

2026 GACVPR Annual Meeting

The Importance of Pulmonary Rehabilitation in Lung Transplant

Lorenzo Zaffiri, MD PhD

Assistant Professor

Medical Director

Emory Lung Transplant Program

- Overview of Lung Transplant
- Impact of Pulmonary Rehabilitation on Lung Transplant Outcomes
- Recent Efforts of Emory Lung Transplant

- The **first human lung transplant** was performed in **1963** by James Hardy at the University of Mississippi Medical Center.
 - The patient survived only 18 days due to complications and rejection

In **1982**, the **first successful long-term** single-lung transplant was performed by Joel Cooper in Toronto.

The New York Times

Georgian Undergoes Lung Transplant

 Share full article  

AP

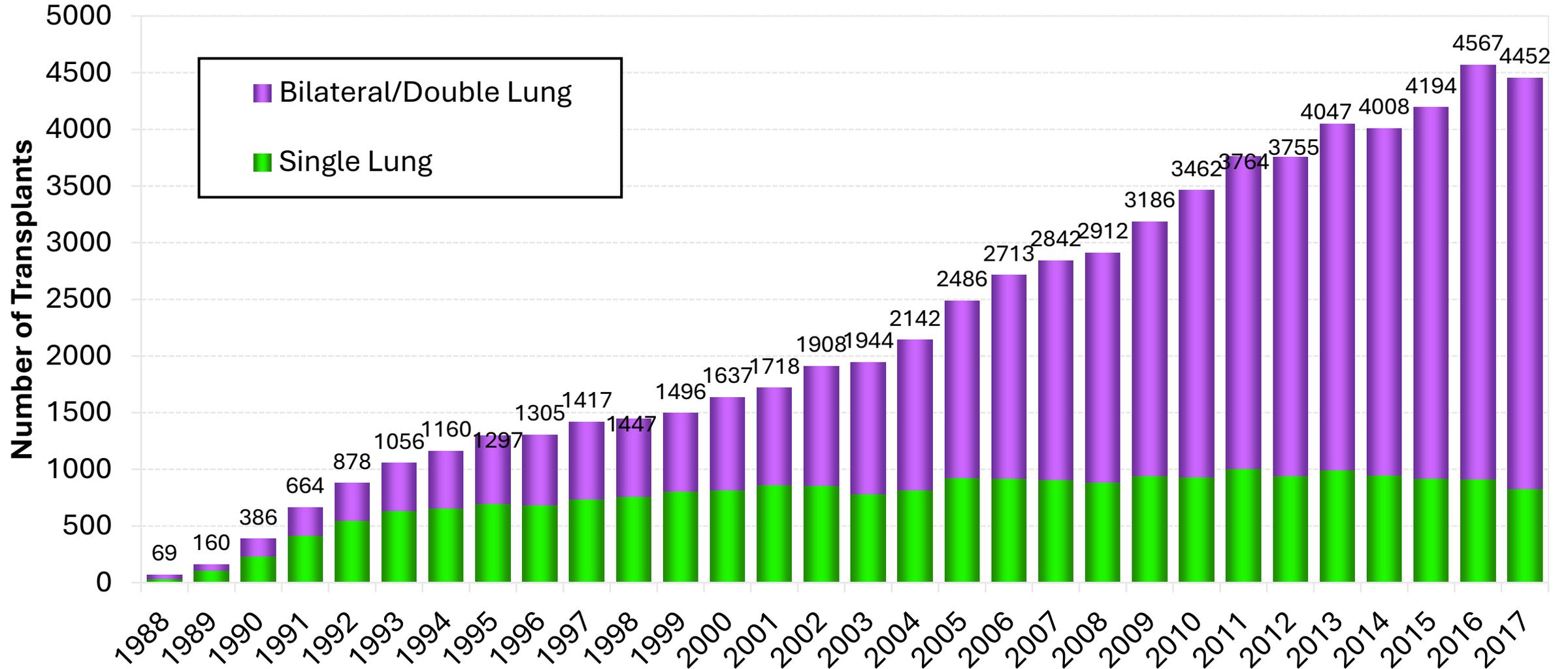
Aug. 31, 1982



Donor Lung was
procured in Atlanta

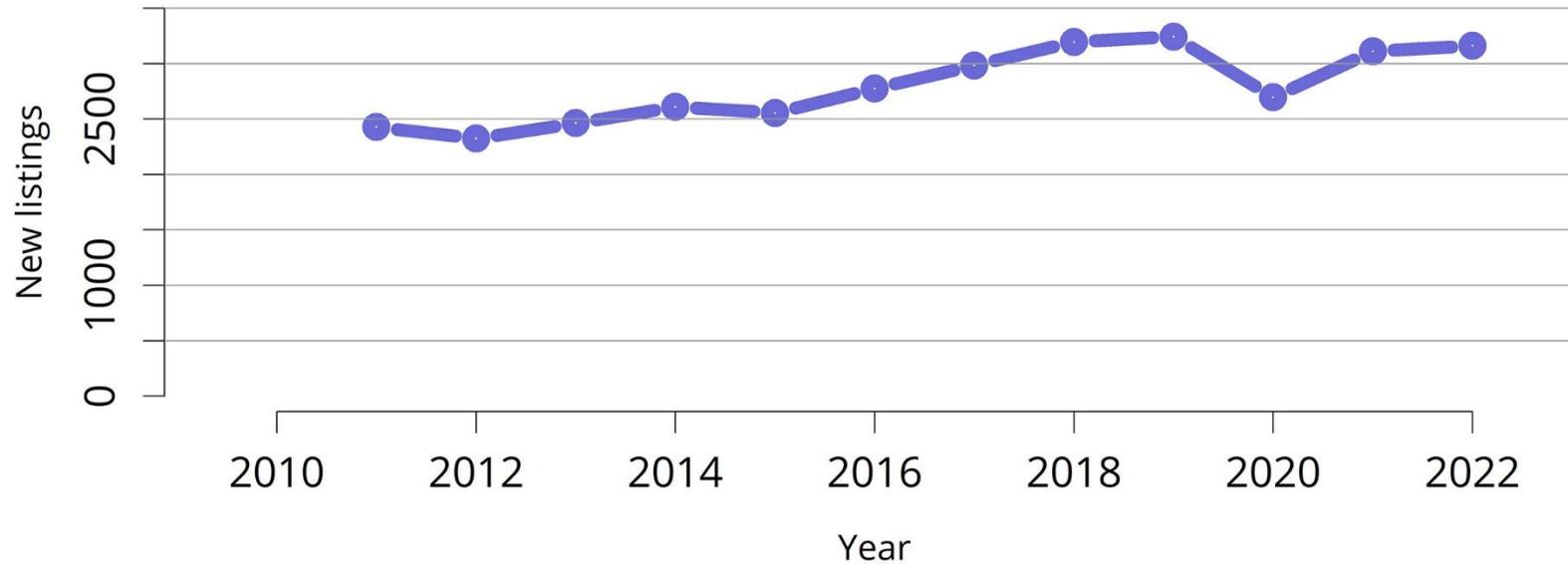


Modern Transplant Volumes





Lung Transplant Volumes in USA



OPTN/SRTR 2022 Annual Data Report

- Over the course of the last 10-15 years, Lung transplant has become treatment for patients with end stage lung disease with 2500 procedures performed every year

What are the impacts of lung transplant?

1. Quality of Life

2. Length of life



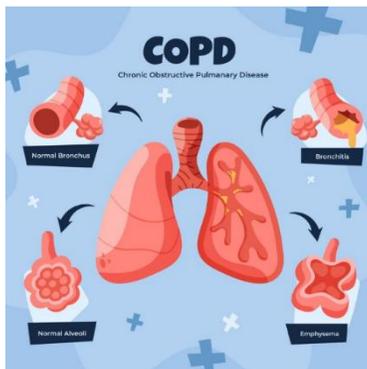
Lung Transplant Overview

- Why do you need a lung transplant?

1. Progressive Scarring of lungs – **Fibrosis** (65-75%)
2. Damage caused by Smoking – **COPD, emphysema** (20-25%)
3. Cystic Fibrosis (~5%)
4. High Blood Pressure in the Lung Circulation (Pulmonary Hypertension) (~5%)



Current Guidelines for Referral: **IT IS NEVER TOO EARLY!!!**

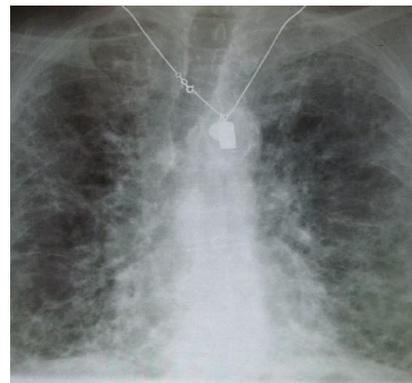


COPD:

BODE index of 5 to 6

Frequent exacerbations

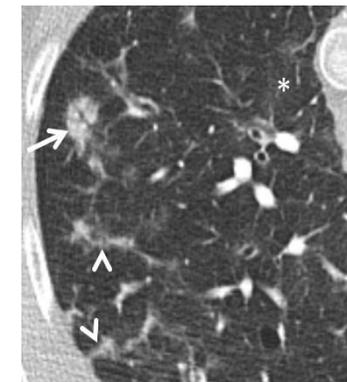
FEV1 <25% of predicted.



IPF:

At the time of a confident radiographic diagnosis of idiopathic pulmonary fibrosis (IPF) or a histologic diagnosis of IPF or fibrosing nonspecific interstitial pneumonia (NSIP)

regardless of lung function.



ILD:

