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Pulmonary Valve Replacement

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(No disclosures)

The Society of Thoracic Surgeons

EACTS
European Association For Cardio-Thoracic Surgery

Scope of the problem.

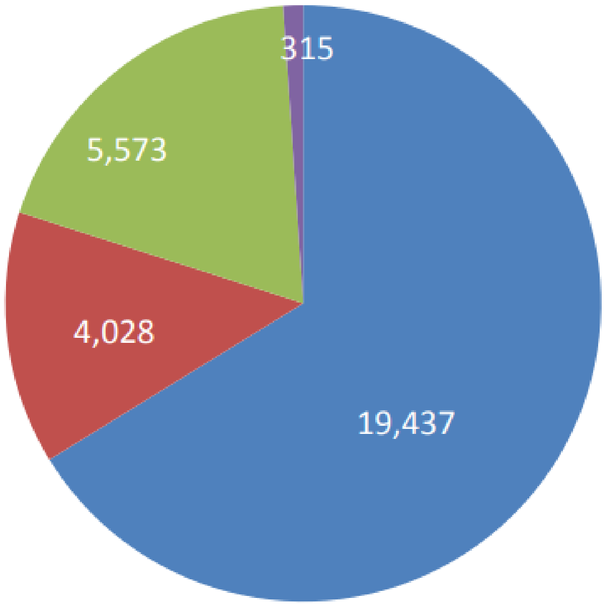
- CHD with PS or PA require a RVOT procedure.
  - Tetralogy of Fallot. (Valvulotomy, Infund Patch, TAP)
  - Pulmonary stenosis. (Perc. Or Surg Valvuloplasty)
  - D TGA with PS. (Rastelli, Nikaidoh) (RV PA conduit)
  - LTGA with PS (LV or RV PA conduit)
  - Truncus arteriousus. (RV PA conduit)
  - VSD baffling incorporates the PV. (DOLV, DORV. TGA)
- Ross Procedure

RVOT reconstruction

- Moderate complexity
- Low M/M.
- Substantial late M/M
- Pulmonary stenosis and Regurgitation
- RV dilatation
- RV Failure
- Decrease in functional capacity
- Arrhythmia and Sudden Death

