Debate in CHD - When Should We Replace Pulmonary Valve?
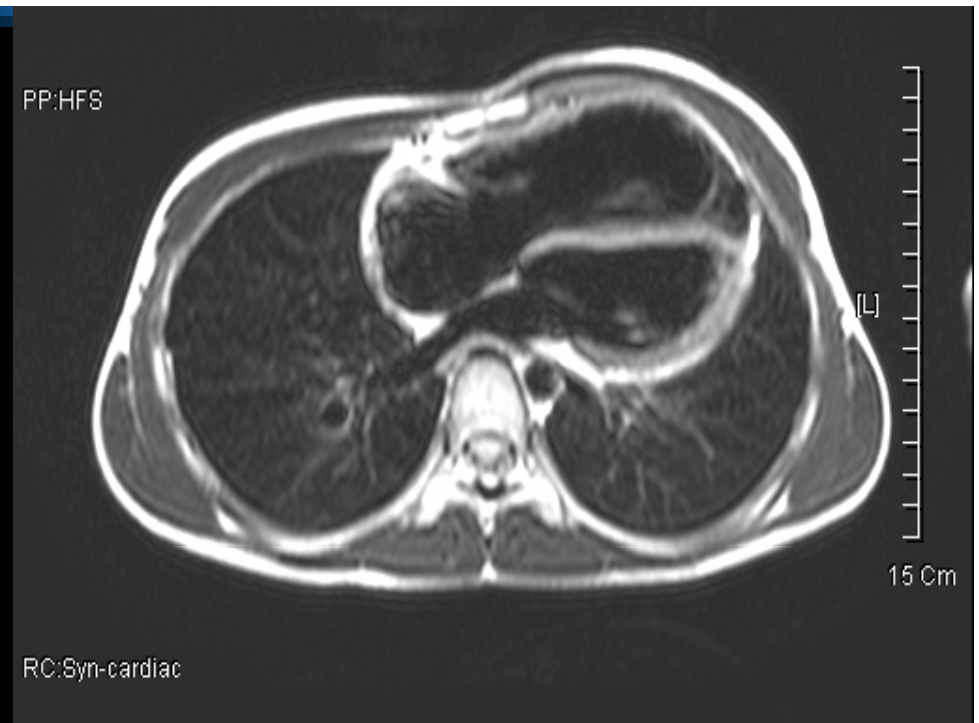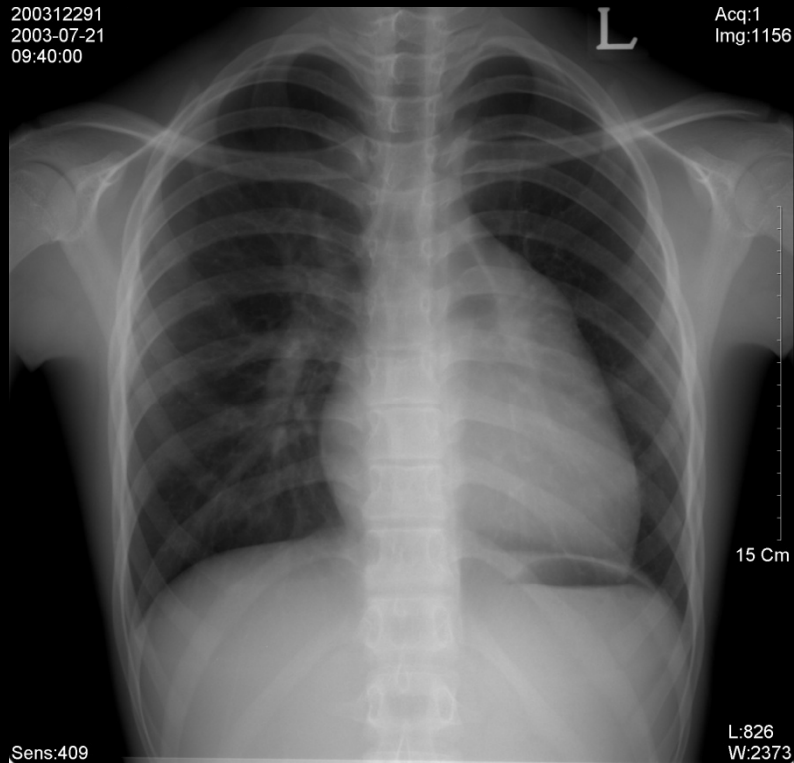
Lee, Jae Young

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The Catholic University of Korea

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.