At time of progression of symptoms:
limitation with activities

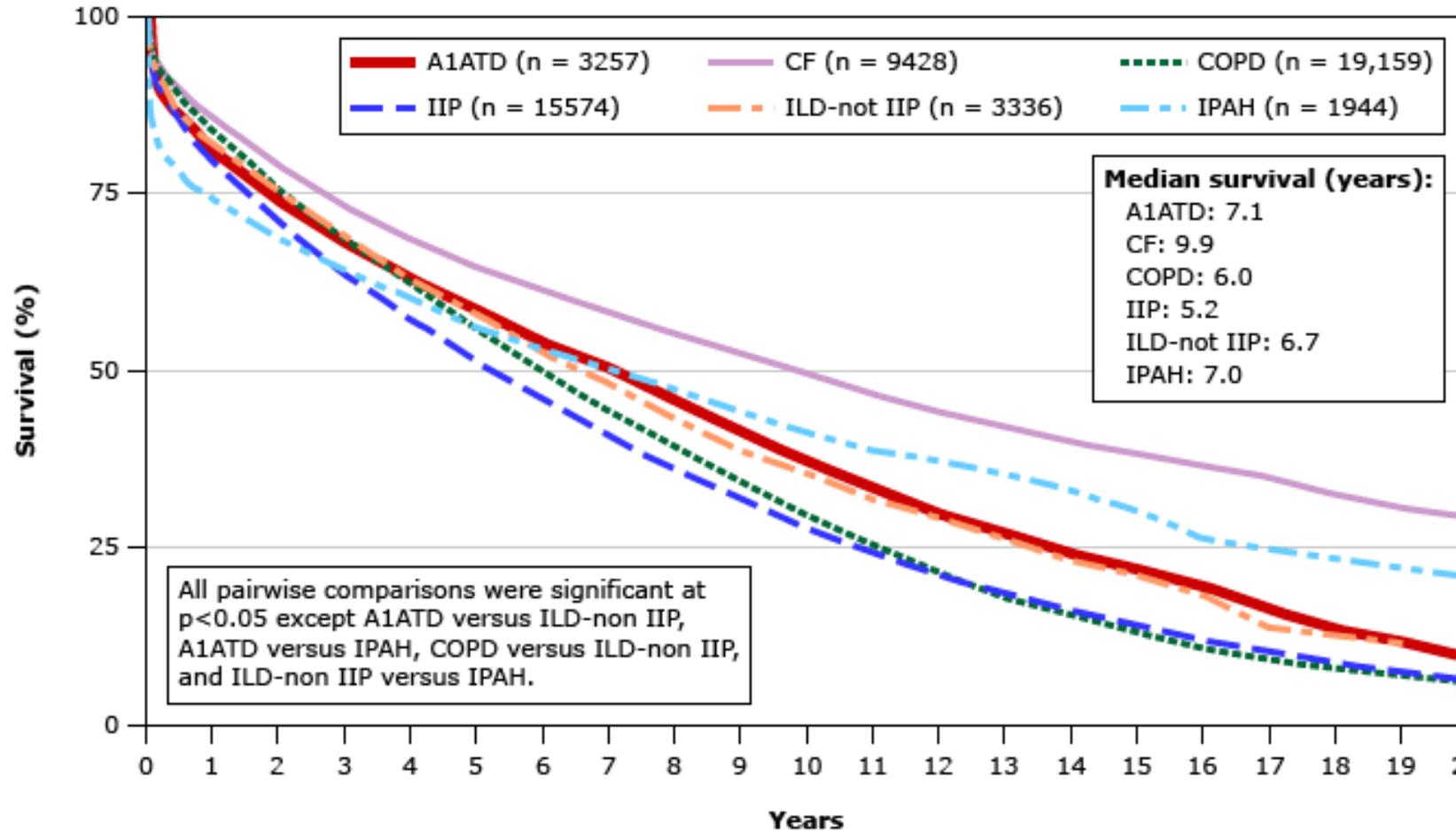
FVC <80% of predicted,

DLCO <40 % of predicted

or the **requirement for supplemental oxygen**, at rest or with exertion.

Survival

Median survival (years):
Double Lung = 7
Single Lung = 5



1 YEAR SURVIVAL



10 YEAR SURVIVAL



CLASSIC ILD

- Hypersensitivity pneumonitis (HP)
- Connective tissue disease–associated ILD (e.g., RA-ILD, SSc-ILD)
- Sarcoidosis
- IPF

EMERGING ILD

- Telomere-related ILD
- MDA 5 ILD

Why Lung Transplant for ILD?

- **Progressive Nature of ILD**

Many forms of ILD are **progressive and irreversible** despite antifibrotic or immunosuppressive therapy.

- **Poor Prognosis**

IPF in particular has a **median survival of 3–5 years** from diagnosis. ***Once oxygen-dependent, survival drops significantly.***

- **Limited Treatment Options: *no curative medical therapy***

- **Improved Outcomes Post-Transplant: EARLY REFERRAL**

Evidence Supporting Poor Prognosis After Oxygen Dependency in ILD

Swedish Registry Study (Nationwide Cohort)

Patients with **oxygen-dependent interstitial lung disease** had a **median survival time of just 8.4 months** after starting oxygen therapy.

