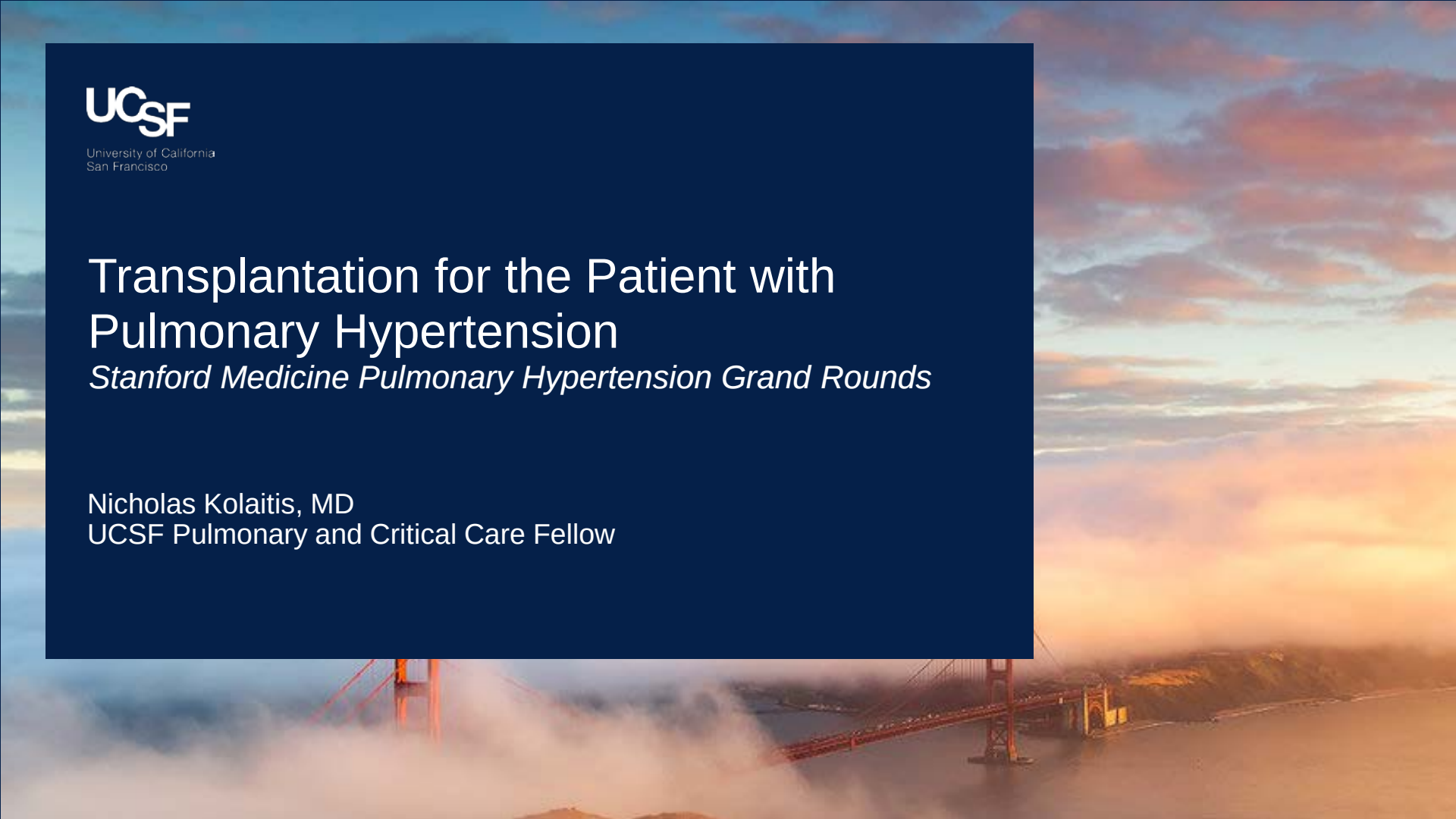

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Transplantation for the Patient with Pulmonary Hypertension

Stanford Medicine Pulmonary Hypertension Grand Rounds

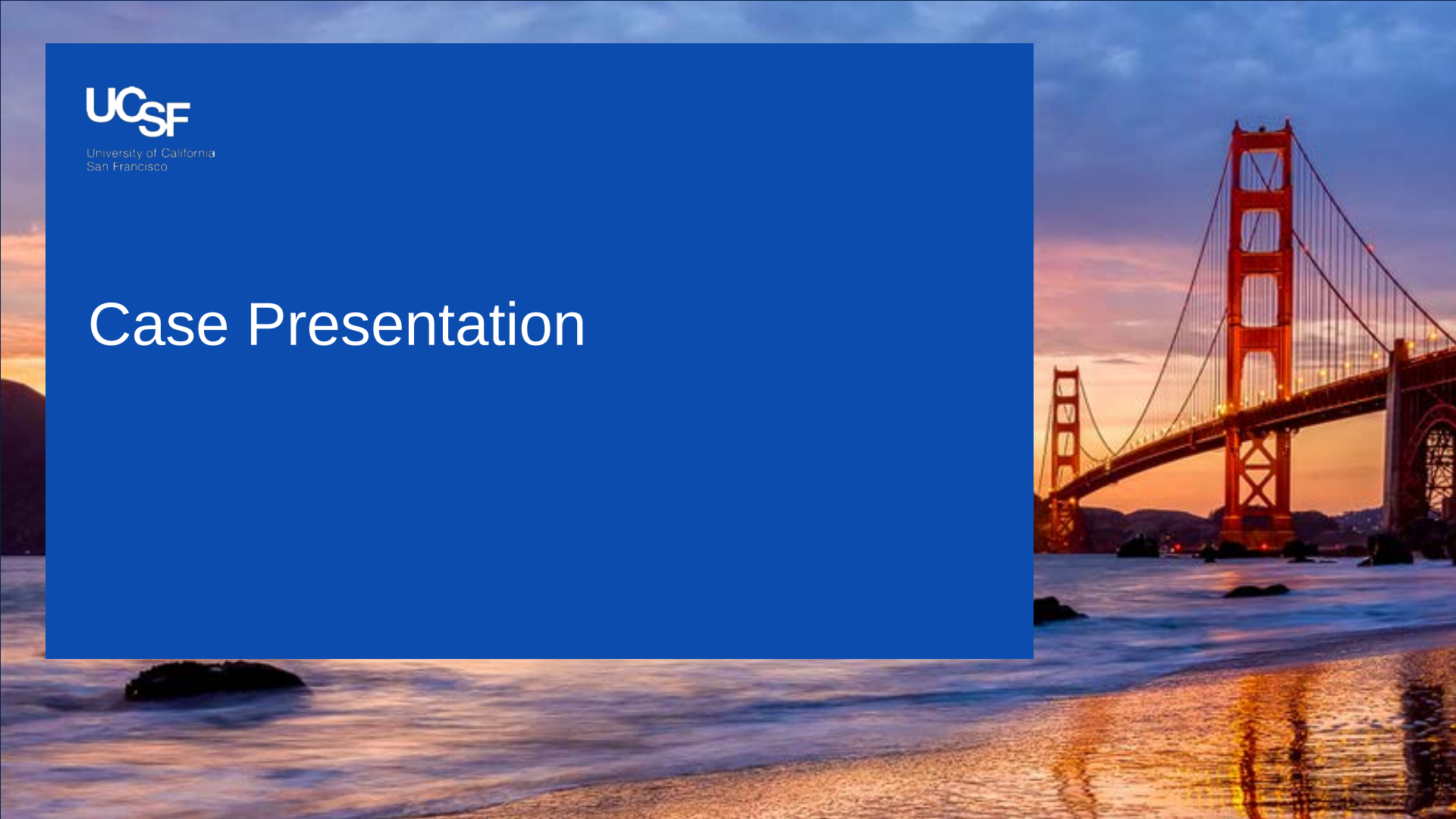
Nicholas Kolaitis, MD
UCSF Pulmonary and Critical Care Fellow

Disclosures

- Sub investigator in clinical trial through United Therapeutics
- Otherwise no relevant financial conflicts of interest

Outline

- Challenges of Organ Transplantation for PAH
- Lung Transplant vs Heart-Lung Transplant
- Deploying ECMO in the setting of PAH
- Perioperative management of transplant in PAH



Case Presentation

Case Presentation: HPI

- 57 yo F with a history of scleroderma, interstitial lung disease (ILD), and pulmonary arterial hypertension (PAH)
- Diagnosed with ILD after developing symptoms of dyspnea
- One year later she had hand swelling
  - Connective tissue disease serologies sent
- Diagnosed with scleroderma
- Underwent right heart catheterization and was diagnosed with PAH

Case Presentation: HPI

- Initially started on sildenafil, ambrisentan, lasix, spironolactone
- Clinically worsened and five years later she was started on Remodulin
- Remodulin was titrated up to 30 ng/kg/min
- Presented to UCSF from Chicago for lung transplant evaluation

Case Presentation: HPI

- Dyspnea with 50 feet
- Required 4-5 L of oxygen with exertion

Case Presentation: Physical Exam

- Vitals: Blood pressure 97/65; ***Pulse 121***; Temp: 36.6 °C; RR: 20, ***SpO2 90 % on 5L NC***
- PULM: ***Bibasilar crackles***, moving air, ***bronchial breath sounds***
- CV: ***JVD elevated, RV Lift noted, Accentuated P2, 2/6 SEM***
- Ext: ***2+ edema*** up to knees bilaterally

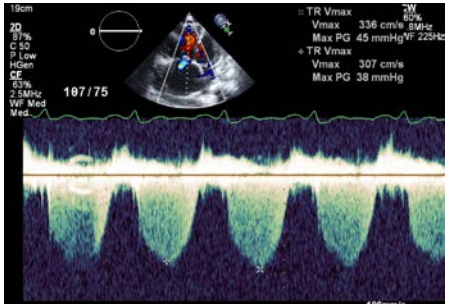
Case Presentation: Labs

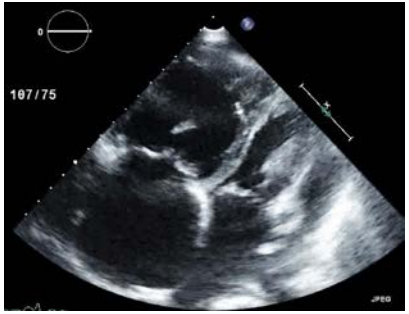
- WBC 4.7
- Hct 37.9
- PLT 161

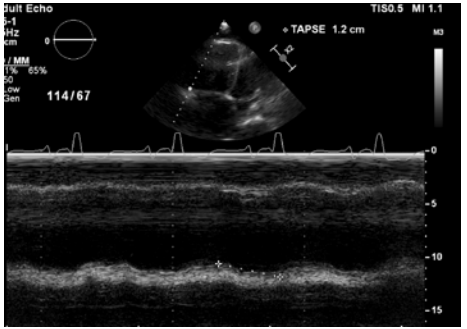
Na	135
K	***3.4***
Co2	24
Cr	0.82
BUN	21
Mg	1.8
Phos	3.9
BNP	***422***

pH	7.45
PCO2	38
PO2	132

Case Presentation: Baseline ECHO







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Case Presentation: Right Heart Catheterization

Pressures:

RA Presure: ***14***

RV Pressure: ***59/2 (16)***

PA Pressure: ***62/27 (41)***

PCW Pressure: 11

PVR: ***6.25 woods units***

Cardiac Output:

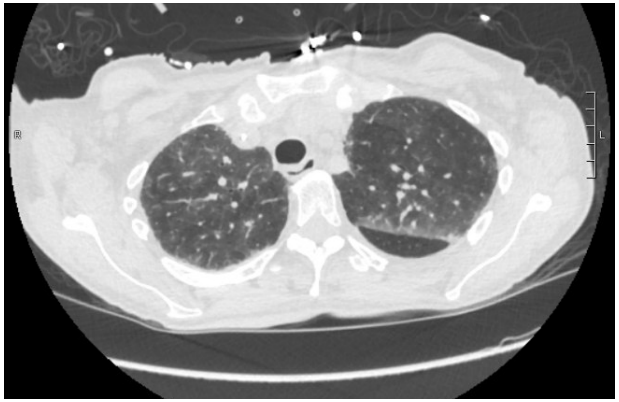
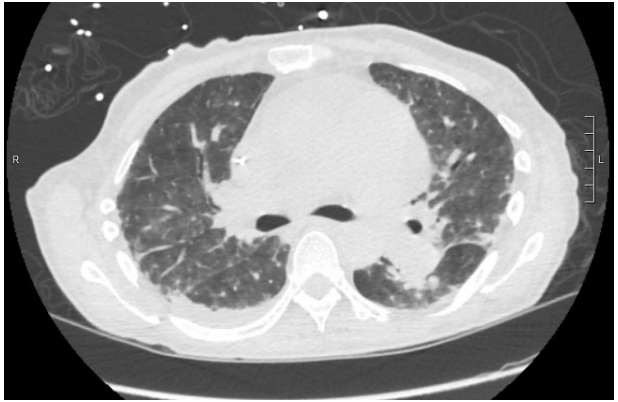
Fick: 4.8 L/min