STS Database Valve Procedures 2011

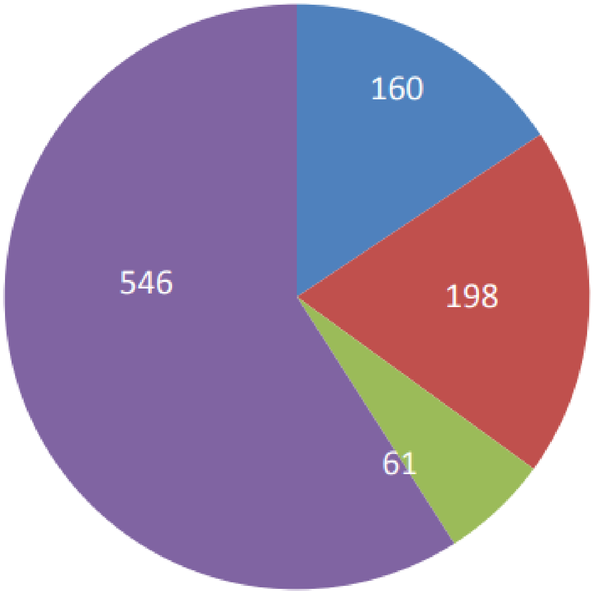
STS Adult Database 2011



29,353 Total Valve Replacements
Pulmonary: 1.07%

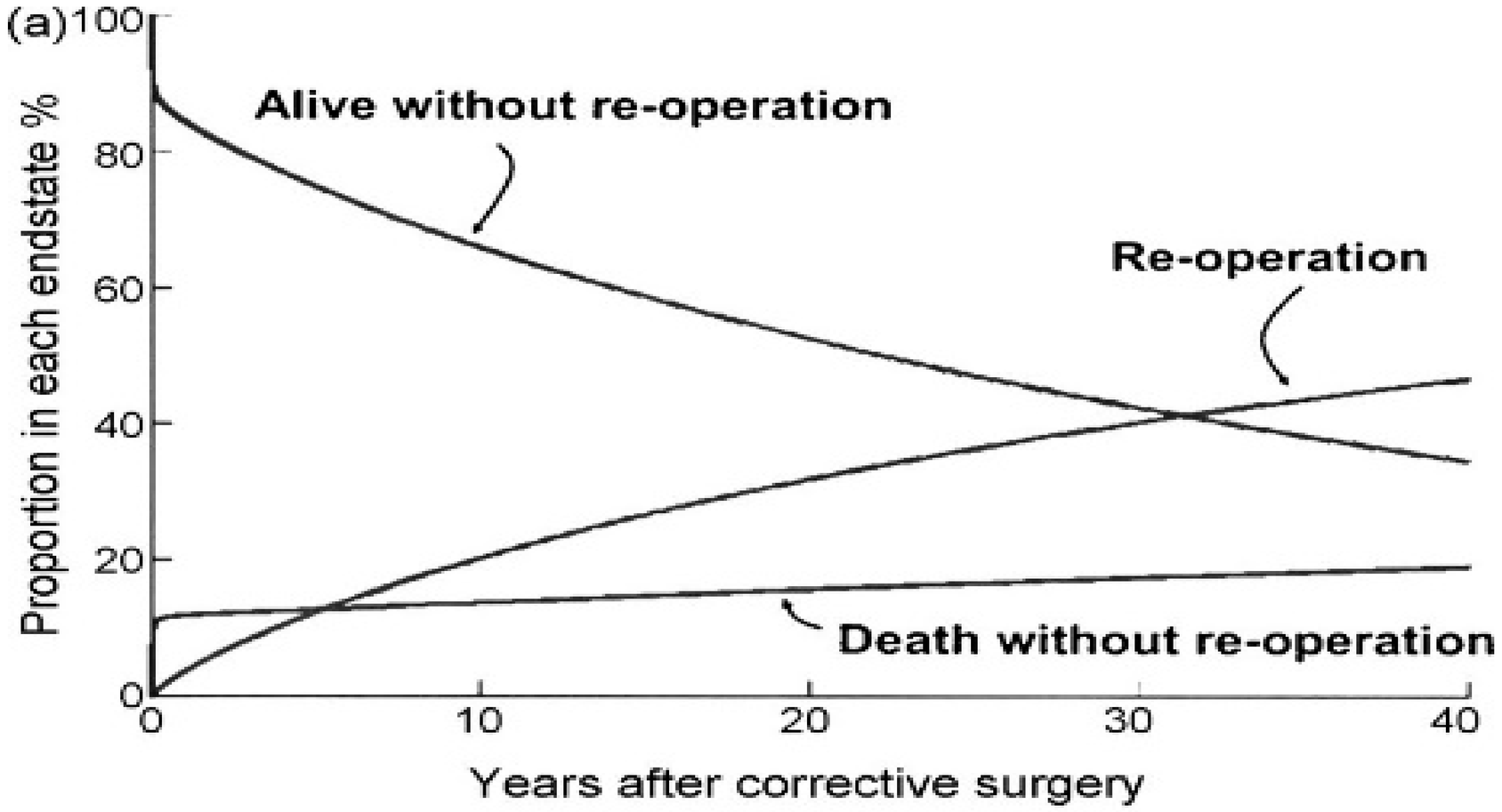
AVR
MVR
TVR
PVR

STS Congenital Database 2011 – Adult only



965 Total Valve Replacements
Pulmonary: 56.6%

Late Outcome of TOF



Hickey EJ et al. Eur J Cardiothorac Surg 2009;35:156-164

Late Outcome of RV PA Conduits

- TGA VSD LVOTO:
  - Rastelli Survival of 50/70 % at 20 years
  - Freedom from RVOTO 24 % at 20 yrs.
- Truncus arteriousus
  - Survival of 73.6 % at 20 years.
  - Freedom from RVOTO reop 4,6 % at 20 yrs
- Pulmonary atresia + VSD (excluded Mapcas)
  - Survival of 75 % at 20 yrs.
- Far from ideal.

Causes of Death in Tetralogy of Fallot Survivors

Table 2. Causes of Death During Long-Term Survival

Causes	n
Cardiac	31 (73.8%)
Sudden cardiac death	15 (35.7%)
Congestive heart failure	8 (19.0%)
Myocardial infarction	4 (9.6%)
Right ventricular aneurysm	1 (2.4%)
Reoperation	1 (2.4%)
Endocarditis	1 (2.4%)
Recurrent VSD	1 (2.4%)
Noncardiac	8 (19.0%)
Suicide	2 (4.8%)
Sepsis	2 (4.8%)
Pneumonia	1 (2.4%)
Stroke	1 (2.4%)
Kidney failure	1 (2.4%)
Unknown	4 (9.6%)

VSD = ventricular septal defect.

Gatzoulis et al. Risk factors for arrythmia and sudden cardiac death late after repair of tetralogy of Fallot: a multicentre study. Lancet 2000;356:975-81.

Do all have the same fate?

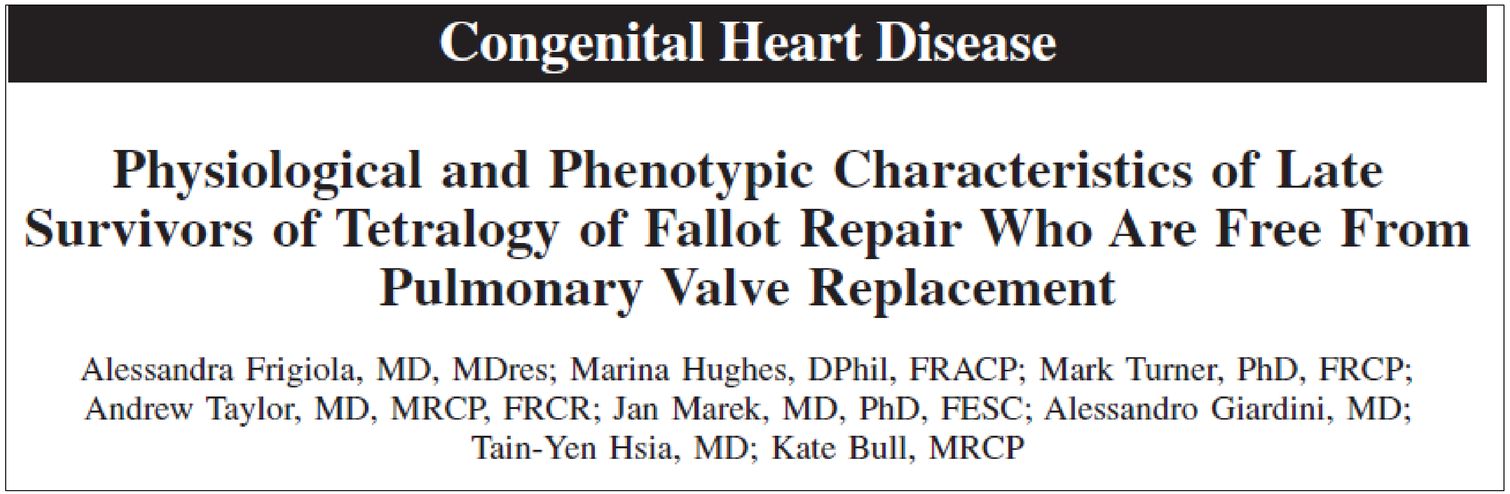
- PR better tolerated in patients with PS or Ross than other CHD
  - Surgical or Percutaneous Baloon valvuloplasty.
  - Normal pulmonary annulus.
  - Normal pulmonary artery tree.
  - No surgical intervention on the RV.
    - No ventriculotomy
    - No surgical acquired RBBB.
  - Late MRI testing more favorable for same degree of PR
- Reproduction of this setting might make a Diff.
- Specially for TOF.