- This underscores how rapidly outcomes can worsen once oxygen dependence begins.

Ahmadi Z, et al. Thorax 2016;71:510–516.

Prospective Cohort Study in IPF (Japan)

- For patients with **idiopathic pulmonary fibrosis (IPF)**, median **survival** after initiation of supplemental oxygen was approximately **17.7 months**.
- This aligns with other retrospective data estimating survival at **15–18 months** post-oxygen initiation.

Kataoka K, et al. Scientific Report 2023; 13:13664

www.nature.com/scientificreports/

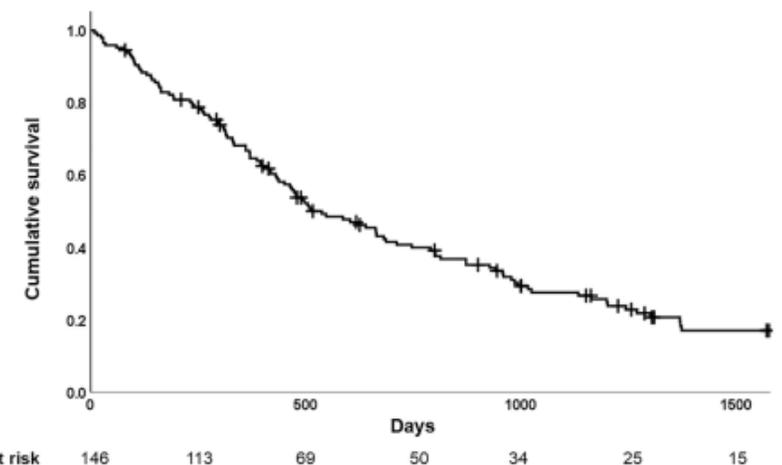


Figure 1. Survival time from the start of oxygen therapy. Median survival time was 537 ± 74 days.

The Key is in the timing

Predictors of death or lung transplant after a diagnosis of idiopathic pulmonary fibrosis: insights from the IPF-PRO Registry

Snyder L et al. Respiratory Research 2019; 105

662 patients enrolled

- Median age 70yo
- 75% male
- 20% were on O2 at rest
- Median FVC 69%
- Median DLco 42%

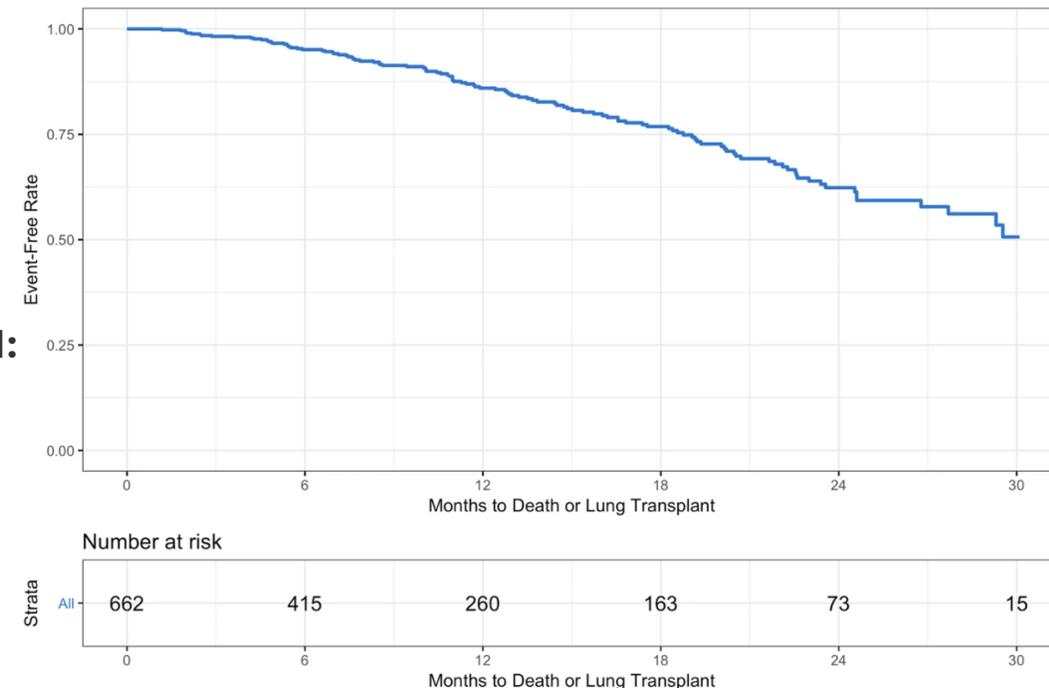
111 patients died or had a lung transplant over a follow-up period of 30 months