Thermodilution: 4.45 L/min

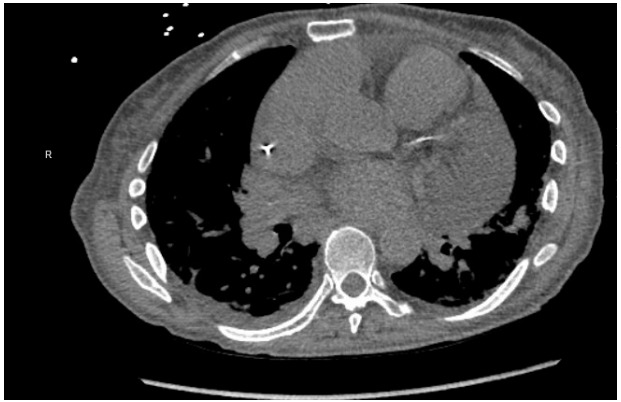
Cardiac Index

Fick: 2.5 L/min/m^2

Thermodilution: 2.32 L/min/m^2





Case Presentation: Next Steps

- Determined to be a candidate for work up
- Recommended diuresis and relocation
- Two weeks later moved to San Mateo to initiate lung transplant evaluation
- Directly admitted for IV diuresis and expedited work up

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Challenges of Organ Transplantation for PAH

Outline

- **Challenges of Organ Transplantation for PAH**
- Lung Transplant vs Heart-Lung Transplant
- Deploying ECMO in the setting of PAH
- Perioperative management of transplant in PAH

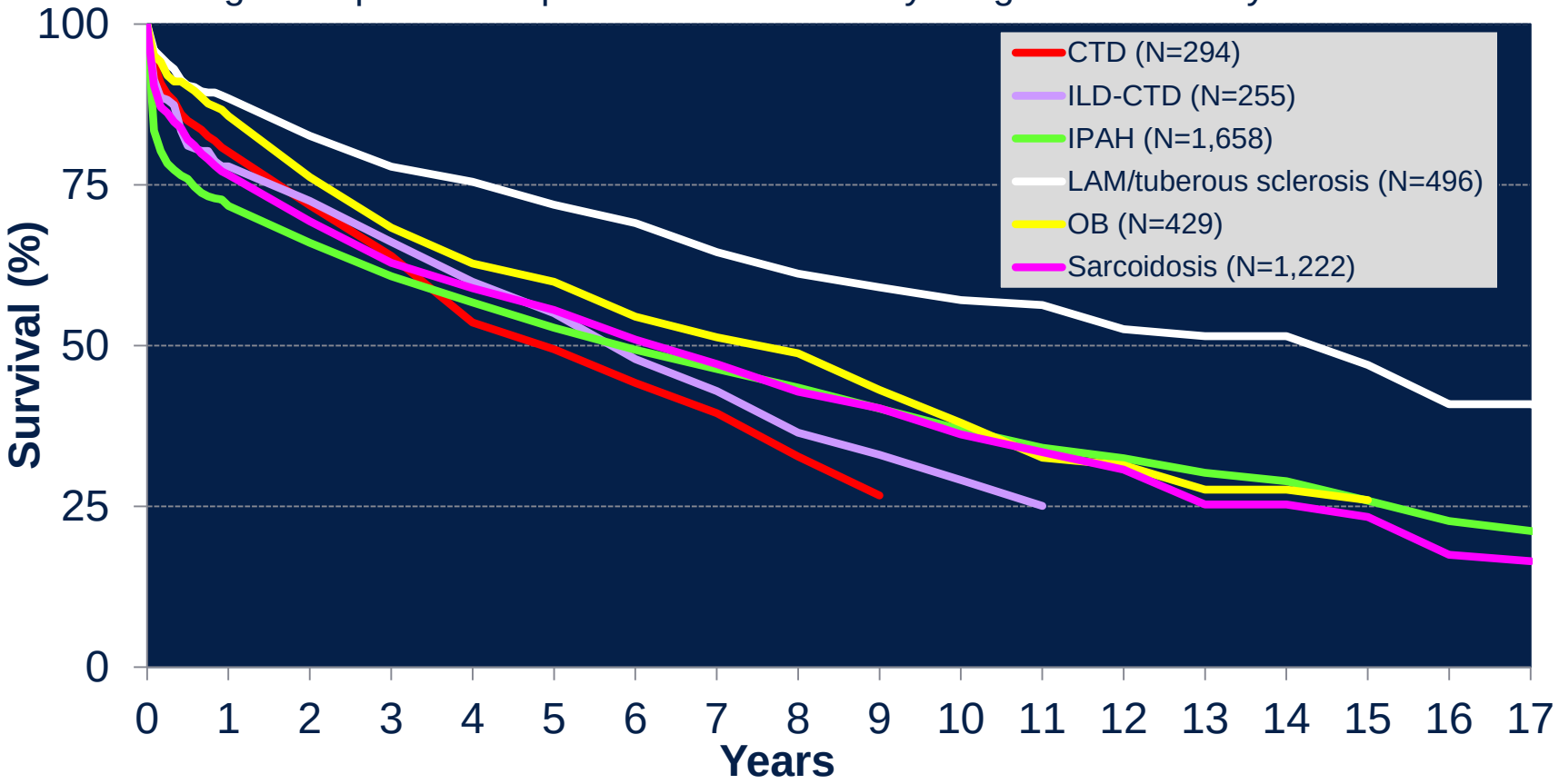
Lung Transplantation in PAH

- Lung transplant is a viable option in PAH to improve life expectancy and quality of life
- Double lung transplant is preferred
  - Improved outcomes when compared to single lung transplant recipients
  - Risk of recurrence of PAH after single lung transplant
- Some patients require heart-lung transplantation when they have severe RV failure or anatomical abnormalities

Lung Transplantation in PAH: Numbers

- January 2004-June 2015 ISHLT Registry had 32,237 lung transplant recipients
  - 897 of them were IPAH and 276 PH-not IPAH (3.6% of lung transplants)
- January 2004-June 2015 ISHLT Registry had 812 combined heart-lung transplant recipients
  - 222 IPAH (27.3% of combined heart-lung transplant recipients)
- Thus, 4.1% of all lung or heart-lung transplant recipients have pulmonary hypertension as primary diagnosis

Adult Lung Transplants - Kaplan-Meier Survival by Diagnosis -January 1990-June 2014



Lung Transplantation in PAH: Survival

- Early survival is worse than in other diagnostic groups
  - Possibly due to increased likelihood of early complications (e.g. primary graft dysfunction)
  - Possibly due to patients being further along in disease progression relative to patients listed with other diagnoses

Lung Allocation History

- In United States donor lung allocation occurs through the Organ Procurement and Transplantation Network (OTPN)
  - Operated by United Network for Organ Sharing (UNOS)
- Prior to 2005, time on waiting list was used to determine priority
- High waiting list mortality for certain diagnoses (e.g. IPF)

Lung Allocation History: Lung Allocation Score

- In May 2005 the OPTN introduced the Lung Allocation Score (LAS)
  - Calculated score by need based on clinical parameters
    - (e.g. FVC, age, 6MWD, oxygen requirements)
  - Goal to maximize transplant benefit and minimize risk of wait list death
  - Score ranges 0 to 100 with higher numbers representing sicker patients

	25th percentile	Median	75th percentile	90th percentile	99th percentile
Current Iteration	33.3	35.5	39.9	47.2	85.6

Lung Allocation History: Kozower et al. 2008

- Kozower J Thorac Cardiovasc Surg. 2008
  - Multicenter retrospective cohort from 5 academic medical centers
- LAS reduced the waiting time for transplant recipients
  - 680.9 days pre LAS vs 445.6 days post LAS; P < .001

Lung Allocation History: Kozower et al. 2008

	Pre-LAS (n = 170)	LAS (n = 171)	P value
Etiology of end-stage lung disease			
COPD	78 (45.9%)	58 (33.9%)	
Cystic fibrosis	39 (22.9%)	22 (12.9%)	
Idiopathic pulmonary fibrosis	25 (14.7%)	42 (24.6%)	.002
Pulmonary hypertension	7 (4.1%)	4 (2.3%)	
Other	21 (12.4%)	45 (26.3%)	

LAS, Lung allocation score; *COPD*, chronic obstructive pulmonary disease.

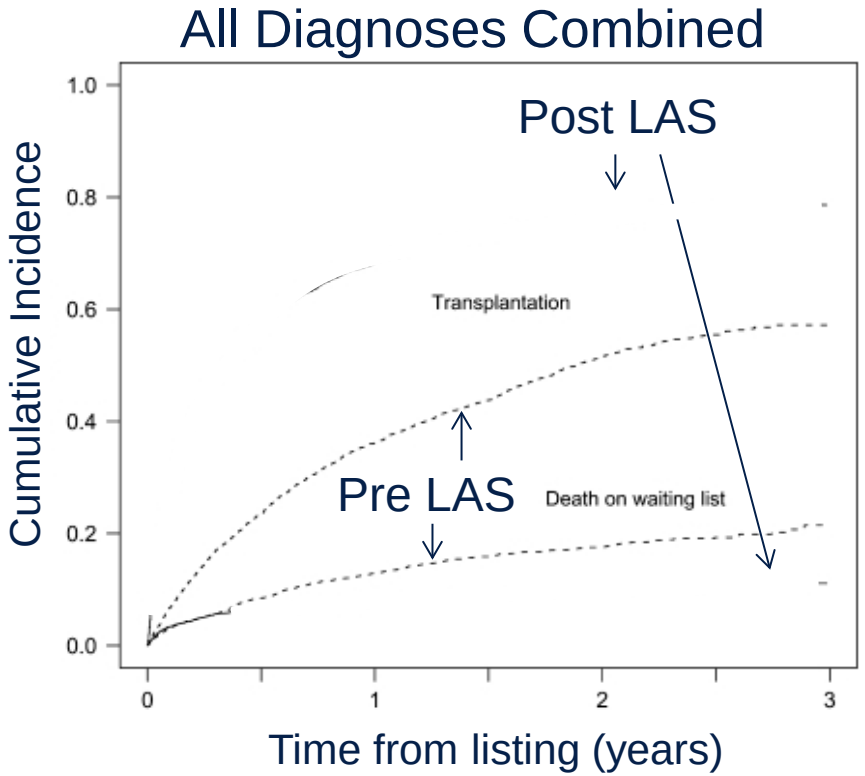
Diagnosis	PAH	IPF	PAH	IPF
Age	37 years old	64 years old	27 years old	54 years old
Assistance	Some	Some	Total	Total
Diabetes	None	Not Diabetic	None	Not diabetic
Assisted Ventilation	None	CPAP at night	Continuous Mechanical	Continuous Mechanical
Oxygen Use	6L at rest	4L at rest	100% on VA ECMO Circuit	100% on tracheostomy
% FVC	4.45 (95% predicted)	1.67 (61% predicted)	Could not obtain	2.6 (75% predicted)
6MWD	948 feet	936 feet	0 feet	591 feet
PASP	95 mmHg	37 mmHg	181 mmHg	94 mmHg
Mean PAP	54 mmHg	23 mmHg	110 mmHg	59 mmHg
CI	2.44 L/min/m2	2.4 L/min/m2	Could not obtain	Could not obtain
CVP	12 mmHg	0 mmHg	11mmHg	9 mmHg
CO2	39	46	40	76
Creatinine	1.51	0.85	2.1	0.52
Bilirubin	0.9	0.8	1.3	1.0
Other Data	On IV epoprostenol and dobutamine	Outpatient	ECMO and ventilator and triple therapy with IV epoprostenol	Trached on ventilator

