Inter-Atrial Shunts for Pulmonary Hypertension: Group I and Group II

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Disclosure Statement of Financial Interest

I, Daniel Burkhoff have the following financial interest, arrangement or affiliation that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation:

Hemodynamic Core Lab/Consultant to Corvia Medical

World Health Organization Classifications for Pulmonary Hypertension

GROUP 1	Primary pulmonary hypertension: idiopathic, familial, drug and toxin induced (appetite suppressant drugs), rare medical conditions
GROUP 2	Secondary to left ventricular disease: mitral valve disease, left ventricular systolic or diastolic failure.
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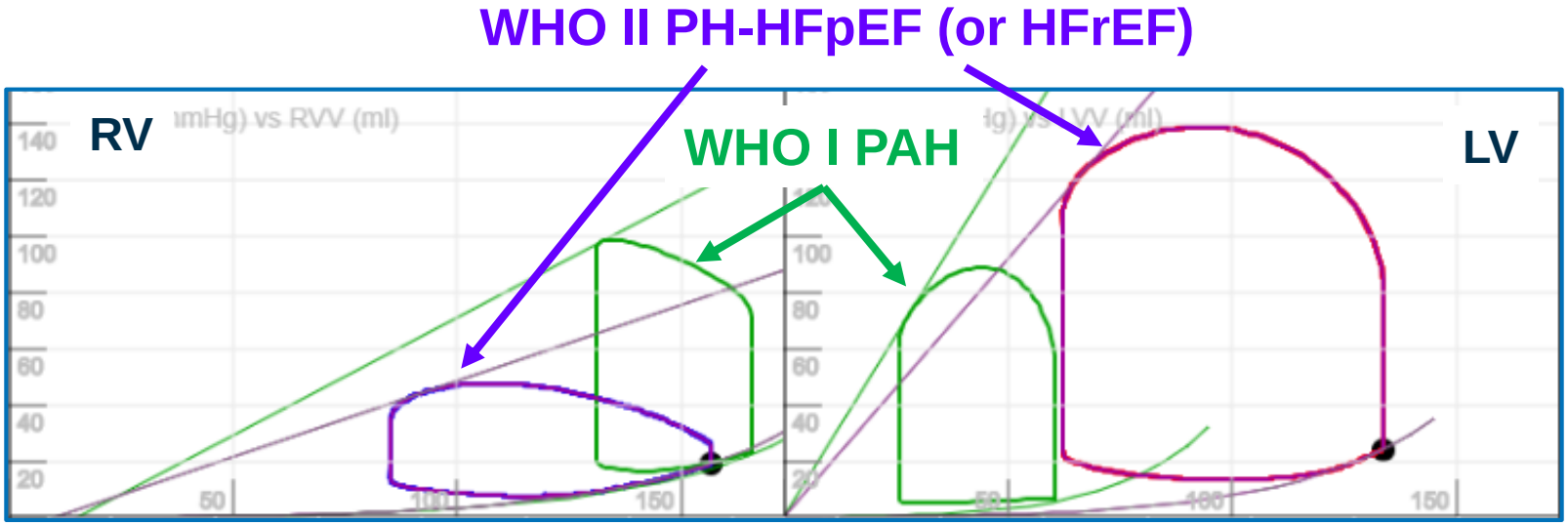
GROUP 4	Secondary to chronic thromboembolism
GROUP 5	Unclear and multifactorial etiologies

