Right Ventricular Outflow Track Reconstructive Surgery – Cardiologist's View

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Right Ventricular Outflow Track Reconstruction (RVOTR)

- A common procedures encountered in congenital heart disease
- Associated with late morbidities
  - PS, PR, and reoperation
  - GUCH patients
- Growing concerns over RV function in the long-term

The Goals of RVOTR

- The avoidance of long-term complications
- Low probability of early and late reoperations

Indications for RVOTR

- TOF / DORV PS
- PA IVS / critical PS
- TOF PA
- Truncus arteriosus
- V-A discordance with VSD, LVOTO
- Arch interruption with VSD, LVOTO
- Aortic valve diseases

Types of RVOTR

- Direct anastomosis and/or RVOT patching
  - Simple patch
  - Monocusp patch
  - Annular augmentation
- Conduit interposition

Issues Concerning RVOTR

- Initial repair
  - Early vs. Delayed / staged - TOF/ PA
    - Symptomatic neonate?
  - Valve/annulus preservation
  - Conduit interposition
    - Valved conduit
    - Nonvalved conduit

Issues Concerning RVOTR

- Late re-operation
  - Timing and indications of PVR for chronic PR after the initial repair
  - Mechanical or bioprosthesis

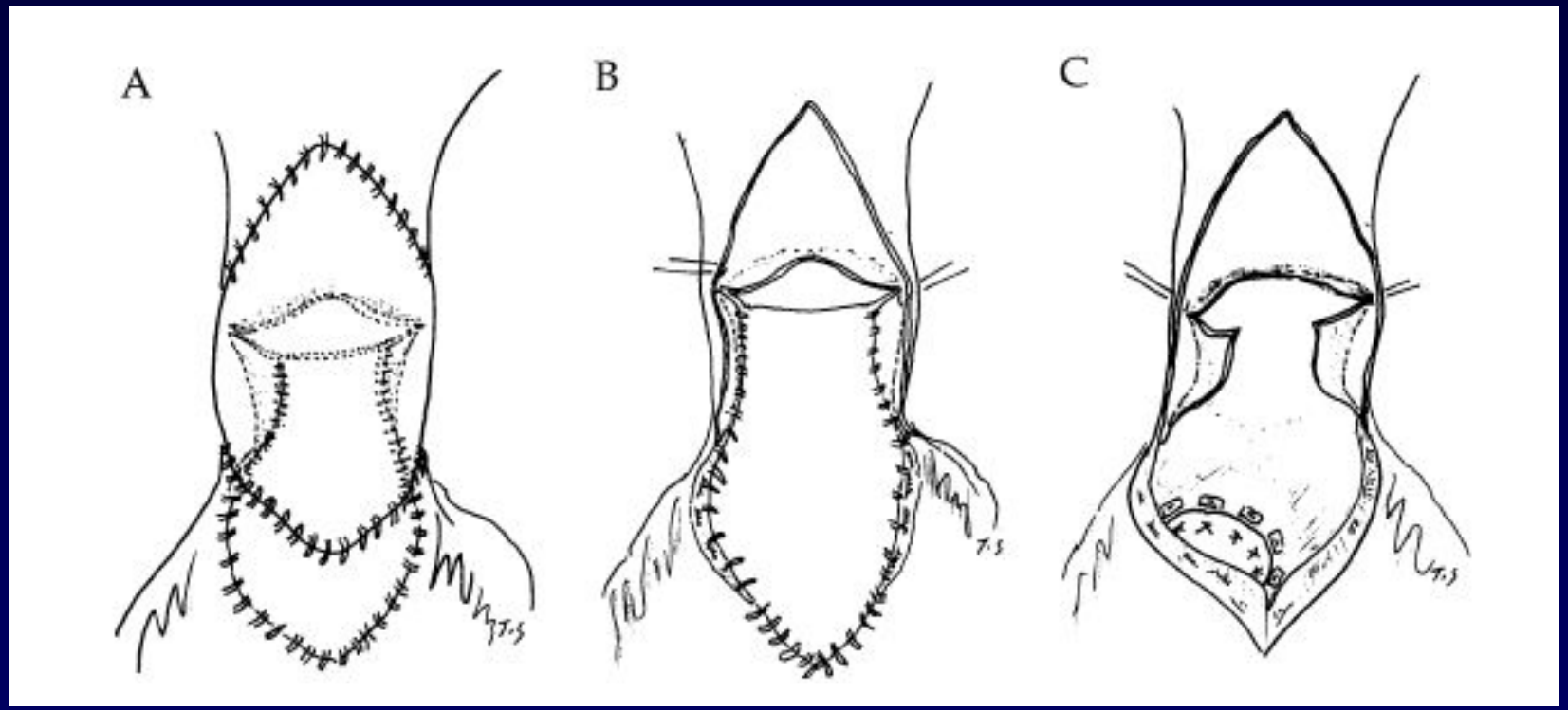
Issues Concerning RVOTR

- Early vs. Delayed / staged
  - Mortality / morbidity
  - ICU / hospital stay
  - Branch PA distortion in palliative shunt
  - Transannular patching / Valve saving
  - Muscle resection - progressive disease

Issues Concerning RVOTR

- Early vs. Delayed / staged
  - Late reinterventions
  - Long term Issues – cadiopulmonary functions
    - Cyanosis / Pressure loading / Myocardial fibrosis
    - Pulmonary artery growth
    - Angiogenesis / alveolar development

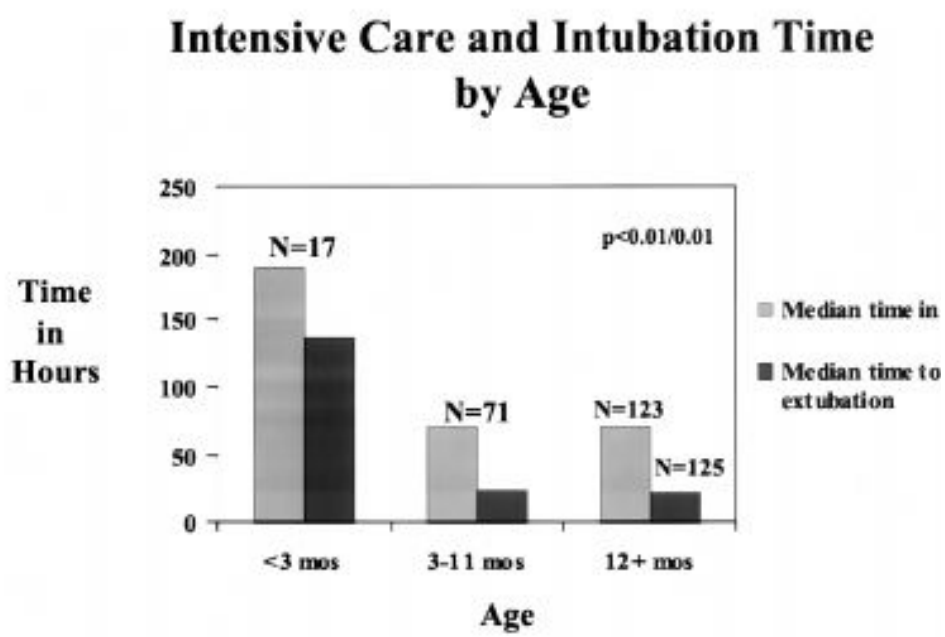
Pulmonic valve annular enlargement

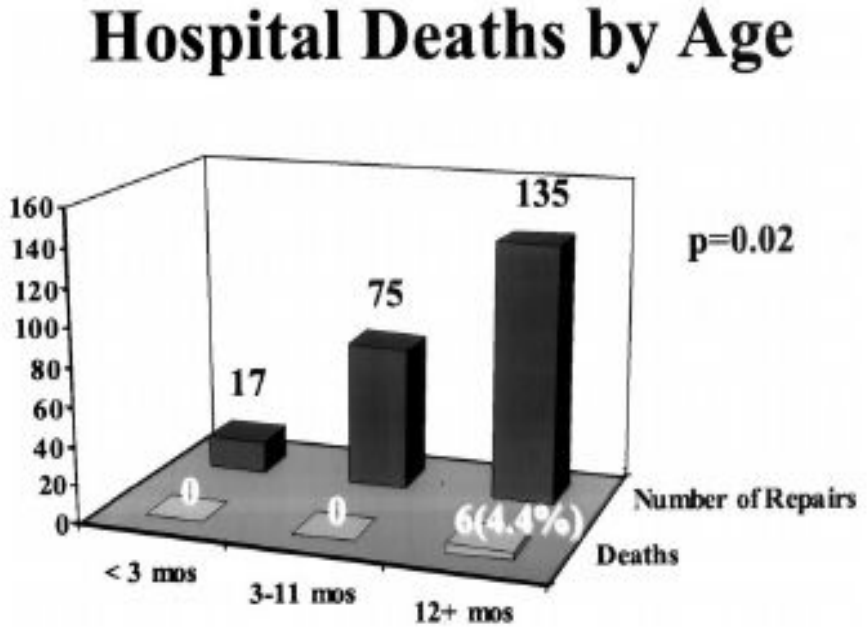


Sung SC et. al. ATS 2003

Optimal Age for Repair of TOF?

- Preop O2 <u>76%</u> 86% 85%





Toronto. Circulation 2000

One-stage repair of TOF (Sejong Hospital)

- 1997 - 2002, 240 patients
- 1 mo - 48 yrs
- 46 (19.2%) < 6 mo ; all were symptomatic
- 2 hospital mortalities
- 5 - reoperations
- 9 - catheter interventions

Lee C et. Al. J Cardiovasc Surg 2006

One-stage repair of TOF (Sejong Hospital)

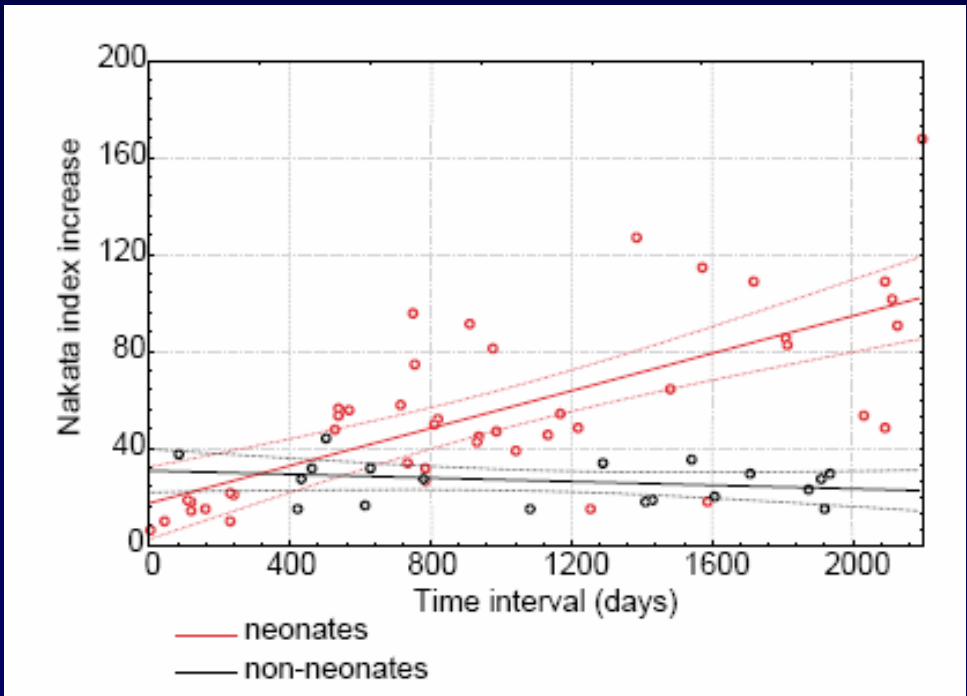
	Early repair group < 6 mo		Late repair group ≥ 6 mo
Ventilator		ns	
Inotropics support		p= 0.003	
ICU stay		p= 0.04	
Hospital stay		ns	
Tansannular patch	69 %	p=0.21	57 %
Ventriculotomy	46 %	p<0.05	22 %

Lee C et. Al. J Cardiovasc Surg 2006

Neonatal repair of TOF

- Mechanical ventilatory support
- ICU stay and hospital stay
- Mortality
- Reintervention

- PA growth



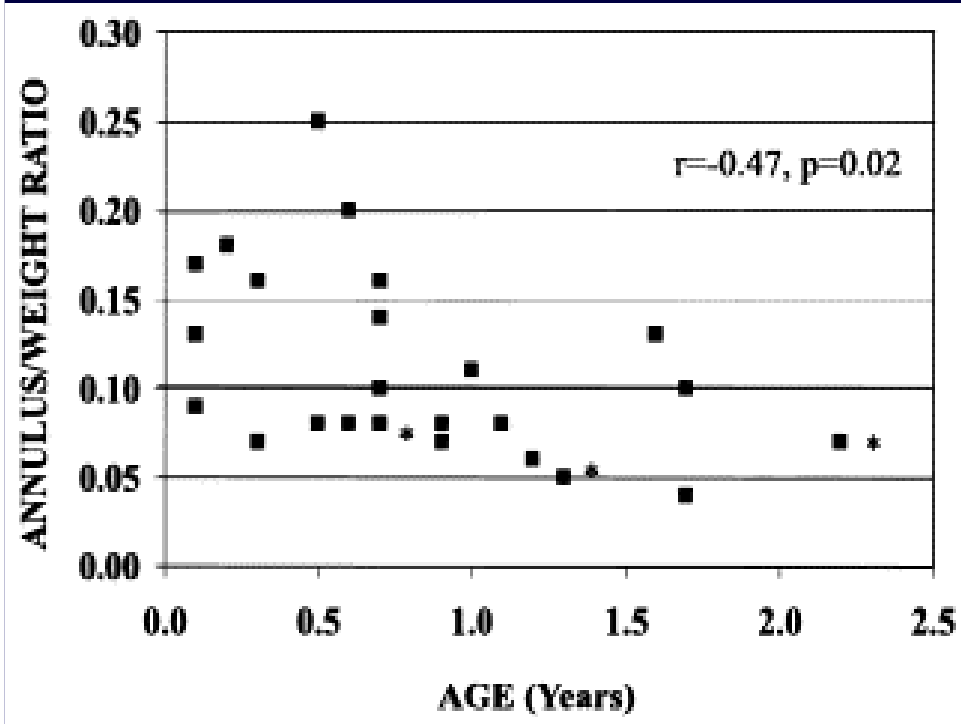
J. Kolcz et. al. Eur J Cardiothorac Surg 2005