LAS Score	32.6076	39.5996	37.1235	94.3824

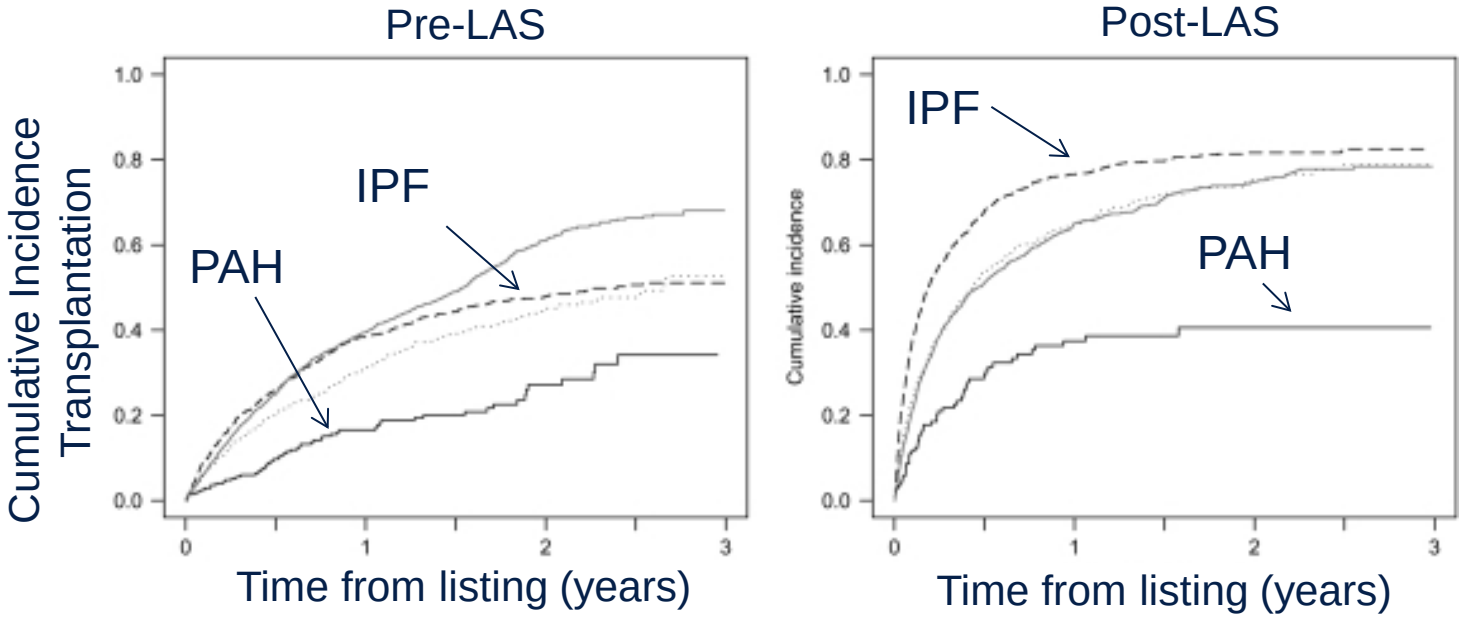
Lung Allocation History: Chen et al. 2009

- Chen et al. Am J Respir Crit Care Med 2009
- 7,952 adults listed for transplant through UNOS between 2002-2008
  - Excluded Heart-Lung Transplant listings
- Compared transplantation, waiting list mortality

Lung Allocation History: Chen et al. 2009

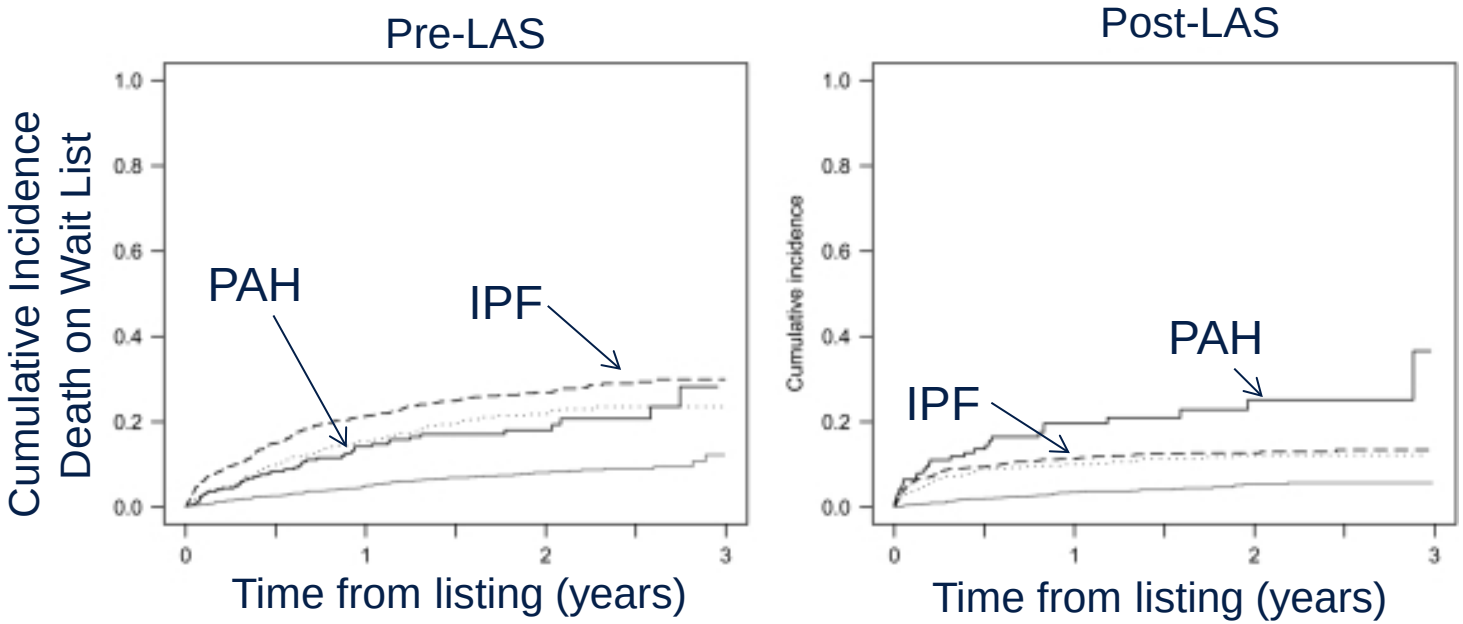


Lung Allocation History: Chen et al. 2009



Idiopathic pulmonary arterial hypertension (*solid line*).
Idiopathic pulmonary fibrosis (*dashed line*).
Chronic obstructive pulmonary disease (*gray line*).
Cystic fibrosis (*dotted line*).

Lung Allocation History: Chen et al. 2009



Idiopathic pulmonary arterial hypertension (*solid line*).
Idiopathic pulmonary fibrosis (*dashed line*).
Chronic obstructive pulmonary disease (*gray line*).
Cystic fibrosis (*dotted line*).

Lung Allocation History: Chen et al. 2009

- Likelihood of transplantation improved for all diagnosis after LAS implementation
- IPAH was the only diagnosis for which wait list mortality did not improve

Lung Allocation History: Exceptions

- In 2006 UNOS started sending out letters to programs for PAH exception
  - Candidates with pulmonary hypertension who are deteriorating on optimal therapy *AND* have RAP >15 mmHg or CI <1.8 L/min/m^2
  - Placed at 90th percentile of National Average

	25th percentile	Median	75th percentile	90th percentile	99th percentile
Current Iteration	33.3	35.5	39.9	47.2	85.6

Lung Allocation History: Exceptions

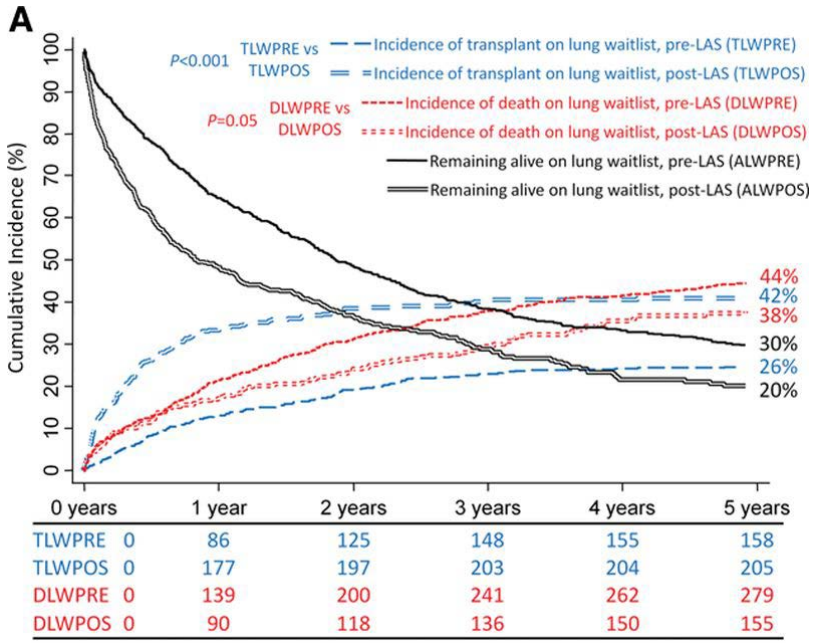
- Many programs started asking for exceptions to get higher score for patients
- Willie et al. J Heart Lung Transplant. 2017 reviewed all exception requests between 2006-2014
  - PAH is the most common diagnostic category for which requests are made
  - Demonstrated more frequent exception requests over time
  - 22 PAH requests in 2006 rose to 118 PAH requests in 2014

Lung Allocation History: Schaffer et al. 2013

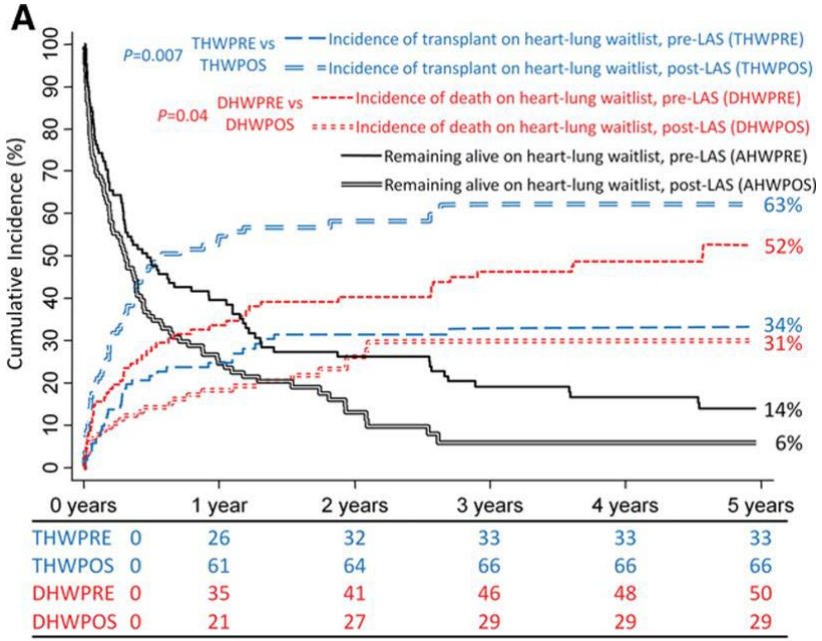
- Schaffer JM et al. Circulation 2013
- 1430 adults listed for lung alone or heart-lung transplant for IPAH
  - 80 months before and after implementation of LAS
  - Analyzed data through 2011 (three years after Chen et al.)
- Evaluated in a competing-outcomes analysis the cumulative incidence of transplantation and mortality on waitlist
- Also evaluated post transplant survival

Lung Allocation History: Schaffer et al. 2013

Lung Transplants

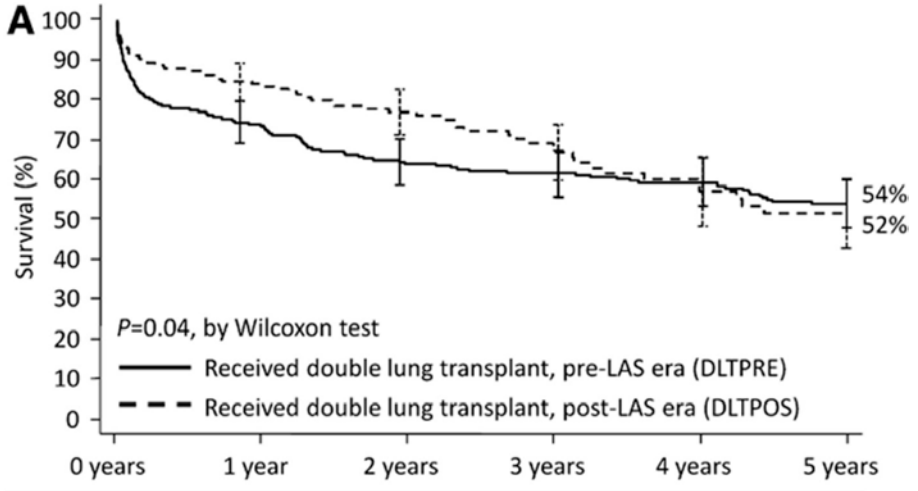


Heart-Lung Transplants



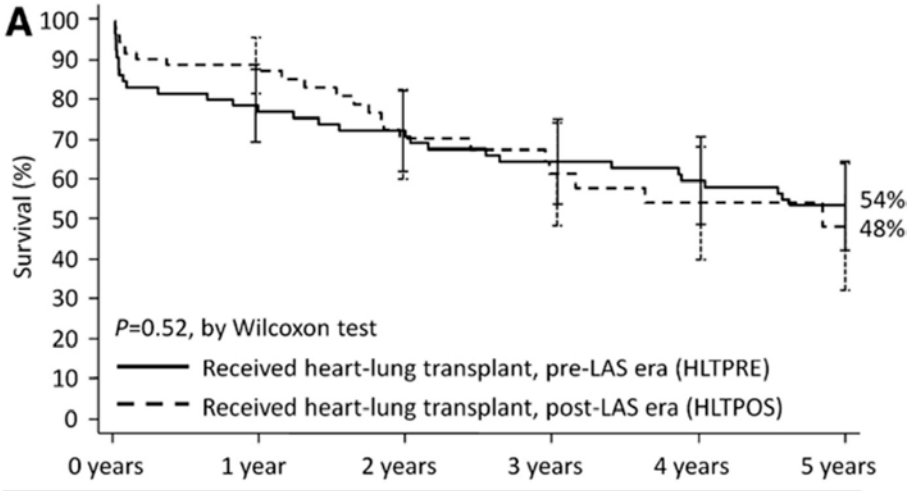
Lung Allocation History: Schaffer et al. 2013

