INTEGRATING ECHOCARDIOGRAPHY WITH CATHETER INTERVENTIONS FOR CONGENITAL HEART DISEASE

Krishna Kumar

SevenHills Hospital,

Mumbai, India

Why talk about it?

- What is the big deal?
- Are we not stating the obvious?
- Everyone who undergoes an intervention has an echo!

Why talk about it?

- To many interventionists the role of echocardiography is not intuitively obvious
- In many institutions echocardiography and interventions are performed by separate individuals.
- Many interventionists have limited echo imaging and performance skills.

Why talk about it?

In the limited resource environment:

- Limited human resources
- Limited time available for the procedure
- Limited hardware
- Limited opportunities for repeat procedure

In all situations:

Shorter procedure time = better outcomes
especially in sick compromised patients

Broad Agenda

- To illustrate with case examples the how echocardiography can be integrated in planning and performing interventions.
- To illustrate how excellence in congenital heart interventions requires excellence in echo image interpretation (and performance) skills

Specific Agenda

- How echocardiography can be used to
  - Determine suitability for intervention
  - Select the type of intervention
  - Plan the procedure precisely
  - Guide the procedure
  - Assess results
  - Follow-up

Suitability for intervention

- Echo critical: Most congenital heart interventions that include
  - ASD, VSD, PDA, many other communications
  - Balloon valvotomy: Pulmonary and aortic stenosis
  - PDA stenting
- Echo may not always help:
  - Coarctation, branch PA stenosis, coronary fistula closure, communications in the lung (arterio-venous malformations, Collaterals)

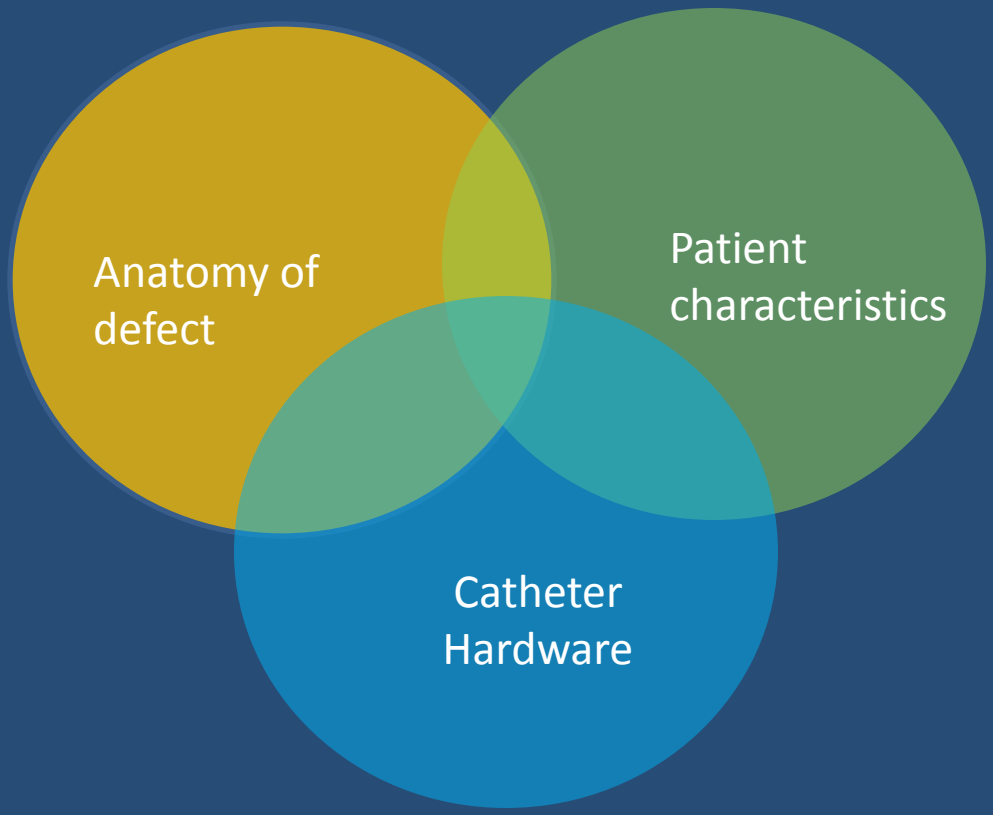
Selecting Type of Intervention

- PDA: Device Vs. Coil
- Multi-fenestrated ASD: Specific device for fenestrated ASD vs. single large vs. multiple devices
- VSD: type of device (ADO vs. asymmetric vs. MVSDO)
- Coarctation:
  - Plain balloon vs. Stent

Plan the procedure during echocadiography

- Device sizing for ASD / PDA/VSD etc
- Route for closure of VSD (Neck Vs. Femoral)
- PDA stenting: Length of stent, diameter of stent, Preferred approach,
- Multi-fenestrated ASD
- Balloon size for aortic and pulmonary balloon valvuloplasty, coarctation
- Deployed stent diameter in coarctation