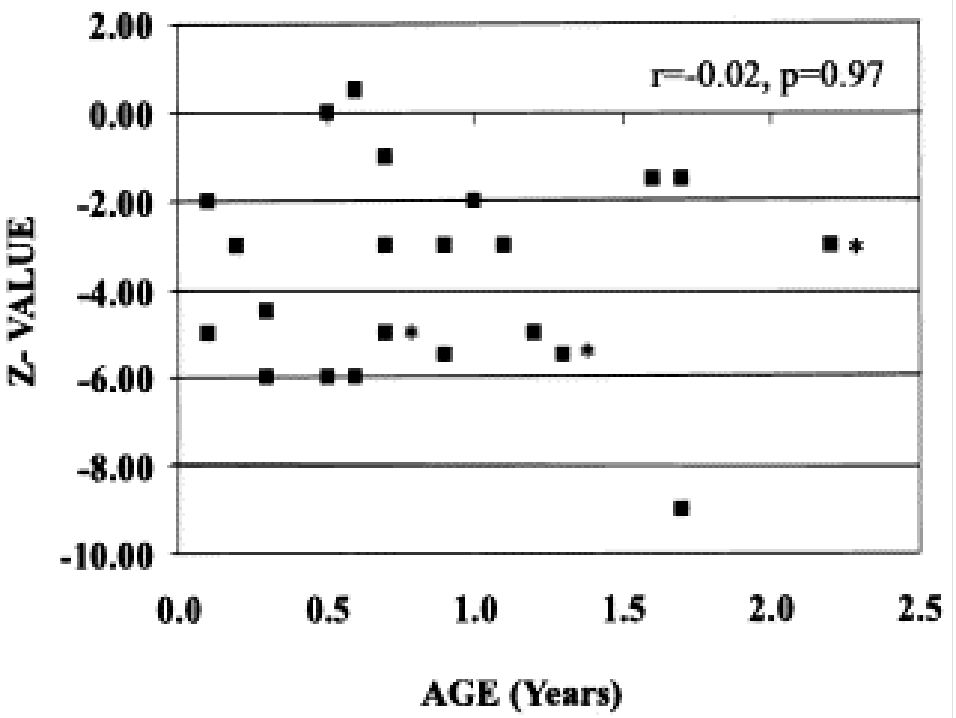
Elective Primary Repair of TOF in Early Infancy

- 42 acyanotic infants aged 4 to 87 days
- Transannular patching : 10 patients (24%)
- Catch-up growth of the pulmonary valve annulus

Parry et al. JACC 2000

Pulmonary valve preservation - Age and PV size



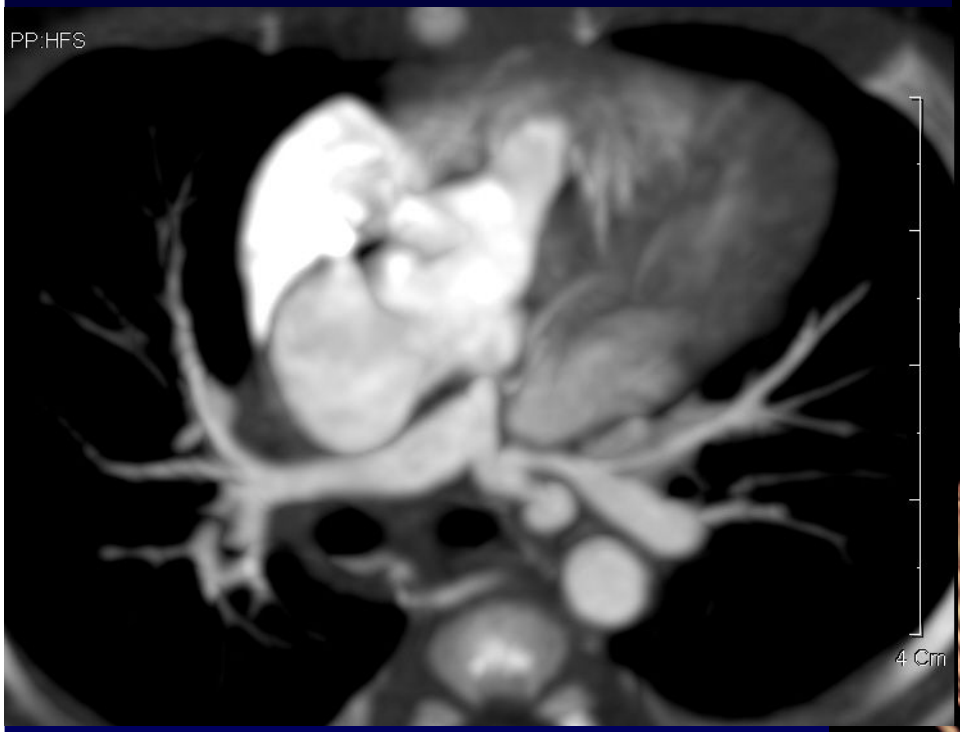


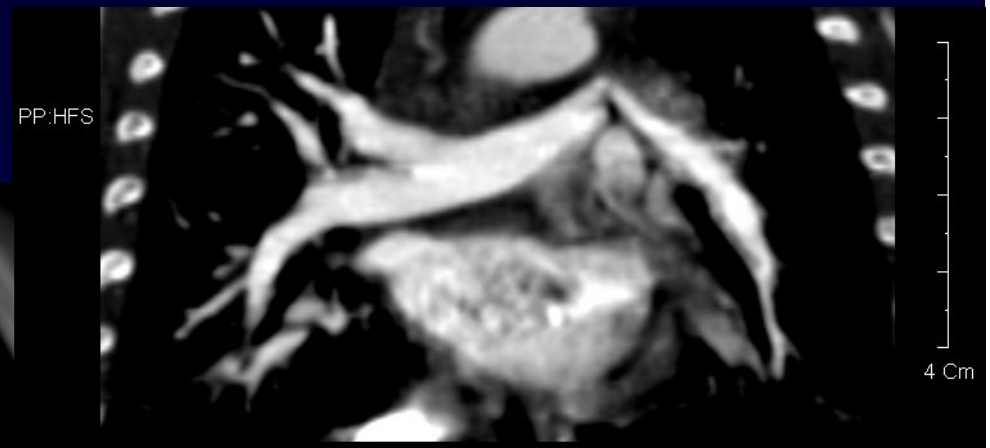
Ann Thorac Surg 2000

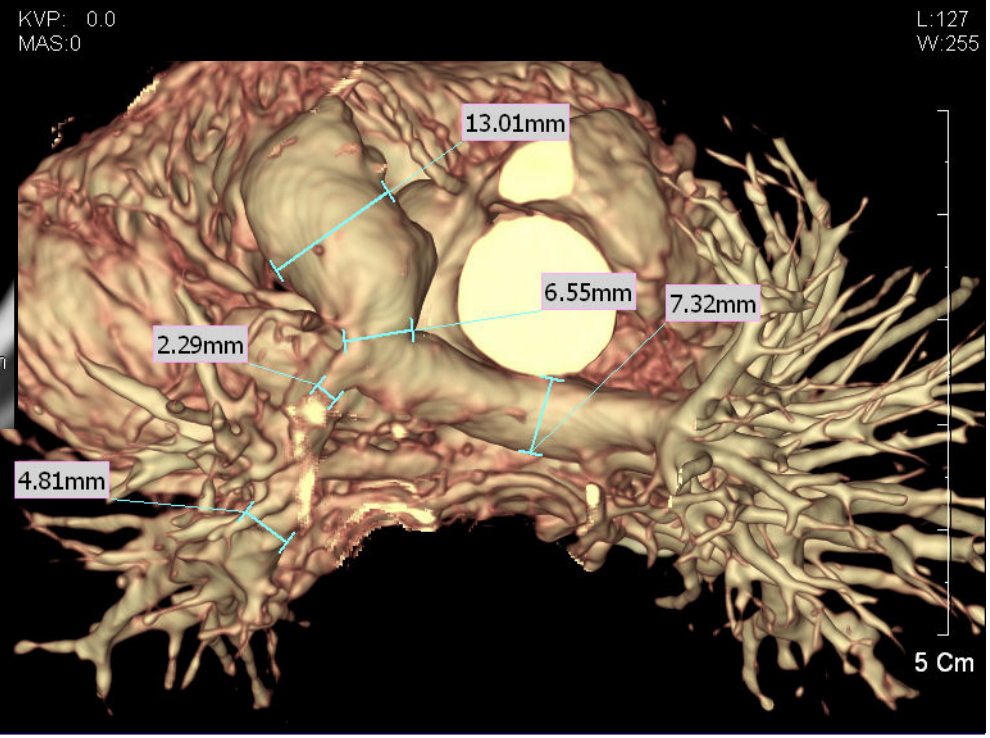
Early repair in TOF
Sejong Hospital

- 2004 –2006 by one surgeon
- 11 symptomatic TOF
- 11 – 84 days
- 10 transannular
- 2 reop, 1 balloon