The probability of being free of both events at month 30 was 50.6% (95% CI: 40.0, 60.2)

Risk factors associated with events

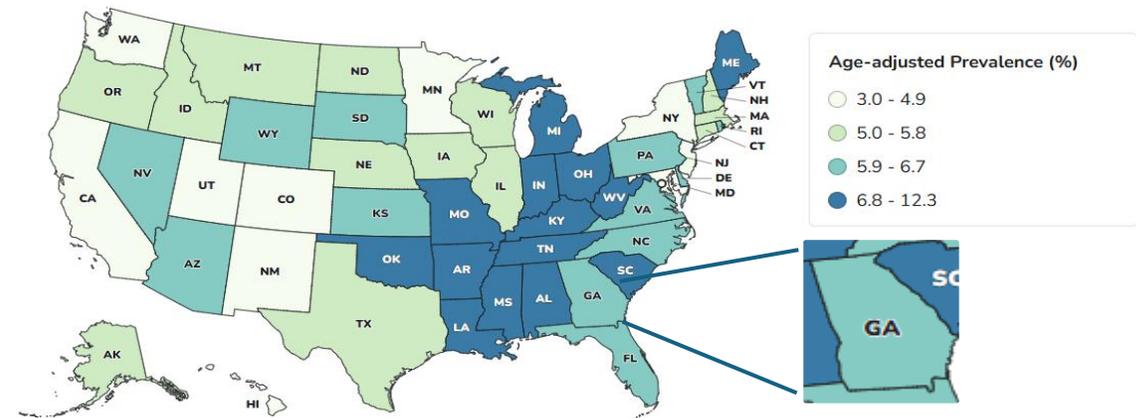
- O2 use at rest [HR] 2.44 [95% CI: 1.45, 4.10]),
- Lower FVC % predicted (HR 1.28 [95% CI: 1.10, 1.49] per 10% decrease)
- Lower DLco % predicted (HR 1.25 [95% CI: 1.04, 1.51] per 10% decrease)

From: [Predictors of death or lung transplant after a diagnosis of idiopathic pulmonary fibrosis: insights from the IPF-PRO Registry](#)



Kaplan-Meier estimate of time from enrolment in the IPF-PRO Registry to death or lung transplant

COPD continues to place a heavy burden on adults in Georgia



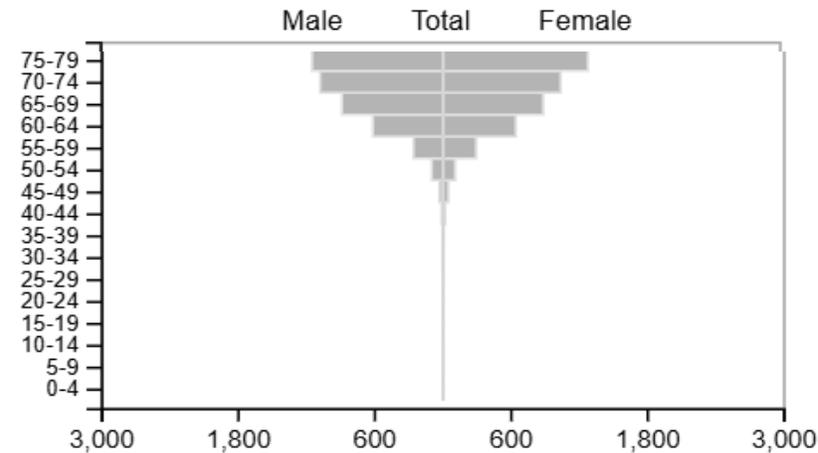
COPD patients face a significantly higher risk of developing depression and anxiety compared to people without COPD.

In Georgia, prevalence of depression in patients with COPD was 44%

Compared to adults without COPD, those diagnosed with COPD in Georgia reported ⁵:

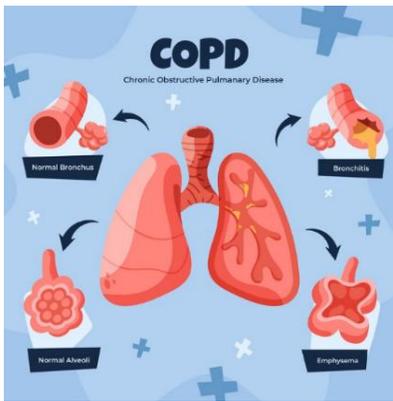
Indicator	COPD	Comparison	No COPD
Having less than a high school education	29.9%	👎	11.7%
Earning less than \$15,000 in household income	13.9%	👎	7.6%
Currently smoking	35.4%	👎	13.6%
Average number of bad mental health days in the last month	16.7	👎	11.1

Georgia, 2022 - 2024



Year	Age in Years	Total Males	Total Females	Total
2022 - 2024	45-49	34	46	80
2022 - 2024	50-54	100	106	206
2022 - 2024	55-59	261	290	551
2022 - 2024	60-64	618	638	1,256
2022 - 2024	65-69	890	880	1,770
2022 - 2024	70-74	1,082	1,033	2,115

In 2022-24 >3500 individuals with COPD died age between age 45-69yo



COPD Referral

BODE index of 5 to 6

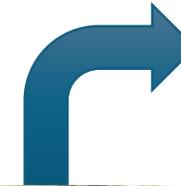
Frequent exacerbations

FEV1 <25% of predicted.

Hypercapnia ($\text{PaCO}_2 \geq 50\text{mm Hg}$ on room air) and/ or Hypoxemia ($\text{PaO}_2 \leq 55\text{ mm Hg}$ on room air)

What are the impacts of lung transplant?