Abbreviations: COPD: chronic obstructive pulmonary disease

RV and LV Mechanics in WHO I PAH

Small LV, Large RV
↑↑ PAP, ↑↑PVR
↑↑CVP, ↓PCWP, ↓CO

RV and LV Mechanics in PAH vs PH HFpEF/HFrEF



Normal LV, Normal RV
↑PAP; nl or mild ↑PVR
Nl CVP, ↑↑PCWP, ↓CO at peak Ex

Interatrial Shunts in WHO I and II PH Treatment Goals

WHO I

- **Right→Left shunt to increase LV filling and CO**
- **Reduce CVP**

WHO II

- **Left→Right shunt to reduce PCWP, especially during exercise**

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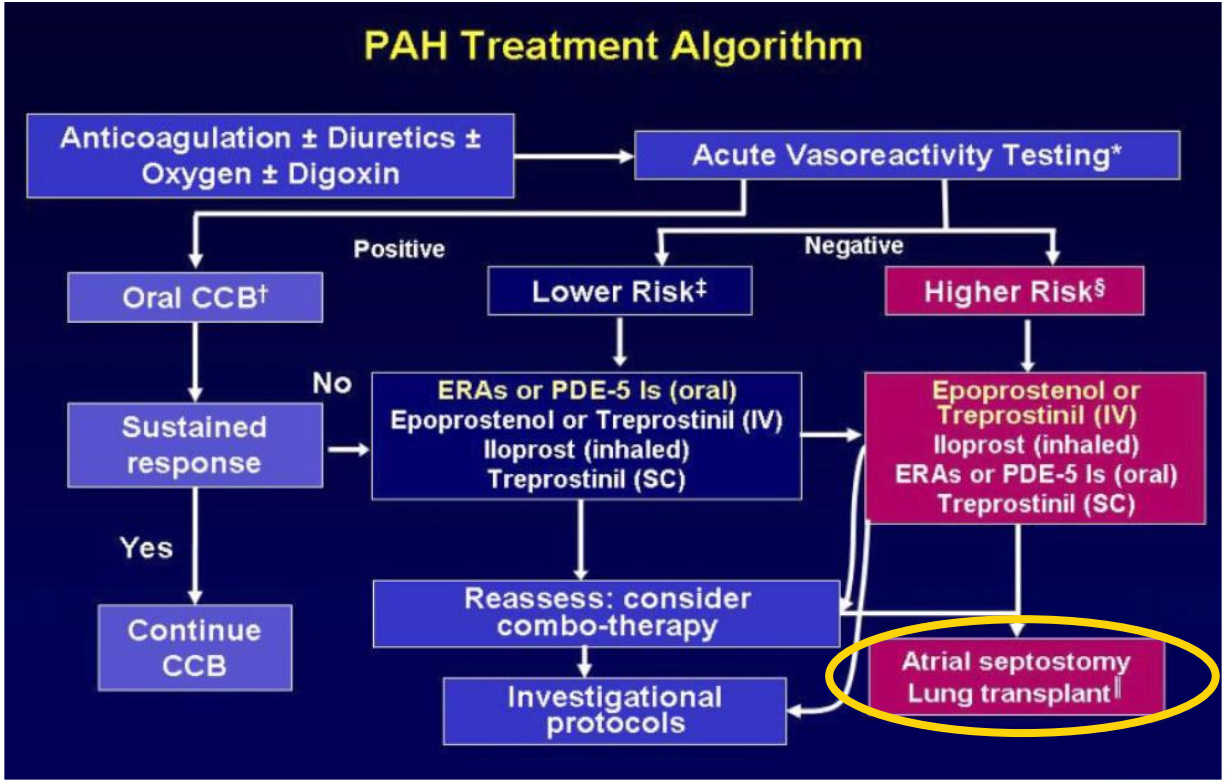
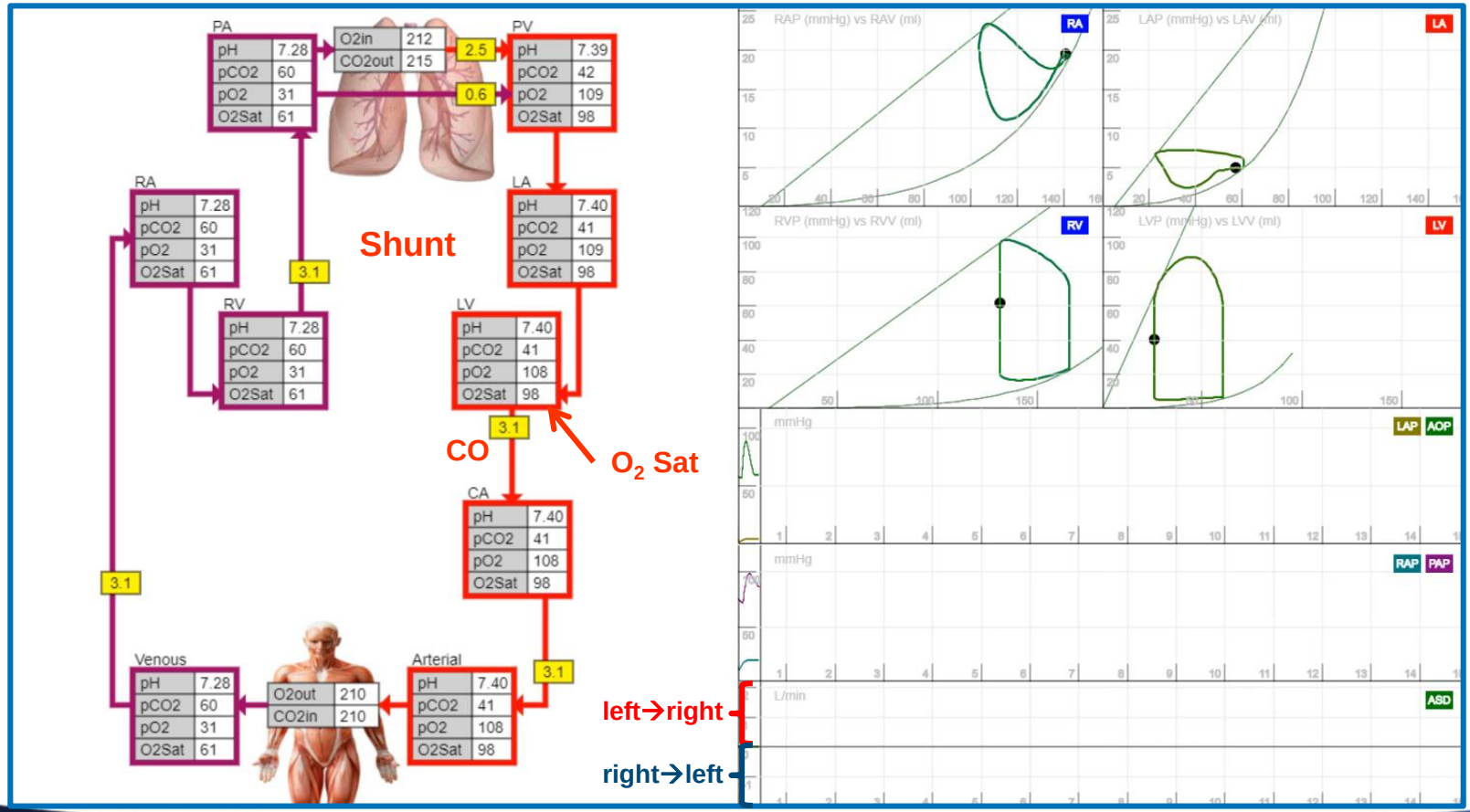
ACCF/AHA 2009 Expert Consensus Document on Pulmonary Hypertension