Case : a patient after TOF repair

- Age; 16 year-old-boy/girl
- Age at TOF repair?
- One unproven episode of <u>dizziness</u>
- NYHA <u>class II</u> and Normal CPET
- EKG: QRS duration 150 ms
- Holter: <u>nonsustained VT</u> and/or PVCs
- MRI: RV volume 150 ml/m^2, EF 55%,
                   PR fraction 40%
- no TR

Background

- PR after repair of TOF
  - Progressive RV dilatation & failure
  - Exercise intolerance
  - Arrhythmia
  - Sudden death

Gatzoulis MA et al, Lancet 2000;356:975-81
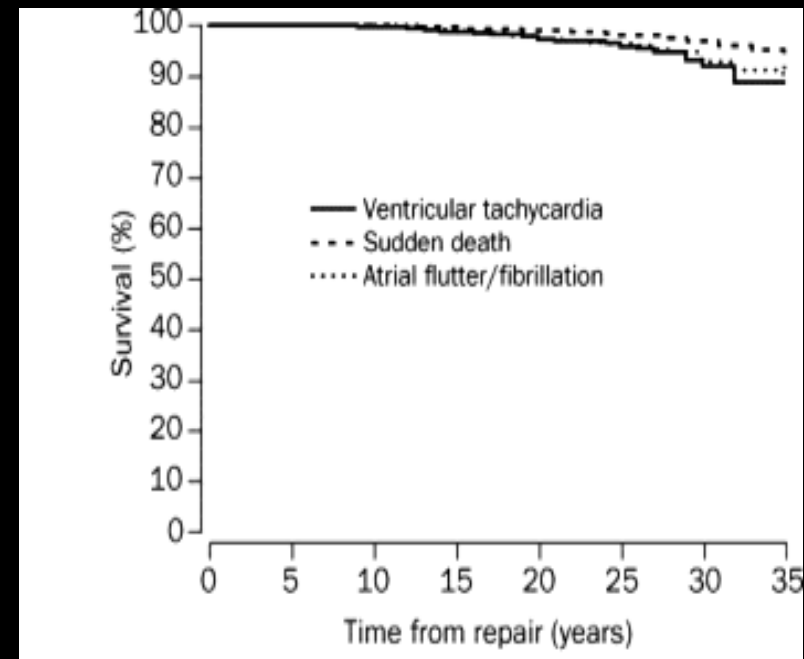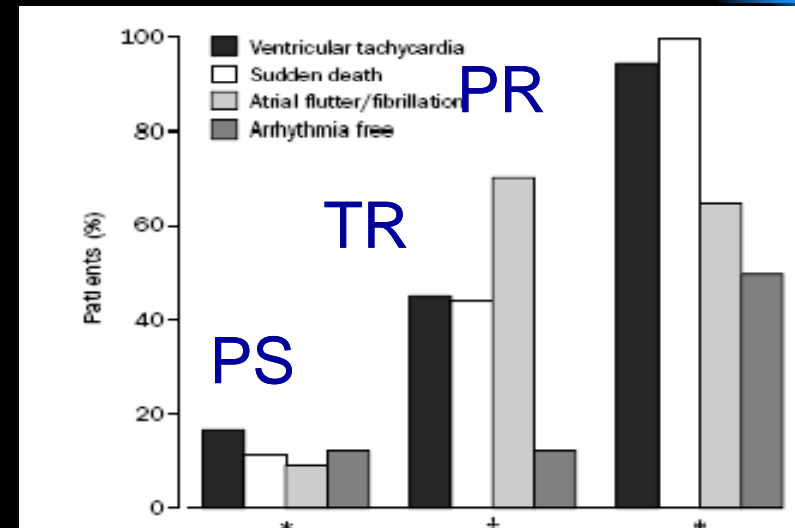
PVR after repair of TOF

- Prevention of irreversible RV dysfunction
- Survival benefit
- Symptomatic improvement

VS.

- Repeated PVR
- Op risk
- Cost
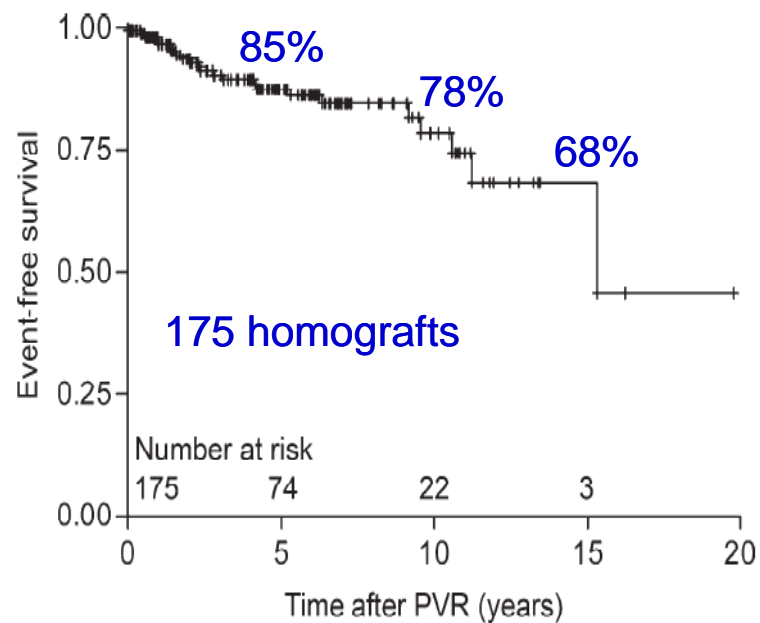
Redo PVR

85%
78%
68%

175 homografts

Figure 2   Event-free survival after PVR. Patient numbers are given.

