Tetralogy of Fallot

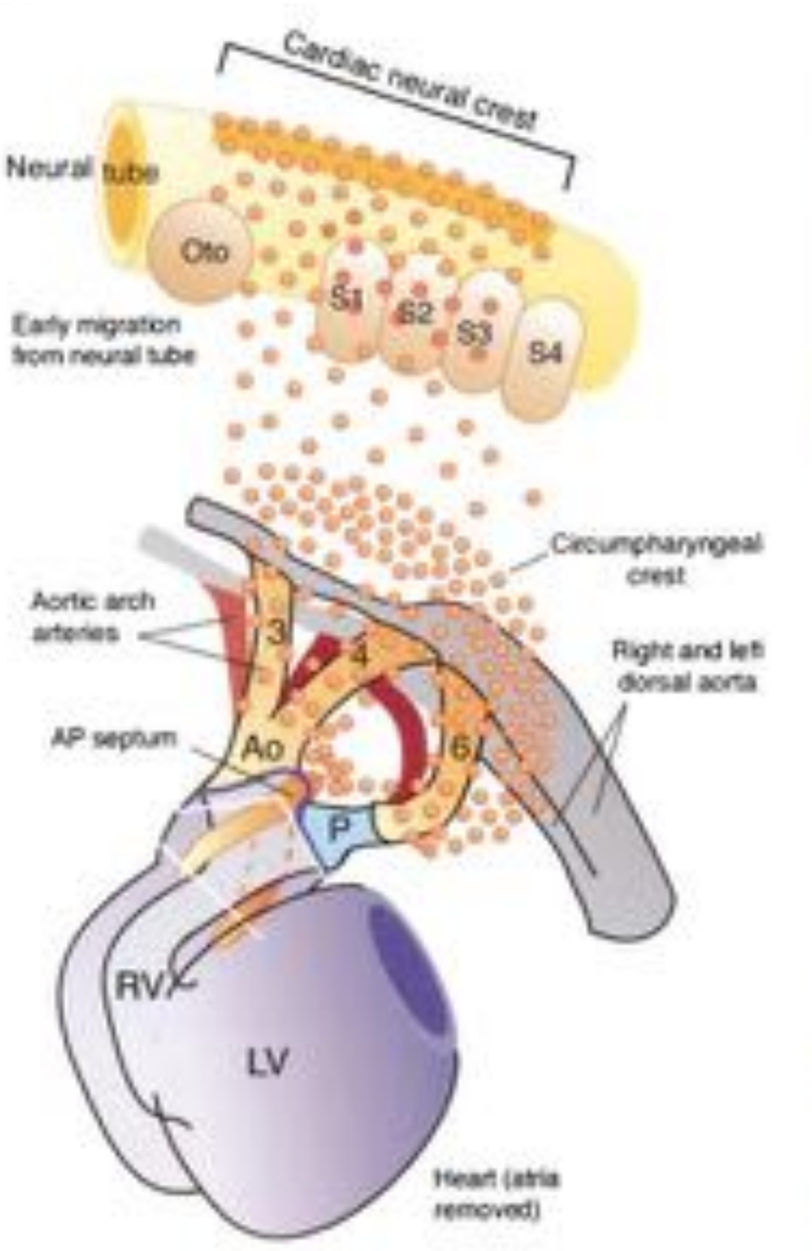
Damien Bonnet

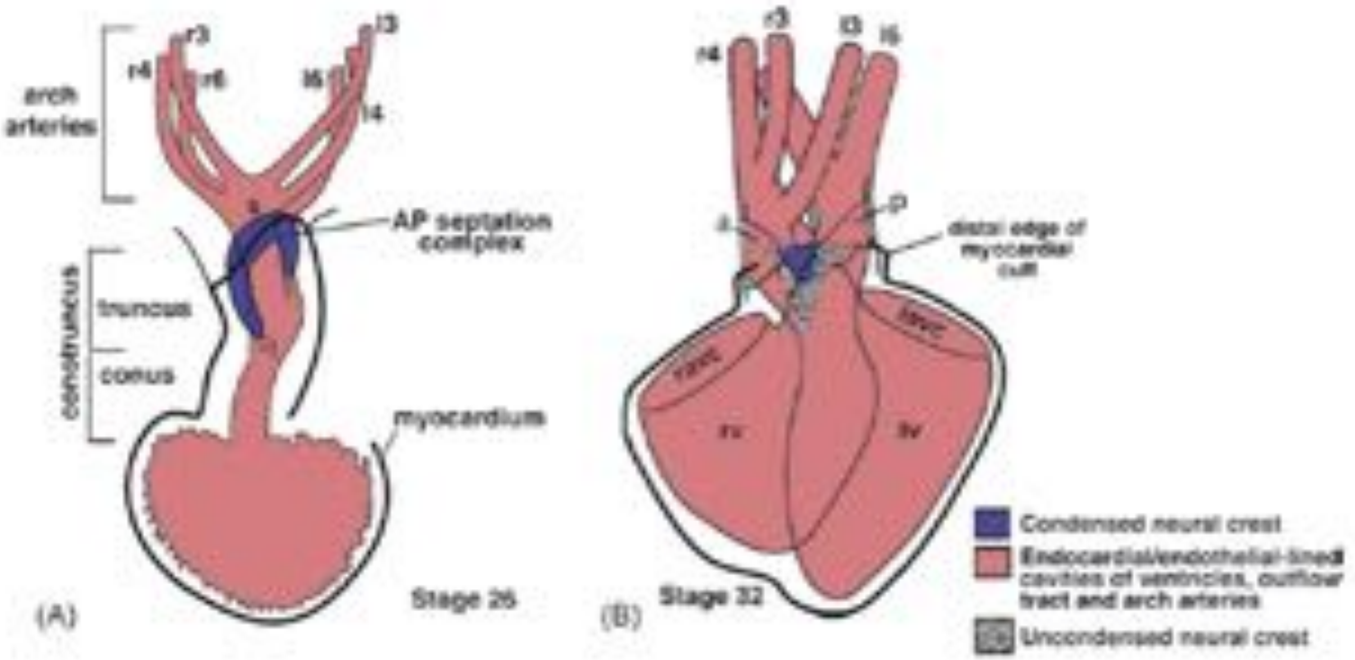
Unité médico-chirurgicale de Cardiologie Congénitale et Pédiatrique
Hôpital Universitaire Necker Enfants malades – APHP, Université Paris Descartes, Sorbonne Paris Cité
IcarP Cardiology, Institut Hospitalo-Universitaire IMAGINE

Centre de Référence Maladies Rares
Malformations Cardiaques Congénitales Complexes-M3C

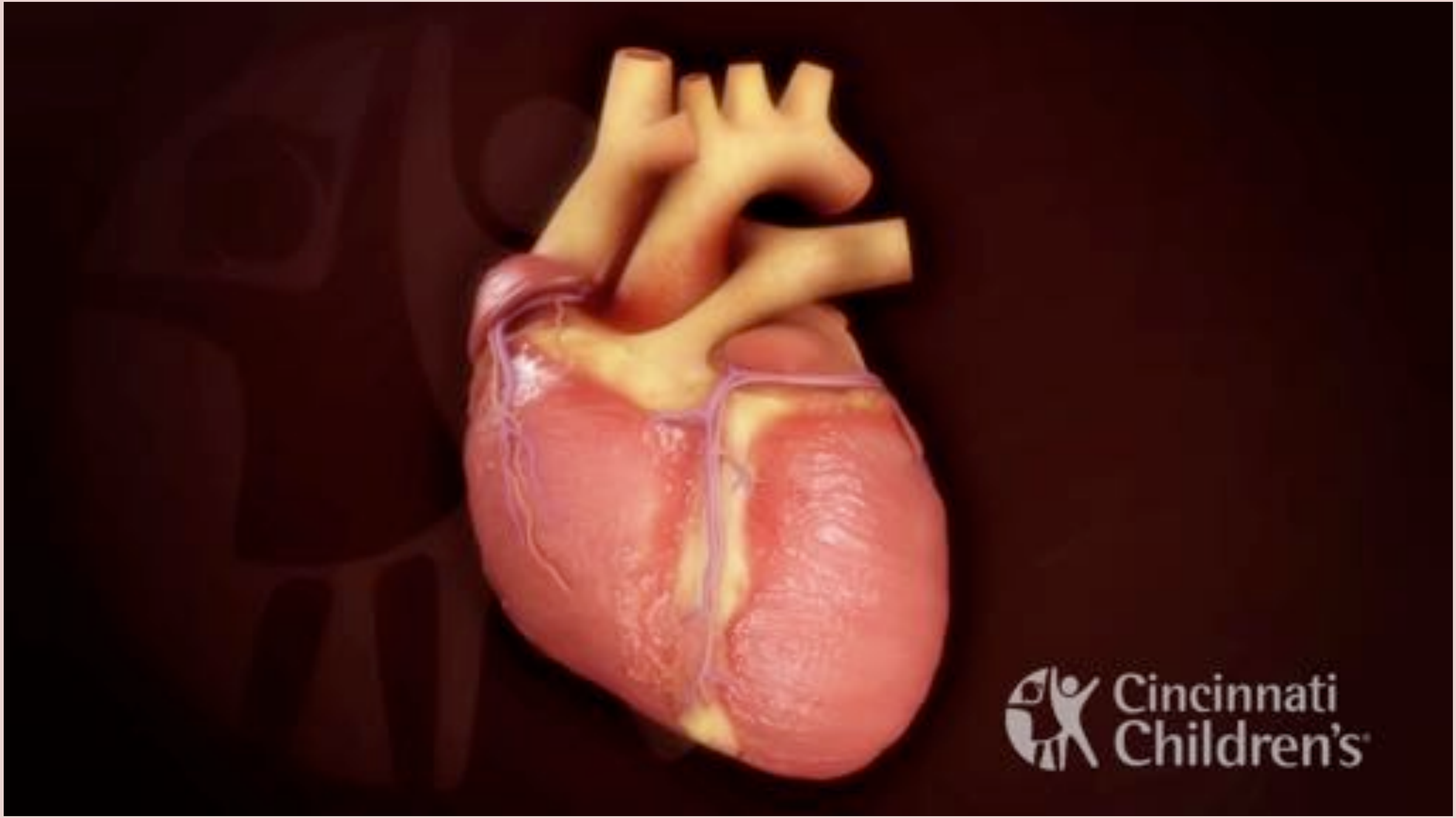
Centre de Référence Maladies Rares
Maladies Cardiaques Héréditaires- CARDIOGEN

Migration of neural crest cells into the outflow tract





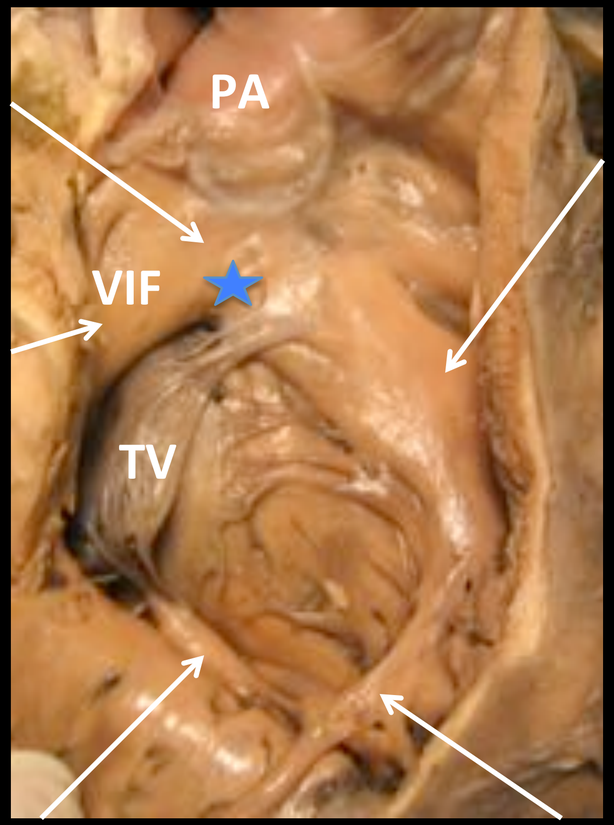
Hutson & Kirby 2007


Cincinnati
Children's

Subpulmonary conus

Septal band

Ventriculo-infundibular fold

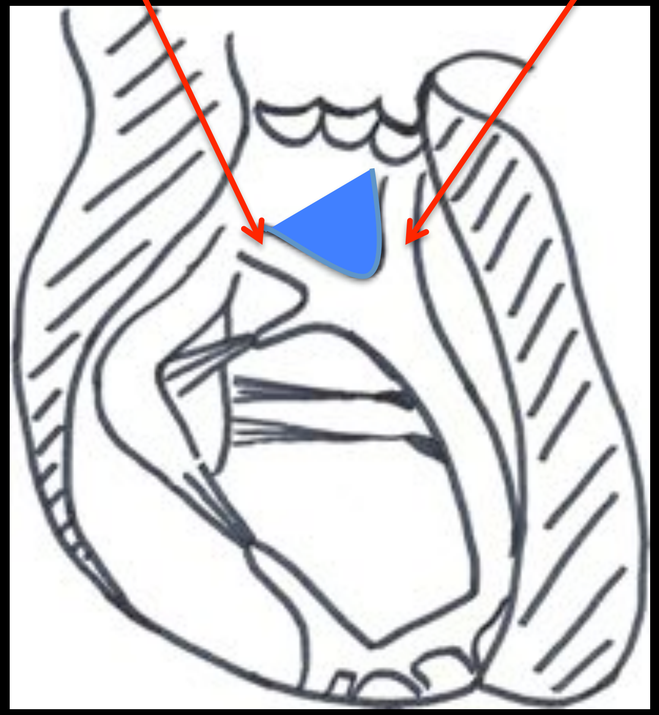


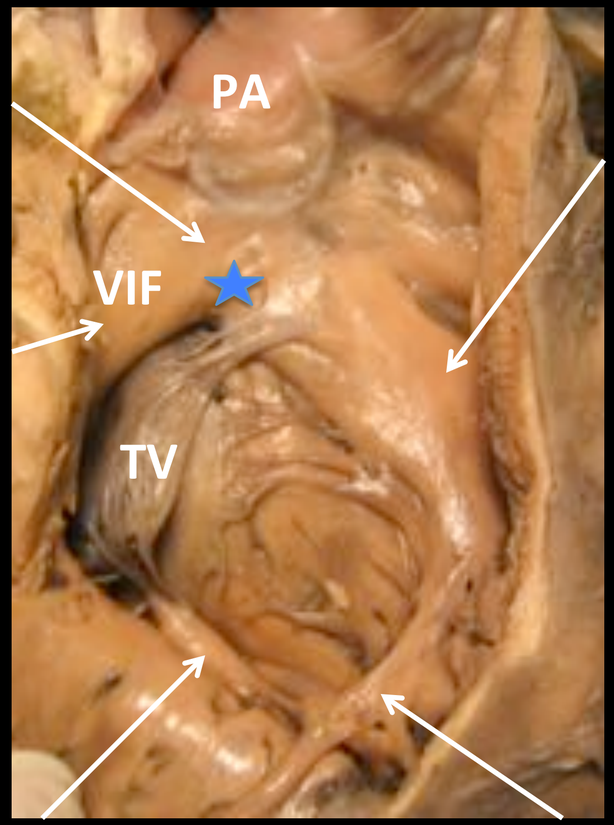
Anterior papillary muscle of the tricuspid valve

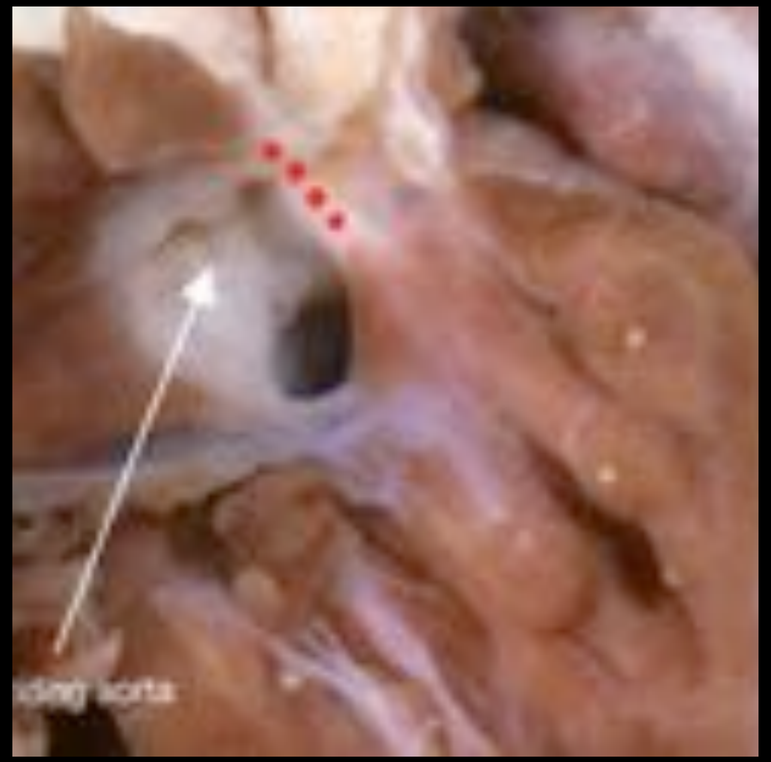
Moderator band

Postero-inferior limb of the septal band

Anterior limb of the septal band




Subpulmonary conus
PA
Septal band
VIF
Ventriculo-infundibular fold
TV
Anterior papillary muscle of the tricuspid valve
Moderator band



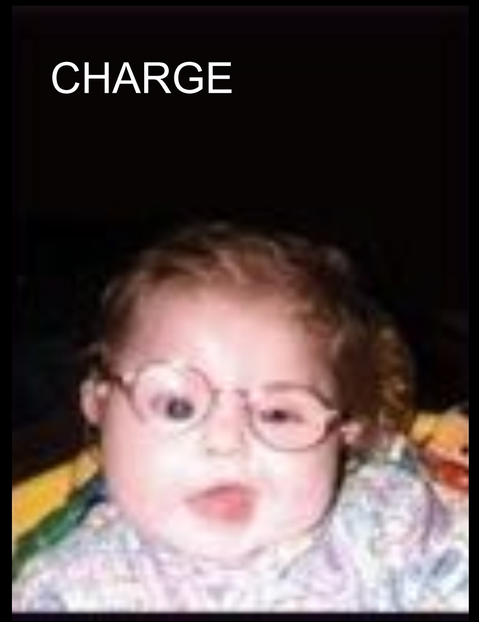
Simple Fallot

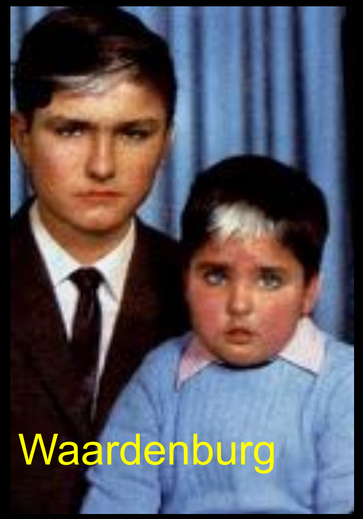
Main topics in tetralogy of Fallot

- Prenatal diagnosis
- Perinatal management
- Strategy for repair
- Late outcomes

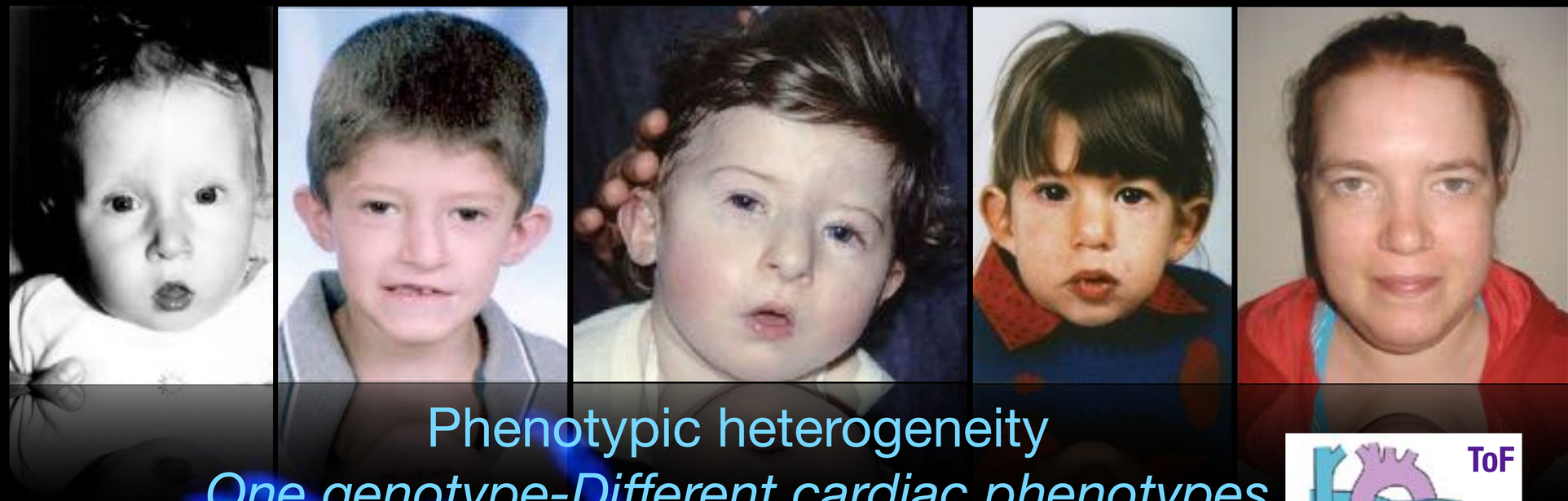
Prenatal diagnosis of tetralogy of Fallot
What are the main issues ?

1. Associated cytogenetic and extra-cardiac anomalies



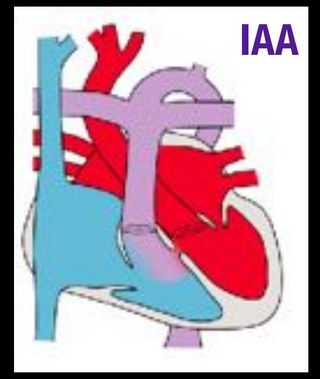


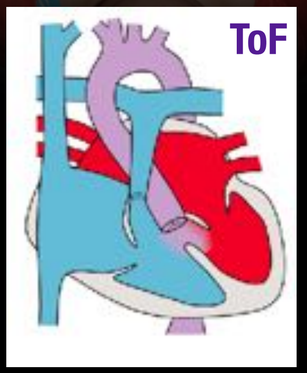
10 % karyotypic anomalies on standard analysis
18% 22q11 deletion : 15% in ToF-PS, 26% in ToF-PA

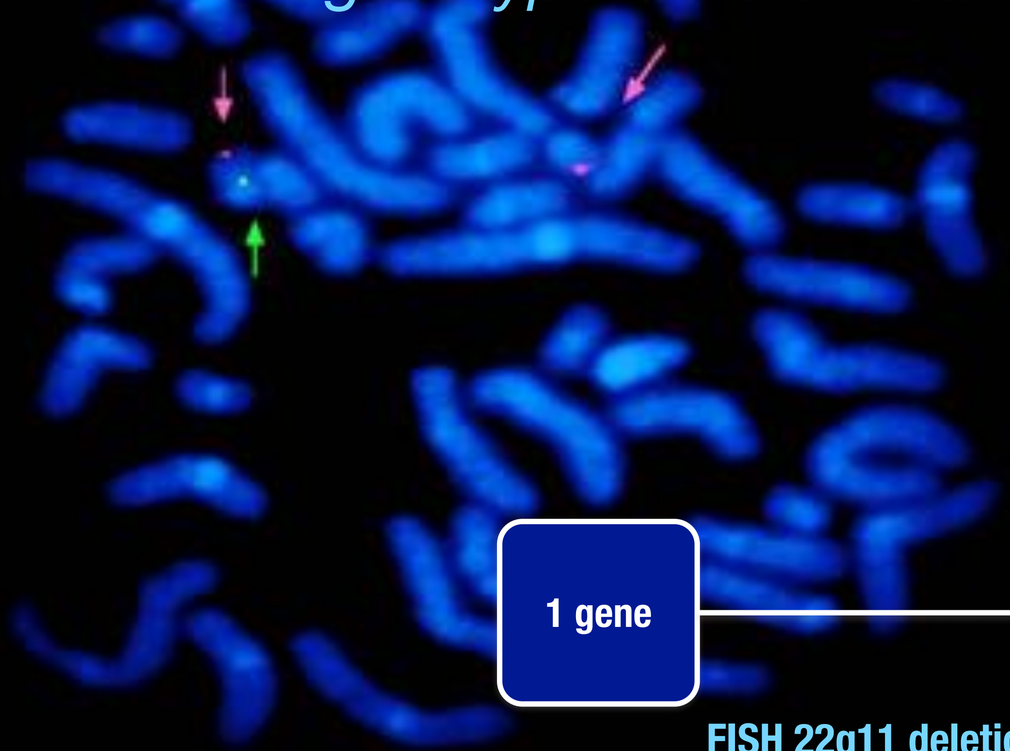


Phenotypic heterogeneity

One genotype-Different cardiac phenotypes

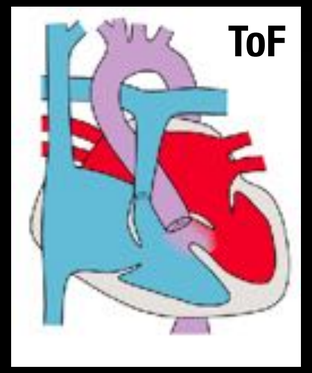


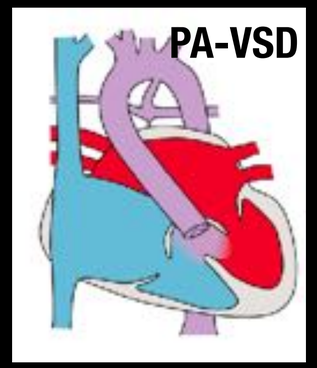


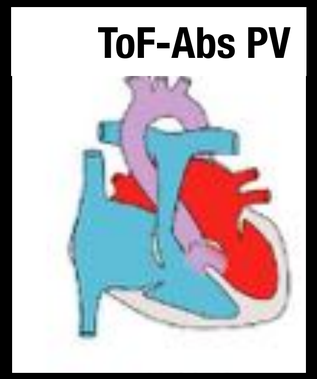


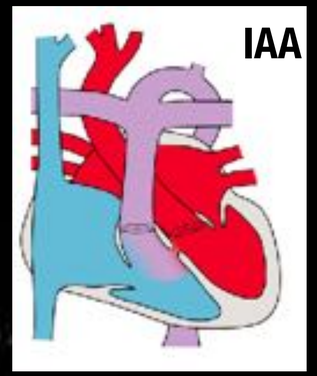
1 gene → X CHD

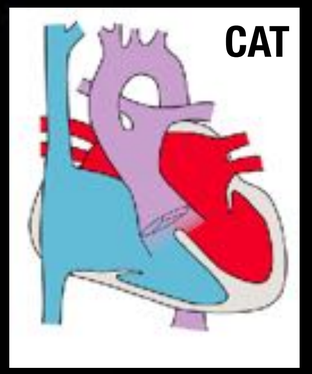
FISH 22q11 deletion

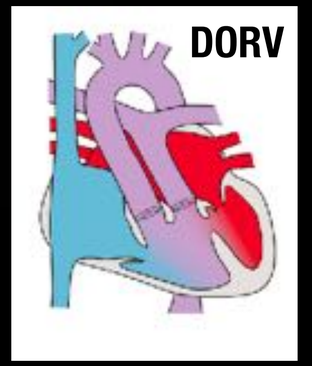

ToF


PA-VSD


ToF-Abs PV


IAA


CAT


DORV

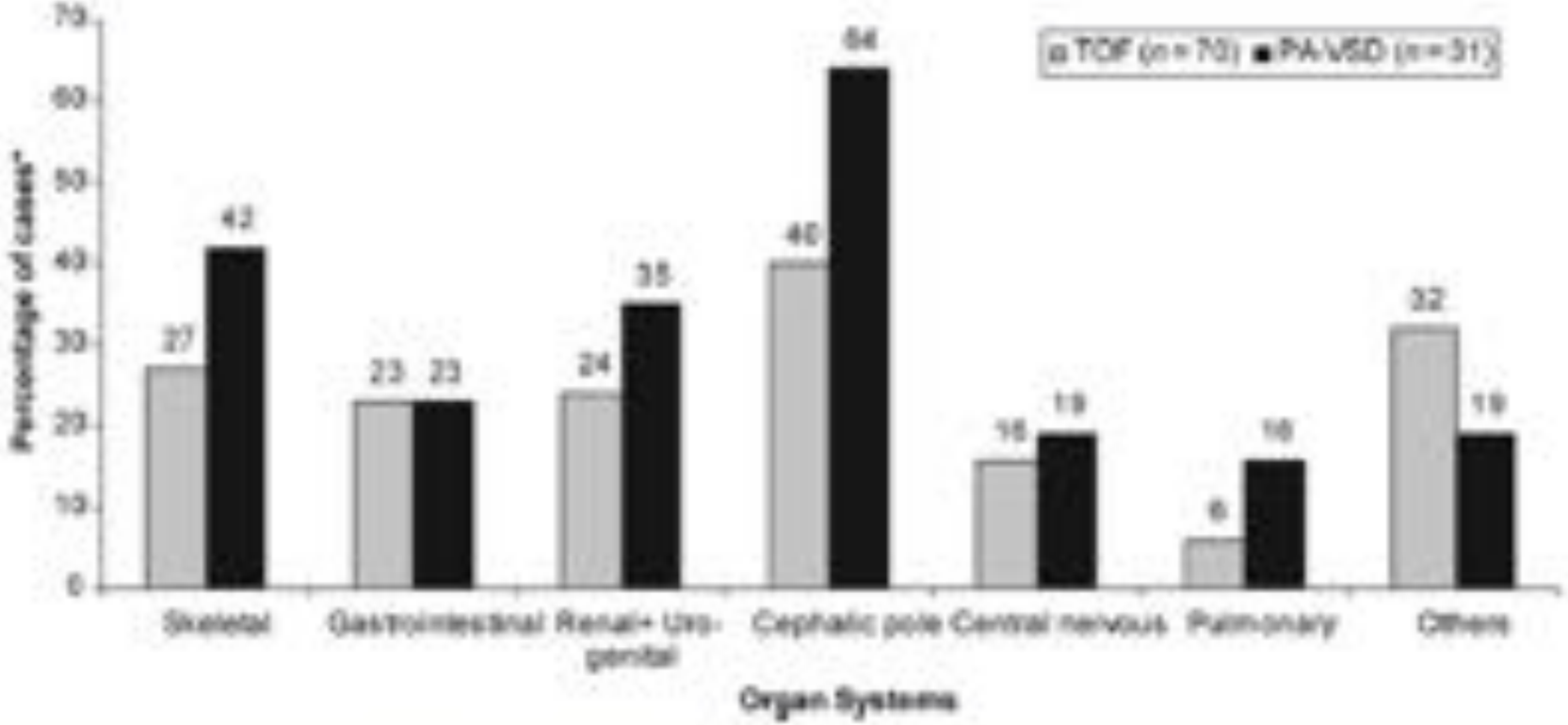


Figure 2 Details on extracardiac anomaly in foetal TOF and PA-VSD. Others, growth and endocrinological abnormalities, mental retardation, ophtalmological anomalies, uniс umbilical artery, cystic hygroma; TOF, tetralogy of Fallot; PA-VSD, pulmonary atresia with ventricular septal defect; the asterisk indicates the number of abnormalities by system/number of foetuses with associated extracardiac malformations per type of CHD (TOF or PA-VSD).

One third of fetuses with ToF had extra cardiac anomalies
15% had intra-uterine growth retardation

Kaguelidou F, Bonnet D. Eur Heart J. 2008 Jun;29(11):1432-8.

Prenatal diagnosis of tetralogy of Fallot
What are the main issues ?

1. Associated cytogenetic and extra-cardiac anomalies

2. Accuracy of diagnosis and decision for in utero transfer

Prenatal diagnosis, pregnancy termination, perinatal and early neonatal mortality for selected (**isolated**) congenital heart anomalies

Paris Registry of Congenital Malformations, 1983-2010

ToF	83-88 %	89-94 %	95-00 %	00-10 %	p
Prenatal diagnosis	**20.0**	**37.5**	**69.7**	**74**	<0.005
Pregnancy termination	10.0	12.5	0	1.8	0.07
First week mortality	0	0	0	0.3	-
Perinatal mortality	0	7.1	2.9	2.0	0.63

Khosnood B et al. Pediatrics 2005;115:95-101

Recent studies show that prenatal diagnosis DOES NOT impact neonatal CHD mortality

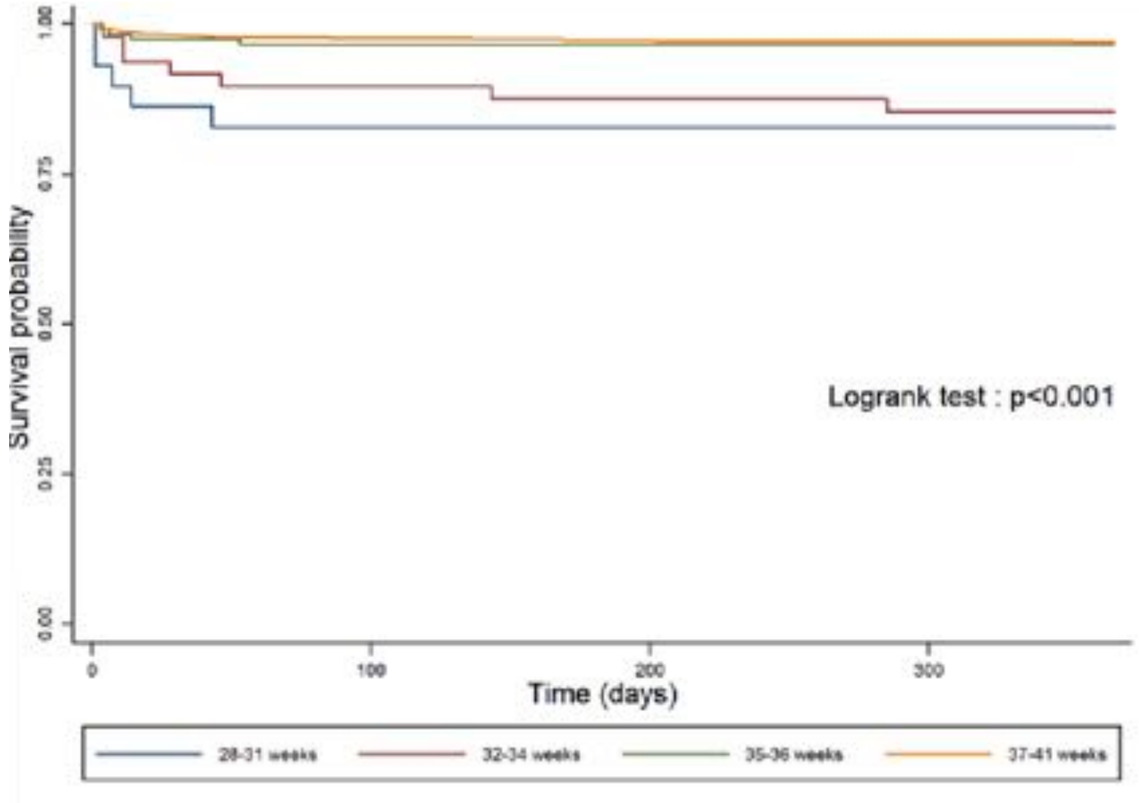
Table 3 Association between prenatal diagnosis and risk of infant mortality for four specific congenital heart defects (CHDs), EPIdémiologie des CARDiopathies congénitales (EPICARD) Population-Based Cohort Study

	Prenatal diagnosis		Infant mortality				
CHD		n*	n†	%	95% CI	Risk ratio	95% CI
Functionally univentricular heart‡	No	7	3	42.9	9.9 to 81.6		
	Yes	32	17	53.1	34.7 to 70.9	1.2	0.5 to 3.1
d-Transposition of the great arteries‡	No	24	1	4.2	0.1 to 21.1		
	Yes	57	5	8.8	2.9 to 19.3	2.1	0.3 to 17.1
Tetralogy of Fallot‡	No	18	2	11.1	1.4 to 34.7		
	Yes	36	1	2.8	0.07 to 14.5	0.3	0.02 to 2.6
Coarctation of the aorta‡	No	44	3	6.8	1.4 to 18.7		
	Yes	29	2	6.9	0.8 to 22.8	1.0	0.2 to 5.7

*N = number of live births (denominator data).
†n= number of deaths (numerator data).
‡Cases with the specific International Paediatric and Congenital Cardiac Code for the given CHD; whether or not other CHD codes were also included, all cases with chromosomal or others anomalies were excluded.