Treatment Algorithm for PAH: ESC/ERS (2016)

Recommendations	Class - Level					
Measure/treatment	**WHO-FC II**		**WHO-FC III**		**WHO-FC IV**	
Hospitalization in intensive care unit is recommended in PH patients with high heart rate (>110 b/min), low blood pressure (Systolic blood pressure <90 mmHg), low urine output and rising lactate levels due or not due to comorbidities.	-	-	-	-	I	C
Inotropic support is recommended in hypotensive patients.	-	-	I	C	I	C
Lung transplantation is recommended soon after inadequate clinical response on maximal medical therapy.	-	-	I	C	I	C
Balloon atrial septostomy may be considered where available after failure of maximal medical therapy.	-	-	IIb	C	IIb	C


PA
pH 7.28
pCO2 60
pO2 31
O2Sat 61
O2in 212
CO2out 215
2.5
0.6
PV
pH 7.39
pCO2 42
pO2 109
O2Sat 98
RA
pH 7.28
pCO2 60
pO2 31
O2Sat 61
Shunt
LA
pH 7.40
pCO2 41
pO2 109
O2Sat 98
3.1
RV
pH 7.28
pCO2 60
pO2 31
O2Sat 61
LV
pH 7.40
pCO2 41
pO2 108
O2Sat 98
3.1
CO
O2 Sat
CA
pH 7.40
pCO2 41
pO2 108
O2Sat 98
3.1
3.1
Venous
pH 7.28
pCO2 60
pO2 31
O2Sat 61
O2out 210
CO2in 210
Arterial
pH 7.40
pCO2 41
pO2 108
O2Sat 98
RAP (mmHg) vs RAV (ml)
RA
LAP (mmHg) vs LAV (ml)
LA
RVP (mmHg) vs RVV (ml)
RV
LVP (mmHg) vs LVV (ml)
LV
mmHg
LAP
AOP
mmHg
RAP
PAP
L/min
ASD
left→right
right→left
AoP
PCWP
PAP
CVP
ASD Flow

