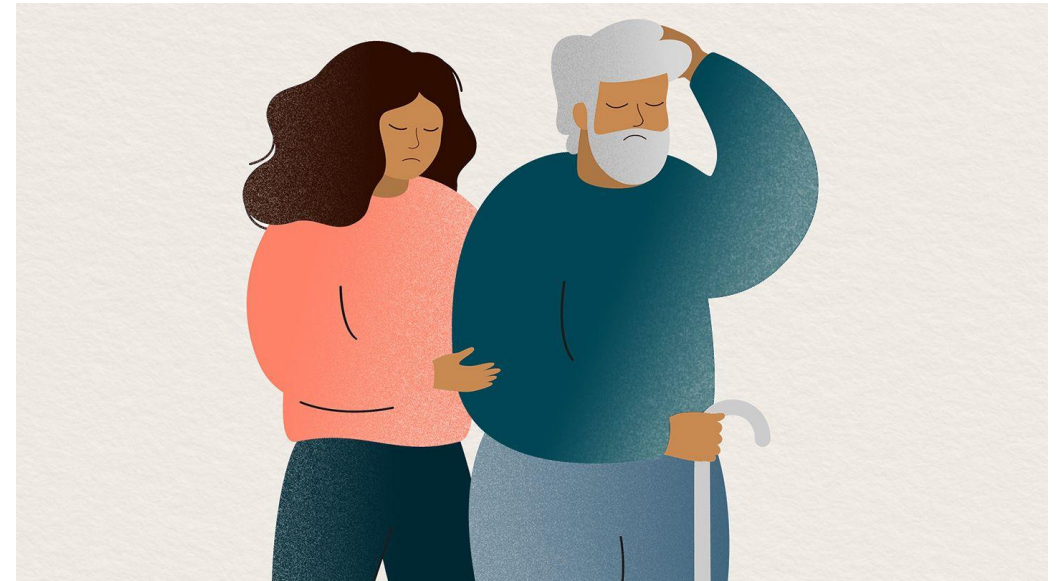
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www.severance.com