Kopecky SL Circulation. 1988;78:1150-6. Roos-Hesselink JW, Eur Heart J. 2006;27:482-8. Puranik, R JTCVS , 143 , 1103 – 1107.

Do all have the same fate?

Subset of healthy survivors:

- mildly dilated right ventricles (right ventricular end-diastolic volume=101±26 mL/m2)
- good systolic function (right ventricular ejection fraction=59±7%).
- Normal exercise capacity.
- Normal pulmonary annulus diameters <0.5 Z score (NO TAP)
- Unobstructed branch pulmonary arteries.



Congenital Heart Disease

Physiological and Phenotypic Characteristics of Late Survivors of Tetralogy of Fallot Repair Who Are Free From Pulmonary Valve Replacement

Alessandra Frigiola, MD, MDres; Marina Hughes, DPhil, FRACP; Mark Turner, PhD, FRCP; Andrew Taylor, MD, MRCP, FRCR; Jan Marek, MD, PhD, FESC; Alessandro Giardini, MD; Tain-Yen Hsia, MD; Kate Bull, MRCP

***Circulation*. 2013;128:1861-1868.)**

Do all have the same fate?

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- mildly dilated right ventricles (right ventricular end-diastolic volume=101±26 mL/m2)

We must do better at the initial procedure

Survivors of Tetralogy of Fallot Repair Who Are Free From Pulmonary Valve Replacement

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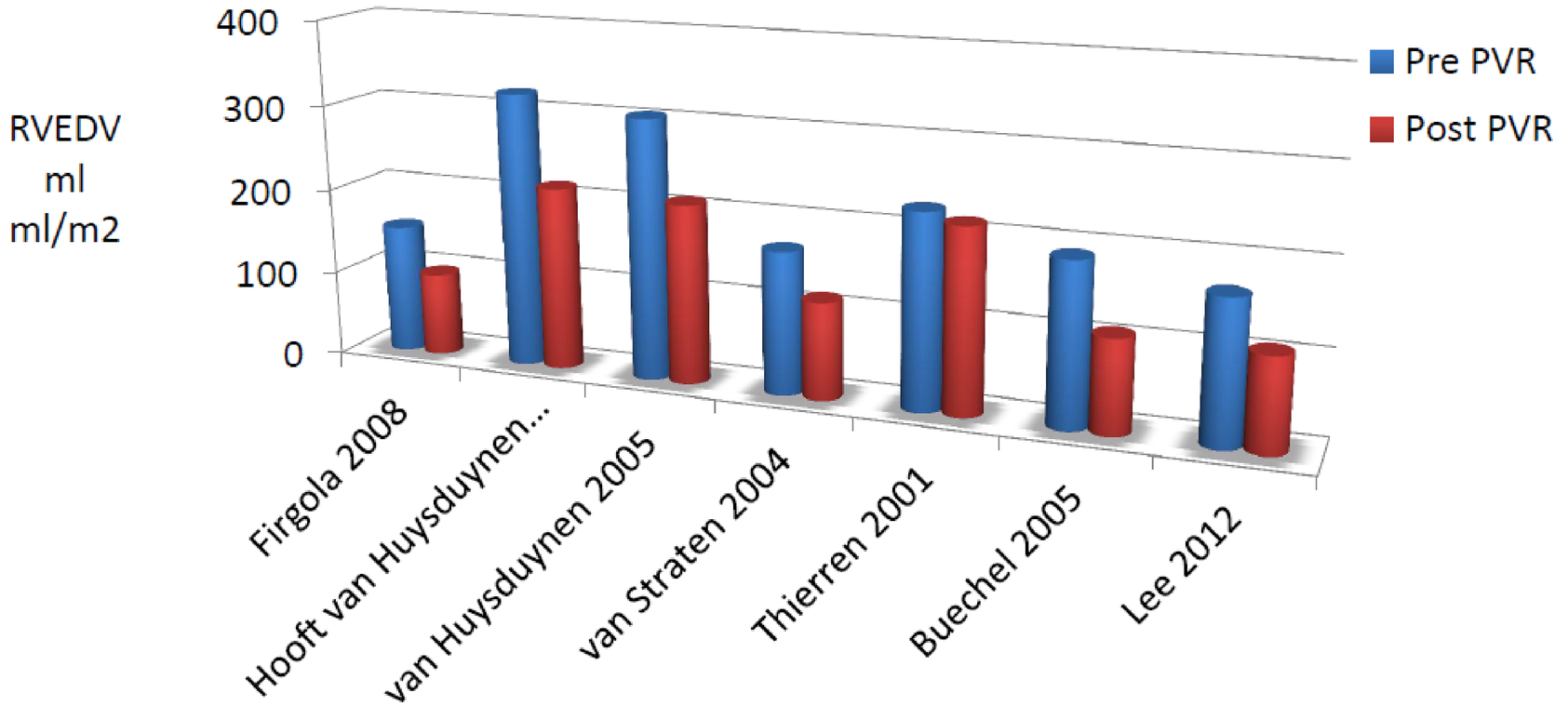
Recommendations for optimal timing of PVR based on pre-operative MRI parameters

RV EDV index	***Therrien et al (2004):***	***170 ml/m2***
	Oosterhov et al (2007):	***160 ml/m2***
	Beuchel et al (2016):	***150 ml/m2***