Khoshnood B et al. BMJ open 2017
van Velzen CL et al. BJOG 2016;123:400–407

Impact of preterm birth on infant mortality for newborns with congenital heart defects
The EPICARD Study Group

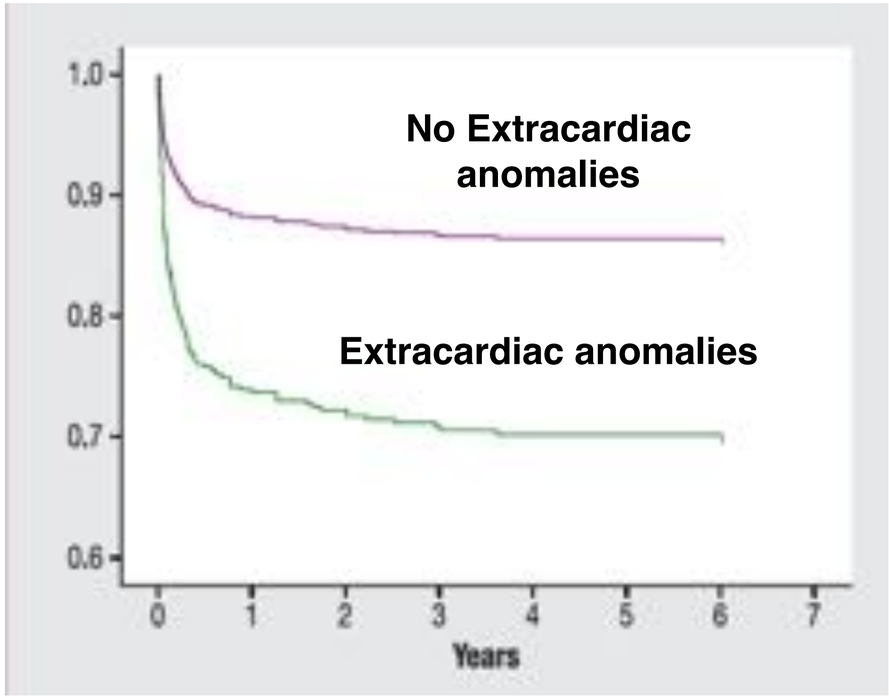


- Preterm birth is associated with an approximately **four-fold higher risk** of infant mortality for newborns with CHD.
- This excess risk appears to be mostly limited to newborns **< 35 weeks of gestation** and is disproportionately **due to early deaths**.

Laas E et al. 2018

Death before hospital discharge in prenatally diagnosed « in-born » CCHD

Type of CHD/predicted physiology	Mortality before discharge n (%)
at risk for Rashkind	8 (2.3)
ductal-dependent pulmonary flow	13 (12.1)
potentially ductal-dependent pulmonary flow	3 (2.1)
ductal-dependent systemic flow	25 (39.6)
potentially ductal-dependent systemic flow	16 (5.2)
TAPVR	1 (12.5)
AV block with CHD	0 (0)
a priori at no risk of early intervention	7 (6.5)
ALL	73 (6.7)



Bensemlali M et al. CiTY 2016
Bensemlali M et al. Arch Cardiovasc Dis 2016

Prenatal diagnosis anticipates and prevents early demise
Is in utero transfer a valid option ?

Common indications for in utero transfer

- **Life threatening CHDs**
  - ***Ex: TGA, TAPVR, HLHS***
- **Evolutive defects**
  - ***Ex: Coarctation of the aorta***
- **Uncertain perinatal physiology**
  - ***Ex: Tetralogy of Fallot***
- **Highly variable/unpredictable postnatal outcome**
  - ***Ex: Ebstein***

Interventions in prenatally diagnosed « in-born » CHD

2543 in-born

TGA

748 in born

21% early demise

87% intervention

Suspected coarctation

486 in born

35% intervention

ToF

287 in born

4% intervention

Bensemlali M et al. CiTY 2016
Bensemlali M et al. Arch Cardiovasc Dis 2016

Prenatal diagnosis of tetralogy of Fallot
What are the main issues ?

1. Associated cytogenetic and extra-cardiac anomalies

2. Accuracy of diagnosis and decision for in utero transfer

3. Prediction of repair

Is information on probability of complete repair individualized ?

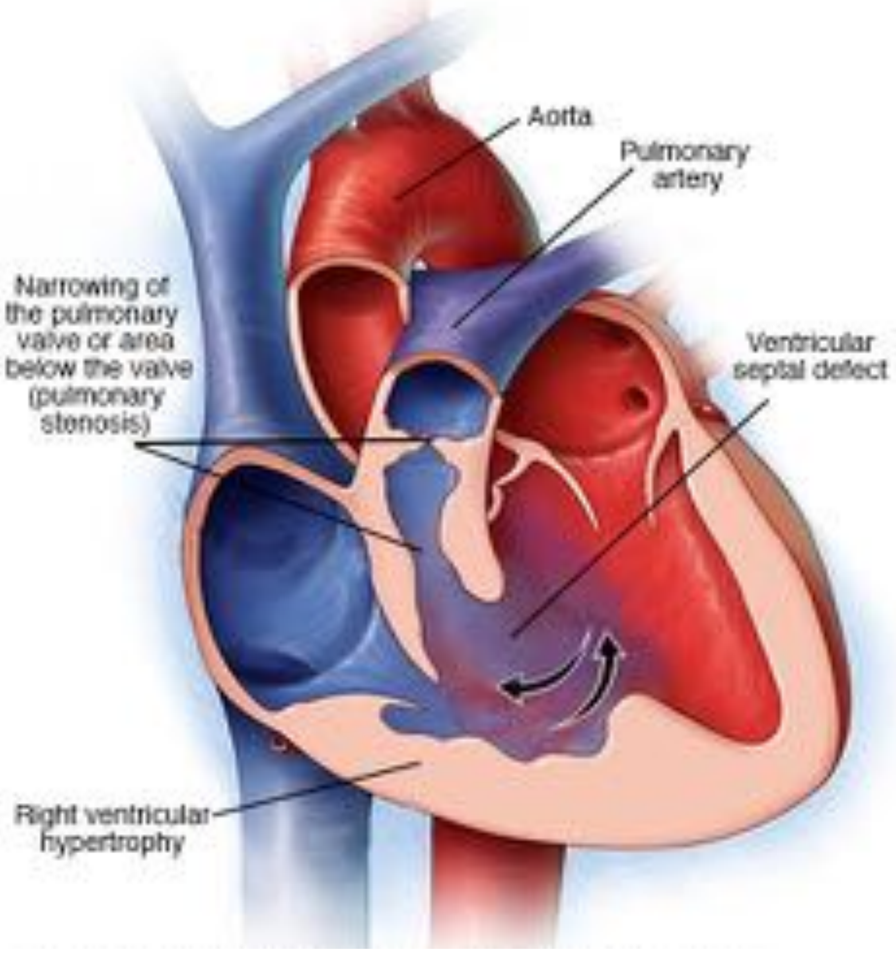
Repair of TOF & PA-VSD at one year is closely related to size of pulmonary artery branches

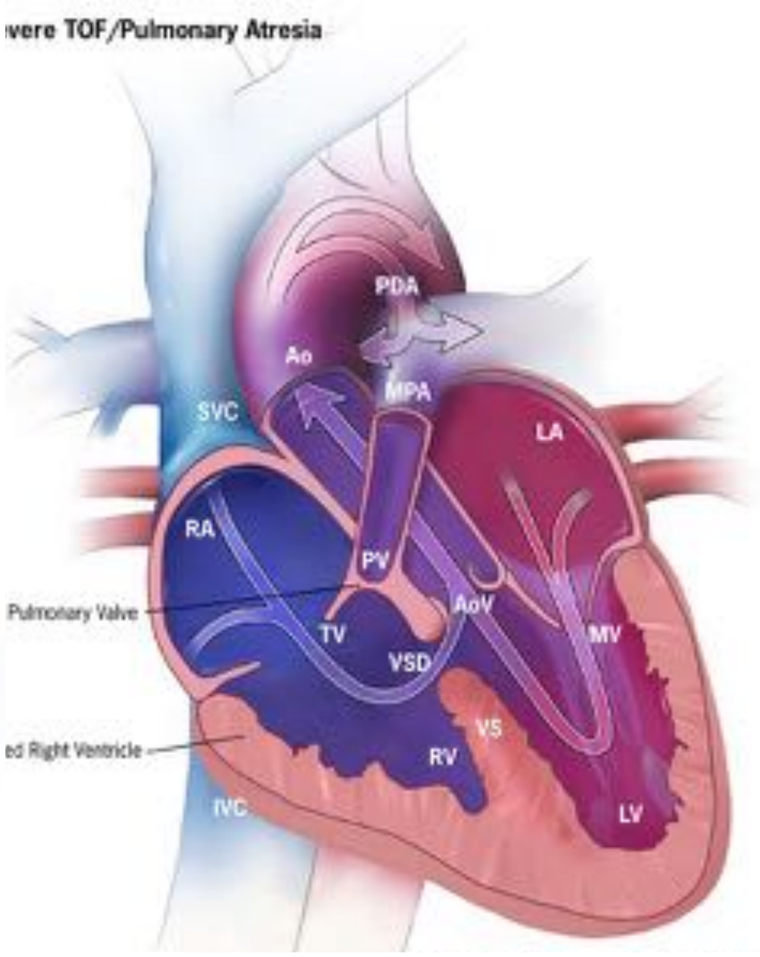
	Repair < 1y %	p
PA branches Normal vs. absent/hypoplastic	86 vs. 55	<0.001
PA trunk present vs. absent	79 vs. 16	0,003
MAPCAs present vs. absent	76 vs. 50	0.17

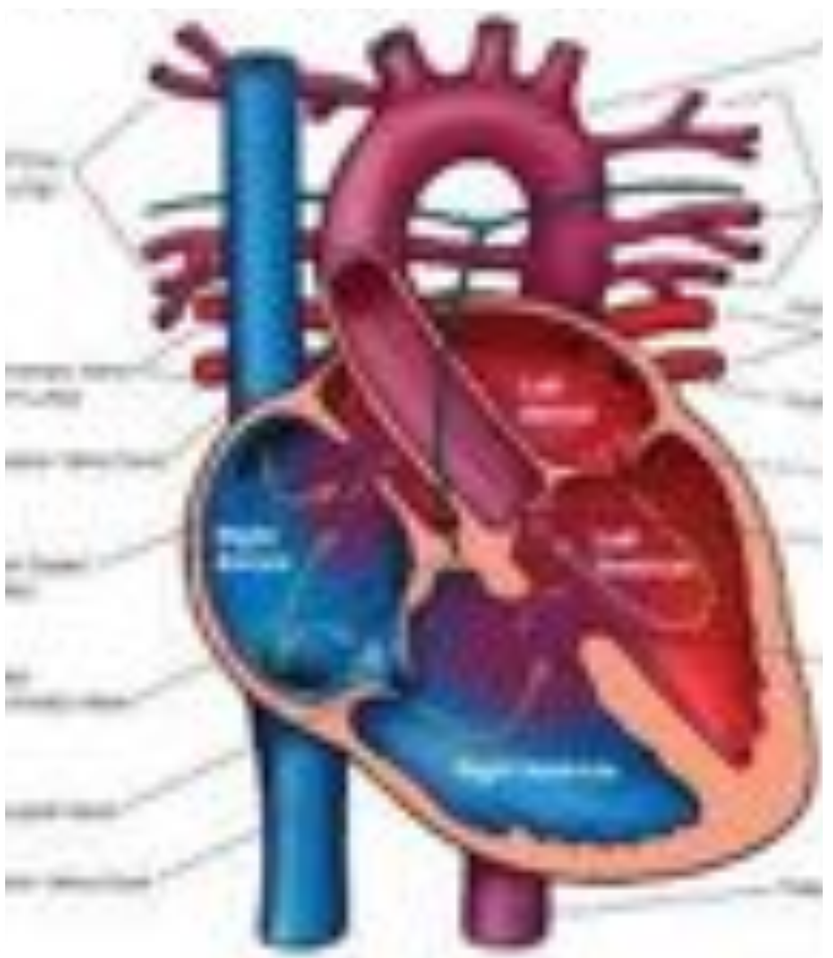
Kaguelidou F et al. Eur Heart J. 2008

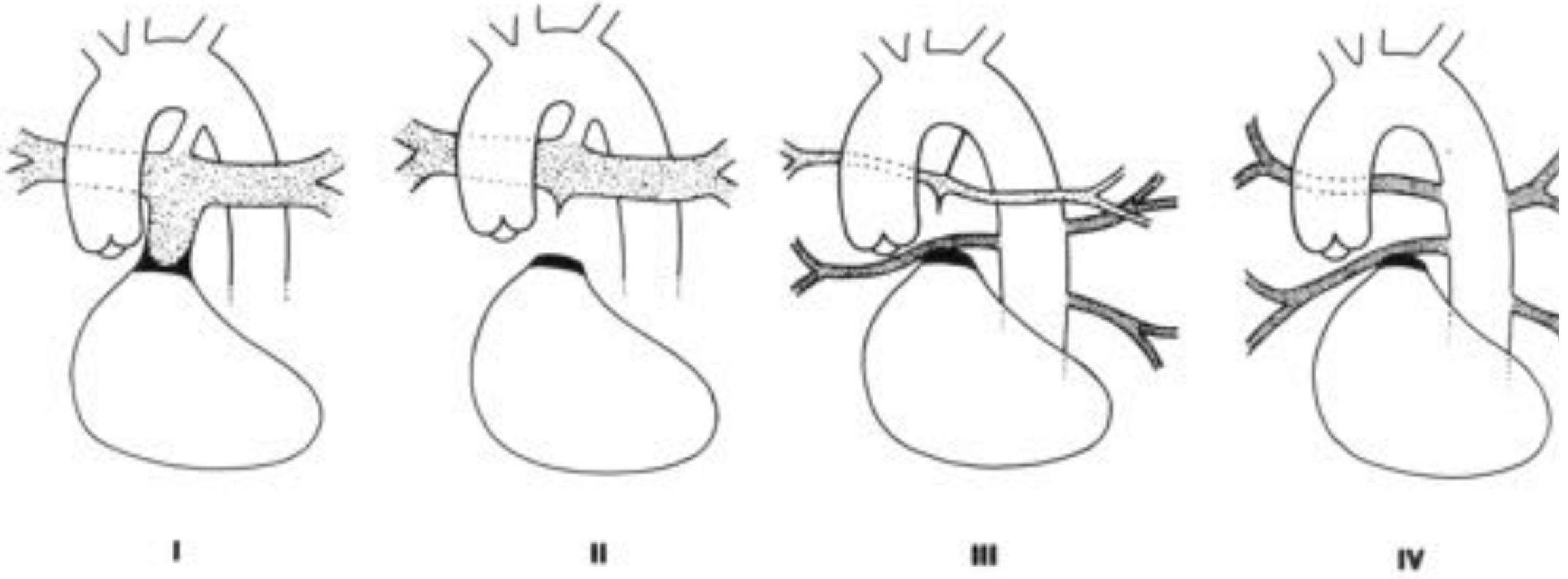
Perinatal management

1. Ducto-dependent defect ?


Aorta
Pulmonary artery
Narrowing of the pulmonary valve or area below the valve (pulmonary stenosis)
Ventricular septal defect
Right ventricular hypertrophy


vere TOF/Pulmonary Atresia
PDA
Ao
MPA
SVC
LA
RA
PV
Pulmonary Valve
AoV
TV
MV
VSD
VS
ed Right Ventricle
RV
LV
IVC

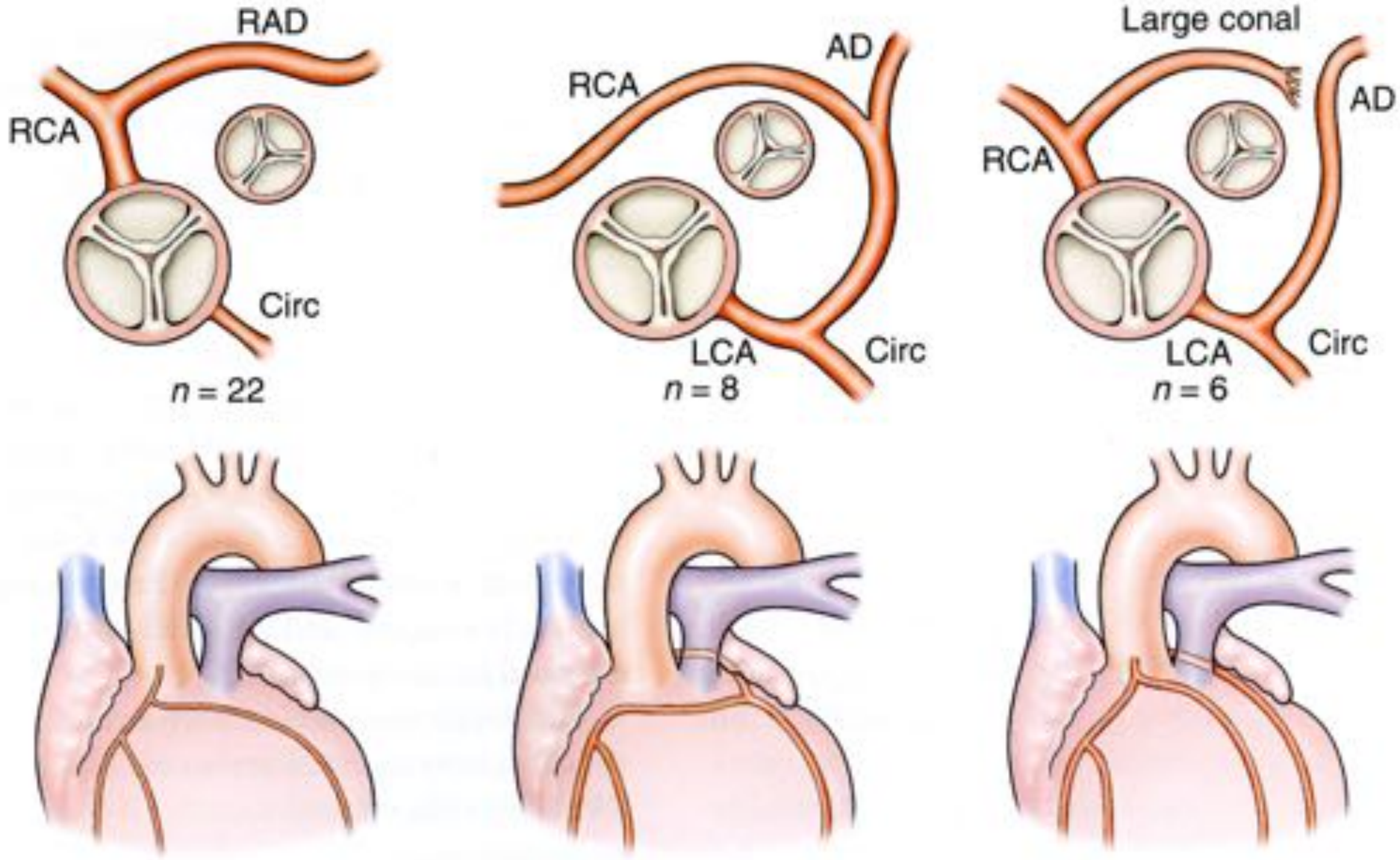


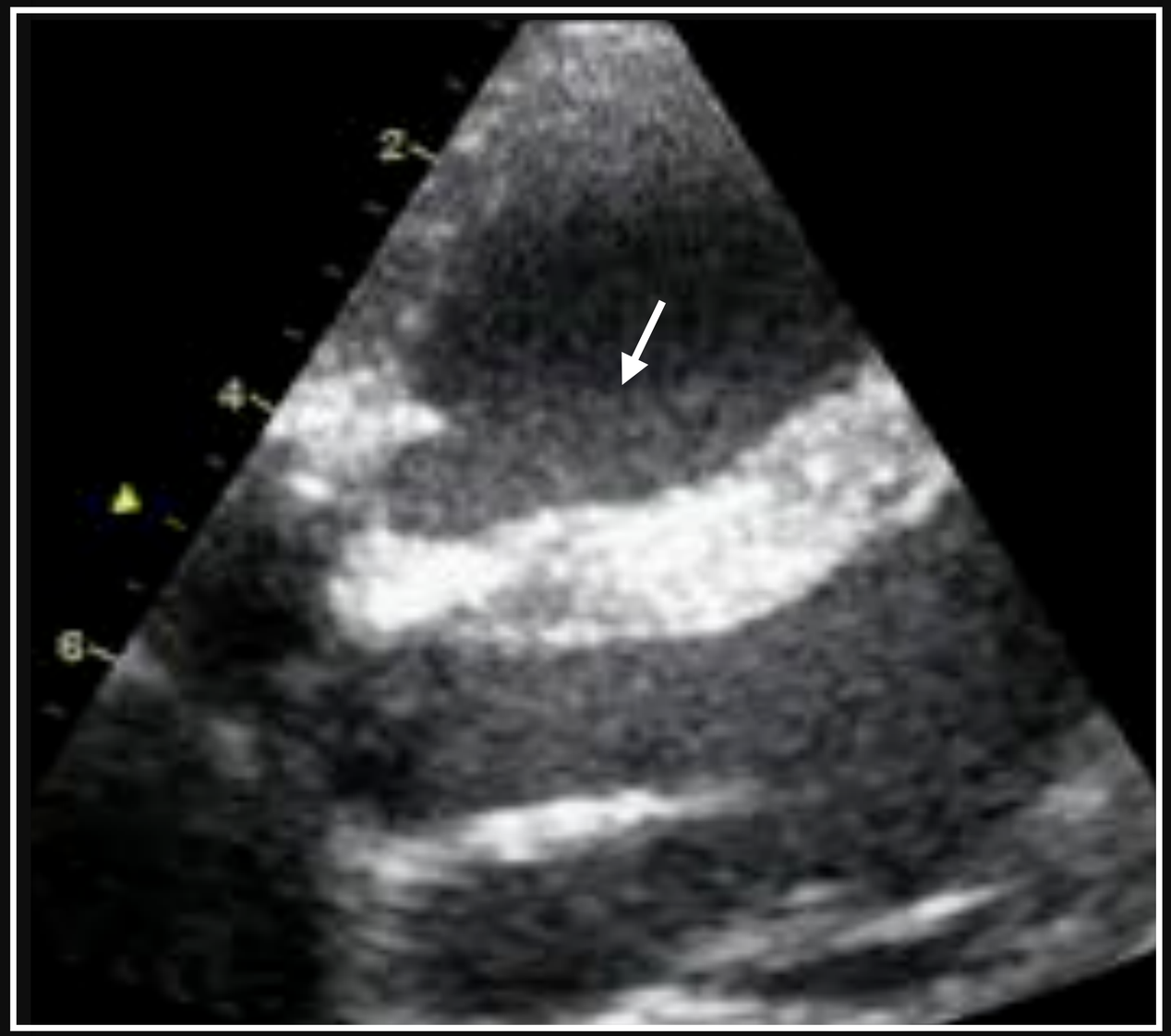

I
II
III
IV

Perinatal management

1. Ducto-dependent defect ?

2. Associated cardiac anomalies

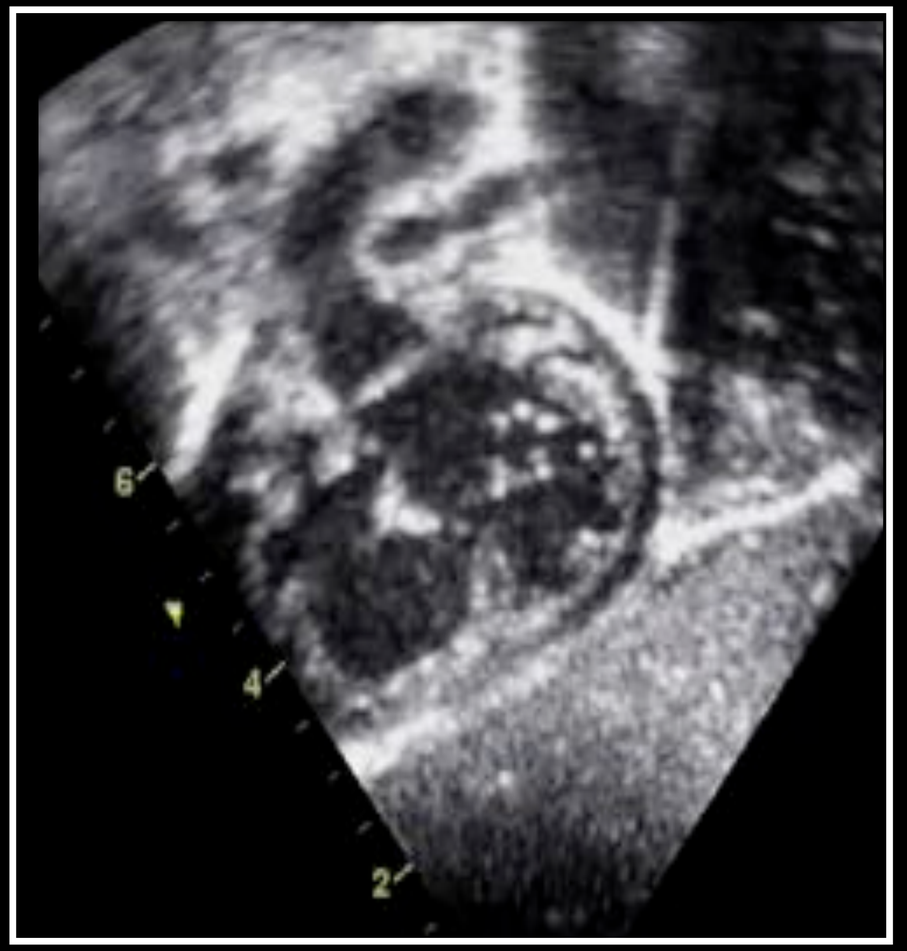

RAD
RCA
Circ
n = 22
AD
RCA
LCA
Circ
n = 8
Large conal
AD
RCA
LCA
Circ
n = 6



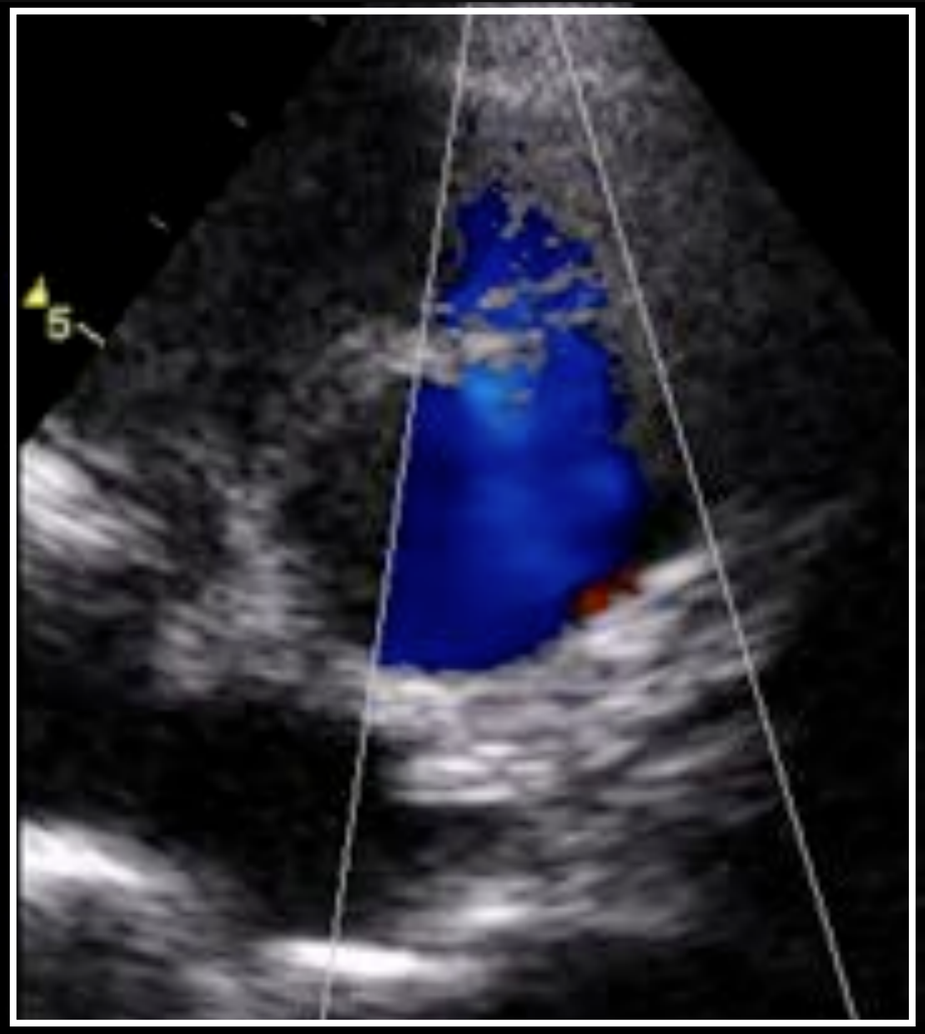
Fallot with LAD from the RCA with anterior course

Pulmonary branches stenosis

Multiple VSDs

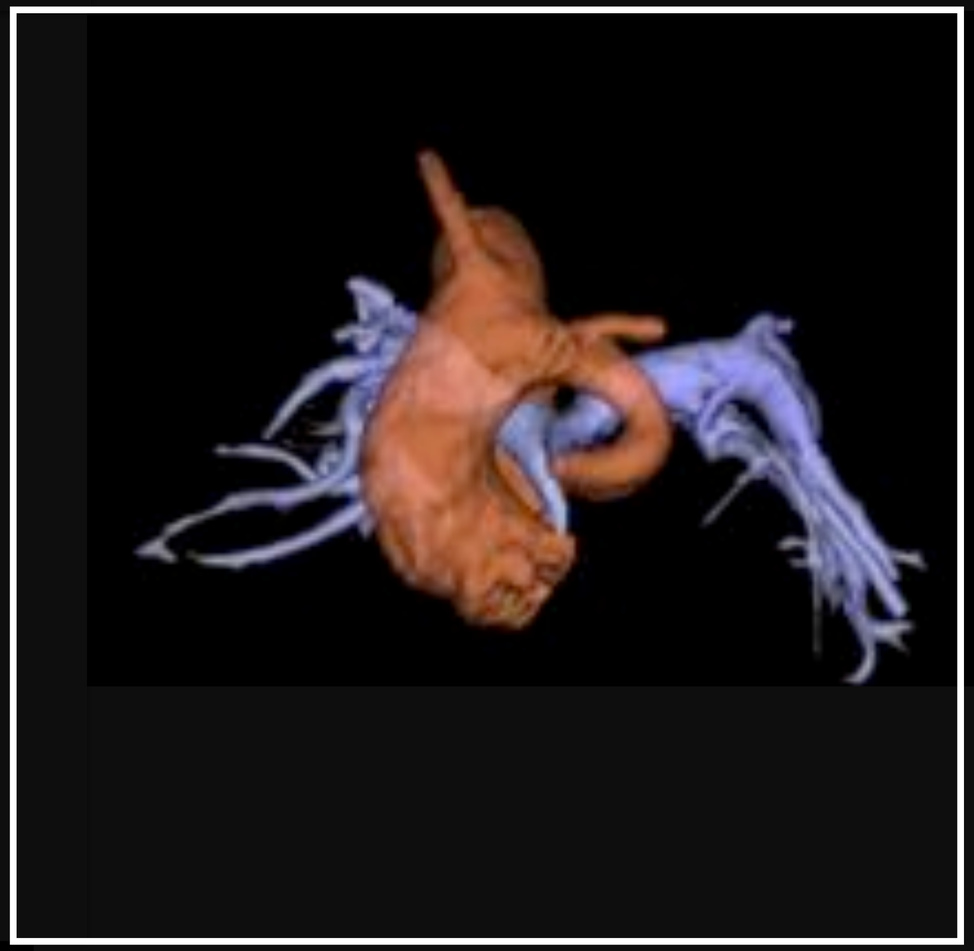


AVSD Fallot



Fallot with outlet VSD and absent conal septum

Patent arterial duct from brachiocephalic trunk



Perinatal management

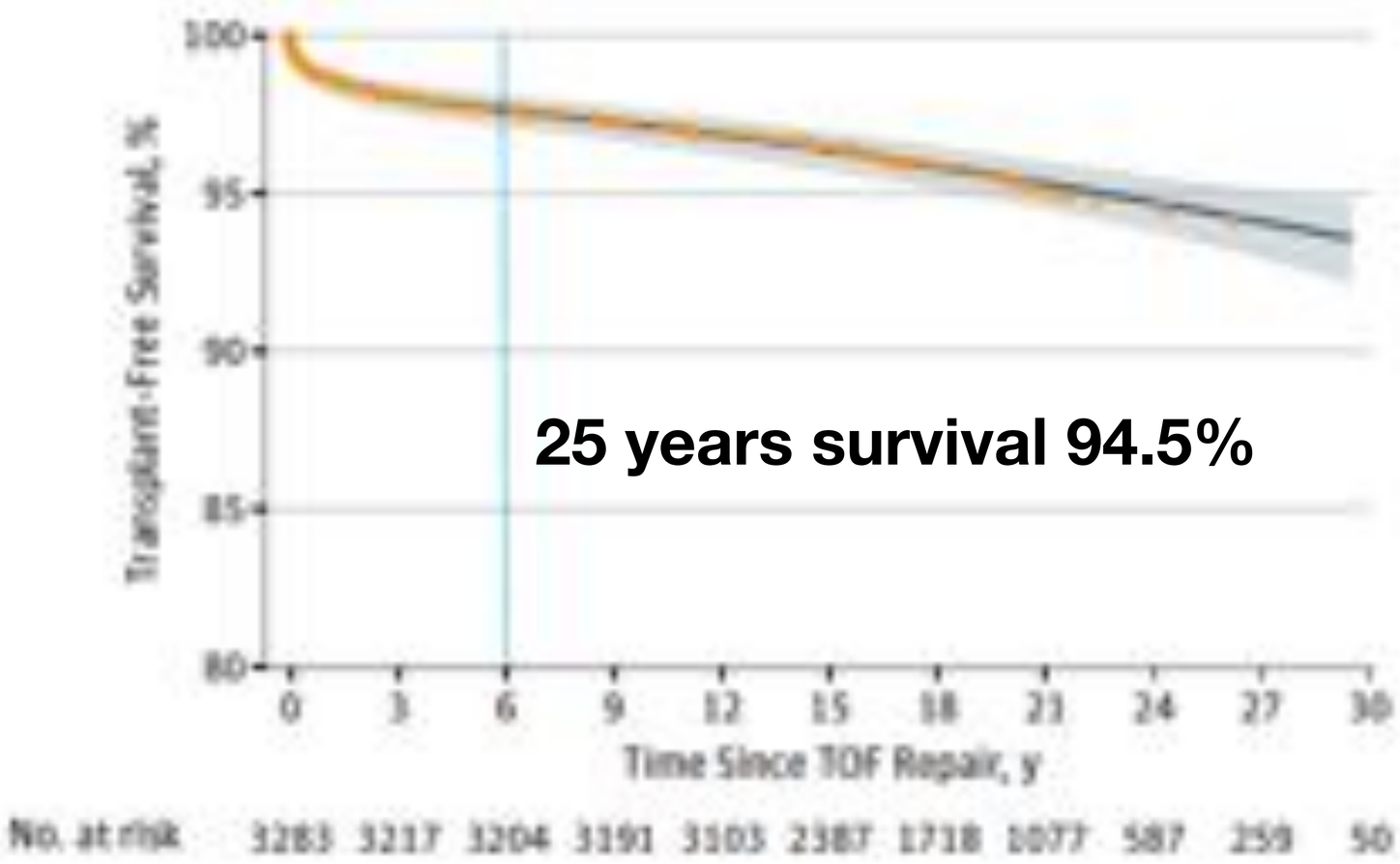
1. Ducto-dependent defect ?

2. Associated cardiac anomalies

3. Strategy in neonates and infants

Predictors of long term outcome
Pediatric Cardiac Care Consortium

3283 patients with simple TOF
Follow-up 18.5 years (maximum, 33 years; IQR, 14.6-22.4 years),
The median age at death was 1.0 years (IQR, 0.6-2.1 years), with range 3 days to 19.7 years.