Future directions

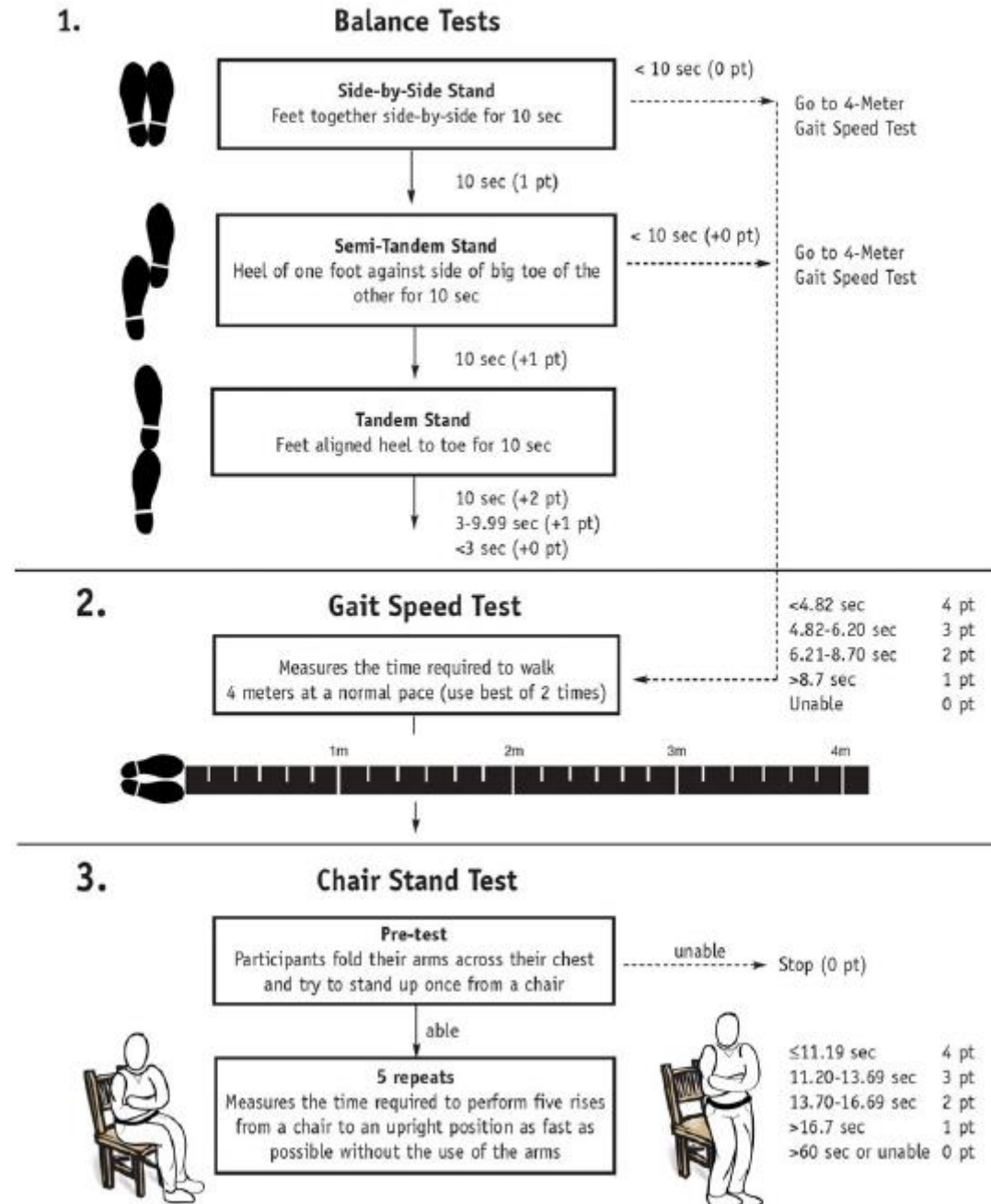
Limitations



Discharge frailty following I

University of Pennsylvania
Lung T, n=118

Short Physical Performance Battery



Predictor of discharge frailty

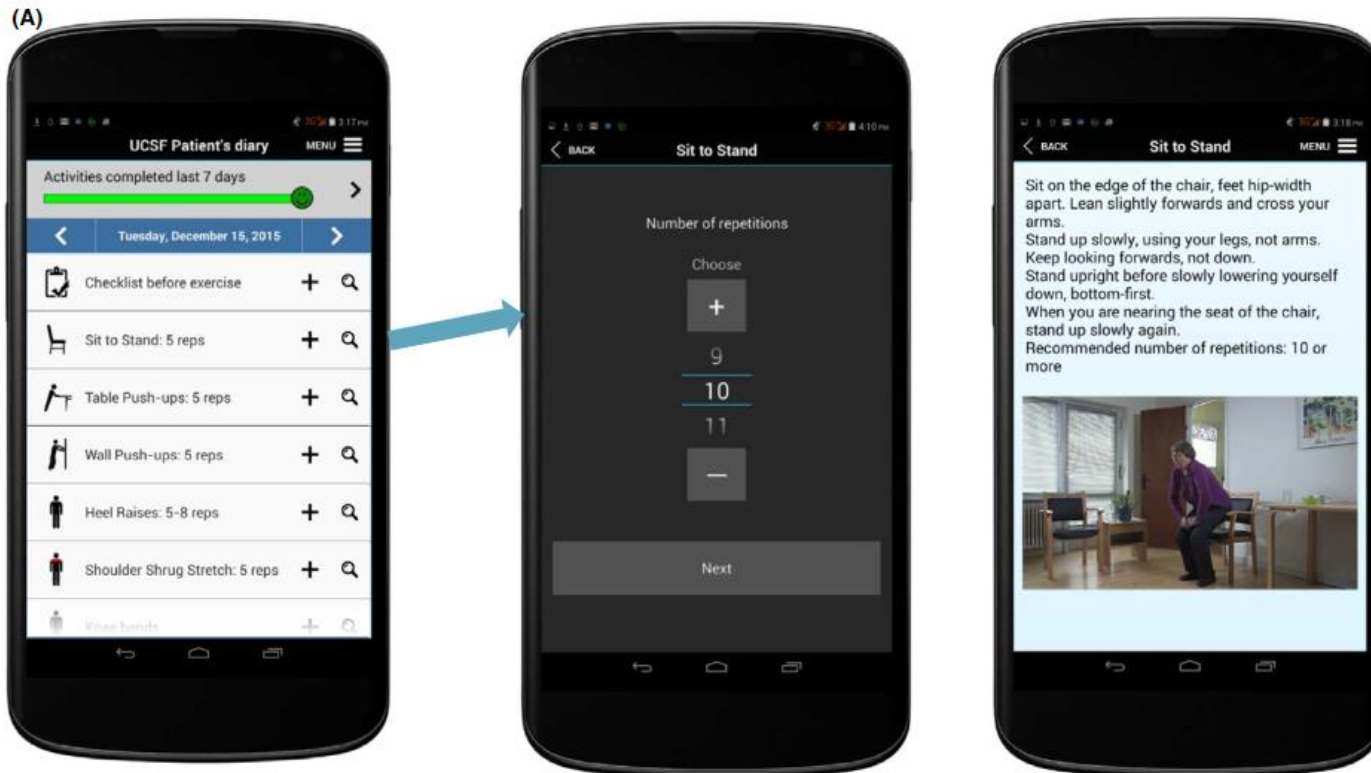
- Female
- AKI
- Prefrail SPPB at listing
- Length of ICU stay
- Length of hospitalization