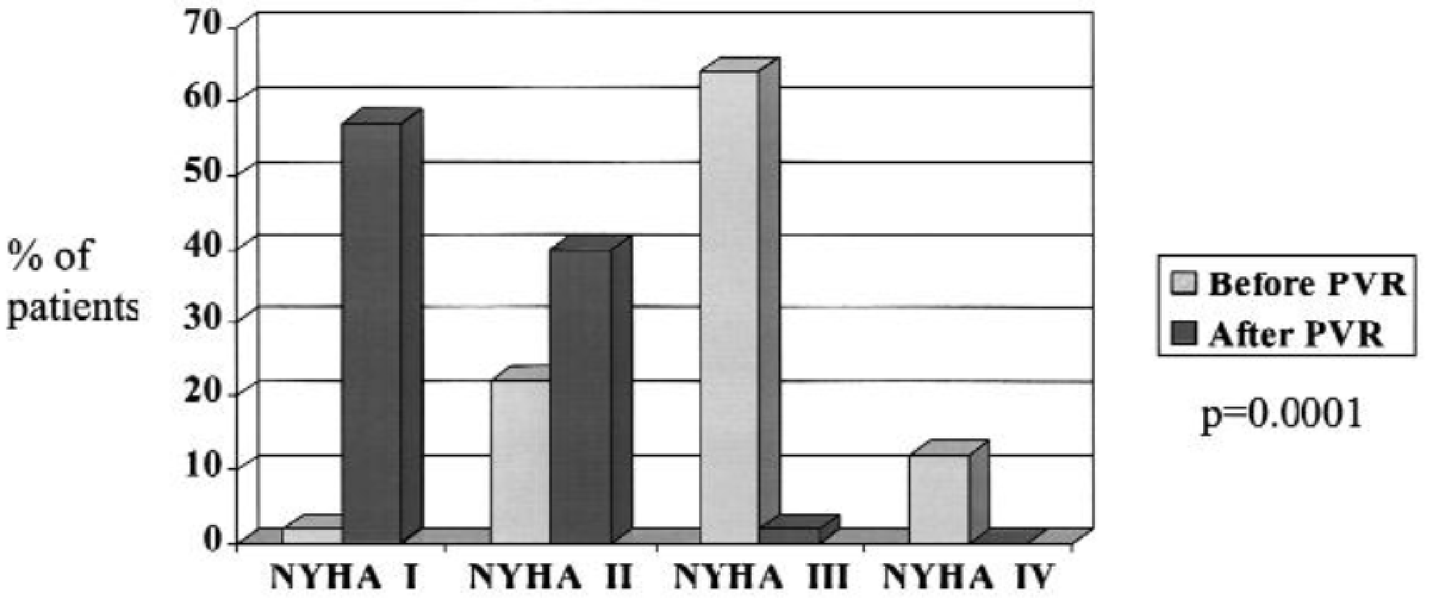
RV ESV index	***Therrien et al (2004):***	***90 ml/m2***
	Geva et al (2010):	***85 ml/m2***
	Bokma et al (2016):	***80 ml/m2***

Does PVR Improve RV Size?

Adamson et al. ICVTS 2009;9:520-7.



Change in NYHA Classification after Pulmonary Valve Replacement



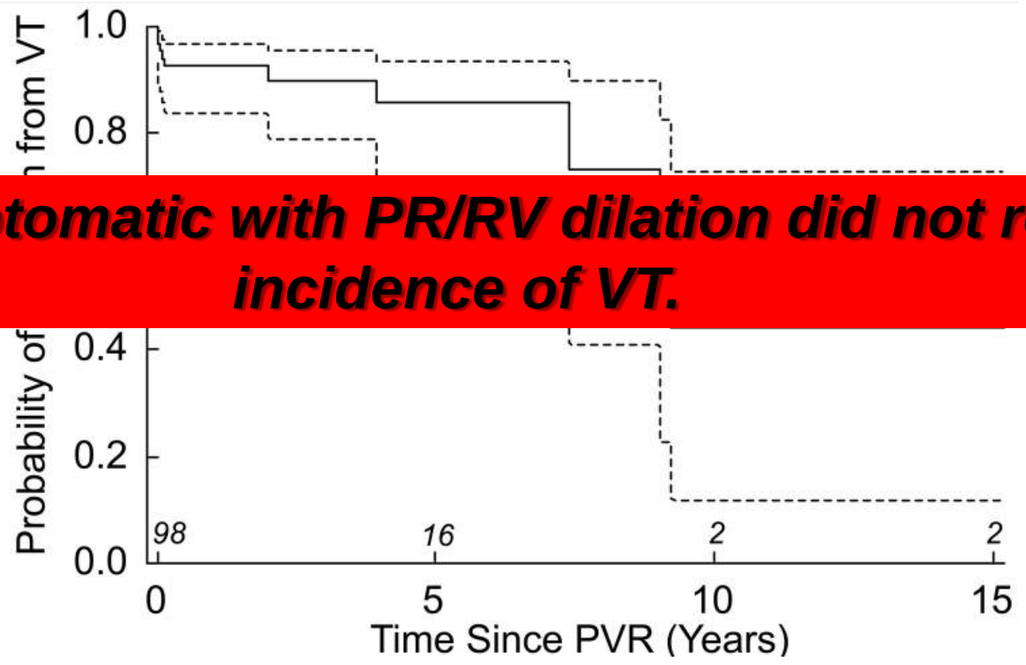
2. NYHA functional class before and at last follow-up in patients undergoing PVR after TOF repair.