Deciding Suitability for Intervention

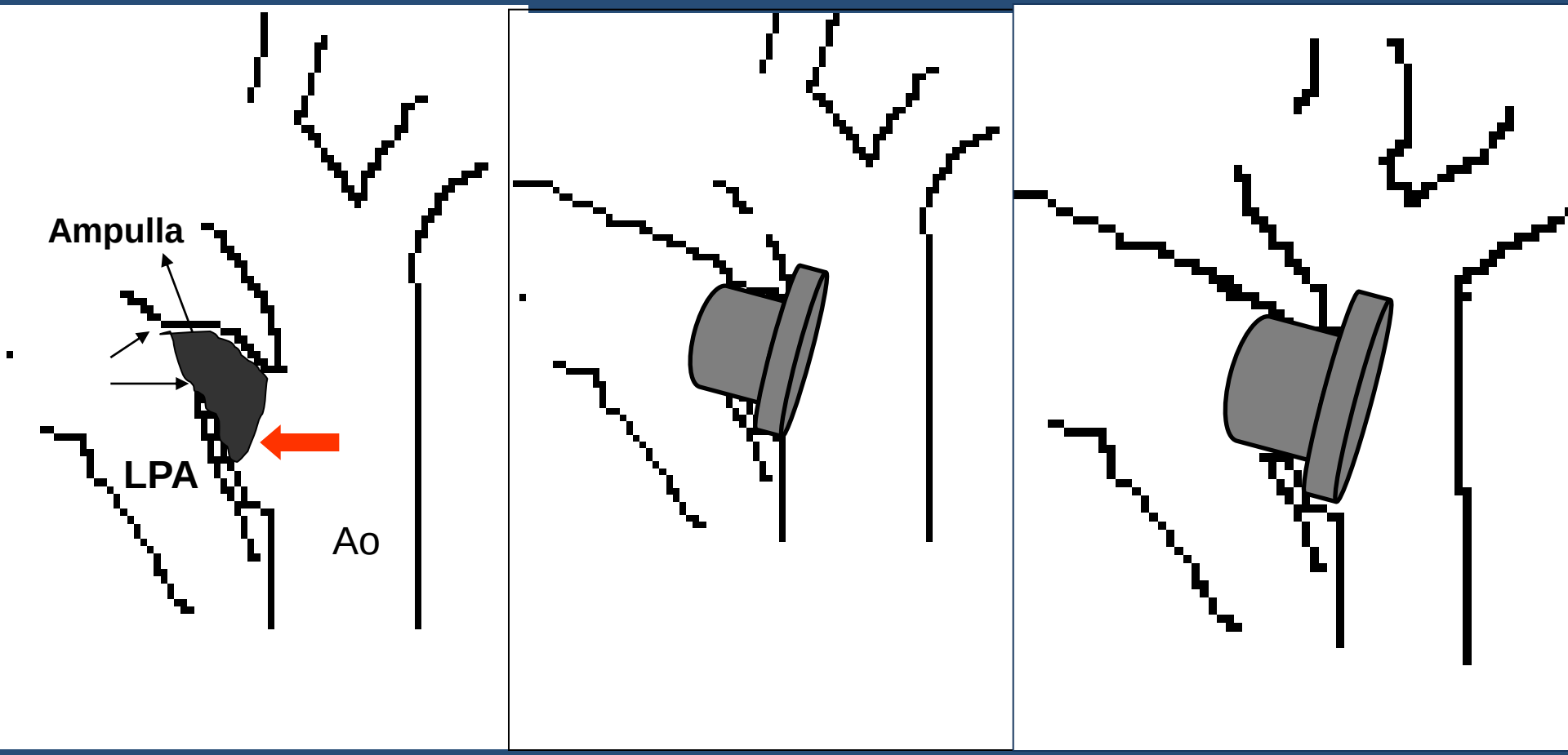


An intimate understanding of all three aspects maximizes the scope of catheter interventions

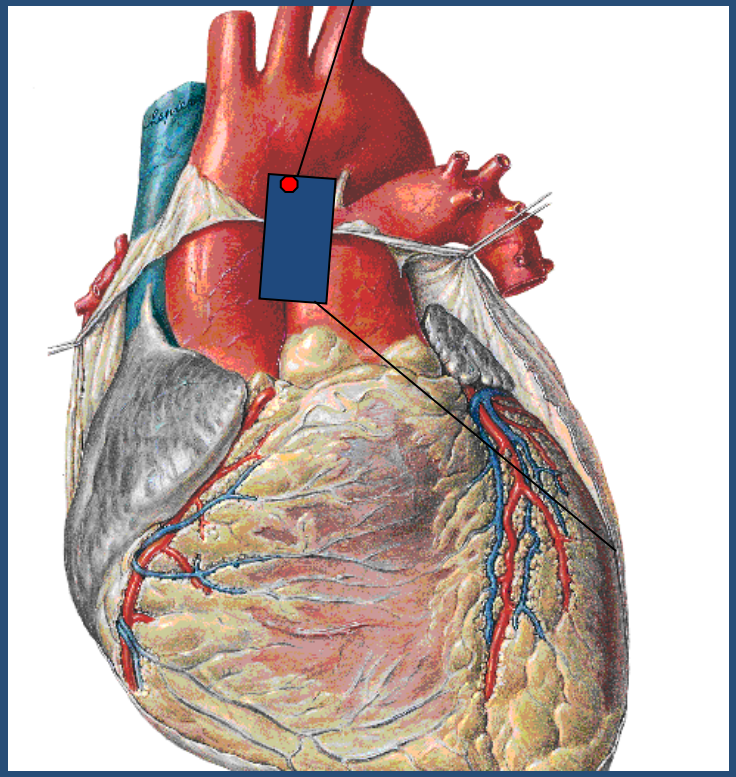
Suitability for Intervention

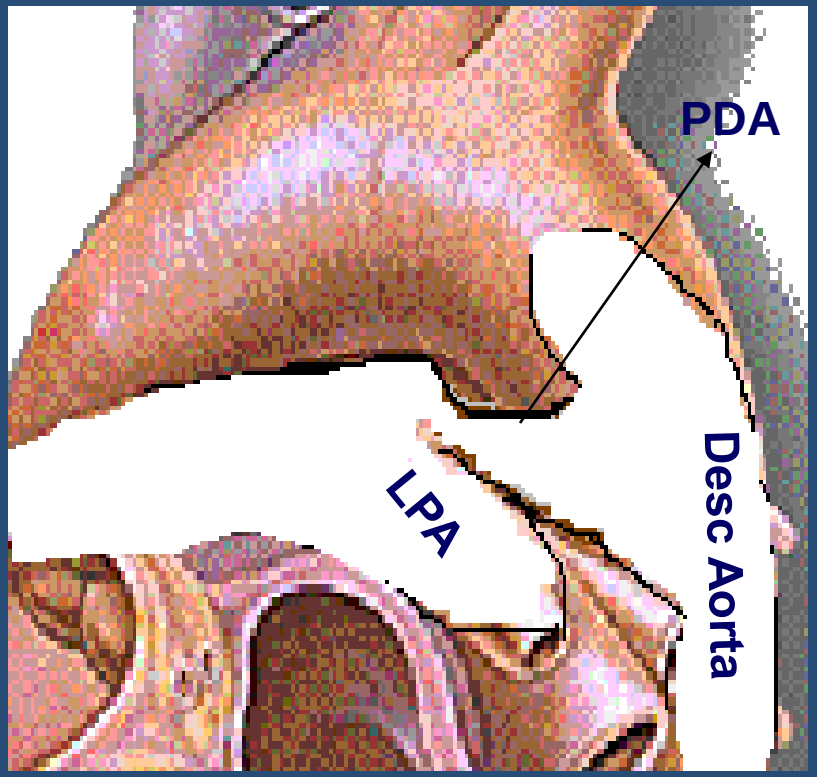
- PDA and other communications
- ASD
- VSD
- Other procedures

Patent Arterial Duct: Transcatheter Closure



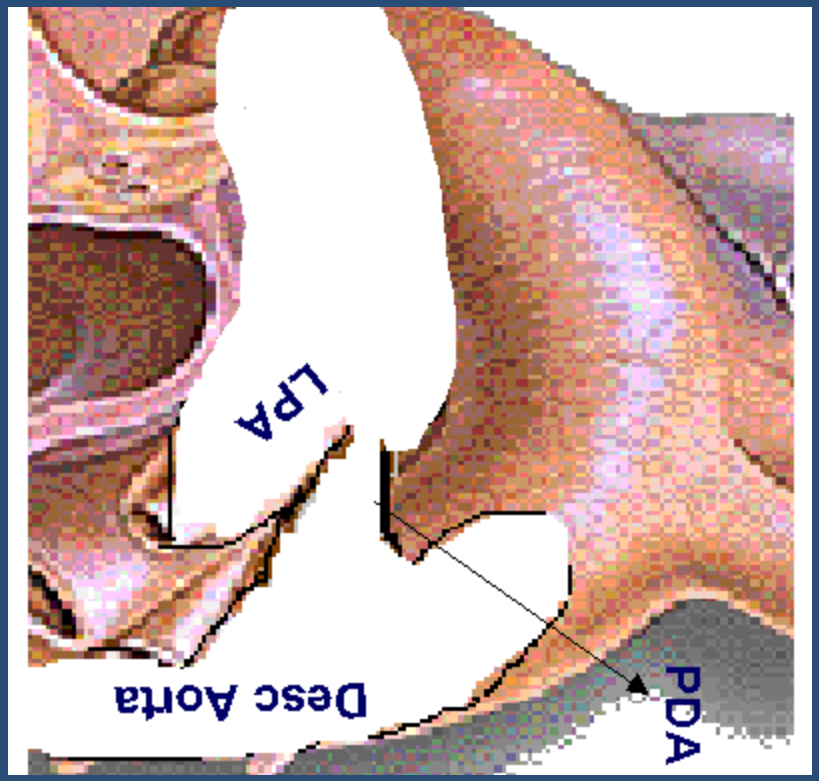
Diagnosis and Definition of the PDA: The High Parasternal or “Ductal View”