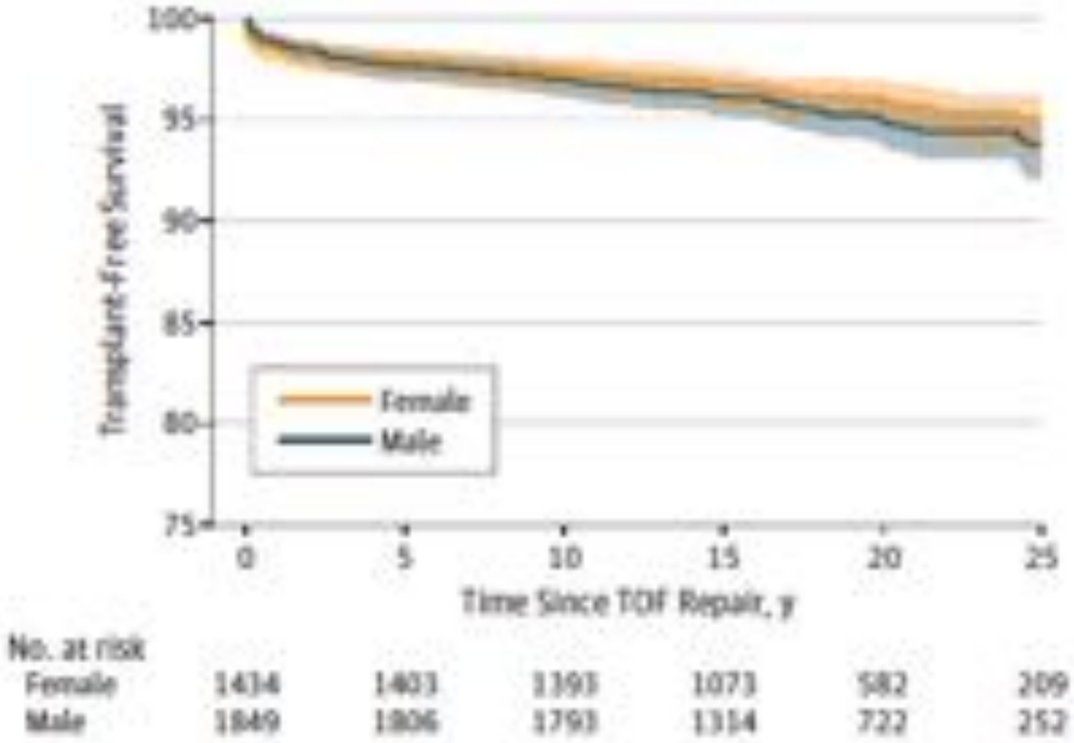


Smith CA et al. JAMA Cardiol 2018

Predictors of long term outcome
Pediatric Cardiac Care Consortium

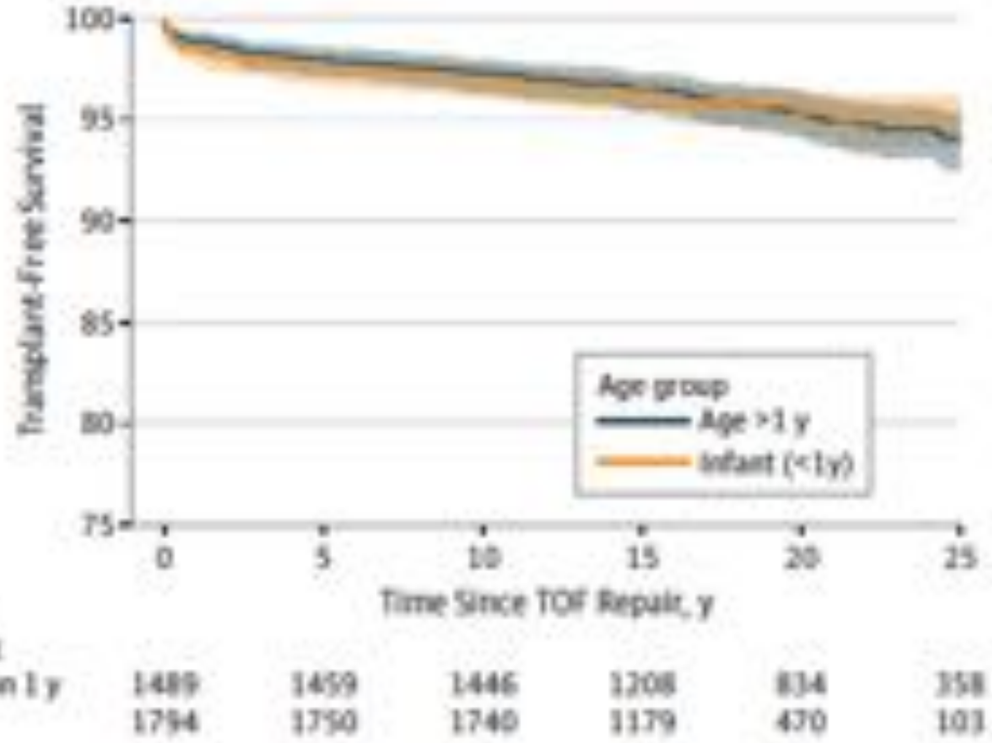
3283 patients with simple TOF
Follow-up 18.5 years (maximum, 33 years; IQR, 14.6-22.4 years),
The median age at death was 1.0 years (IQR, 0.6-2.1 years), with range 3 days to 19.7 years.

SEX



No. at risk						
Female	1434	1403	1393	1073	582	209
Male	1849	1806	1793	1314	722	252

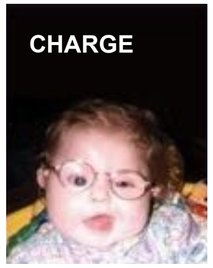
AGE GROUP



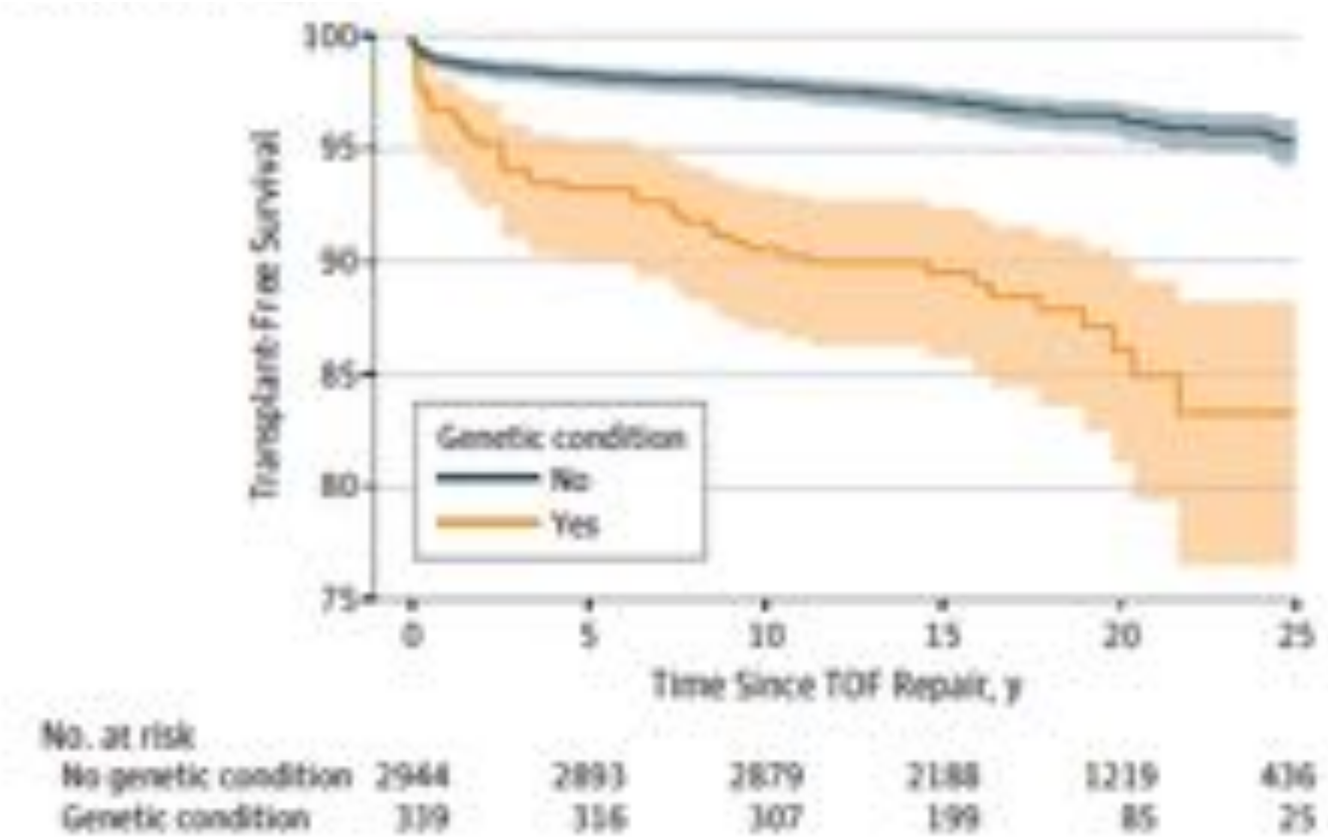
No. at risk						
Older than 1 y	1489	1459	1446	1208	834	358
Infant	1794	1750	1740	1179	470	103

Smith CA et al. JAMA Cardiol 2018

Predictors of long term outcome
Pediatric Cardiac Care Consortium



Non modifiable factor : genetic condition

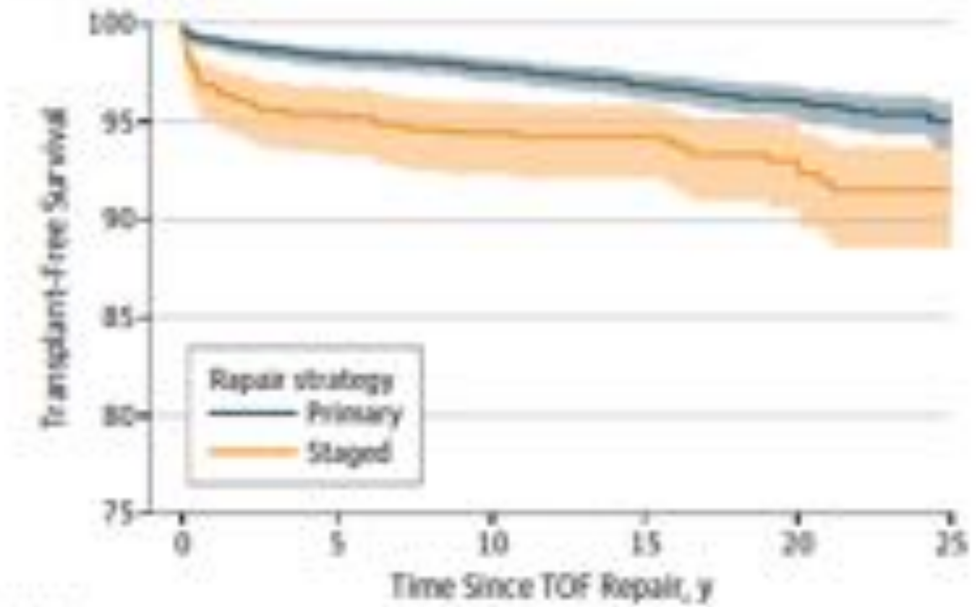


HR 3.64

Smith CA et al. JAMA Cardiol 2018

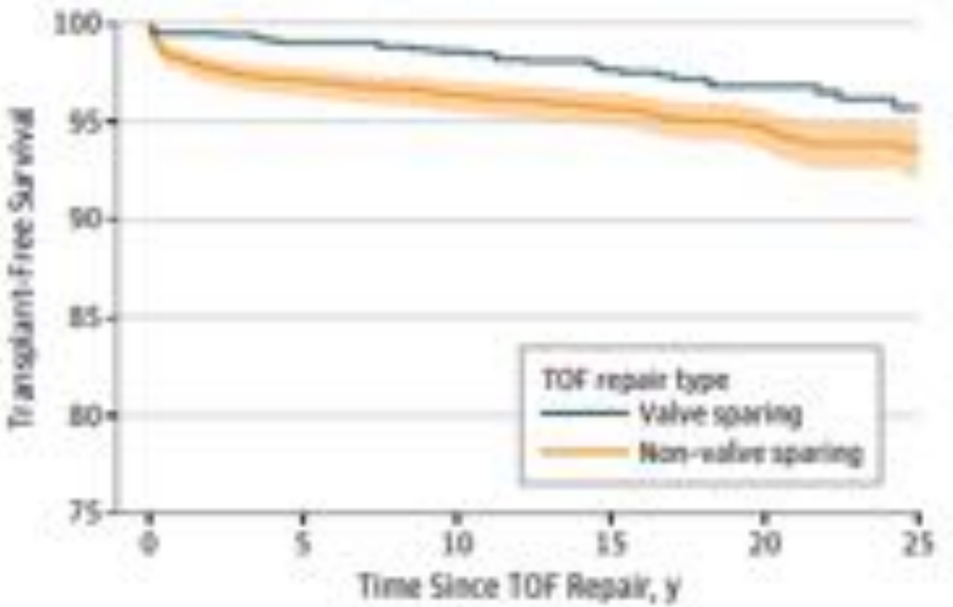
Predictors of long term outcome
Pediatric Cardiac Care Consortium

Repair strategy



No. at risk						
Primary	2672	2627	2610	1952	1041	365
Staged	611	582	576	435	263	96

TOF Repair type



No. at risk						
Valve sparing	1058	1048	1043	778	424	155
Non-valve sparing	2201	2137	2119	1587	866	301

Smith CA et al. JAMA Cardiol 2018

Perinatal strategy in simple ToF
What is the plan during infancy ?

ToF is a **progressive disease** with a potential increase in severity with time.

Optimizing the pulmonary blood flow in the most physiologic fashion may halt this process,

With the objective to **normalize growth of the pulmonary arteries** during infancy.

Thus, **early repair** is thought to be the **optimal** management approach.

Preserving the pulmonary valve predicts a better long-term outcome.

Patients *vs.* Strategies & Alternative techniques

Patients characteristics

Different categories

Non modifiable

-underlying genetic conditions

Time-dependent

-age and weight

-symptoms

Anatomical characteristics

Non modifiable

-location of the VSD

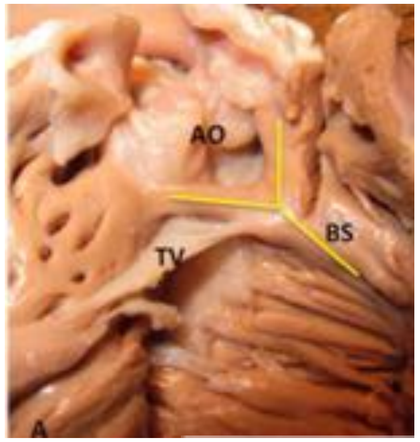
-coronary artery anatomy

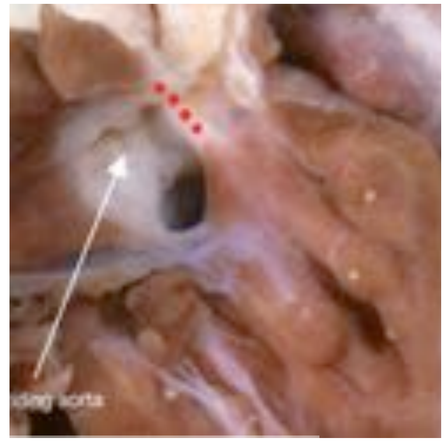
Time-dependent/modifiable

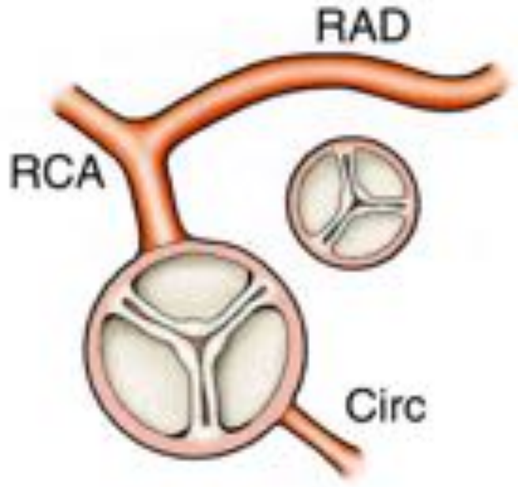
-pulmonary valve and annulus

-pulmonary artery branches (size, contiguity)

-anatomy of the arterial duct







Strategy
Different options

Goal: closed VSD, preserved pulmonary valve without obstruction or regurgitation, normal growth of pulmonary artery branches, normal RV function, no aortic regurgitation

Make plan : elective repair or patient's dependent repair (staged or one step)

Get to work: when ? and how ?

Reach goal: initial strategy and long-term outcomes

Alternative techniques

Palliate:

Blalock

or Stenting the arterial duct

or surgical right ventricle to pulmonary connection

or stenting the right outflow tract

Repair:

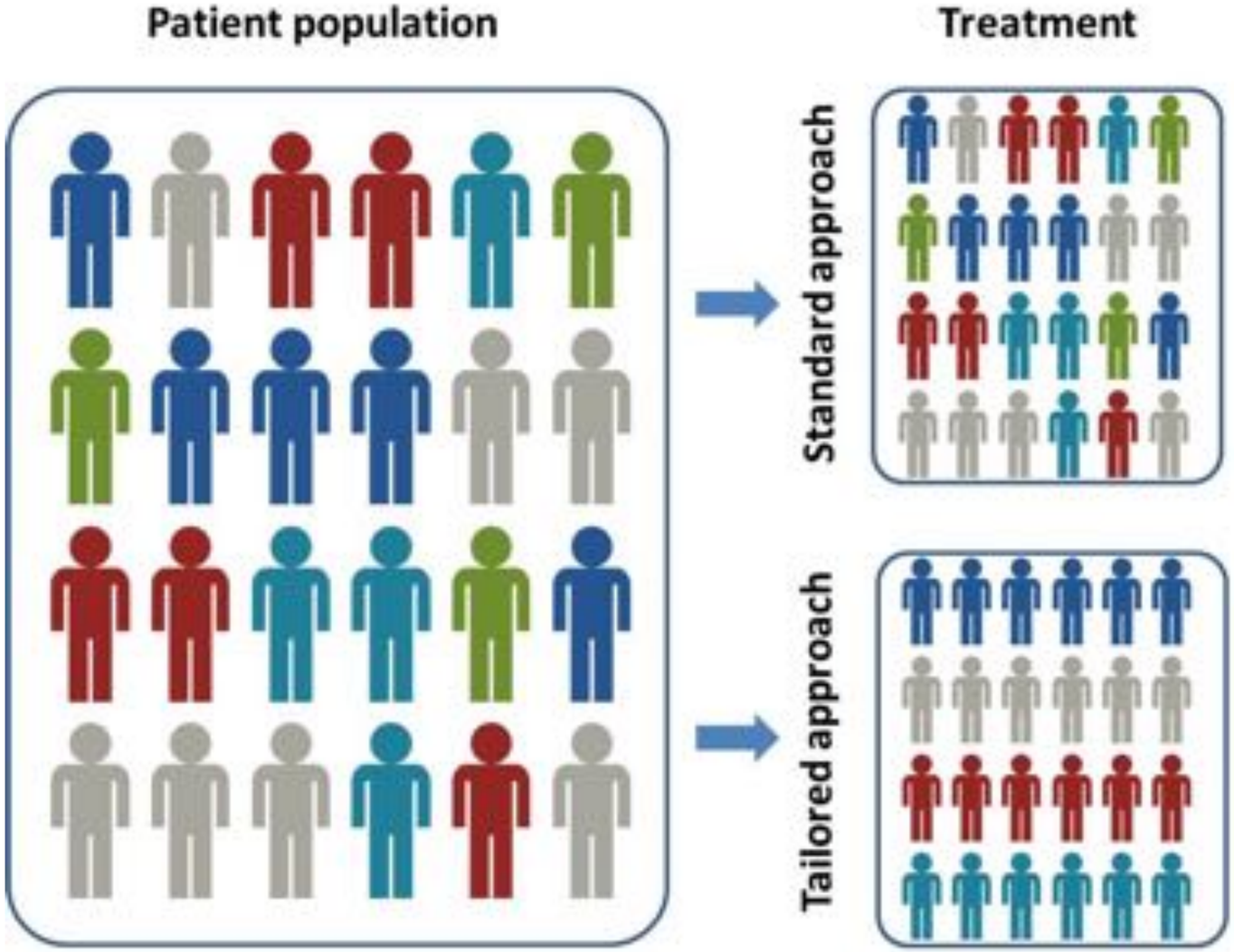
Trans-annular patch

Preserve pulmonary valve

RV-PA conduit

Limit right ventriculotomy

Simple ToF(s) or one patient/one ToF



Low mortality
Tolerated morbidity (early and late)

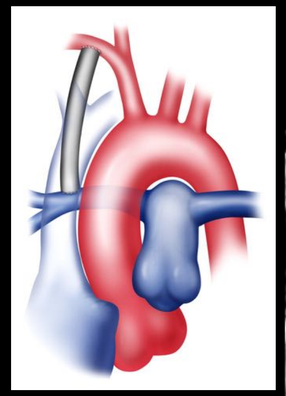
Reduced mortality?
Reduced morbidity (early and late)
Improve patients reported outcomes

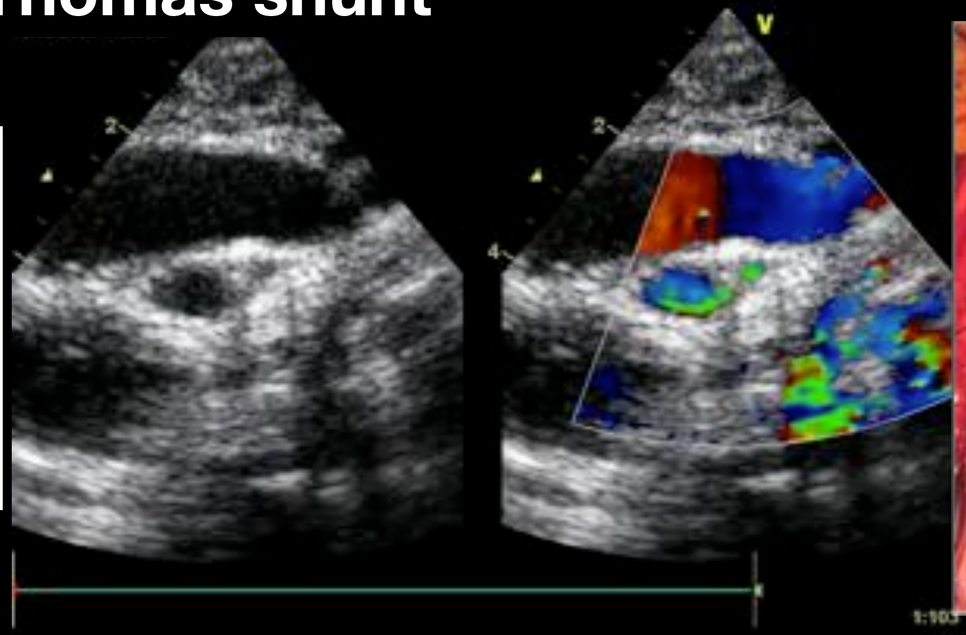
Helen Taussig

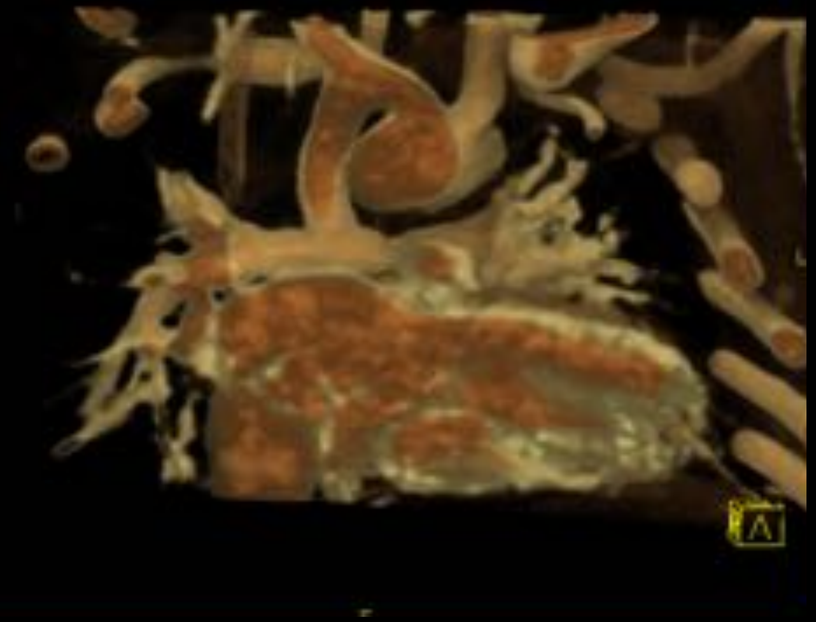
Alfred Blalock and Eileen Saxon

Vivien Thomas

Blalock-Taussig-Thomas shunt

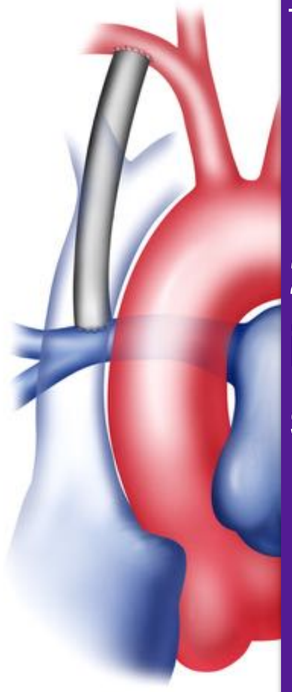






Initial strategy in symptomatic neonates with ToF

Non elective intervention



<u>Outcomes of BT shunts</u>

In hospital mortality (4-5%)

Inter-stage mortality (3.6%)

24% of acute post-operative events including shunt thrombosis, pulmonary overcirculation, shunt stenosis, and pulmonary artery stenosis

Hobbes B et al. Ann Thorac Surg 2017;104:1365–70

-vs. complete repair in neonatal period

Initial strategy in symptomatic neonates with ToF

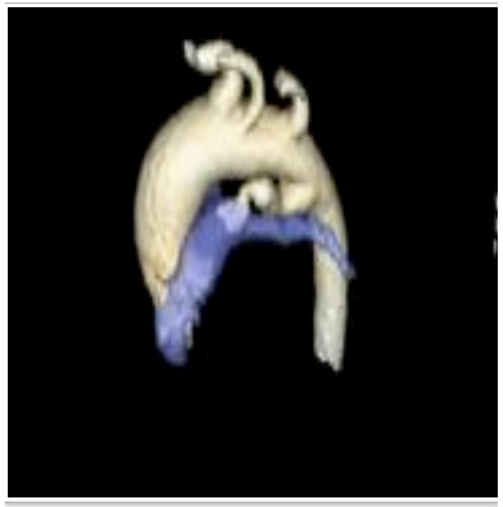
Non elective intervention

Stenting of arterial duct

1-Patients characteristics

-Tendency for complex PDA–pulmonary artery morphology.

LPA coarctation



Tortuous

Underneath
the aortic arch

From innominate artery
Right aortic arch

Initial strategy in symptomatic neonates with ToF

Non elective intervention

Stenting

2-Strategy

-avoid sur

cess

Outcomes of PDA stenting in ToF

Aggravation of PA branch stenosis

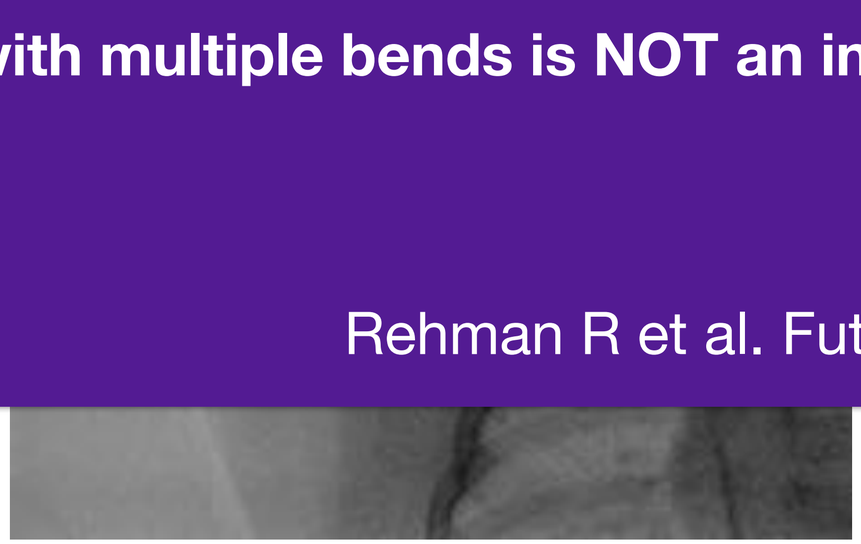
Poor growth of vessel ‘jailed » by stent

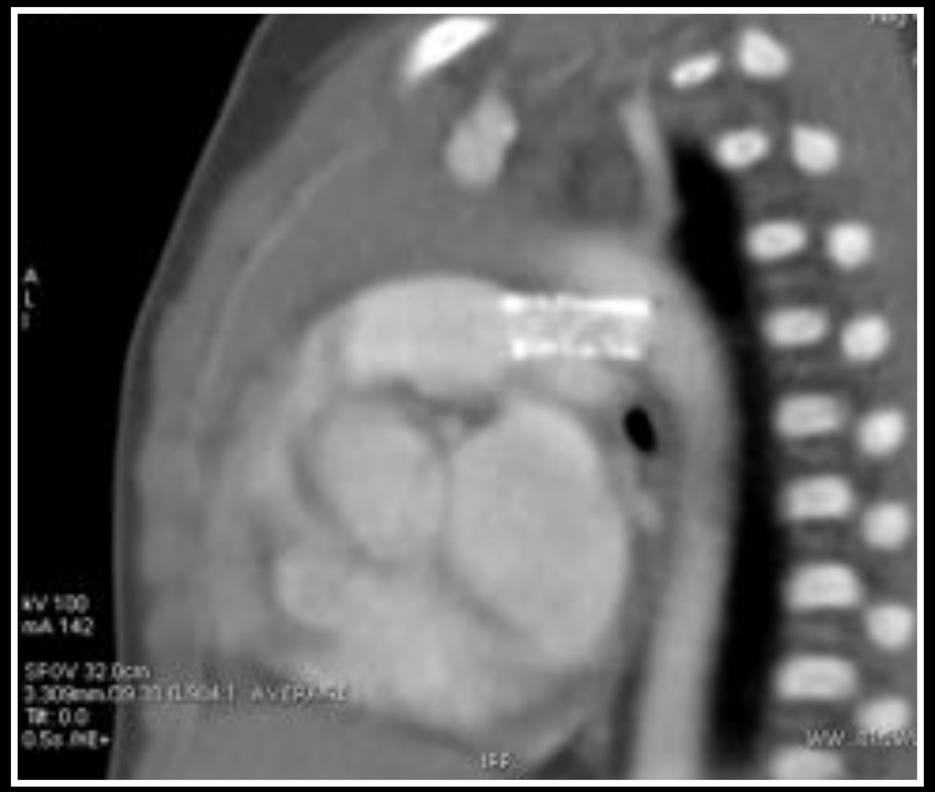
Shorter duration of palliation vs. BT shunt

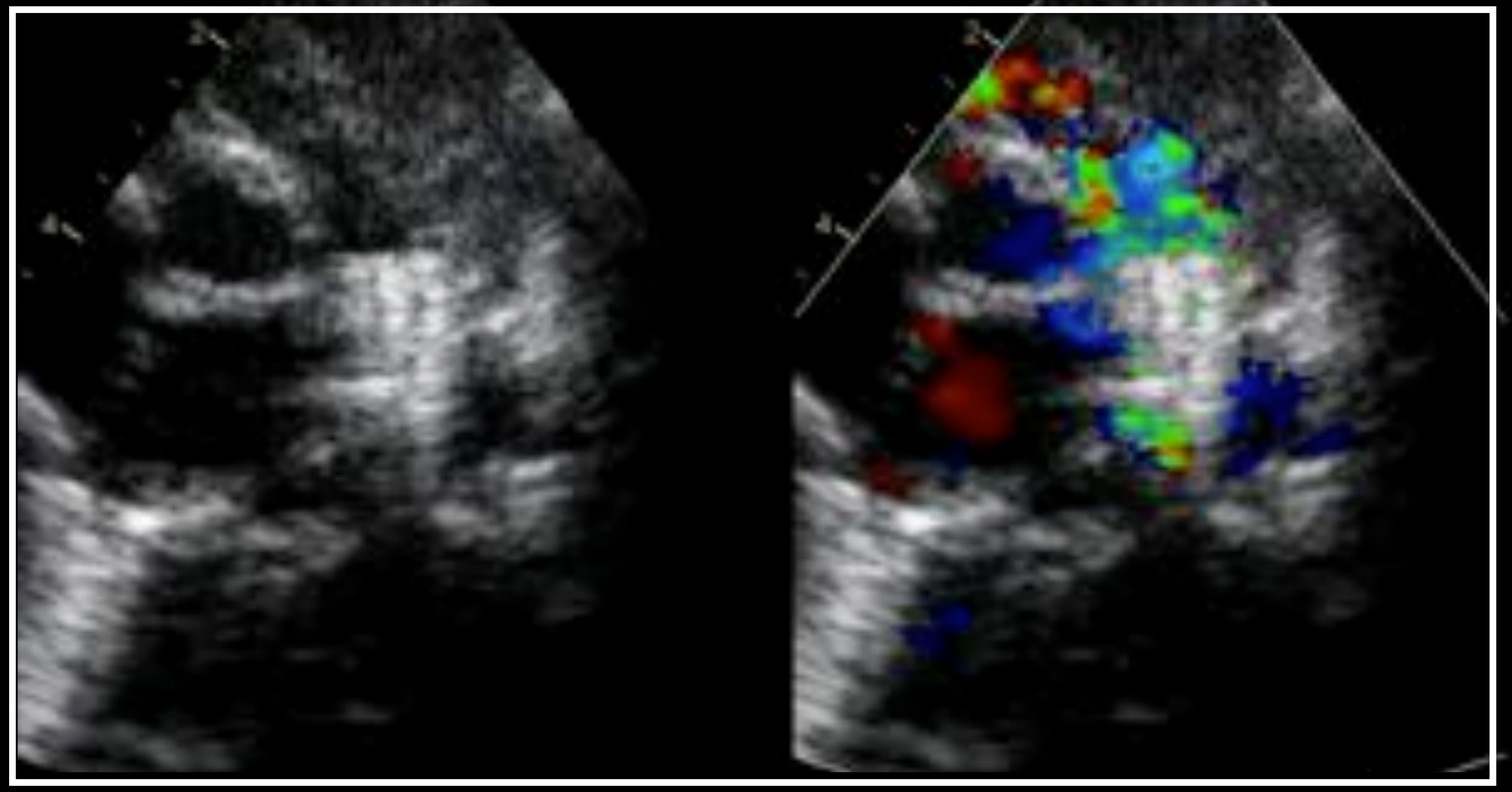
Acute stent thrombosis

Tortuous PDA with multiple bends is NOT an indication

Rehman R et al. Future Cardiol 2018




kV 100
mA 142



Initial strategy in symptomatic neonates with ToF

Non elective intervention

Surgical right ventricle to pulmonary connection

1-Patients characteristics

-small sized pulmonary arteries or LPA stenosis or disconnected PA

-with very diminutive RVOT

2-Strategy

-promote symmetrical growth of PA

-more physiological than shunt

3-Alternative techniques

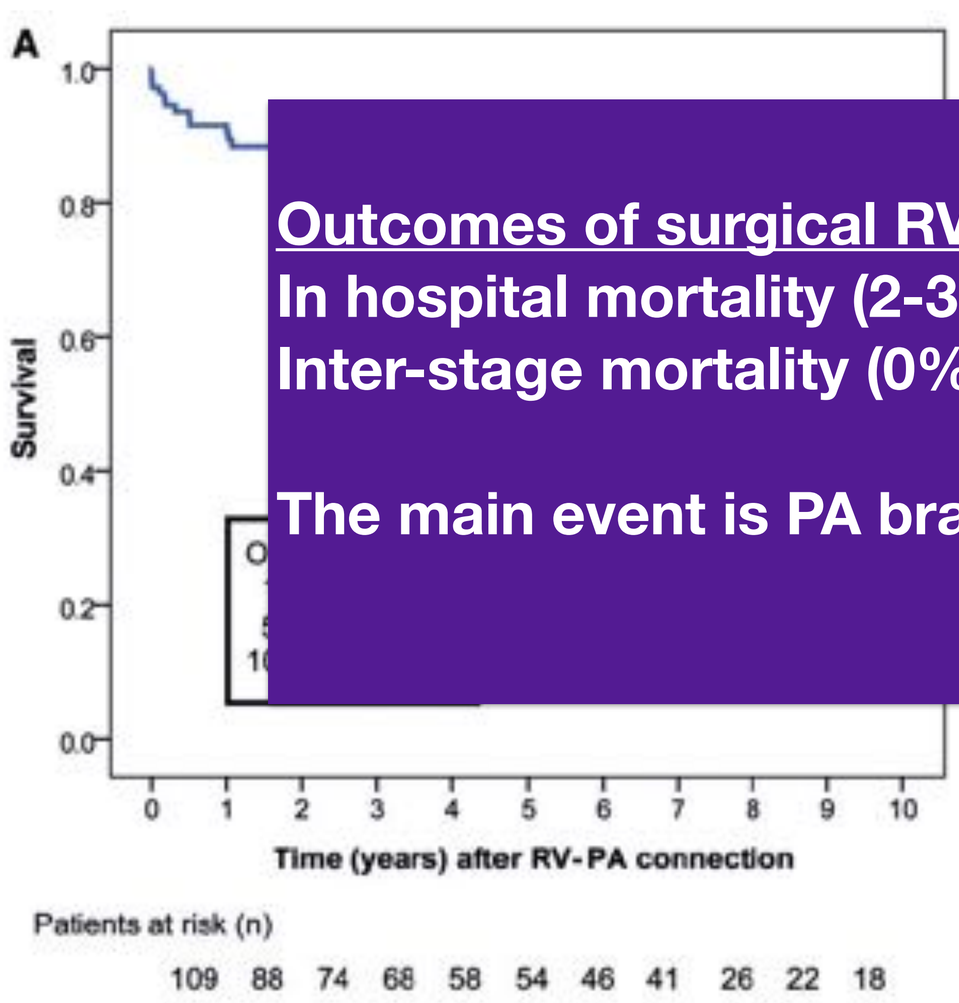
-vs. stenting of the RVOT

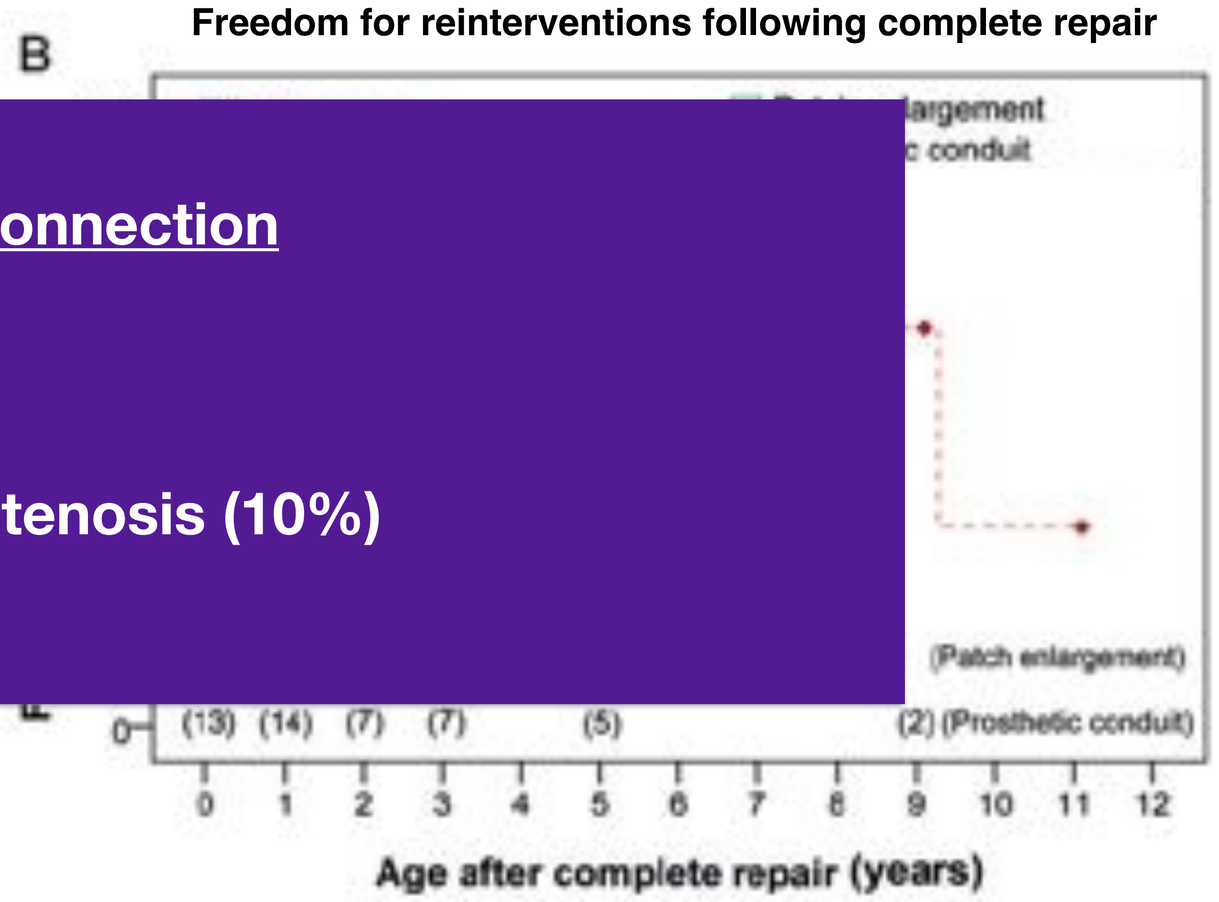
-vs. complete repair in neonatal period

Initial strategy in symptomatic neonates with ToF

Non elective intervention

Neonatal right ventricle to pulmonary connection





<u>Outcomes of surgical RV-PA connection</u>

In hospital mortality (2-3%)