Quality of Life

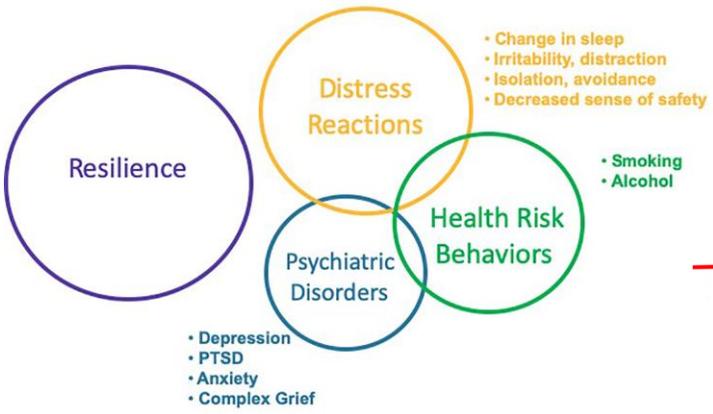


Length of life

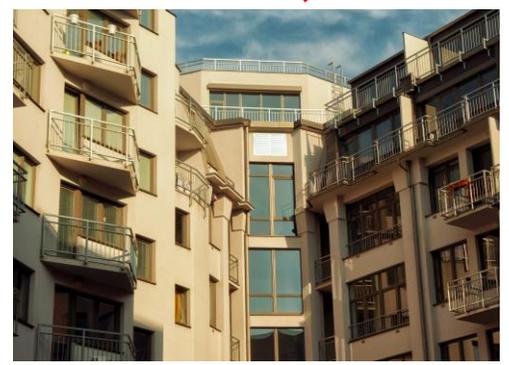


EMORY
UNIVERSITY

Emory Lung Transplant COPD Initiative



1. Mental Health Support
New Lung Transplant
Psychologist for outpatient
and inpatient



2. Housing opportunity expansion
to allow relocation



**4. Development of Robotic
Lung Transplant Program**



**3. Physical Therapy Pre-TXP
Bootcamp**

Improved Survival Outcomes

- **Comprehensive assessment**: multidisciplinary assessment of candidacy
- **Medical optimization**: Patients can receive interventions to stabilize or improve their condition, such as pulmonary rehabilitation, nutritional support, or management of comorbidities.
- **Avoid late-stage deterioration**: late referrals may become too sick to undergo transplant, increasing mortality
- **Access to bridging therapies**: Early referral gives time to consider mechanical ventilation or ECMO as bridges to transplant if needed

Psychosocial and Financial Planning

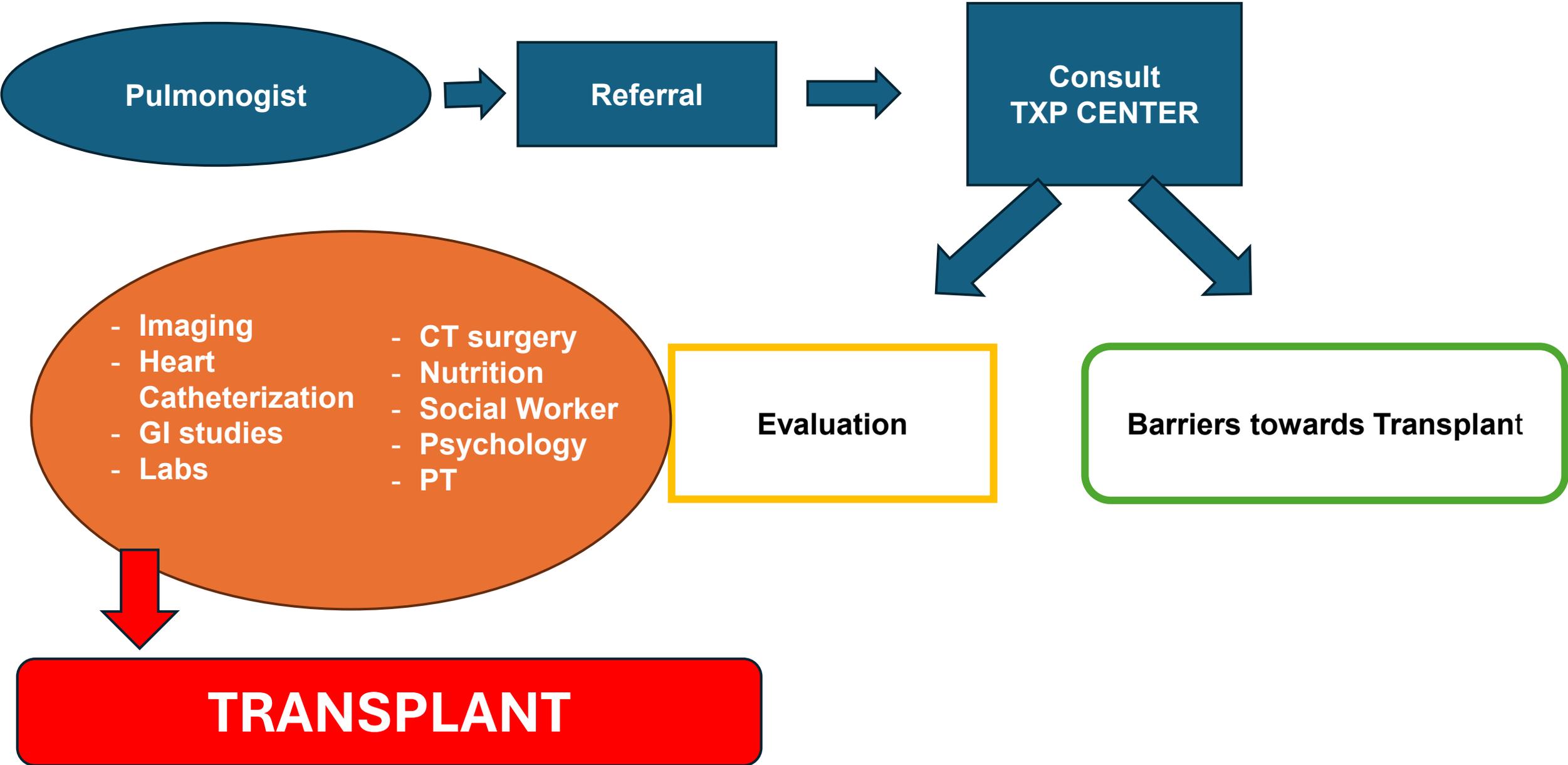
- **Mental preparedness**: Early discussions help patients and families mentally and emotionally prepare for transplant.
- **Social support systems**: Time to build or strengthen support networks, which are crucial for post-transplant recovery.
- **Insurance and logistical planning**