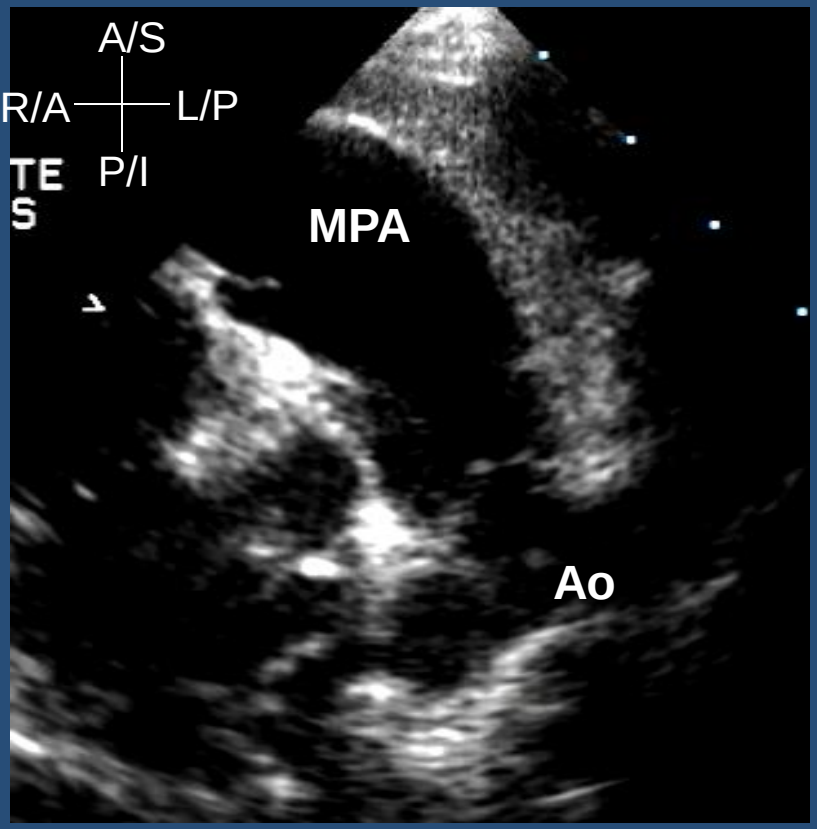




The high parasternal or the ductal view is obtained by placing the transducer high in the precordium (usually in the first intercostal space) and obtaining a section of the MPA-LPA and the descending aorta in the parasagittal plane.

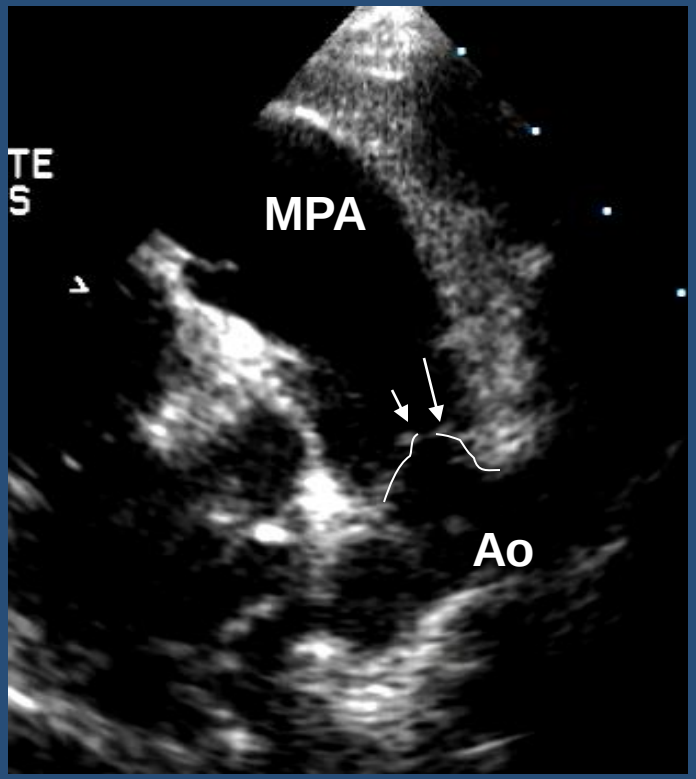
The High Parasternal or "Ductal View": Echo-Anatomy Correlation