Telemedicine

ORIGINAL ARTICLE

A mobile health technology enabled home-based intervention to treat frailty in adult lung transplant candidates: A pilot study

University of California, San Francisco.







































Telemedicine

(B)

Diary

UCSF Patient


[+ Add activities](#)

	Checklist before exercise			
	Sit to Stand: 5 reps			
	Table Push-ups: 5 reps			
	Wall Push-ups: 5 reps			
	Heel Raises: 5-8 reps			
	Shoulder Shrug Stretch: 5 reps			
	Knee bends: 5 reps			
	Walking			
	Exercise Bike			

Add activities

Søg


47 results



Shoulder exercise

This exercise strengthens the muscles in your arms.


[Add to diary](#)



Walking

Regular walking strengthens the heart and lungs and increases overall fitness.

already in diary



Tandem walking

The tandem walking exercise can help to reduce the risk of a fall.

[Add to diary](#)

Clinical Transplantation 32, e13274.. doi:10.1111/ctr.13274

Telemedicine

TABLE 5 Change in frailty scores and states over the course of the intervention by participant

Participant	Short Physical Performance Battery (Frailty defined as score ≤ 9)				Fried Frailty Phenotype (Frailty defined as score ≥ 3)			
	Baseline	Intervention end	Frailty resolved ^a	Change in score (positive score = improved frailty)	Baseline	Intervention end	Frailty resolved ^a	Change in score (negative score = improved frailty)
1	Not frail (10)	Not frail (10)		0	Frail (3)	Not frail (2)	Yes	-1
2	Frail (9)	Not frail (12)	Yes	+3	Not frail (2)	Not frail (1)		-1
3	Frail (9)	Frail (9)	No	0	Not frail (2)	Not frail (1)		-1
4	Not frail (10)	Not frail (12)		+2	Frail (3)	Not frail (2)	Yes	-1
5	Not frail (11)	Frail (8)		-3	Frail (3)	Frail (5)	No	2
6	Not frail (10)	Not frail (12)		+2	Not frail (1)	Not frail (0)		-1
7	Not frail (11)	Not frail (12)		+1	Not frail (1)	Not frail (1)		0
8	Frail (9)	Frail (9)	No	0	Not frail (1)	Not frail (2)		1
9	Not frail (11)	Not frail (10)		-1	Not frail (1)	Not frail (1)		0
10	Not frail (11)	Not frail (11)		0	Not frail (1)	Not frail (0)		-1
11	Frail (9)	Not frail (12)	Yes	+3	Frail (3)	Frail (3)	No	0
12	Not frail (10)	Not frail (12)		+2	Frail (3)	Not frail (1)	Yes	-2
13	Frail (8)	Not frail (12)	Yes	+4	Frail 4	Frail (3)	No	-1