Lung Transplant



DLTPRE	225	164	140	134	126	111
DLTPOS	223	143	94	57	39	19

Heart-Lung Transplant



HLTPRE	66	51	46	42	38	35
HLTPOS	75	54	31	20	15	8

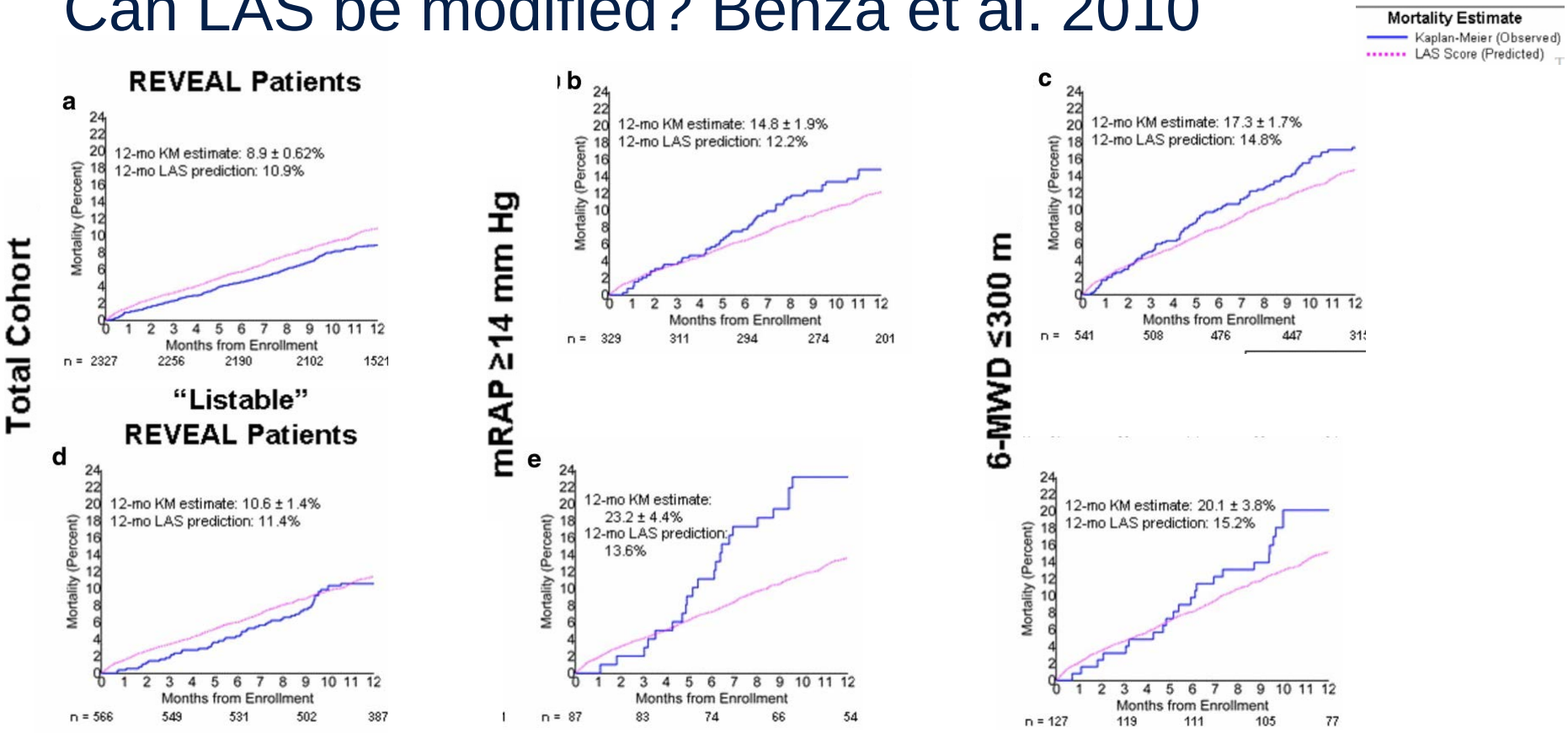
Lung Allocation History: Schaffer et al. 2013

- Incidence of transplantation has increased after LAS for IPAH
- Wait list mortality has now decreased in patients with IPAH after LAS
  - Later time period than Chen et al.
- Despite transplantation of a sicker cohort of patients (based on need) early post-transplant survival has improved

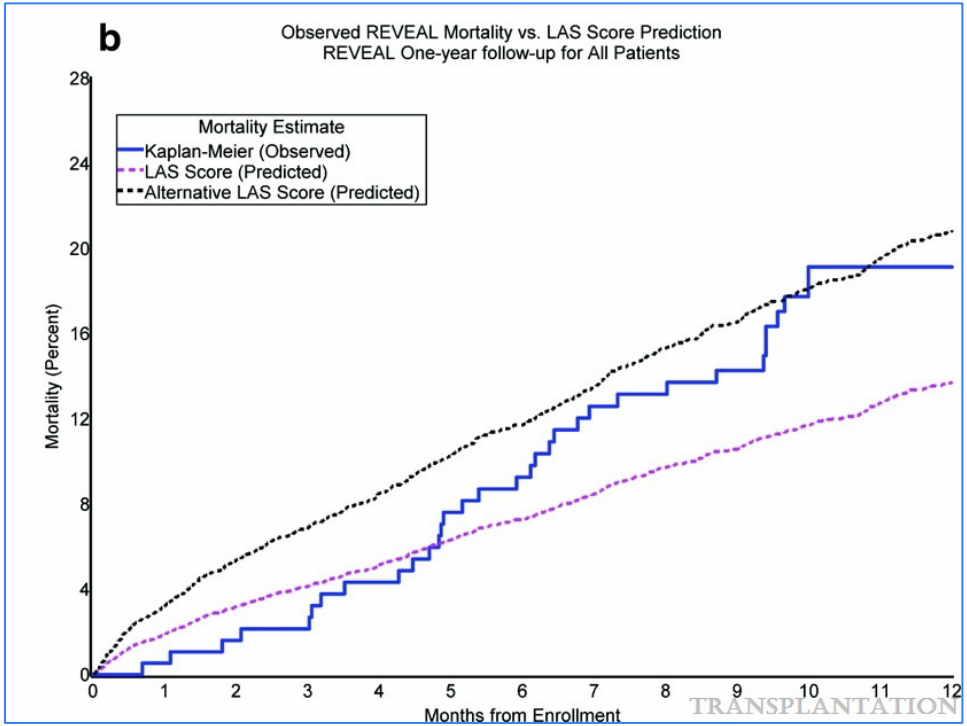
Can LAS be modified? Benza et al. 2010

- Benza et al. Transplantation 2010
- 2327 Patients in REVEAL registry
- Compared predicted mortality by LAS to observed mortality in REVEAL
- Sought to identify key parameters independently associated with death
  - Identified 6MWD and mean right atrial presssure (mRAP)
- Created alternative LAS using 6MWD and mRAP

Can LAS be modified? Benza et al. 2010

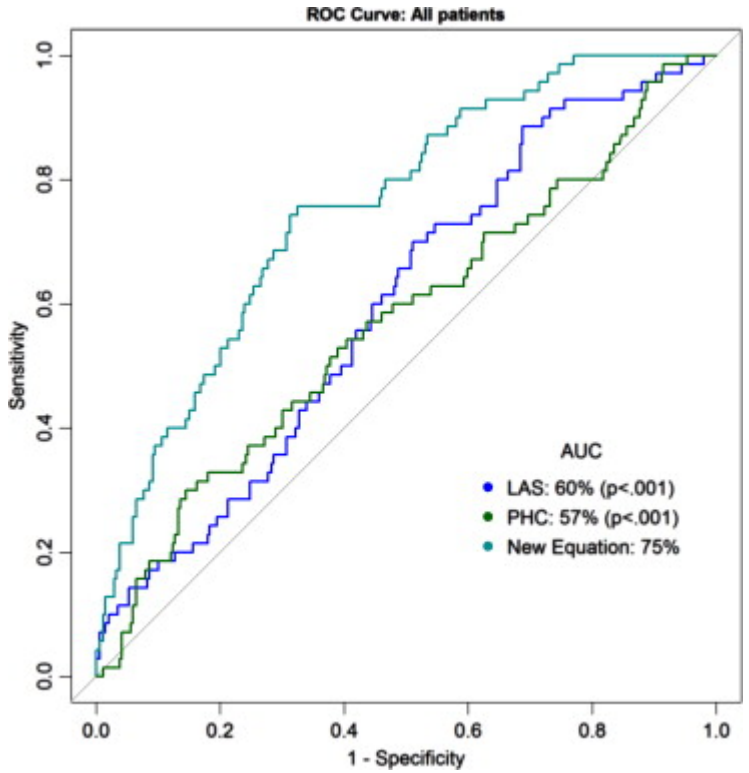


Can LAS be modified? Benza et al. 2010



Can LAS be modified? Gomberg-Maitland et al. 2013

- Gomberg-Maitland et al. J Heart Lung Transplant 2013
  - Created a new equation using 6MWD, cardiac output and resting O2 requirement
  - Outperformed LAS to predict 1 year survival



2015 LAS Revision

- Revision to LAS was made on February 19, 2015
  - Now used Cardiac Index and CVP in algorithm
    - Previous collected but not used
  - Total Bilirubin was added to algorithm
  - Adjusted 6MWD cut offs for impact on score

Diagnosis	PAH	IPF	PAH	IPF
Age	37 years old	64 years old	27 years old	54 years old
Assistance	Some	Some	Total	Total
Diabetes	None	Not Diabetic	None	Not diabetic
Assisted Ventilation	None	CPAP at night	Continuous Mechanical	Continuous Mechanical
Oxygen Use	6L at rest	4L at rest	100% on ECMO Circuit	100% on tracheostomy
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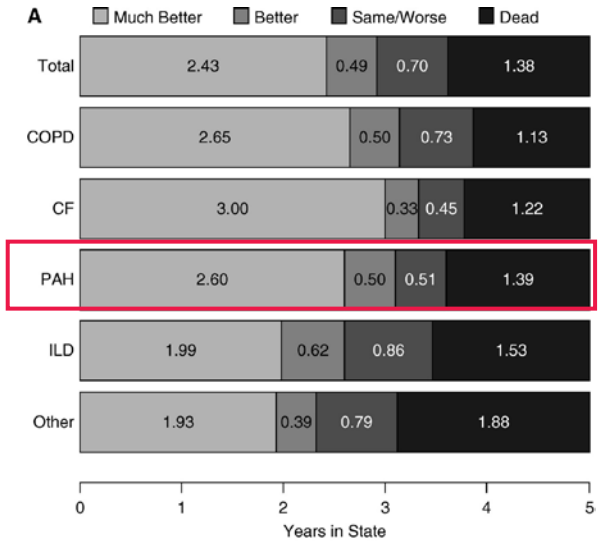
CO2	39	46	40	76
Creatinine	1.51	0.85	2.1	0.52
Bilirubin	0.9	0.8	1.3	1.0
Other Data	On IV epoprostenol/dobutamine	Outpatient	On ECMO and ventilator	Trached on ventilator
LAS Score	32.607	37.1235	39.5996	94.3824
LAS Score after revision	43.6503	36.7965	76.4832	89.2568