Freedom from redo-PVR

87.9 ± 9.5 %

Eur Heart J 2006,
Netherlands
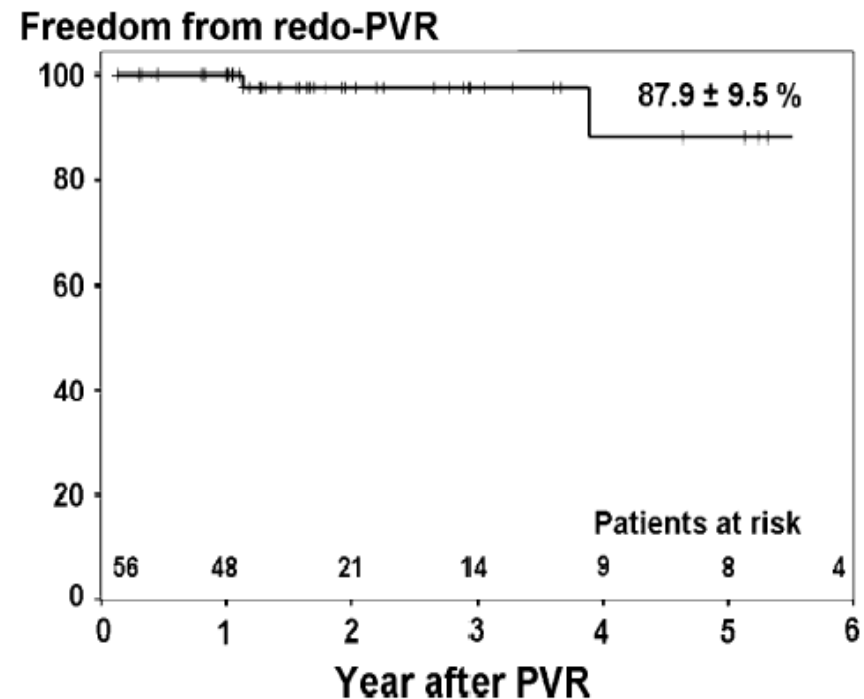
JY LEE, Eur J Cardio-thoracic
Surg, 2003, Korea, Sejong GH

Longevity of prosthetic pulmonary valves and valved conduits
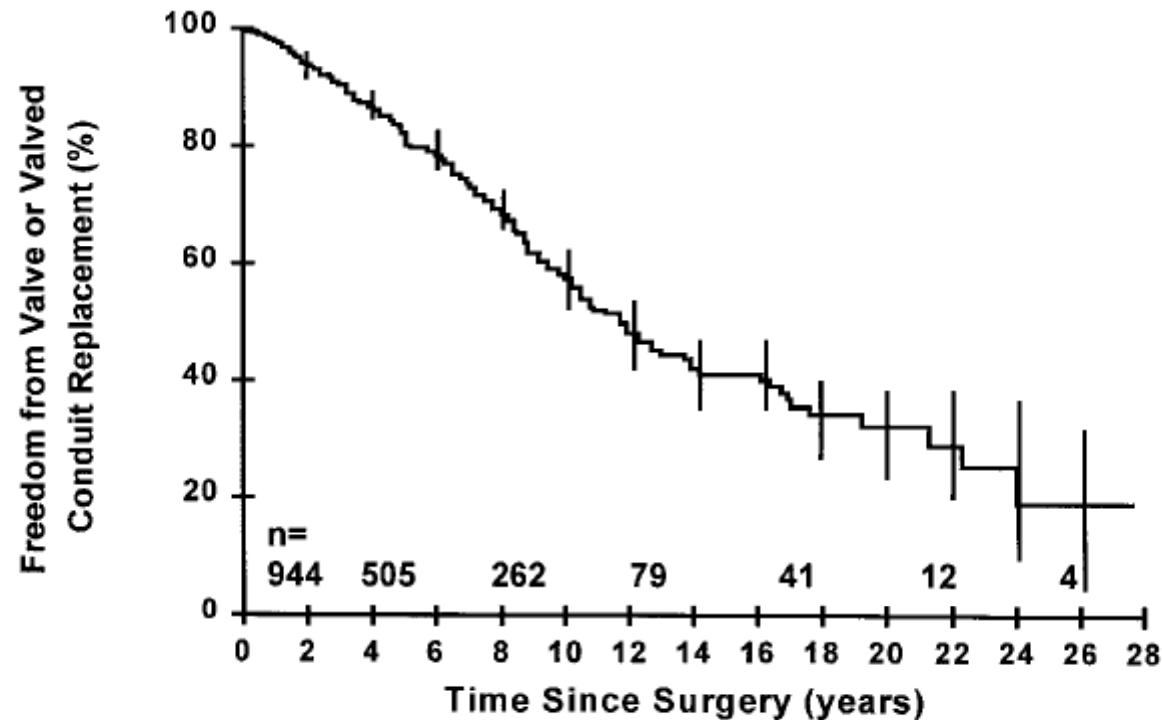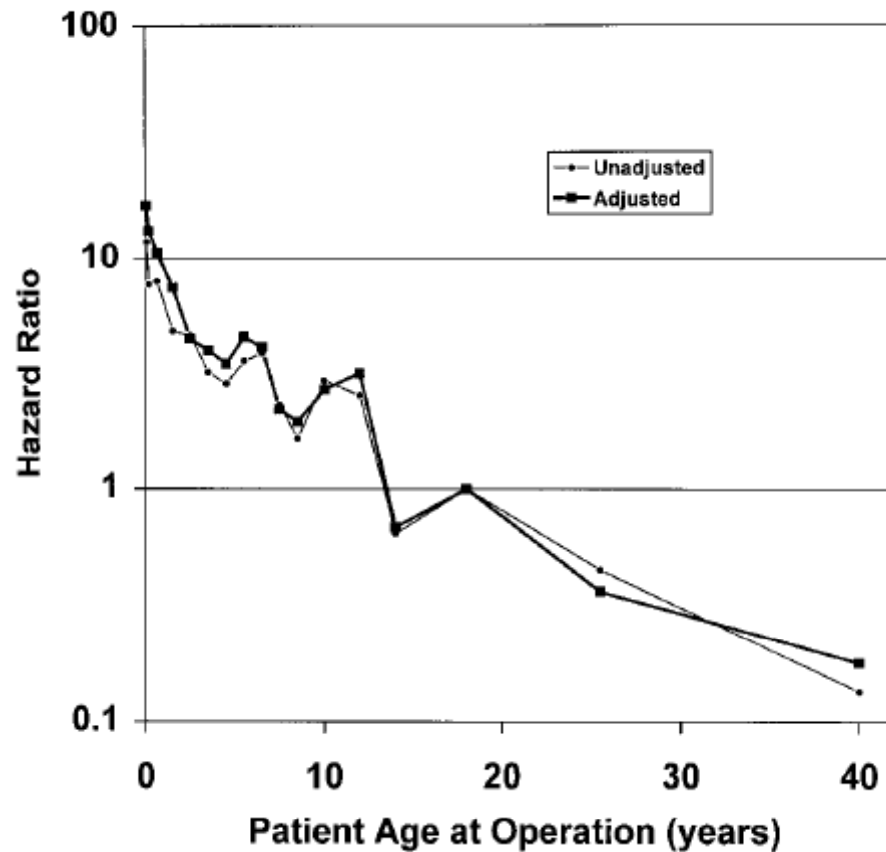