Discigil et al. Late Pulmonary Valve Replacement after repair of Tetralogy of Fallot. JTCVS 2001;121:344-51

Pulmonary Valve Replacement in Tetralogy of Fallot: Impact on Survival and Ventricular Tachycardia

David M. Harrild, MD, PhD[1], **Charles I. Berul, MD**[1], **Frank Cecchin, MD**[1], **Tal Geva, MD**[1], **Kimberlee Gauvreau, ScD**[1], **Frank Pigula, MD**[2], and **Edward P. Walsh, MD**[1]

[1]Department of Cardiology, Children's Hospital Boston; Departments of Pediatrics, Harvard Medical School, Boston, MA



PVR for symptomatic with PR/RV dilation did not reduce the incidence of VT.

Circulation 2009.

Indications for PVR

Asymptomatic pt with 2 or more of the following criteria:

-RVEDV> 150ml / m2 or Z score> 4 or RVEDV/LV> 2

-RVESV> 80ml / m2

-FEy VD <47%

-LVEF<55%

-Mod TR

RVOT aneurysm

-QRS> 140ms

-Tachyarrhythmia secondary to RV overload

In TOF pts who had undergone PVR, preoperative RV ESV 80 mL/m2 was the best threshold to achieve mid-to-late RV normalization.

Pts operated when RV ESV was 95 mL/m2 were at increased risk for both suboptimal haemodynamic outcome and adverse clinical events. Bokma et al 2016

Type of PVR

- Percutaneous (procedure of choice)
  - Bovine Jugular, Porcine pericardial.
  - Limited use in RV aneurysms.
  - ⬆ Endocarditis
- Surgical:
  - Tissue:
    - Stented: Perimount. Hancock, Epic, CE, Magna, Mitroflow, etc
    - Homografts: Aortic, Pulmonary
    - Bovine Jugular Conduit
    - Porcine Aortic Root: Free Syle (NR)
  - Mechanical.

Surgical PVR

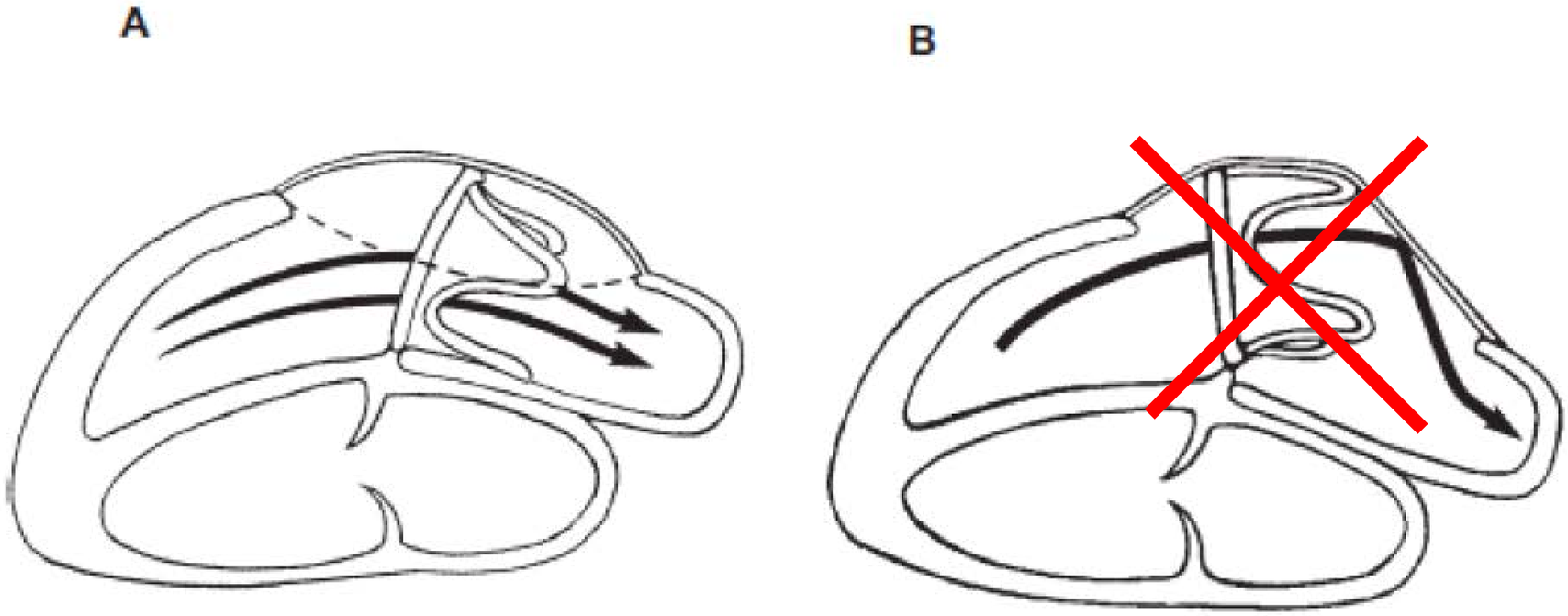
- Low mortality
  - RV rupture at sternotomy.
  - RV failure.
  - Arrhythmias.
- Adressing other lesions (TR, residual VSD, PA branch stenosis)
- Freedom from Valve failure of 70% at 10 years
- Best Prosthesis? Abbas JR Interact Cardiovasc Thorac Surg. 2013 Nov;17(5):854-60.
  - Meta analysis 141 papers
  - 12 art Homografts perform better tan xenografts (Not Stat significant).
  - Two articles have suggested that xenografts outperform homografts.
- Chen PC. JTCVS 2012.
  - No differences in late outcome.
  - Predictors of structural valve deterioration
    - Younger age.
    - Valve oversizing.

Technical considerations

- Strut Position – 6/10/2 o'clock
- Valve Orientation (laminar flow)
- Not too large prosthesis. (z score < 2)
- Need for pulmonary arterioplasty
- Possible RV Remodeling
  - Resection of Transannular Patch
  - Enlargement of RVOT
- Consider future operation
  - Percutaneous Valve Insertion

LABELED SIZE (OD) (mm)	AORTIC BIOPROSTHESES	ID
19	Magna Ease valve	18
	Magna valve	18
	PERIMOUNT valve	18
	Mosaic	17.5
	Mosaic Ultra	17.5
	Epic Supra / SJM Biocor Supra	19
	Mitroflow	15.4

Technical considerations



Optimal pulmonary valve positioning within the right ventricular outflow tract.