Acute Hemodynamic Effects After Septostomy

Parameter	Before	After	p
mRAP, mmHg	**14.6 ± 8.0**	**11.6 ± 6.3**	**0.001**
mLAP, mmHg	**5.7 ± 3.3**	**8.1 ± 4.0**	**0.001**
CI, L/min/m^2	**2.04 ± 0.69**	**2.62 ± 0.84**	**0.001**
SaO_2 %	**93.3 ± 4.1**	**83.0 ± 8.5**	**0.001**
mPAP, mmHg	64.3 ± 17.6	65.7 ± 18.3	0.169

Rich and Lam, AJC1983; 51: 1550-51

Graded balloon dilation atrial septostomy in severe primary pulmonary hypertension

	1 year Survival	2 year survival	3 year survival
Atrial septostomy	92%	92%	92%
Historical Controls	73%	59%	52%
NIH Registry	61%	49%	38%

Sandoval, et al. JACC 32:1998;297-304

Comments (courtesy of Stuart Rich, Northwestern):

- Clinical response is unpredictable. Some patients have a dramatic improvement, others may not.
- Hypoxemia is generally well tolerated
- Guidelines suggest do not do AS if RA pressure >20 mmHg or O2 sat on room air <90%
- Staged procedures may be preferred: start with small hole and increase as tolerated if no clinical response
- Currently underutilized as physicians think drugs work better which they usually do not

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PH-HFpEF/rEF

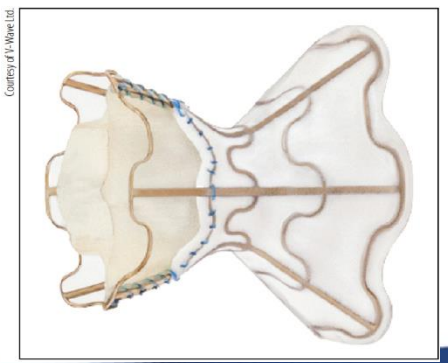
Interatrial Shunt for PAH-HFpEF?

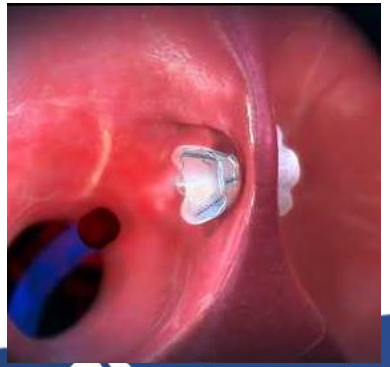
REDUCE LAP-HF TRIAL II (Corvia)