Fig 3. Kaplan-Meier estimates of freedom from valve replacement. *Vertical lines* represent 95% confidence intervals. The freedom from valve replacement at 5 years is 82%, at 10 years is 58%, and at 15 years is 41%.

Longevity of prosthetic pulmonary valves and valved conduits

Age is a dominant risk factor predictive of pulmonary valve prosthesis failure

Mortality

Table 3 Operative Mortality of Pulmonary Valve Replacement After TOF Repair

Institution	Year	No. of Patients	Early Mortality
SUNY, Syracuse[111]	1985	11	0
Children's Memorial Hospital, Chicago[112]	1997	70	1
University of Toronto[103]	1997	85	1
Mayo Clinic[100]	2001	42	1
Children's Hospital, Atlanta[113]	2002	100	1
Leiden University, The Netherlands[70]	2002	22	1
New England Med Ctr, Boston[106]	2003	36	0
University of Zurich, Switzerland[102]	2005	39	0
		405	5 (1.2%)

Semin Thorac Cardiovasc Surg
Pediatr Card Surg Ann, 2006

SJH   114   2 (1.8%)

Indications of PVR

- Symptoms
  - RV failure
  - Exercise intolerance
    - Functional class
    - Cardiopulmonary exercise test (CPET)
- Arrhythmias
- RV / LV function
- Associated conditions

Indications of PVR

- Cardiopulmonary exercise test
  - Still no definite criteria
  - Observe the trend

Cardiopulmonary exercise test

TABLE 2 Cardiopulmonary Exercise Characteristics at Follow-Up

Variable	Age at Repair of Tetralogy of Fallot		p Value
	≤18 mo (n = 22)	>18 mo (n = 52)	
Peak VO$_2$ (ml/kg/min)	31.9 ± 6.9	34.0 ± 7.6	0.25
VAT (ml/kg/min)	22.6 ± 6.3	24.4 ± 6.0	0.28
Peak heart rate (beats/min)	172 ± 20	177 ± 18	0.17
VE/VCO$_2$ slope	33 ± 6	32 ± 8	0.45
Abnormal O$_2$ pulse slope	12 (55%)	14 (27%)	0.03
Percent predicted VO$_2$ (%)	70 ± 15	75 ± 16	0.23
Percent predicted VAT (%)	69 ± 18	75 ± 18	0.17
Percent predicted heart rate (%)	85 ± 9	87 ± 9	0.46
Nonsustained VT	2 (9%)	2 (4%)	0.16
Ventricular premature complexes			
Rare	4 (18%)	8 (15%)	
Occasional	2 (9%)	4 (7%)	
Frequent	1 (4%)	2 (4%)	ns

O$_2$ = oxygen; VT = ventricular tachycardia.