^aCells populated only if participant was frail at baseline assessment.

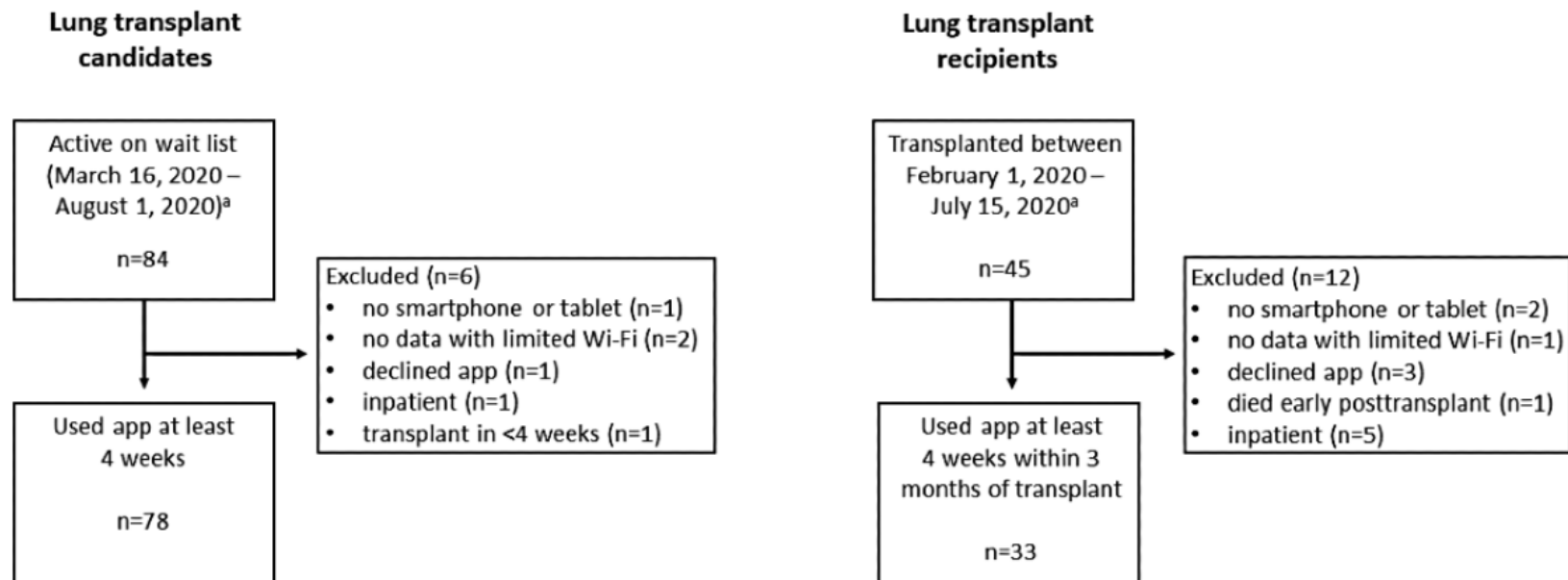
Telerehabilitation

Original Paper

Telerehabilitation for Lung Transplant Candidates and Recipients During the COVID-19 Pandemic: Program Evaluation