Criteria for Lung Txp Consideration

- Life expectancy of 18 to 24 months.
- Poor Quality of Life precluding to perform daily living activities
- No other life-threatening systemic disease
- Medical and Psychosocial status that will ensure the best chance of good outcome



Lung Transplant Journey



Common Barriers at Consultation

1. BMI > 33 **goals: 33 for eval and 30 for listing**
2. Deconditioning: 6MWT < 300mt **goal > 300**
3. Caregiver Support challenges: spouse, relatives, work
4. Financial Planning: Out of pocket costs of transplant
5. Lack of Abstinence: 6 months

Absolute Contraindications to Lung Transplant

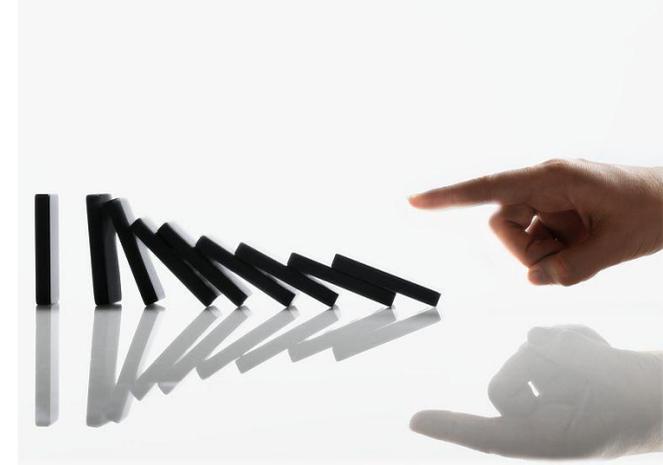
- **Lack of acceptance** or willingness
- **Active disseminated infection** or severe infection causing sepsis
- Newly diagnosed and/or untreated **Malignancy** with high risk of recurrence
- **Significant dysfunction of other organs**
 - Kidney, Liver , Heart Failure
 - Coronary Artery Disease not amenable to revascularization
 - Untreatable hematologic disorders (bleeding, bone marrow dysfunction)
 - Stroke within 30 days
- **Active Substance use or dependence** including tobacco, Alcohol, cannabis and IV drugs
- **Limited Functional status with poor potential for improvement**
- Repeated episodes of **non-adherence**

The Importance of Pulmonary Rehabilitation

Chronic Lung Disease

Sarcopenia/Frailty

Increased Mortality



- Up to 40–60% of candidates are frail at listing
- Rehabilitation is a modifiable factor

Published in final edited form as:

Am J Transplant. 2021 June ; 21(6): 2018–2024. doi:10.1111/ajt.16439.

Frailty and Aging-Associated Syndromes in Lung Transplant Candidates and Recipients

Joanna M. Schaenman¹, Joshua M. Diamond², John R. Greenland³, Cynthia Gries⁴, Cassie C. Kennedy⁵, Amit D. Parulekar⁶, Dmitry Rozenberg⁷, Jonathan P. Singer³, Lianne G. Sinaer⁷, Laurie D. Snyder⁸, Sanaeeta Bhorade⁹

A clinical state indicating a loss of resilience and decreased functional status, independent of comorbidity or disability.

Schaenman et al.

Page 14

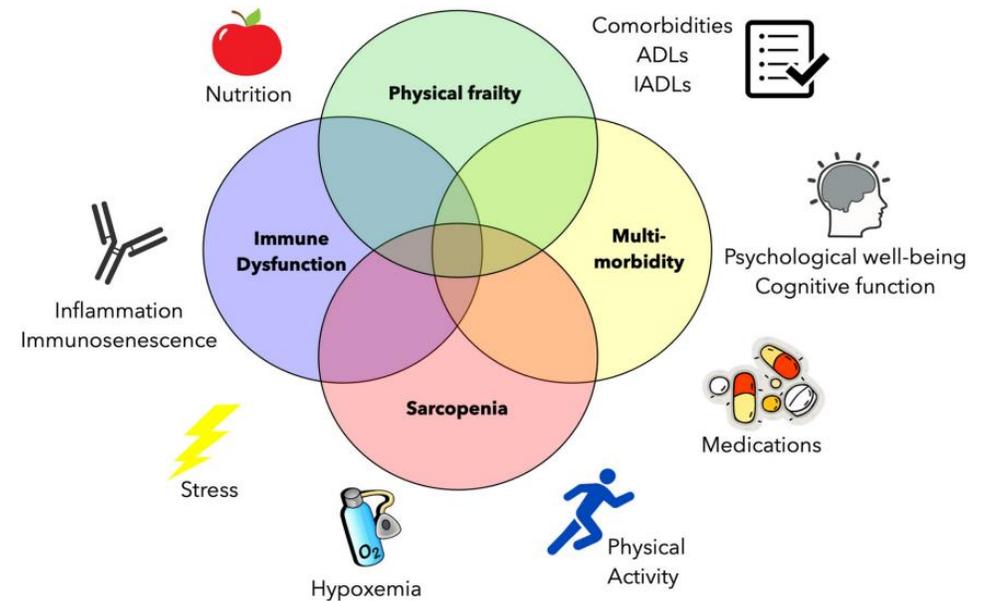


Figure 1: Conceptual Framework of Frailty and Aging-associated Dysfunction in Lung Transplant Candidates. Venn diagram demonstrates the age-related biologic constructs that may overlap with frailty, including multi-morbidity, sarcopenia, and immune system dysfunction, along with health-related issues that may contribute to these manifestations of aging.

frailty is not strictly determined by chronological age

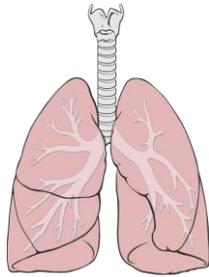


Systemic Inflammation
Muscle Protein Breakdown

Chronic Hypoxia
Mitochondrial Dysfunction

**Physical Inactivity &
Dyspnea Cycle**

Chronic Lung Disease



**Respiratory Muscle
Involvement**

Oxidative Stress

Energy Imbalance

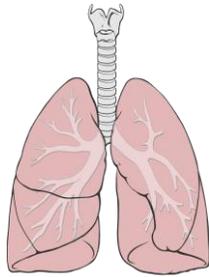


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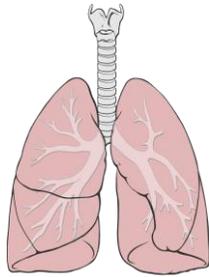