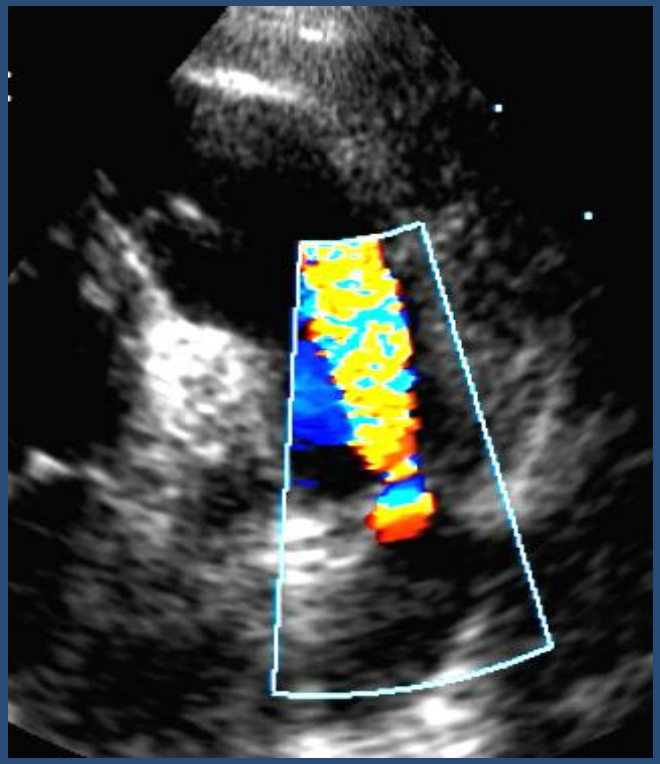




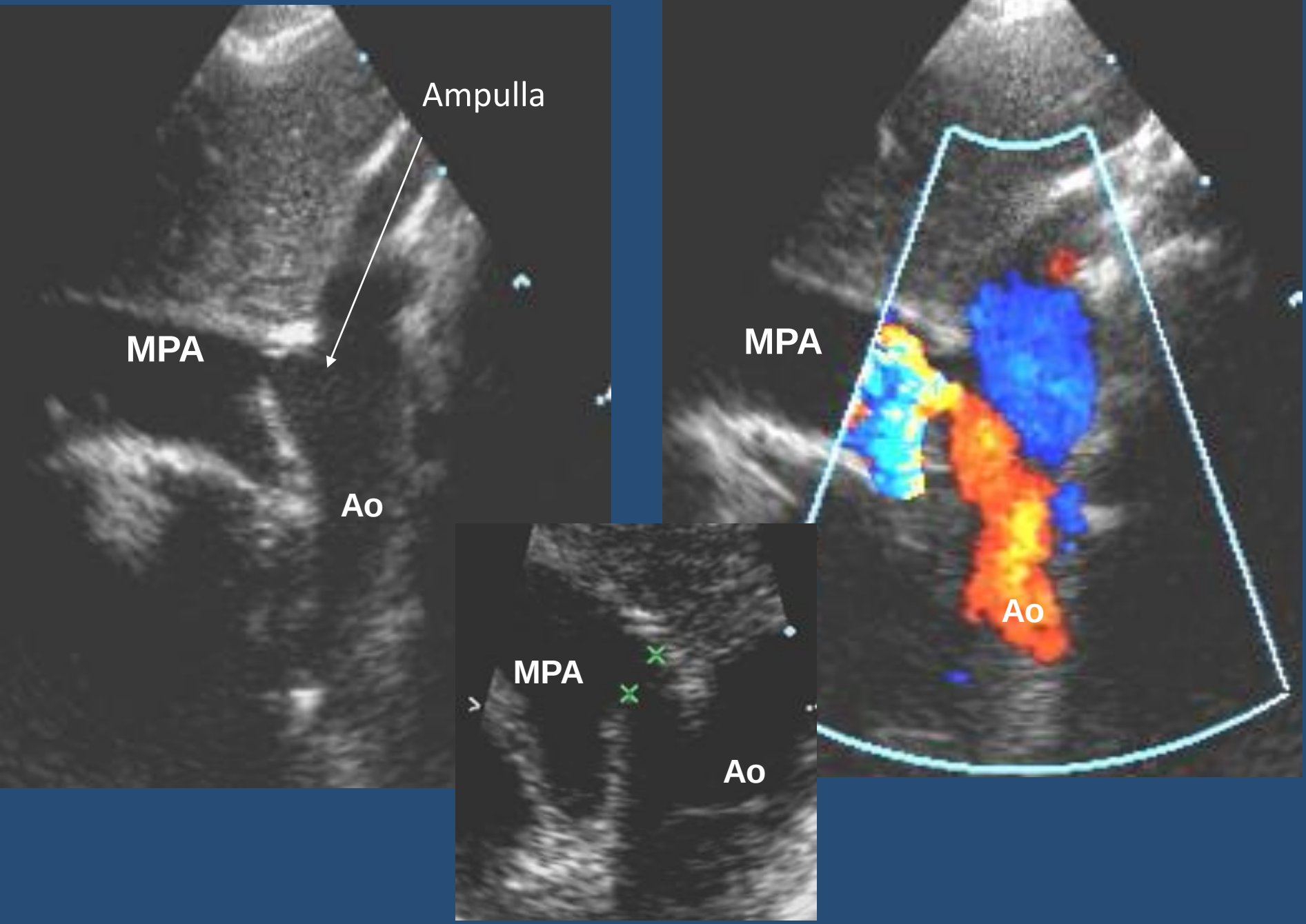
To understand the echo images the picture in the previous figure has been rotated by 90^0 in a clockwise direction. The anterior structures are displayed closest to the transducer.

The High Parasternal or “Ductal View”

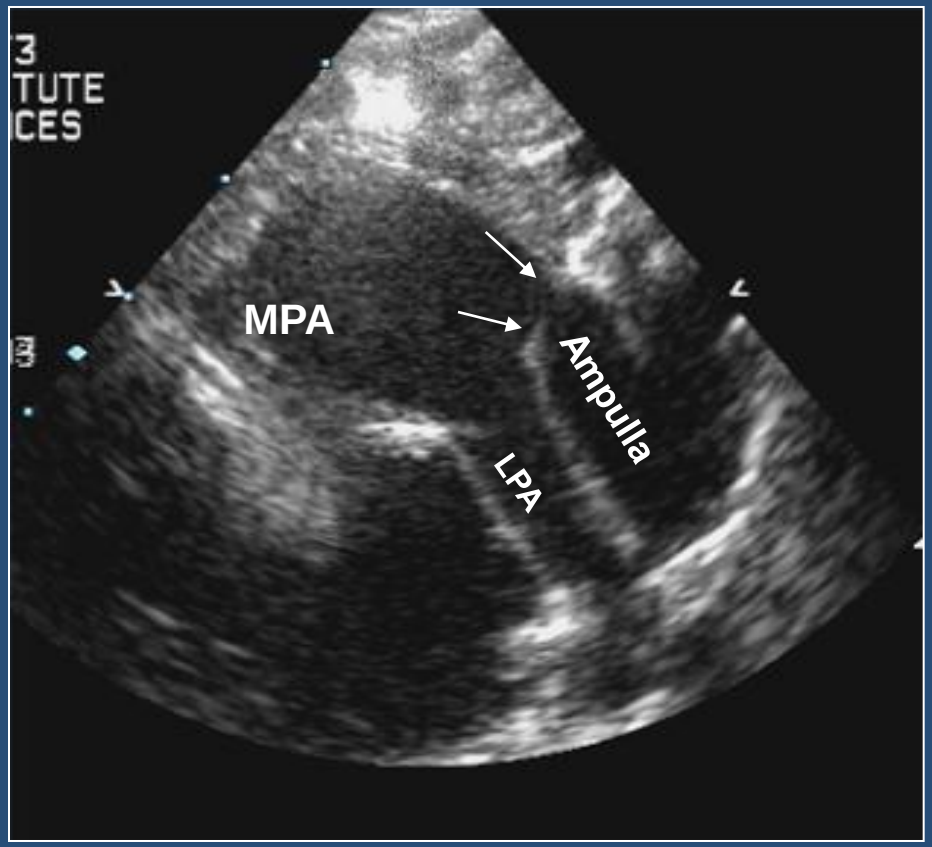


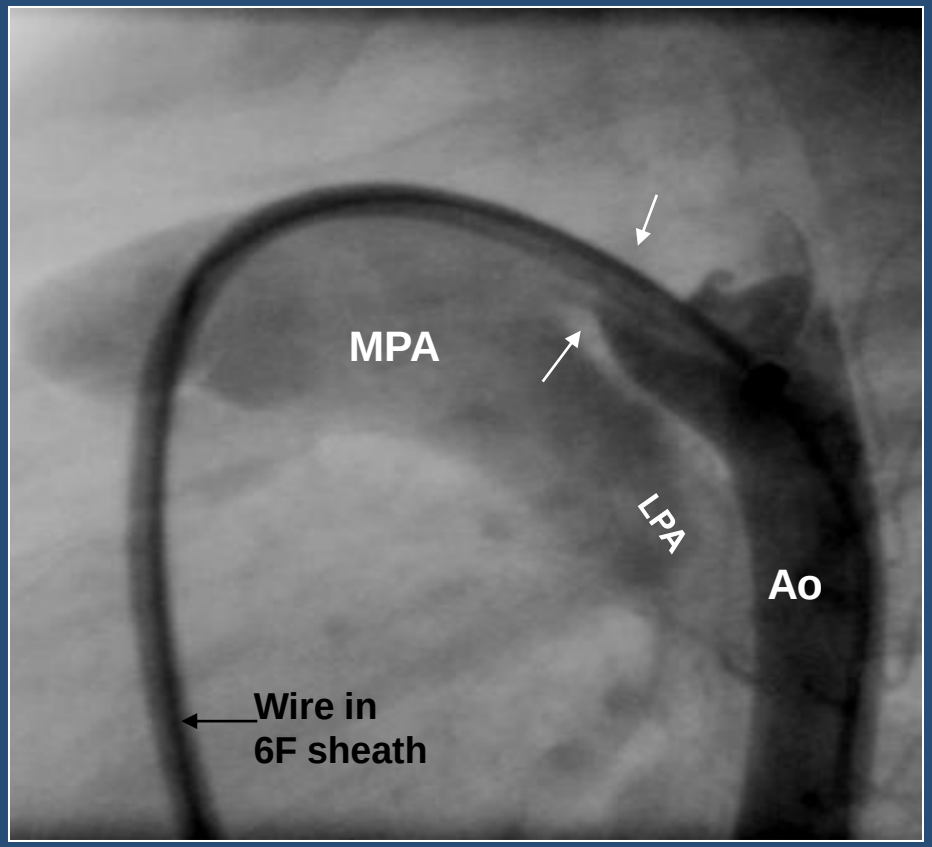


The two small white arrows indicate the points where the duct is measured at its PA insertion. The white line indicates the ampulla.