Challenges in Transplant for PAH: HRQL



Singer LG et al. Am J Respir Crit Care Med 2015

Table 5: Effect of lung transplantation on HRQL by disease category

	Early change	Test of difference
SF12-PCS (MCID = 5)		
Group A (COPD)	15.9 (11.5, 20.3)	p < 0.001
Group B (PAH)	7.9 (1.0, 14.7)	
Group C (CF)	23.8 (19.5, 28.1)	
Group D (PF)	13.8 (11.9, 15.8)	
SF12-MCS (MCID – 5)		
Group A (COPD)	2.7 (–0.9, 6.4)	p = 0.020
Group B (PAH)	0.1 (–5.6, 5.7)	
Group C (CF)	10.3 (6.4, 14.1)	
Group D (PF)	4.8 (3.1, 6.6)	
AQ20-R (MCID = 1.75)		
Group A (COPD)	7.7 (6.4, 9.1)	p = 0.021
Group B (PAH)	4.5 (2.1, 6.9)	
Group C (CF)	9.4 (8.2, 10.6)	
Group D (PF)	7.9 (7.3, 8.6)	
EQ5D (MCID = 0.06)		
Group A (COPD)	0.15 (0.08, 0.21)	p – 0.003
Group B (PAH)	0.07 (–0.05, 0.19)	
Group C (CF)	0.30 (0.22, 0.39)	
Group D (PF)	0.16 (0.13, 0.19)	
EQVAS (MCID = 10)		
Group A (COPD)	23.3 (16.2, 30.5)	p = 0.003
Group B (PAH)	18.4 (2.6, 34.2)	
Group C (CF)	43.0 (36.8, 49.3)	
Group D (PF)	30.8 (27.4, 34.3)	

Singer JP et al. Am J Transplant 2017

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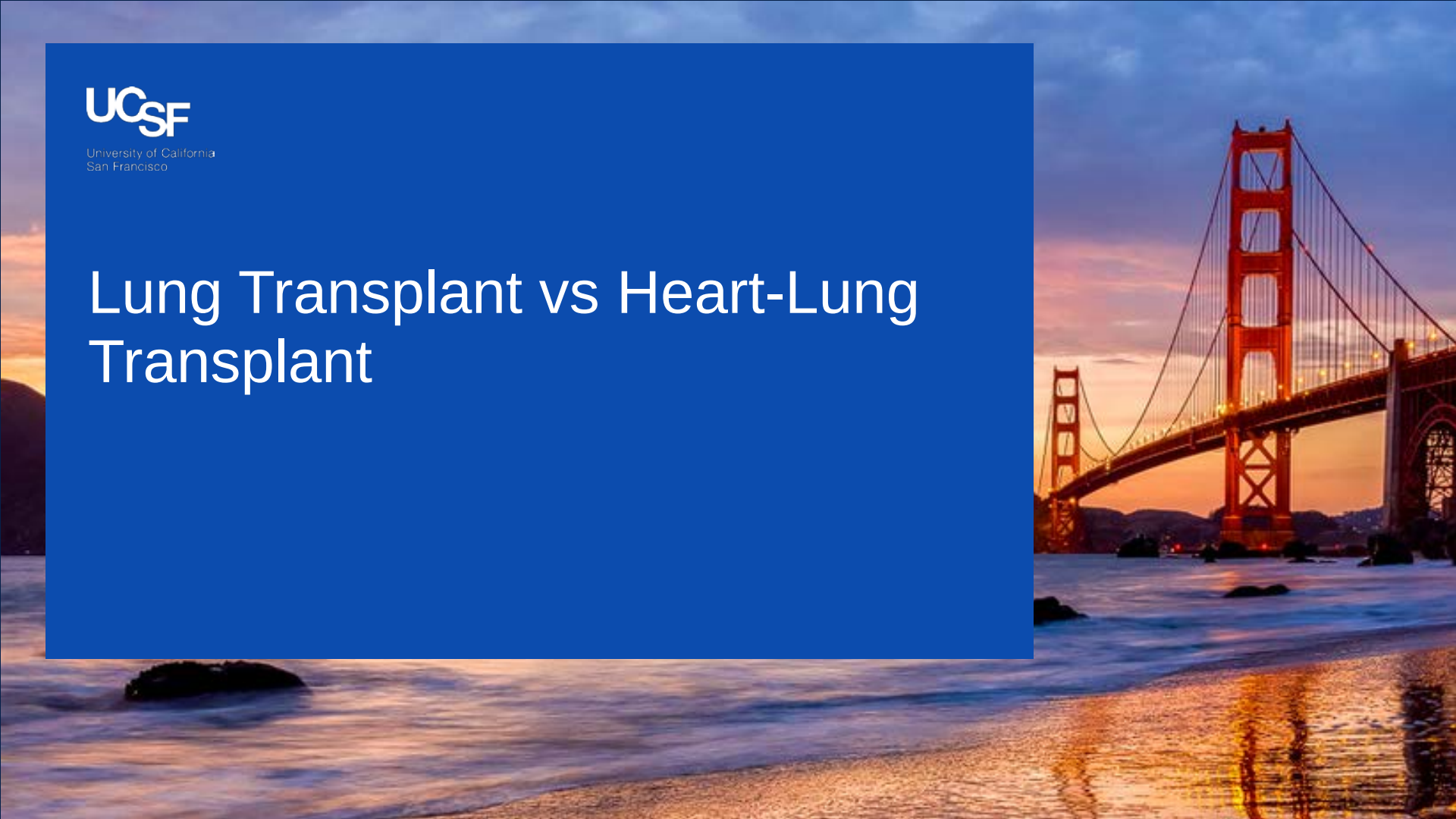
Lung Transplant vs Heart-Lung Transplant



Outline

- Challenges of Organ Transplantation for PAH
- **Lung Transplant vs Heart-Lung Transplant**
- Deploying ECMO in the setting of PAH
- Perioperative management of transplant in PAH

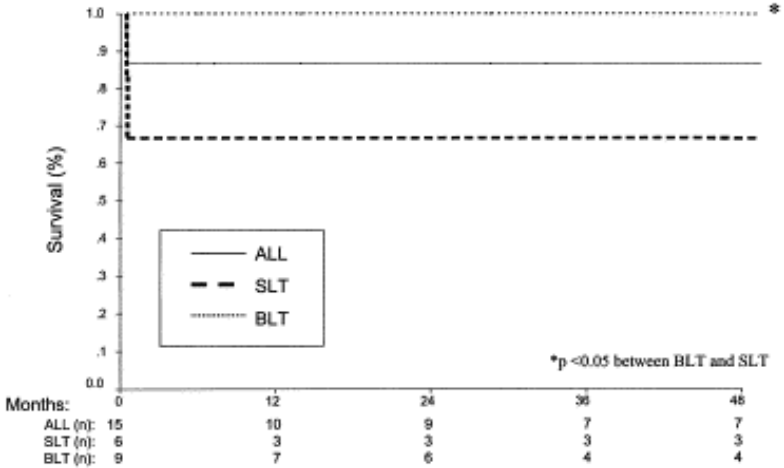
Case Presentation

- Patient admitted to hospital and initiated on IV diuresis, TAPSE was 1.2 cm
- Remodulin increased to 32 ng/kg/min
- Sildenafil increased to 80 mg TID
- Repeat ECHO demonstrates TAPSE down to 0.9 cm

- Faced with decision: Which organ transplant should she be offered?

Type of Organ Transplant: Single vs Double

- Conte JV et al. Ann Thorac Surg. 2001
- 15 PAH lung transplant recipients at Johns Hopkins



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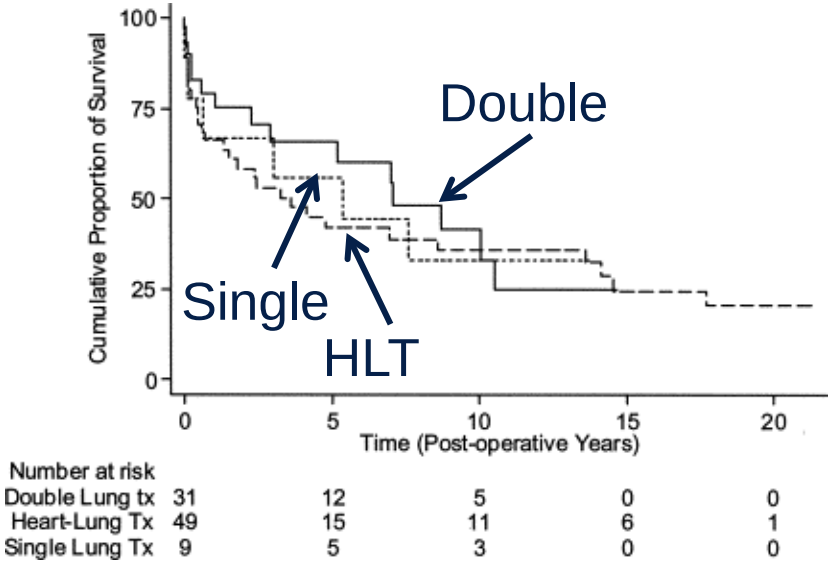
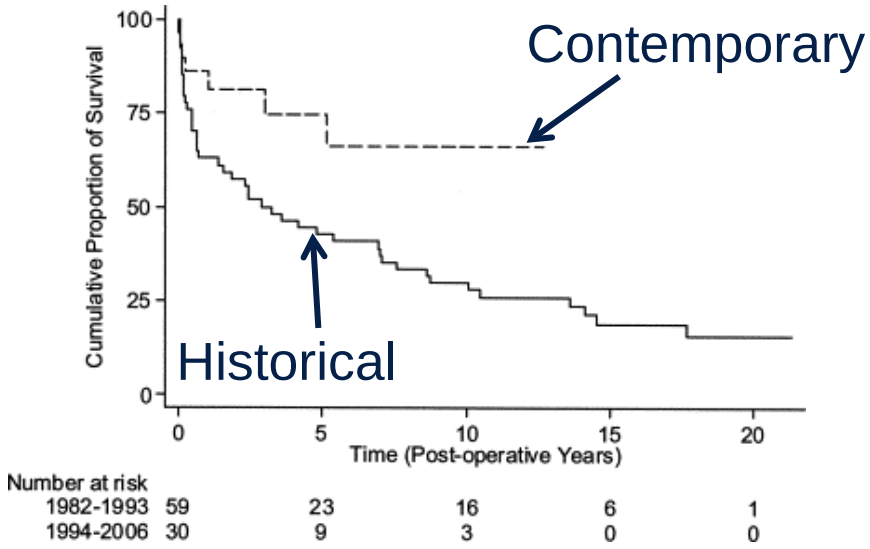
Type of Organ Transplant: Single vs Double

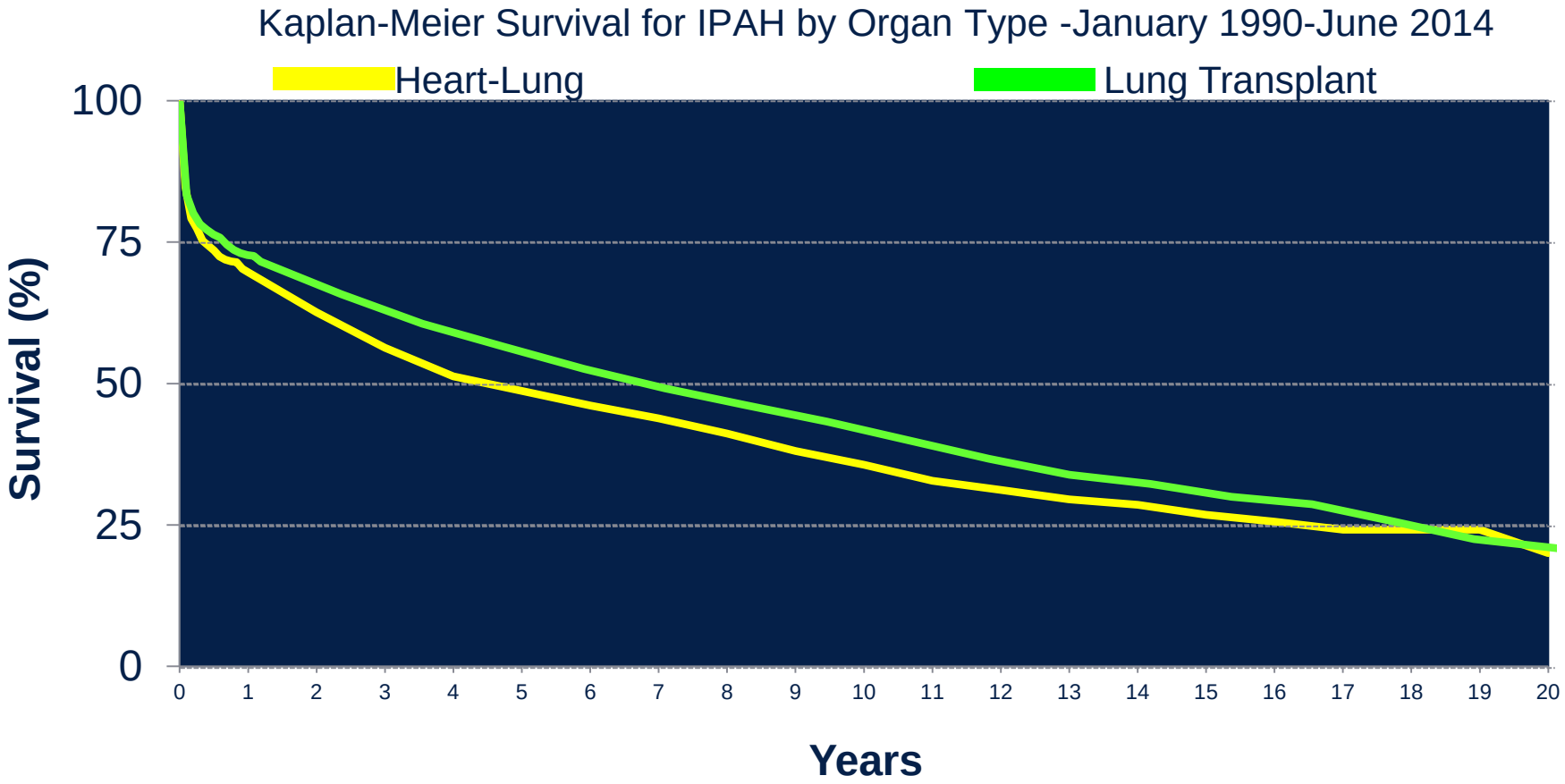
- Consensus became that double lung transplantation was preferred to single
  - Risk of recurrence of PAH
  - Better long term outcomes