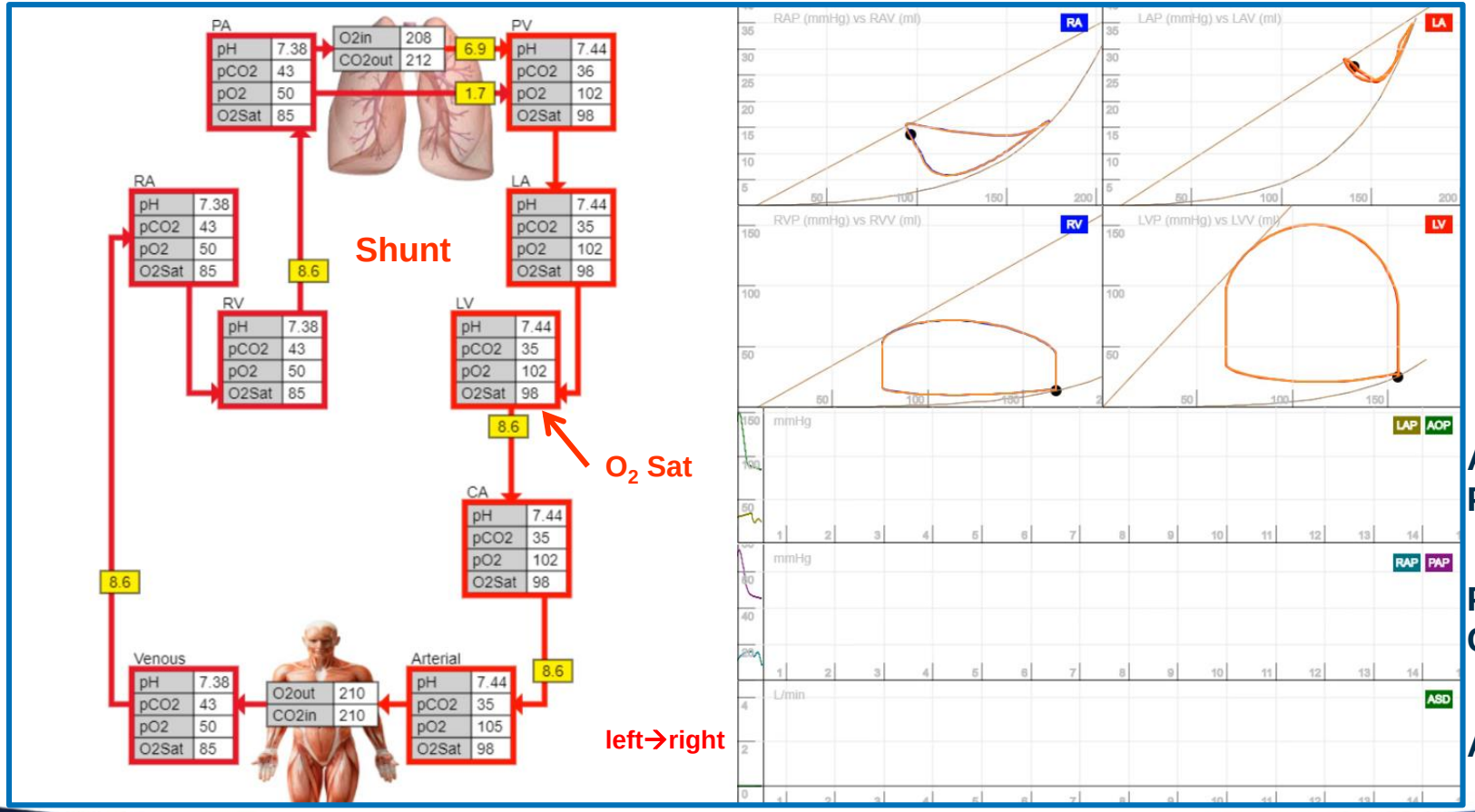
- NYHA II/III/IVa
- LVEF ≥ 40%
- PCWP > CVP by ≥5 mmHg
- RAP < 14 mmHg
- PVR < 4 WU
- TAPSE > 14 mm

RELIEVE HF (V-Wave)