Inter-stage mortality (0%)

The main event is PA branch stenosis (10%)

Gerelli et al. EJTCS 2013

Lenoir M et al. EJTCS 2017

Initial strategy in symptomatic neonates with ToF

Non elective intervention

Stenting of right ventricle outflow tract

1-Patients characteristics

-small sized pulmonary arteries

-with very diminutive RVOT

2-Strategy

-promote symmetrical growth of PA

-more physiological than shunt

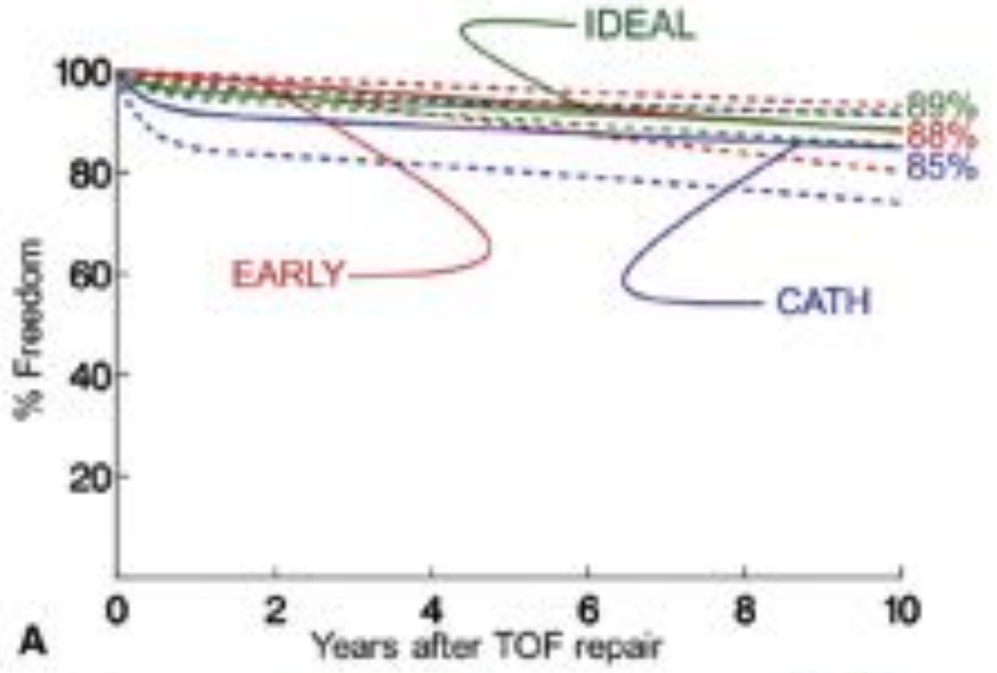
3-Alternative techniques

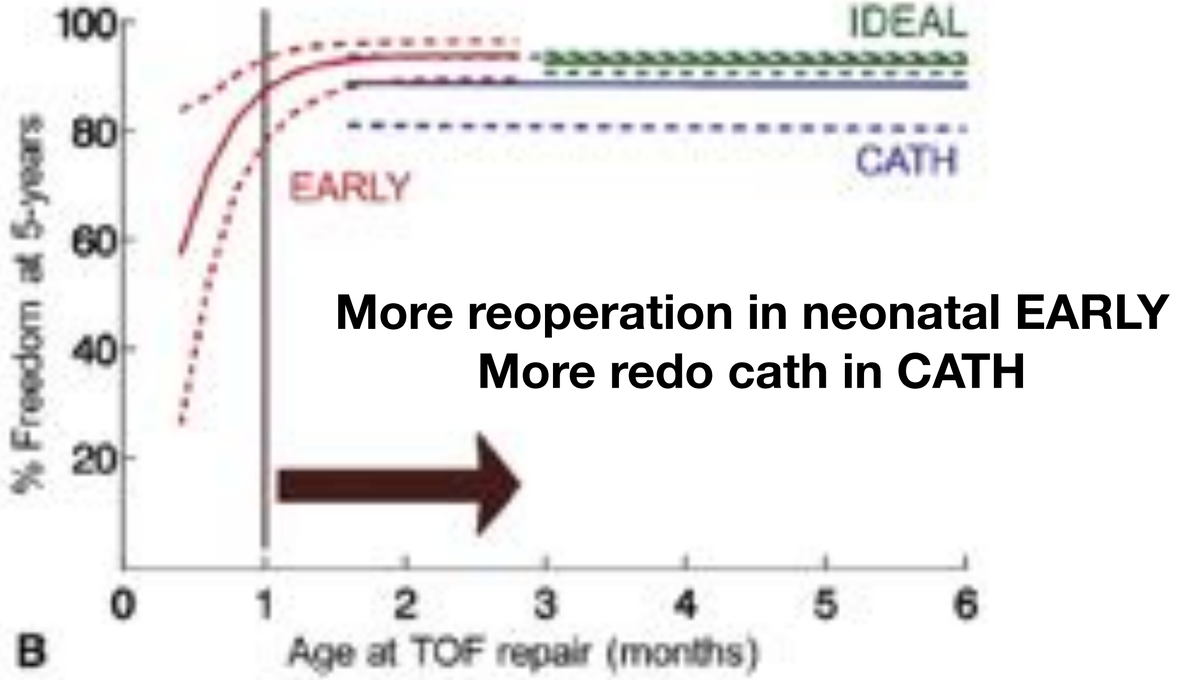
-vs. complete repair in neonatal period

Initial strategy in symptomatic neonates with ToF

Non elective intervention

Stenting of right ventricle outflow tract





More reoperation in neonatal EARLY
More redo cath in CATH

IDEAL : elective repair > 3 months

CATH: Stenting

EARLY: repair before 3 months

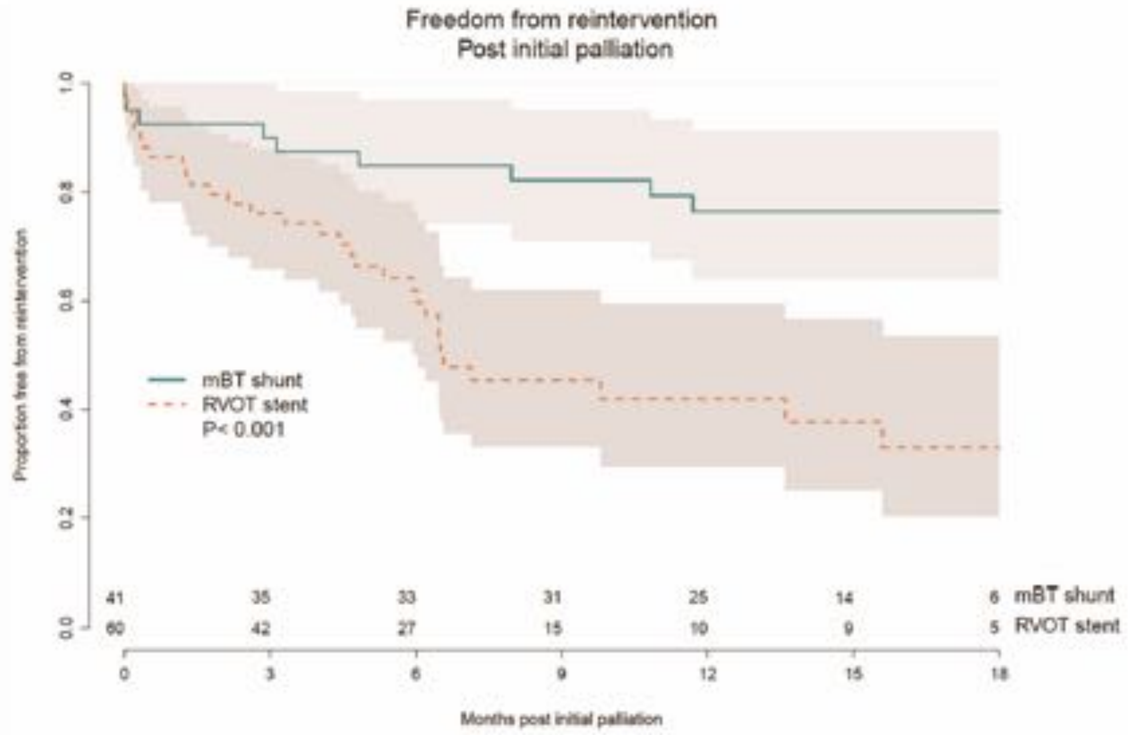
Wilder TJ et al. JTCVS 2017

Sandoval JP et al. Circ Cardiovasc Interv 2016

Initial strategy in symptomatic neonates with ToF

Non elective intervention

Stenting of right ventricle outflow tract vs. BT shunt



More reinterventions in stent
No mortality
Severe complications in 4-5%
No difference in late survival
Reduced ICU LOS
Better oxygenation?
Better growth of PA branches

Quandt D et al. J Am Coll Cardiol Intv 2017;10:1774–84)
Quandt D et al. Heart 2017;103:1985–1991

Initial strategy in symptomatic neonates with ToF

Non elective intervention

Non elective primary repair *vs.* shunt in infants < 3 months

BT patients were significantly younger (14 vs 25 days, P < .0001),
had a higher incidence of extracardiac congenital abnormalities (41% vs 33% , P .02),
had a higher rate of prematurity (17% vs 12% , P .04),
and more frequently received PGE1

No difference in mortality between the two techniques

Irrespective of the surgical approach, younger patients (OR 1.03, P . 007), patients with noncardiac congenital anomalies (OR 2.48, P .016), and those with prematurity (OR3.28, P .007) had a higher risk of mortality.

Ramakrishnan KV et al. World Journal for Pediatric and Congenital Heart Surgery 2018, Vol. 9(5) 539-545

Initial strategy in Asymptomatic neonates with ToF

Elective neonatal repair

Metanalysis

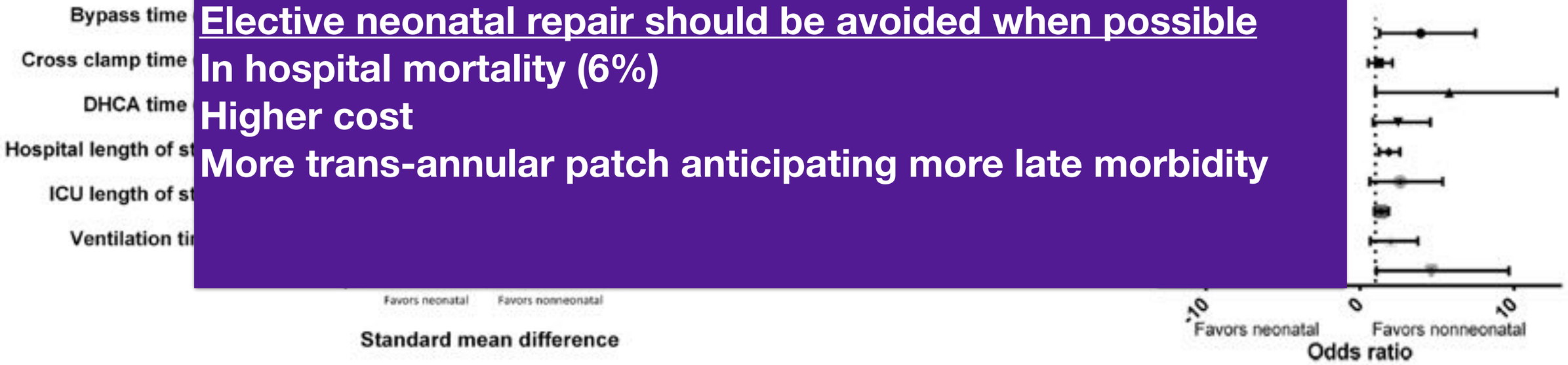
3858 patients in 8 studies with 724 (19%) having undergone neonatal repair (6-20 days) and 3134 (81%) having undergone non-neonatal repair (60-220 days)

Elective neonatal repair should be avoided when possible

In hospital mortality (6%)

Higher cost

More trans-annular patch anticipating more late morbidity



Loomba RS et al. Pediatr Cardiol 2017;38:893–901

Strategy in Asymptomatic infants > 3 months with ToF

Elective repair

Elective repair 6 kgs/3 months

1-Patients characteristics

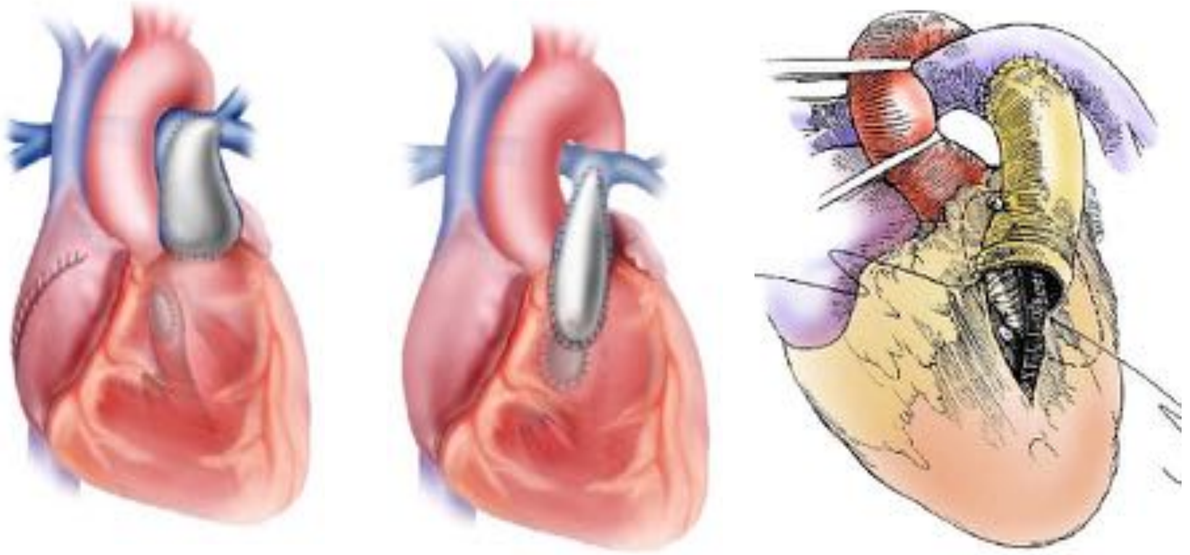
-acceptable sized pulmonary arteries
-pulmonary valve ?
-coronary artery epicardial course ?
-multiple VSD ?

2-Strategy

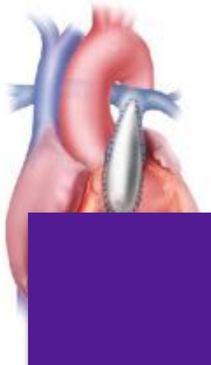
-limit late complications

3-Alternative techniques

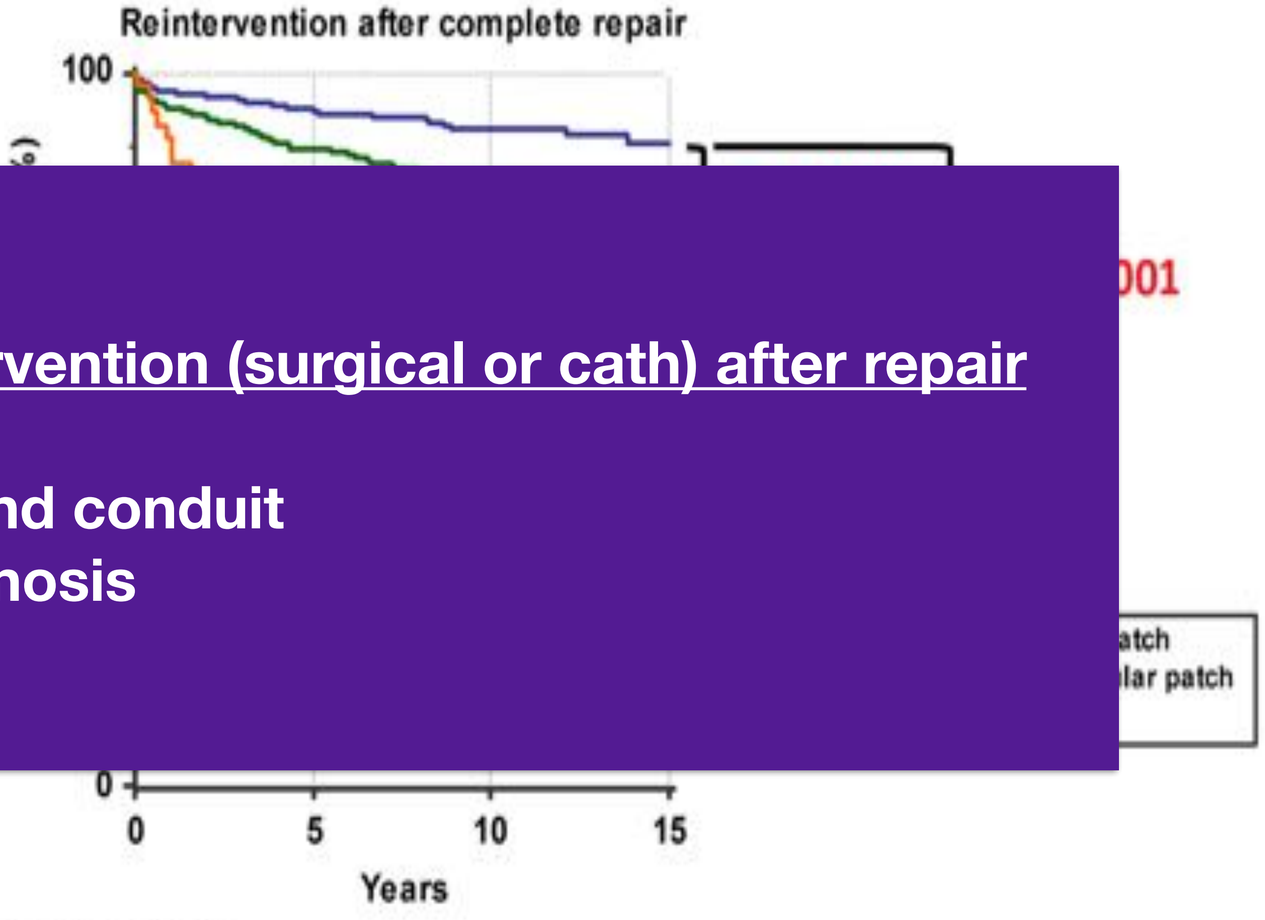
-None



Outcomes ToF
Parisian experience (07-17): 923 ToF (PA-VSD excluded)



46%



Risk factors for reintervention (surgical or cath) after repair

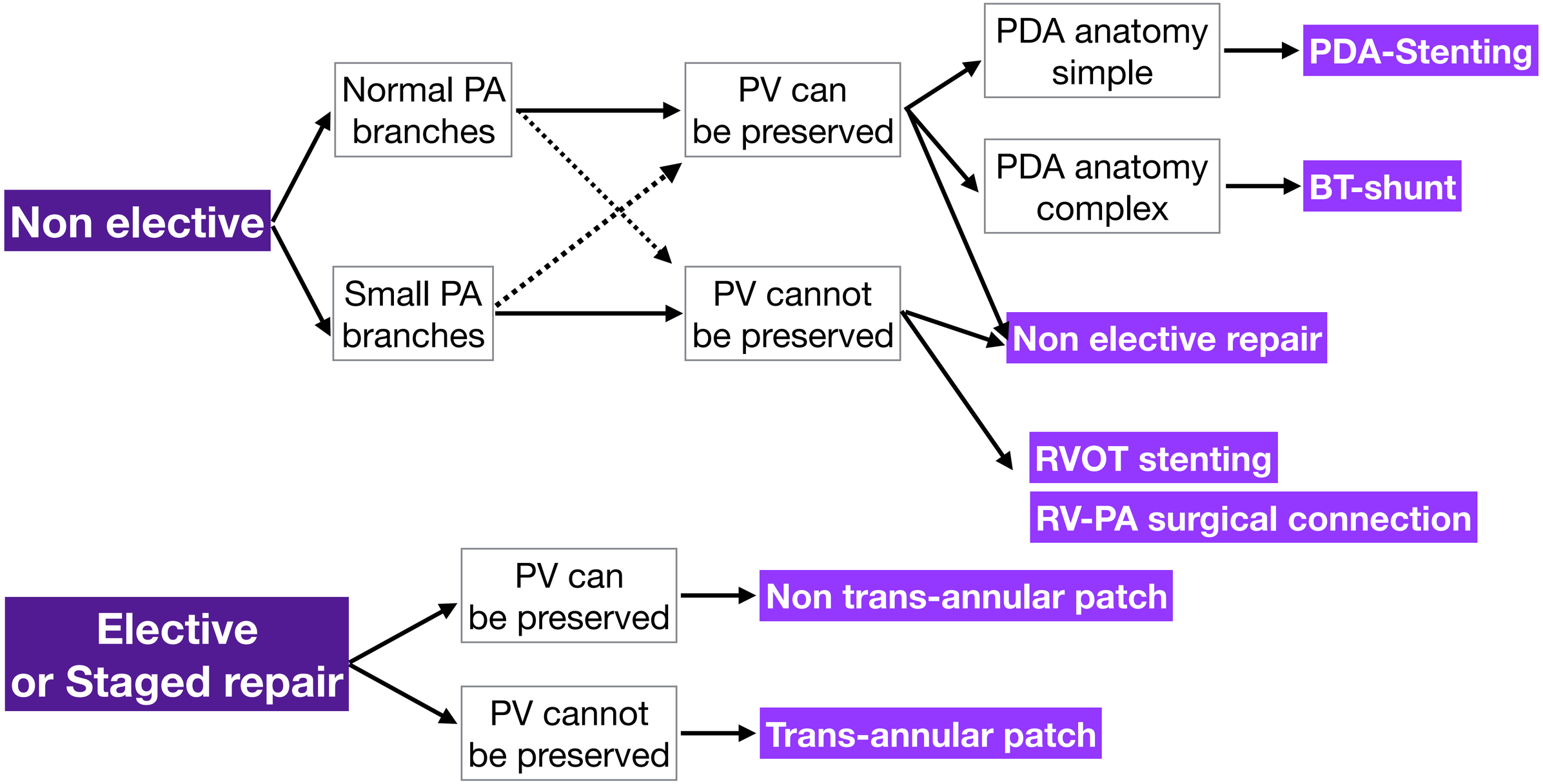
Initial staged strategy

Trans-annular patch and conduit

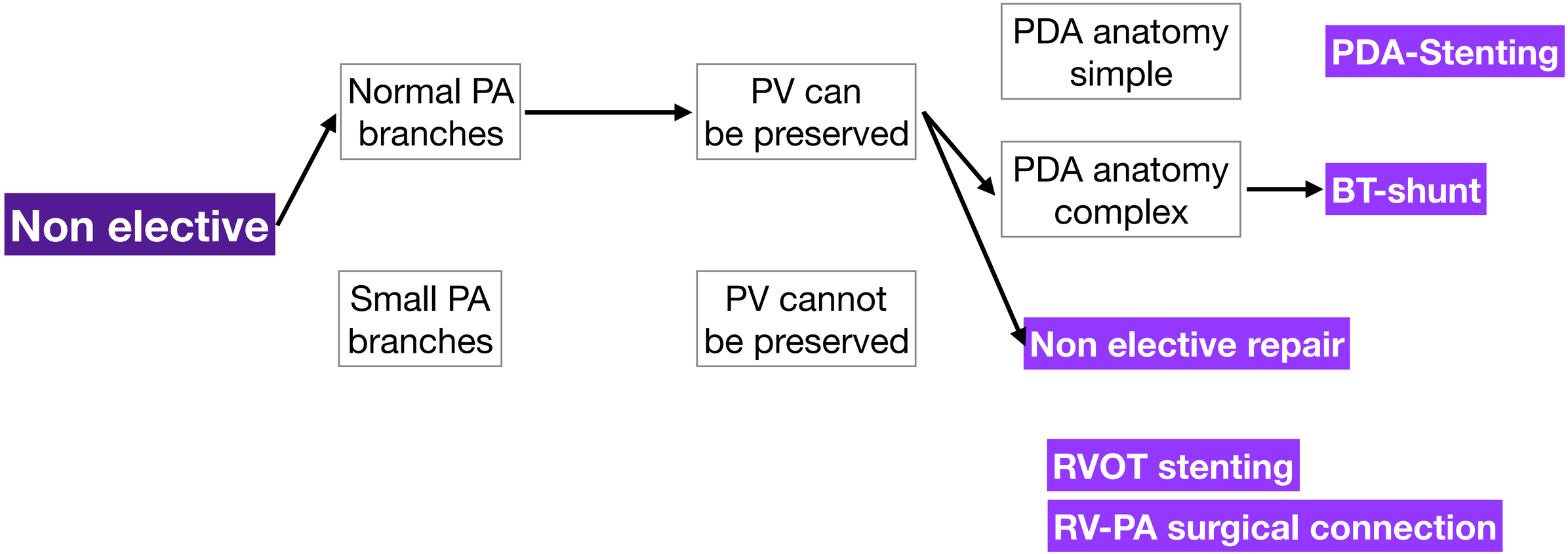
Pulmonary branch stenosis

Mostefa-Kara M et al. in preparation

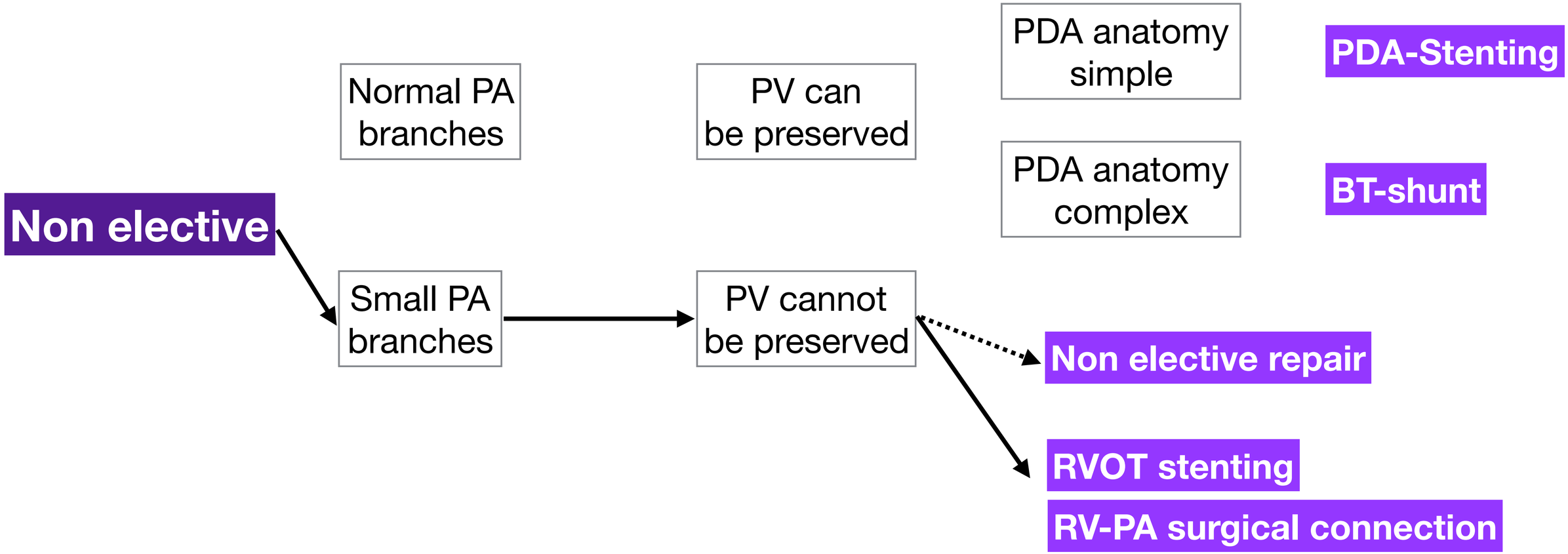
Can we have an algorithm in simple ToF ?



Can we have an algorithm in simple ToF ?



Can we have an algorithm in simple ToF ?

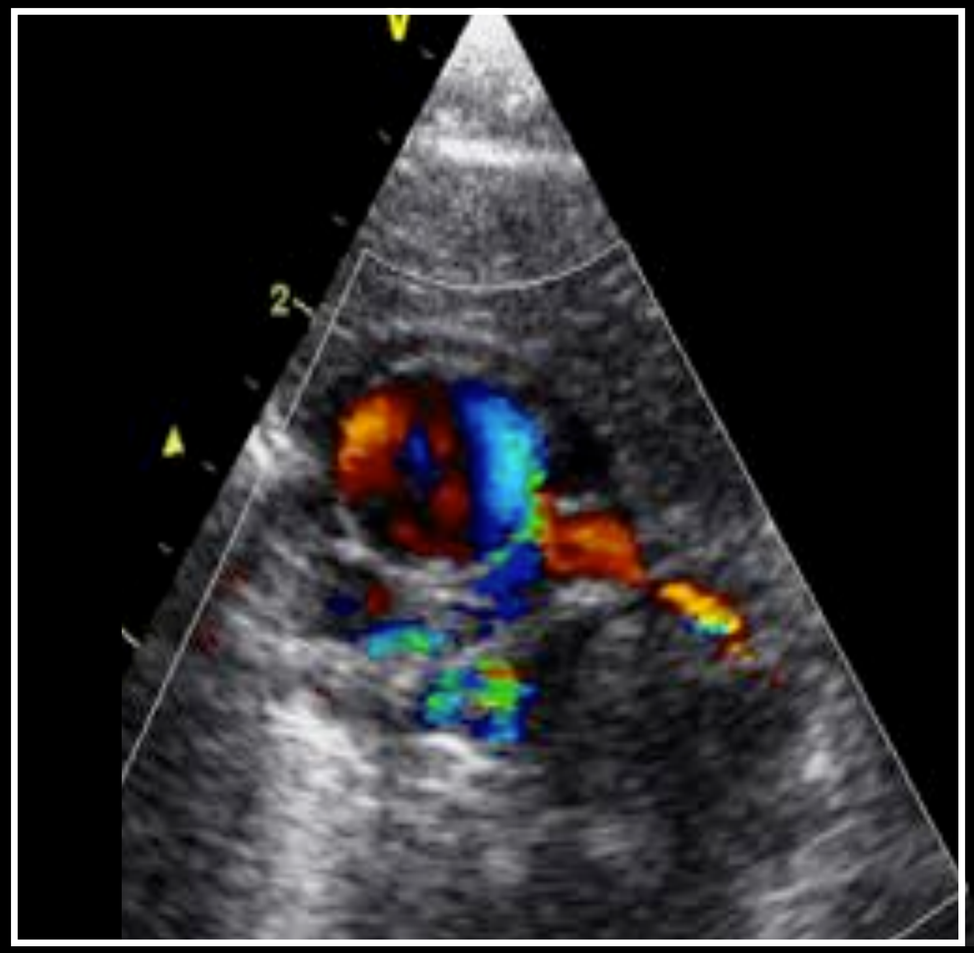


Tetralogy of Fallot with pulmonary atresia

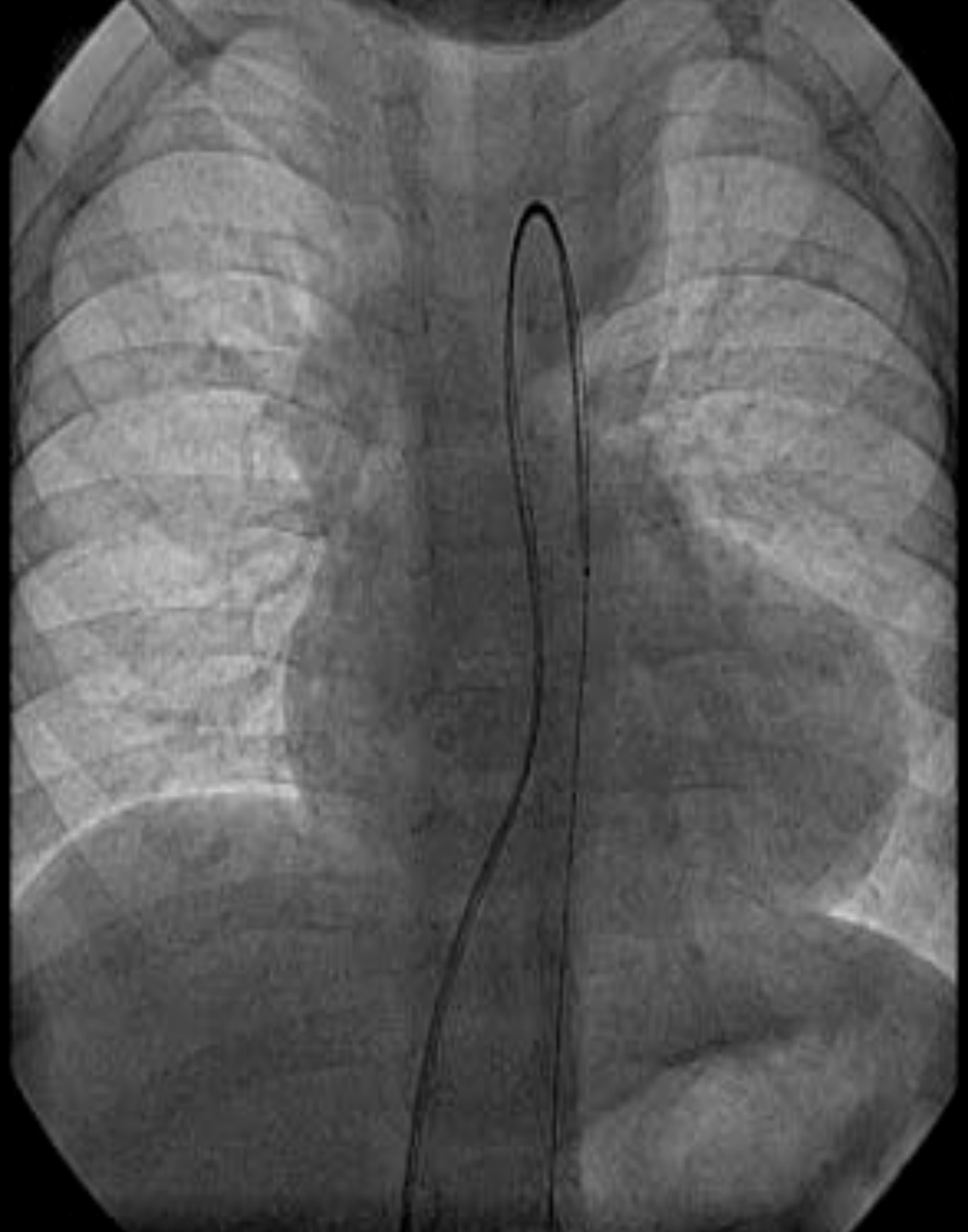
or

Pulmonary atresia with VSD

MAPCAs in ToF-PA



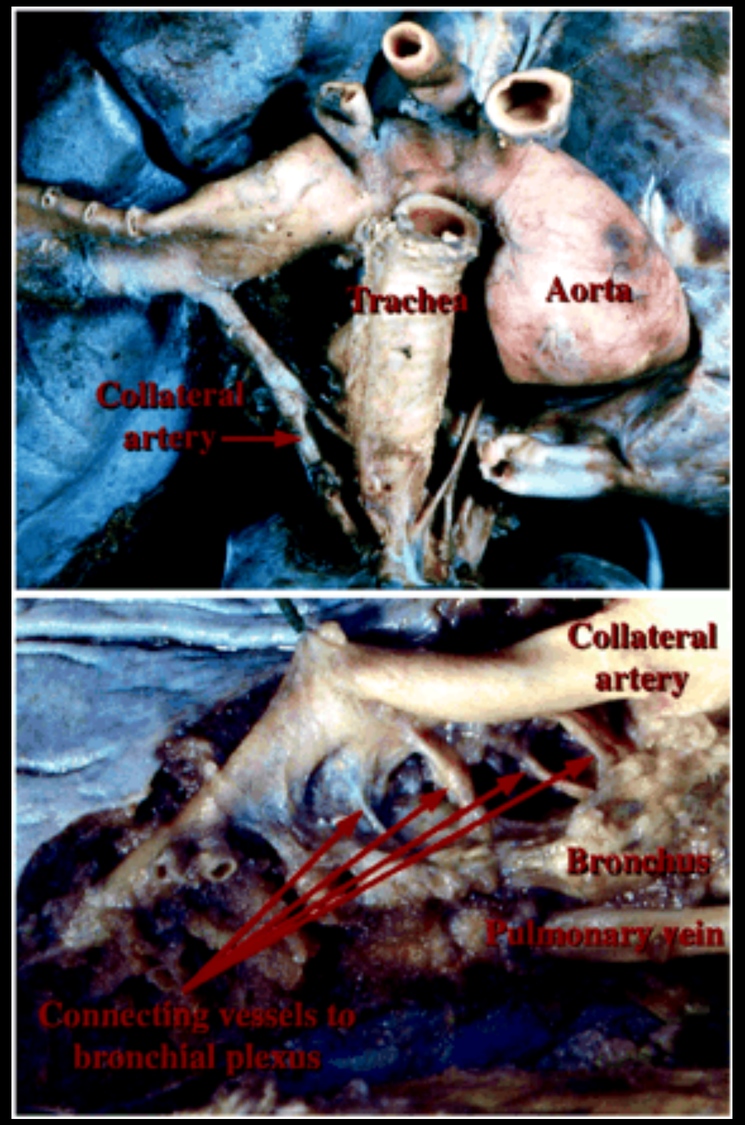
MAPCAs in ToF-PA



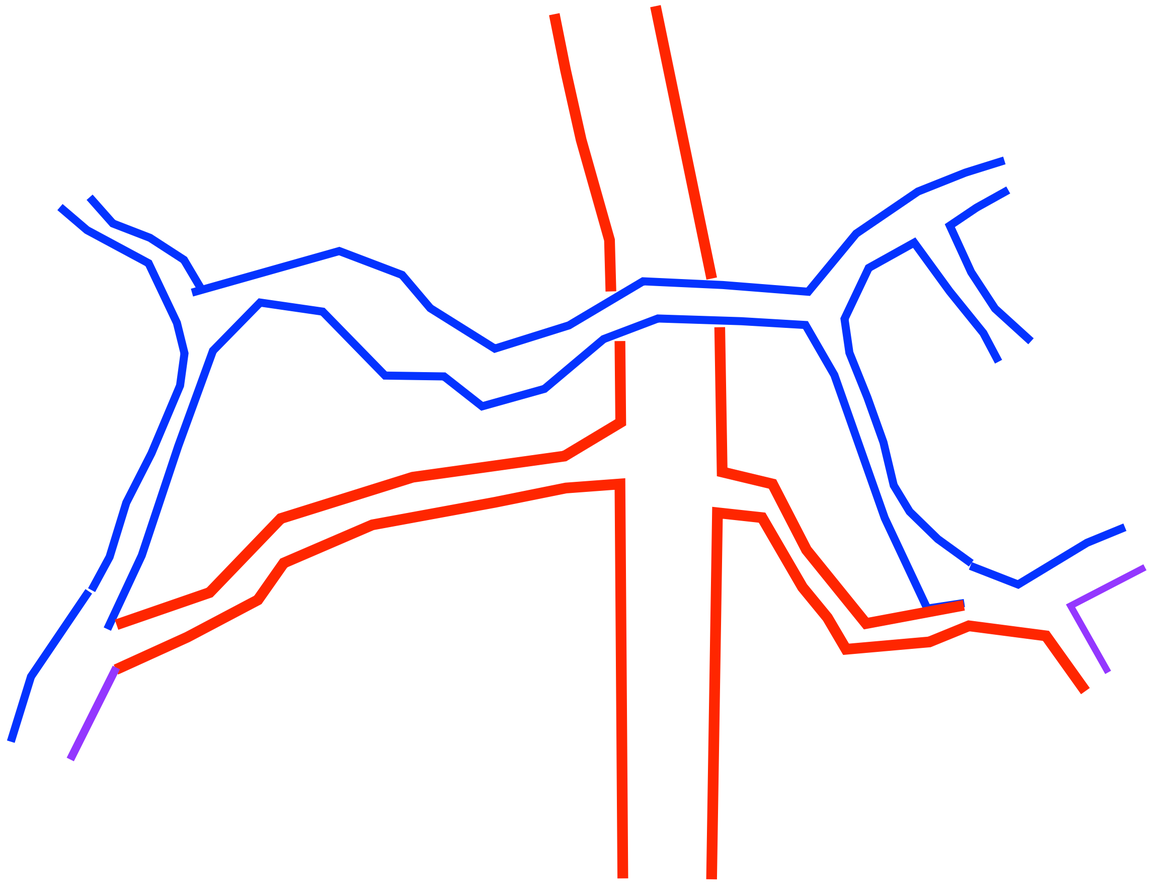
Left main coronary to pulmonary artery fistula in ToF-PA