Type of Organ Transplant: SLT vs DLT vs HLT

- Toyoda et al. Ann Thorac Surg. 2008
- 59 PAH patients undergoing transplant at Pittsburgh

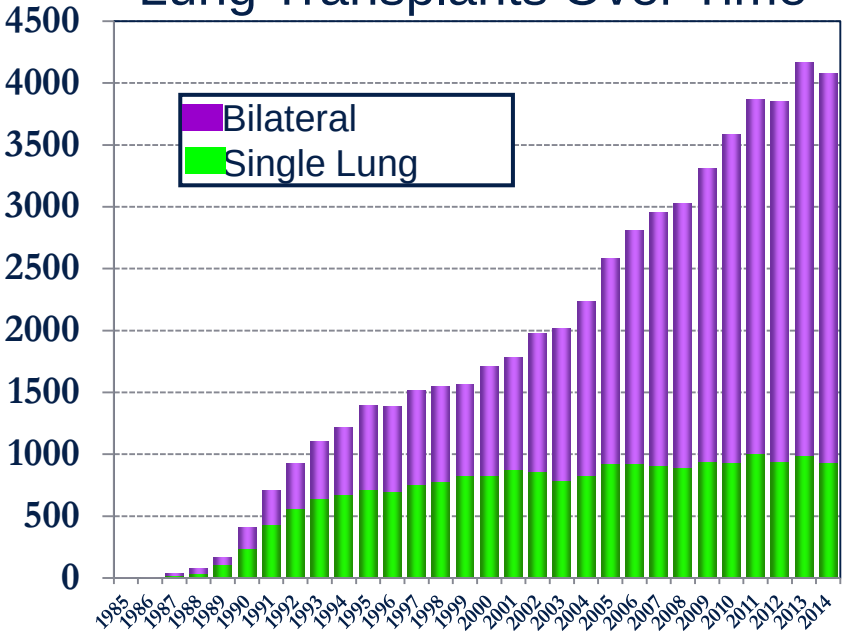




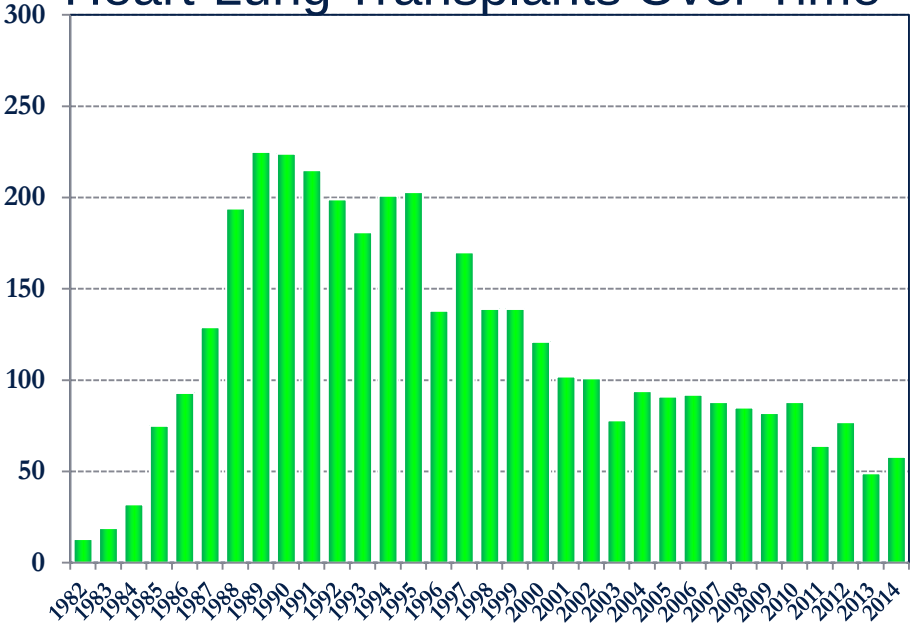

Kaplan-Meier Survival for IPAH by Organ Type -January 1990-June 2014
Heart-Lung
Lung Transplant
Survival (%)
100
75
50
25
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Years

Challenges of Organ Transplantation in PAH: Allocation

Lung Transplants Over Time



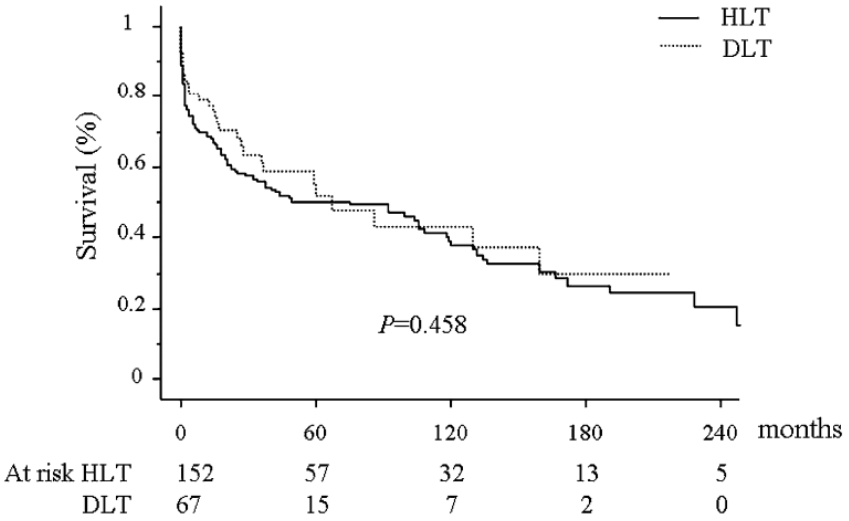
Heart-Lung Transplants Over Time



Type of Organ Transplant: Lung vs Heart-Lung

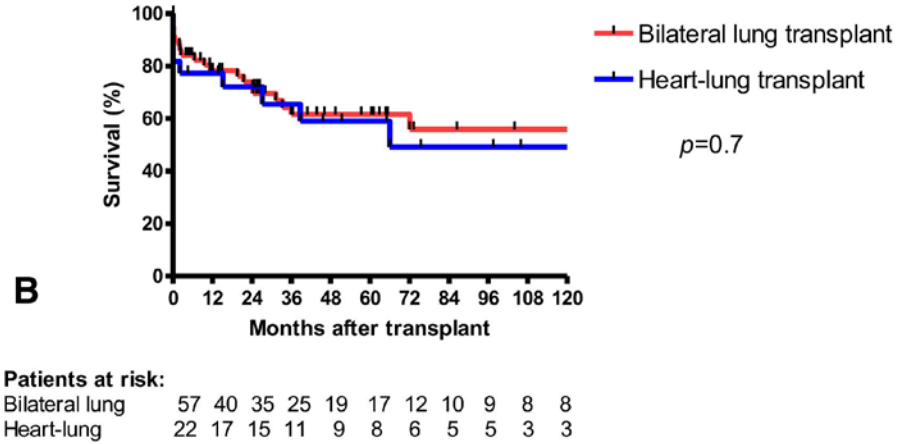
- Fadel et al. Eur J Cardiothorac Surg. 2010
  - Paris-Sud University, Paris, France
  - 219 patients
- Decision for Heart-Lung when
  - Systemic to Pulmonary Shunts or RV failure
  - Severe RV enlargement
  - Cardiac index lower than 2.2 L/min/m^2
  - Preoperative renal failure

Type of Organ Transplant: Lung vs Heart-Lung



Type of Organ Transplant: Lung vs Heart-Lung

- De Perrot et al. J Thorac Cardiovasc Surg. 2012
- 79 patients with Pulmonary Hypertension in Toronto



Type of Organ Transplant: Lung vs Heart-Lung

- Historical Studies demonstrated survival benefit of double lung transplant over combined heart-lung transplant
- Not seen in more contemporary studies

Type of Organ Transplant: Lung vs Heart-Lung

- 2014 ISHLT Consensus Document for Selection of lung transplant recipients
  - *"**Irreversible myocardial dysfunction** or **congenital defects with irreparable defects of the valves or chambers** in conjunction with intrinsic lung disease or severe PAH are considered for heart-lung transplantation"*
  - *"In the **absence of objective assessment of infarcts or fibrotic changes** of the right ventricle, heart-lung transplantation is usually not indicated"*

Case Presentation

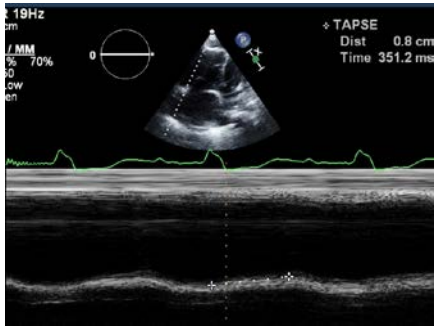
- Repeat ECHO demonstrates TAPSE down to 0.9 cm
  - How to tell if reversible myocardial dysfunction?
- Performed Dobutamine ECHO
  - RV function improved and TAPSE went up to 1.6 cm with dobutamine
- Patient listed for Lung Transplant

Case Presentation

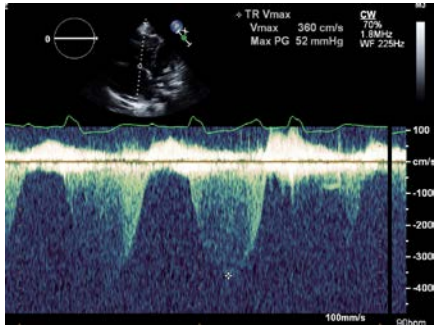
- Patient becomes hypotensive and requires initiation of dobutamine
- Worsening hypotension, patient started on epinephrine
- Despite dobutamine and epinephrine RV function continued to decline
  - Repeat ECHO had TAPSE 0.8 cm

Case Presentation: ECHO on Dobutamine/Epi





Case Presentation

- Decision to list for heart-lung transplant
  - Removed from lung transplant waiting list
- Patient deteriorates further and becomes more hypoxemia and hypotensive

- Faced with decision: How to support the patient further?

