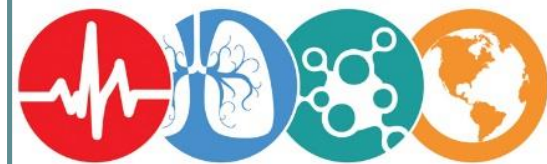


## Pulmonary valve: Imaging assessment

Fraisse

Royal Brompton and Harefield Hospital

London, U.K.



A lifetime of specialist care

Consultant and Proctor for medtronic

# Potential consequences of pulmonary valve Dysfunction

- RV obstruction leading to RV hypertension (pressure overload) is deleterious<sup>1-3</sup>
- RV volume overload also deleterious<sup>1, 4-7</sup>
  - Progressive RV dilation and eventual failure
  - Enlarged RV promotes arrhythmogenicity
  - RV dysfunction ultimately leads to LV dysfunction
  - RV failure leads to early mortality
  - Timely intervention can save RV function and regress dilatation

1. Bacha EA, et al. *The Journal of thoracic and cardiovascular surgery*. 2001;122:154-61.

2. Kirklin JW, et al. *The Journal of thoracic and cardiovascular surgery*. 1992;103:706-23.

3. Ilbawi MN, et al. *The Journal of thoracic and cardiovascular surgery*. 1987;93:36-44.

4. Geva T. Seminars in thoracic and cardiovascular surgery Pediatric cardiac surgery annual. 2006;11-22.

5. Gatzoulis MA, et al. *Lancet*. 2000;356:975-81.

6. Hayes CJ, et al. *Circulation* 1993 Feb;87(2 Suppl):128-37.

7. Meyer RA, et al. *Am J Cardiol*. 1982 Jul;50(1):143-8.

# Imaging methods to assess pulmonary valve function

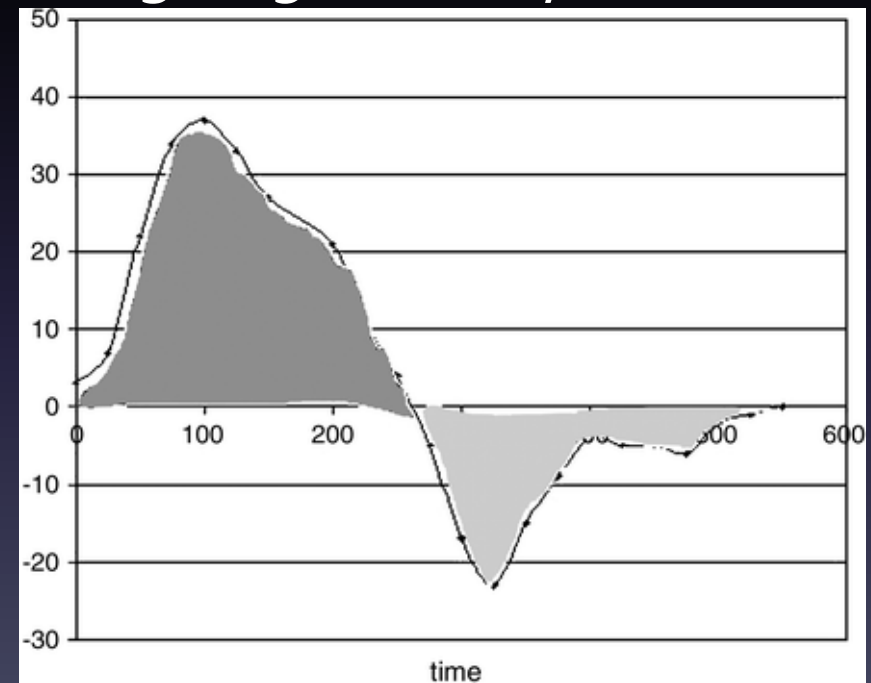
- Transthoracic echocardiography
  - For pulmonary stenosis
- CMR
  - For pulmonary regurgitation
- Transesophageal and/or intracardiac echocardiography
  - For endocarditis...

# Indications for pulmonary valve replacement: CMR based

Symptoms.... Arrhythmias

Severe PR (RV  $>40\%$ ), RVEDV  $> 130-150\text{ml/m}^2$ , RVESV  $> 85\text{ ml/m}^2$

RV and/or LV dysfunction



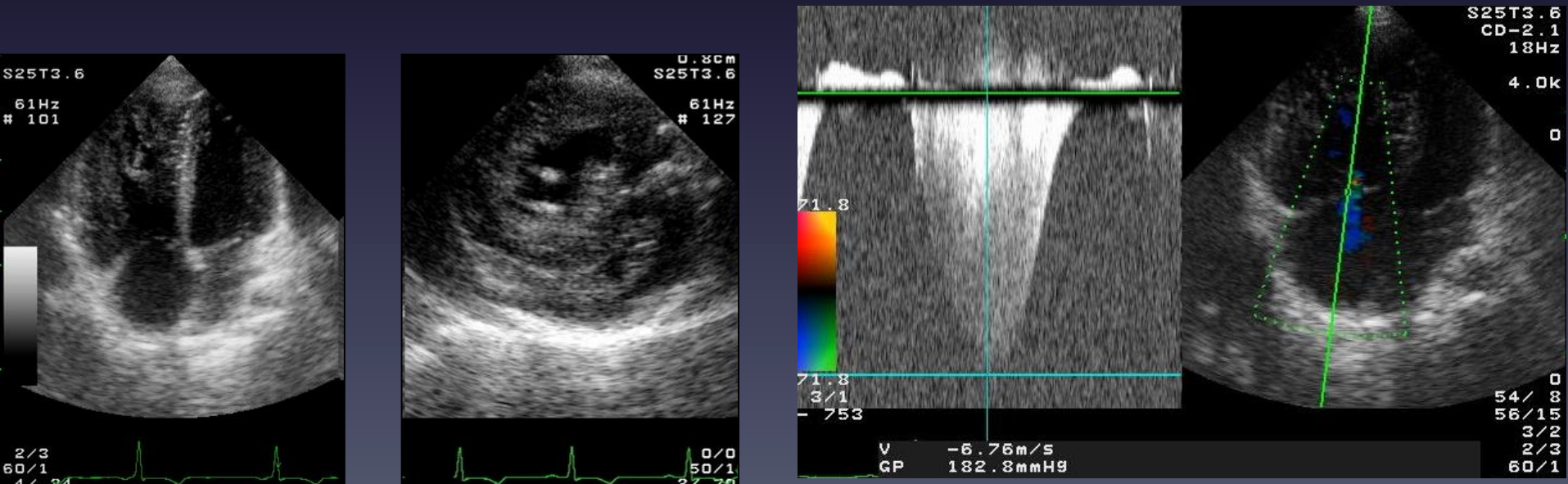
Geva J Cardiovasc Magn Reson 2011

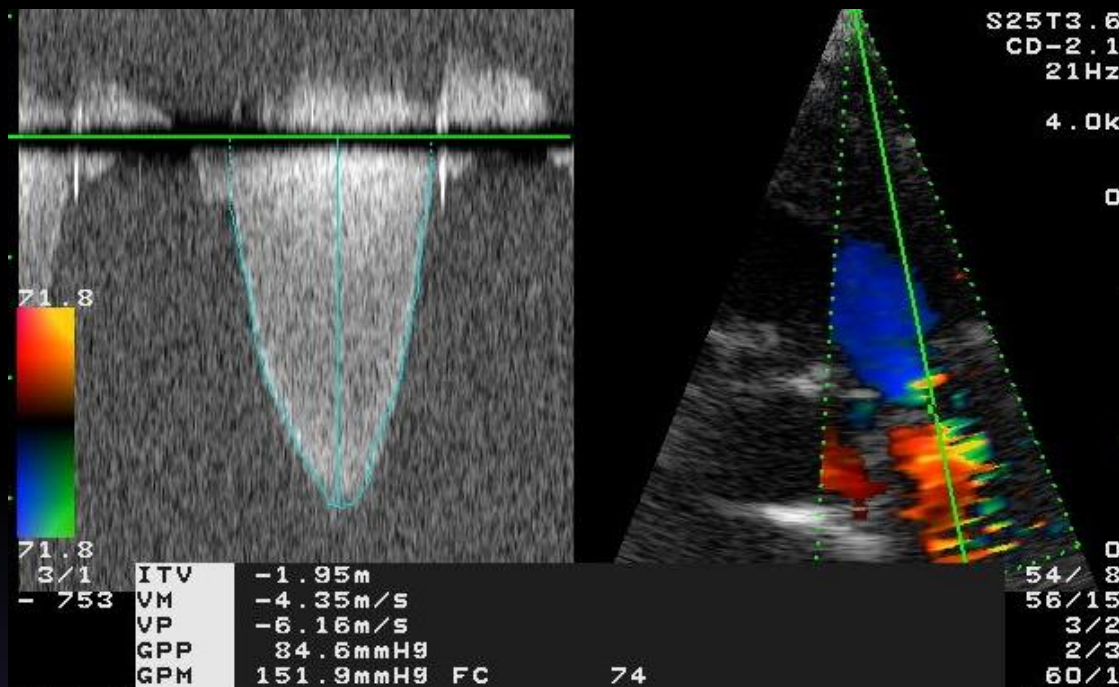
# ***Pulmonary valve stenosis: may be extreme in asymptomatic patient***

*RVH*

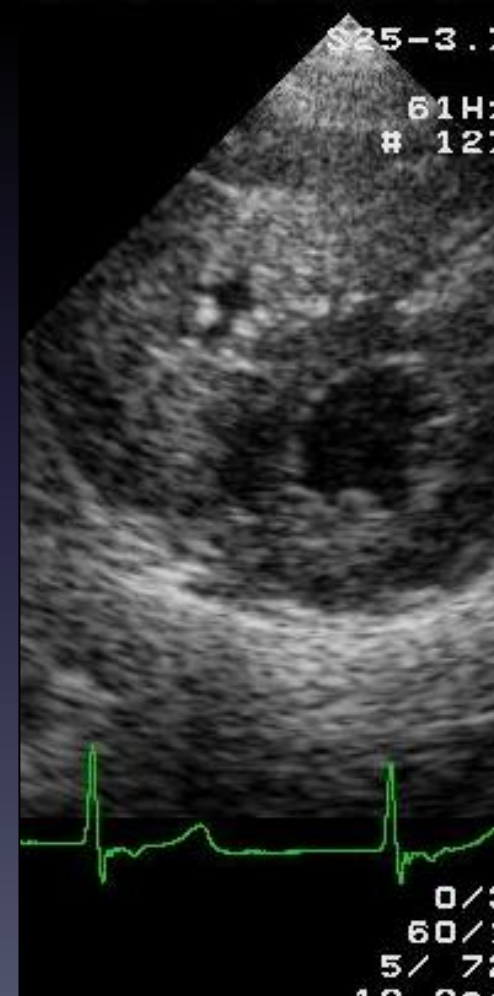
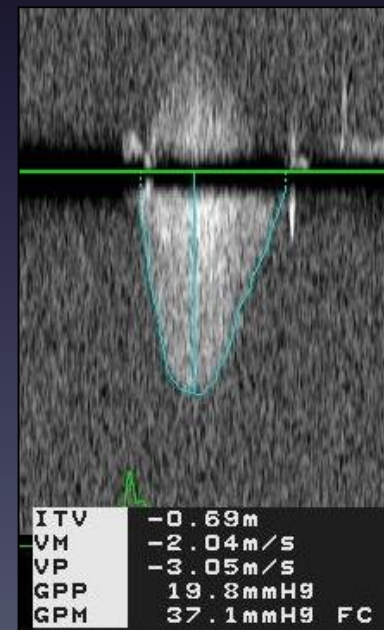
*Paradoxical IV septum*