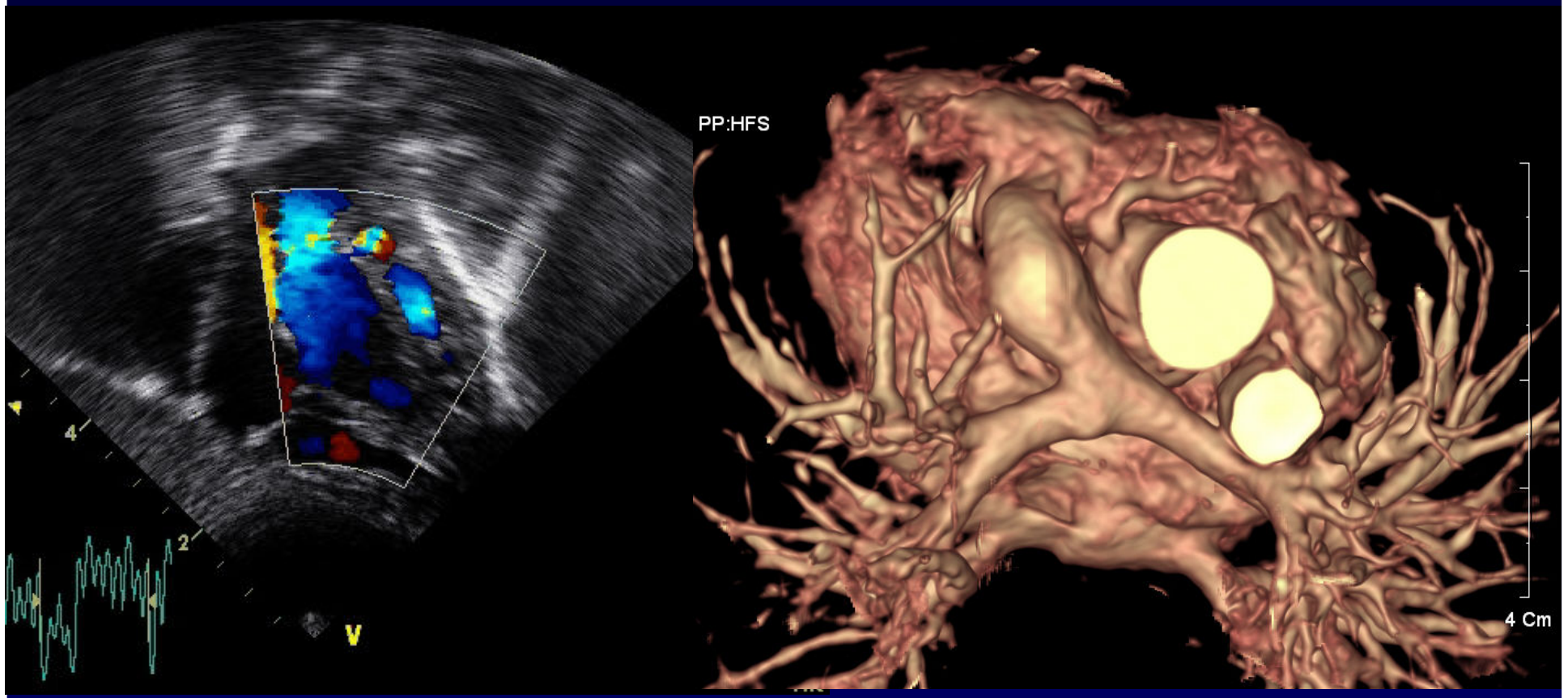
ToF 20d - repair
5 mo - CT



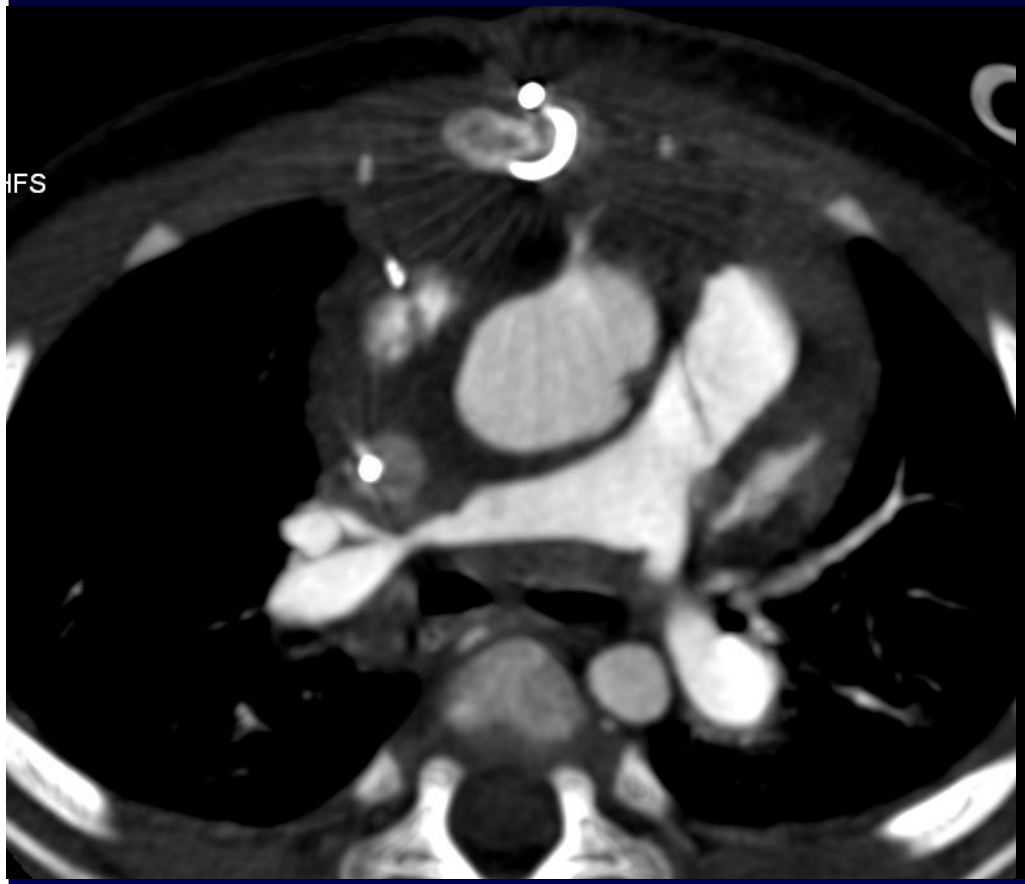


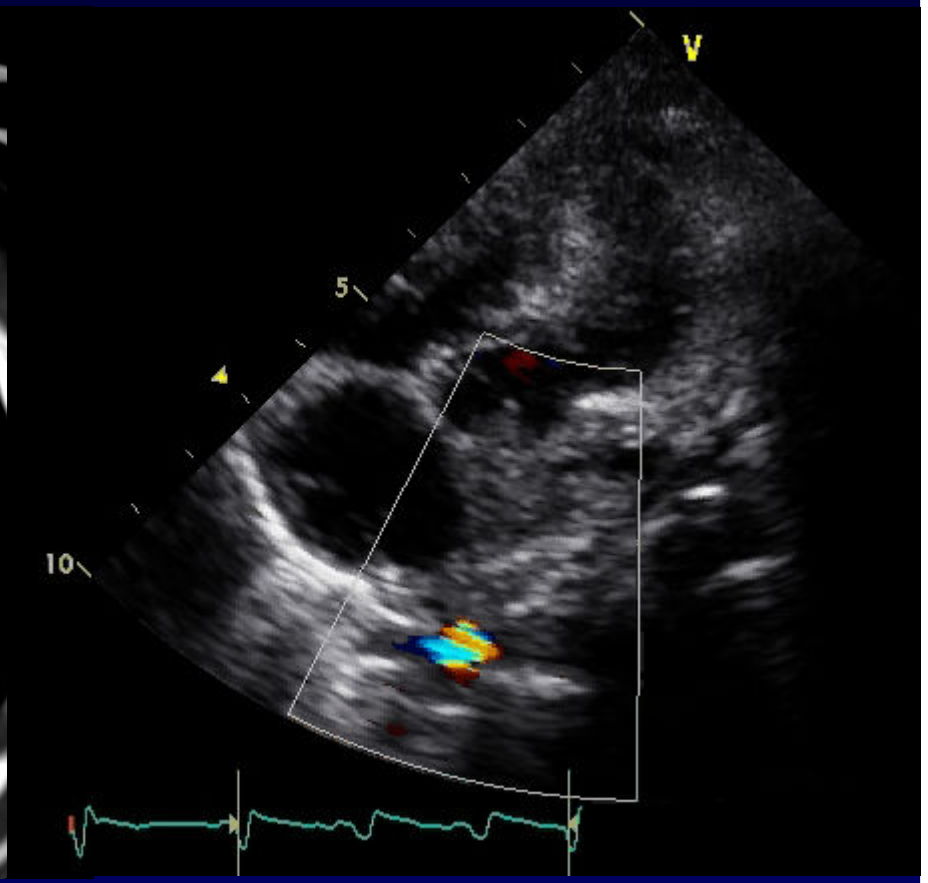


ToF 11 d – total rapair
1 mo - CT



5 day - rt m-BT shunt
15 mo - total repair with transannular patch

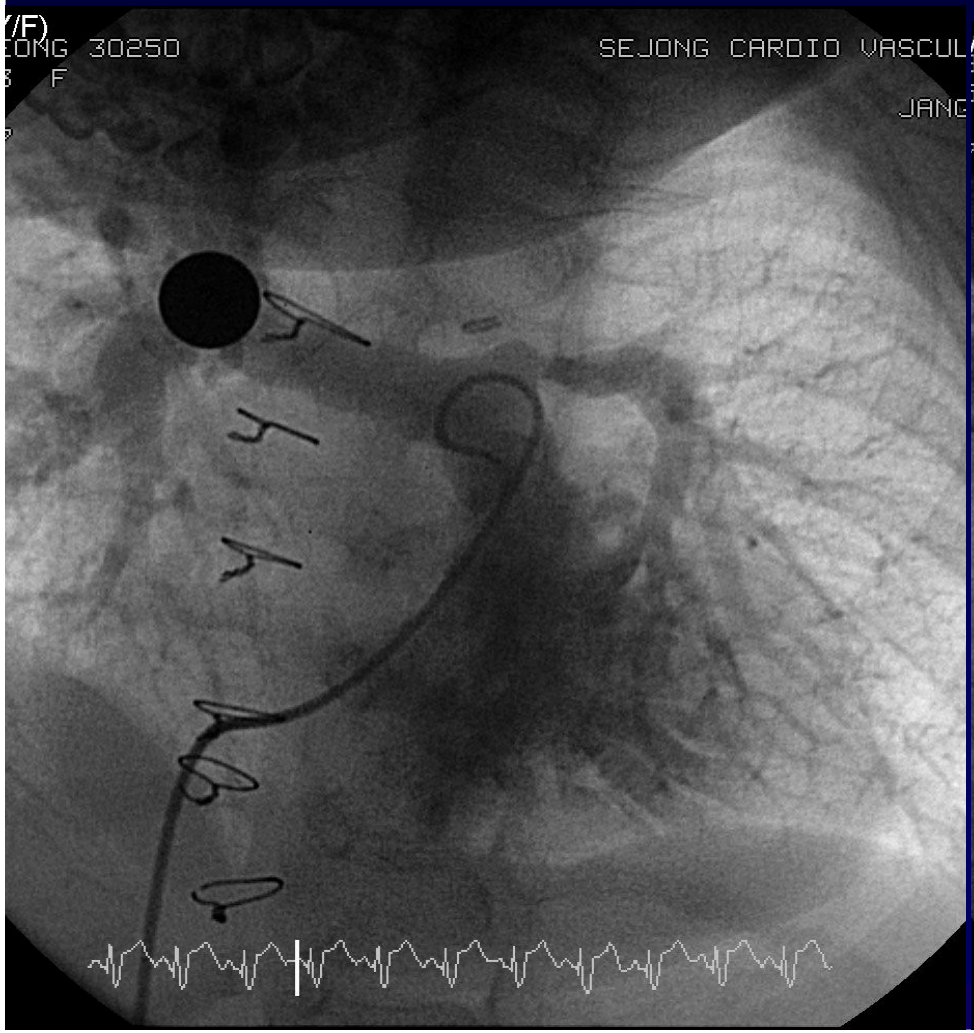


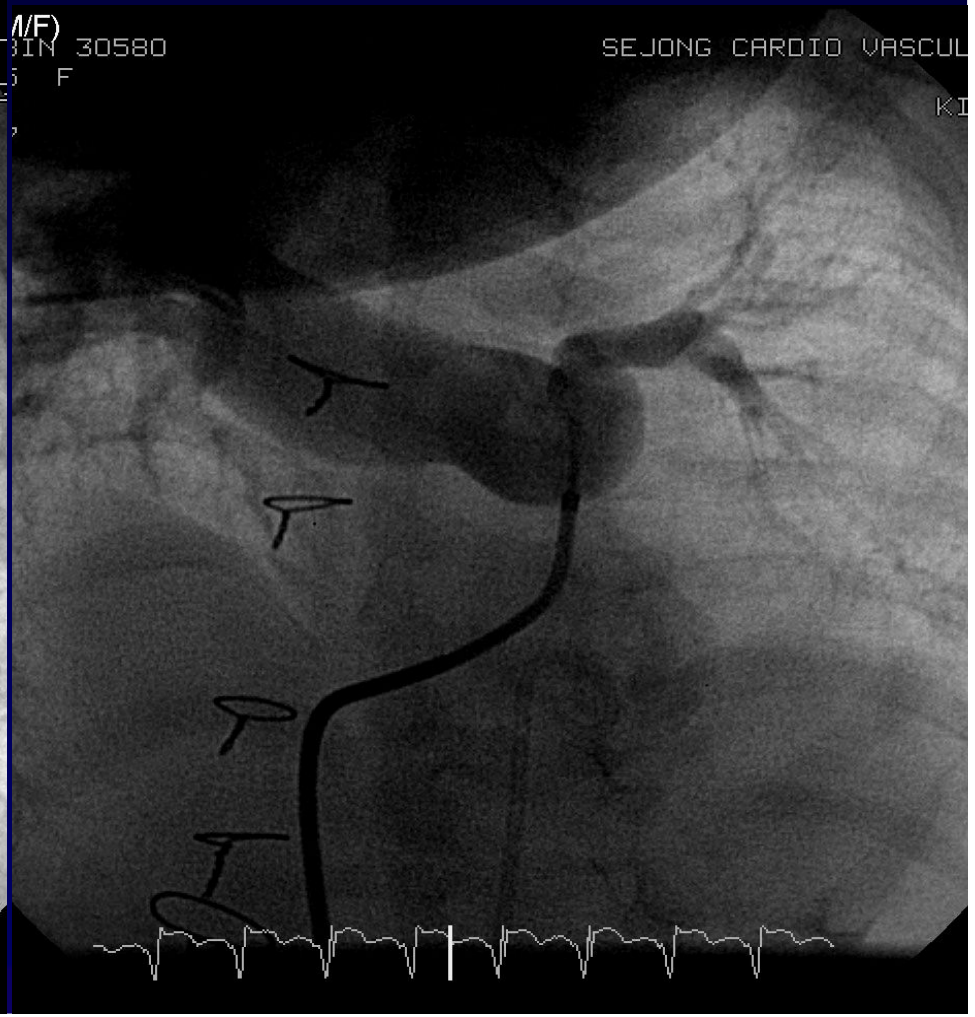


Early repair in PA VSD
Sejong Hospital

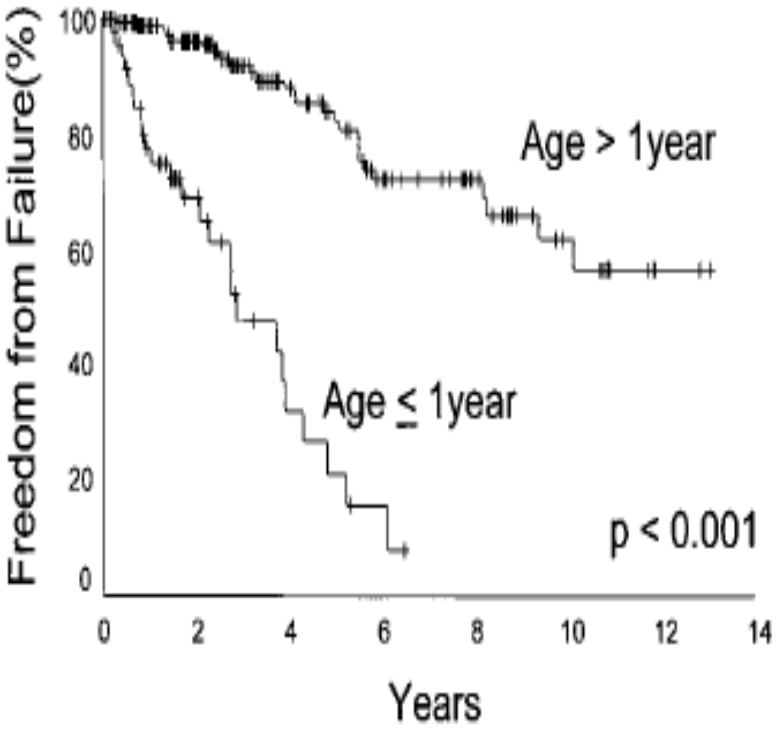
- 12 PA VSD (2004-2006), 15 – 40 days
- 10 ;REV-like RVOTR with GA-fixed autopericardium
  2 ; Valveless GA-fixed autopericardial roll
- 6 ; reinterventions - 5 reop (3,5,6,7, 21 mo after op)
  3 conduits
  2 angioplasty
  - 6 balloon angioplasty
- 1 late mortality – multiple anomaly

Early repair in PA VSD
Sejong Hospital





Conduit interposition in infants Homograft



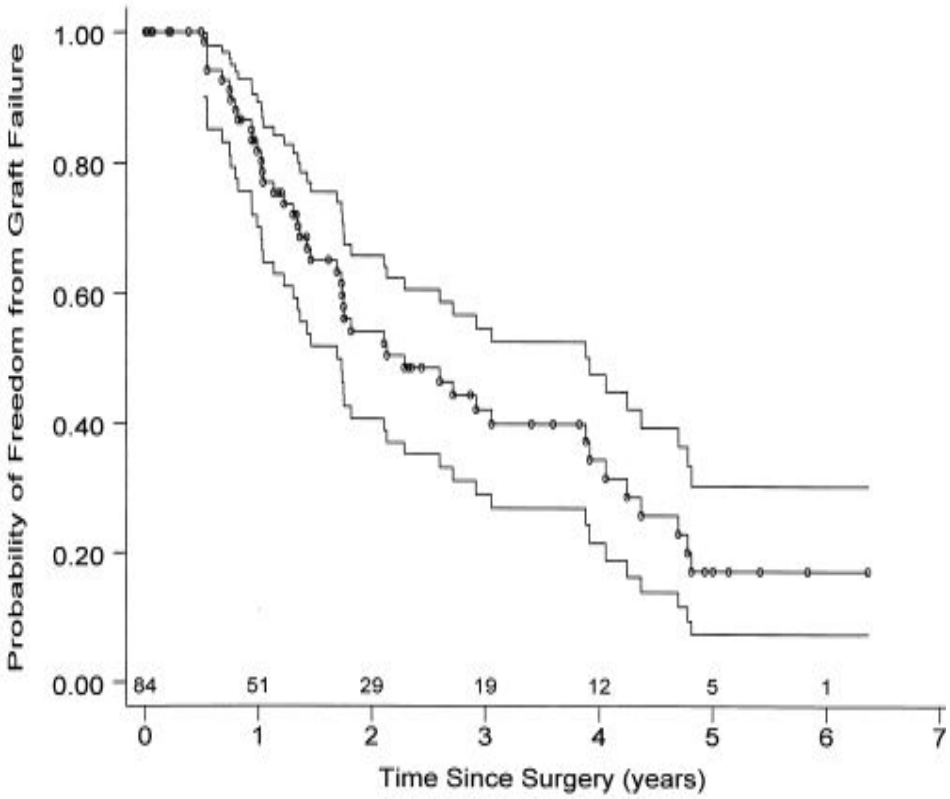
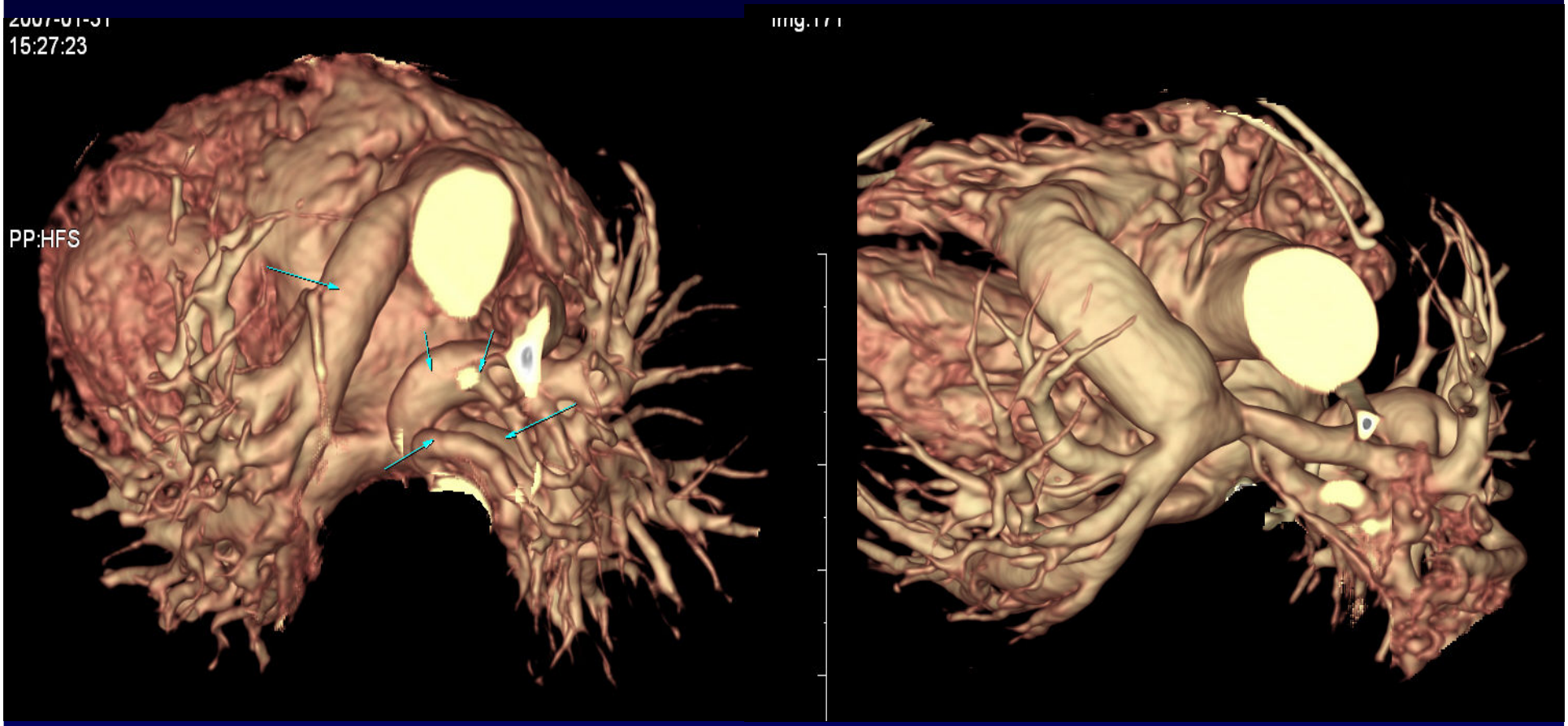