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Use of ECMO in Patients with PAH

Outline

- Challenges of Organ Transplantation for PAH
- Lung Transplant vs Heart-Lung Transplant
- **Deploying ECMO in the setting of PAH**
- Perioperative management of transplant in PAH

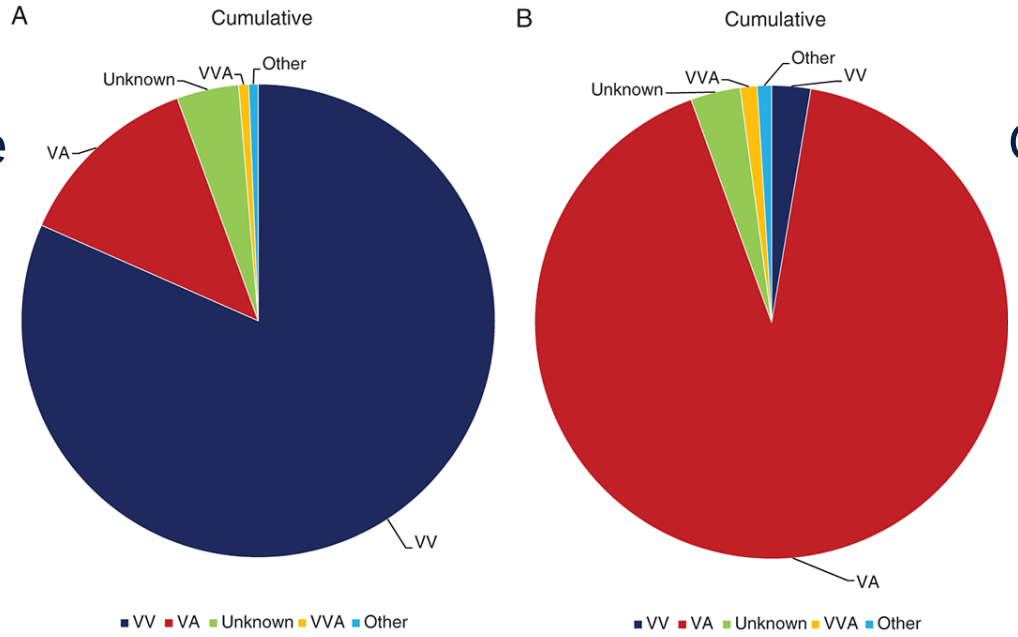
Extracorporeal Membrane Oxygenation

- Device which pumps blood out of body through an oxygenator and then back into the body
  - Takes oxygen-poor blood and converts it to oxygen-rich blood
  - Acts as a pump to improve circulation
  - Scavenges carbon dioxide

ECMO Strategy: Sorokin V. et al. 2017

- Sorokin V. et al. Eur J Heart Fail 2017 reviewed Extracorporeal Life Support Organization Registry

Respiratory Failure



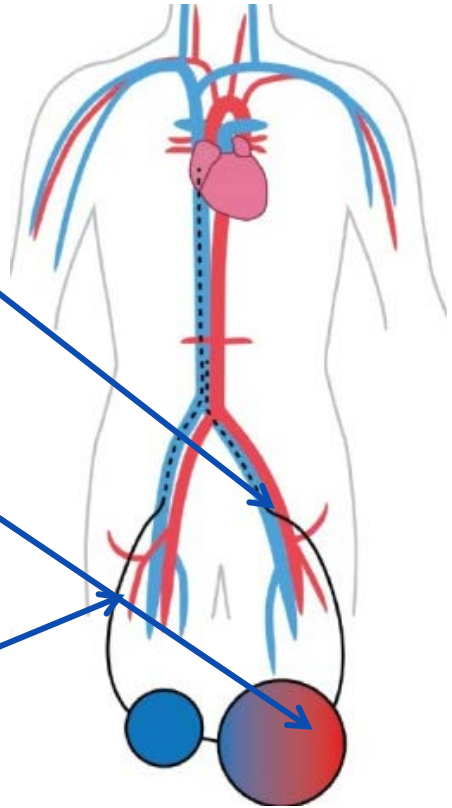
Cardiac Failure

Veno-venous ECMO

Entered back into body in venous system

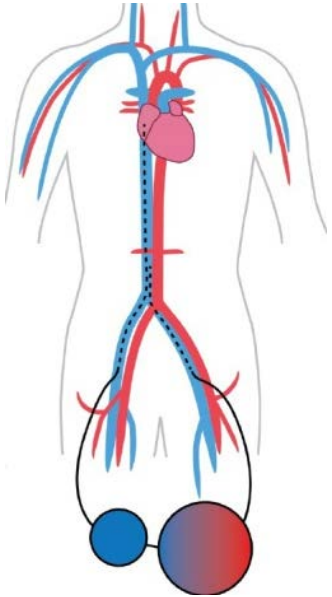
Passes through oxygenator

Venous blood comes out of body

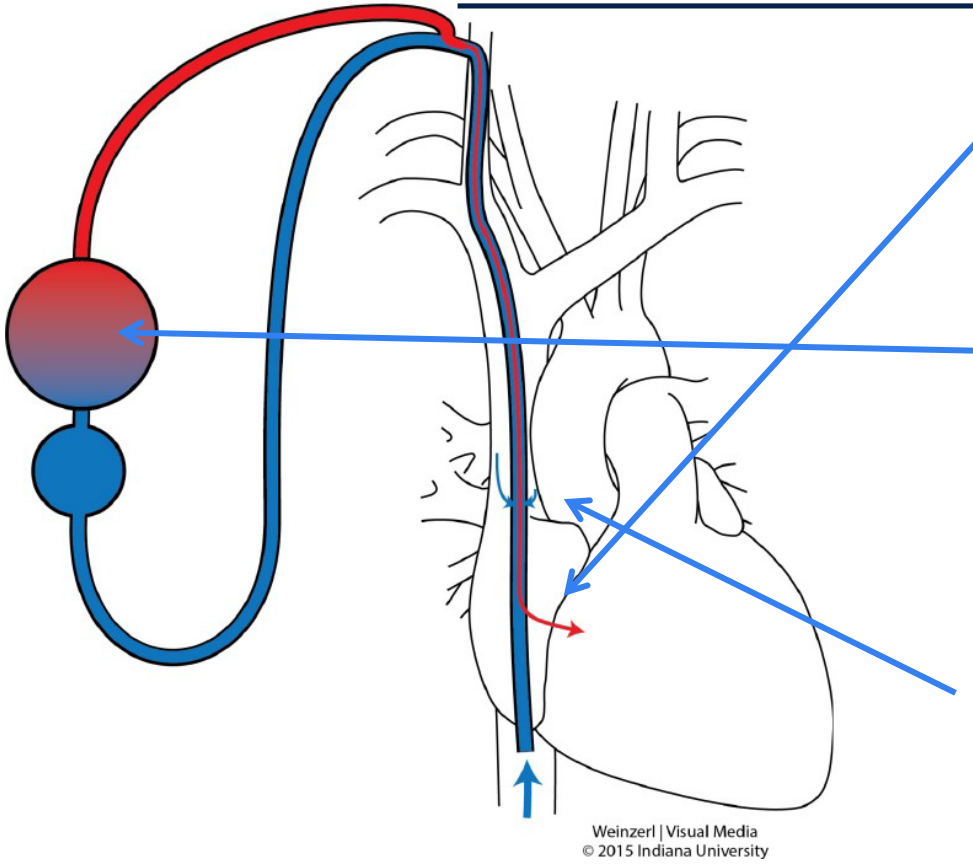


Extracorporeal Membrane Oxygenation: Peripheral VV

- Pro:
  - Less bleeding risk
  - Low stroke risk
  - Can detect improvements by monitoring ABG
- Con:
  - Venous stasis from two cannulas in the IVC
  - Limits mobility
  - Limited use in PAH



Avalon Catheter ECMO



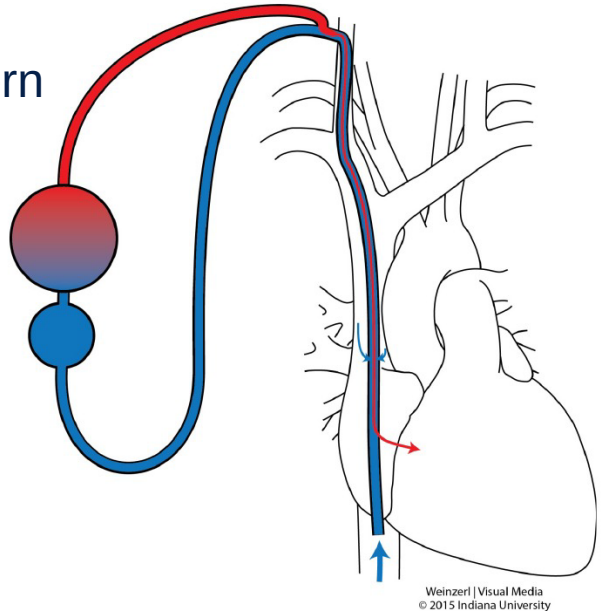
Entered back into body through port directed to tricuspid valve

Passes through oxygenator

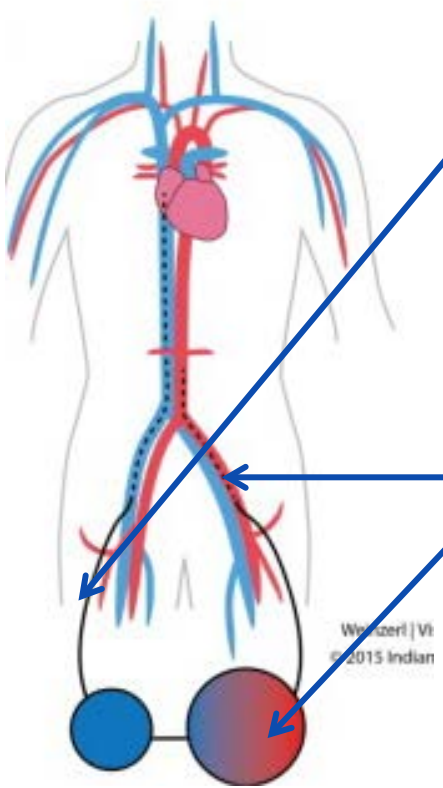
Venous blood comes out of SVC and IVC

Extracorporeal Membrane Oxygenation: Avalon

- Pro:
  - Allows for mobilization
  - Circulation through natural pattern
- Con:
  - No cardiac support
  - Limited use in PAH



Veno-arterial ECMO



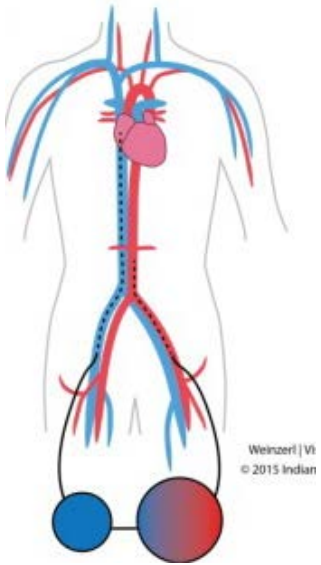
Venous blood comes out of body via femoral vein

Passes through oxygenator

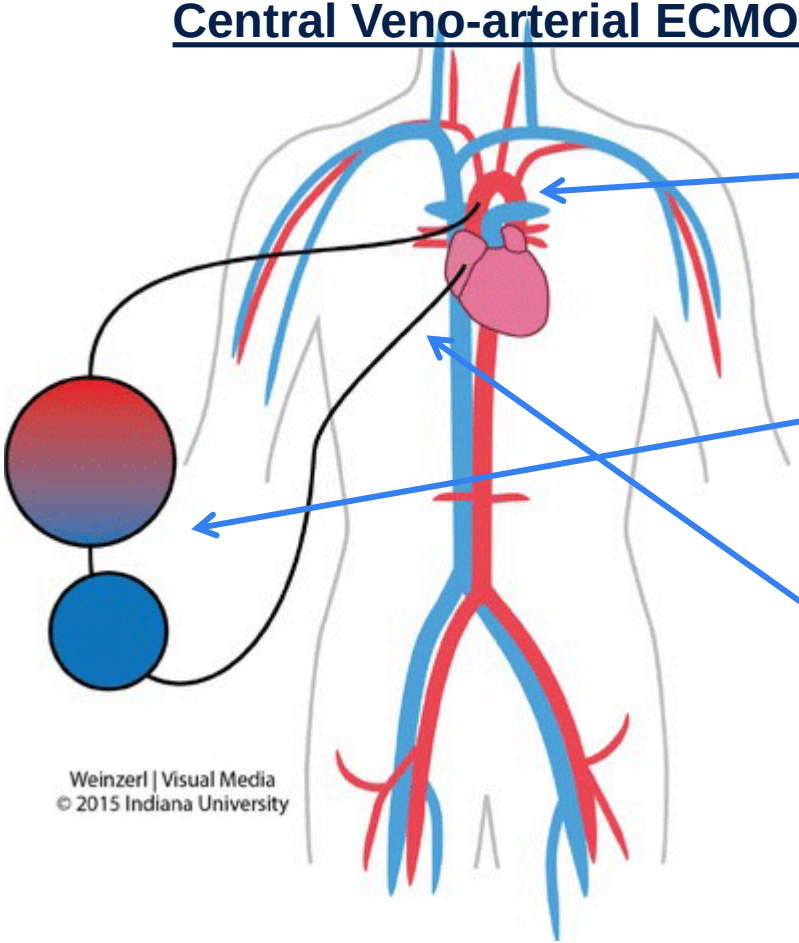
Entered back into body in femoral artery

Extracorporeal Membrane Oxygenation: Peripheral VA

- Pro:
  - Allows for cardiac support via arterial system
  - No problem with overwhelming the RV
- Con:
  - Limits Mobility
  - Impaired venous return from contralateral leg
  - Higher risk of stroke then VV ECMO
  - Harlequin Syndrome from unequal arterial oxygenation
    - Most deoxygenated blood goes to coronaries and cerebral flow