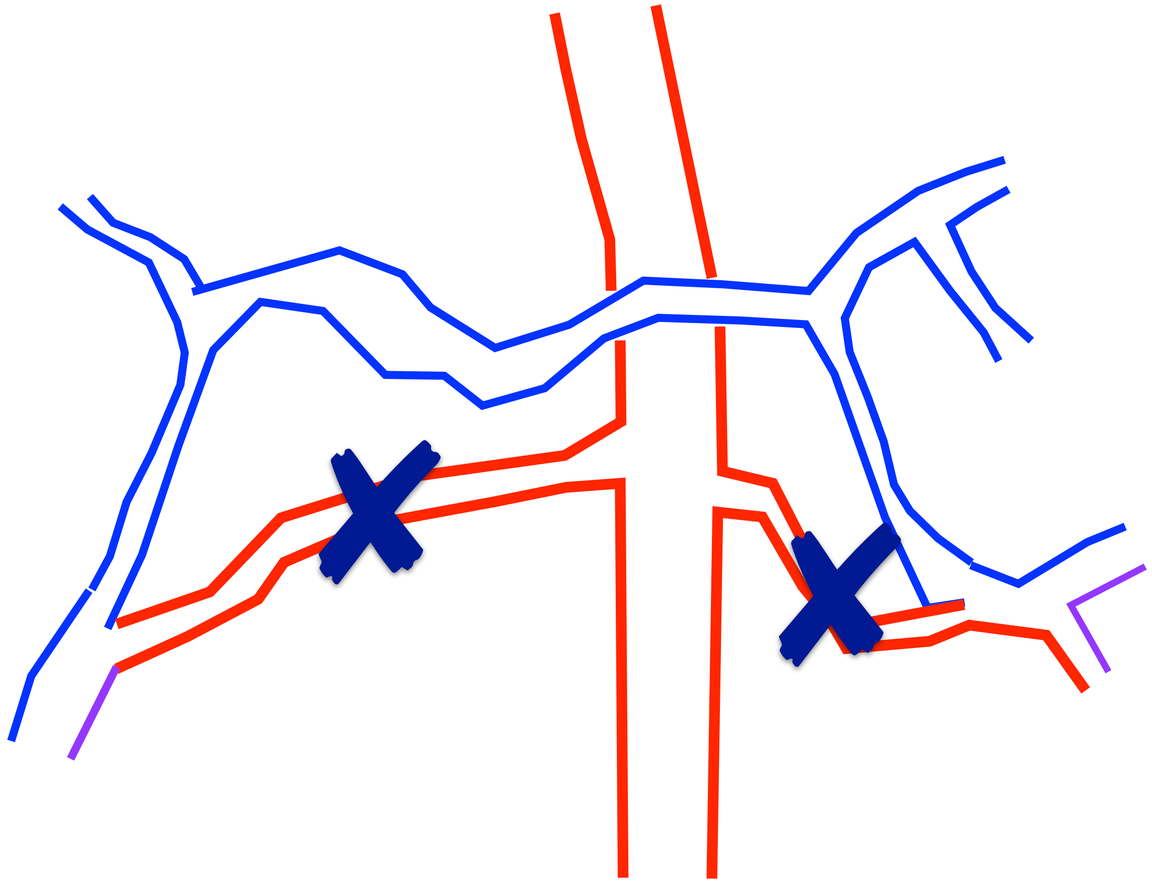
MAPCAs in ToF-PA

Vicinity with bronchi

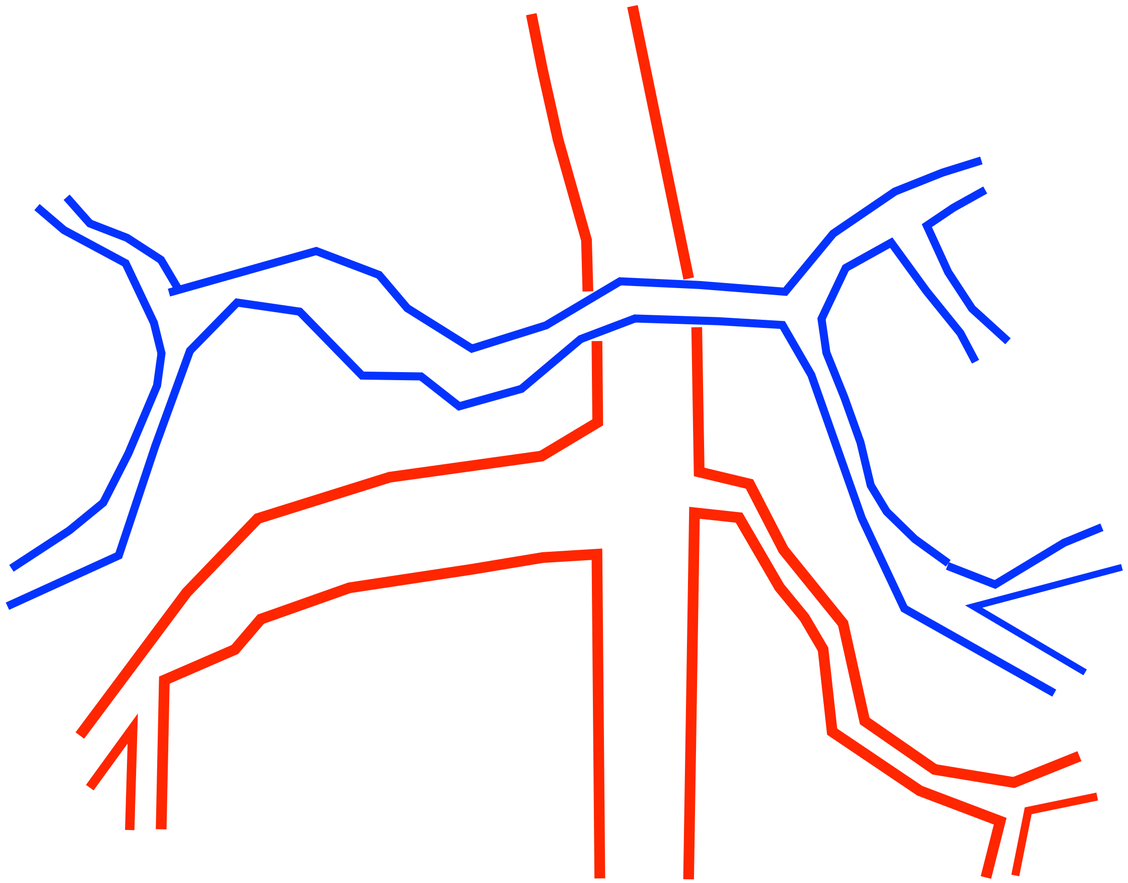


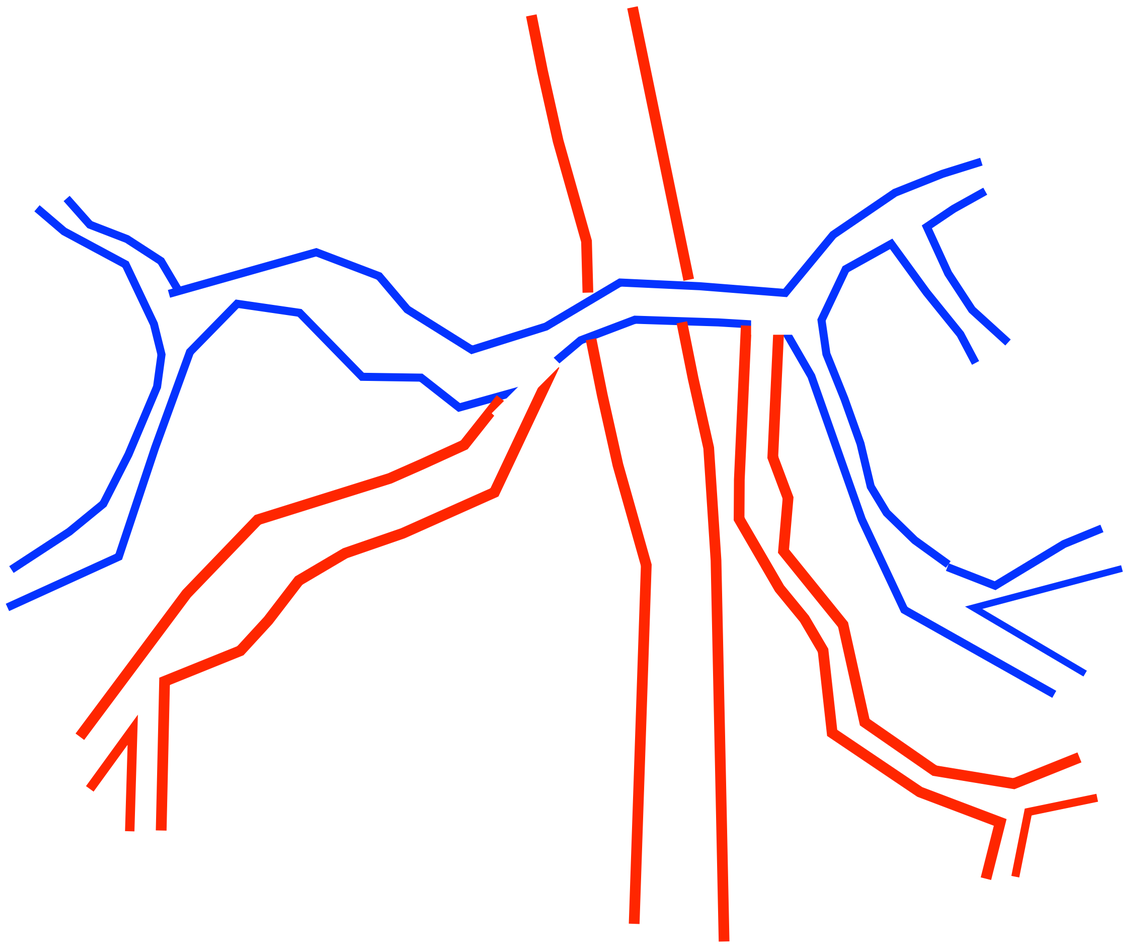
MAPCAs with or without communication with the pulmonary arteries



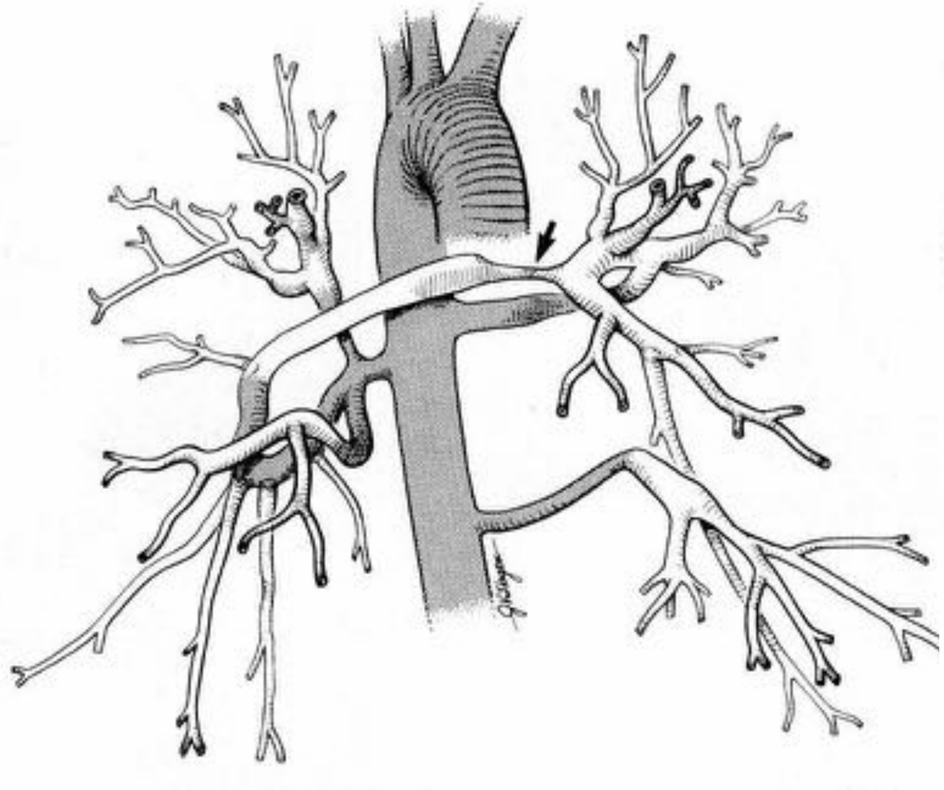


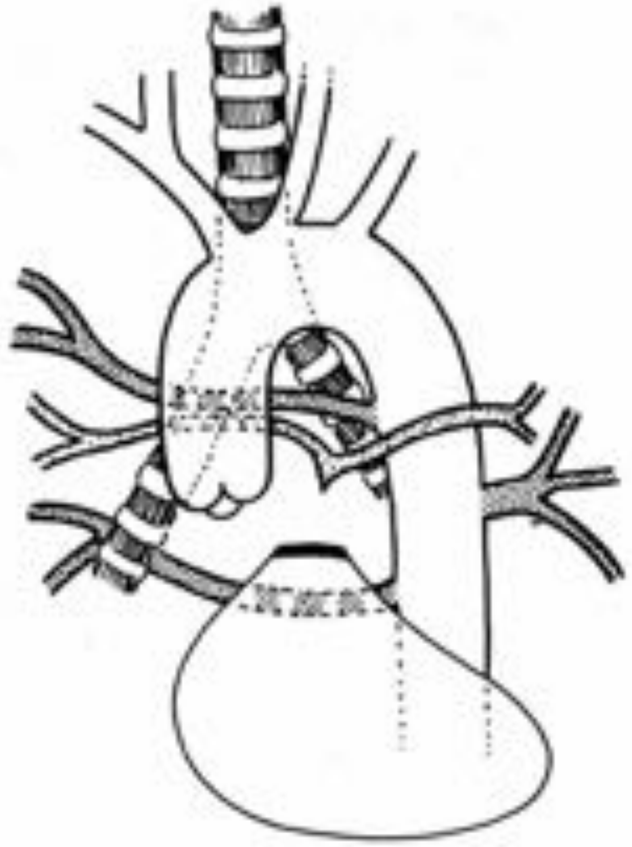
MAPCAs with or without communication with the pulmonary arteries



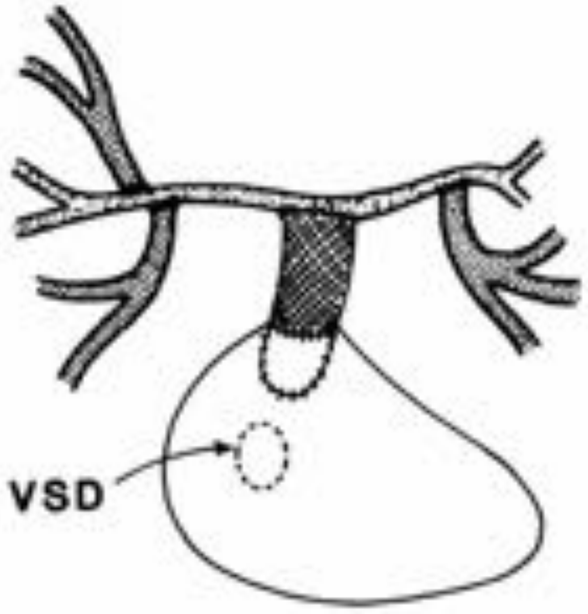


Unifocalisation





TOF/PA, MAPC
(PAi 50 mm^2/M^2)

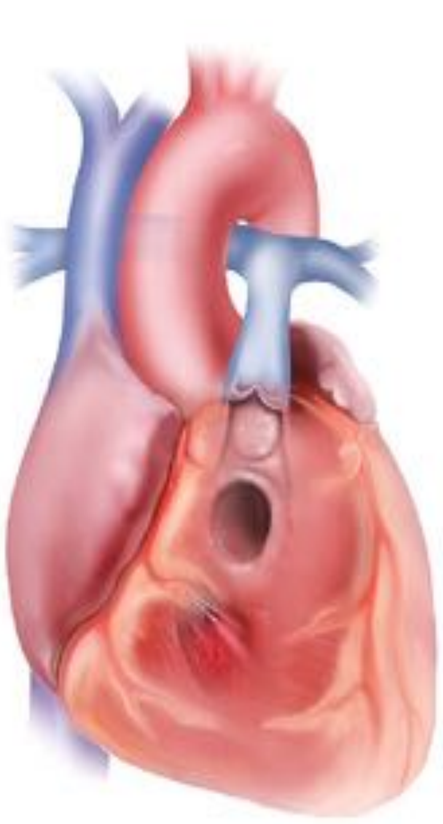


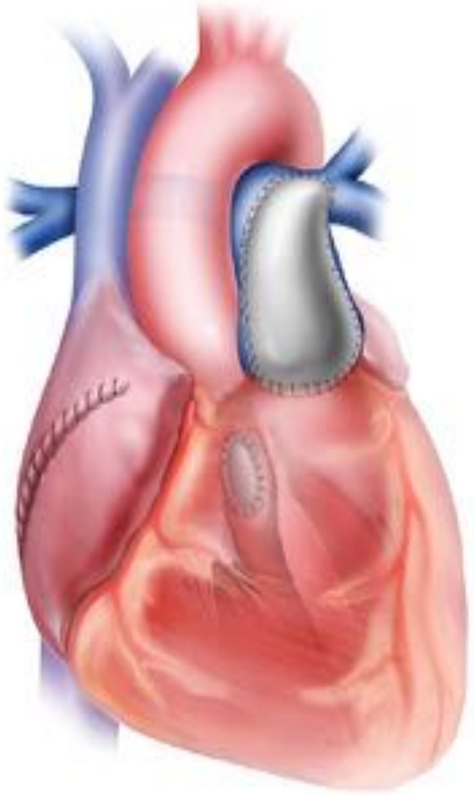
RV–PA homograft
and bilateral
unifocalization

Stategy for repair
What are the main issues ?

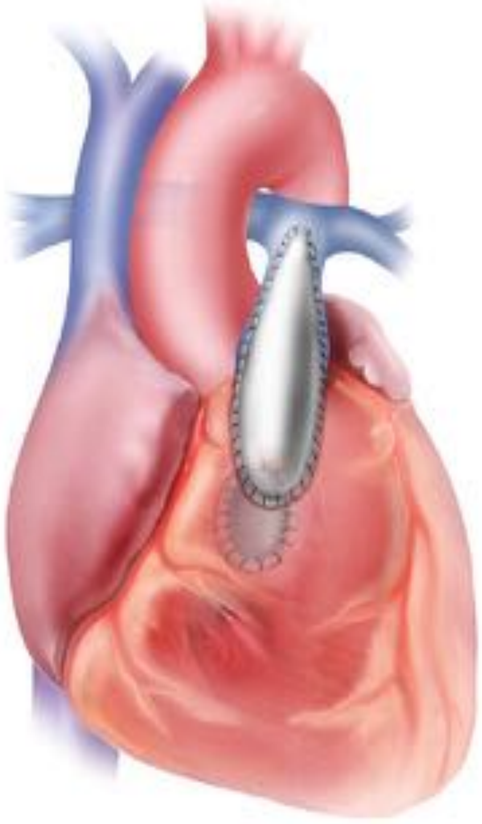
- Neonatal repair should not be performed
  - closure of VSD is difficult
  - pulmonary arteries size and PVR do not allow repair without conduit
- Repair with closure of the VSD in children > 6 kgs
  - If closure of VSD is possible : multiple VSD
  - Without conduit : coronary artery anatomy
  - Without valve : size/stenosis of pulmonary artery branches

Surgical repair of tetralogy of Fallot

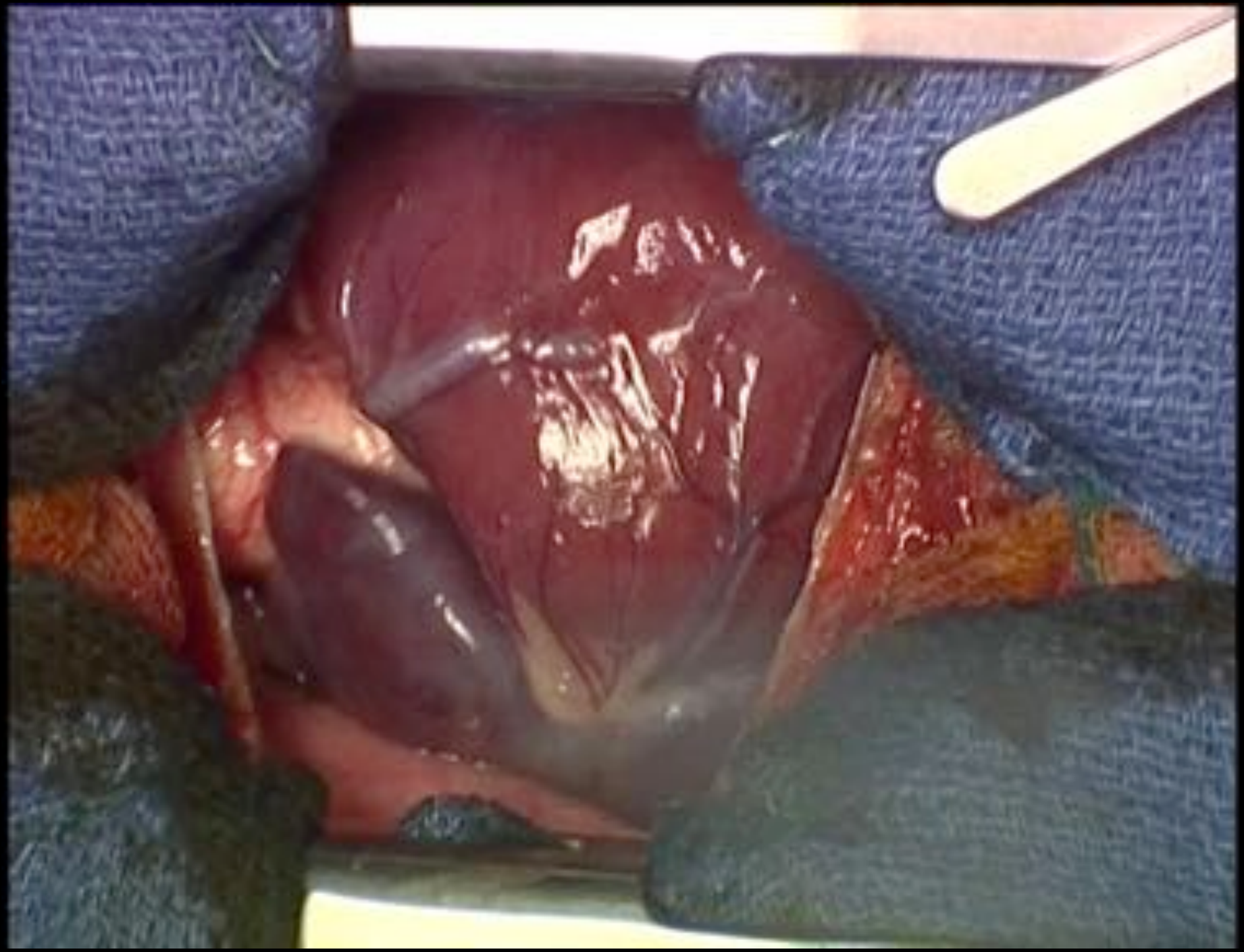




Atrial route



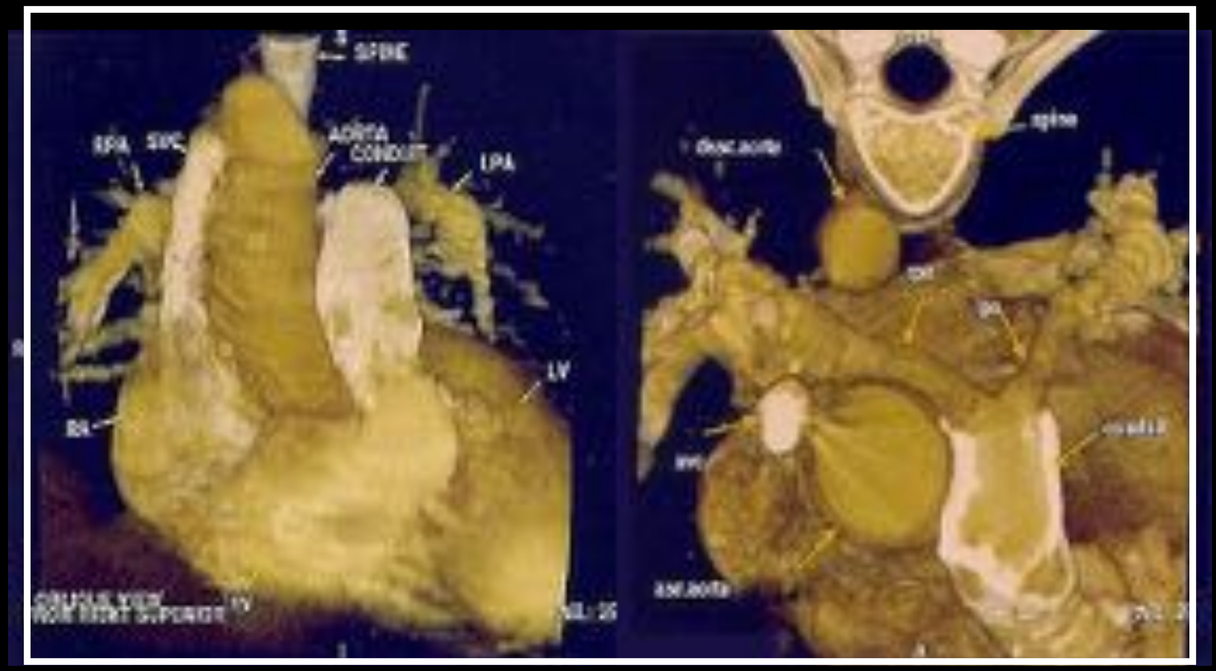
Trans-annular patch

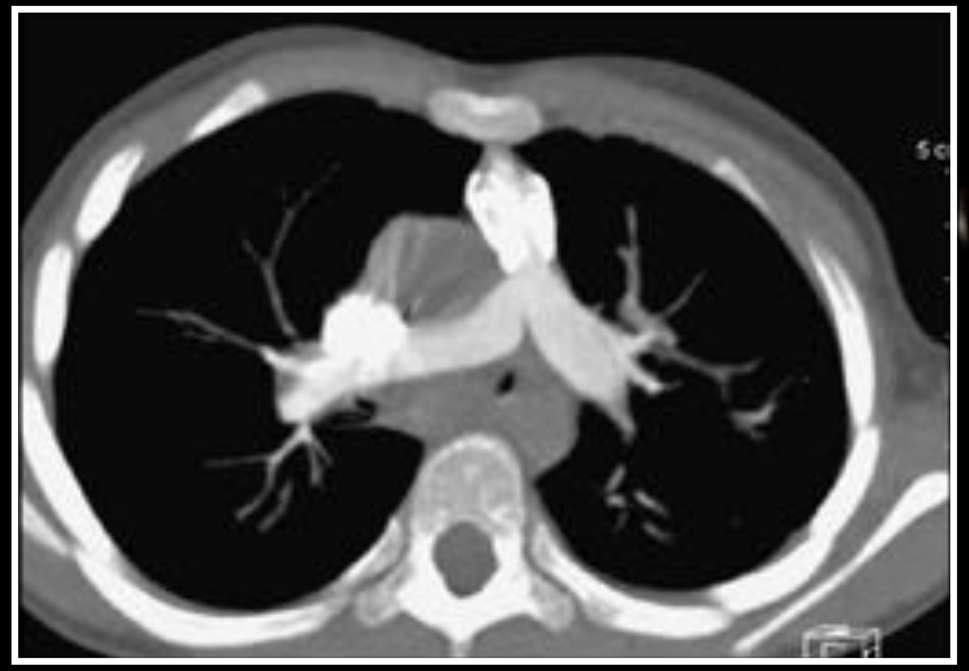


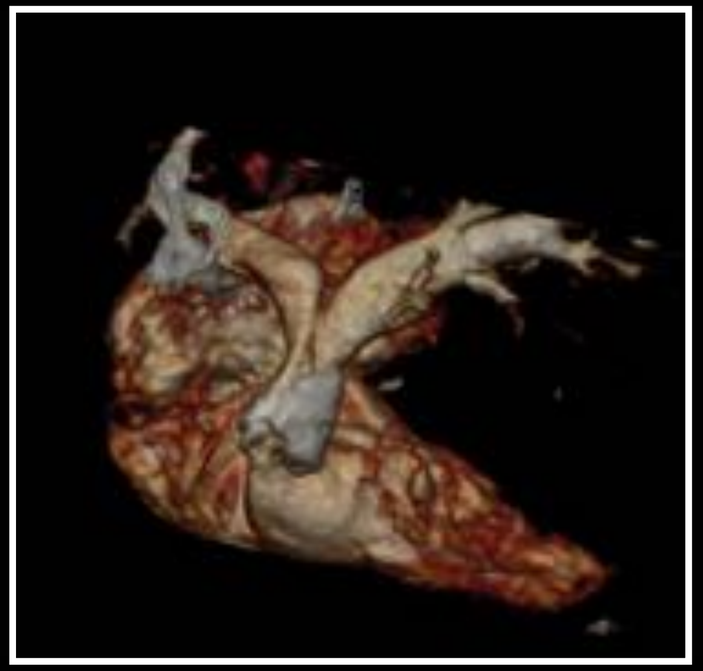
Fallot after repair with preserved annulus

Late outcome
What are the issues ?