AJC, 2001, Toronto

Cardiopulmonary exercise test

Cardio-pulmonary exercise test data

$n = 15$	Pre	Post	p-value
Maximal VO_2 (% predicted)	71.2 ± 21.4	65.6 ± 14.1	0.38
Anaerobic threshold (% of maximal VO_2)	48.6 ± 11.9	42.7 ± 14	0.057

Preoperative and 1 year postoperative right ventricular volume and function MRI assessment

| MR Data ($n = 19$)	Preoperative	One year after pulmonary valve insertion	p-value
PRF (%)	40 ± 9	9 ± 13	<0.001
RVEDV (ml/m^2)	158 ± 51	103 ± 36	<0.001
RVESV (ml/m^2)	85 ± 42	49 ± 24	0.001
Effective RV stroke volume (ml/m^2)	43 ± 10	48 ± 7	0.019
RV ejection fraction (%)	48 ± 10	54 ± 7	0.029

Eur J Cardio-thoracic Surg, 2007

Cardiopulmonary exercise test

Normalization of VE/VCO$_2$ post PVR

Table 3. Cardiopulmonary Exercise Test Results (n=57)

	Pre	Post	*P* Value
Peak VO$_2$, mL/kg/min	25±10	25±9	0.350
AT, mL/kg/min	15±5	14±6	0.148
VE/VCO$_2$	35.9±5.8	34.1±6.1	0.008
VE, L/min	58±22	58±20	0.811
Workload, watts	120±54	124±49	0.161
Peak heart rate, beats/min	154±41	163±24	0.053
Respiratory rate	46±14	43±11	0.021
RER	1.07±0.3	1.13±0.9	0.044

VO$_2$ indicates oxygen consumption; VE, ventilation; RER, respiratory exchange ratio.

ROC Curve

Age at PVR > 17.5 y

-sensitivity=87%
-specificity=87%

Circulation 2008, London
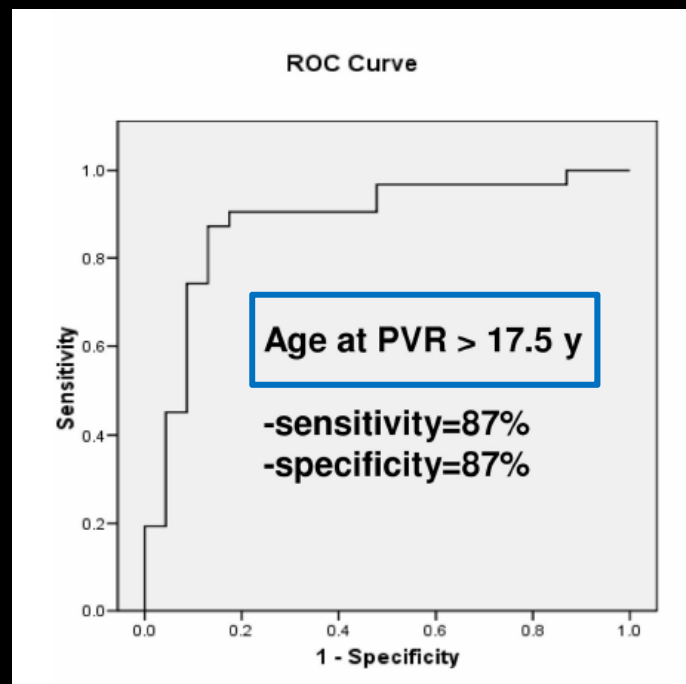
Indications of PVR

- Arrhythmia
  - ◆ Sustained VT
  - ◆ IART (flutter / fibrillation)
- QRS duration
  - ◆ Associated with VT and SCD
    - > 180 ms
    - Rate of change - 3.5 ms / yr

Lancet 2000

Risk factors for arrhythmia and sudden cardiac death late after repair of tetralogy of Fallot: a multicentre study

Michael A Gatzoulis, Seshadri Balaji, Steven A Webber, Samuel C Siu, John S Hokanson, Christine Poile,
Mark Rosenthal, Makoto Nakazawa, James H Moller, Paul C Gillette, Gary D Webb, Andrew N Redington

	Ventricular tachcardia	Sudden death	Atrial flutter/ fibrillation	Arrhythmia free	p
Electrocardiographic and radiographic data					
Number of patients	31	14	24	691	
Mean (SD) RR interval (ms)	826 (186)	790 (235)	815 (72)	797 (272)	0·69
QRS superior axis (−180° to 0°)	11 (33%)	5 (31%)	11 (37%)	159 (22%)	0·098
U waves	3 (9%)	1 (6%)	6 (20%)	36 (5%)	0·009
QRS duration (ms)					
Mean (SD) maximum duration	191·5 (21)*	179 (24)*	166·9 (21)*	146·7 (24)	<0·0001
Duration ≥180 ms	29 (88%)*†	10 (63%)*	10 (34%)*	42 (5·9%)	<0·0001
Mean (SD) rate of change (ms/year)	4·1 (2·2)*†	3·5 (1·9)*	2·1 (1·2)	1·5 (1·2)	<0·0001
Cardiothoracic ratio	0·58 (0·05)*	0·63 (0·06)*	0·61 (0·05)*	0·53 (0·05)	<0·0001
Holter data					
Number of patients	26	10	22	288	
Ventricular arrhythmia according to Lown criteria					
0: no ectopy	2	0	2	29	0·54
I: <30 uniform ventricular extrasystoles per hour	7	3	5	117	
II: >30 uniform ventricular extrasystoles per hour	6	1	10	62	
III: couplets or <30 multiform ventricular extrasystoles per hour	7	2	4	45	
IV: coupletsor >30 multiform ventricular extrasystoles per hour	2	0	1	32	
V: >3 consecutive ventricular contractions with mean rate >110 beats/min	1	0	0	8	
Number with equal or more than grade II	16 (62%)	3 (38%)	15 (68%)	137 (48%)	0·24

*p<0·001 vs arrhythmia-free. †p<0·005 vs atrial flutter/fibrillation.