Ampulla
MPA
Ao
MPA
Ao
MPA
Ao

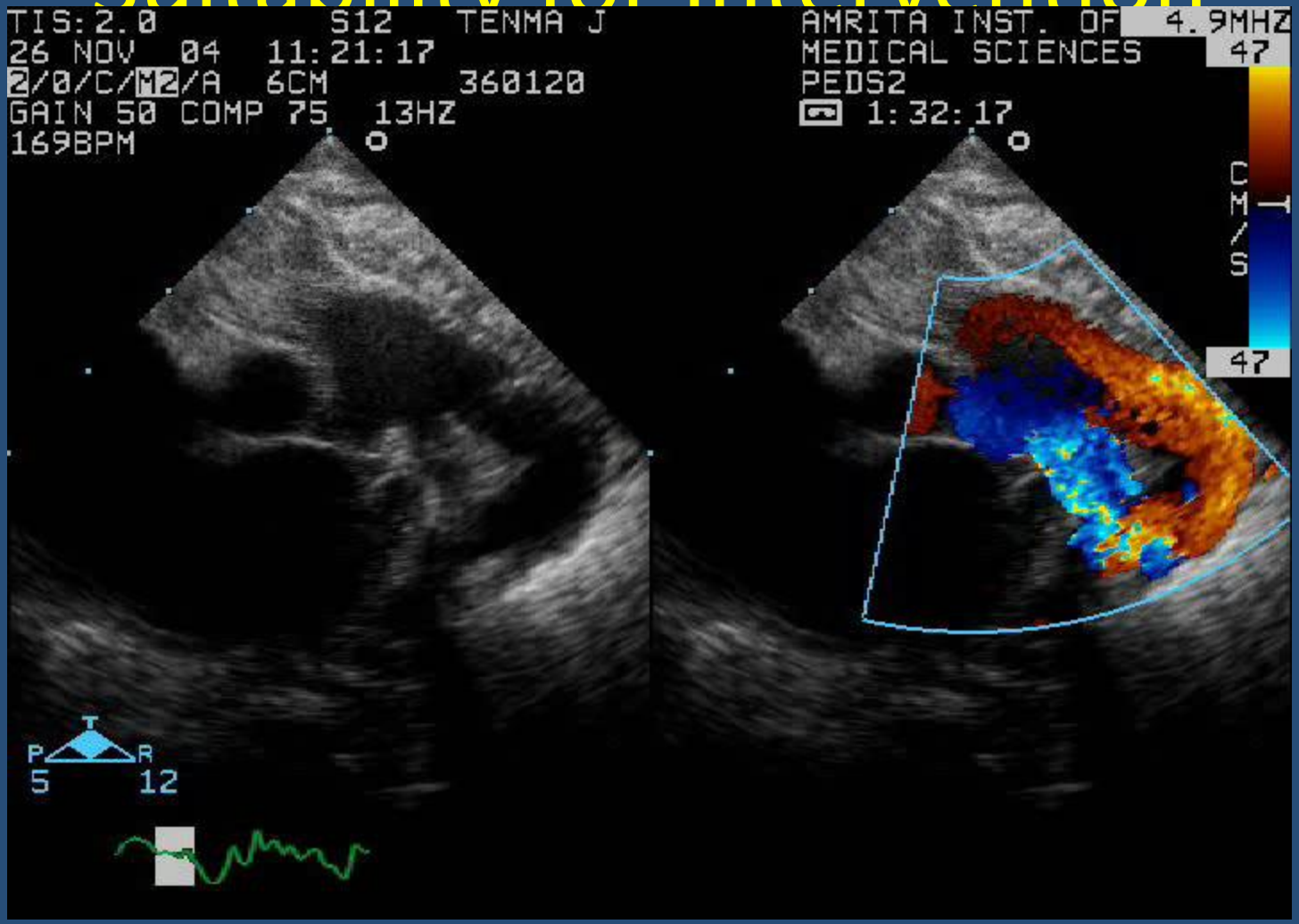
Suitability for Intervention





Near exact reproduction of angiogram is often possible especially in infants and children