- Right outflow tract obstructions
- Pulmonary branches stenoses
- Chronic pulmonary regurgitation
- Ventricular tachycardia, other arrhythmias and sudden death

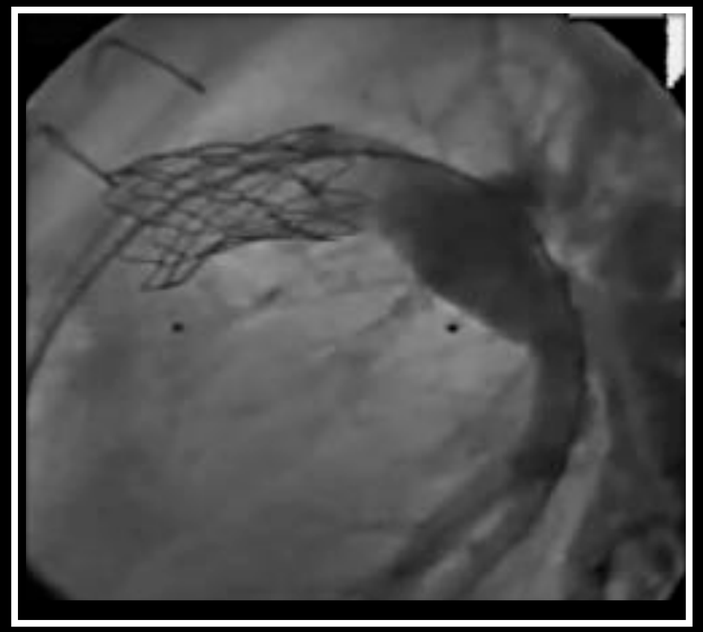


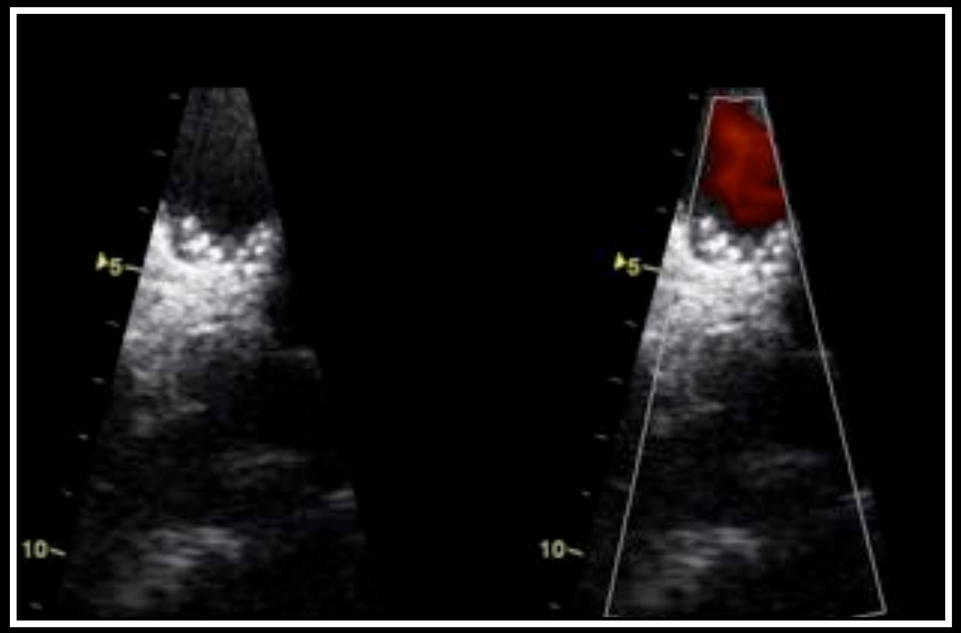




Calcification of RVOT
Dysfunctioning RVOT

Stenting of the RVOT

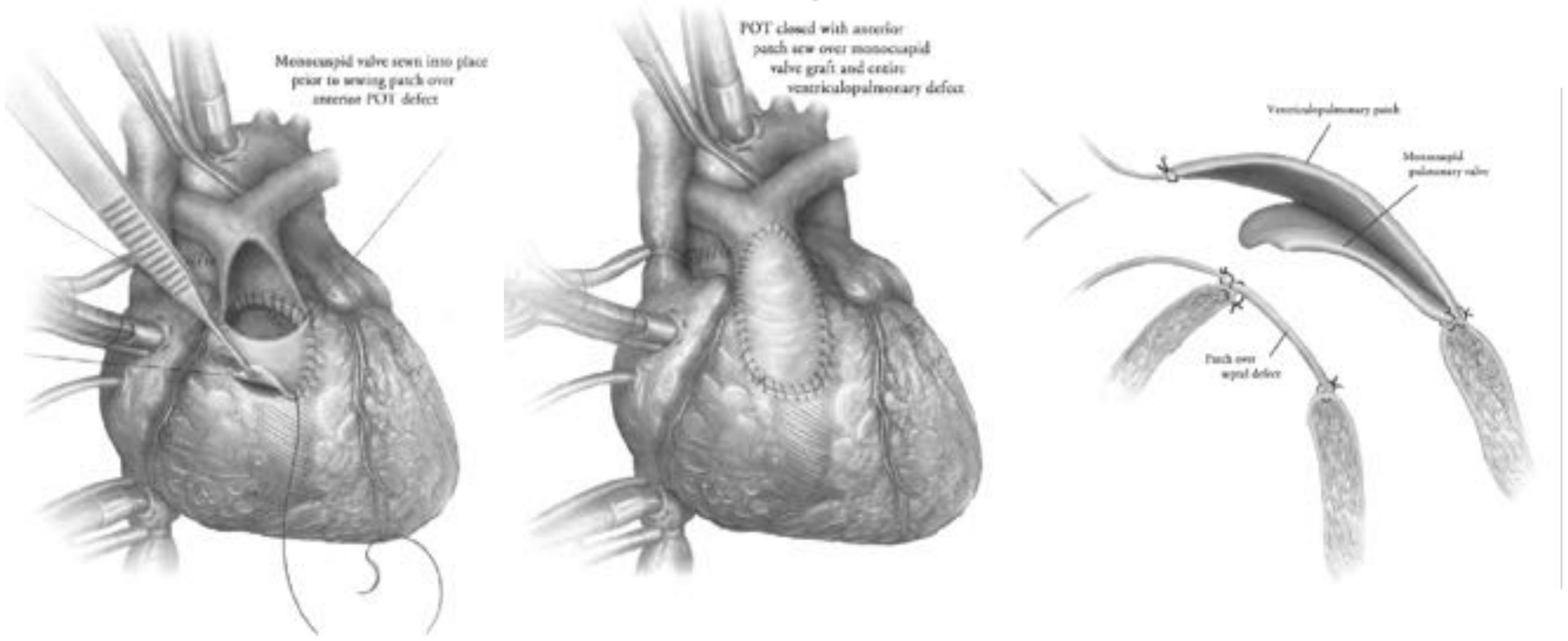




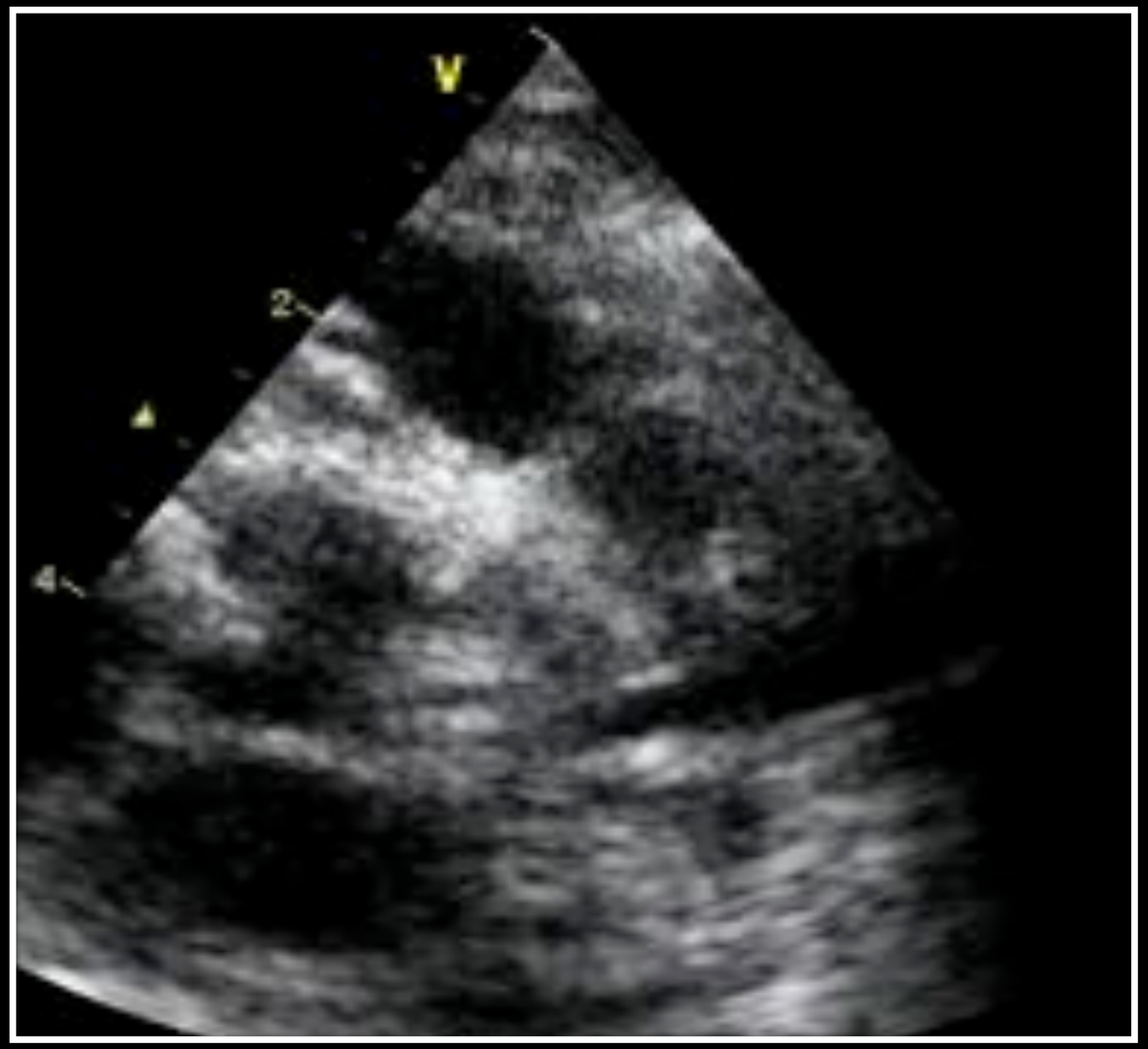
Stenting of pulmonary artery bifurcation

RVOT conduits

Monocusp in tetralogy of Fallot

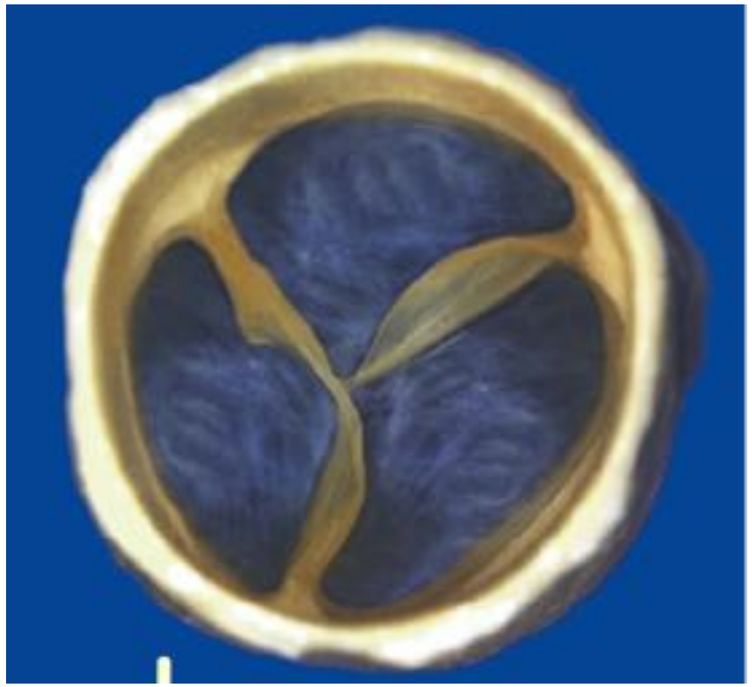


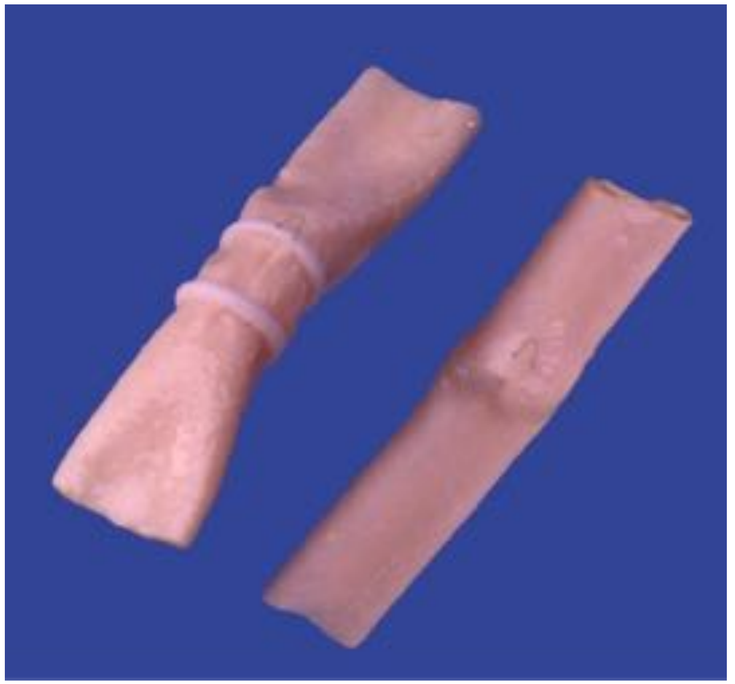
Monocusp in ToF



Pulmonary homograft

Contegra - Venpro conduit



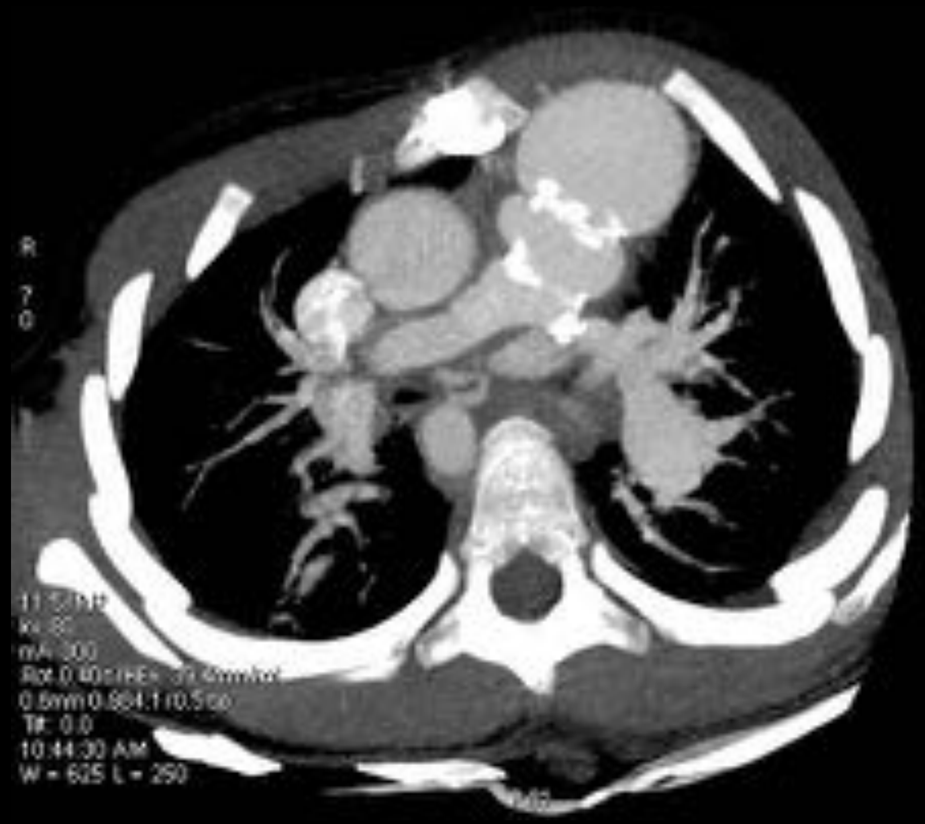


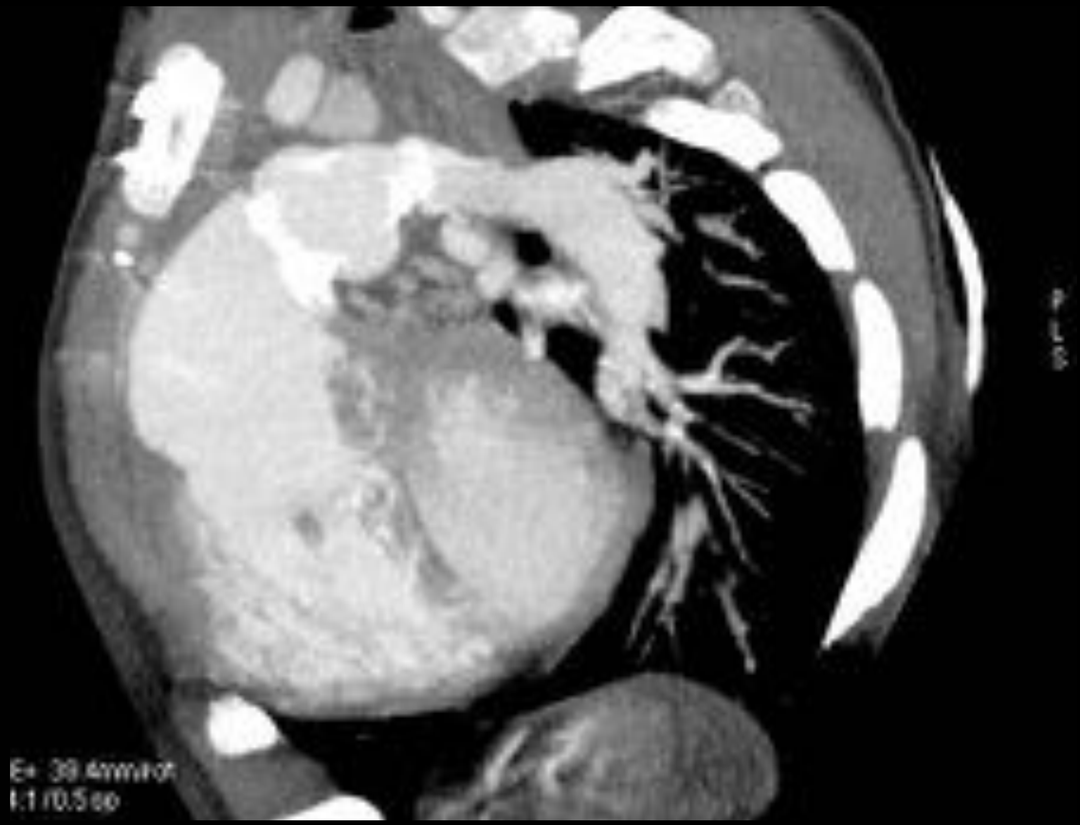
Labcor

VenPro

Calcified RV-PA conduit

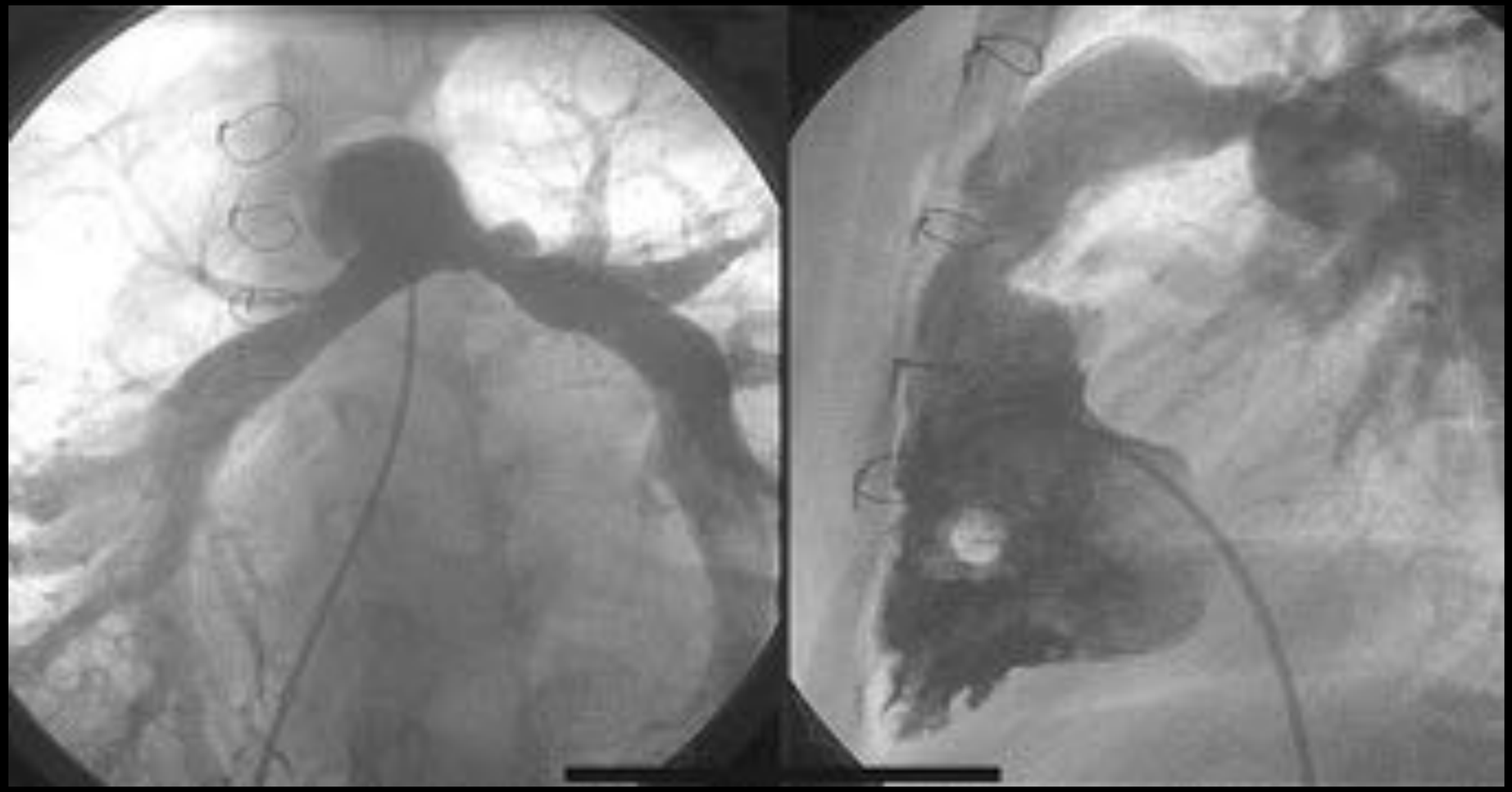
Calcified RV-PA conduit





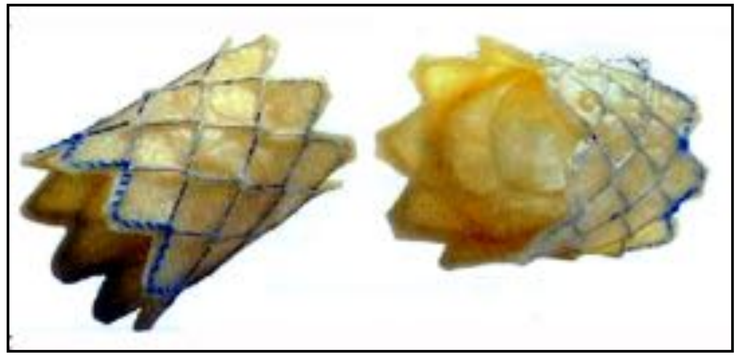
Calcified RV-PA conduit

Calcified RV-PA conduit

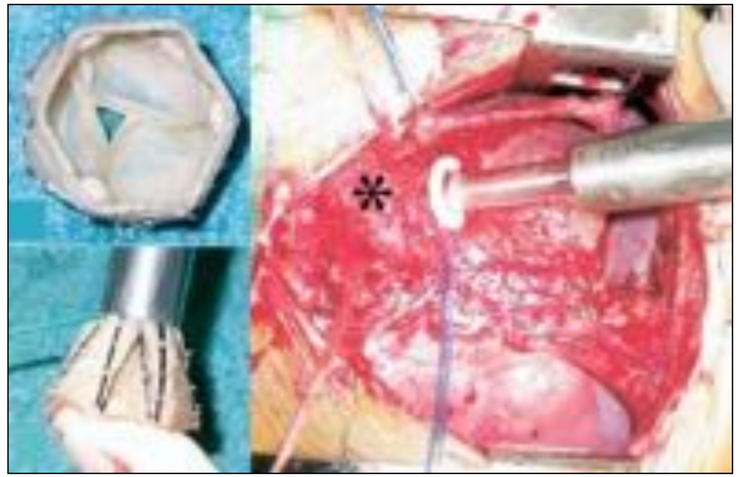


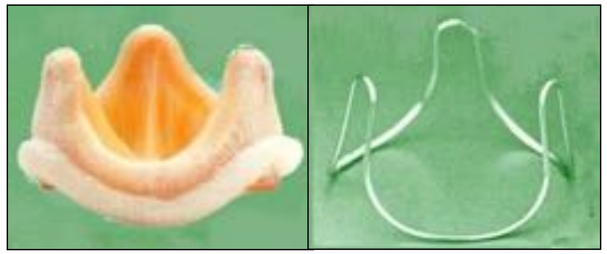
Percutaneous pulmonary valves

«Melody»

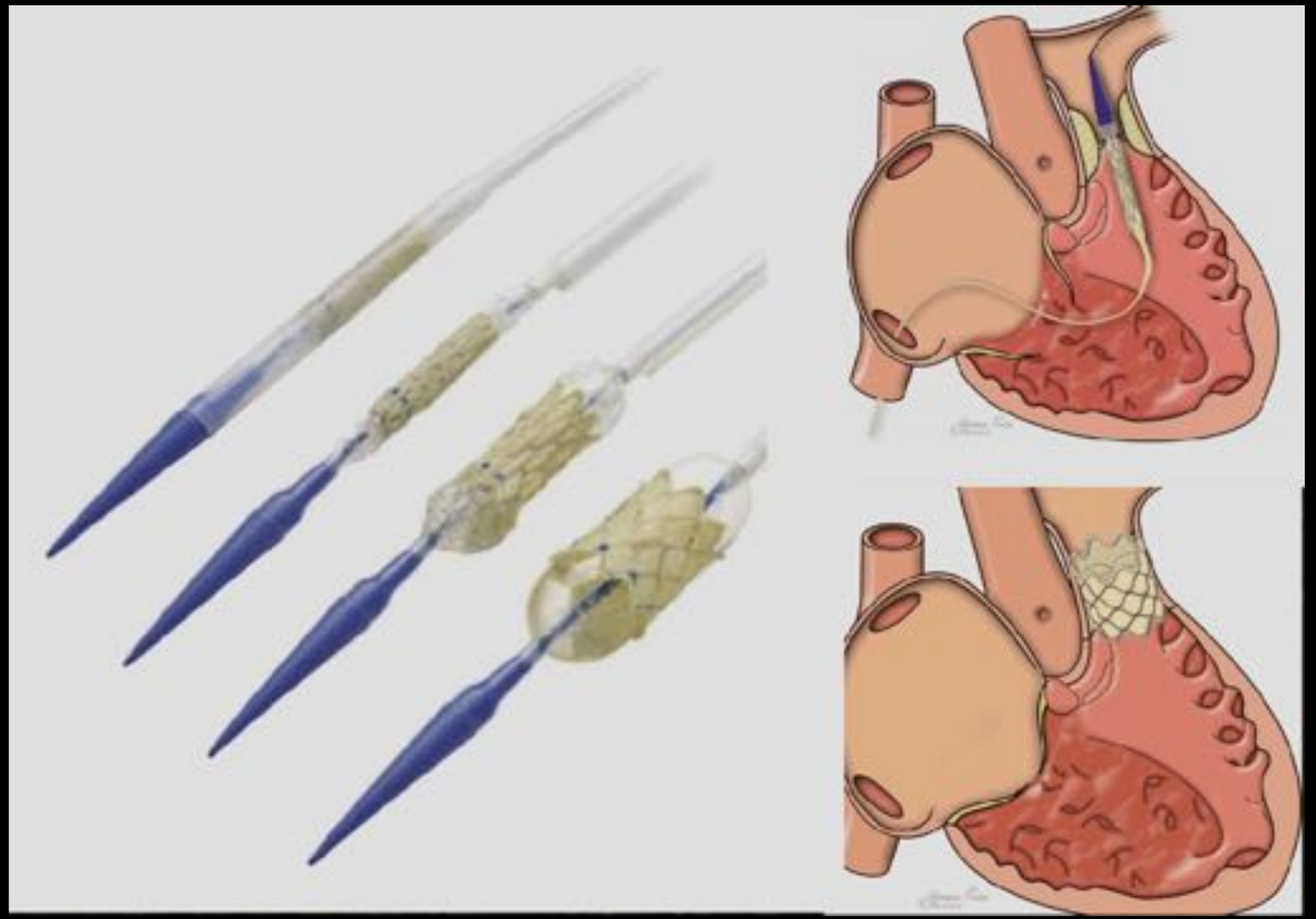


«Shelhigh»

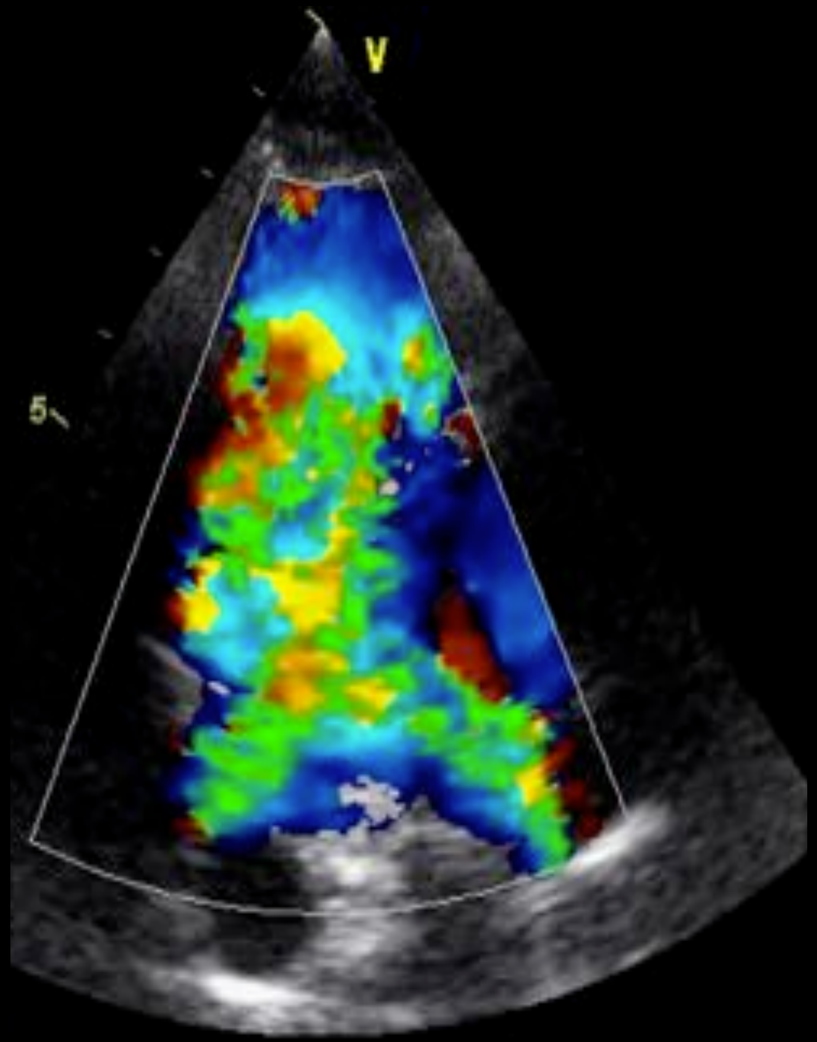


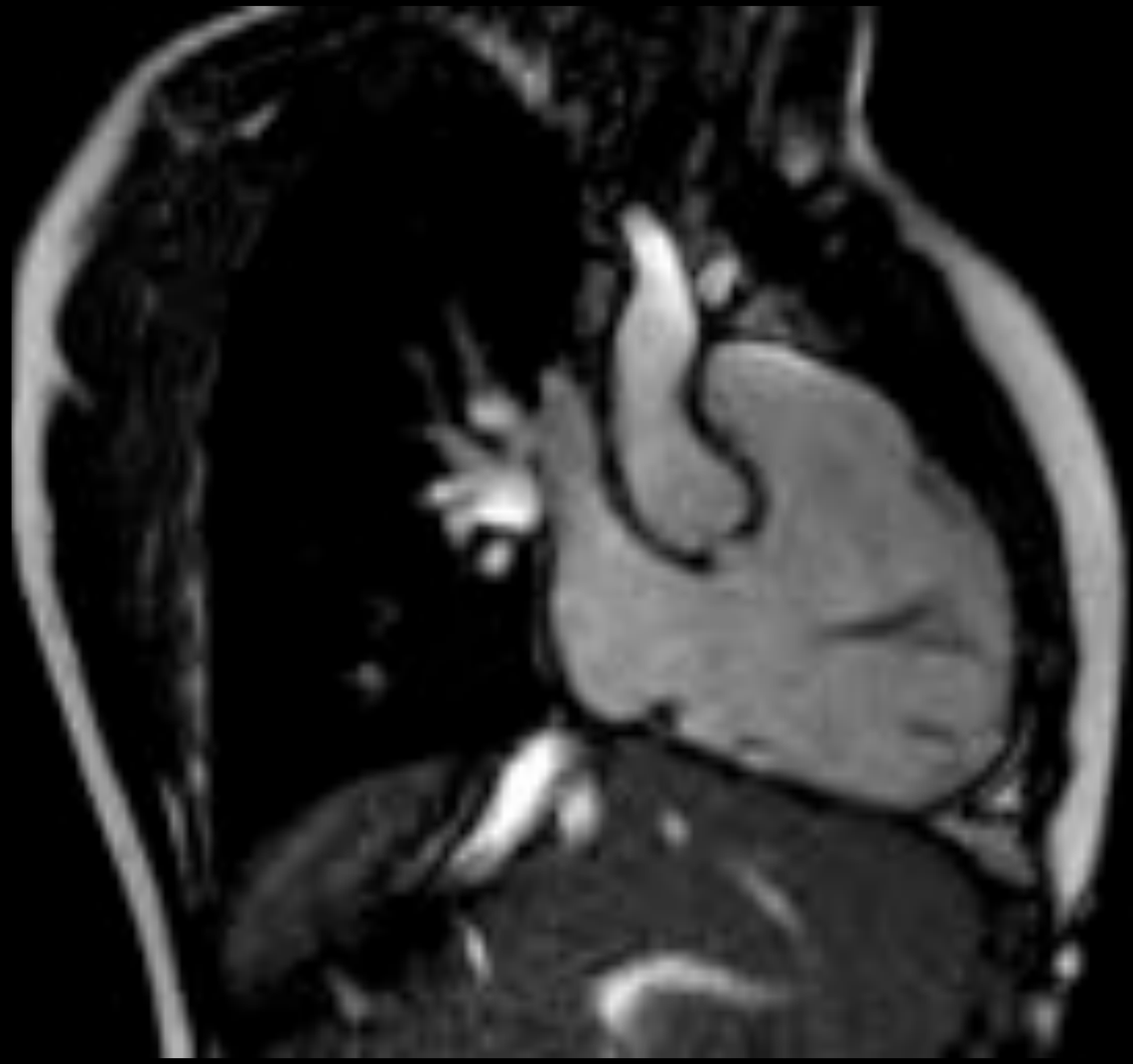


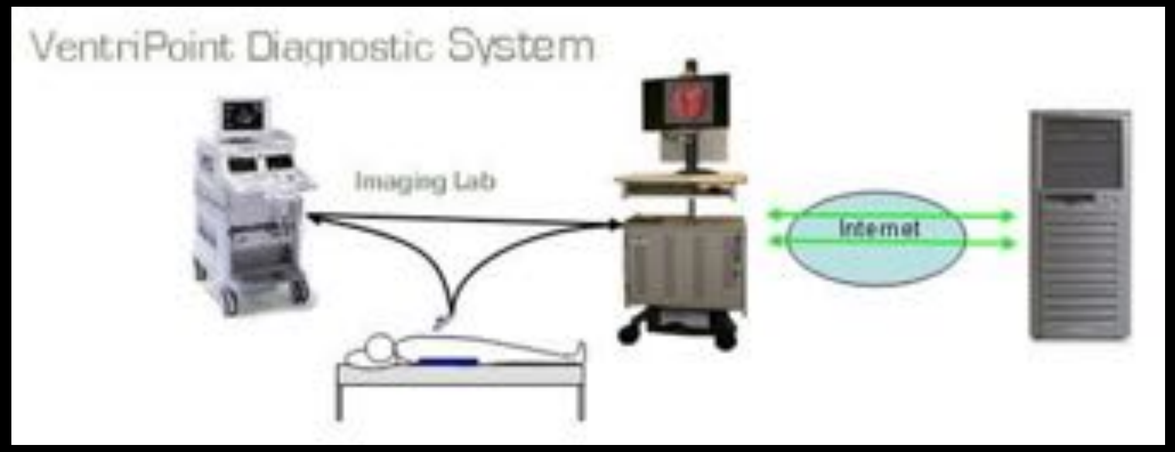
Schreiber. J Thorac Cardiovasc Surg 2006

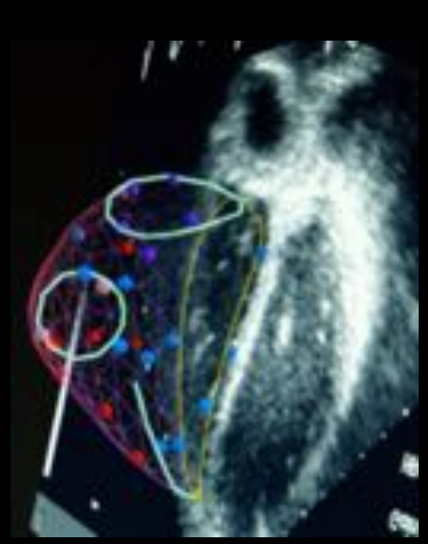


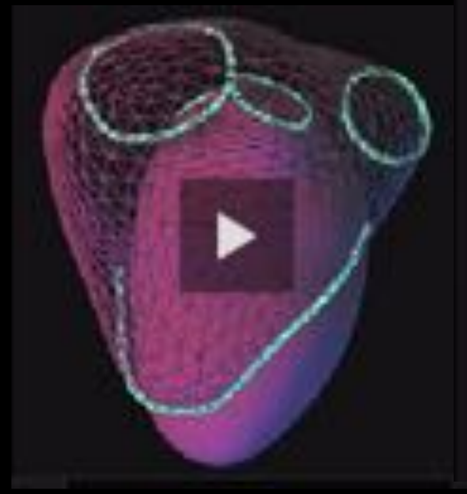
Pulmonary regurgitation in after ToF repair with trans-annular patch