University of Toronto, Canada

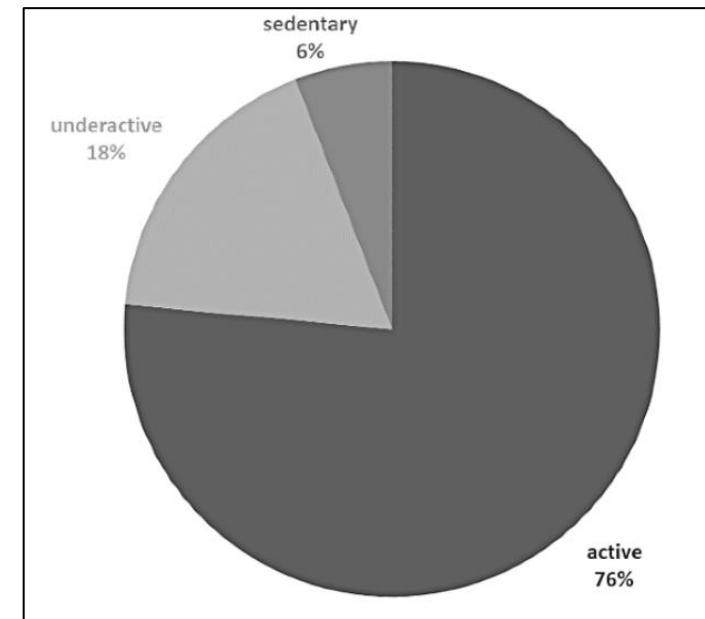
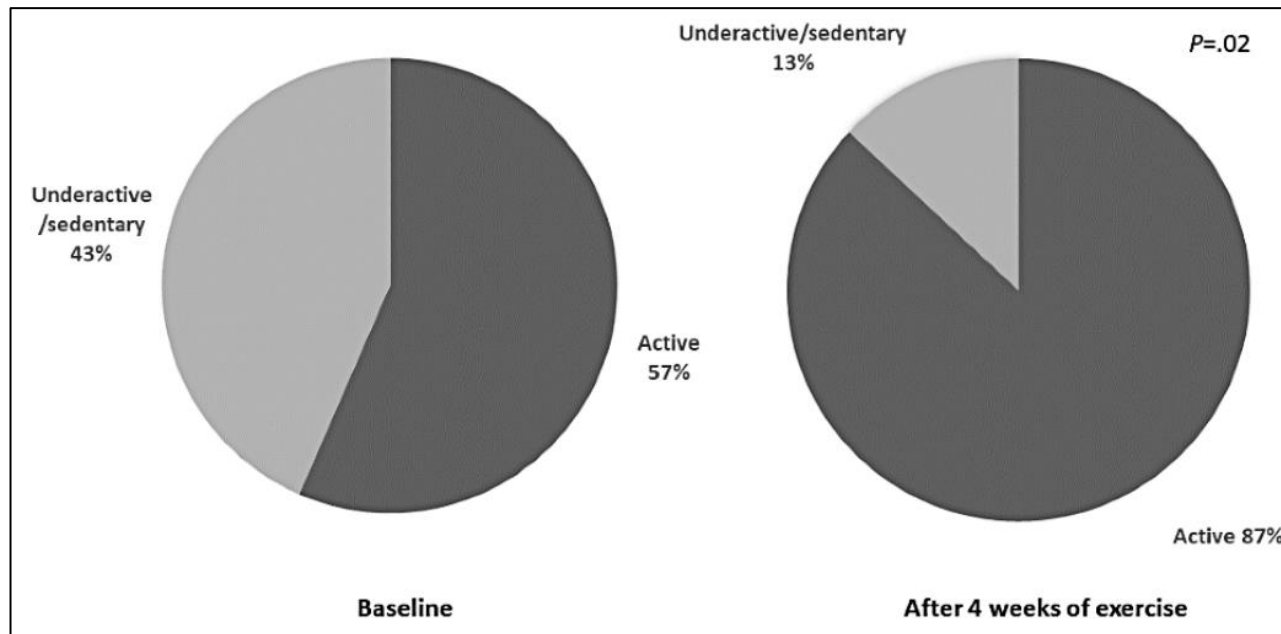
Web-based, Remote monitoring app for at least four weeks between March 16 and September 1



Telerehabilitation

lung transplant candidates (n=78)

Post-transplant (n=33)



Active: 30 minutes or more of moderate intensity physical activity 5 or more days per week. Underactive: some moderate physical activity but not every week or less than 30 minutes per day. Sedentary: rarely or never do any physical activities

Telerehabilitation

Table 3. Changes to function and exercise training pretransplant and posttransplant after four or more weeks of home rehabilitation.