Table 2: Electrocardiographic, radiographic, and Holter data

Prognostic significance of ventricular arrhythmia after repair of tetralogy of Fallot: a 12-year prospective study

- 48-h ambulatory ECG in 86 patients (3 to 45 years)
- Followed up prospectively for 12 years

	n	%	Death
Normal rhythm	31	36	1 (SCD)
Infrequent uniform PVC (<30/hr)	16	19	
Frequent uniform PVC (> 30/h)	2	2	1 (non sudden death)
Complex PVC (couplets or multiform)	30	35	
Nonsustained ventricular tachycardia	7	8	
total	86	100	

Cullen S et al. J Am Coll Cardiol 1994;23:1151–55

RV functions

- MRI study – gold standard
- Echocardiography
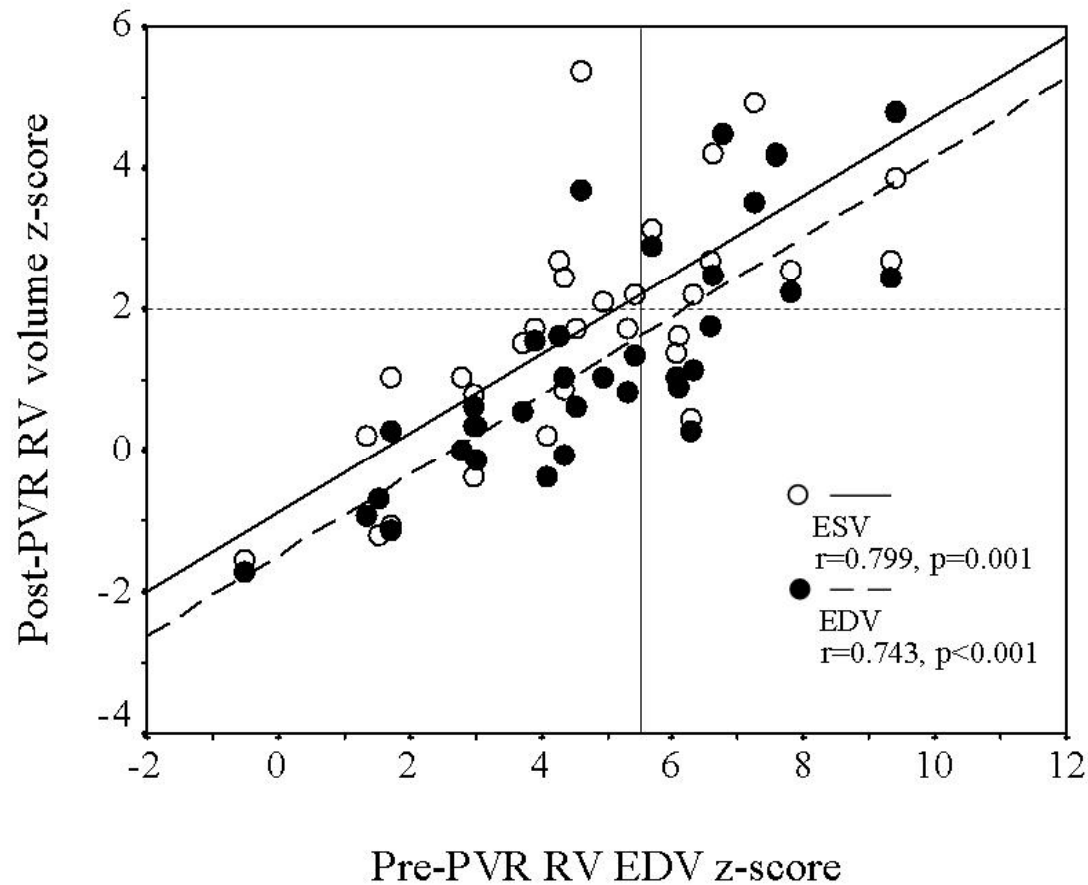
RV functions