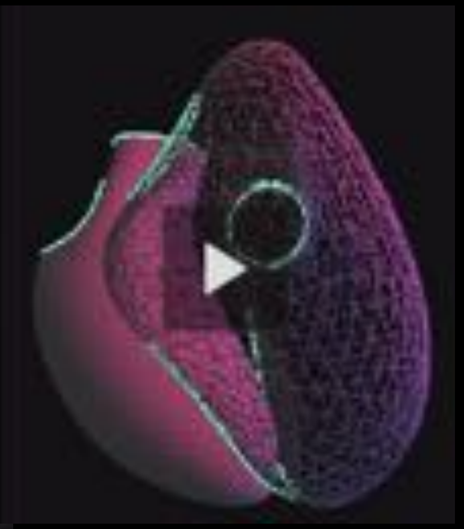


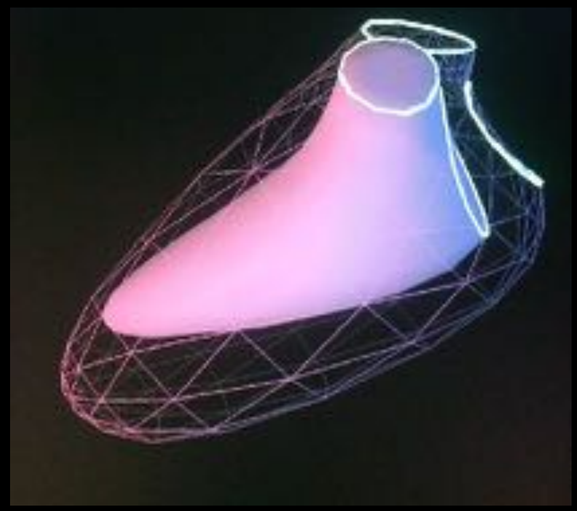




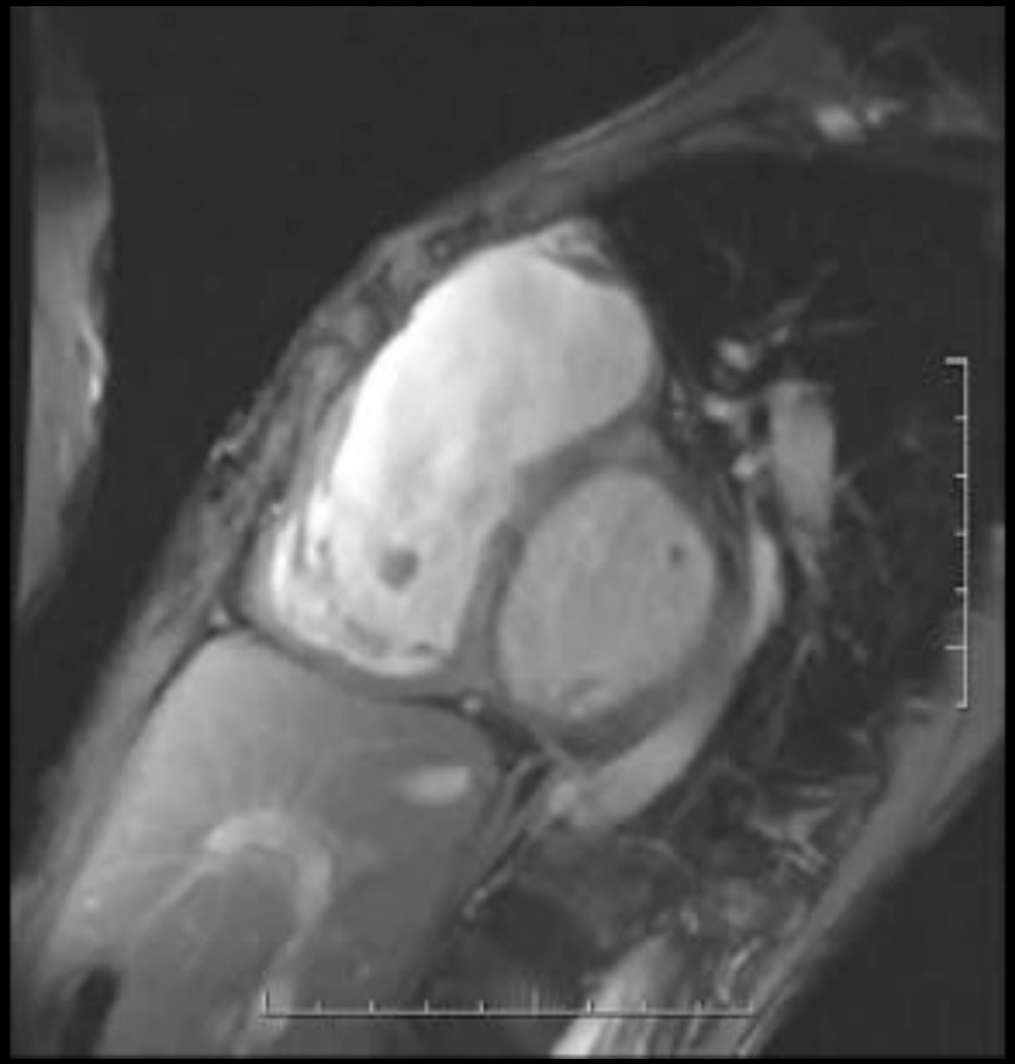


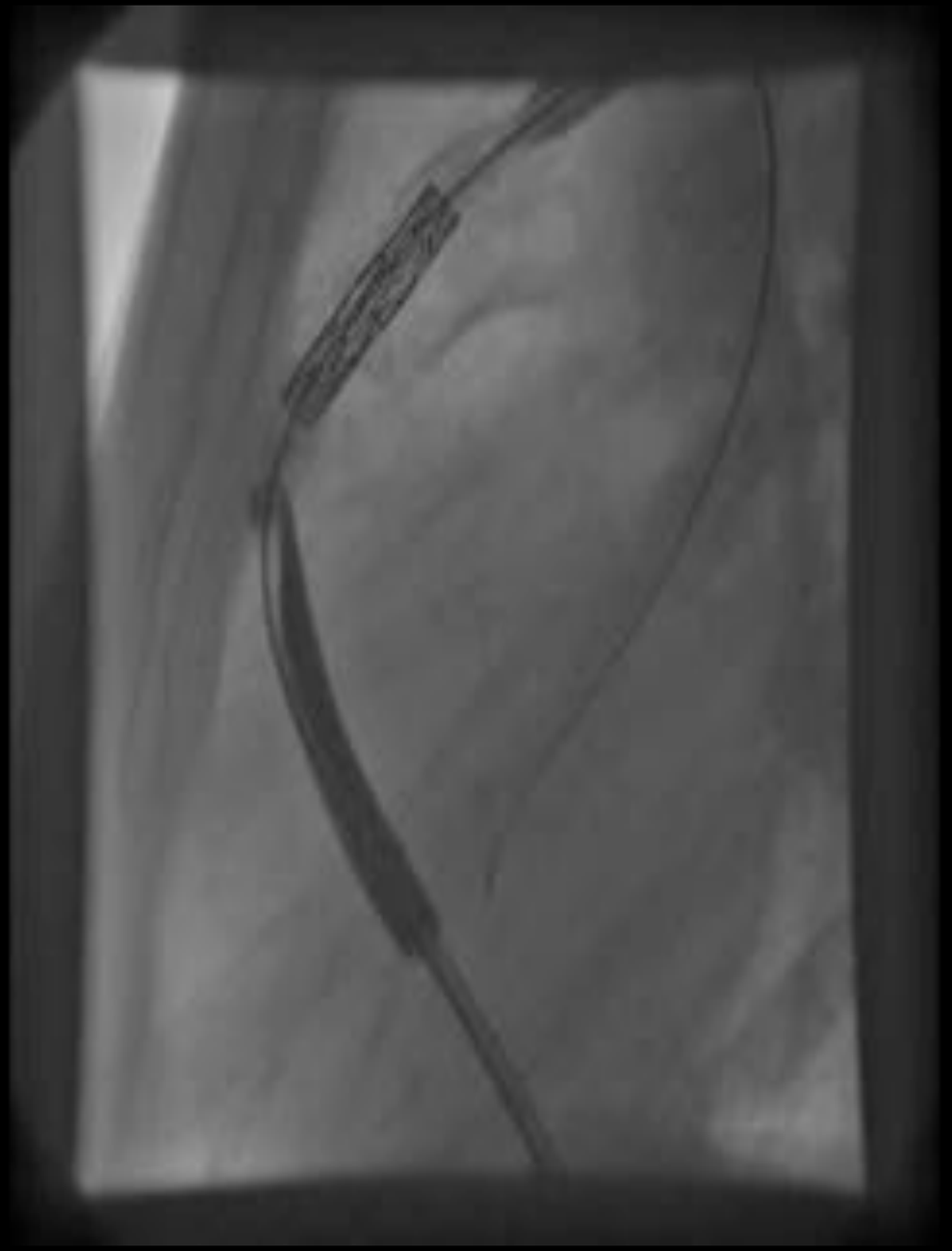


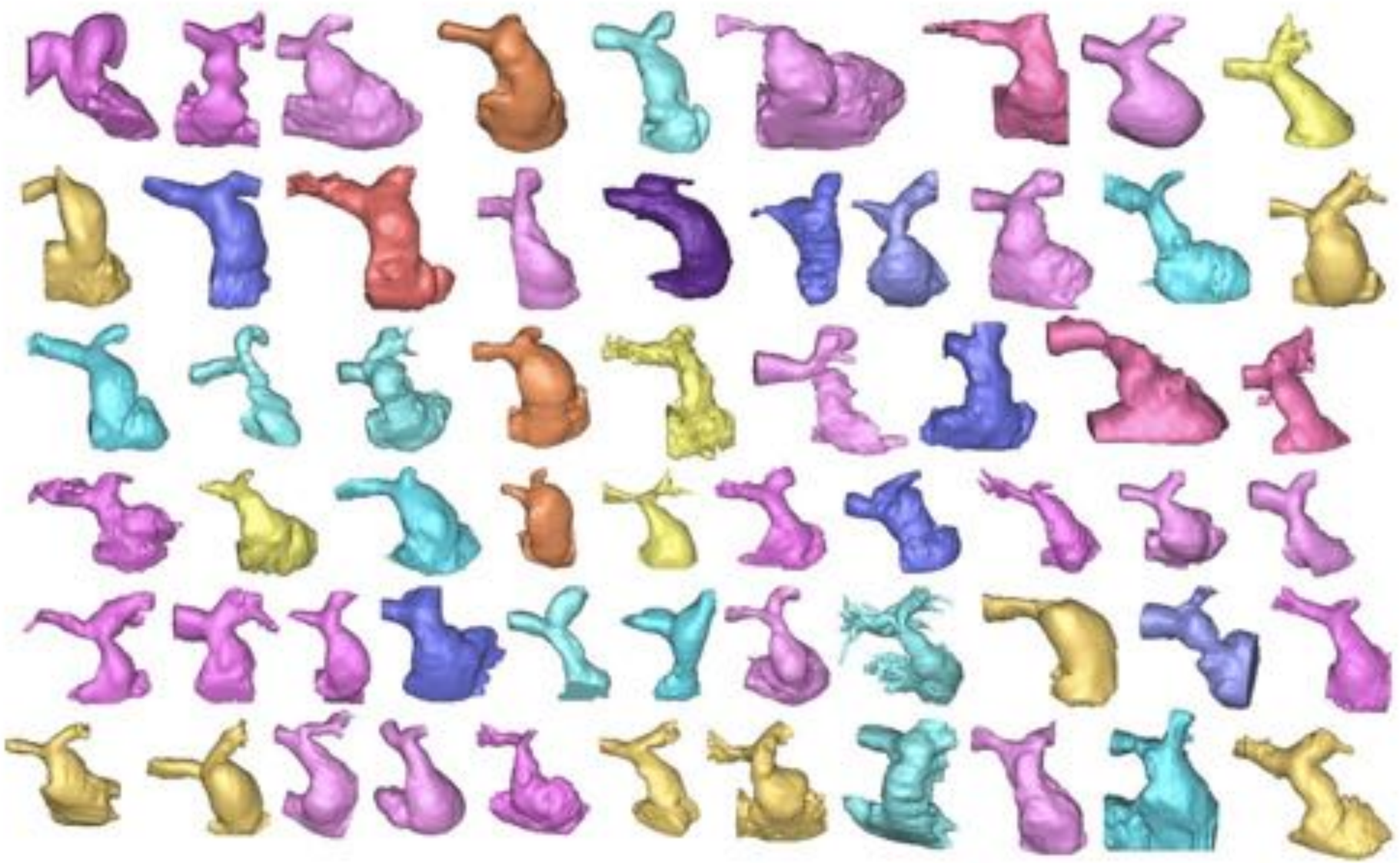




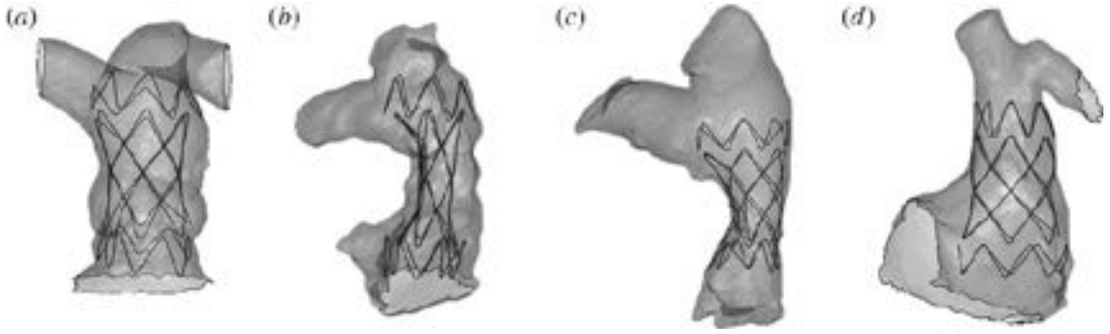
3D Knowledge system

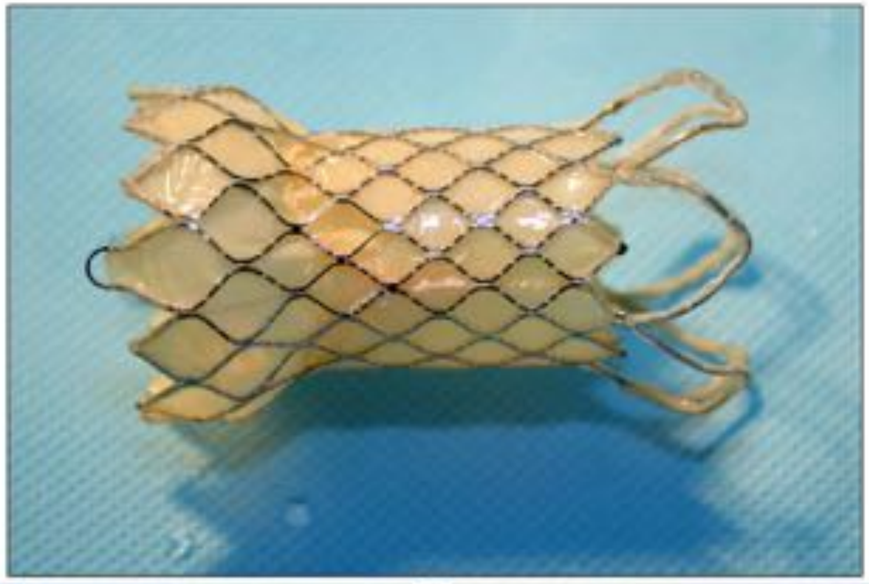


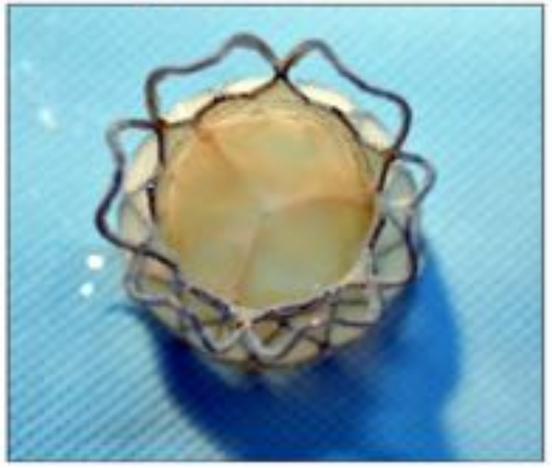


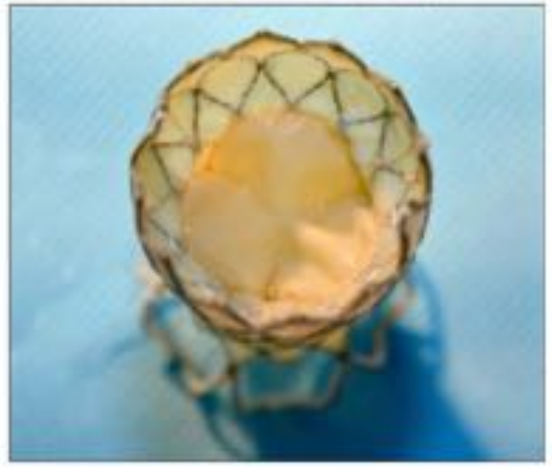


Capelli et al. 2011


(a)
(b)
(c)
(d)

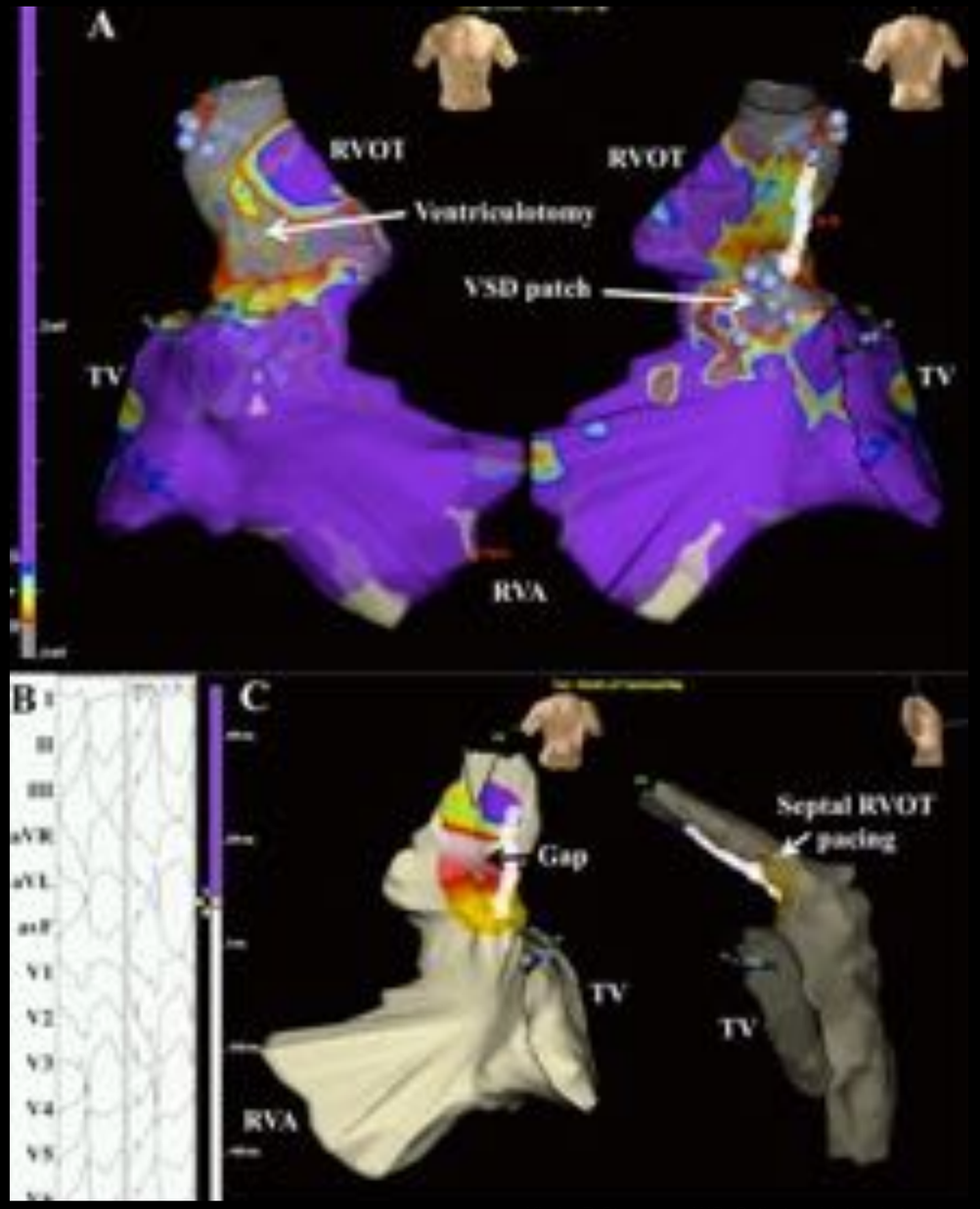






Indications	Class[a]	Level[b]
Aortic valve replacement should be performed in patients with severe AR with symptoms or signs of LV dysfunction	I	C
PVRep should be performed in symptomatic patients with severe PR and/or stenosis (RV systolic pressure >60 mmHg, TR velocity >3.5 m/s)	I	C
PVRep should be considered in asymptomatic patients with severe PR and/or PS when at least one of the following criteria is present: • Decrease in objective exercise capacity • Progressive RV dilation • Progressive RV systolic dysfunction • Progressive TR (at least moderate) • RVOTO with RV systolic pressure >80 mmHg (TR velocity >4.3 m/s) • Sustained atrial/ventricular arrhythmias	IIa	C
VSD closure should be considered in patients with residual VSD and significant LV volume overload or if the patient is undergoing pulmonary valve surgery	IIa	C

Voltage and pace mapping of ventricular tachycardia in tetralogy of Fallot



Khairy P, Stevenson WG. Catheter ablation in tetralogy of Fallot. Heart Rhythm 2009;6(7):1069-74.71.

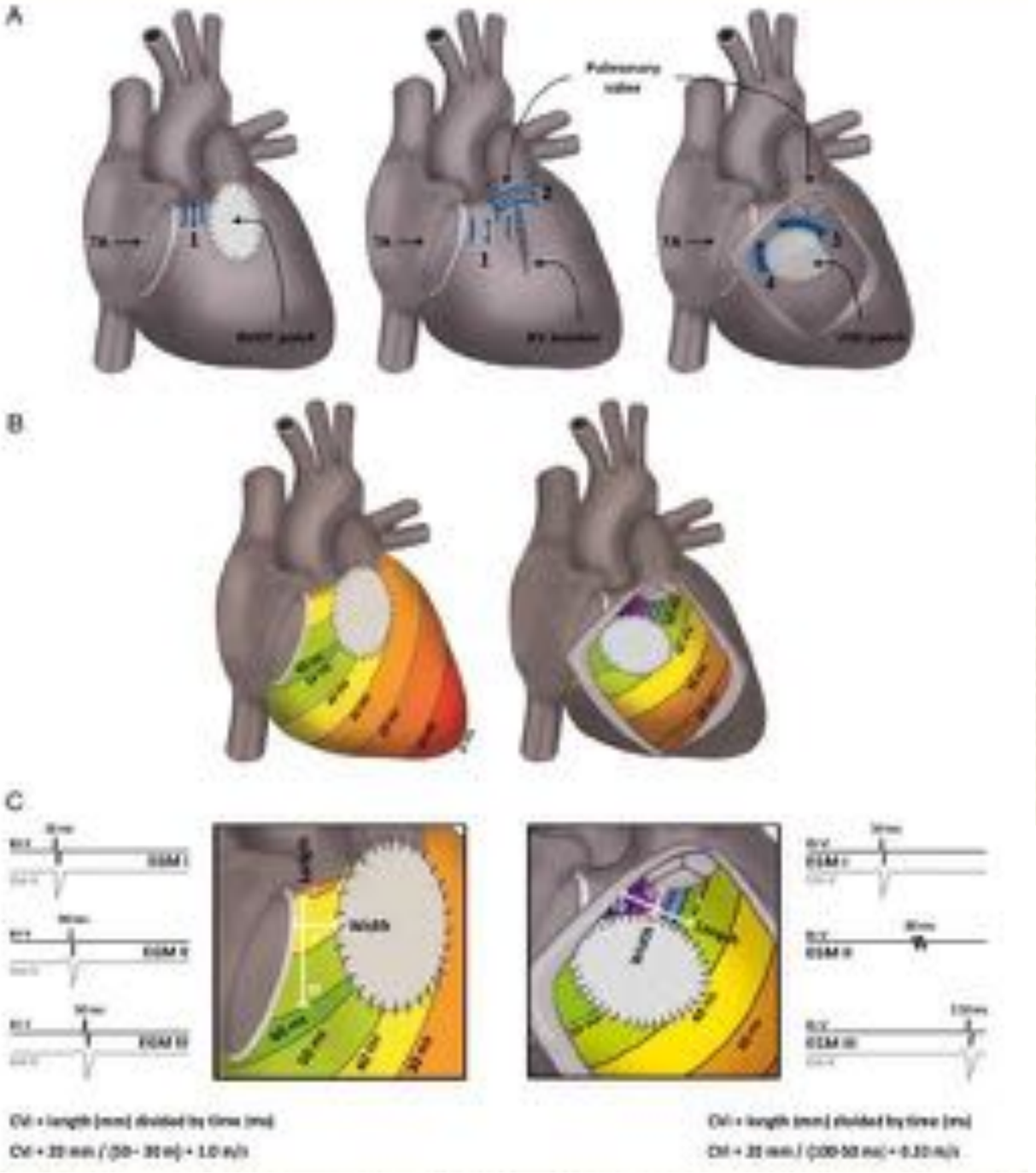
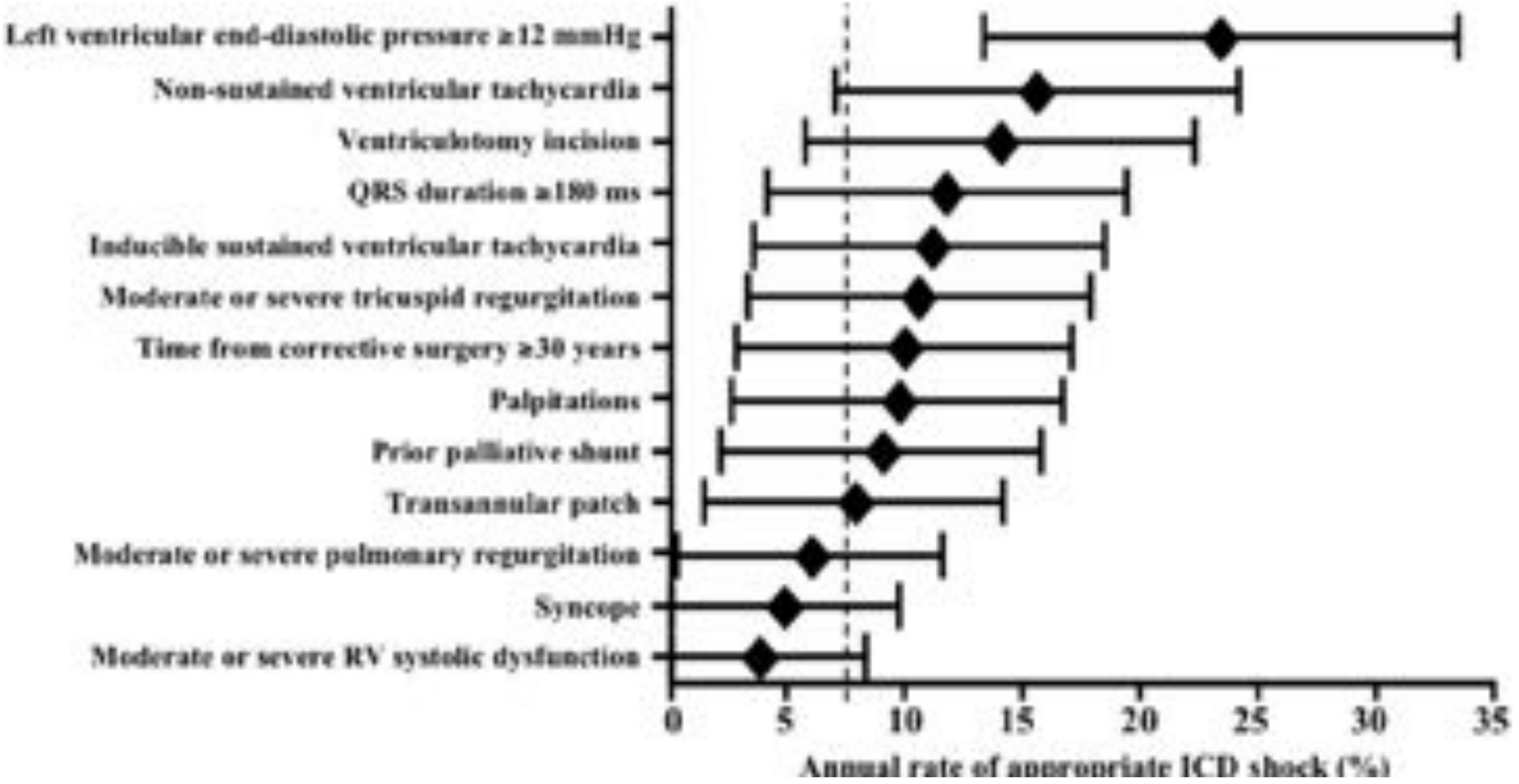
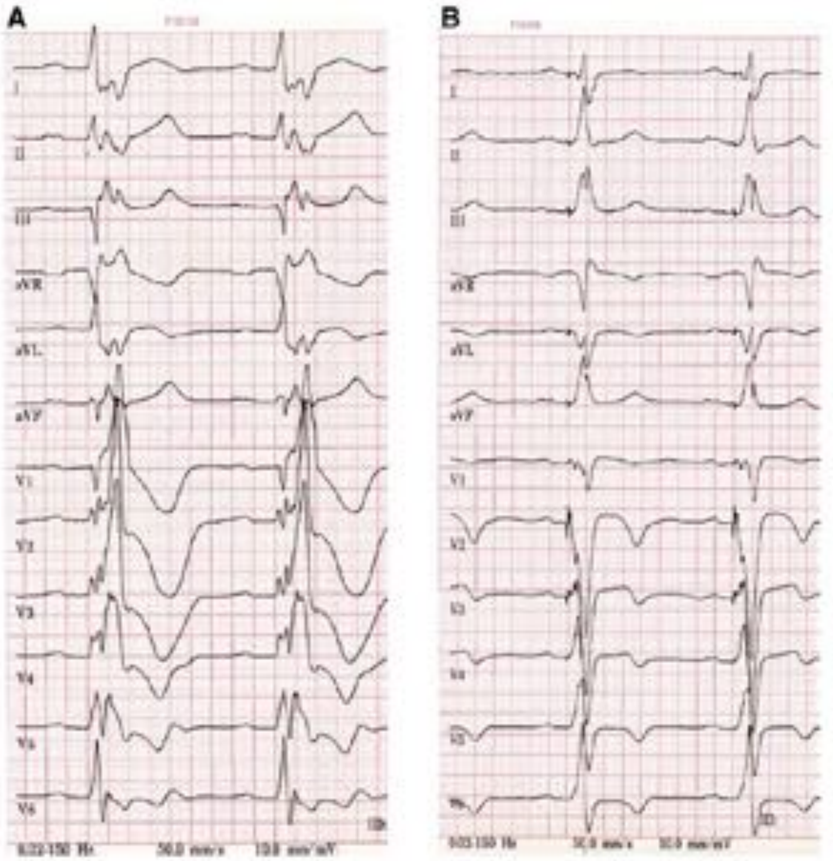


Figure 1 (A) Schematic overview of the four potential anatomical isthmuses (blue brackets). Isthmus 1 bordered by tricuspid annulus and right ventricular outflow tract patch/right ventricular incision, isthmus 2 by right ventricular incision and pulmonary valve, isthmus 3 by pulmonary valve and ventricular septal defect patch, isthmus 4 by ventricular septal defect patch and tricuspid annulus. (B) Schematic activation of the right ventricle during SR displayed as colour-coded isochronal (10 ms) map from red (early activation) to purple (latest activation). (C) Enlarged views of anatomical isthmus 1 (left) and 3 (right) with corresponding electrograms recorded from sites I–II–III, as indicated. Isthmus width, distance between unexcitable anatomical boundaries; isthmus length, distance between normal electrograms (I and II) recorded at entrance and exit site of the anatomical isthmus. Conduction time through the anatomical isthmus, difference in local activation time between the entrance and exit of the anatomical isthmus. Conduction velocity index calculated as indicated. EGM, electrogram; RVOT, right ventricular outflow tract; RV, right ventricular; VSD, ventricular septal defect.

Kapel GFL et al. Eur Heart J 2017


Left ventricular end-diastolic pressure ≥12 mmHg
Non-sustained ventricular tachycardia
Ventriculotomy incision
QRS duration ≥180 ms
Inducible sustained ventricular tachycardia
Moderate or severe tricuspid regurgitation
Time from corrective surgery ≥30 years
Palpitations
Prior palliative shunt
Transannular patch
Moderate or severe pulmonary regurgitation
Syncope
Moderate or severe RV systolic dysfunction
0
5
10
15
20
25
30
35
Annual rate of appropriate ICD shock (%)

Resynchronization for failing right ventricle after repair of tetralogy of Fallot



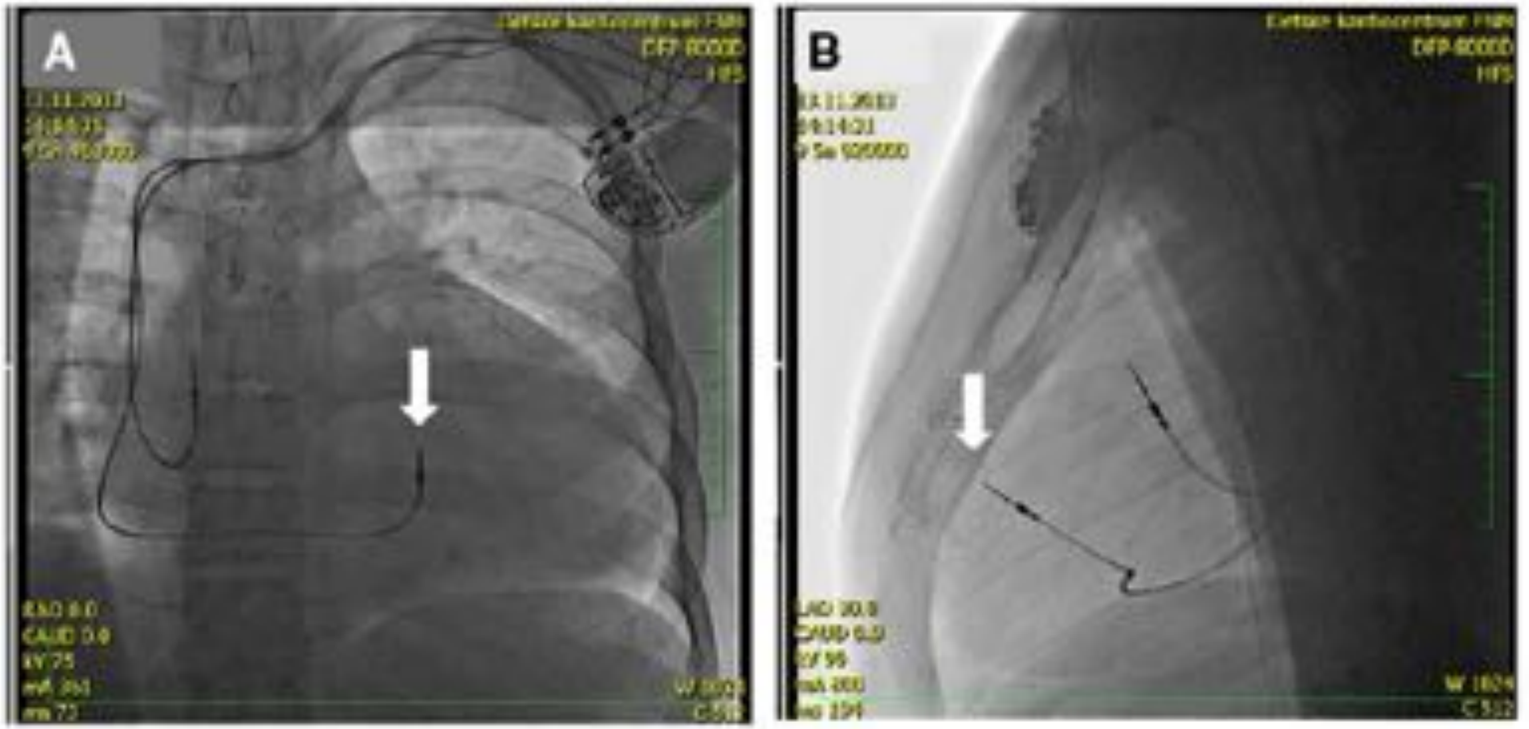
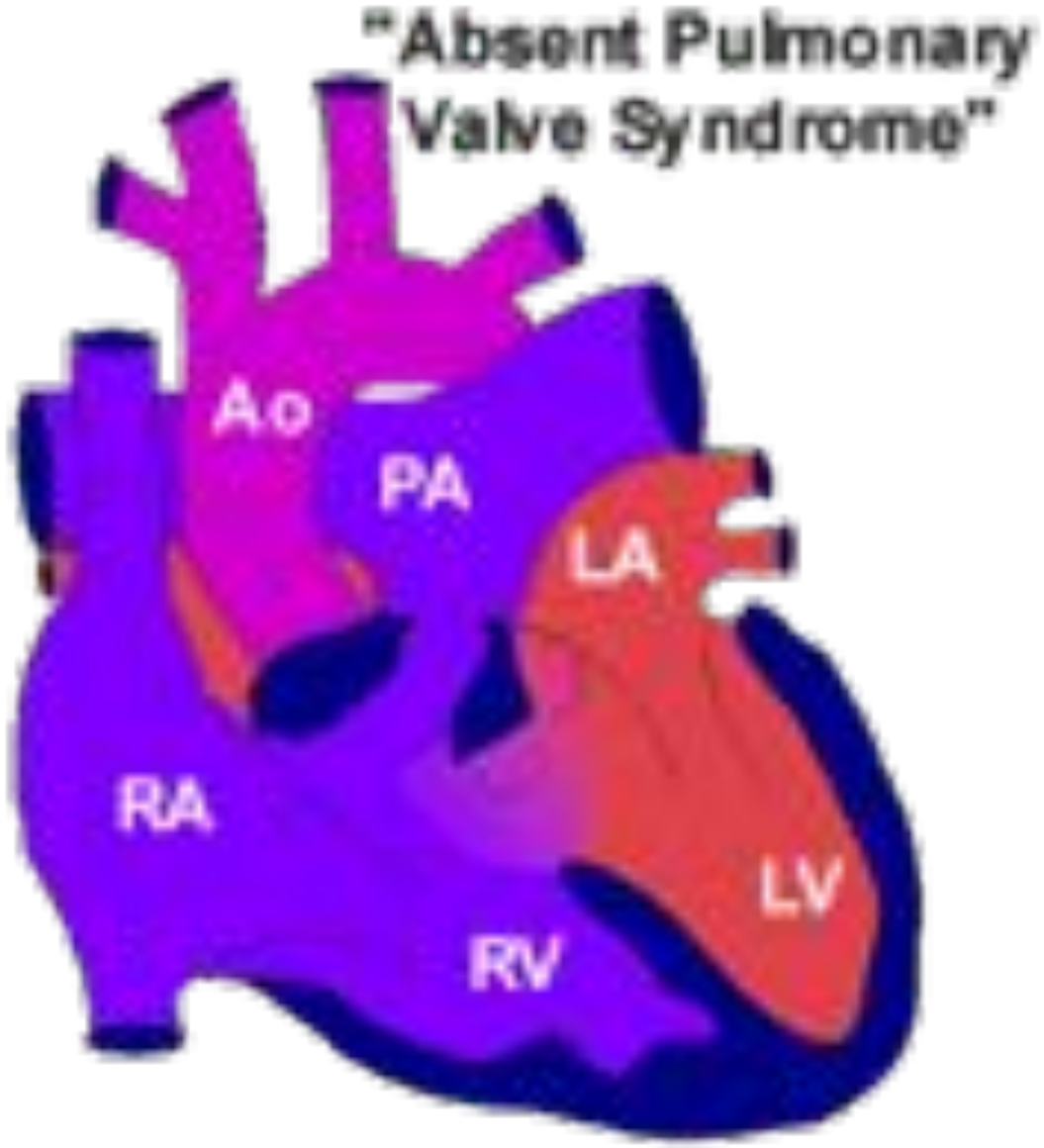