*Mean gradient > 50mmHg through CW Doppler*





*Success after balloon dilation*

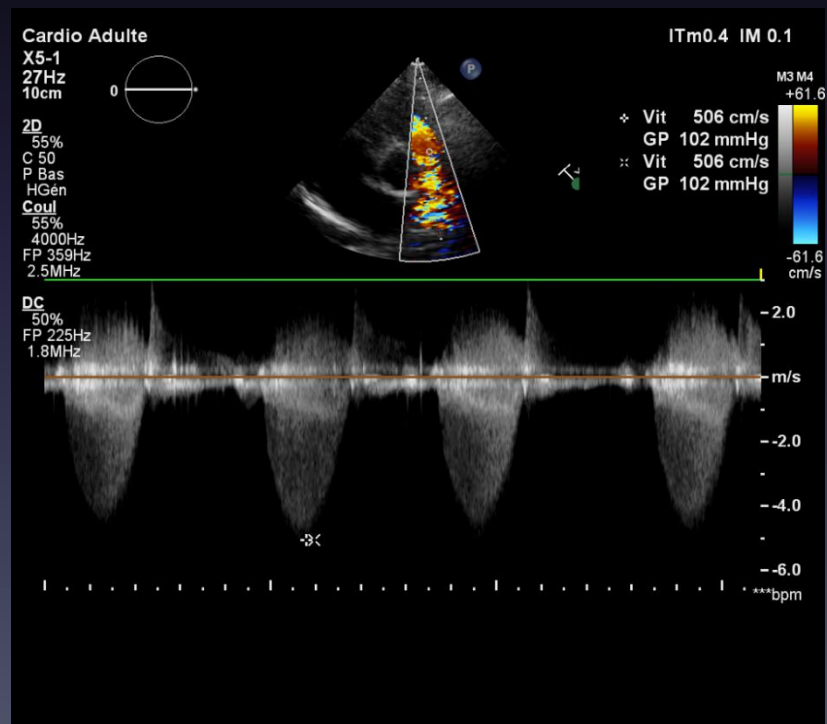
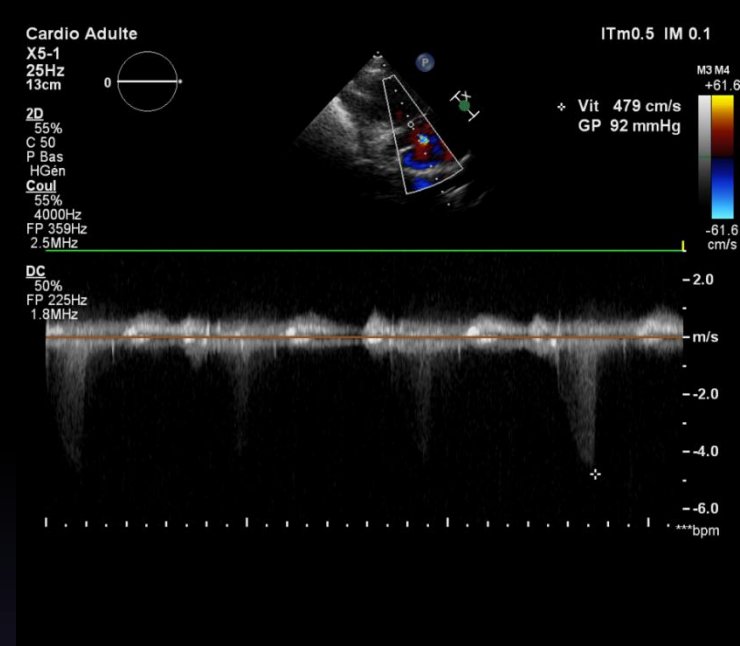
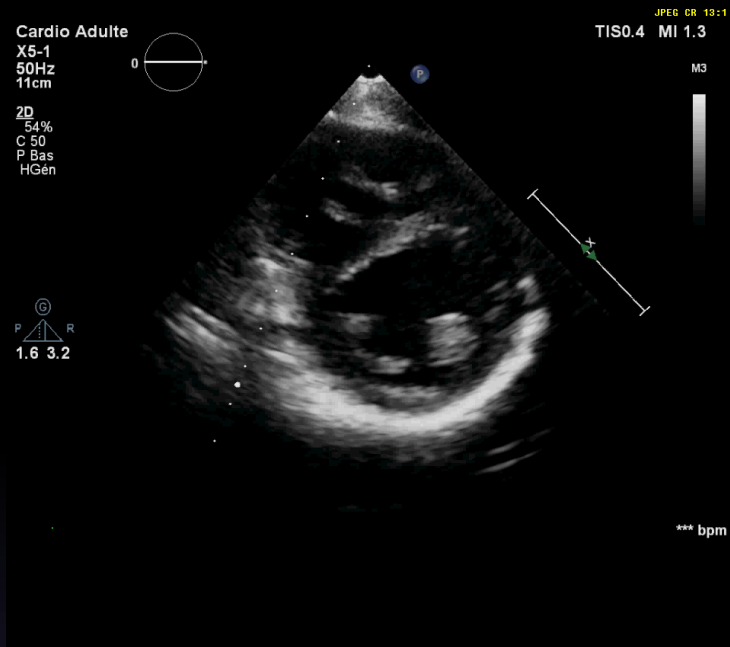


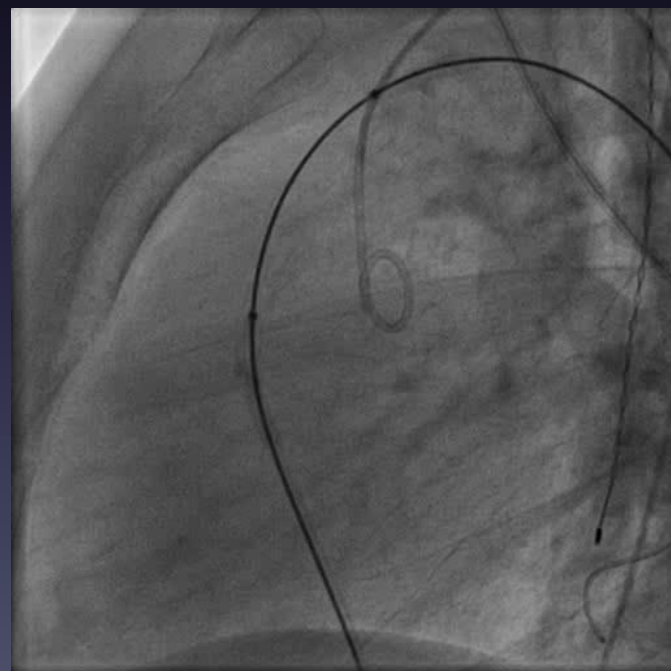
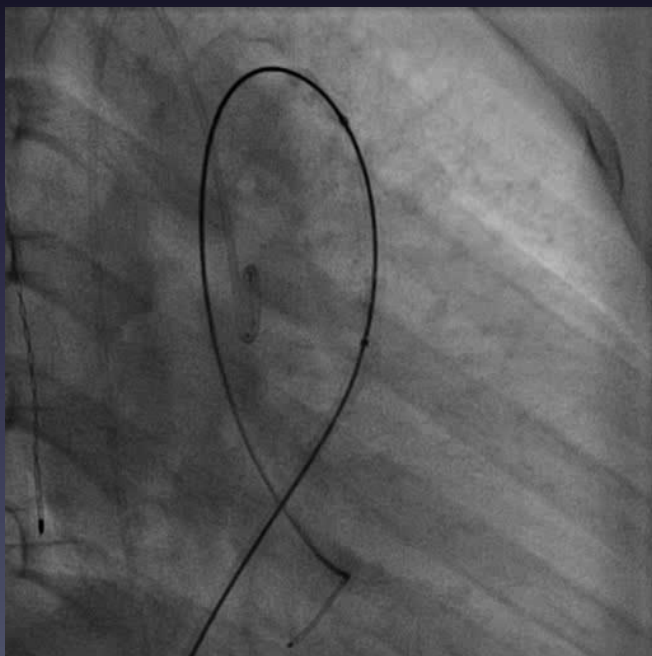
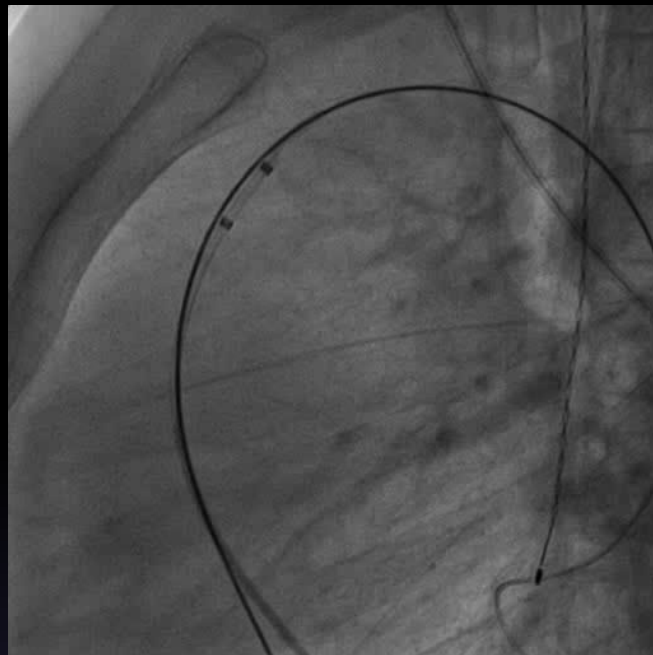
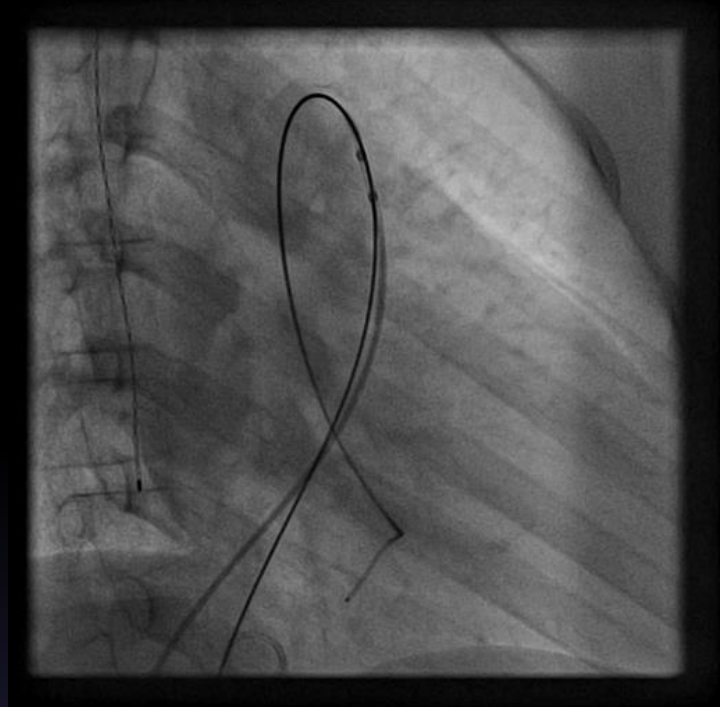
# CASE WITH REFRACTORY PS: DYSPLASTIC PULMONARY VALVE: PULMONARY VALVULATION AND NOONAN SYNDROME