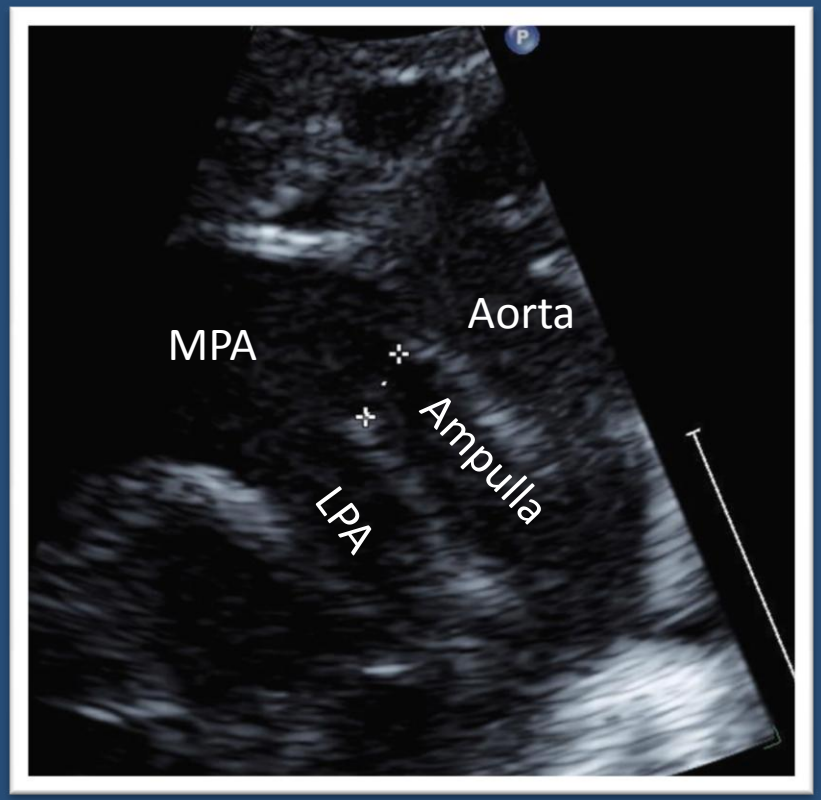
Suitability for Intervention



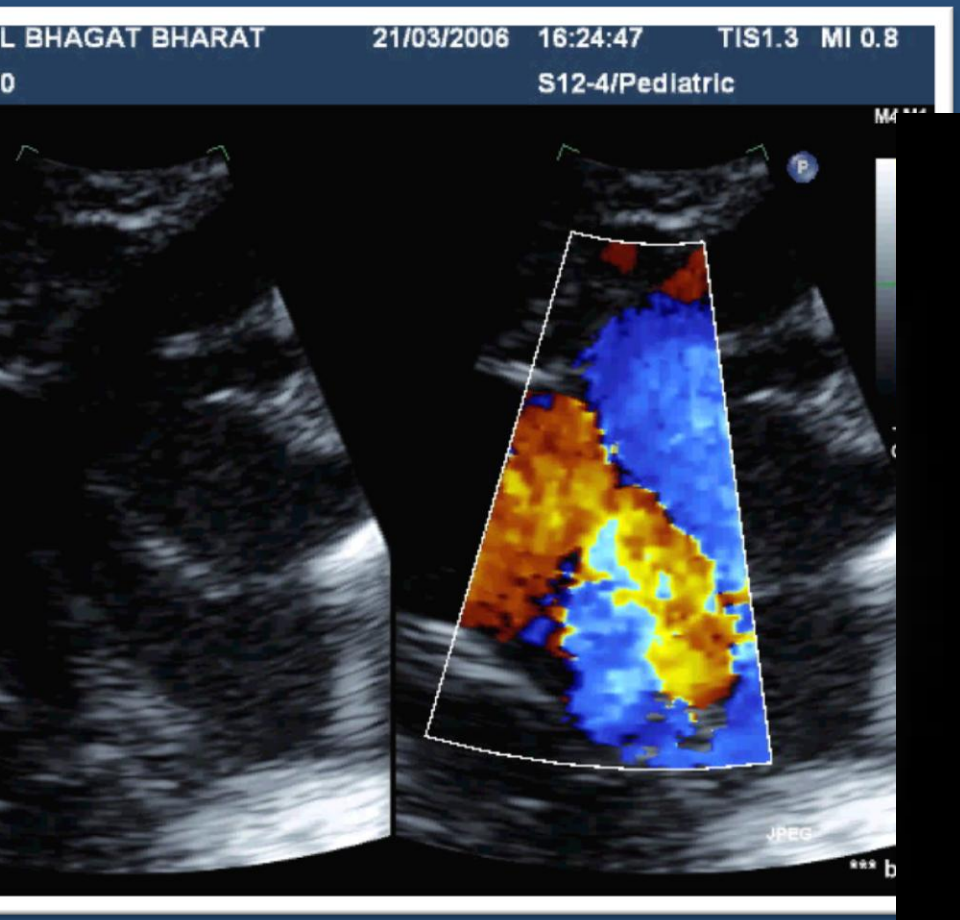
Very Large duct in a small infant (2.1Kg); Will require a very large occlusive device that can only be delivered via a large sheath with potential for aortic occlusion

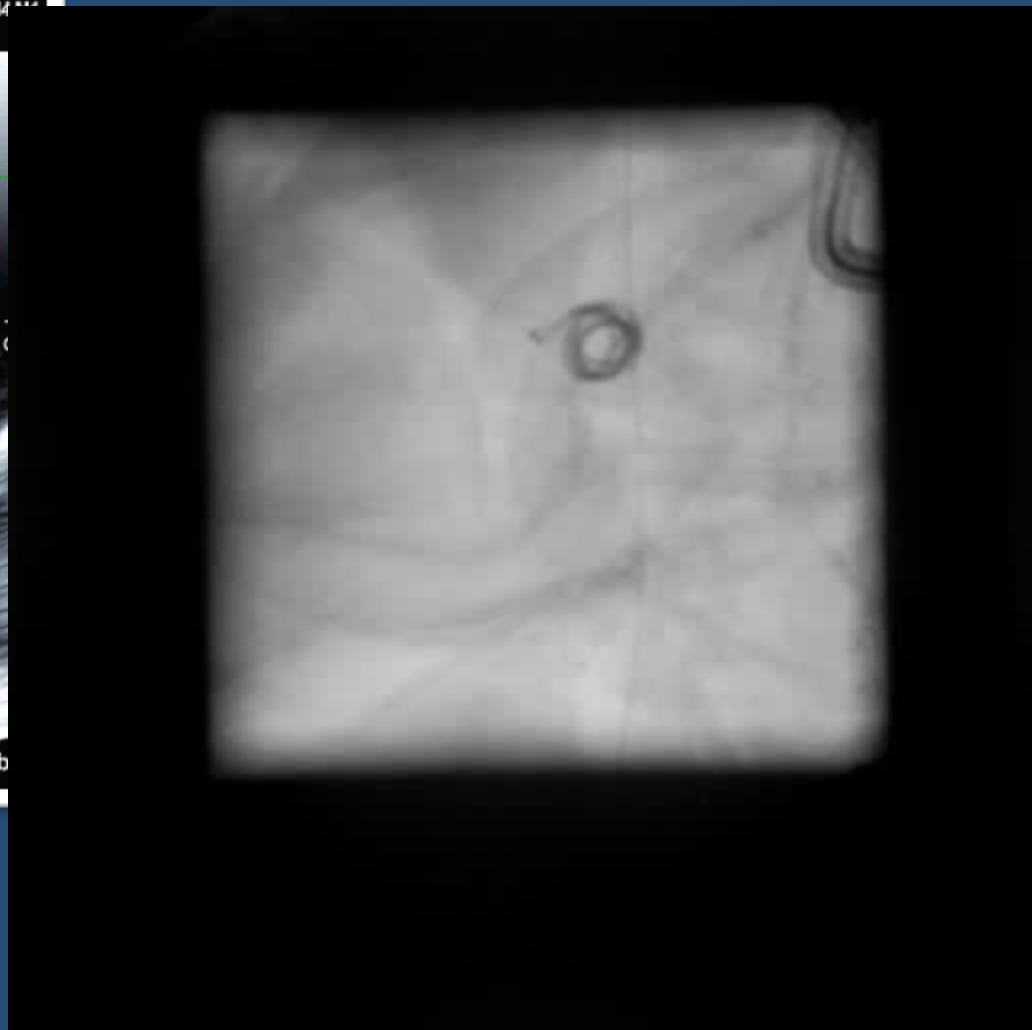
Challenge #1: Large Duct in a Small Infant

- 3 months old ex-preterm
- 700 g at birth
- Tachypnea since DOL 20
- Failure to thrive, 1.1 Kg at presentation
- Bounding pulses, large heart, loud systolic murmur, diastolic flow murmur at apex, liver enlargement