- NYHA III/IVa
- No EF restriction
- PAS <70 mmHg / PVR<4 WU
- TAPSE > 12 mm






PA
pH 7.38
pCO2 43
pO2 50
O2Sat 85
O2in 208
CO2out 212
6.9
1.7
PV
pH 7.44
pCO2 36
pO2 102
O2Sat 98
RA
pH 7.38
pCO2 43
pO2 50
O2Sat 85
Shunt
LA
pH 7.44
pCO2 35
pO2 102
O2Sat 98
8.6
RV
pH 7.38
pCO2 43
pO2 50
O2Sat 85
LV
pH 7.44
pCO2 35
pO2 102
O2Sat 98
8.6
O2 Sat
CA
pH 7.44
pCO2 35
pO2 102
O2Sat 98
8.6
8.6
Venous
pH 7.38
pCO2 43
pO2 50
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O2out 210
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RAP (mmHg) vs RAV (ml)
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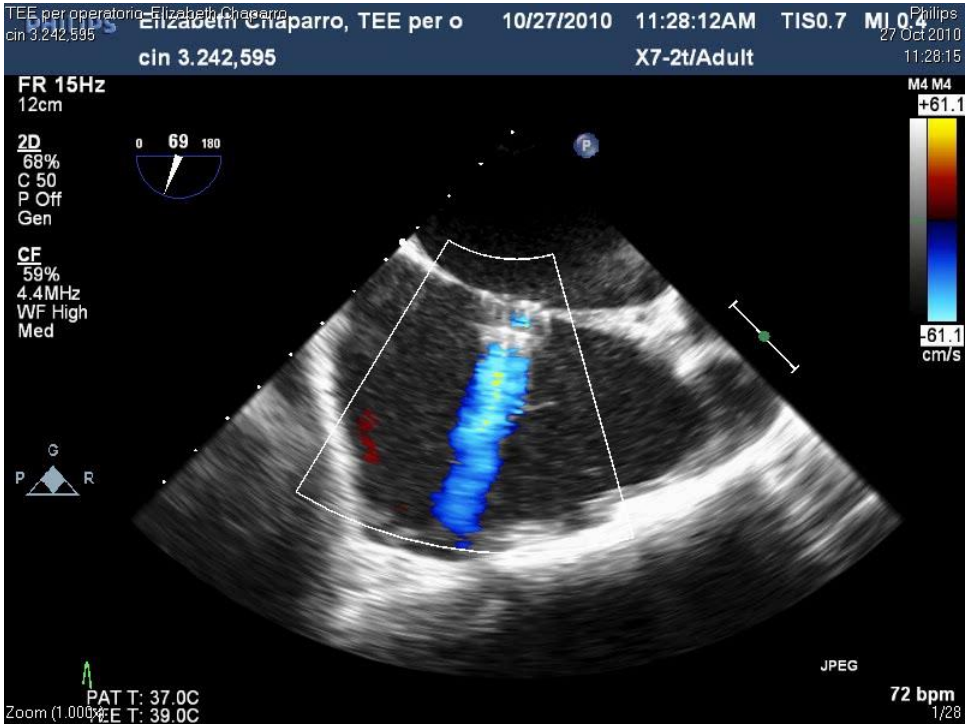
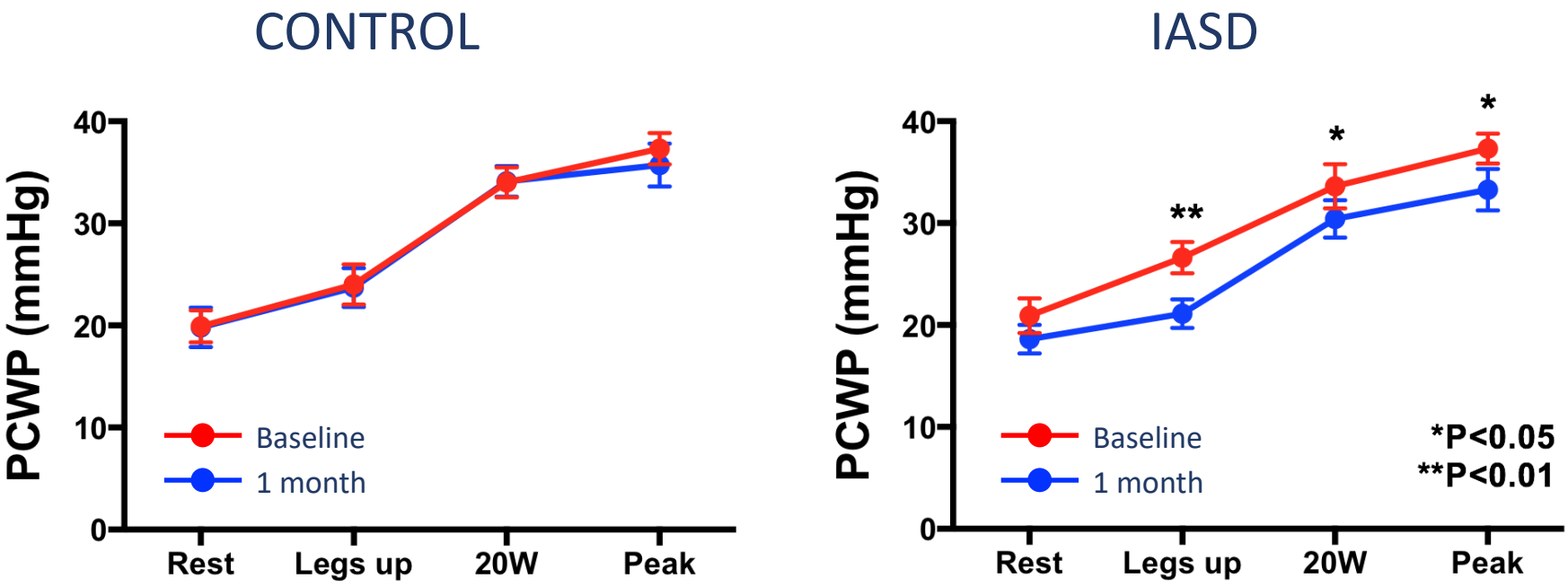
RV
LVP (mmHg) vs LVV (ml)
LV
mmHg
LAP
AOP
mmHg
RAP
PAP
L/min
ASD
AoP
PCWP
PAP
CVP
ASD Flow