Figure 3. Kaplan-Meier freedom from homograft valve failure

Truncus arteriosus
total repair with autologous pericardium



The effect of repair technique on postoperative right-sided obstruction in patients with truncus arteriosus

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Julie S. Glickstein, MD[b]
Ryan R. Davies, MD[a]
Michelle L. Mercando, BA[a]
William E. Hellenbrand, MD[b]
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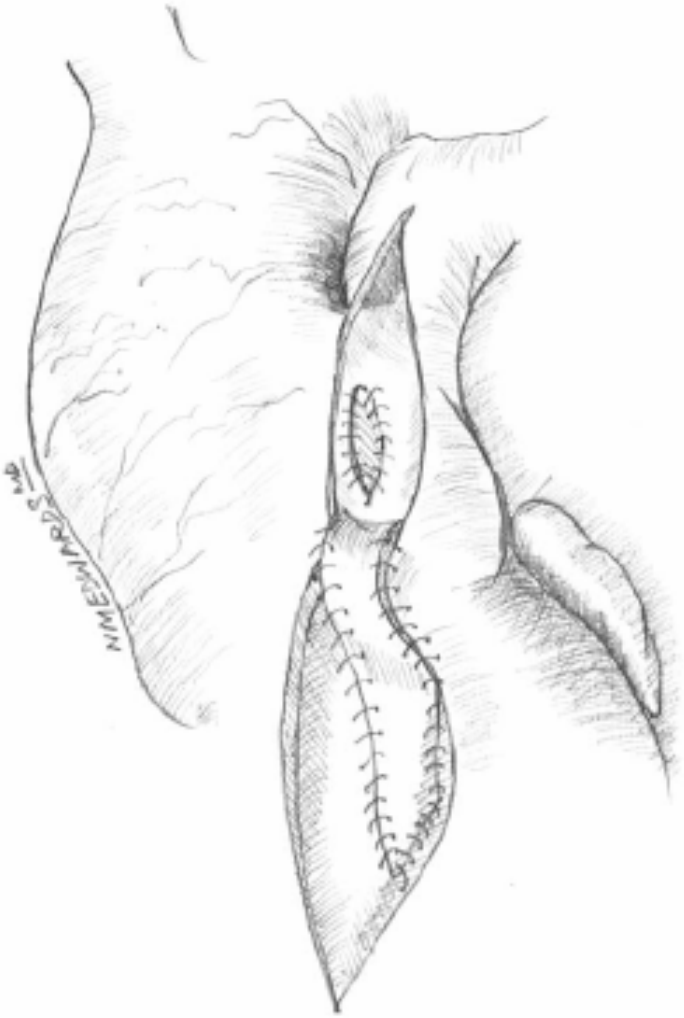
Valved homograft
- high reop rete (40% vs 15%)

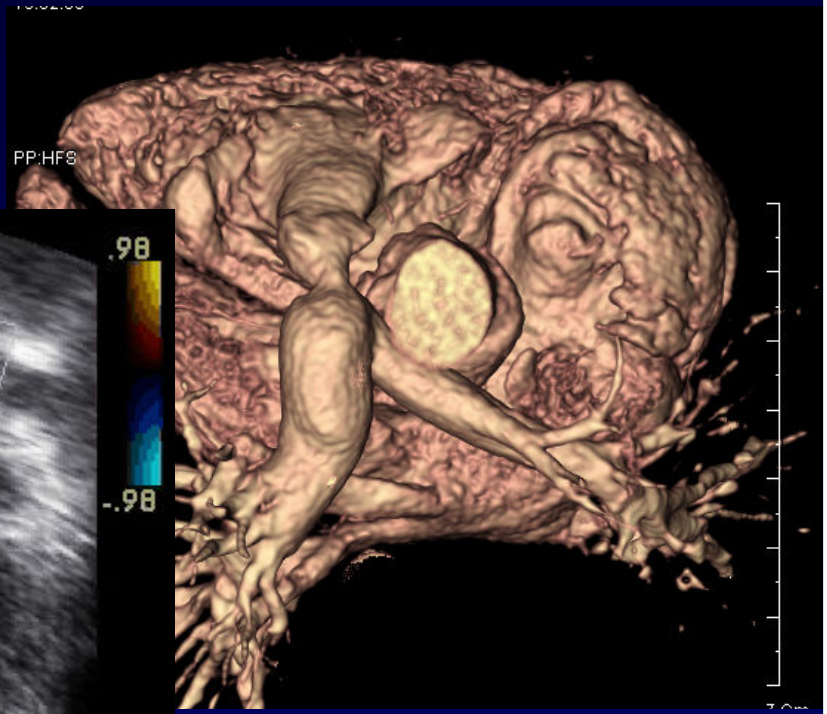
PTFE hoods
- lowest rete of reinterventions

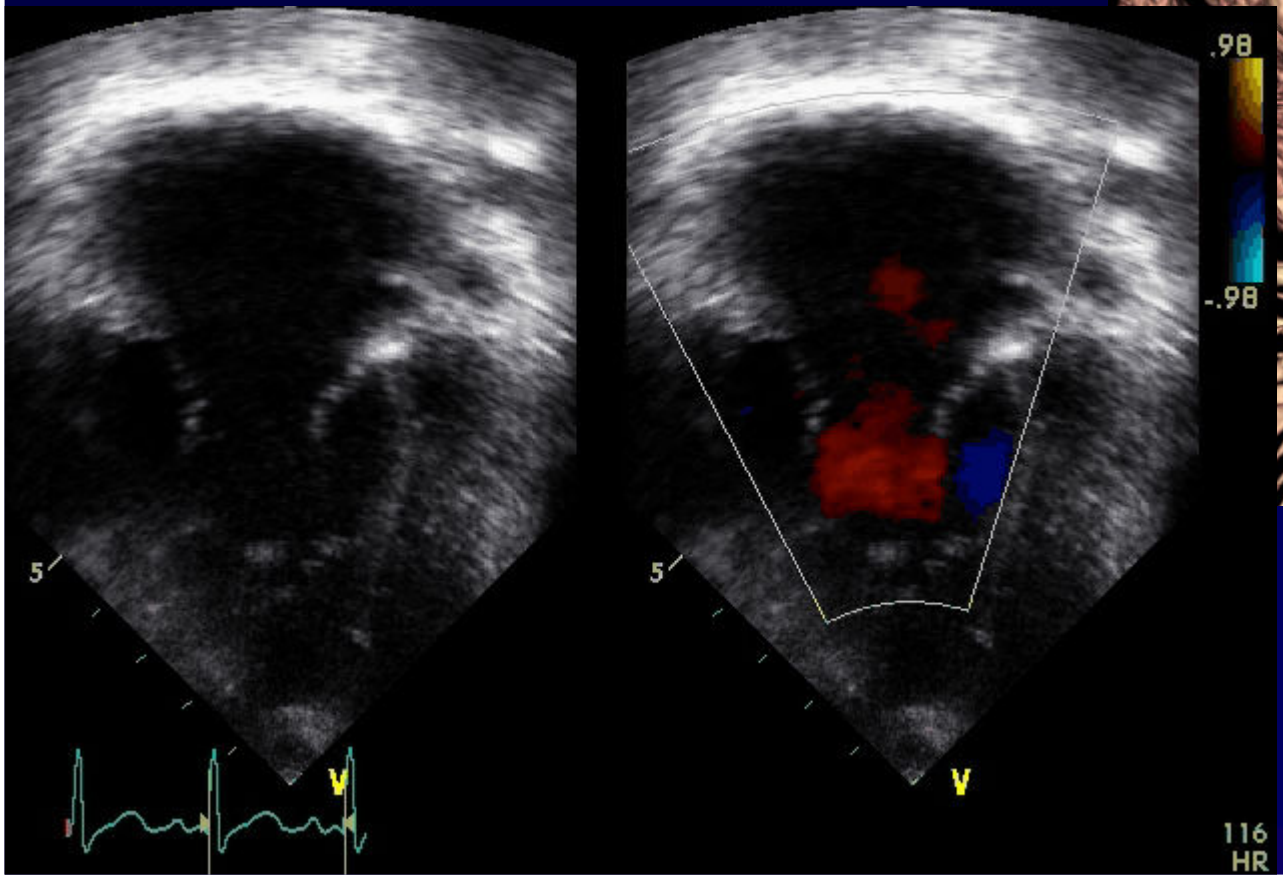
Chen et al. JTCS 2005



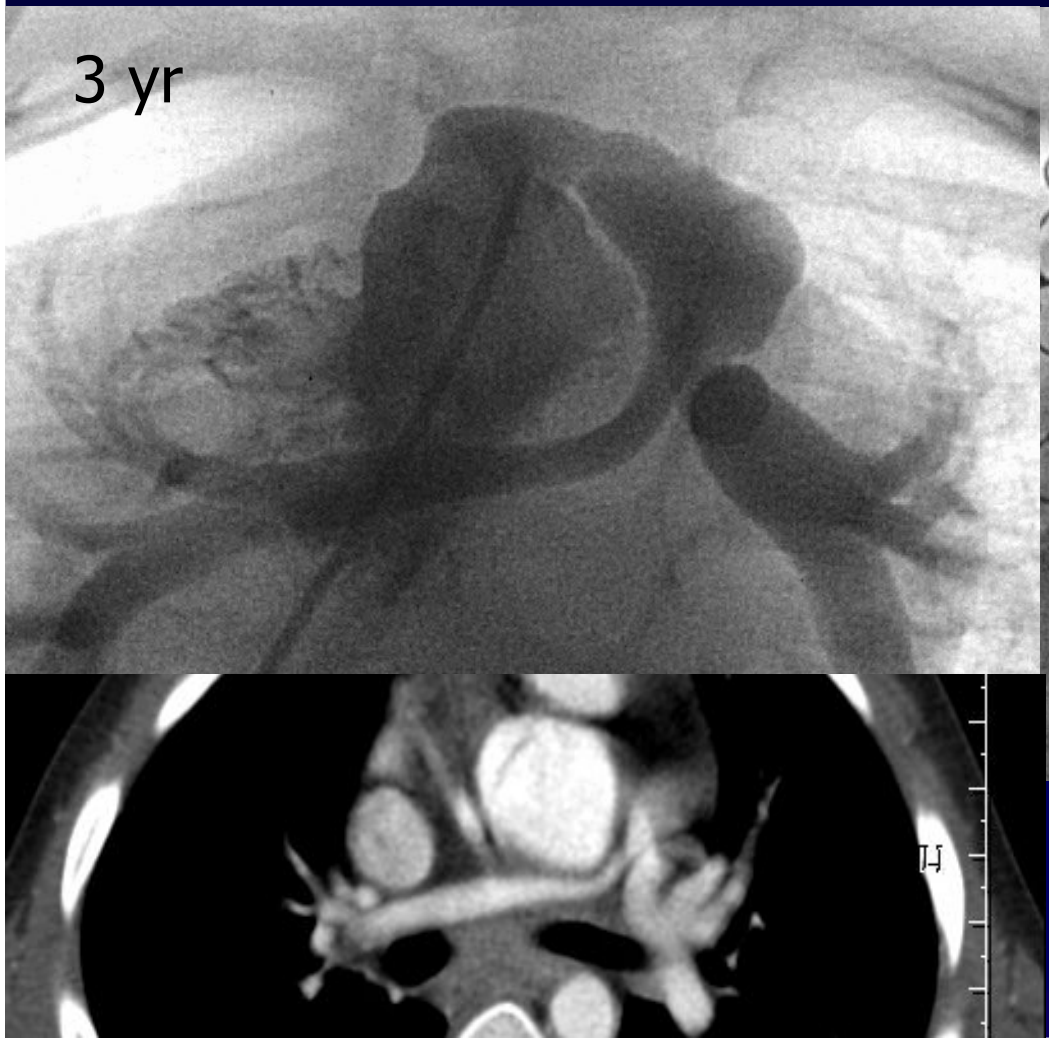
5 yr, 17 kg
Ross (Shelhigh 16mm → 8 mo after - CE valved conduit 18mm)

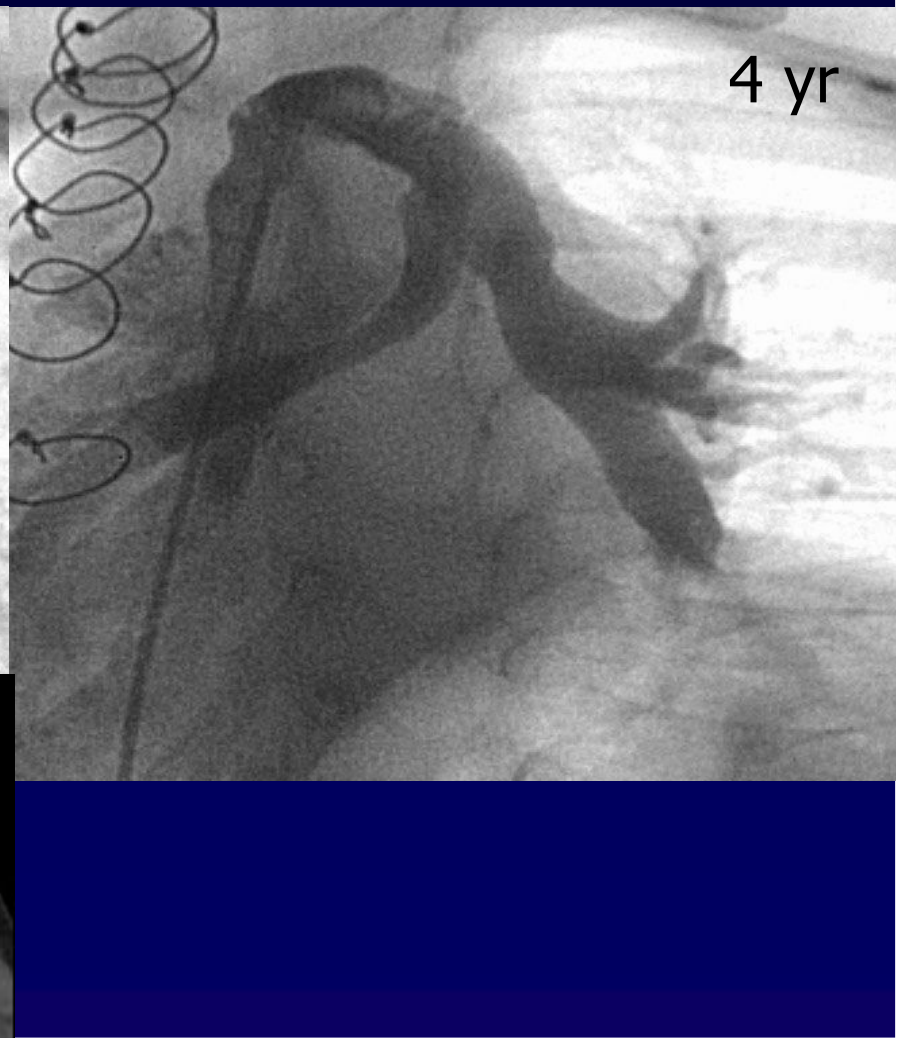
* Valveless conduit in infancy?