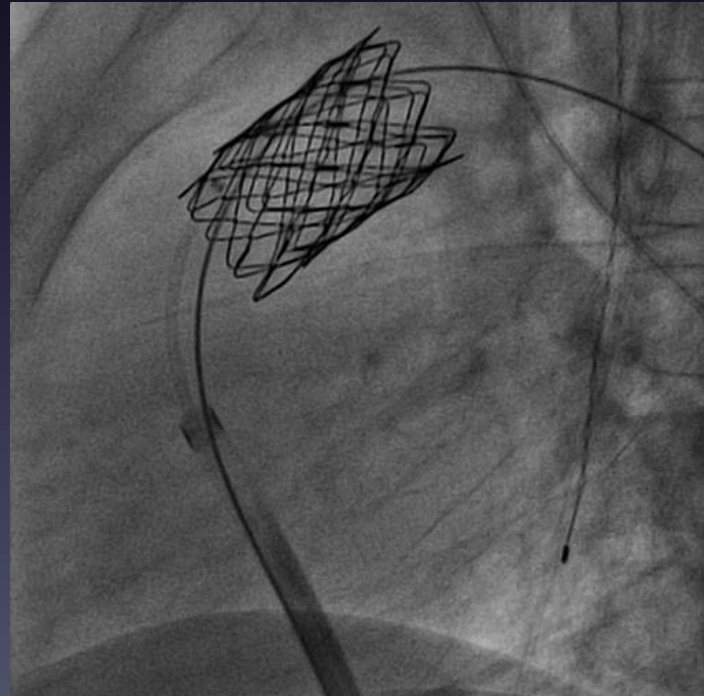
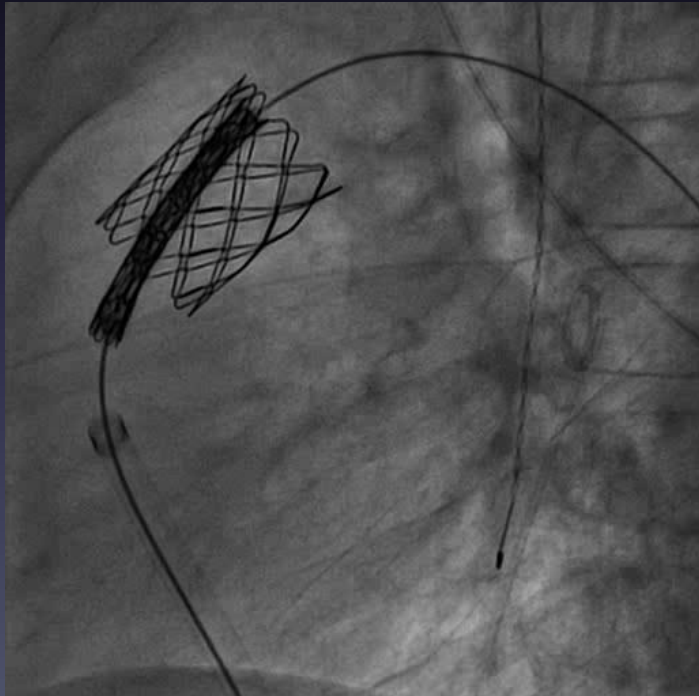
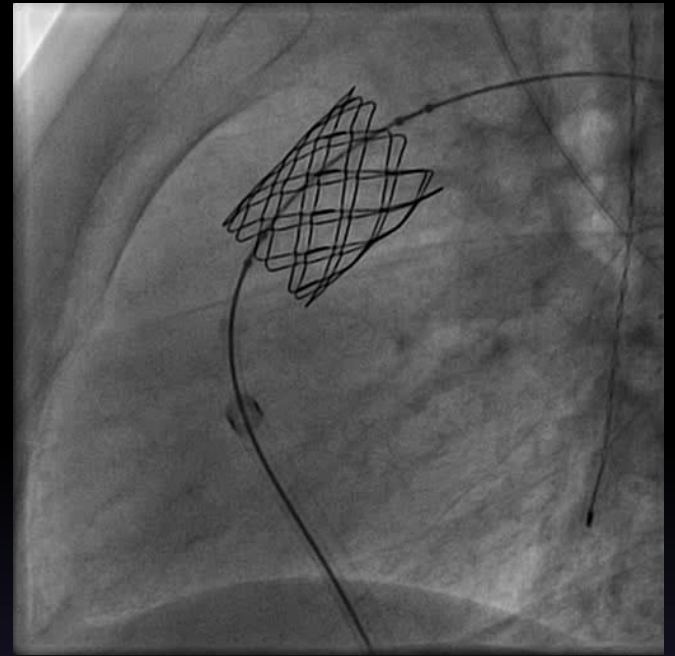
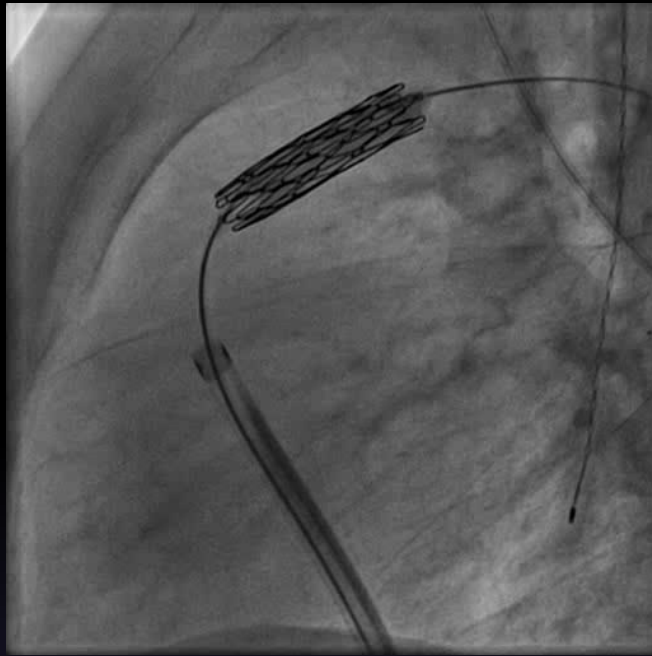
- 12 yo female, Noonan syndrome and severe PS
- S/P BD at 2 and 7 months with mild improvement (RV pressure from systemic to slightly infrasytemic)
- Stable RVOT gradient till 2010 (35-40 mmHg mean Gradient by Doppler)
- After 3 years of lost for F/U, presented in Dec 2013

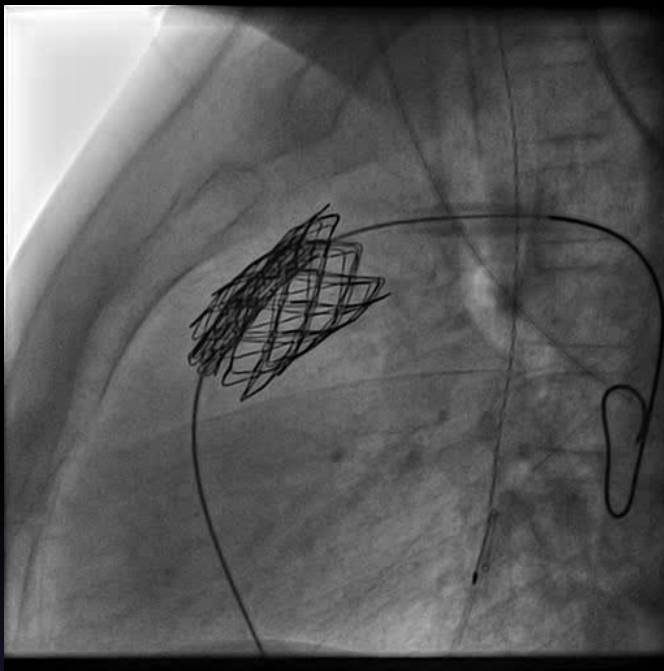
- 40 kg, 145 cm, SaO<sub>2</sub> 100%
- NI ECG
- Asymptomatic
- Echo: mean gradient 65-70 mmHg, 95 mmHg syst RVP hypertrophic RV with good syst function
- MRI : RVED vol 56 mL/m<sup>2</sup>, RVEF 72%.

No PR

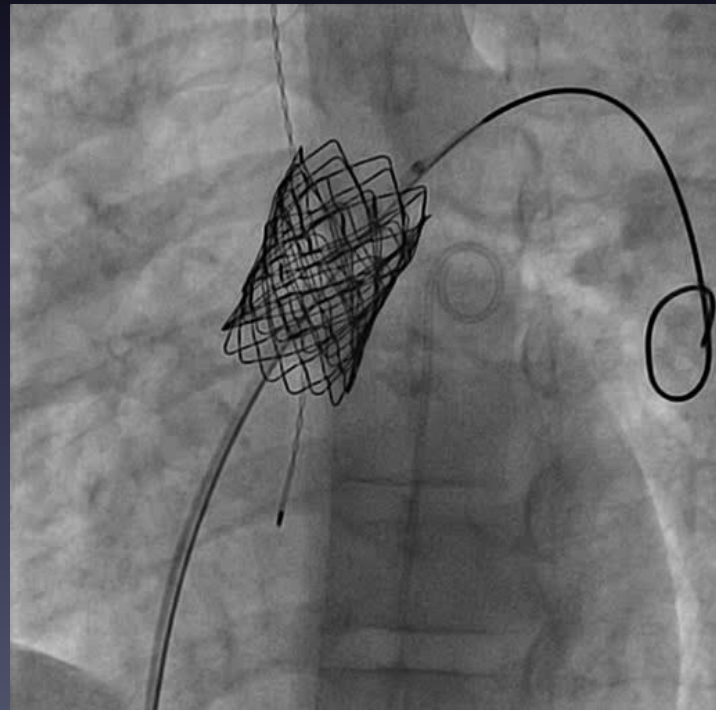
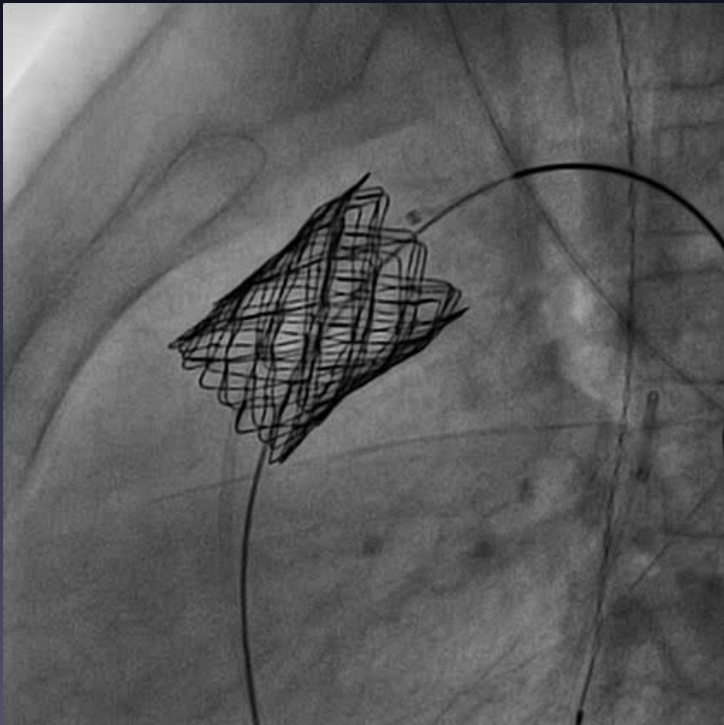


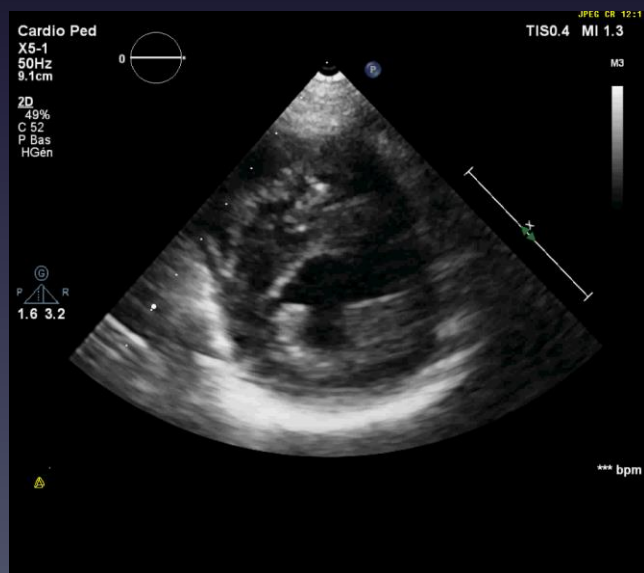
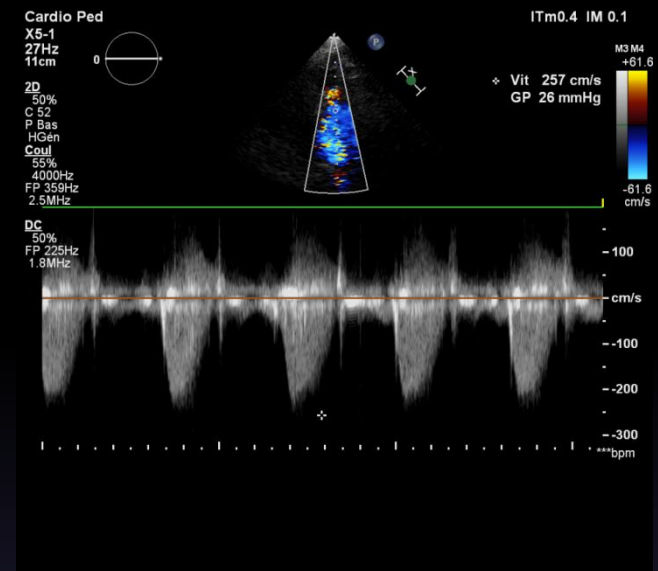
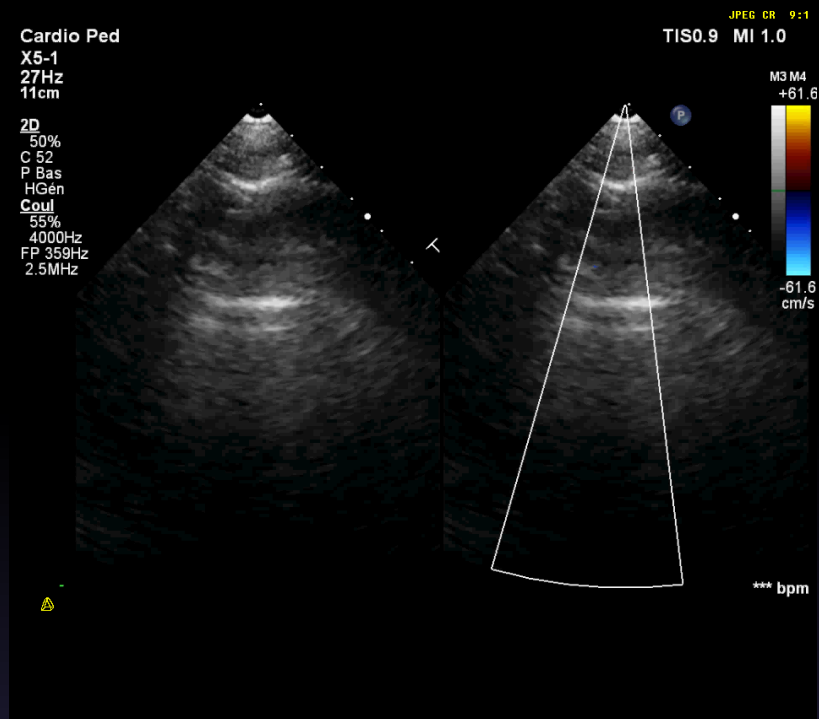