Outcome measures	Baseline	After ≥4 weeks of rehabilitation	<i>P</i> value
Lung transplant candidates			
Six-minute walk distance (meters), n=45, mean (SD)	346 (84)	307 (85)	.002
Total Short Physical Performance Battery, n=42, median (IQR)	12 (9.5-12)	12 (10-12)	.90
Treadmill speed (mph), n=26, mean (SD)	1.7 (0.6)	1.75 (0.6)	.31
Treadmill duration (minutes), n=26, mean (SD)	16 (9)	22 (10)	.002
Quadriceps weight (pounds), n=37 ^a , median (IQR)	3.5 (2.4-5)	4.3 (3-5)	.08
Lung transplant recipients			
Treadmill speed (mph), n=9, mean (SD)	1.9 (0.7)	2.7 (0.7)	.003
Treadmill duration (minutes), n=9, mean (SD)	19 (8)	26 (8)	.07
Quadriceps weight (pounds), n=15 ^a , median (IQR)	3 (0-3)	5 (3.8-6.5)	<.001

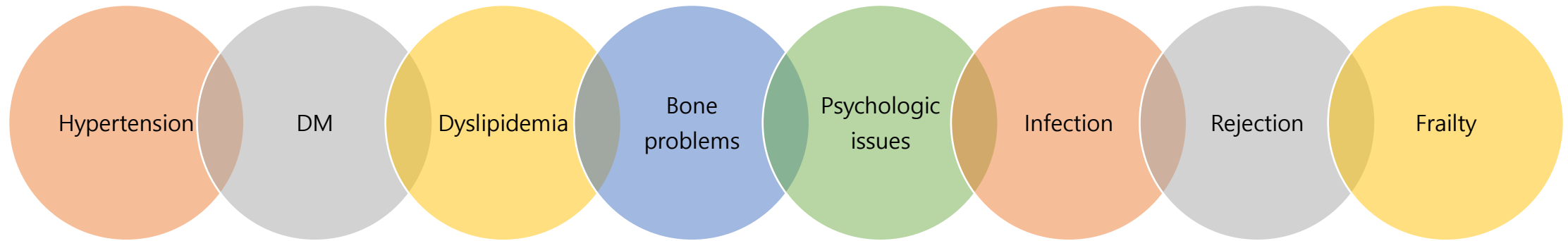
Happily ever after...