RV EDVI >170 ml/m² or RV ESV > 85 ml/m²
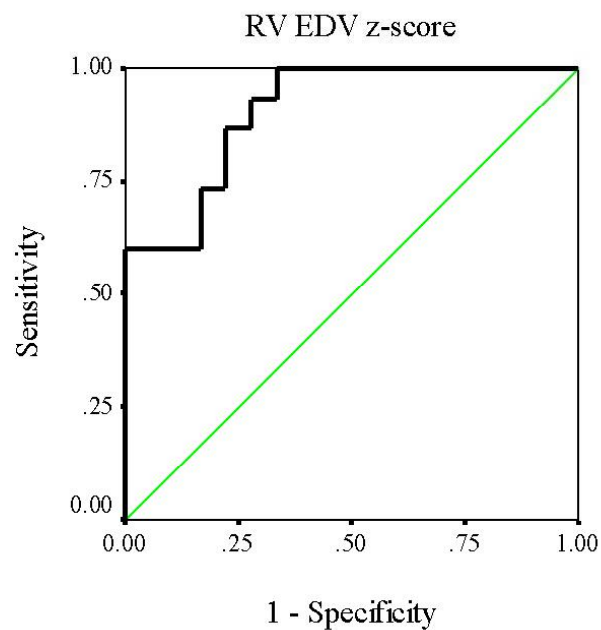

AJC 2005, Toronto
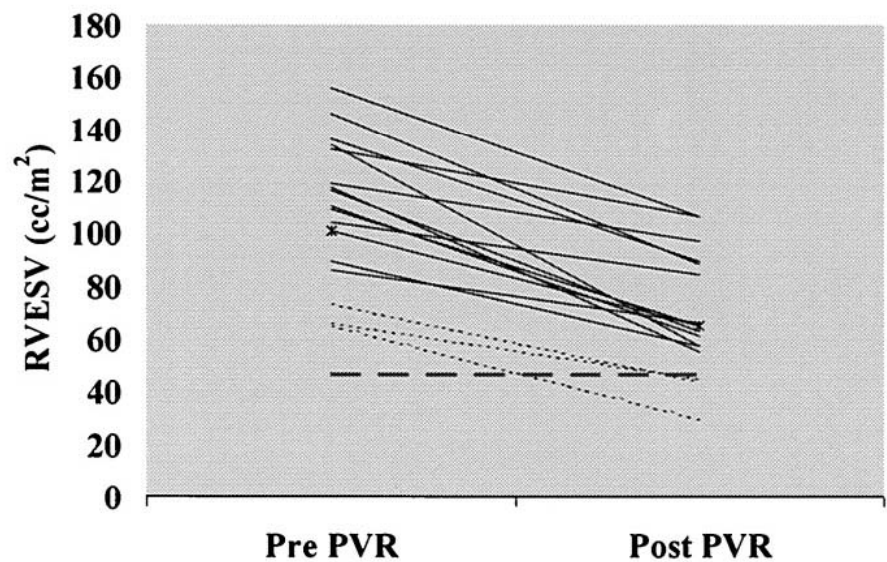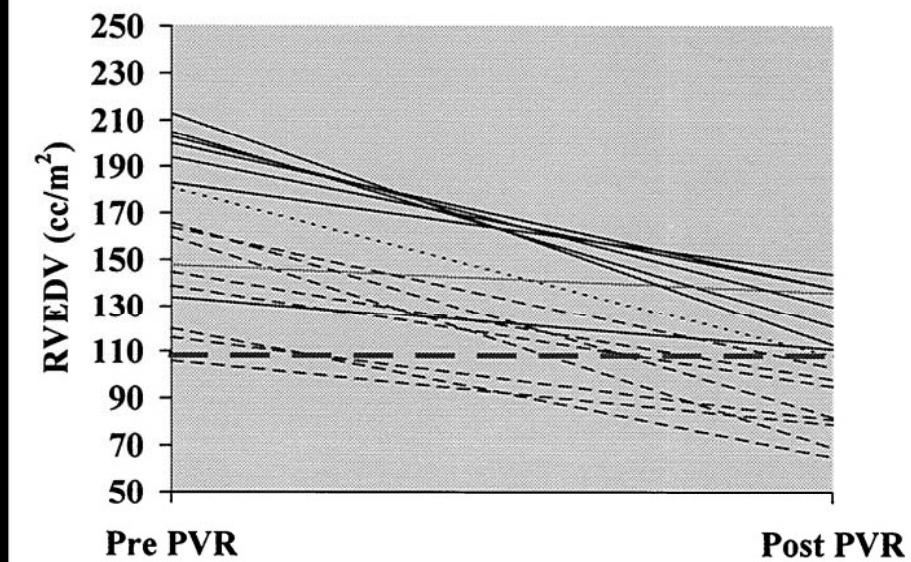
MRI study

- 33 patients
  - ◆ Age at PVR (median); 15.8 yrs   (5.8 - 46 yrs)
  - ◆ Age at TOF repair (median); 2.7 yrs (0.7 - 36 yrs)
  - ◆ MRI study
    - Median 9 days (6 - 45 days) before
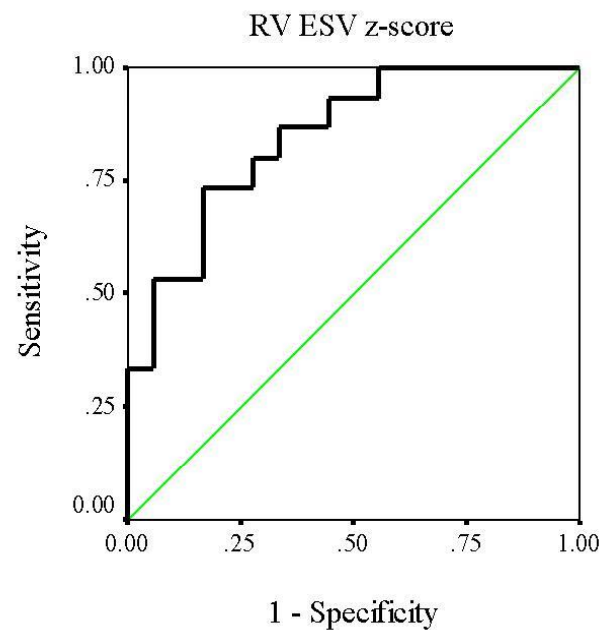   - Median 9.9 mo (6.7 – 11.9 mo) after PVR