Diminitive asc. Ao (2mm) with VSD
-Norwood with Rastelli (nonvalved conduit)
-Both PA angioplasty & Conduit change with Shelhigh 16 mm
& Neo-Ao sinus reduction



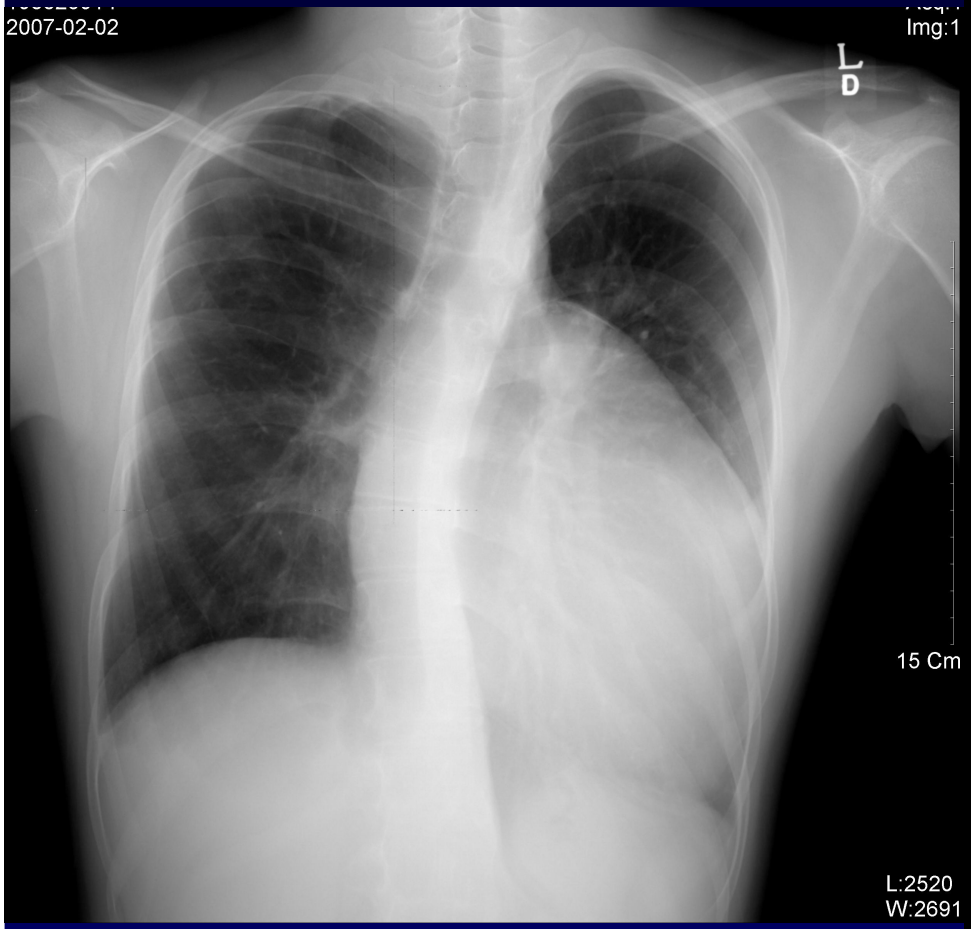


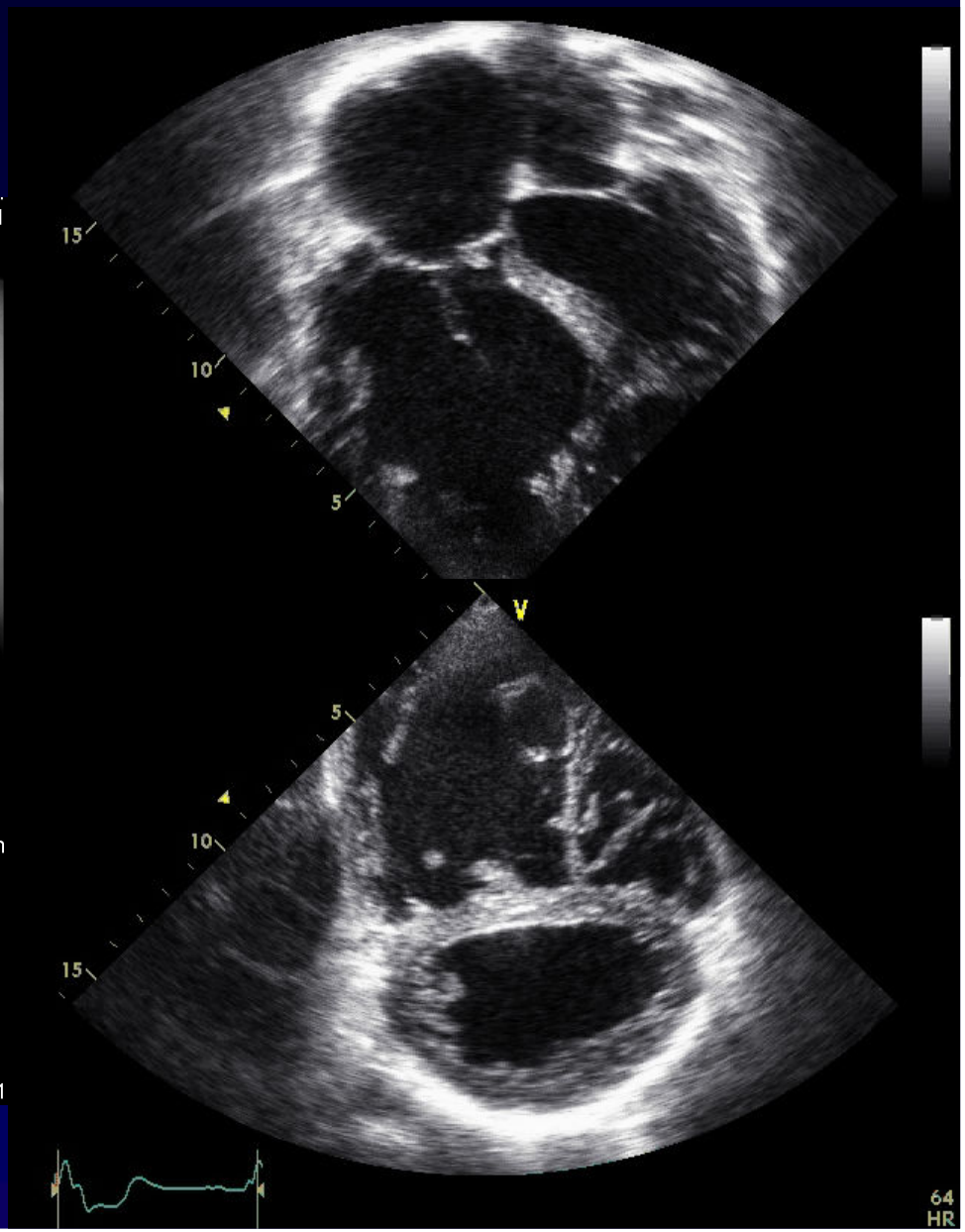
Late re-intervention

- Interventional therapy for RVOTO/PS
  - Balloon / stent / valved stent
- Conduit replacement
- PVR for chronic PR