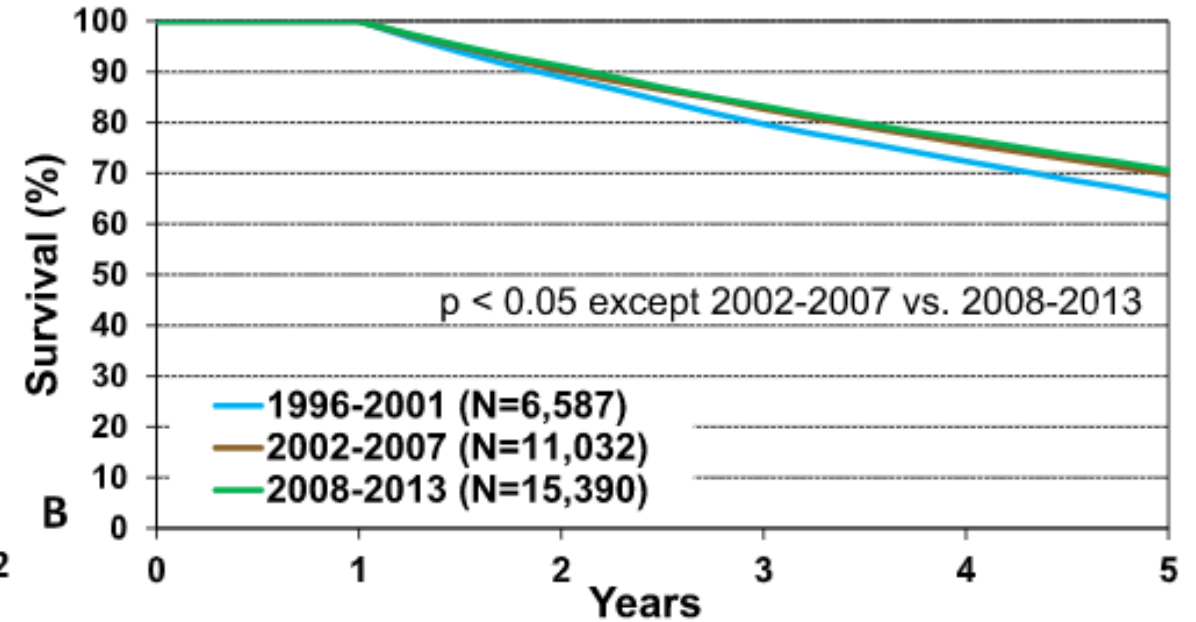
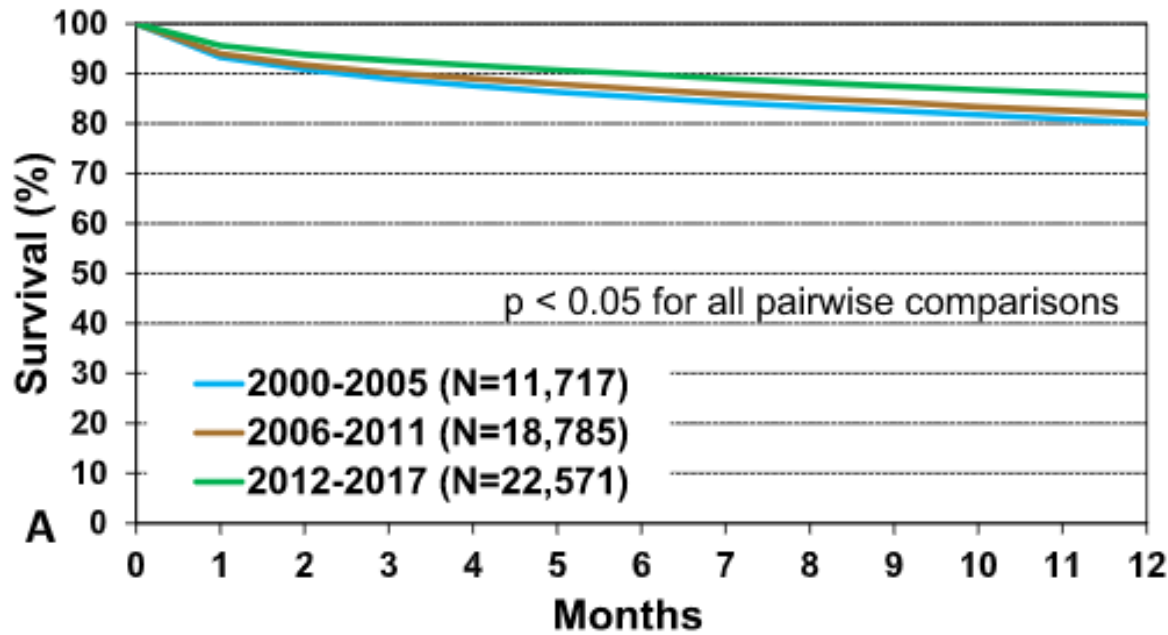
Happily ever after?