Late Results

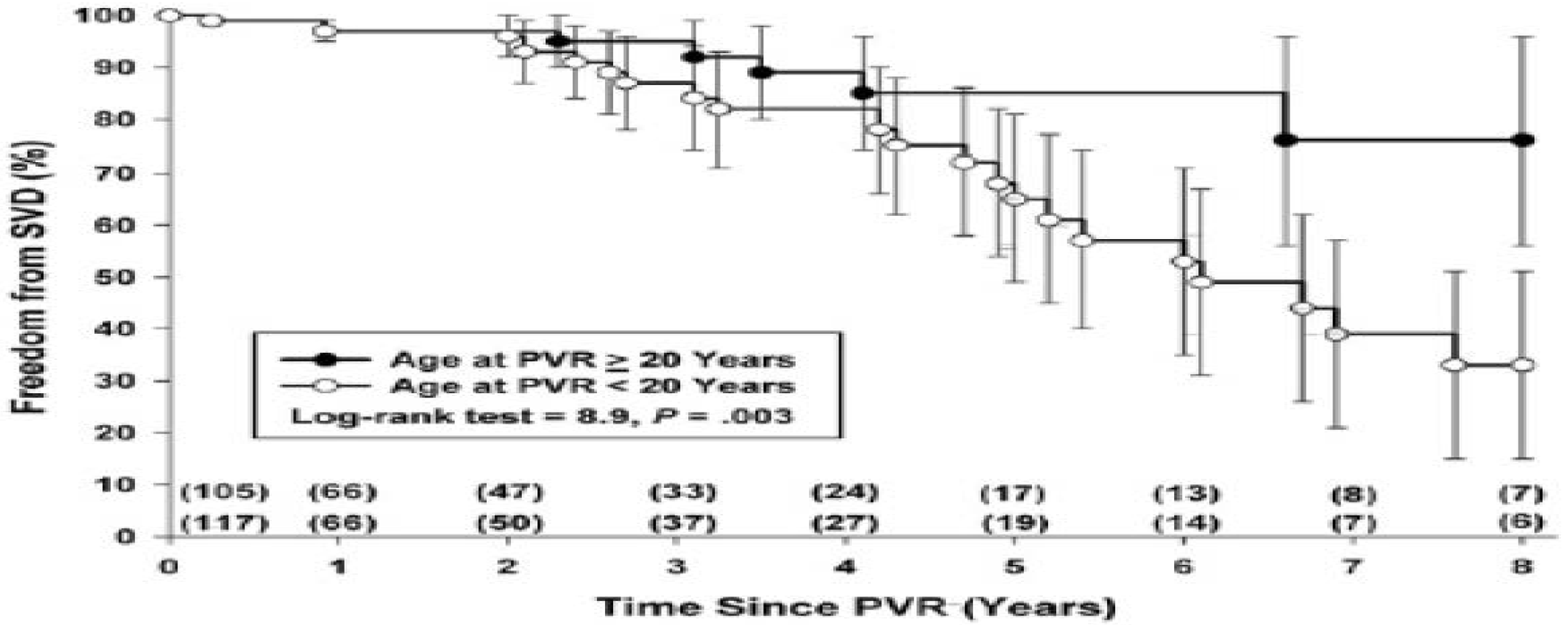
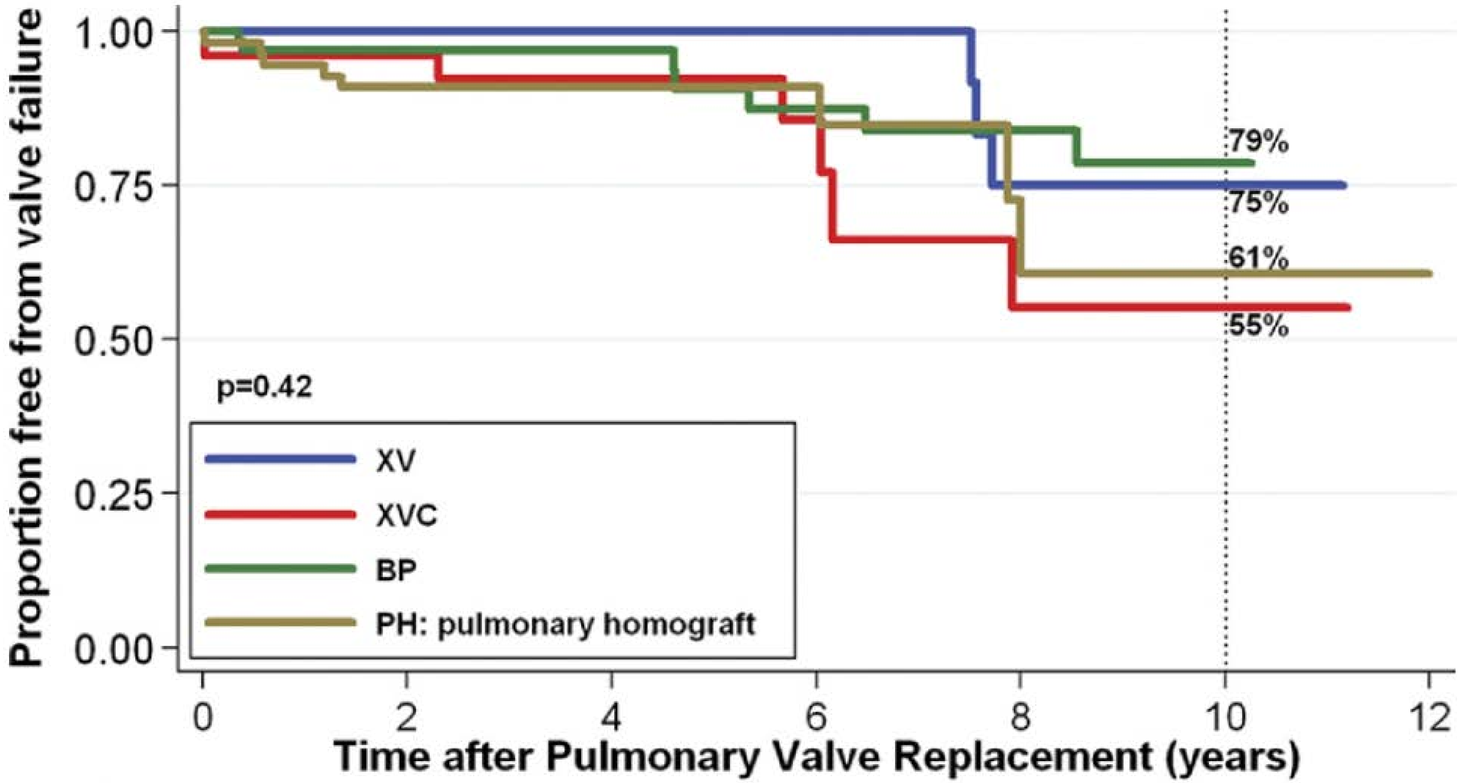
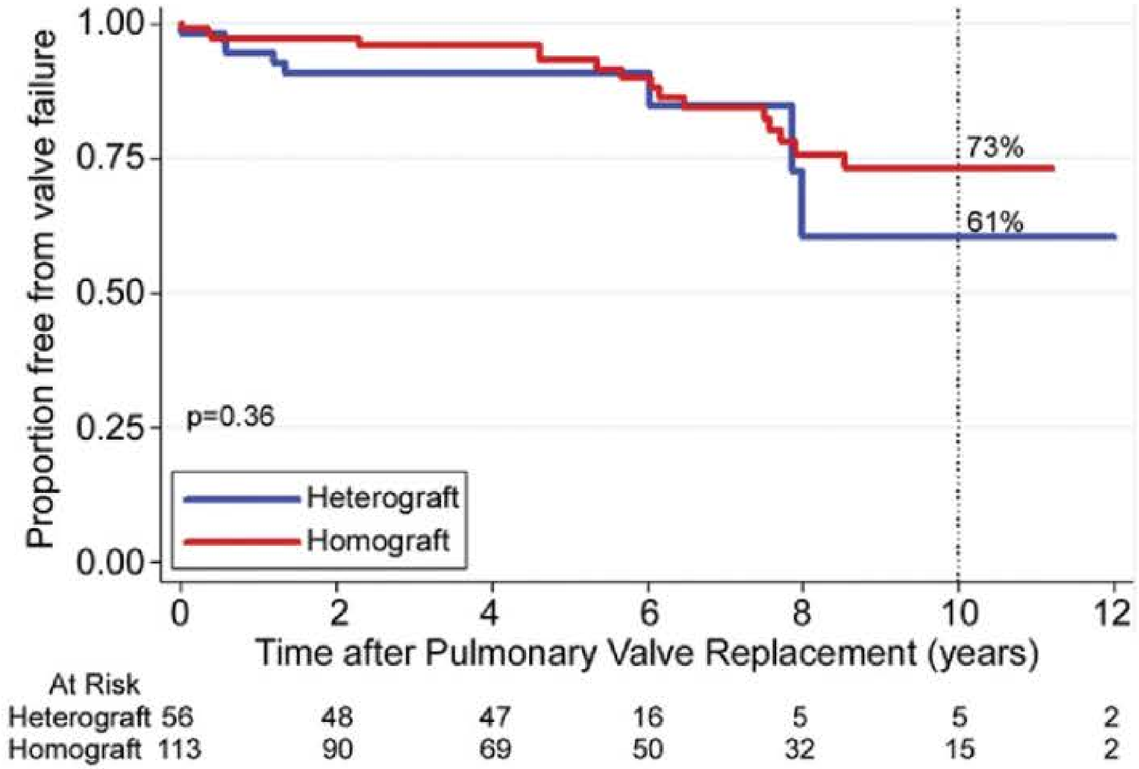