PVR for chronic PR

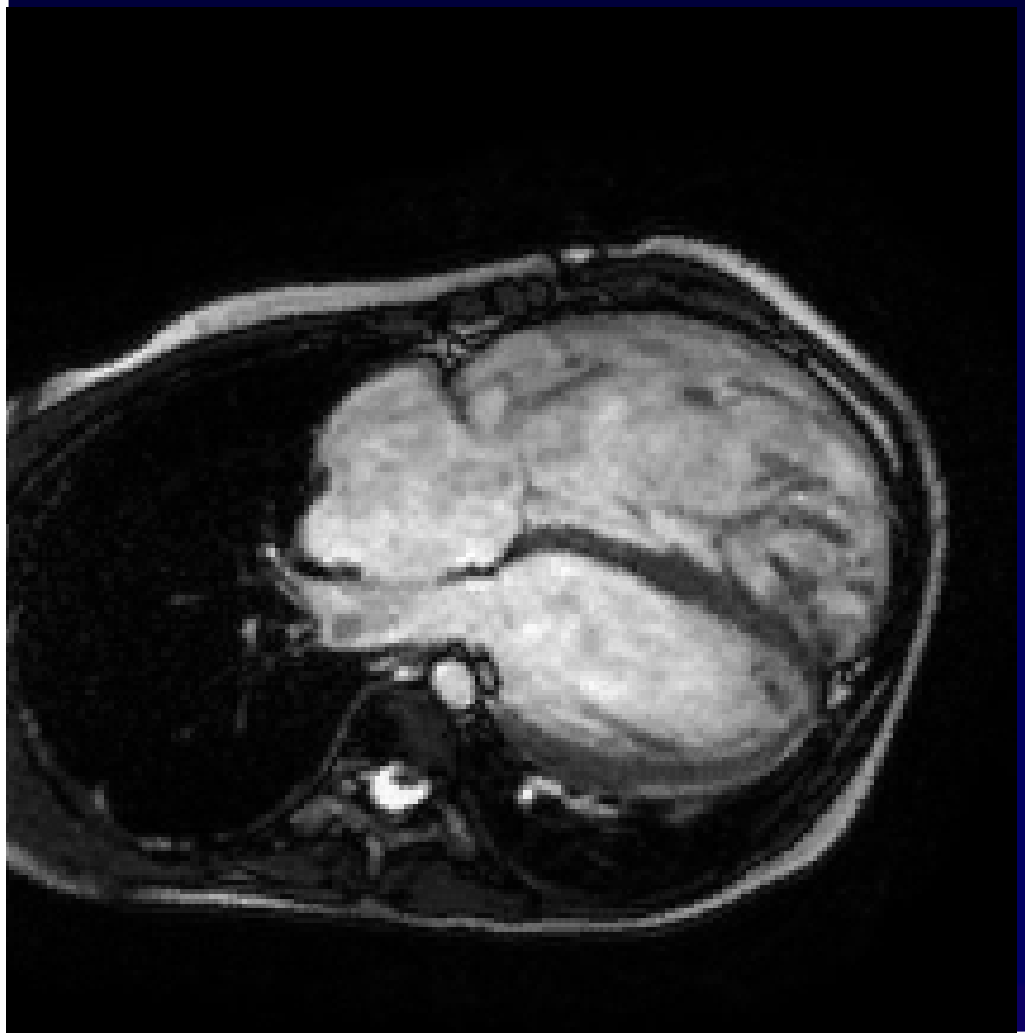
19yr/M, ToF repair (1yr), FC III





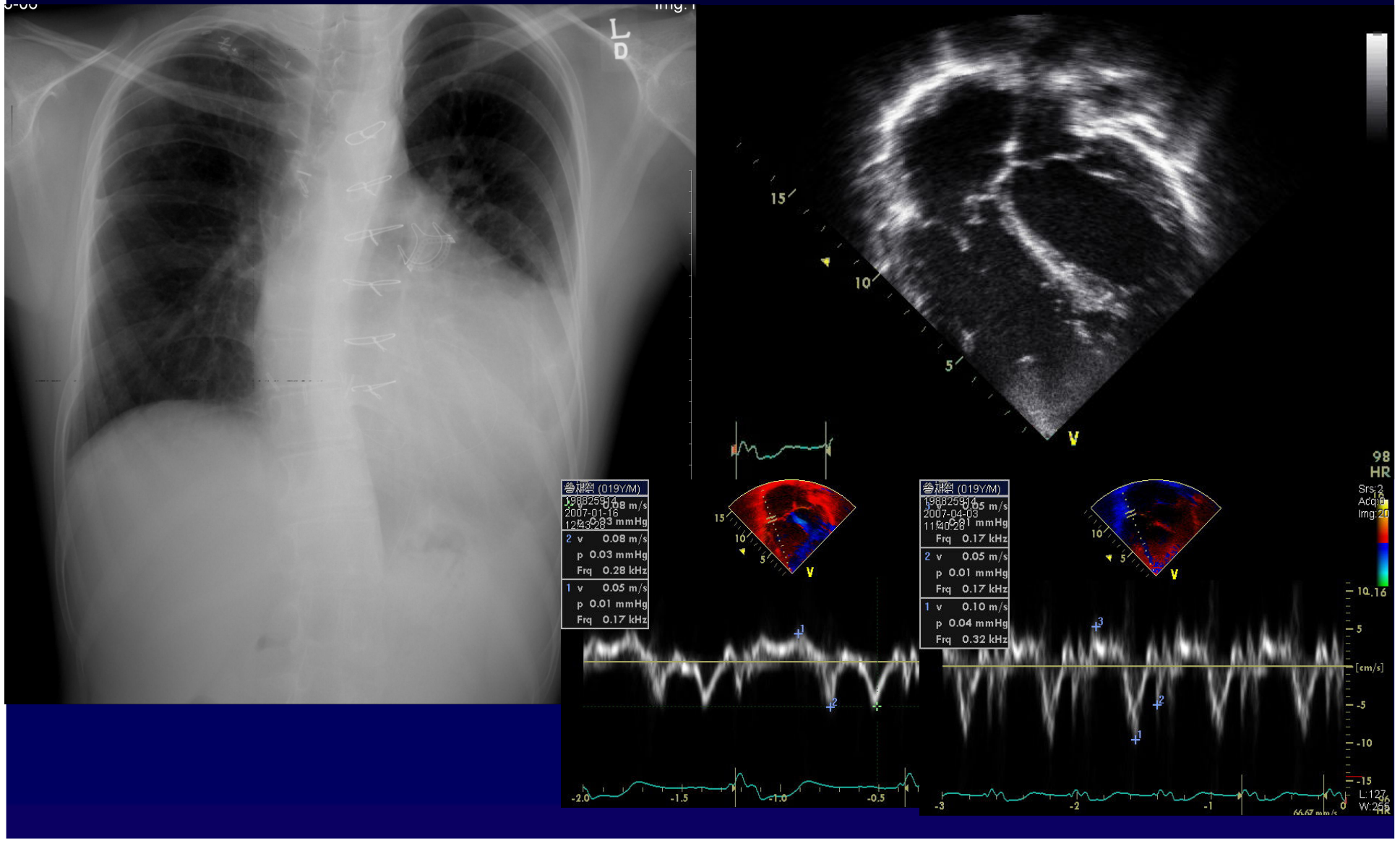
PVR for chronic PR

19yr/M, ToF repair (1yr), FC III

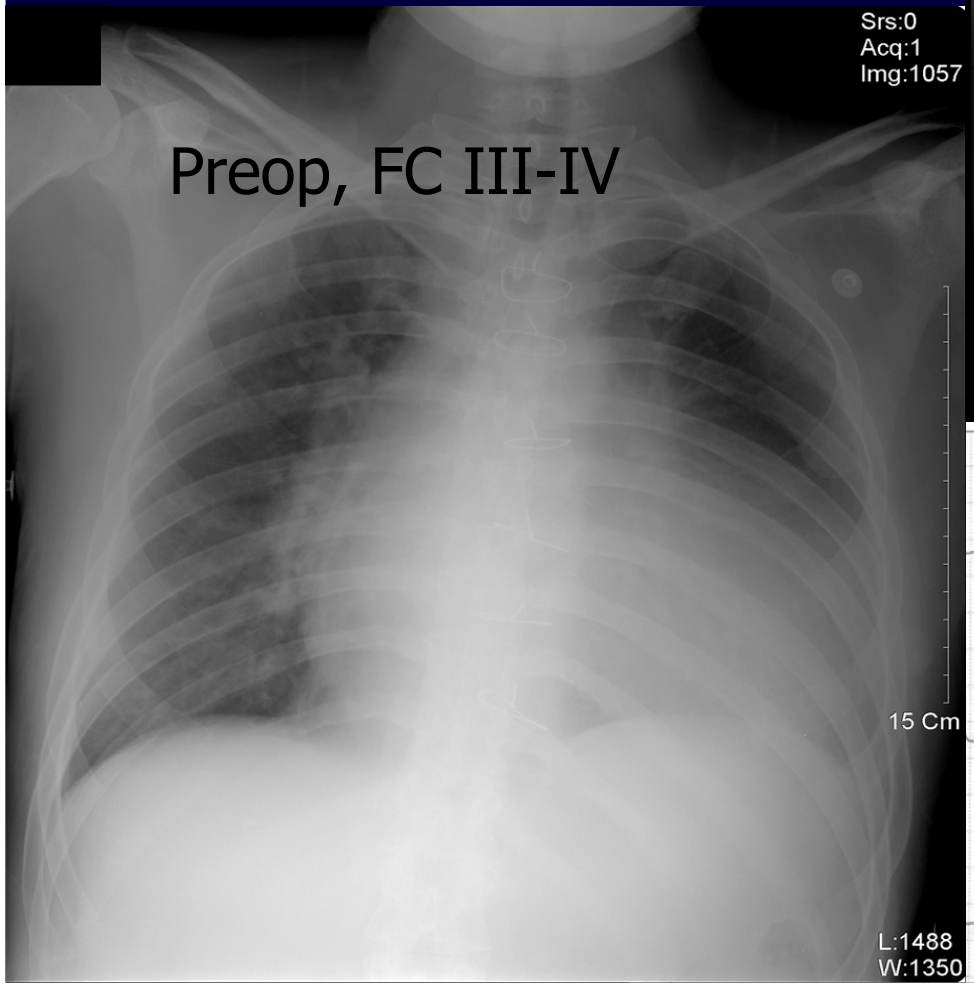


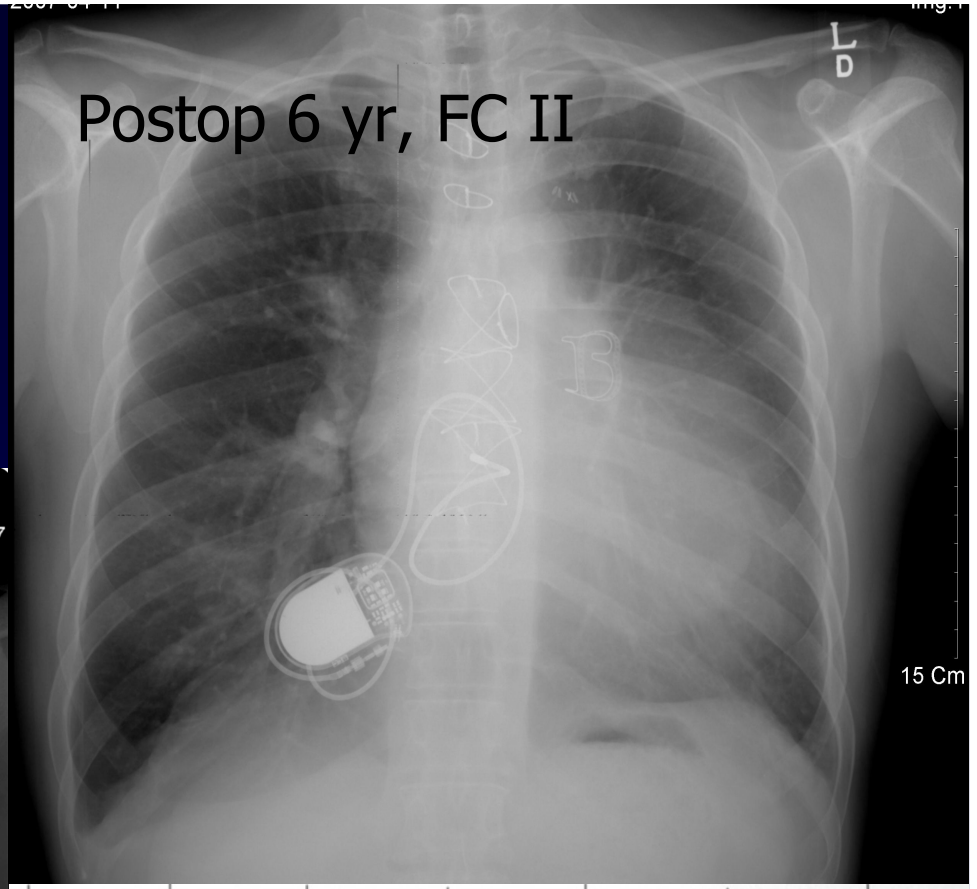
PR Fraction - 65%
RV EDV index - 352ml/m2
RV ESV index - 314ml/m2
RV EF - 11%
LV EF - 33%
TR, mild. AR, mild

PVR, RV aneurysmectomy, PA angioplasty – PO 2 mo



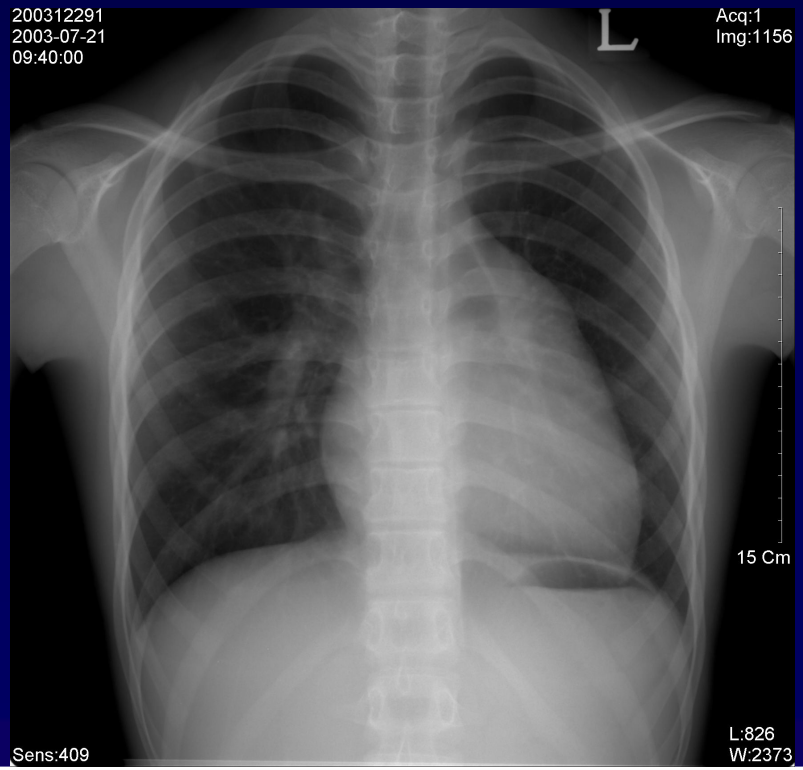
- **43 yrs / F**
- **TOF repair (20 years)**
- **Palpitation, decreased activity generalized edema,**
- **severe PR & TR & RAE**





14 yr /m, TOF repair (1yr)
FC I

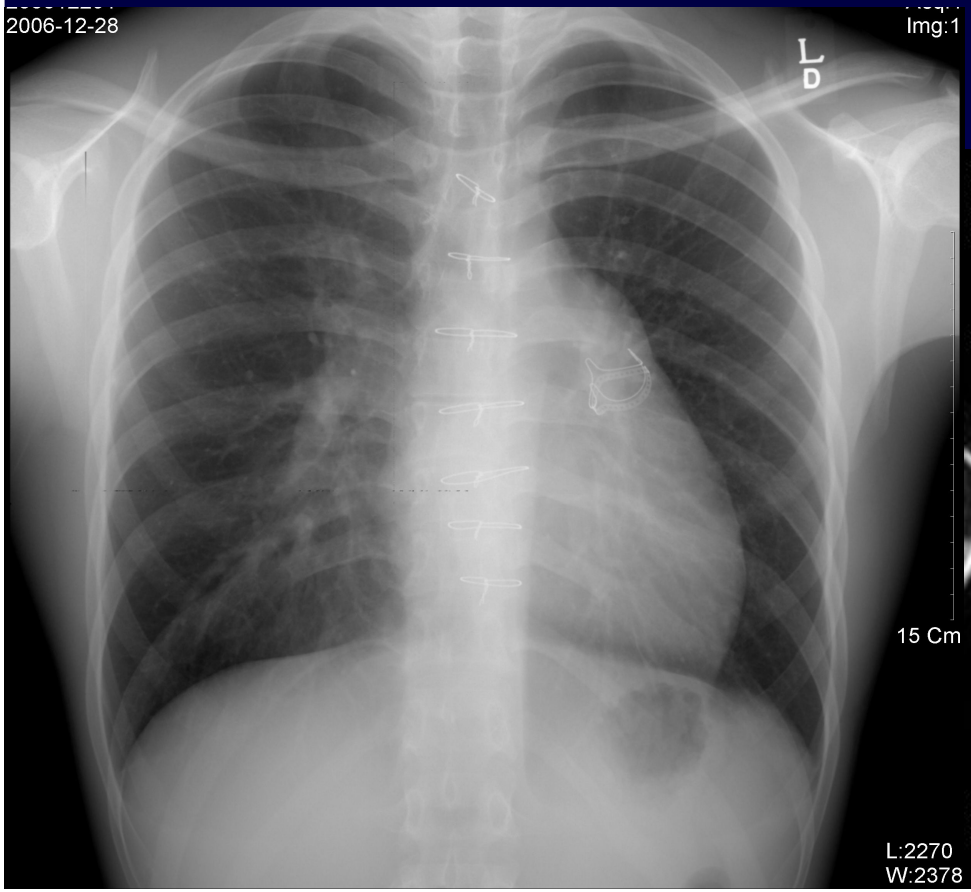
PR Fraction - 48 %
RV EDV index - 186ml/m2 (z=11)
RV ESV index - 101ml/m2 (z=10)
RV EF - 46 %
LV EF - 58 %
TR, mild.



14 yr /m, TOF repair (1yr)
FC I

16 mo after PVR

RV EDV index – 130 ml/m2 (z=3.8)
RV ESV index – 72 ml/m2 (z=5)
RV EF - 58 %
LV EF - 61 %



PVR for chronic PR

- Preserve RV function
  - Before irreversible change
- Symptomatic improvement
- Survival benefit

  vs.
- Cost, Op risks
- Minimize repeated operation

PVR for chronic PR

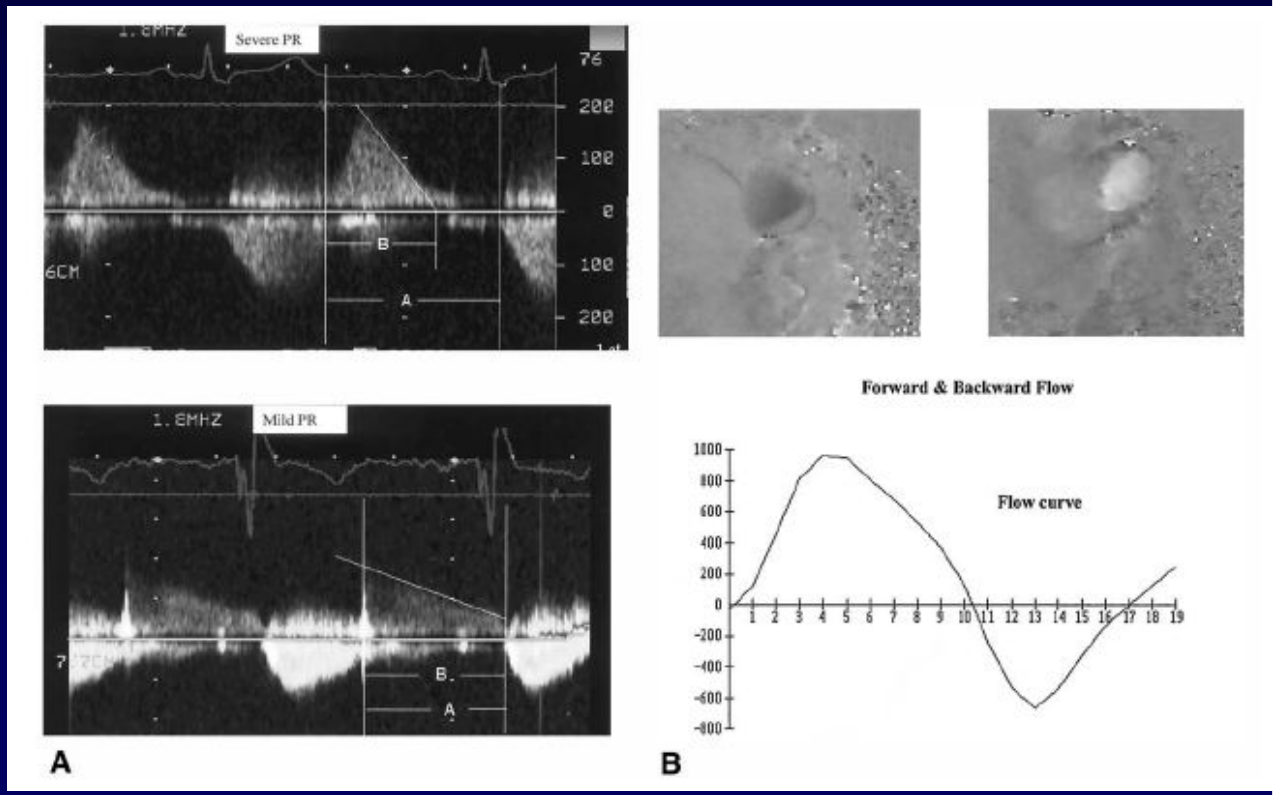
- Indications
  - More than moderate PR
  - Exercise intolerance, Sx of heart failure
  - Arrhythmia - IART , sustained VT
  - Progressive RV dysfunction
    - progressive TR
  - Associated defects
  - Social issues – occupation, pregnancy

PVR for chronic PR

- Assessment of PR – very difficult

- Echo Doppler
  - Color
  - PHT <100 ms
  - PR Index < 0.77

- MRI > 20-40%



PVR for chronic PR

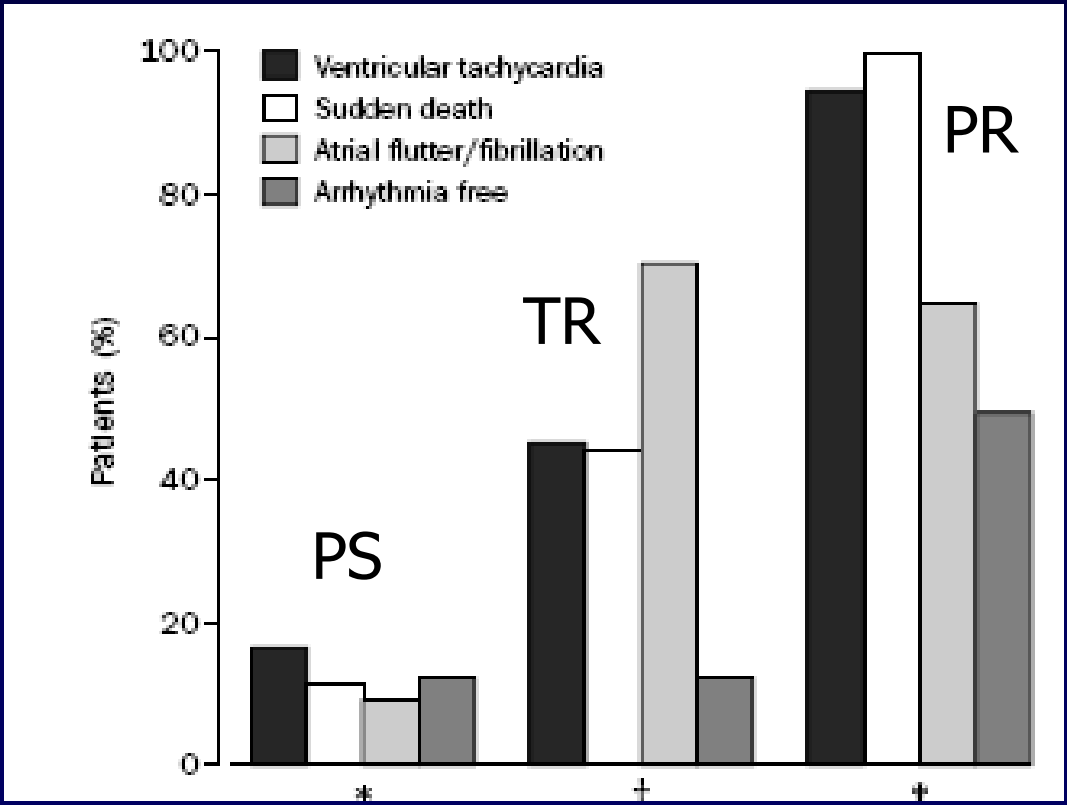
- Exercise intolerance
  - Cardiopulmonary exercise test – criteria?
  - Serial test can be helpful