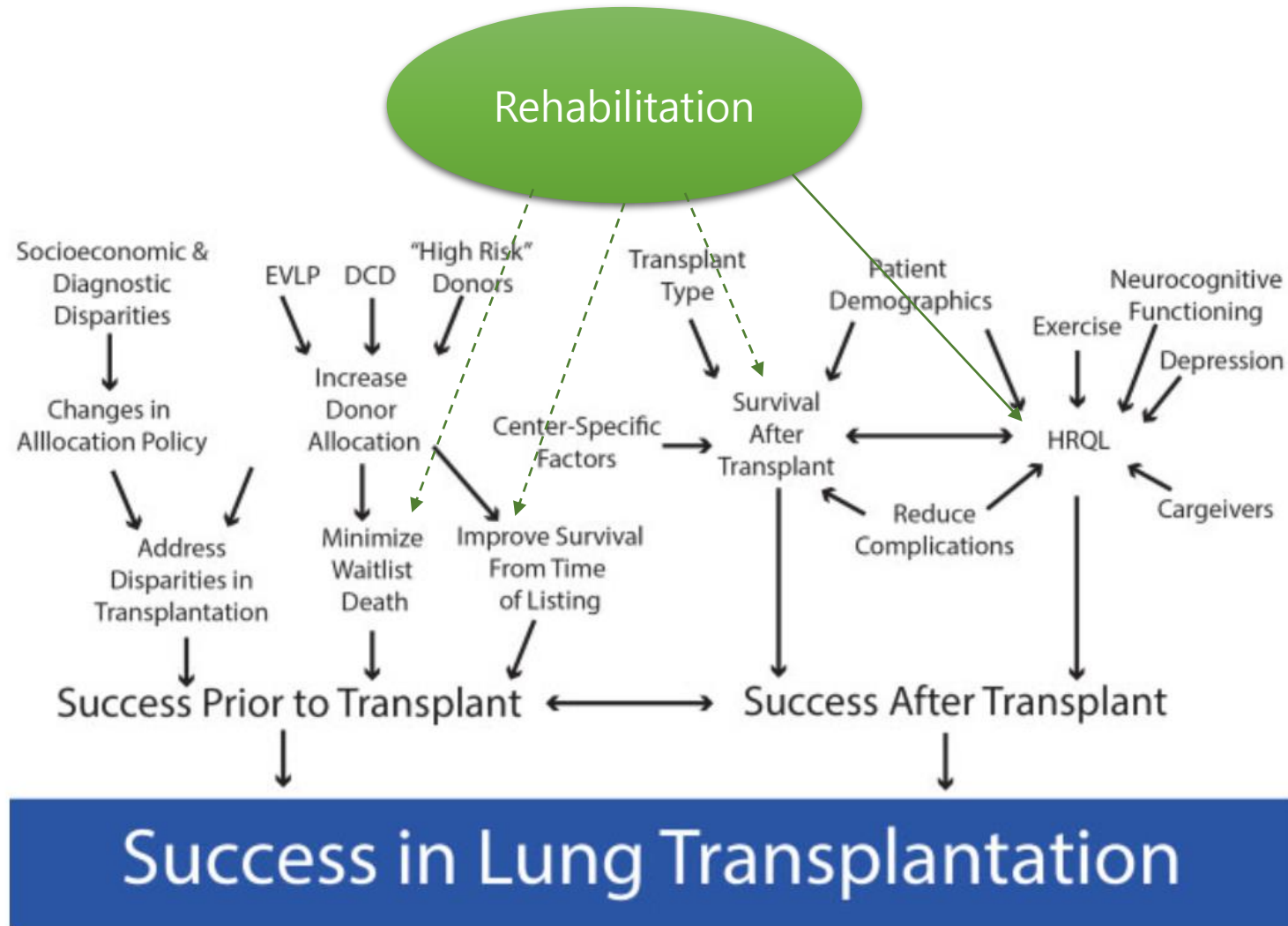
Patients after lung transplant



Goal of lung transplantation: Survival?



Success in lung transplantation





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