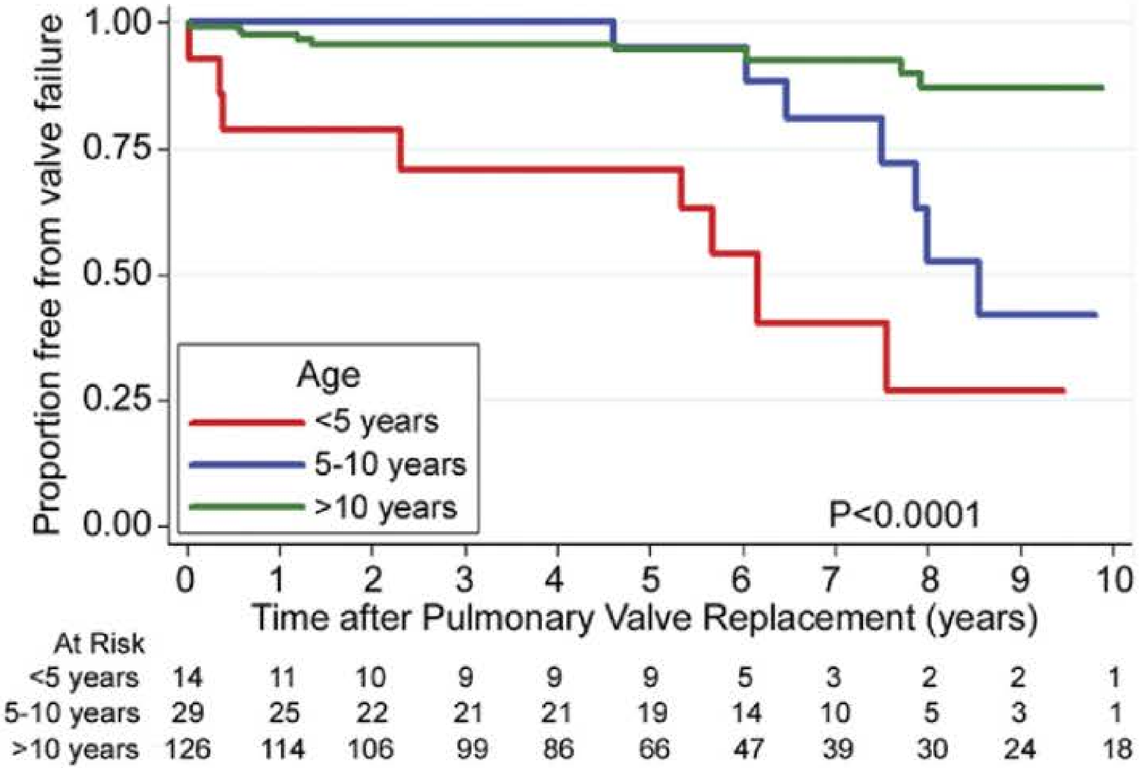
FIGURE 2. Effect of age on freedom from structural valve deterioration. *PV*, Pulmonary valve; *PVR*, pulmonary valve replacement.