- Systolic RVP 31 mmHg
- No PR
- No complications





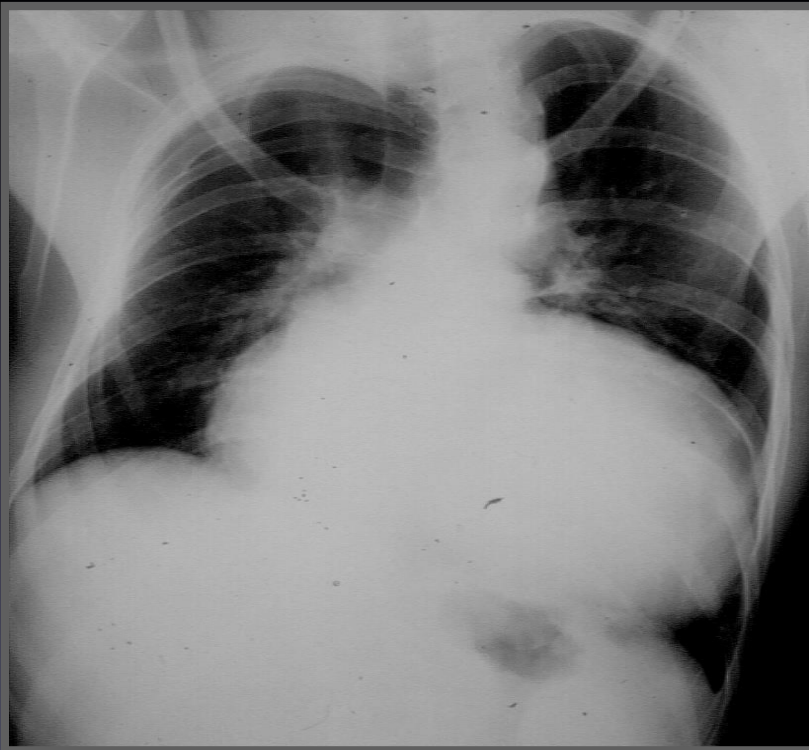
# Follow-up

- Doing well, normal RV pressure
- 7 mo F/U MRI: no regurgitation, good RV ft

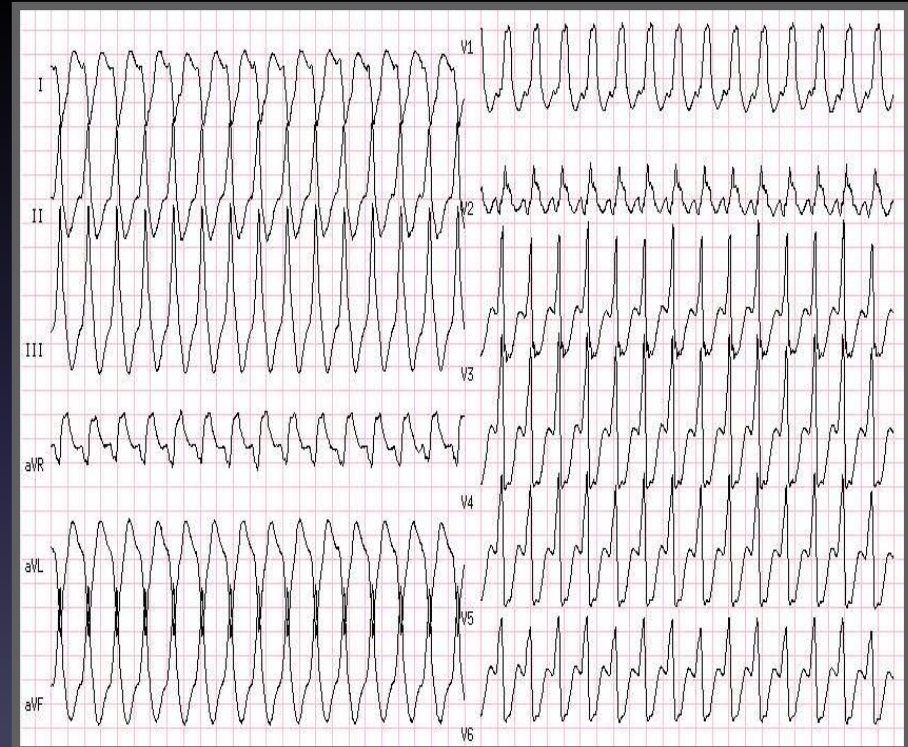


# Pulmonary regurgitation

RV dysfunction

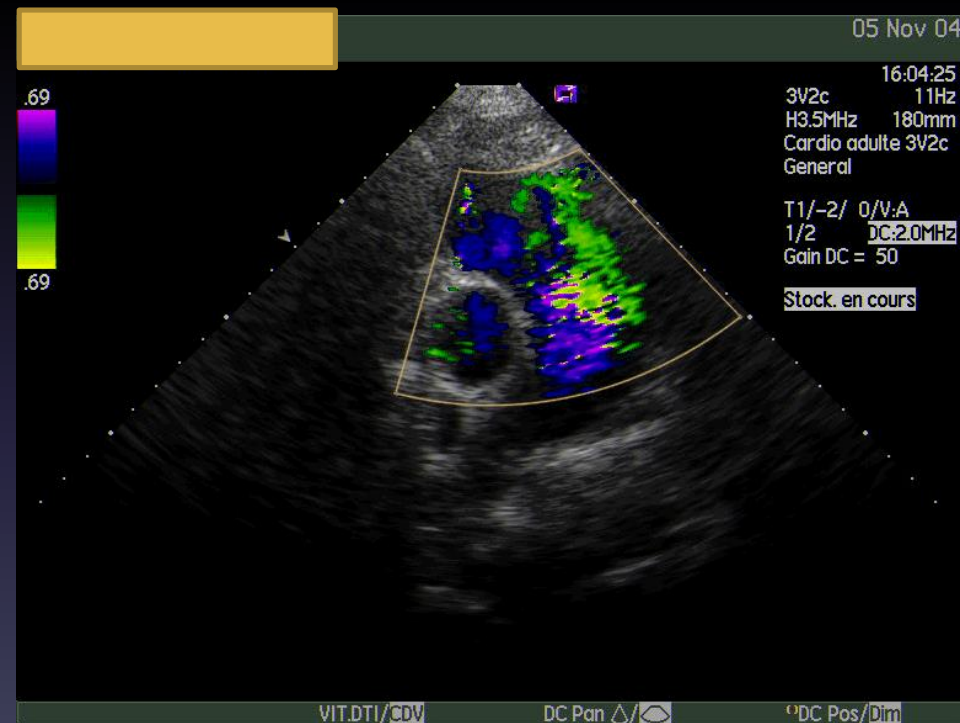
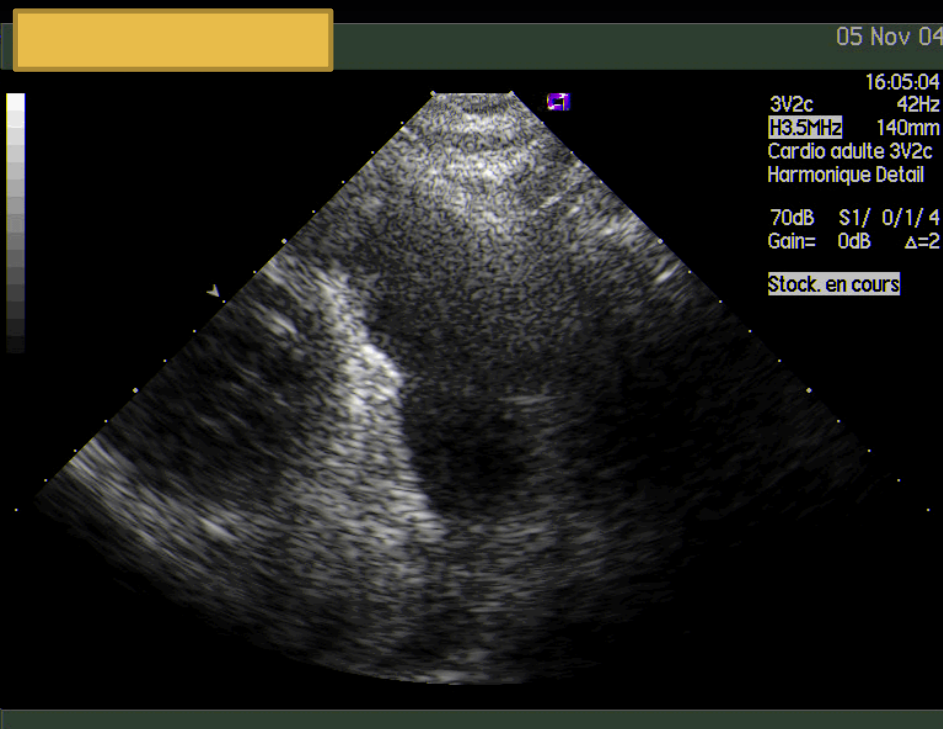