	Studied group, $N=60$	Control group, $N=28$	P studied and control group	Studied PG(−), $N=26$	Studied PR(+), $N=34$	P PR(+) and PR(−)
BNP (pg/ml)	34.8±27.1	11.5±6.5	0.000001	36.1±25.9	34.4±28.1	NS
Peak VO2 (ml/kg/min)	24.7±5.5	36.6±7.6	0.00001	23.5±7.0	26.2±5.3	NS
Peak VO2%	64.7±13.0	93.8±14.2	0.00001	58.5±12.1	69.6±11.8	0.0005
HR (max, bpm)	178.6±24.0	192.1±15.3	0.001	170.8±33.0	173.4±12.9	NS
HRmax %	92.1±12.6	99.9±15.3	0.00001	93.1±16.9	95.9±7.4	NS
BPmax (mm Hg)	148.0±23.8	168.9±15.3	0.00006	144.7±26.4	149.1±22.6	NS
VE/VCO2	36.5±6.3	29.7±4.7	0.004	37.6±7.9	35.7±5.7	NS
RQ	1.08±0.04	1.2±0.1	0.001	1.07±0.03	1.06±0.04	NS
FVC (l)	3.6±1.0	4.9±1.1	0.00001	3.8±1.0	3.6±1.0	NS
FVC %	86.9±14.3	103.3±9.3	0.00001	83.6±16.2	87.6±12.6	NS
FEV 1 (1)	3.0±0.6	4.0±0.9	0.00001	3.0±0.7	3.0±0.4	NS
FEV1%	82.9±12.6	98.4±11.1	0.00001	80.0±14.2	84.0±10.9	NS