Continuous L → R Flow



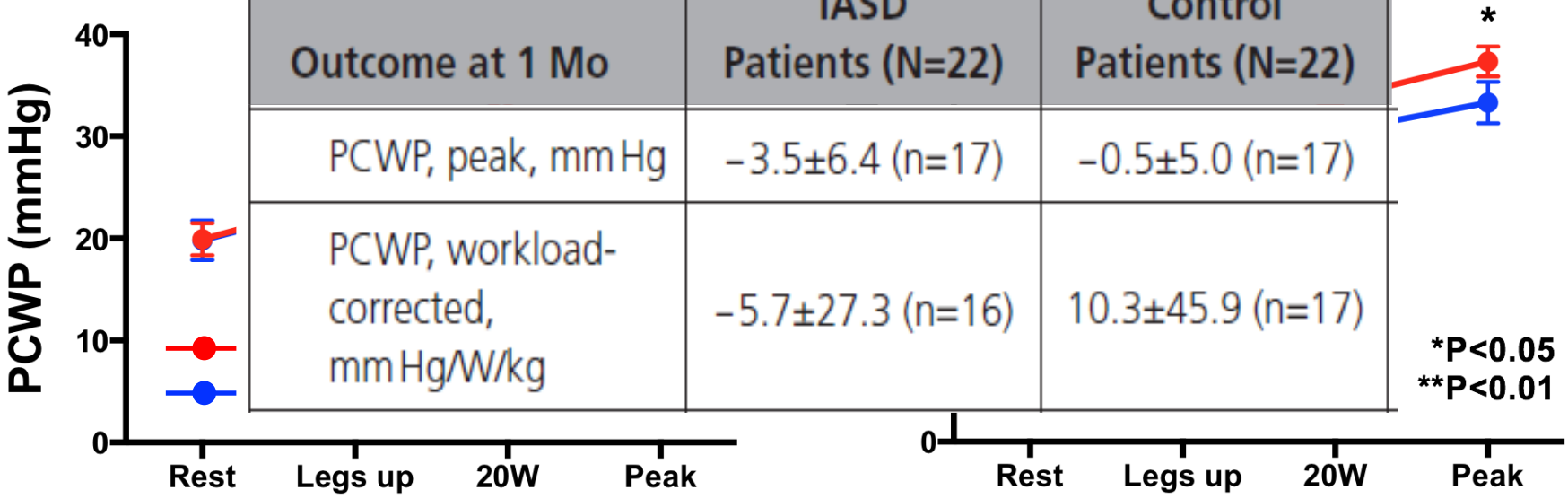
45 Days after implant

REDUCE LAP-HF I RCT: Results



ΔPCWP: Baseline vs 1 Month

Outcome at 1 Mo	IASD Patients (N=22)	Control Patients (N=22)
PCWP, peak, mm Hg	−3.5±6.4 (n=17)	−0.5±5.0 (n=17)
PCWP, workload-corrected, mm Hg/W/kg	−5.7±27.3 (n=16)	10.3±45.9 (n=17)



Interatrial Shunts

WHO I

- **R→L to increase LV filling and CO and decrease CVP**
- **Arterial desaturation limiting factor**
- **No randomized trials, but improved outcomes vs historical controls**

WHO II

- **Subgroup of WHO II patients included in trials**
  - **Upper limits to PVR, RVF and CVP for inclusion**
- **L→R to reduce PCWP**
- **Hemodynamic studies show ↓PCWP despite ↑Ex Tol**
- **Randomized studies underway**
- **Multiple device-based options under development and investigation**