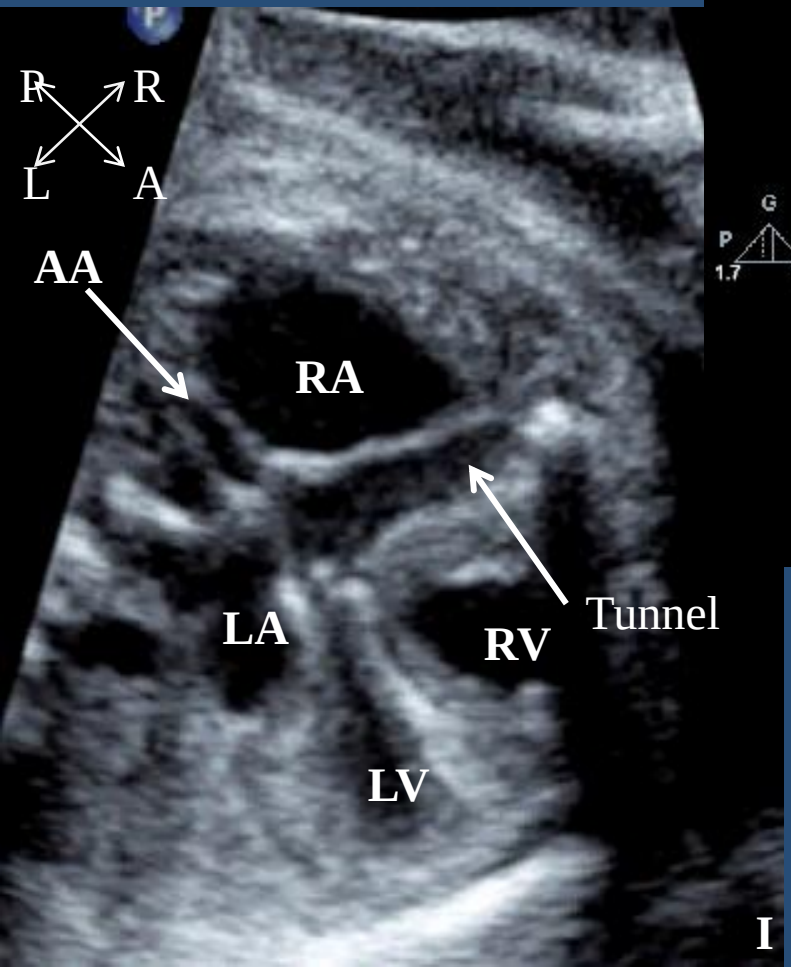


Preterm infant with large duct



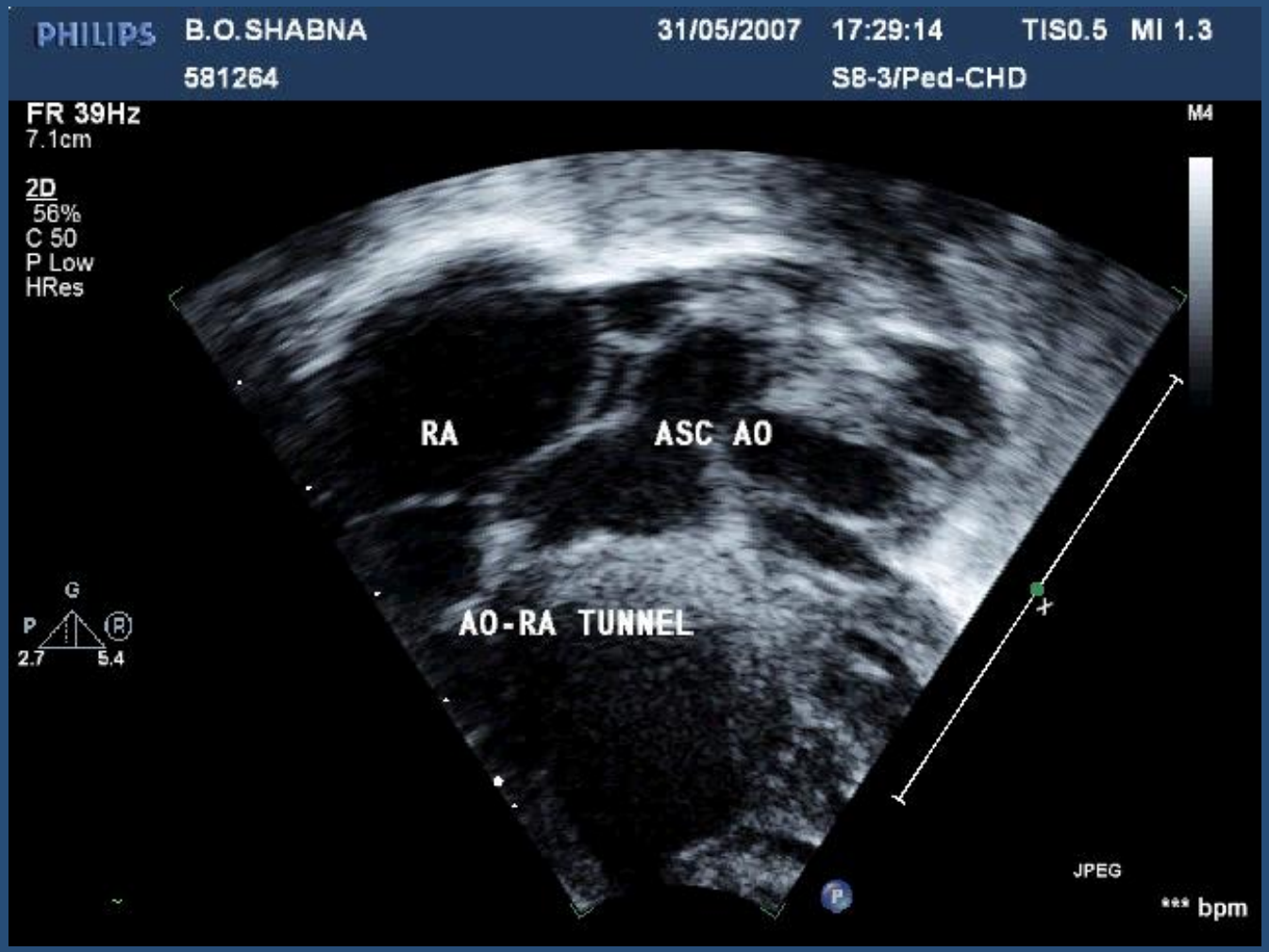


Third trimester gestation: Referred for unusual cardiac problem suspected during obstetric ultrasound evaluation