Arrhythmia

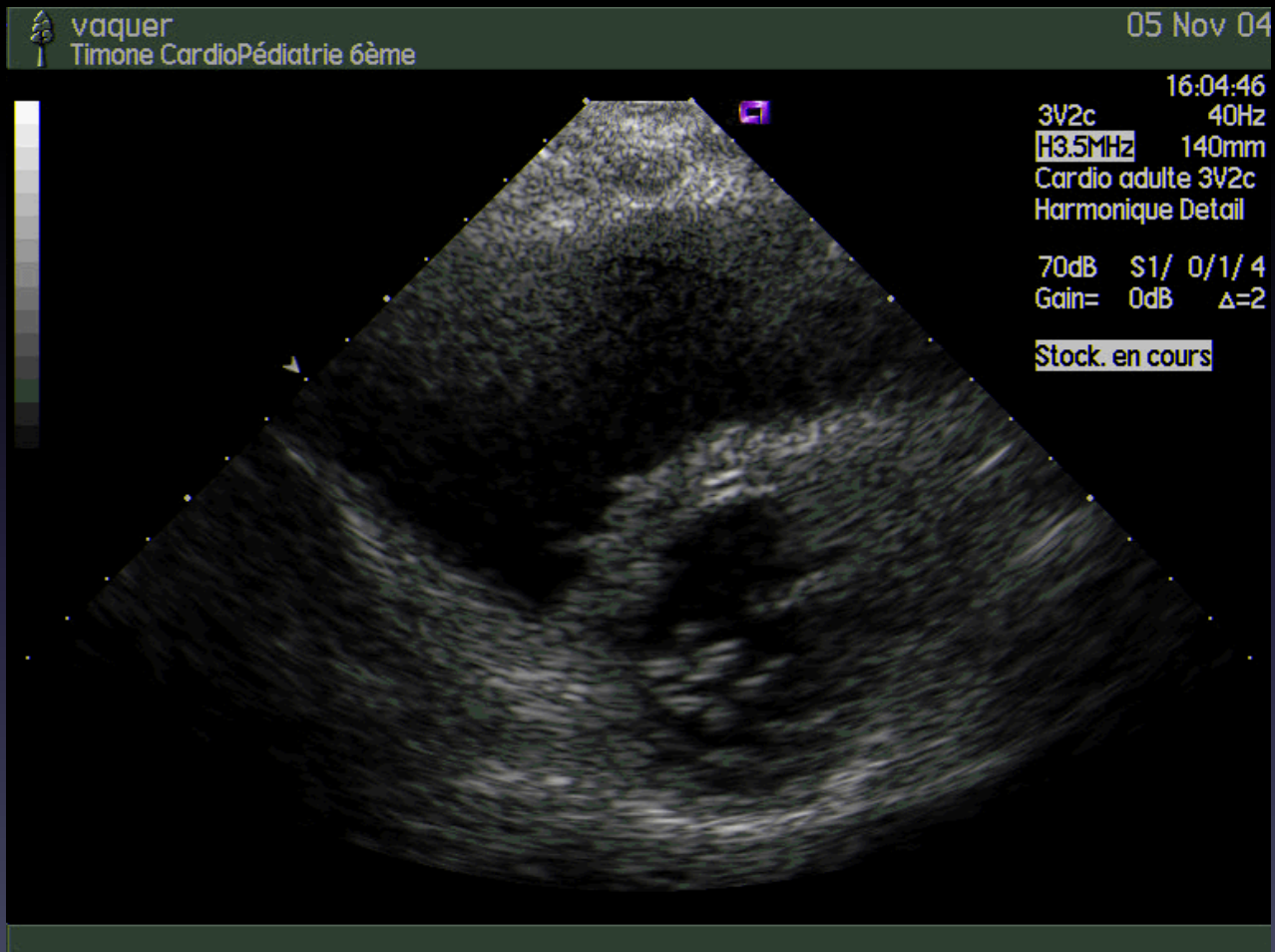


long-term consequences of PR

# PR in a 34 yo patient S/P surgical valvotomy in infancy



# RV overload



# Dilated RV



vaquer  
Timone CardioPédiatrie 6ème

05 Nov 04

16:04:07



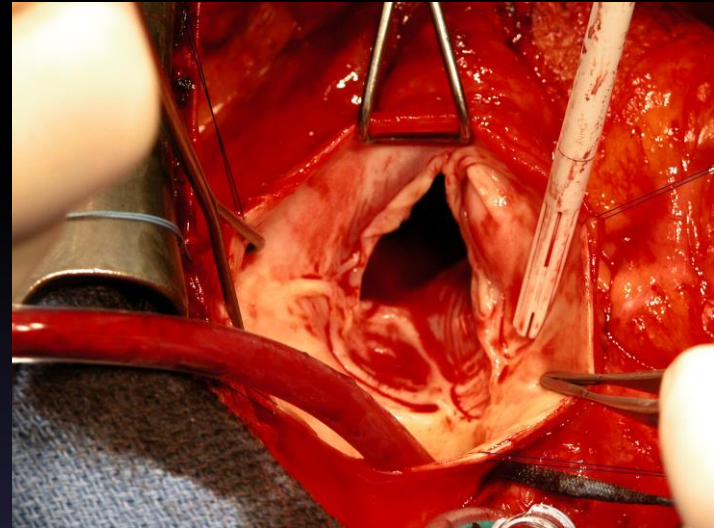
Stock. en cours

70dB S1/ 0/1/ 4  
Gain= 0dB  $\Delta=2$

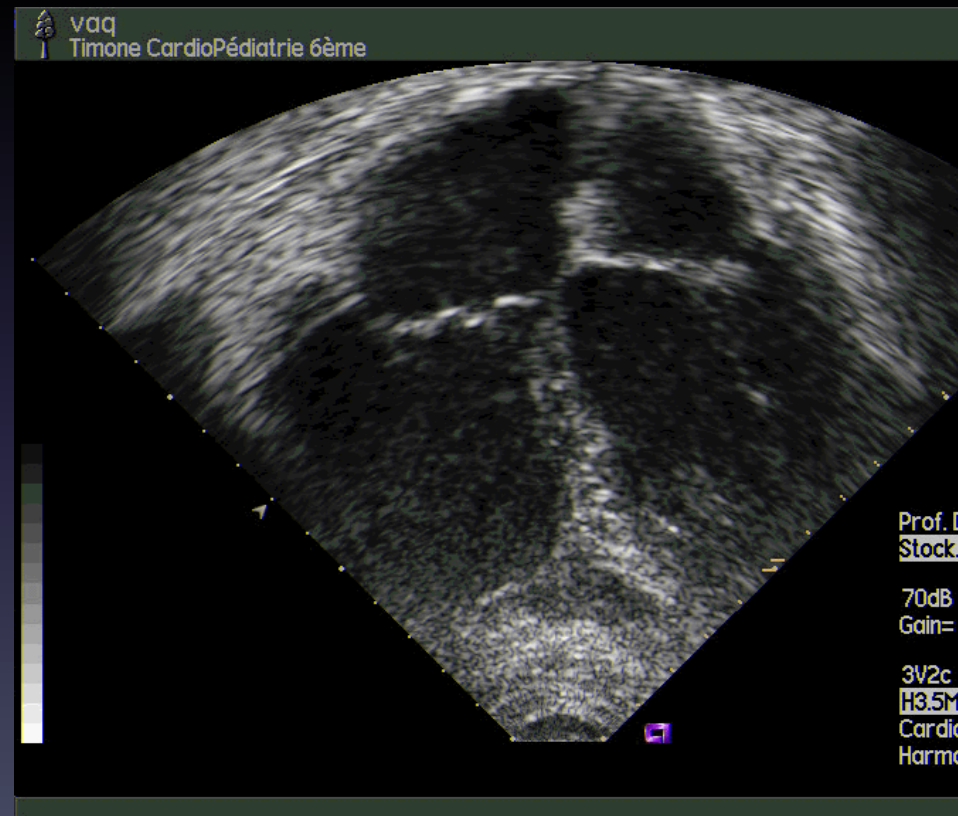
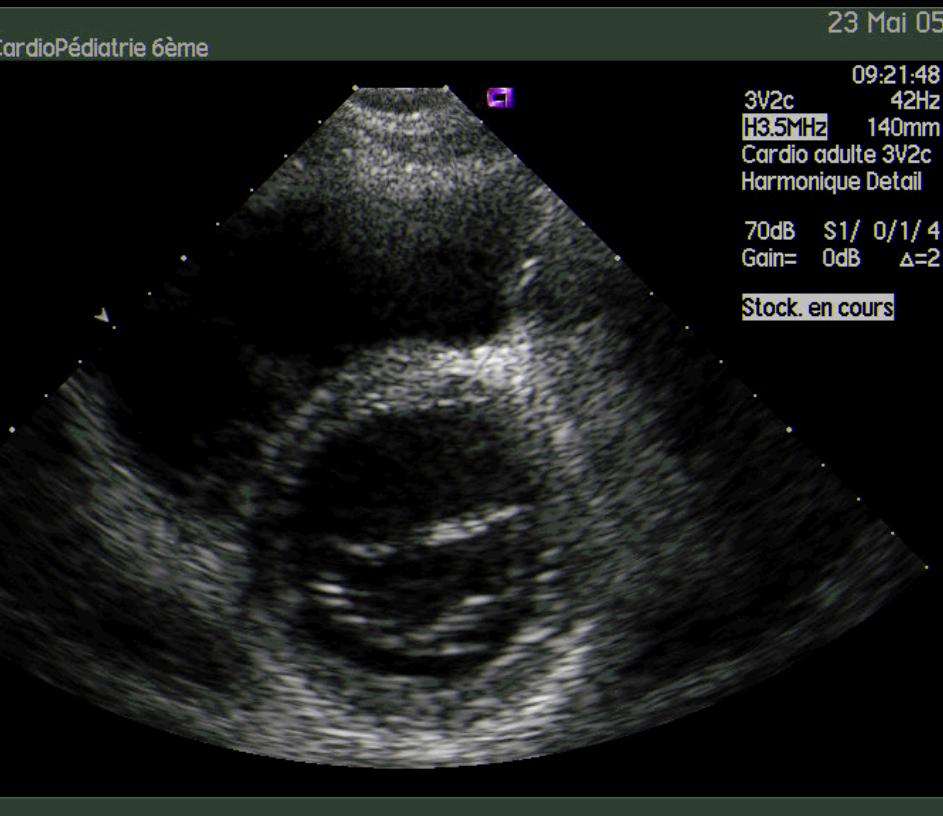
3V2c 21Hz  
H3.5MHz 180mm  
Cardio adulte 3V2c  
Harmonique Detail

# Treatment and outcome

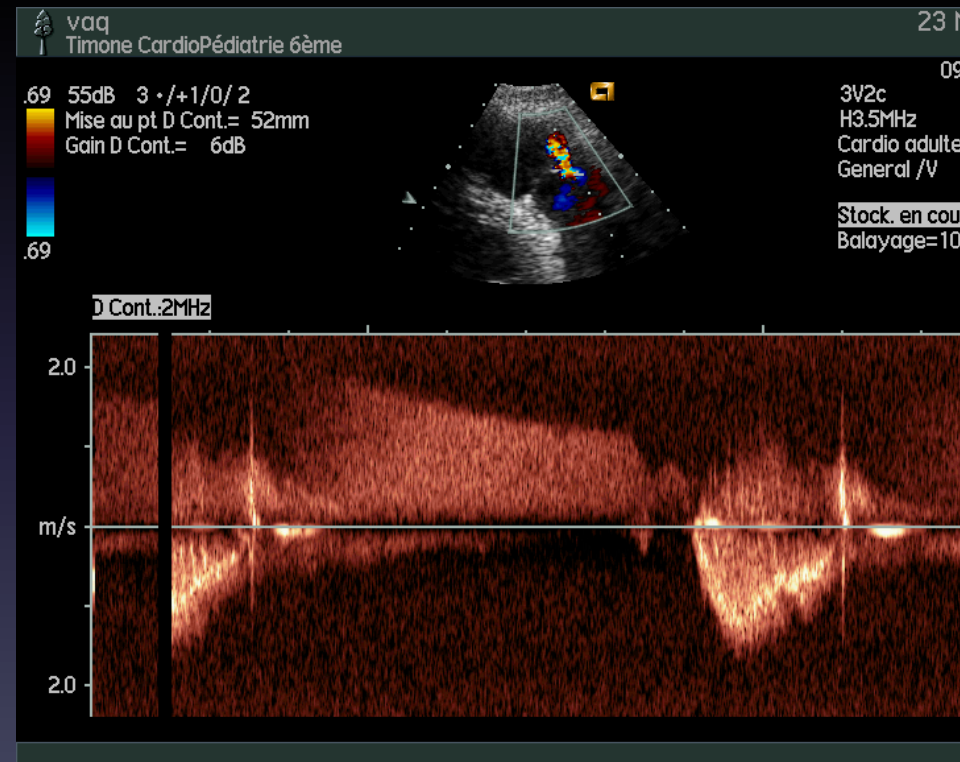
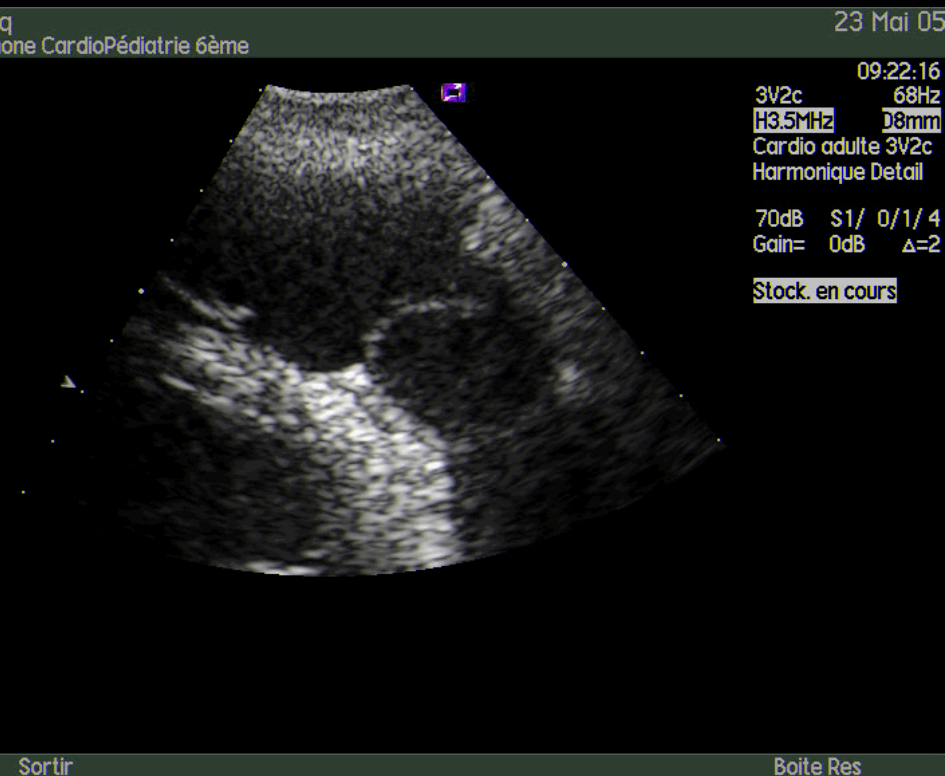
- Surgery:
  - Surgical plasty of RV infundibulum
  - 28mm pulmonary homograft implantation
- Outcome :
  - Asymptomatic
  - Normal 24h Holter monitoring