Int J Cardiol 2006

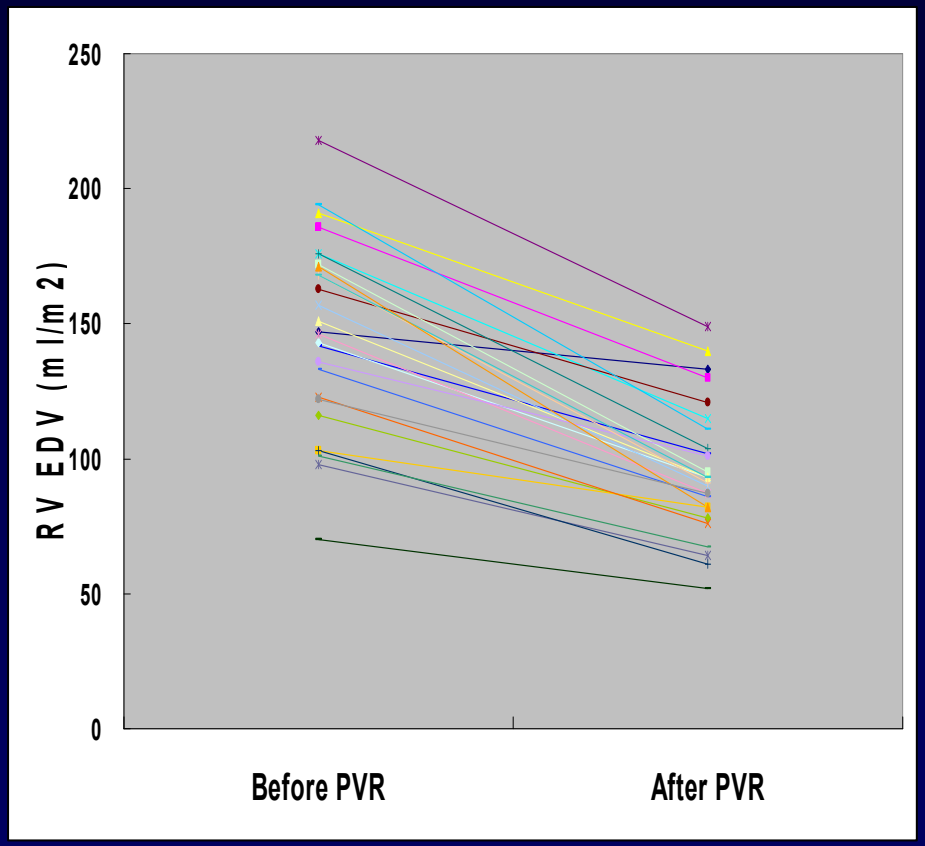
PVR for chronic PR

- Arrhythmia / sudden death

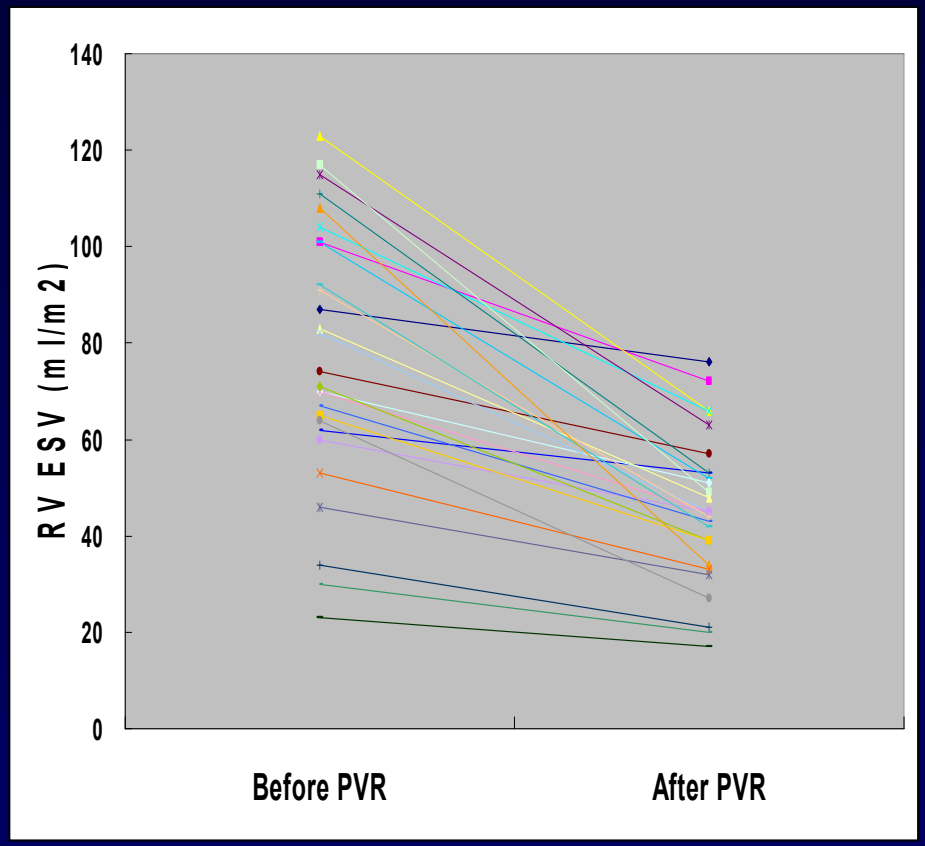


Lancet 2000

PVR for chronic PR
RV function

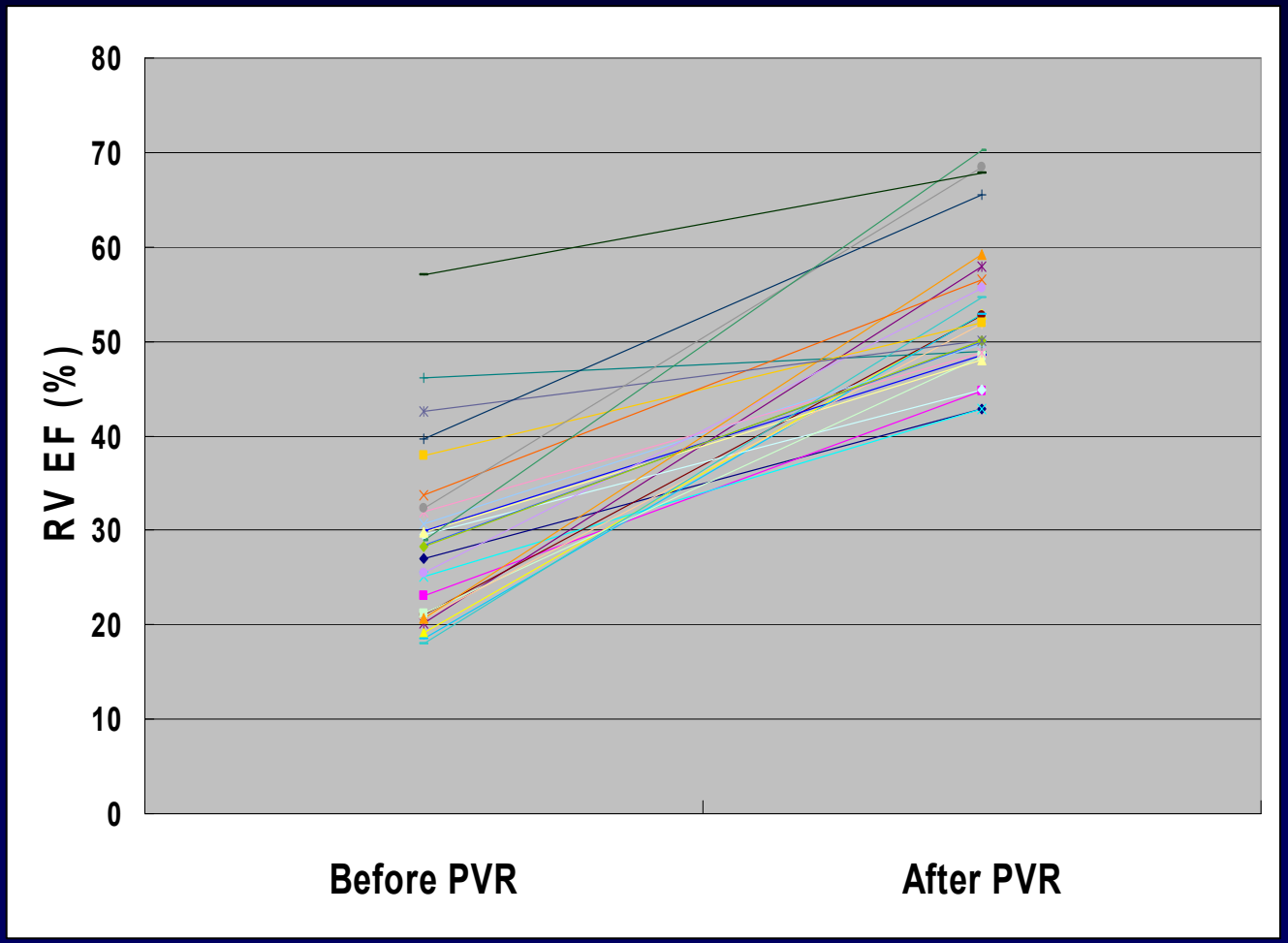


RV EDV Index



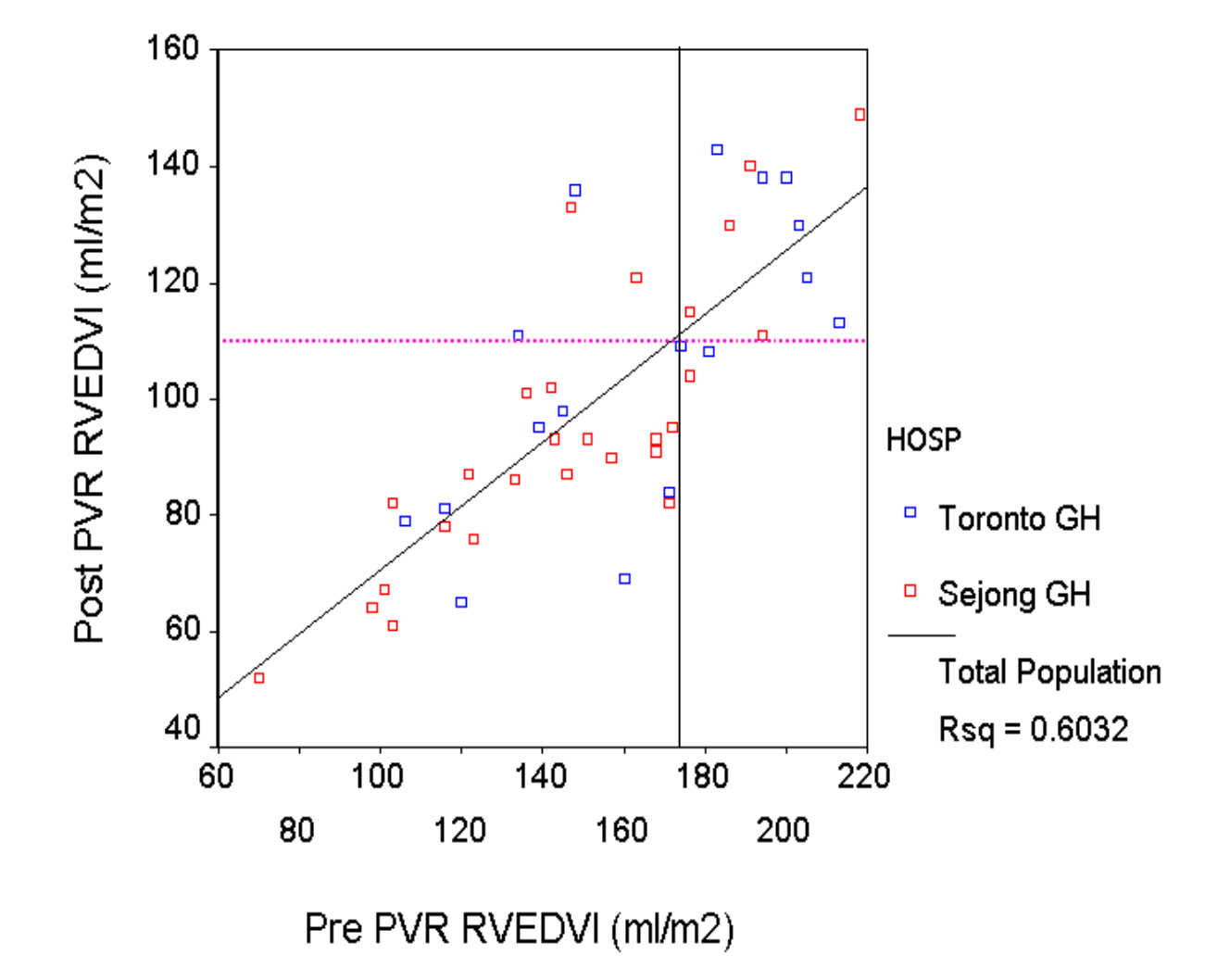
RV ESV Index

PVR for chronic PR
RV function

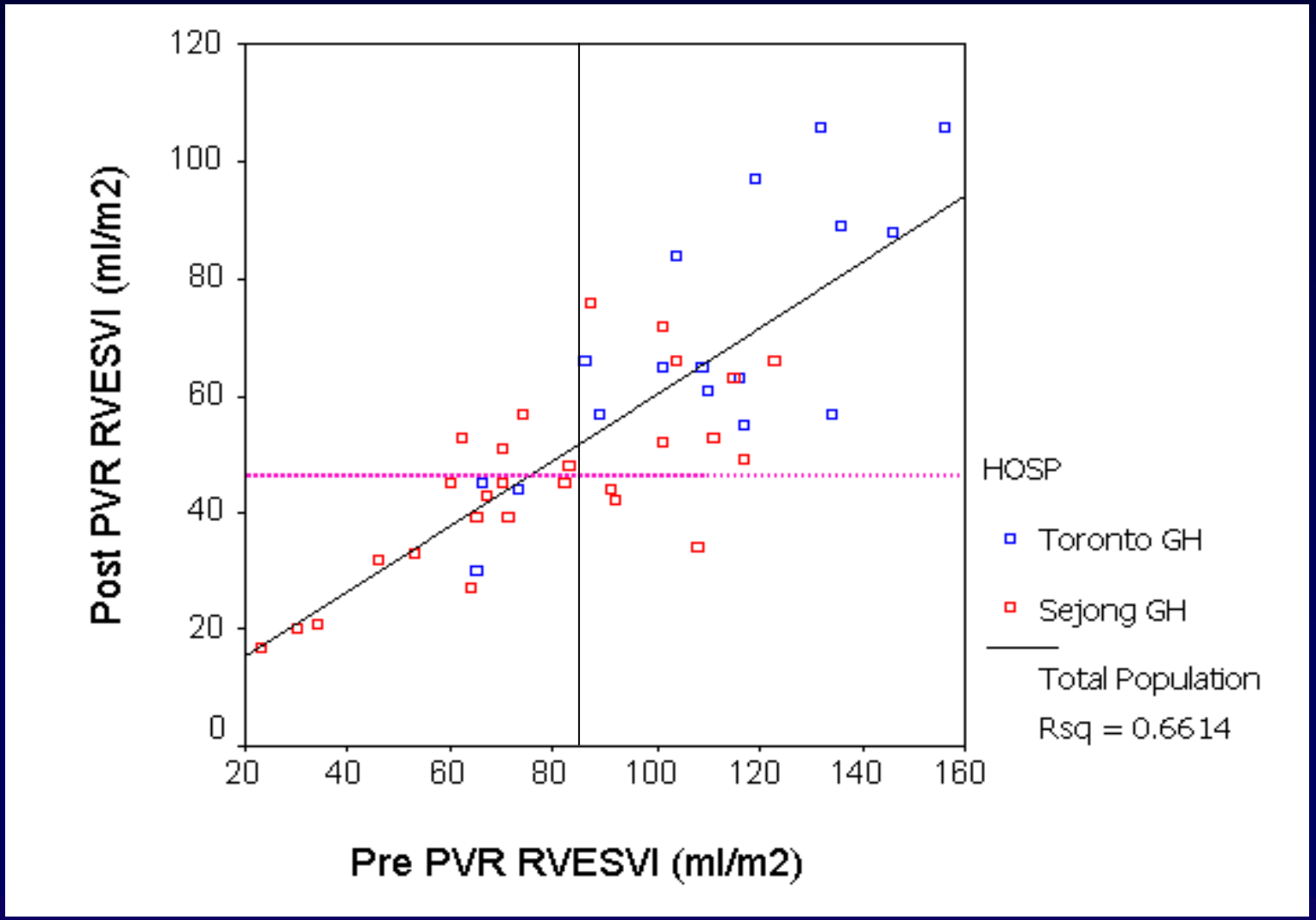


*EF before PVR was corrected for PR ; net pulmonary pulmonary flow / RVEDV

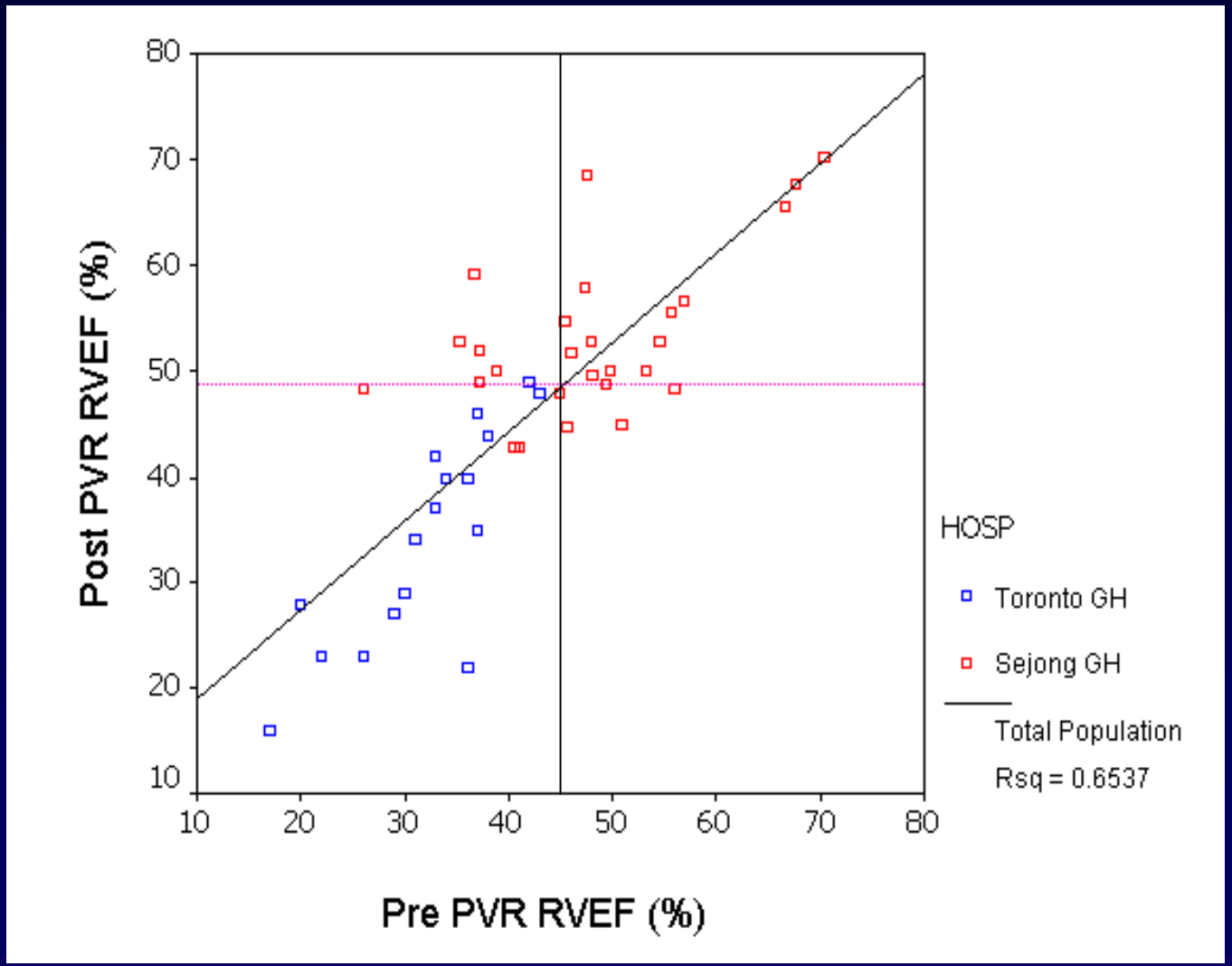
PVR for chronic PR
RV function



PVR for chronic PR
RV function

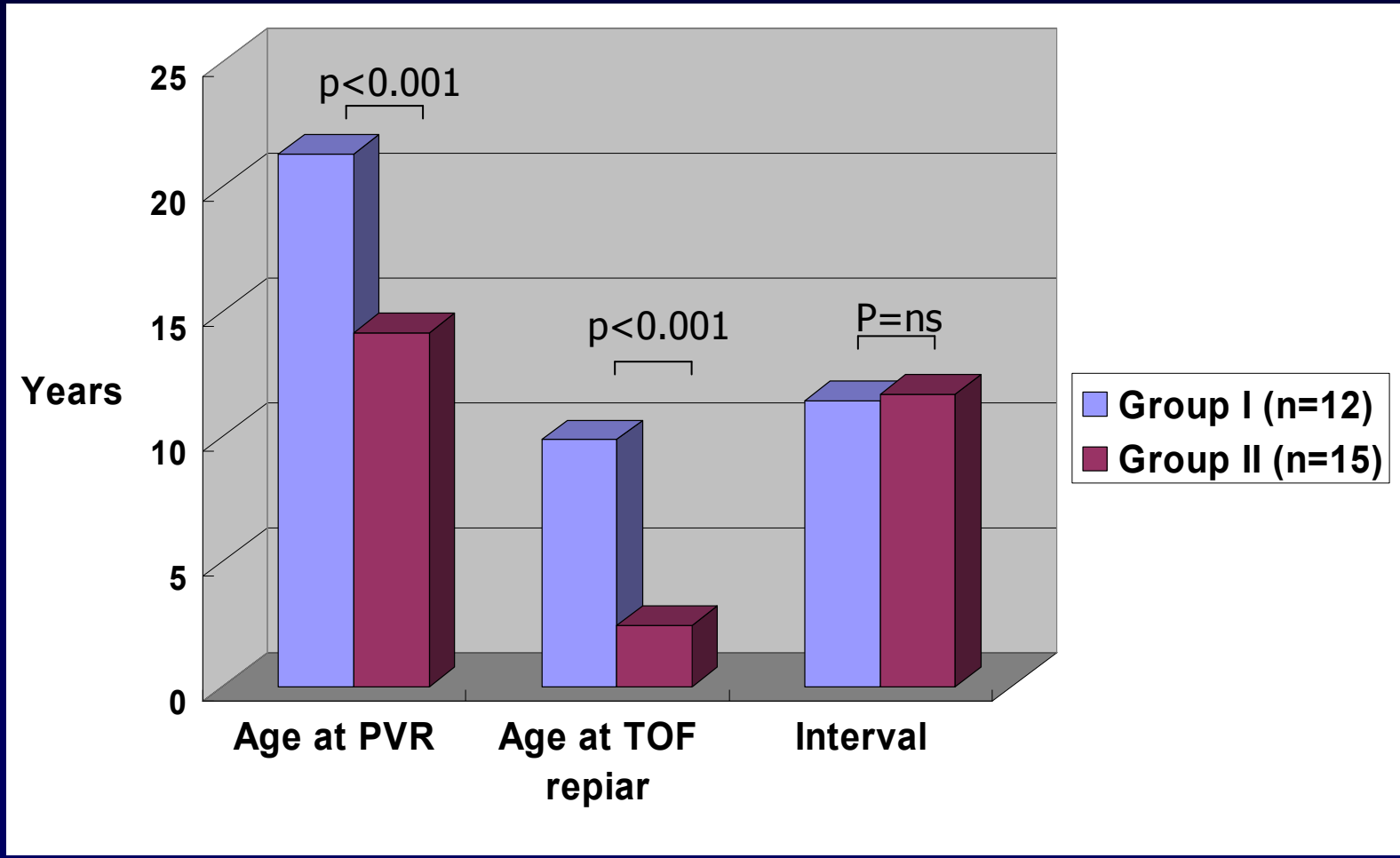


PVR for chronic PR
RV function



PVR for chronic PR - age

Group I ; patients with persisted RV dilatation after PVR



Optimal Timing for Pulmonary Valve Replacement in Adults After Tetralogy of Fallot Repair

Judith Therrien, MD, Yves Provost, MD, Naeem Merchant, MD, William Williams, MD, Jack Colman, MD, and Gary Webb, MD

RV EDV I >170 ml/m² or RV ESV I > 85 ml/m²

(Am J Cardiol 2005;95:779–782)

TABLE 1 Demographics, Surgical, and Magnetic Resonance Imaging Characteristics

Patient	Age at TOF Repair (ys)/Sex	Age at PVR (ys)	Additional Procedures	RVEDVi Pre-PVR (ml/m²)	RVEDVi Post-PVR (ml/m²)	RVESVi Pre-PVR (ml/m²)	RVESVi Post-PVR (ml/m²)	RVEF Pre-PVR (%)	RVEF Post-PVR (%)
2	7 M	20	2	106	79	66	45	38	44
16	3 M	22	1	183	143	104	84	37	35
3	5 F	23	1,2	116	81	73	44	37	46
17	4 F	23	1	200	138	156	106	22	23
15	22 M	24		139	95	89	57	34	40
7	2 M	24	1	134	111	86	66	36	40
14	2 M	26	6	203	130	136	89	30	29
11	7 F	32		174	109	116	63	33	42
13	5 F	32	1,5	194	138	132	106	26	23
8	8 F	35	1	145	98	101	65	31	34
9	15 F	38	1,2,4	181	108	110	61	33	37
10	3 F	38	3	213	113	117	55	43	48
6	8 F	39	1,2	171	84	109	65	36	22
1	10 F	43	2,5	205	121	146	88	29	27
4	11 M	43	2,5	160	69	134	57	17	16
5	21 F	59	2	148	136	119	97	20	28
12	23 M	62	5	120	65	65	30	42	49

F = female; M = male; RVEDVi = right ventricular end-diastolic volume index; RVEF = right ventricular ejection fraction; RVESVi = right ventricular end-systolic volume index; 1 = right ventricular outflow tract relief; 2 = tricuspid annuloplasty; 3 = shunt closure; 4 = right ventricular outflow tract aneurysm resection; 5 = cryoablation; 6 = right atrial maze procedure.

PVR for chronic PR
- mechanical valve?

MECHANICAL VALVES IN THE PULMONARY POSITION: A REAPPRAISAL

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Objectives: To evaluate midterm results of mechanical valves in pulmonary position in patients with pulmonary regurgitation and right ventricular dysfunction as an alternative to bioprostheses. *Patients:* Mechanical valves (six tilting disc valves and two bileaflet valves) were implanted in eight patients previously operated on for tetralogy of Fallot ($n = 7$) and truncus arteriosus ($n = 1$), with severe right ventricular dysfunction caused by massive pulmonary regurgitation. *Results:* All patients survived prosthesis implantation and are currently well. At follow-up (3 months to 9 years), they do not show signs of valve failure, and right ventricular function has dramatically improved in all but one, who still shows moderate ventricular hypokinesia. *Conclusion:* After operative correction of congenital heart defects in selected patients who show severe dysfunction of the right ventricle caused by pulmonary regurgitation/stenosis, mechanical valves may represent an alternative to bioprosthetic valves. The selection of the valve type is still a matter of debate. However, according to literature data, complications seem to have occurred only in patients with bileaflet mechanical valves in the pulmonary position, whereas no thromboembolic episodes or valve failure is reported in subjects with tilting disc valves in the right ventricular outflow. Tilting disc valves might perform better in the right ventricular outflow than bileaflet valves. (J Thorac Cardiovasc Surg 1998; 115:1074-9)

PVR for chronic PR - mechanical valve?

- The risk of reoperation can be much higher than normal and to avoid any further reoperations
- Patients that use anticoagulative medication for other reasons

Waterbolk T et al. Eur J Cardio-thoracic Surg (2006)


Thank You !!!