Correlation; pre & postop RV volumes

RV dysfunction after PVR

RV EDV Z score > 5.5
(RV EDV ≈ 160ml/m²)
sensitivity 67%, specificity 83%

RV ESV z-score > 6.0
(RV ESV≈ 82 ml/ m2)
sensitivity 73%, specificity 78%

RV dysfunction after PVR

	RV EDV z-score < 5.5 AND RV ESV z-score < 6.0	RV EDV z-score > 5.5 OR RV ESV z-score > 6.0	p value
Patients, n	16	17	
NYHA class > II, n	1	4	ns
Post-PVR RV dysfunction, n (%)	2 (13%)	13 (73%)*	< 0.001
Post-PVR RV EDV z- score	0.10 ± 0.93	2.30 ± 1.42	< 0.001
Post-PVR RV ESV z- score	0.65 ± 1.26	2.93 ± 1.37	< 0.001
Post-PVR RV EF, %	56 ± 8.0	51 ± 4.7	< 0.05

*Fisher's exact test odds ratio for RV dysfunction; 22.8 (95% CI 3.6 - 146, p < 0.001).

RV function : RV EF

AJC 2005, Toronto
Data from SJH

* , p<0.001
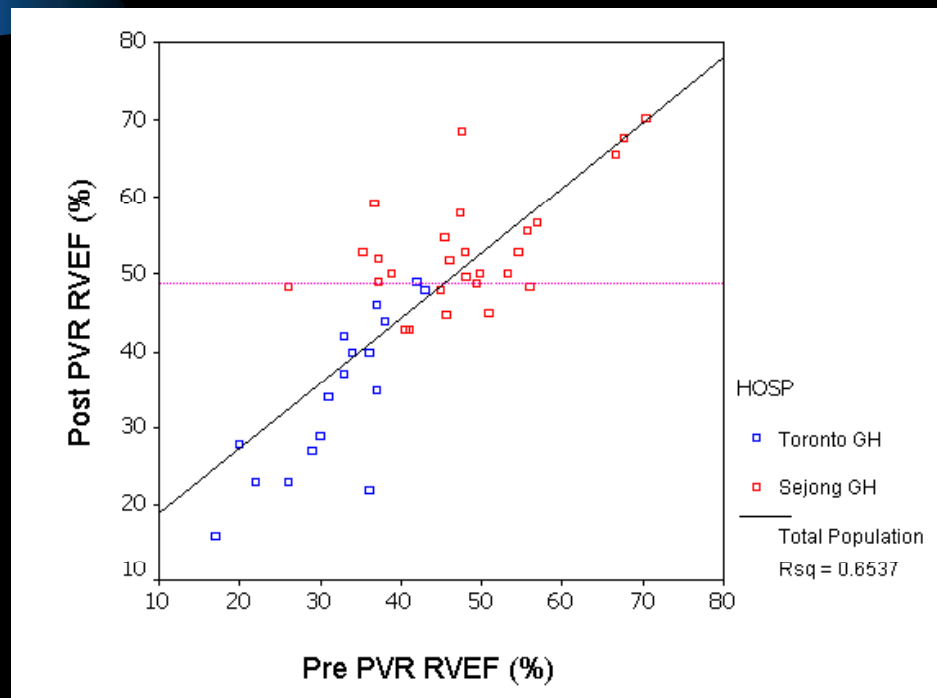
	Pre PVR RV EF (%)	
	< 45	≥ 45
Post PVR RV EF (%)	40 ± 11*	55 ± 8*
Relative risk (95% CI)	2.8 (1.4 – 5.6)	0.2 (0.1 – 0.6)

RV functions

- RV EDV > 160-170 ml/m^2
- RV ESV > 80-85 ml/m^2
- RV EF < 45 %

- ✓ LV dysfunction

Associated lesions

- Residual VSD
- Severe TR
- RVOTO or huge neurysm
- PS, branch PA
- AR
- Lung problems

This Case – You'd better fu medically

	Indicator	Patient	OP ?
PR fraction	25-40%	40 %	May consider
Age	?	16 yr	?
Symptom	+	Dizziness	?
NYHA class	> II or III ?	II	?
CPET	?	Normal	no
QRS duration	>180 ms	150 ms	no
Holter	?	Nonsustained VT	no
Clinical VT	Yes	no	no
RV EDV	> 160-170 ml/m2	150 ml/m^2	no
RV EF	< 45%	55 %	no
Associated lesions	Yes	no	no

Issues remain

- RV dysfunction after PVR
  - How bad is too bad?

- Percutaneous valve insertion
  - New indication?

- Mechanical valve?
  - Bioengineered valve?

감사합니다.