Late Results



Late Results





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Stentless Xenografts

- Stentless xenografts as an alternative to pulmonary homografts in the Ross operation.

Eur J Cardiothorac Surg. **2013 Jul;44(1):**

- 288 adults (>18 years) Ross
- Pulmonary Homografts vs Porcine aortic root
- At 5 yrs Mean RVOT regurgitation was 0.1 ± 0.4 in the SX group and 0.8 ± 0.6 in the PH group (P = 0.008).
- Patients with the SX presented significantly higher calcium scores than those with PH (P = 0.01). (Conduit only)

Porcine aortic root in PVR.

Background. We used the Medtronic Freestyle valve (Medtronic, Minneapolis, MN) as an orthotopic conduit in pulmonary valve replacement in repaired tetralogy of Fallot and as part of the Ross procedure. Midterm outcomes and hemodynamic status of this conduit were analyzed and performances in both subgroups were compared.

Methods. From February 2002 to July 2012, 115 Freestyle valves were implanted in 52 patients with tetralogy of Fallot and 63 patients within the Ross procedure. Preoperative and perioperative data were reviewed retrospectively in this bicentric study.

Results. Mean age at valve surgery was 37 ± 13 years. Median implanted valve size was 27 mm (21 to 29). Early postoperative mortality was 3.48%. There was 100% follow-up for the survivors at a mean of 4.38 ± 2.52 years. There was 1 case of thromboembolism (0.89%), 6 endocarditis (5.4%), and 9 (7.8%) conduit re-interventions. Echocardiography at discharge and last follow-up showed average peak systolic transvalvular gradients of 12.4 ± 5.1 and 18.7 ± 8.8 mm Hg, respectively. Ten patients had significant proximal anastomotic gradients of greater than 50 mm Hg and 4 moderate conduit regurgitations. Survival was 96.52%. No valve degeneration was seen in 87.82% at 5 years. The only risk factor identified for valve re-intervention was conduit implantation without infundibular hood ($p = 0.01$ in multivariate analysis).

Conclusions. Mid-term data show that Freestyle valves are well suited for pulmonary valve replacement in adults in both categories. The surgical technique used in valve implantation is important to ensure conduit durability. These results and accessibility to the Freestyle valve make this an acceptable alternative to homografts.

(Ann Thorac Surg 2015;100:1047–53)

My Experience

- 1/07 to 1/17 40 PVR.
  - 31 Free style, 9 (Stented Tissue valves)
- Mean Age= 19,3 yrs (7 – 41 yrs)
- Mean weight= 48,8 Kg. (22 - 80 Kg).
- TOF, (n=29), Rastelli (n=10), TGA post ASO (n=1).
- CPB T= 46,7 min (30 a 130 min)
- Ao x Clamp T= 42,5 min (0 - 88 min).
- PA branches plasty (n=9) Residual VSD (n=2)

My Experience

- One early death.
- Complications
  - Bleeding (n=3)
  - Mediastinitis (n=1)
  - Stroke (n=2) (no Cross Clamp, Hidden PFO?)
  - 5 pts with proximal peak RVOT gradients > 40 mmhg
- LOS= 7,2 d (5 - 31).
- At 5 years.
  - Freedom from reintervention from PVR is 96 %
  - Freedom from reintervertion from stenosis is 77 %.
  - 3 Melody in Free Style
  - 2 replacements.

Summary, results of PVR

- Resolution or marked reduction of PR.
- 30/40 % reduction in RVED and RVES volumes.
- Unchanged RV EF.
- Slightly increased LV size w/ unchanged EF.
- Decreased in RV systolic pressure
- No change in arrhytmia burden for symptomatic patients.
- Improvement in NYHA functional class.
- No clear change in objective exercise parameters.
- No clear advantages between prosthesis

Conclusions

- RVOT reconstruction is a time bomb
  - Eventually all will fail for PR.
  - Prevention at initial procedure.
  - Don´t wait too long for PVR
- Comprehensive care of the TOF patient
  - Fixed but not cured.
  - Annual evaluation.
- Comprehensive care of other CHD with Conduits.
  - Rastelli’s don’t do well.
  - A RV PA conduit is a faster time bomb.

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Thank You

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