# Postop Echo : RV less dilated



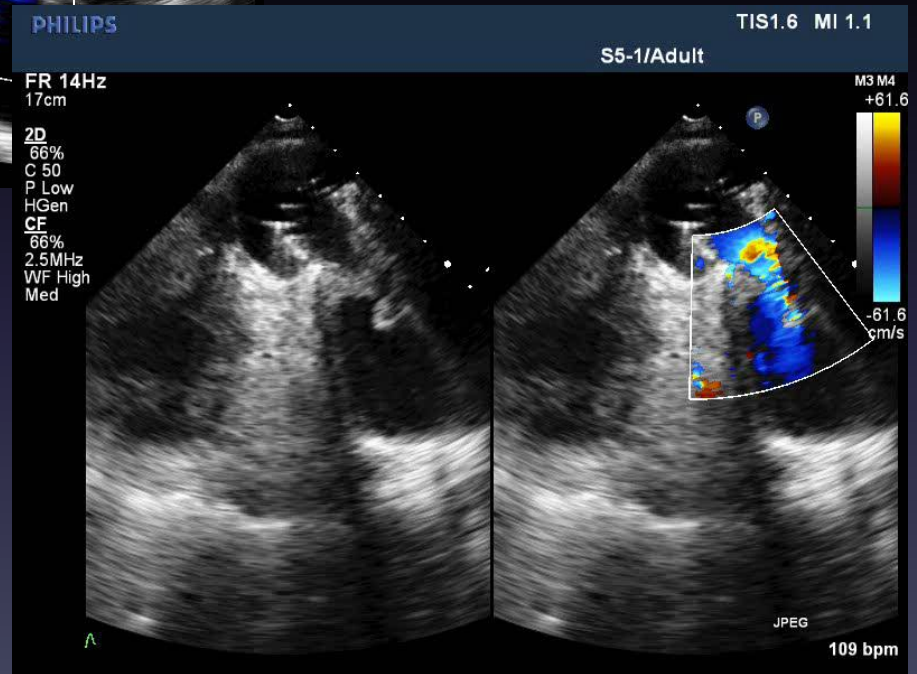
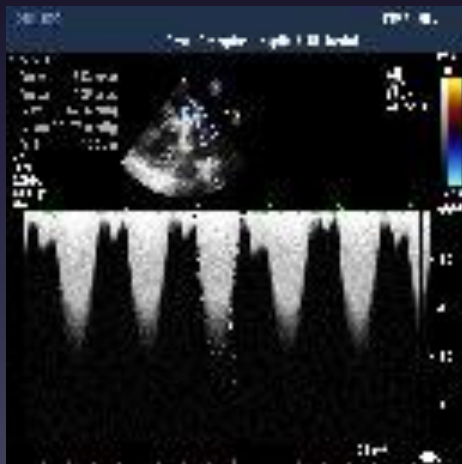
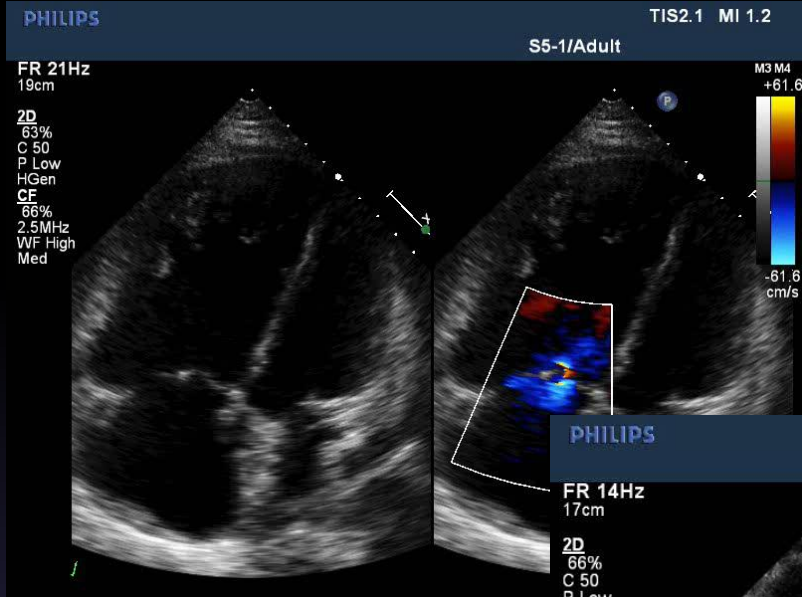
# Good function of the homograft



# TEE and intracardiac echo for endocarditis

- 29 yo, ToF Agenesia of pulm valve S/P complete repair, S/P Melody valve implantation in 2012, presenting with severe RVOT obstruction due to multiple vegetation.
- Microdeletion 22/11
- The RV function is severely impaired and it is decided to proceed with transcatheter desobstruction of the RVOT as palliative procedure

- 79 kg, SaO<sub>2</sub> 95%
- Dental abscess treated in feb 16
- NI ECG
- Severe RV failure but no septic shock
- Echo: mean gradient 65-70 mmHg, 95 mmHg syst RVP, dilated RV with very depressed syst function
- Huge vegetation mass obstructing the Melody valve mainly at its distal end