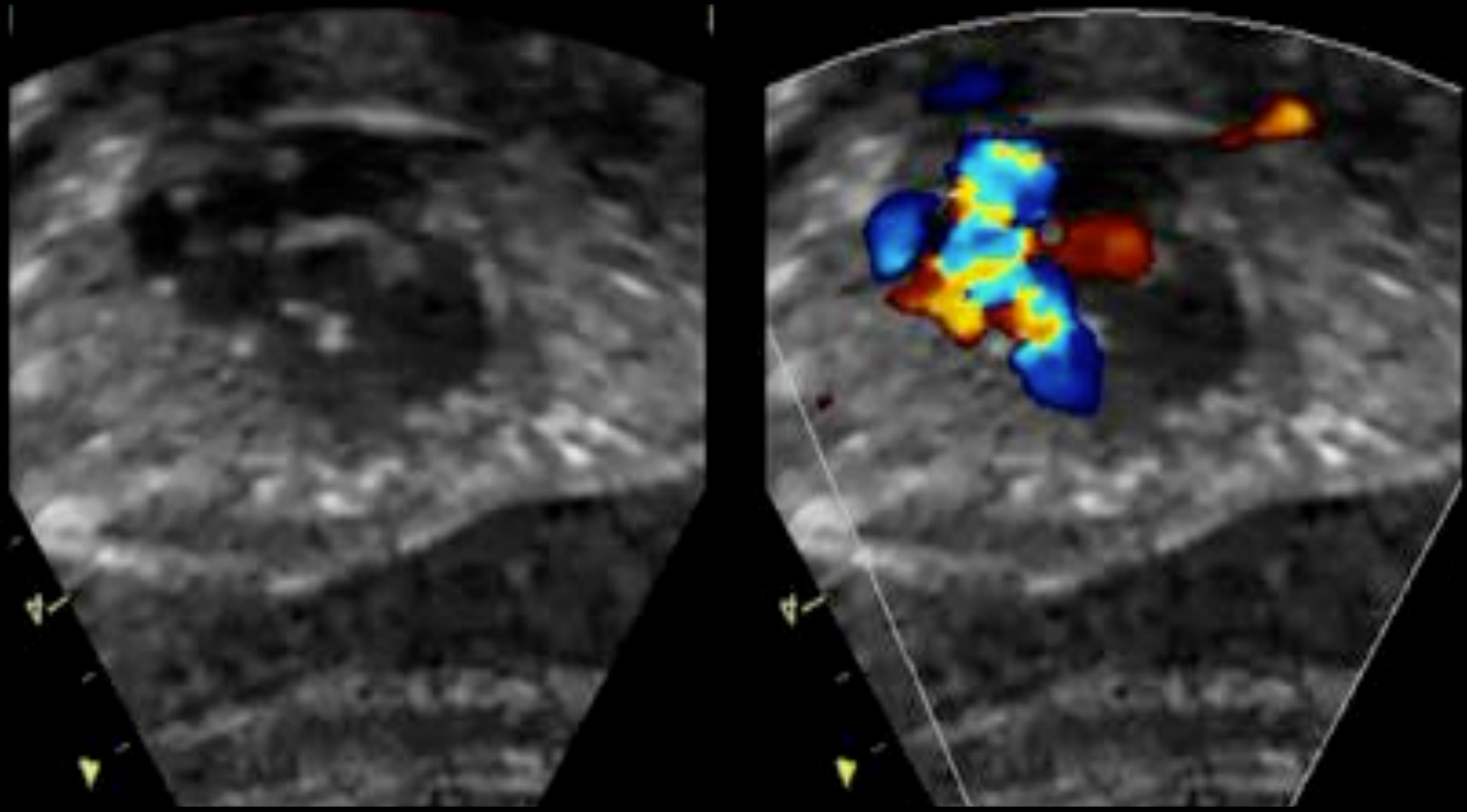
Figure 2. Twelve-lead ECG. **A**, Before pacing: sinus rhythm, spontaneous ventricular activation with complete right bundle-branch block morphology. **B**, After resynchronization: major decrease in QRS complex duration during dual mode, dual chamber, dual sensing (DDD) pacing with an atrio-ventricular delay adjusted to achieve complete fusion with spontaneous ventricular depolarization. Leads aVR, aVL and aVF indicates augmented limb leads.

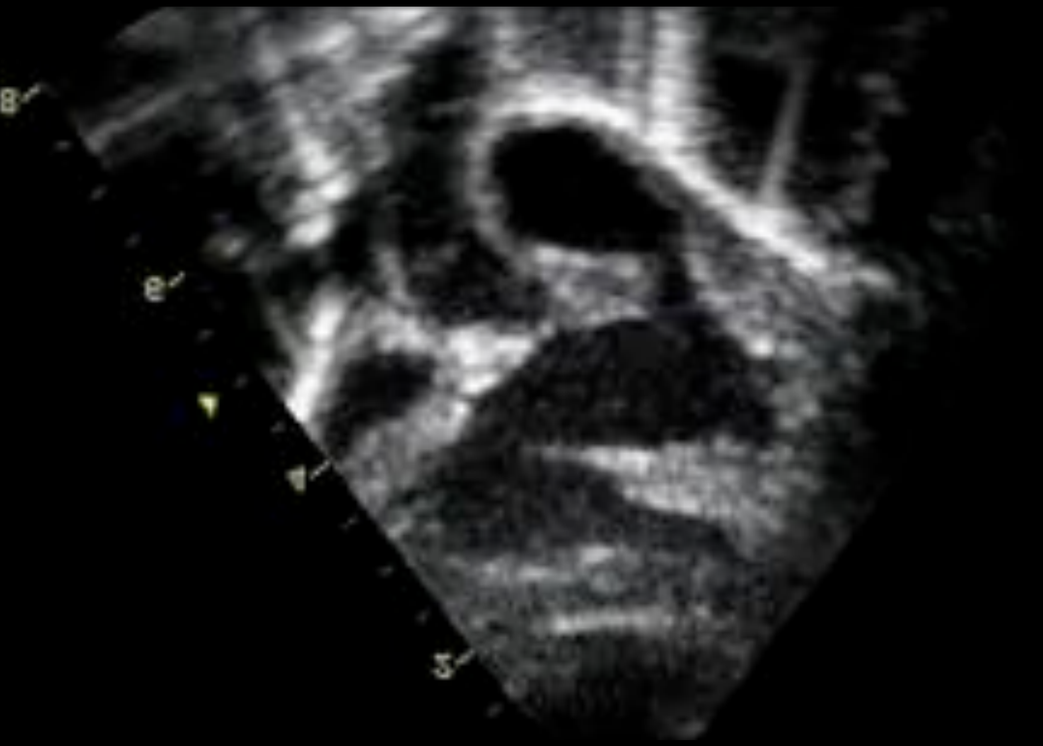
Kubus P et al. Circulation 2014

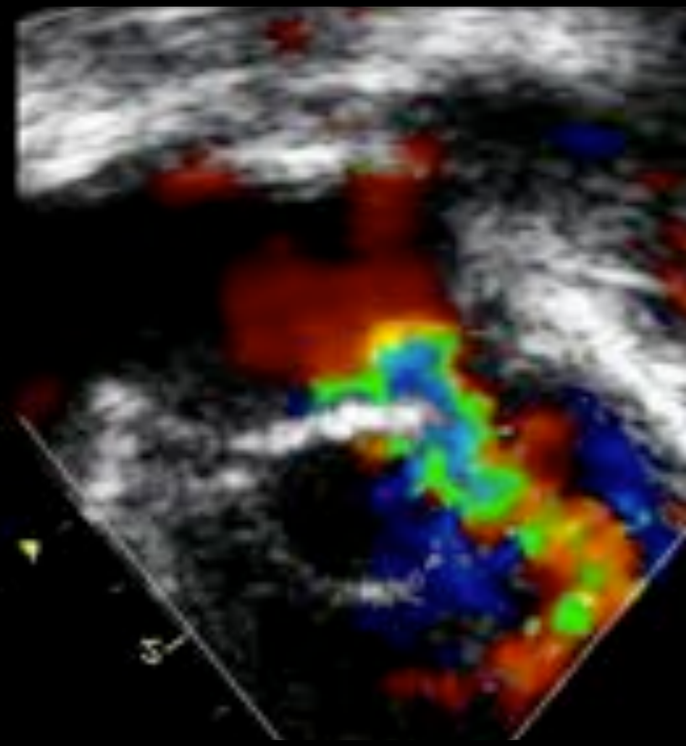
Tetralogy of Fallot with absent pulmonary valve



Tetralogy of Fallot with absent pulmonary valve

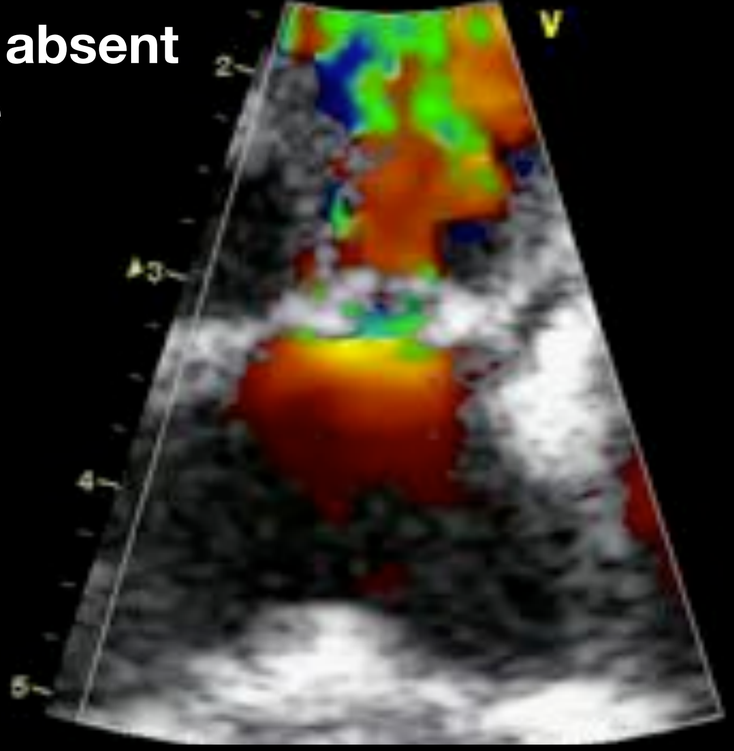


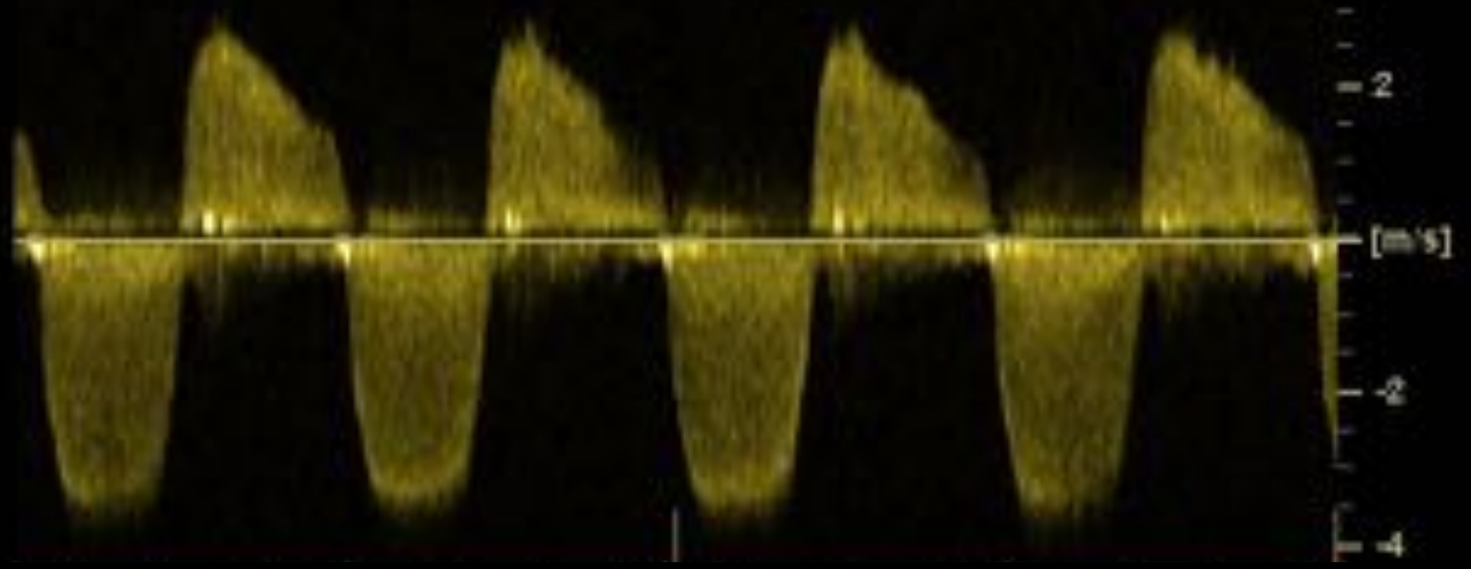


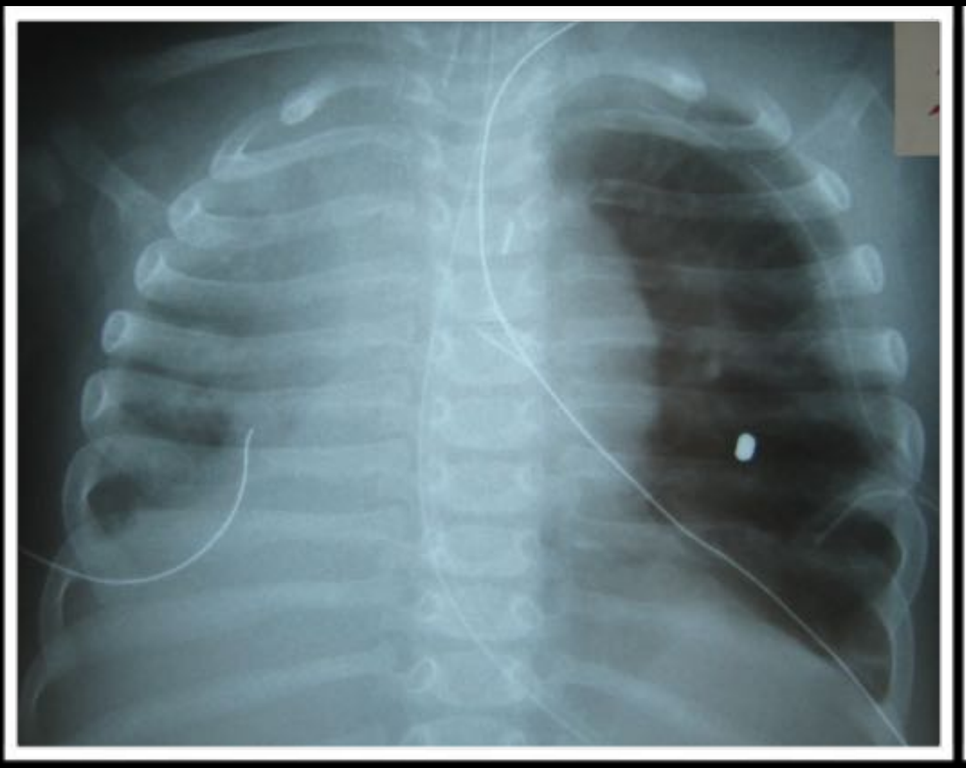


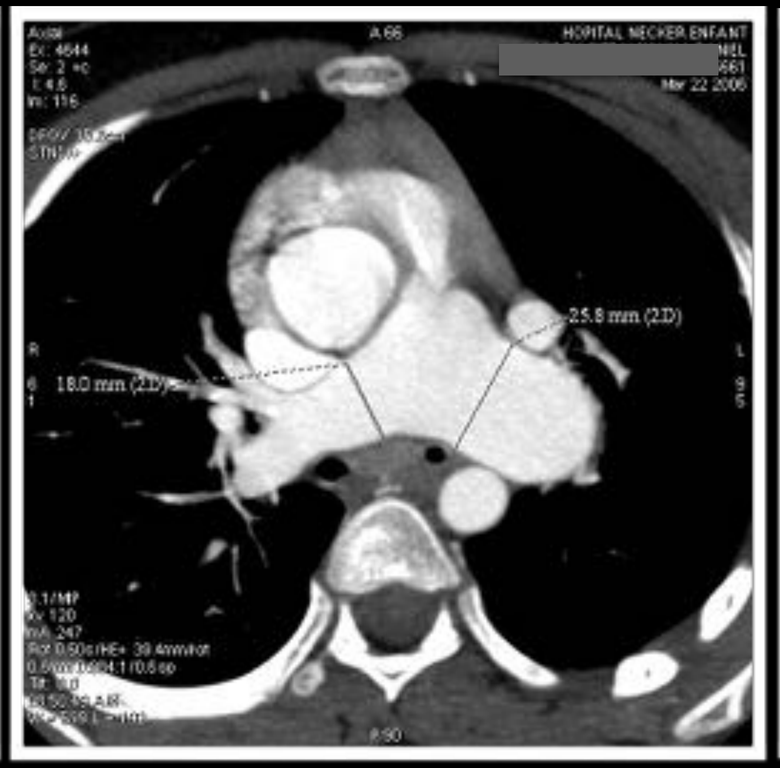
Tetralogy of Fallot with absent pulmonary valve

Tetralogy of Fallot with absent pulmonary valve

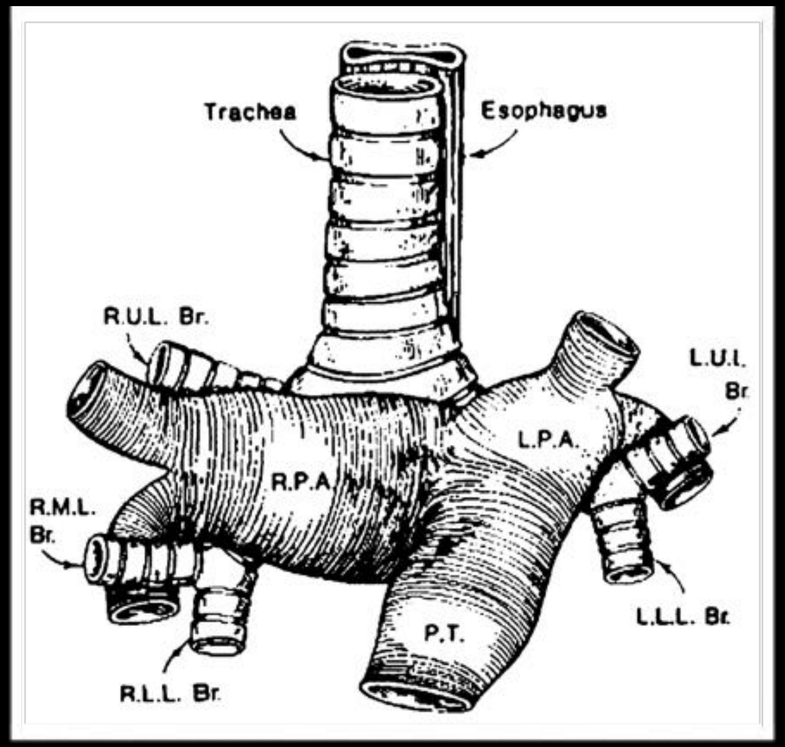


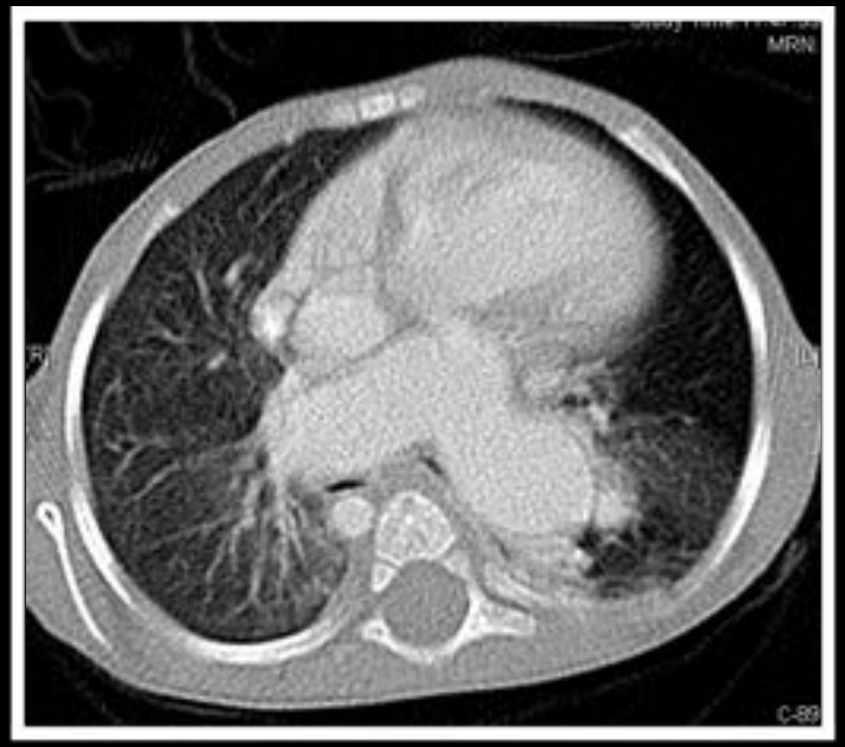






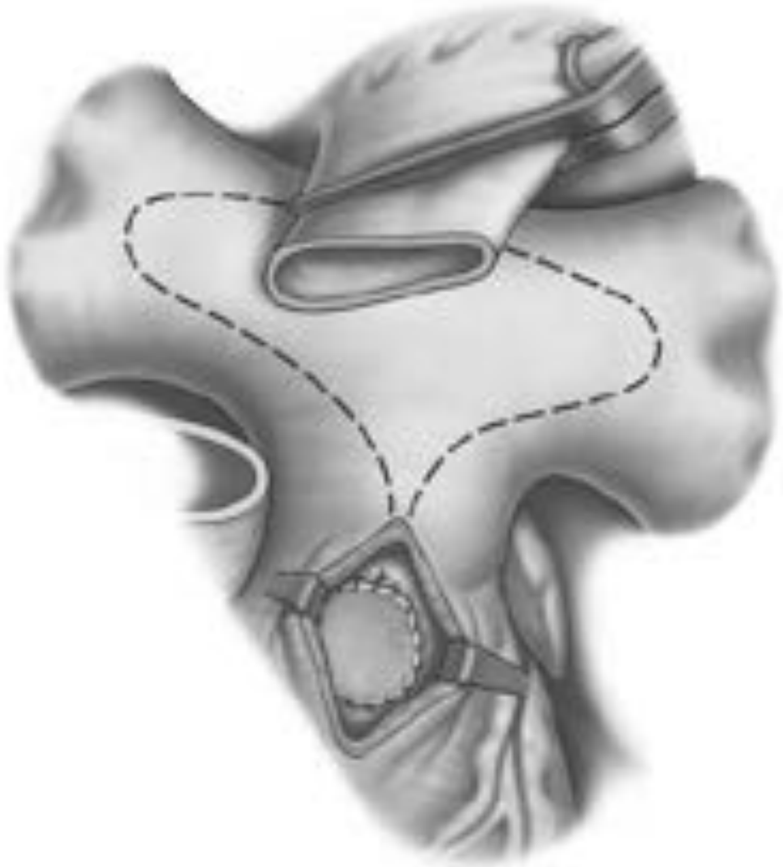
Tetralogy of Fallot with absent pulmonary valve

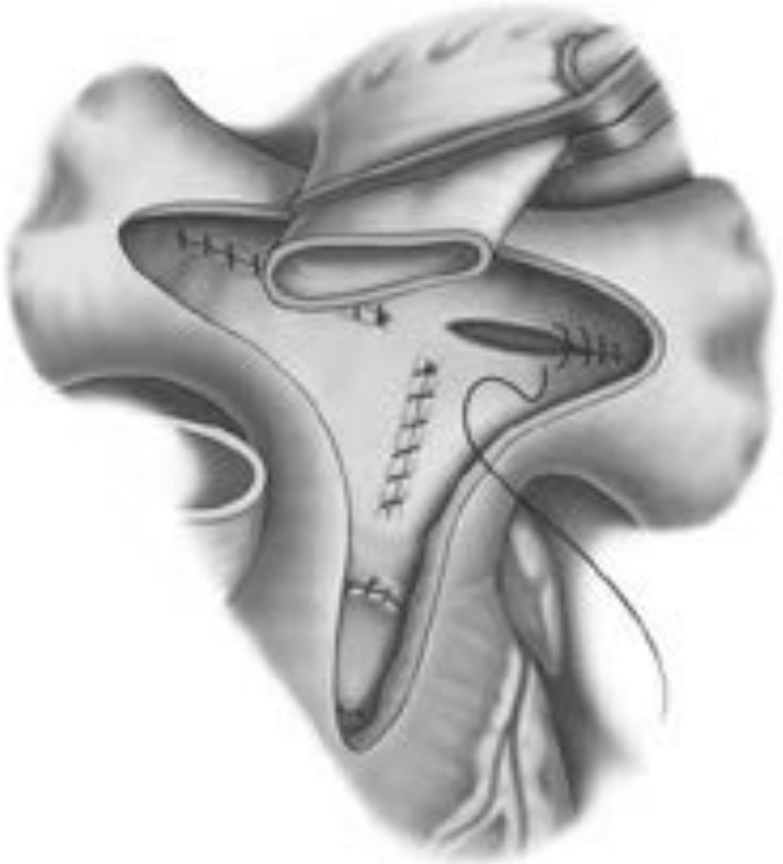


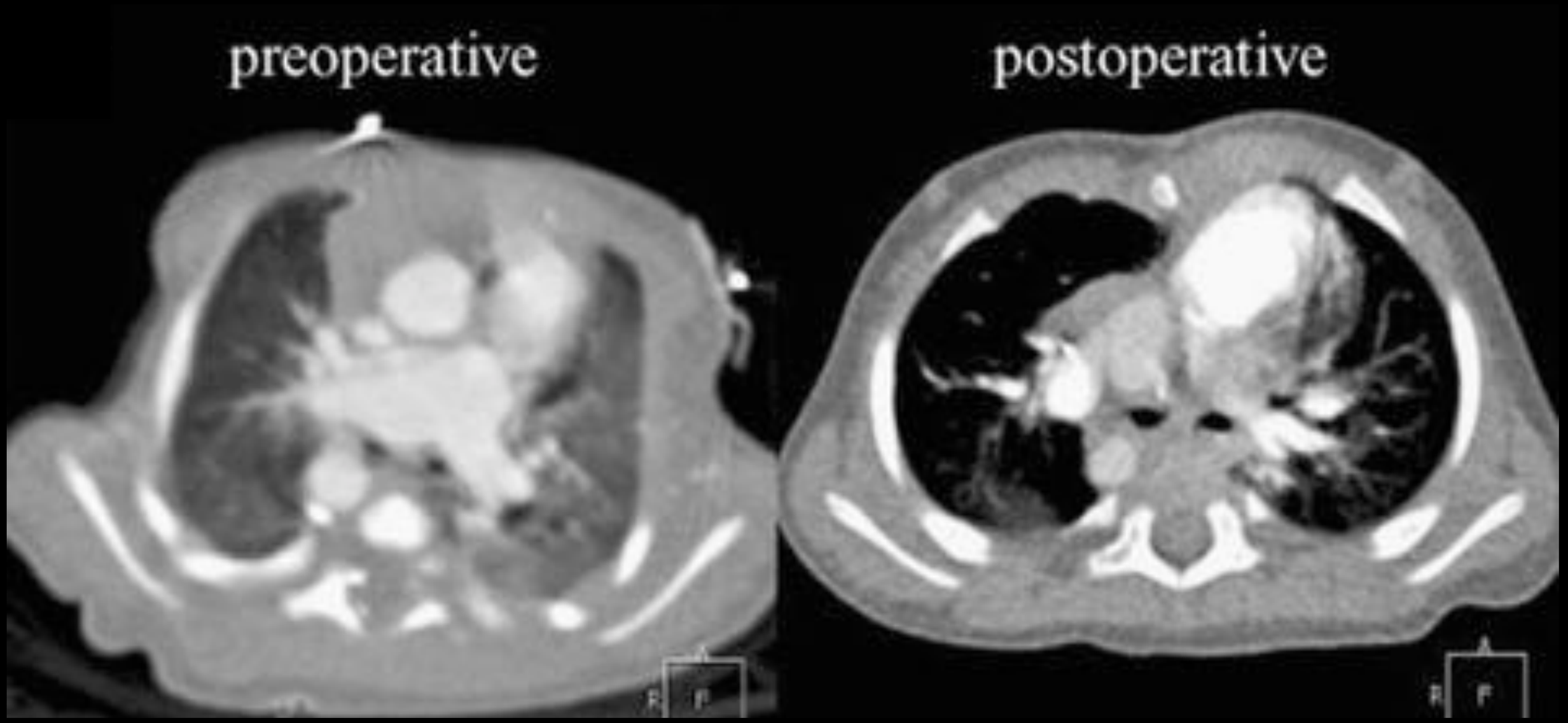


Tetralogy of Fallot with absent pulmonary valve

Tetralogy of Fallot-Absent pulmonary valve: repair

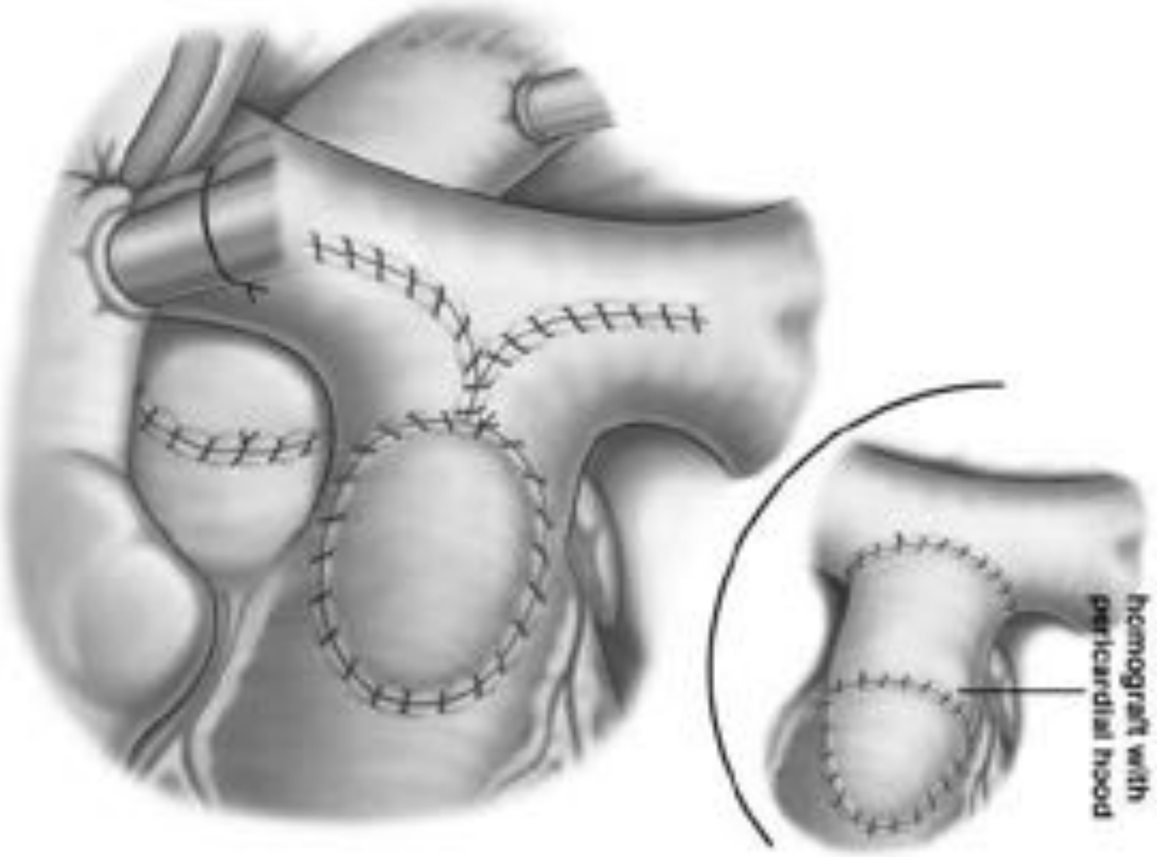


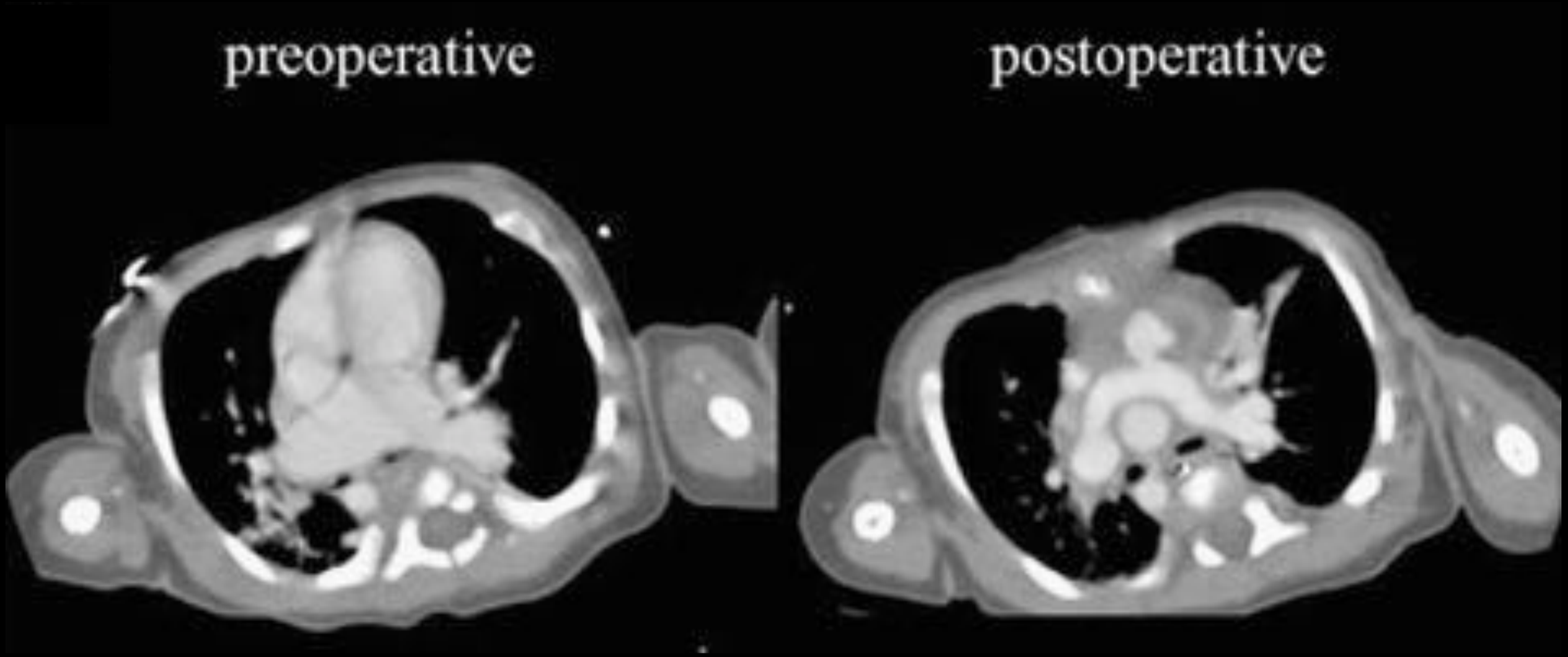




Tetralogy of Fallot with absent pulmonary valve

Tetralogy of Fallot-Absent pulmonary valve: repair
With Lecompte manoeuver





Tetralogy of Fallot with absent pulmonary valve


M3C
« Tetralogy of Fallot »
Thank you