Central Veno-arterial ECMO



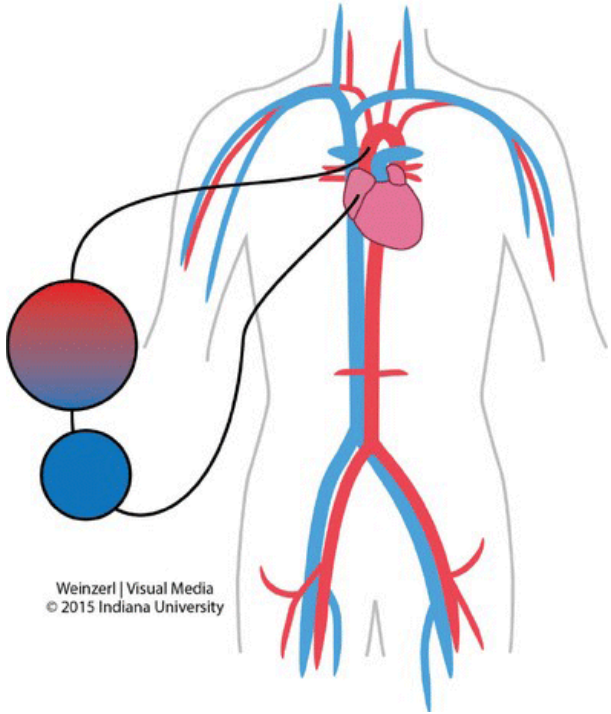
Entered back into body via aorta

Passes through oxygenator

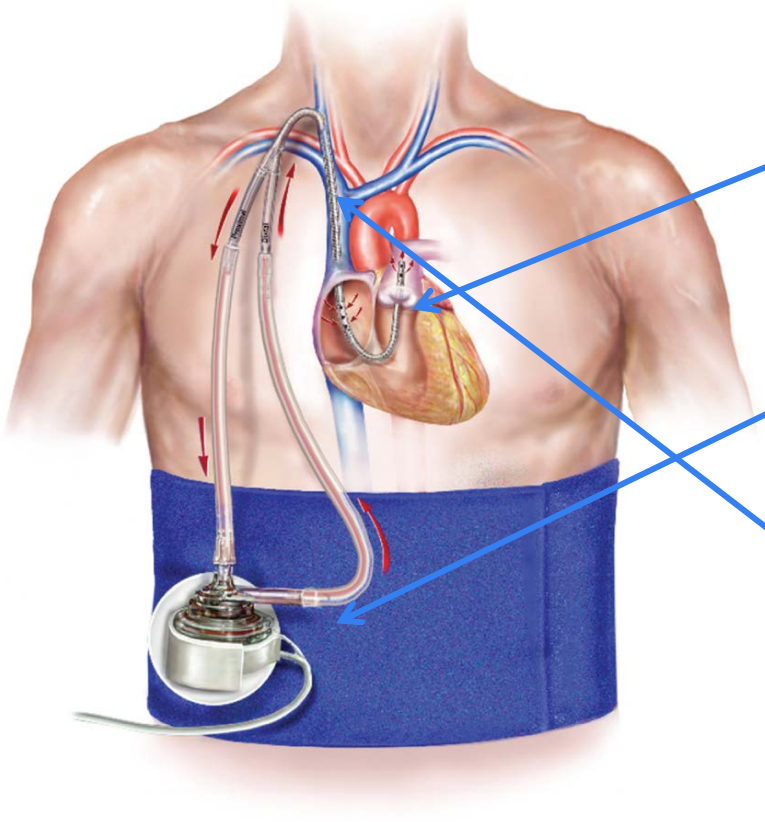
Venous blood comes out of Right Atrium

Extracorporeal Membrane Oxygenation: Central VA

- Pro:
  - Very effective mode of ECMO
  - No Harlequin Syndrome
  - Can mobilize
  - Can be used if peripheral arteries diseased
- Con:
  - Higher risk of complications from bleeding/infection
  - Have to leave chest open
  - Higher risk of strole



ProtekDuo ECMO



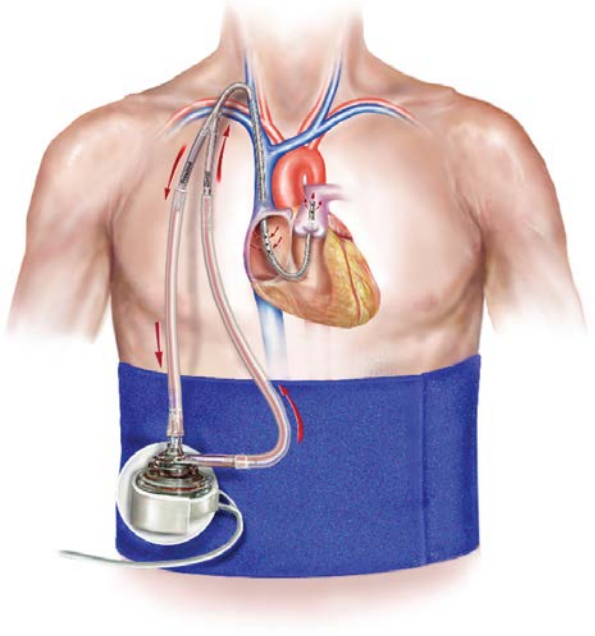
Entered back into body via pulmonary artery

Passes through oxygenator

Venous blood comes out of Right Atrium

Extracorporeal Membrane Oxygenation: ProtekDuo

- Pro:
  - Can mobilize in patients with RV failure
  - More physiologic circulation
  - Acts as RV Assist Device
- Con:
  - High rates of hemolysis
  - Can flip into RV if cannula is too short
  - Very complex placement

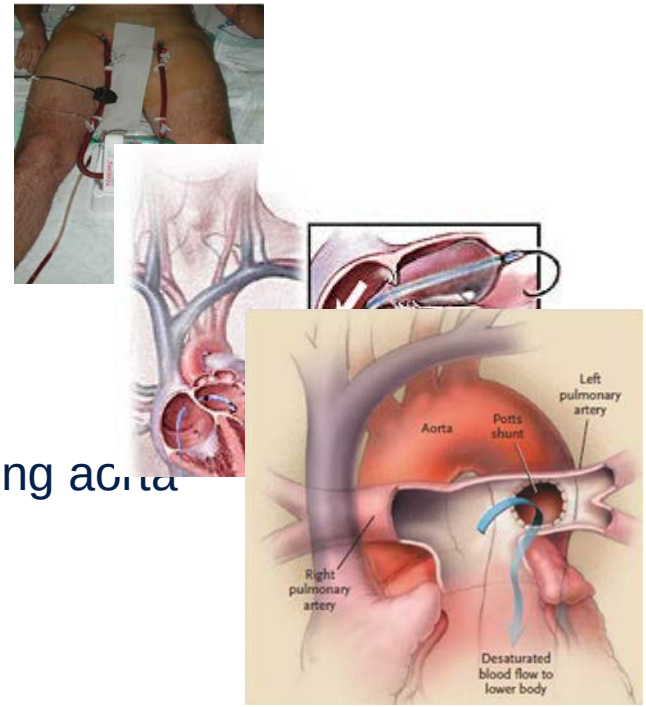


Extracorporeal Membrane Oxygenation: Center Practice

- Generally prefer Avalon (dual lumen VV) in all patients
  - Do not use in PAH
- Typically use VA ECMO in patients with PAH
- Have tried the Protek catheter a few times but have had limited success

Other Bridging Techniques

- Novalung – pumpless ECMO, not approved by FDA
- Atrial Septostomy
  - Creation of inter-atrial right-to-left shunt
- Transcatheter Potts Shunt
  - Connect the left pulmonary artery to the descending aorta



Corris & Degano Eur Respir Rev. 2014

Case Presentation

- Patient deteriorates further and becomes more hypoxemia and hypotensive while on dobutamine and epinephrine
- Decision to place patient on VA ECMO
- Patient gets offer for Heart-Lung Transplantation

Perioperative Management of PAH Undergoing Lung Transplant

Outline

- Challenges of Organ Transplantation for PAH
- Lung Transplant vs Heart-Lung Transplant
- Deploying ECMO in the setting of PAH
- **Perioperative management of transplant in PAH**

Perioperative Management: General Principles

- Patients with PAH are susceptible to hypotension and cardiac arrest during transplant surgery
  - Anesthetic drugs reduce sympathetic tone
  - Positive pressure ventilation alters venous return
  - Mobilization of lungs can impair venous return
- Risk factors for hemodynamic compromise
  - History of syncope, NYHA Class IV, low 6MWD, RV failure

Castillo M. Curr Opin Anaesthesiol. 2011
Schlisler T. Semin Cardiothorac Vasc Anesth. 2017

Perioperative Management: Induction

- Induction is high risk for hemodynamic compromise
  - Venodilation by anesthesia
  - Reduced venous return by positive pressure ventilation
  - Reduced RV stroke volume by paralysis

de Boer WJ Ann Thorac Surg. 2001
Schlisler T. Semin Cardiothorac Vasc Anesth. 2017

Perioperative Management: Induction

- Tools for management
  - Vasoactive drugs on standby
  - Rapid Sequence Intubation
  - Prophylactic awake ECMO
    - First described in 2001 in case series of thoracic organ transplants

de Boer WJ Ann Thorac Surg. 2001
Schlisler T. Semin Cardiothorac Vasc Anesth. 2017

Perioperative Management: Intraoperative

- Patients converted to central ECMO during procedure
- Intraoperative monitoring with TEE
- Can utilize iNO during procedure to decrease pulmonary artery pressure
  - Some centers use milrinone or inhaled prostacycline

Perioperative Management: Primary Graft Dysfunction

- After anastamosis the lung is inflated and PA clamp is released
- Reperfusion injury can occur – Primary Graft Dysfunction
  - Impaired gas exchange, increased capillary permeability
  - Worsened by loss of lymphatic drainage

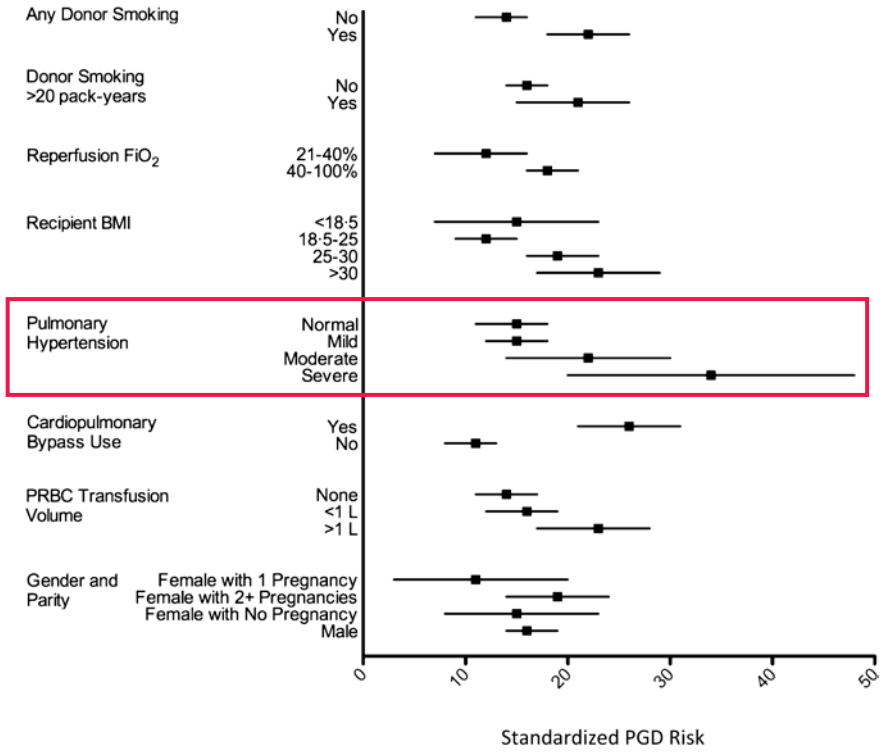
Diamond JM. et al. Am J Respir Crit Care Med 2013

Perioperative Management: Primary Graft Dysfunction

- Primary Graft Dysfunction has long term effects
  - Increased duration of mechanical ventilation
  - Longer ICU Stay time
  - Increased risk of BOS
  - Increased risk of mortality in first year

Diamond JM. et al. Am J Respir Crit Care Med 2013

Perioperative Management: Primary Graft Dysfunction



Diamond JM. et al. Am J Respir Crit Care Med 2013

Perioperative Management: ICU Care Post Surgery

- When PGD is occurring
  - Typically utilize low volume ventilation to minimize further barotrauma
  - Diuresis to help keep lungs less edematous
- Standard ICU Care
  - Typically utilize dobutamine and iNO
  - Wean off as patient tolerates

Case Presentation

- Patient undergoes combined Heart-Lung Transplant
- Three weeks later she was discharged from hospital
- 6/20/2017: Patient was just seen in clinic and continues to do well

Summary

Summary

- Challenges of Organ Transplantation for PAH
  - PAH patients negatively impacted by LAS
  - Hopefully improving after 2015 revision
- Lung Transplant vs Heart-Lung Transplant
  - Prefer double lung transplant
  - Selected patients undergo combined Heart-Lung Transplant
- Deploying ECMO in the setting of PAH
  - VA ECMO is means of choice
  - ProtekDuo is conceptually ideal, more experience needed
- Perioperative management of PAH
  - Minimizing risks

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Thanks!


Questions?