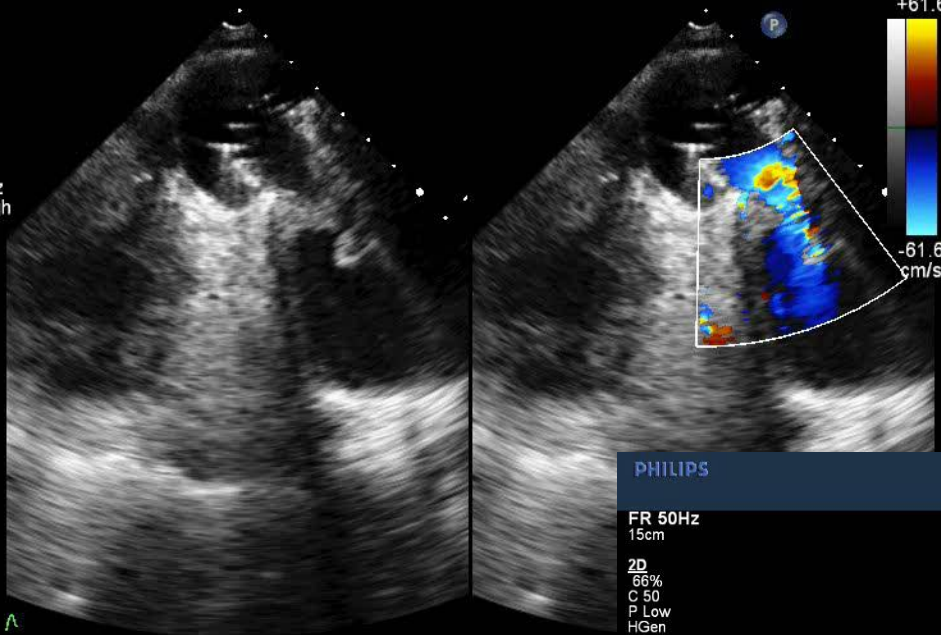
PHILIPS

TIS1.6 MI 1.1

S5-1/Adult

FR 14Hz  
17cm

2D  
66%  
C 50  
P Low  
HGen  
CF  
66%  
2.5MHz  
WF High  
Med



Conference

PHILIPS

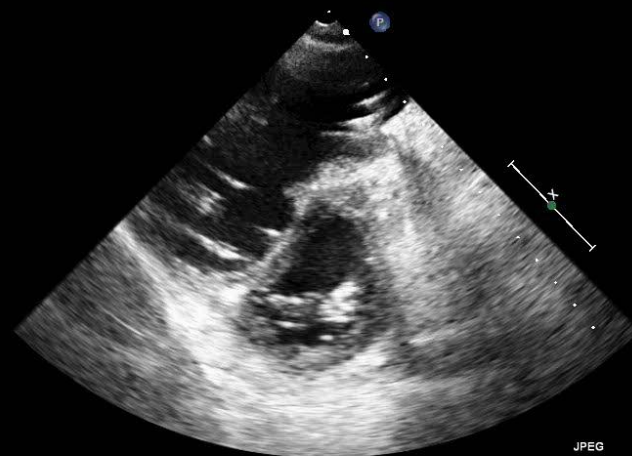
TIS0.8 MI 1.4

S5-1/Adult

FR 50Hz  
15cm

2D  
66%  
C 50  
P Low  
HGen

P R  
1.7 3.4



JPEG

110 bpm

PHILIPS

PETERS, SAMUEL

20/08/2016

01:16:55

TIS0.2 MI 0.5

H46624

X7-2t/Adult

FR 32Hz  
7.5cm

3D Beats 1

M4

3D  
3D 52%  
3D 40dB



PAT T: 37.0C  
TEE T: 40.0C

PHILIPS

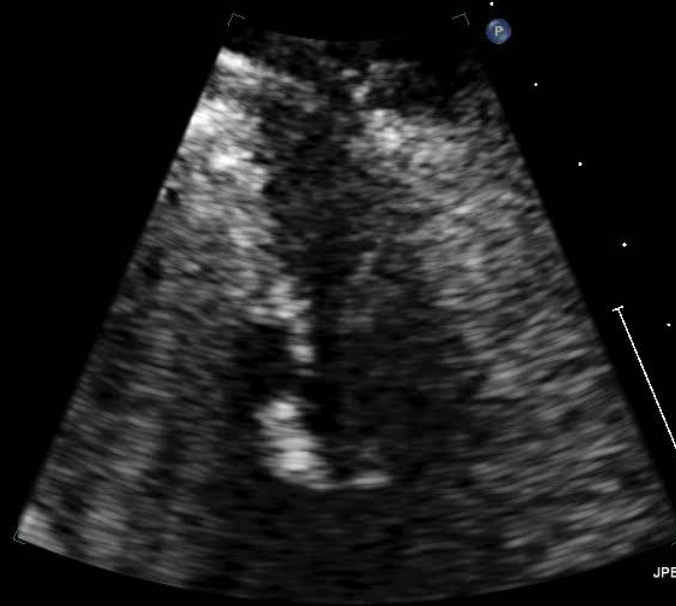
TIS0.9 MI 1.2

FR 126Hz  
9.3cm

S5-1/Adult

M3

2D  
63%  
C 50  
P Low  
HGen



JPEG

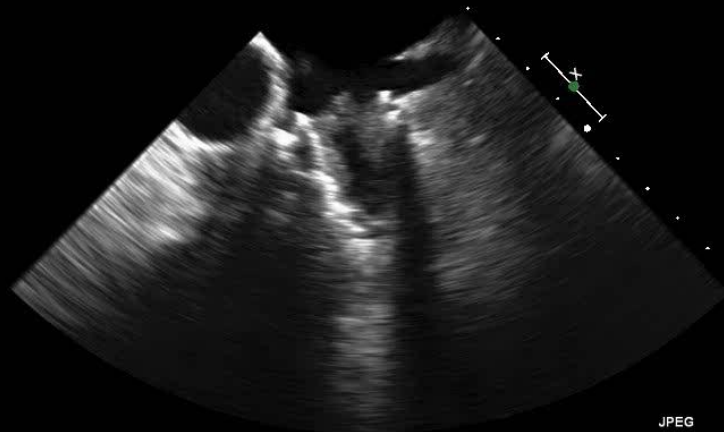
108 bpm

FR 50Hz  
12cm

2D  
65%  
C 50  
P Off  
Gen



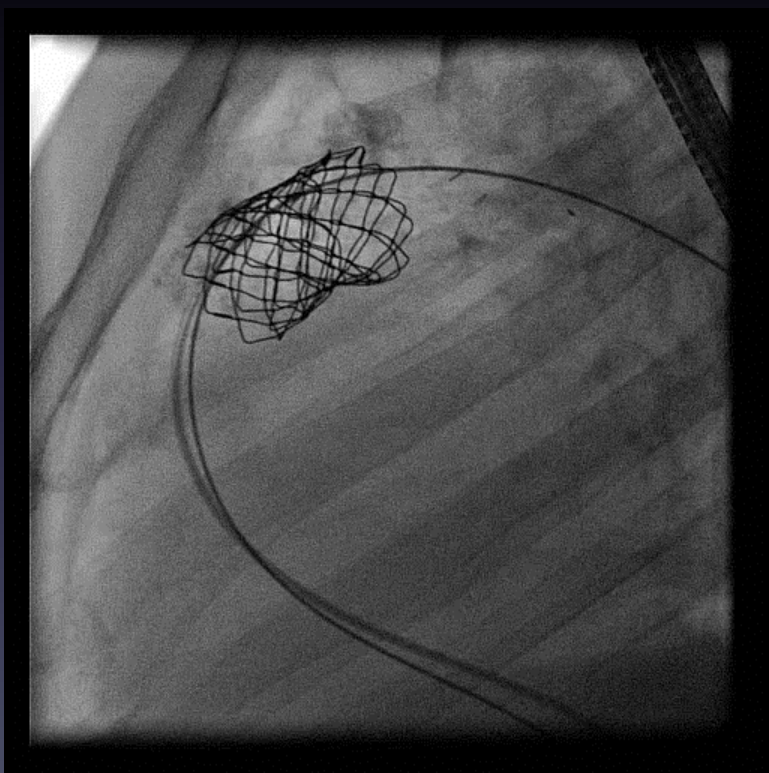
G  
P R

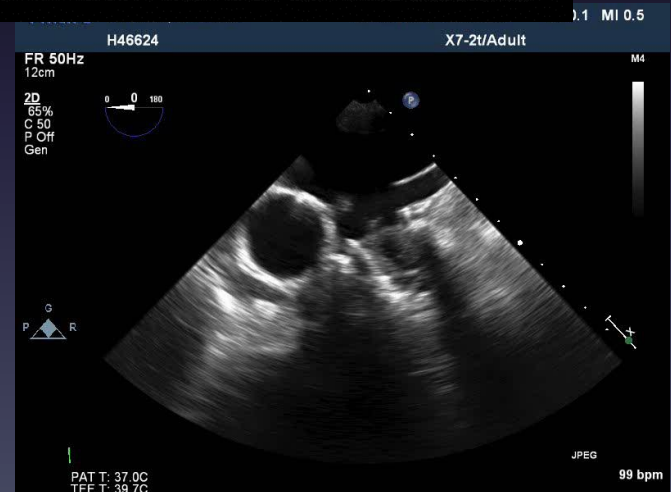
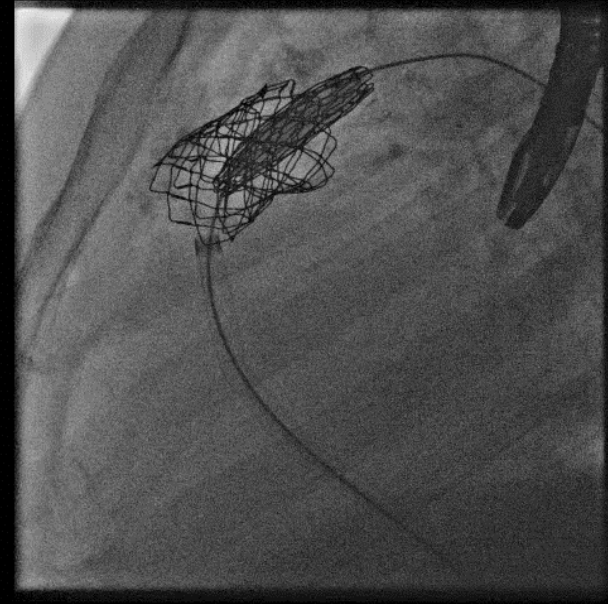
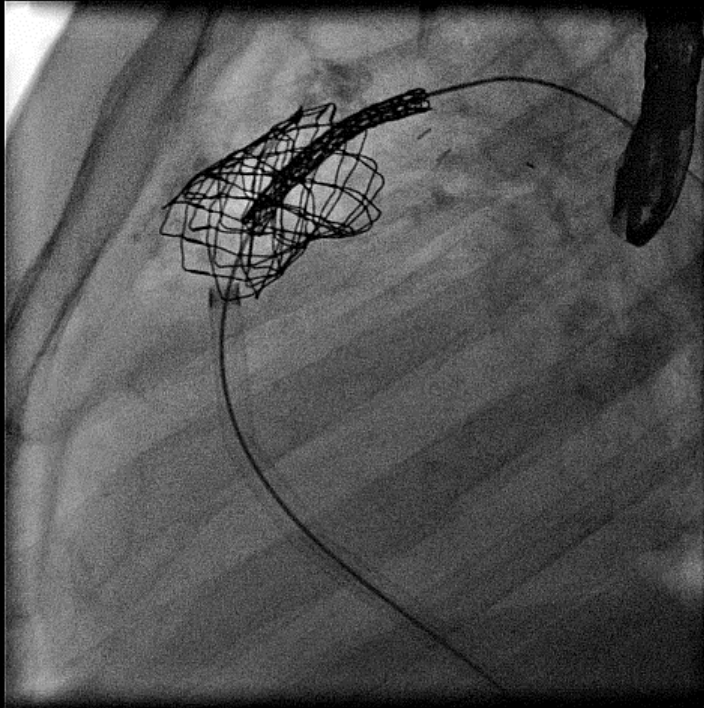


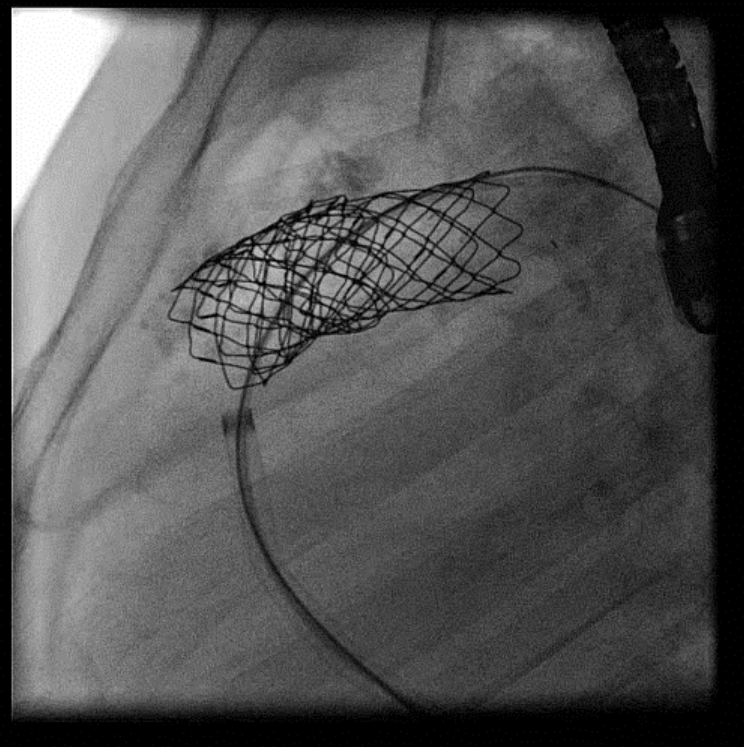
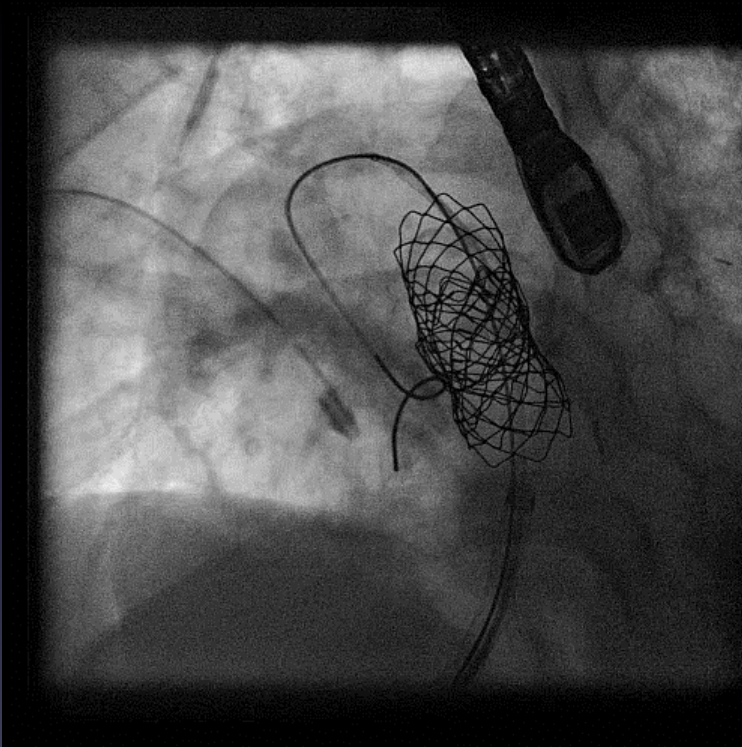
PAT T: 37.0C  
TEE T: 39.8C