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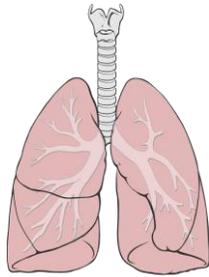
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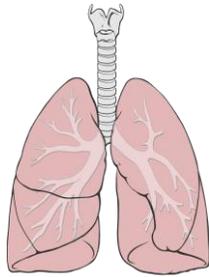


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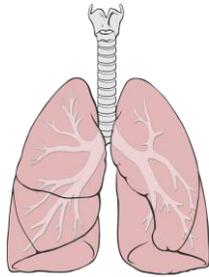


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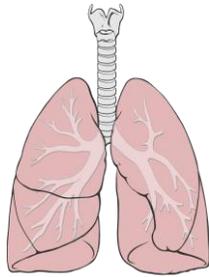


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Why It Becomes a Vicious Cycle

Chronic Lung Disease

Sarcopenia

Increased Mortality



STOP

This cycle strongly predicts:
Hospitalization risk
ICU admission
Mortality

“an evidence-based, multidisciplinary, and comprehensive intervention for symptomatic patients with chronic respiratory disease that present decreased activities of daily living.”

***PR aims to:
reduce symptoms,
optimize functional status,
increase participation,
reduce healthcare costs
making the manifestations of the
disease stable or reversible”***





PRE TRANSPLANT PULMONARY REHAB



Pulmonary rehabilitation in lung transplant candidates

Melinda Li, MD,^a Sunita Mathur, PhD,^b Noori A. Chowdhury, MPH,^c Denise Helm, BSc, PT,^{b,c} and Lianne G. Singer, MD^{a,c}

The Journal of
Heart and Lung
Transplantation
<http://www.jhltonline.org>

The pulmonary rehabilitation program

- stretching,
- aerobic exercise
- resistance training

Aerobic exercises include arm ergometer, cycle ergometer and treadmill training

3 times per week for 1.5 to 2 hours per session

In a **retrospective cohort of 345 lung transplant candidates**, exercise capacity was preserved and training volumes increased during pulmonary rehab, with **higher final 6-minute walk distance (6MWD) associated with shorter post-transplant hospital stays**



ORIGINAL CLINICAL SCIENCE

Lung transplant candidates' quadriceps strength is a modifiable predictor of recovery in exercise capacity after transplantation



James R. Walsh, BPhy PhD,^{a,b,c}
Norman R. Morris, BSc DipEd BAppSc(Phty) PhD,^{b,c}
Stephanie T. Yerkovich, BSc (Hons) MBIostats PhD,^{d,e}
Matthew P. Linnane, BPhy,^b
Daniel C. Chambers, MBBS (Hons) MRCP FRACP MD,^{a,f} and
Peter M.A. Hopkins, MBBS (Hons) FRACP^{a,f}

The Journal of
Heart and Lung
Transplantation
<http://www.jhltonline.org>

342 Lung Transplant Recipients enrolled
192 males;
mean (± SD) age 51 ± 14 years;

119 COPD, 93 IIP, 72 cystic fibrosis,
and 58 other

Pre-transplant quadriceps strength and 6MWD are **independent predictors of post-transplant exercise recovery**, indicating muscular strength gained in rehab translates to functional gains after surgery.

Pre-lung Transplant Physical Conditioning Afforded Through Pulmonary Rehabilitation: Assessment Via Cardiopulmonary Exercise Testing and Associations With Post-transplant Clinical Outcomes

D. R. Nunley¹, G. S. Bauldoff², E. Martini³, A. Strickland⁴, K. Maas³, T. Yurjevic³, J. Thistlethwaite⁵;

¹Pulmonary Medicine, The Ohio State University, Columbus, OH, United States, ²College of Nursing, Ohio State Univ, Columbus, OH, United States, ³Ohio State University Wexner Medical Center, The Ohio State University, Columbus, OH, United States, ⁴Pulmonary Diagnostic Lab, The Ohio State University Wexner Medical Center, Columbus, OH, United States, ⁵Health and Sports Studies, Wittenberg University, Springfield, OH, United States.

- Higher functional measures correlated with better one-year clinical outcomes. **6MWD ≥ 1200 ft had significantly more hospital-free days in the first post-transplant year (p = 0.02).**
- Improvements in peak work and 6MWD after pre-LTX PR were observed and associated with favorable outcomes
- Overall, both baseline conditioning and modifiable improvements through PR predicted greater recovery and reduced health-care utilization in the first year.

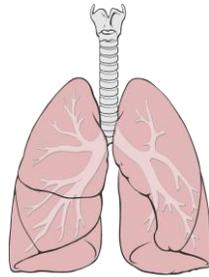


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Post-Transplant Challenges

SCIENTIFIC REPORTS

OPEN Pulmonary rehabilitation improves survival in patients with idiopathic pulmonary fibrosis undergoing lung transplantation

Juliessa Florian^{1,2,3}, Guilherme Watte^{2,3}, Paulo José Zimmermann Teixeira^{3,4}, Stephan Altmayer⁵, Sadi Marcelo Schio², Letícia Beatriz Sanchez², Douglas Zaione Nascimento², Spencer Marcantonio Camargo², Fabiola Adélia Perin², José de Jesus Camargo², José Carlos Felicetti² & José da Silva Moreira¹

Study of 89 patients with idiopathic pulmonary fibrosis\

36-session, 3-times-a-week, structured outpatient, supervised PR program including warm-up, muscle strengthening, and aerobic exercises.

- **Completing a 36-session pulmonary rehabilitation program while on the waiting list reduced the risk of death after transplantation by 54% (hazard ratio 0.464, 95% CI 0.222-0.970)**

Original Article



Effectiveness of pulmonary rehabilitation on exercise capacity in adult patients with lung transplantation: a systematic review and single-arm meta-analysis

Peijian Wang^{1#}, Beiyao Gao^{1#}, Siyuan Wang^{1#}, Zhao Wang¹, Li Zhao^{2,3,4,5,6}, Yajing Duan¹, Lijun Ge¹, Shan Jiang¹, Wenhui Chen^{2,3,4,5,6}

Meta-Analysis:

- Pooled data from 21 studies show pulmonary rehab post lung txp
- 1488 participants

Structured PR significantly improves:

- 6MW distance
- handgrip strength
- quadriceps force

Mental health-related quality of life consistently improves following pulmonary rehabilitation.

- A large retrospective analysis of 811 lung transplant candidates demonstrated that the mental component summary of the SF-36 improved by 8.7 ± 13.5 points ($P < 0.001$) after a 5-week inpatient rehabilitation program, representing clinically meaningful improvement.
- Study of 722 post-transplant patients found significant improvements in mental component scores regardless of whether patients received single or double lung transplantation (improvements ranging from 7-10 points)

Klenn et al Transplantation 2015 May;99(5):1072-7.

Schneeberger et al Respiration 2017. 2017;94(2):178-185

Common barriers:

- Dyspnea limiting effort
- Hospitalizations interrupting PR
- Fluctuating oxygen requirements
- Patient motivation and psychosocial factors

Approaches:

- Pacing strategies, supplemental oxygen planning
- Coordination with transplant teams
- Psychosocial support integration
- Telerehab

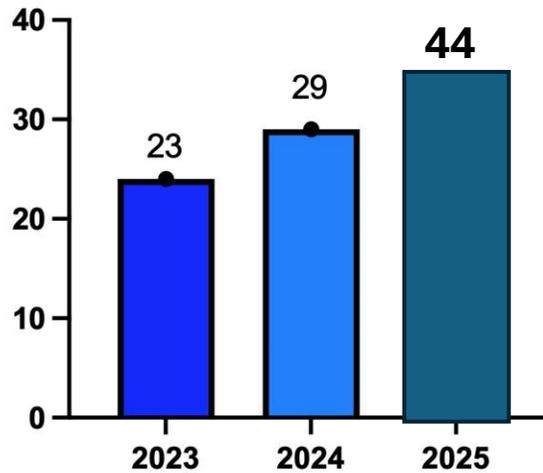
- Lung transplant patients remain one of the most **clinically complex populations** we manage.
- Rehab expertise is central to **optimizing both survival and quality of life.**
- **Your role in delivering and refining PR protocols directly influences transplant success**



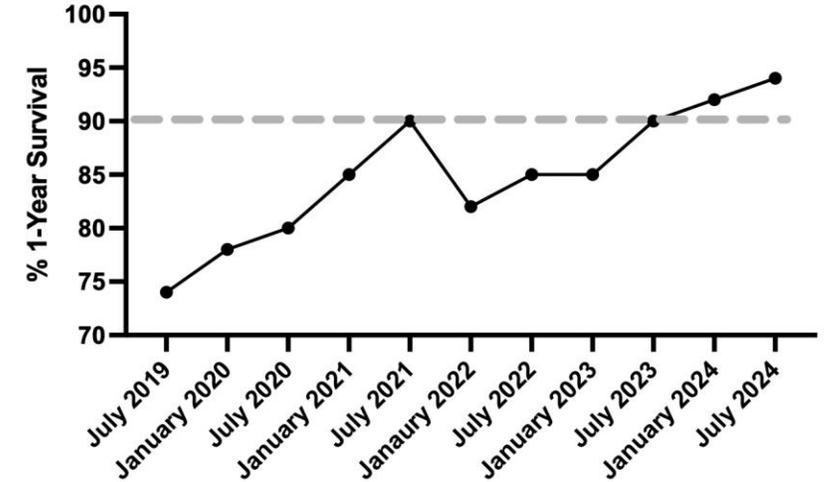
Improved Metrics of Emory Lung Transplants



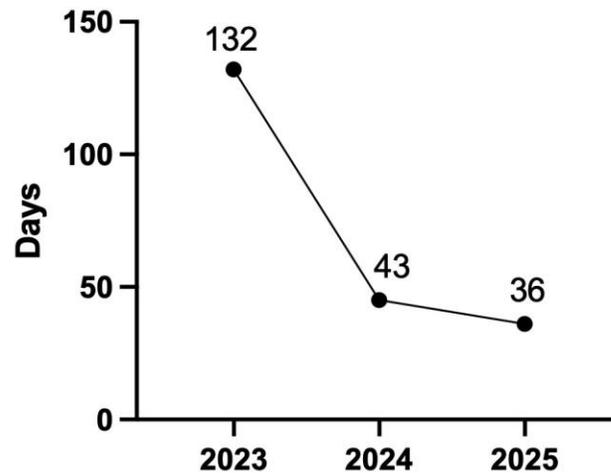
Lung Transplants (N)



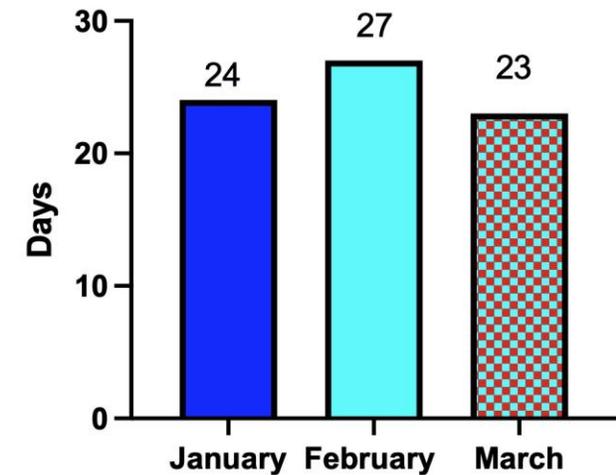
1-Year Survival



Waitlist Time



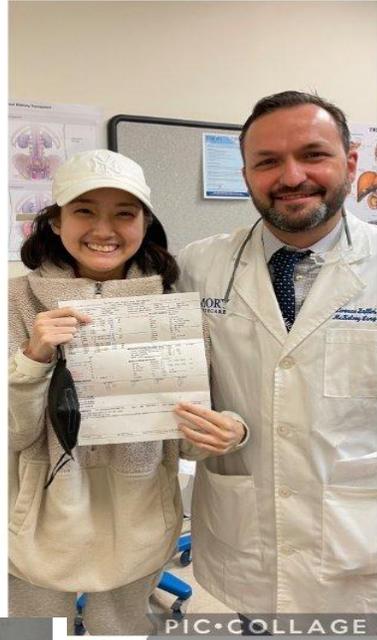
Post-TXP length of stay



WHY DO WE DO IT?

1. To Improve the Quality of Life: Reduce symptoms, stop using oxygen, improving social functioning
2. To increase Survival: transplant can significantly extend their lifespan
3. To Be Present in important life events







Lorenzo Zaffiri

Email: lorenzo.zaffiri@emory.edu