JPEG

85 bpm





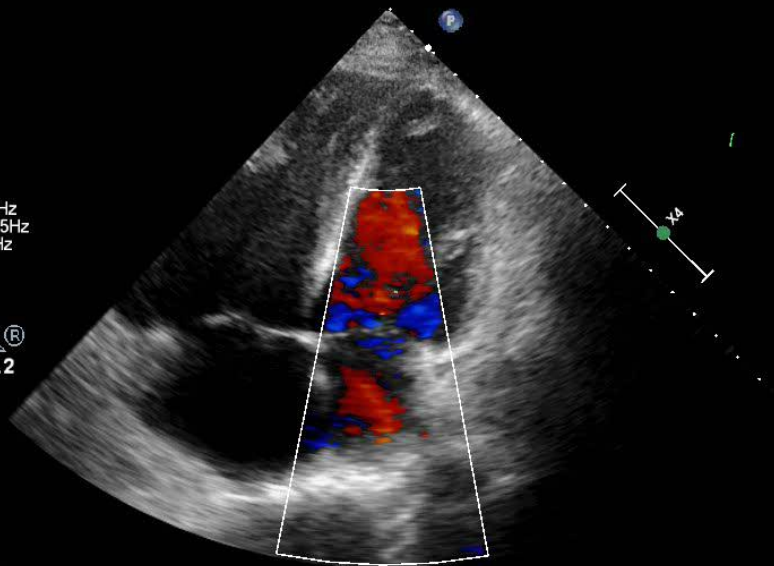


RBH  
S5-1  
21Hz  
18cm

2D  
78%  
C 55  
P Low  
HRes

CF  
48%  
3857Hz  
WF 385Hz  
2.5MHz

⊙  
P ⊙ R  
2.1 4.2



105 bpm

PHILIPS

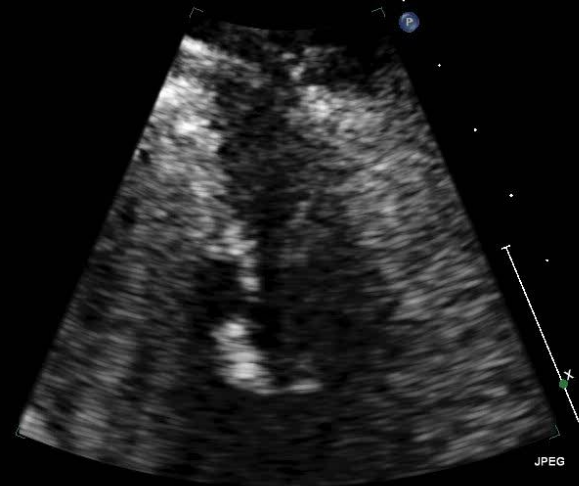
TIS0.9 MI 1.2

S5-1/Adult

FR 126Hz  
9.3cm

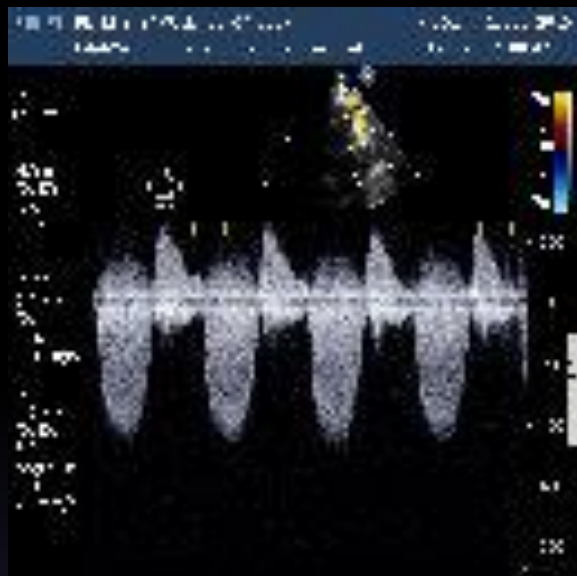
2D  
63%  
C 50  
P Low  
HGen

⊙  
P ⊙ R  
1.7 3.4



108 bpm

59.4  
cm/s

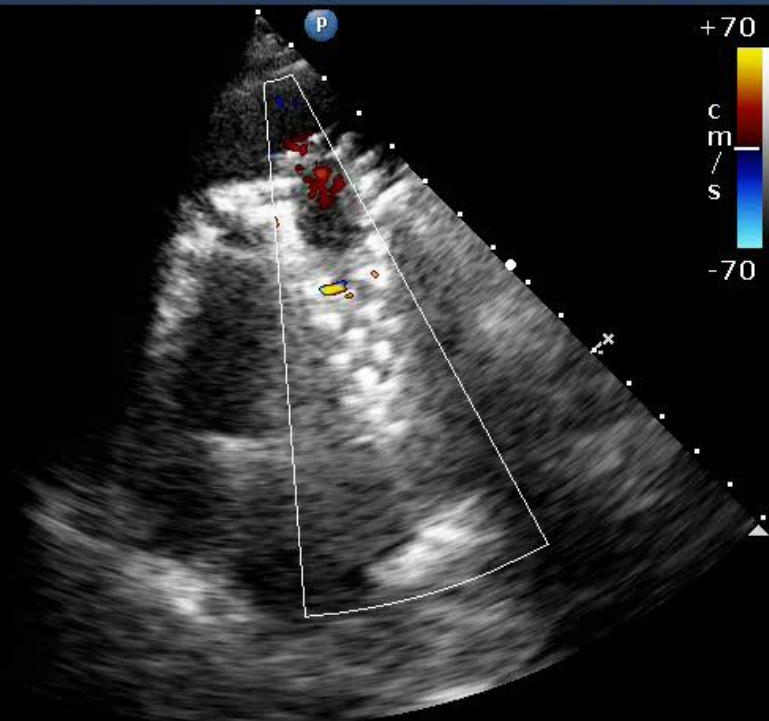


Gn 41  
4/5/0  
Fltr High

ⓐ  
P R  
1.6 3.2

22/07/1987  
al Brompton Hospital

MI 0.9  
TIS 1.3  
23/08/2016  
11:00:26



| Site          | Condition 1:                |                                | Condition 2:<br>After RVOT stenting |                                |  |
|---------------|-----------------------------|--------------------------------|-------------------------------------|--------------------------------|--|
|               | Pressure<br>S/D/M<br>(mmHg) | Sats (%)<br>FiO <sub>2</sub> : | Pressure<br>S/D/M<br>(mmHg)         | Sats (%)<br>FiO <sub>2</sub> : |  |
| IVC           |                             |                                |                                     |                                |  |
| SVC           |                             |                                |                                     |                                |  |
| RA            | 24 (mean)                   |                                |                                     |                                |  |
| RV            | 97/23                       |                                | 64/9                                |                                |  |
| MPA           | 25/20/22                    |                                |                                     |                                |  |
| LPA           |                             |                                |                                     |                                |  |
| RPA           | 26/19/22                    |                                |                                     |                                |  |
| Radial artery | 95 (systolic)               |                                | 124/75/95                           |                                |  |
|               |                             |                                |                                     |                                |  |
|               |                             |                                |                                     |                                |  |
|               |                             |                                |                                     |                                |  |

# Outcome

- Dramatic clinical improvement
- Afebrile, CRP 45, negative cultures
- CT scan on 21/8/16 and on 26/08/16

# Imaging F/U

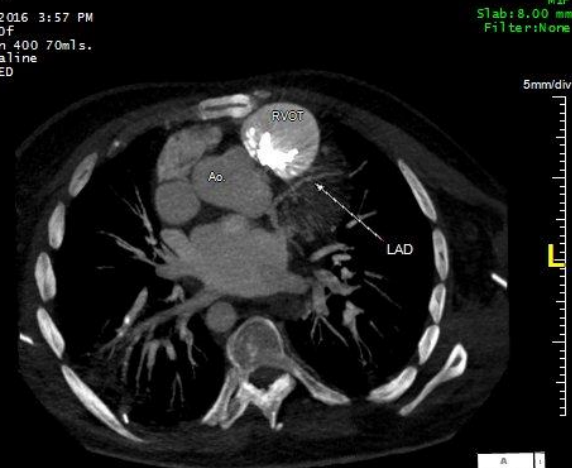
- CT scan on 21/8:
  - 1. Stent insitu as demonstrated on reconstructed images - residual filling of the anterosuperior bulge in the original homograft.
  - 2. Segmental pulmonary emboli with multiple peripheral 'fluffy' nodules which may represent mycotic embolic foci
  - 3. Features of aspiration in the right lower lobe.
- CT scan on 26/8: Stable appearance of the small segmental pulmonary emboli with an increase in the number and size of peripheral areas of wedge shaped consolidation consistent with pulmonary infarcts. This may reflect maturation of previous regions of infarction described previously.

Set:12  
21-Aug-2016 3:57 PM  
Kern:B30F  
.Iomeron 400 70mls.  
40mls Saline  
C:APPLIED



Filter:None

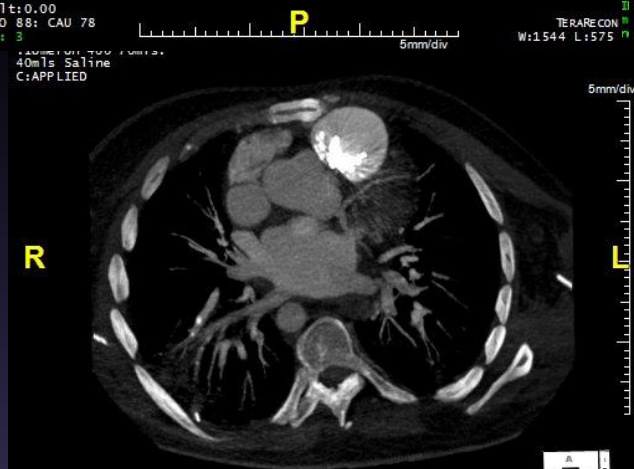
Set:12  
21-Aug-2016 3:57 PM  
Kern:B30F  
.Iomeron 400 70mls.  
40mls Saline  
C:APPLIED



Slab:8.00 mm  
Filter:None

FOV:292.00 mm  
120 kV  
578 mA  
Tilt:0.00  
LAO 88: CAU 78  
No: 3

W:1544 L:575  
TERARE CON  
C:APPLIED



FOV:292.00 mm  
120 kV  
578 mA  
Tilt:0.00  
LAO 88: CAU 78  
No: 1

W:1077 L:480  
TERARE CON



FOV:292.00 mm  
120 kV  
578 mA  
Tilt:0.00  
LAO 88: CAU 78  
No: 2

W:1544 L:575  
TERARE CON



Set:12  
21-Aug-2016 3:57 PM  
Kern:B30F  
.Iomeron 400 70mls.  
40mls Saline  
C:APPLIED

FOV:292.00 mm  
120 kV  
578 mA  
Tilt:0.00  
LAO 88: CAU 78  
No: 4

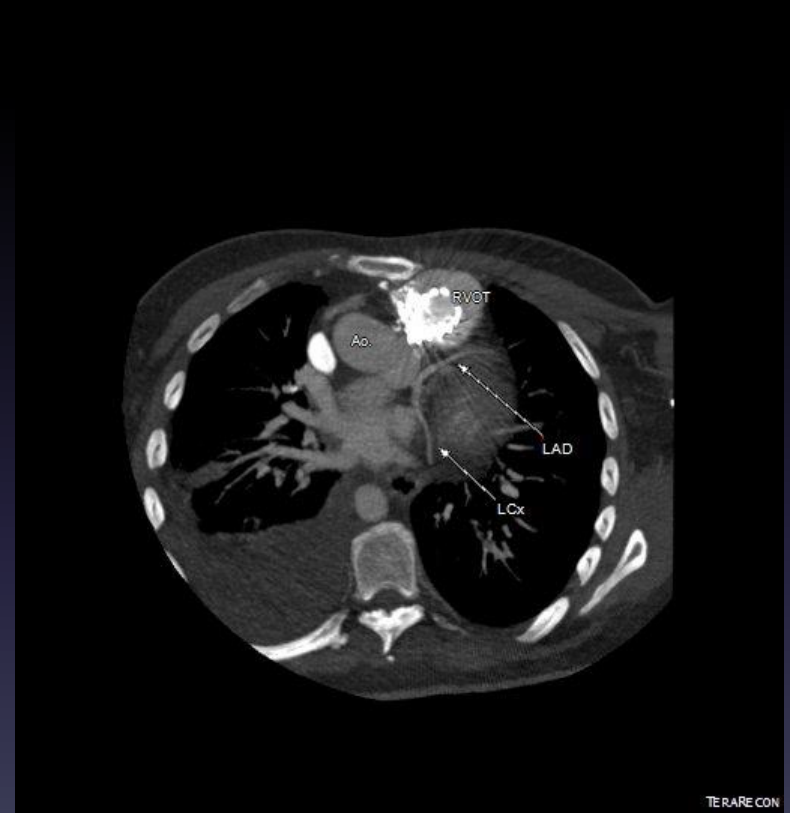
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TERARE CON

Filter:None

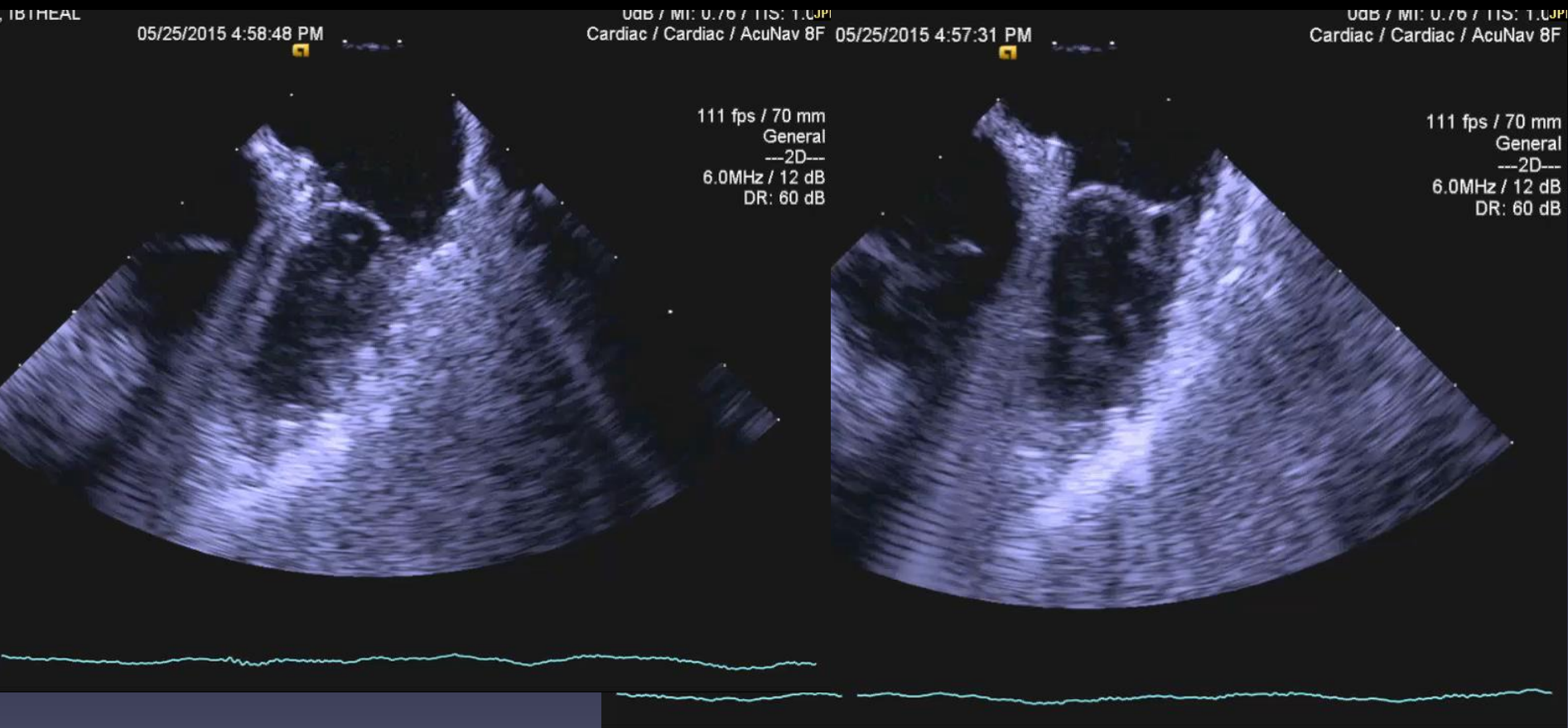
# Surgery on 6/9/16

- RVOT surrounded by huge amount of inflammatory and fibrotic tissue
- Very difficult dissection
- Easy removal of the RVOT stent
- Implantation of homograft but uncontrolled bleeding and severely depressed LV function on postoperative TEE
- Suspicion of LMCA stenosis, confirmed in cath lab
- Despite successful LMCA stenting, change of RVOT conduit with 24 mm Hancock valve, bleeding remained uncontrolled and was followed by patient's death
-

# Retrospective review of CT scan....



# Other examples: intracardiac echo showing small vegetations



# Conclusions

- Multidisciplinary imaging strategy
- Accurate assessment is crucial for treatment and outcome
- In very dysplastic pulmonary valves sophisticated echocardiography (3D, intracardiac...) is helpful in difficult situations and also to better define treatment strategy (Surgery VS Interv cath)
- The most important part of the imaging assessment is not the pulmonary valve but the RV (and LV...) function