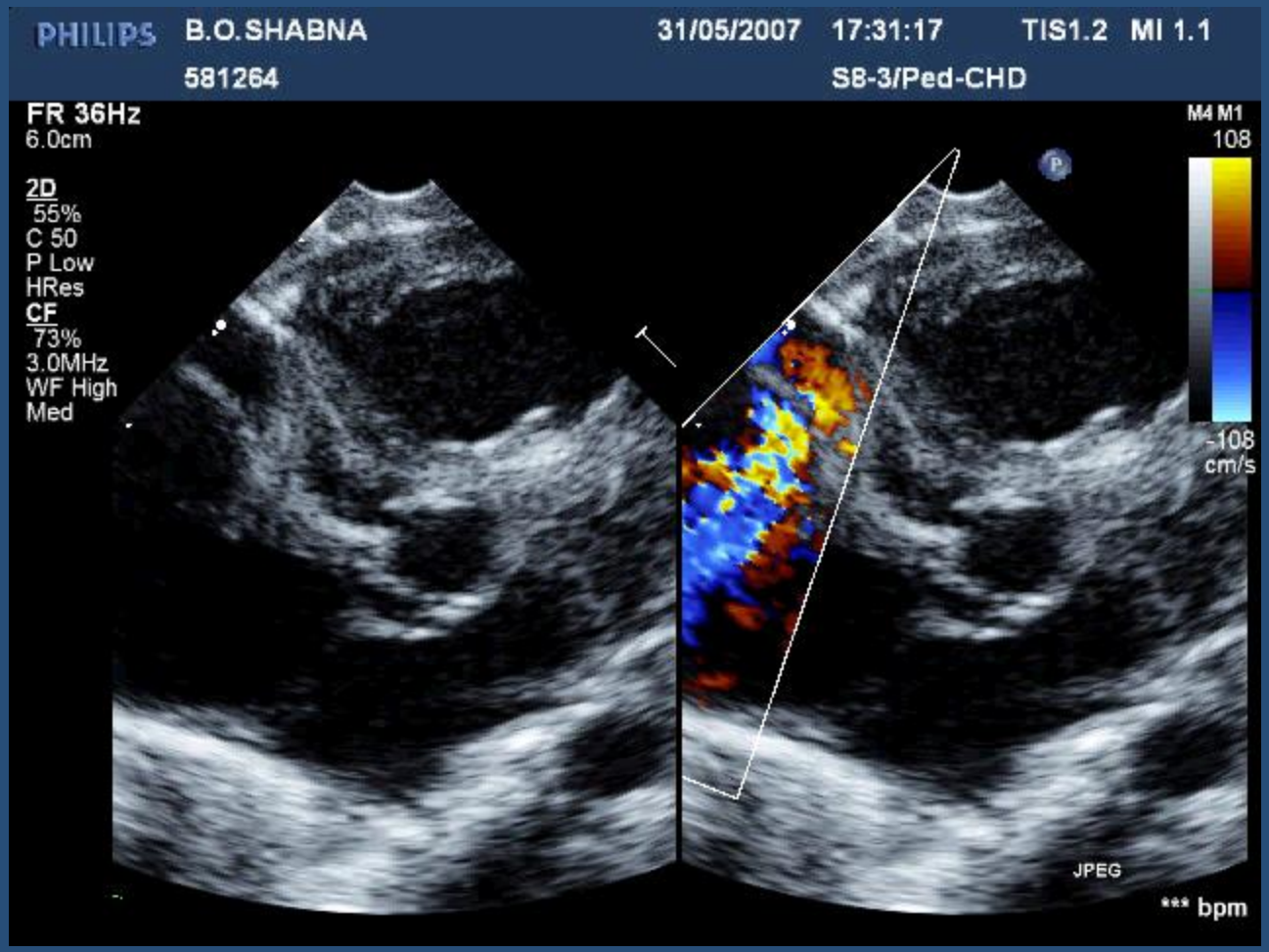


I

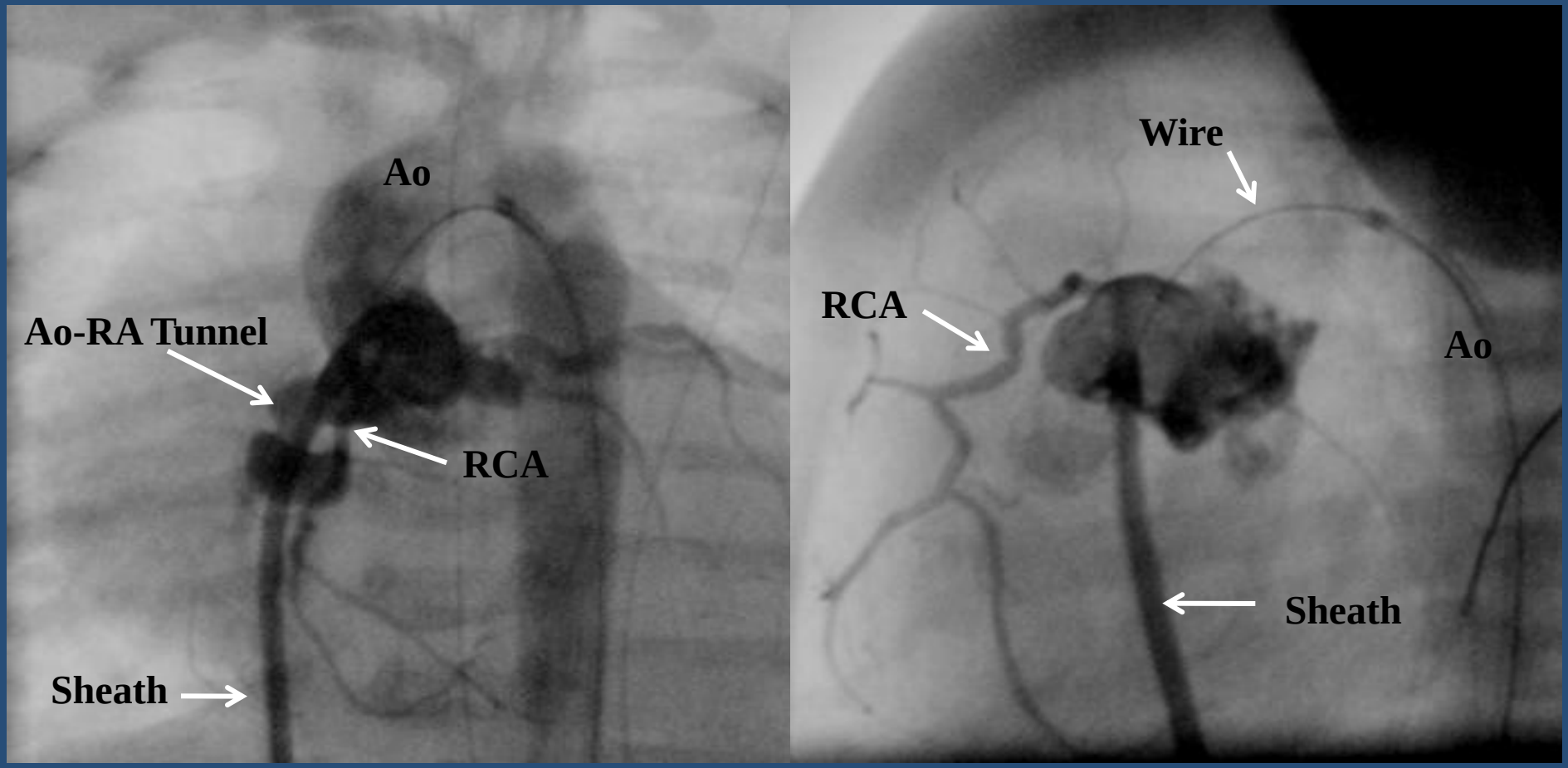
Echocardiogram after birth



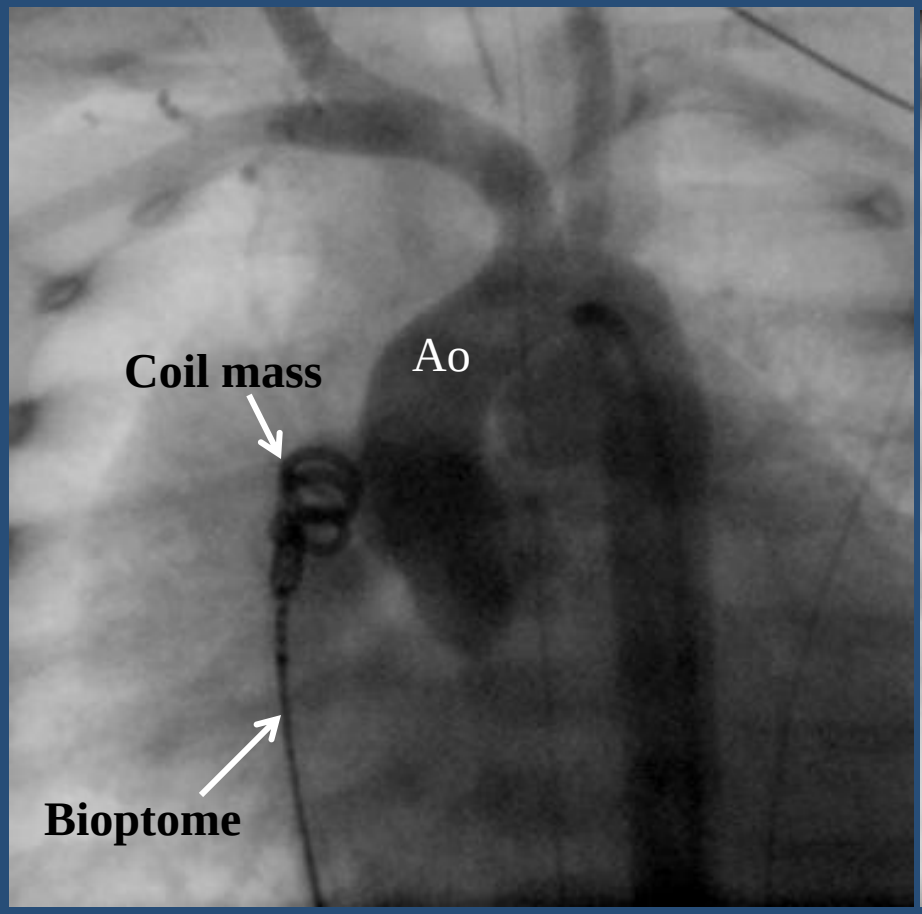
Echocardiogram soon after birth

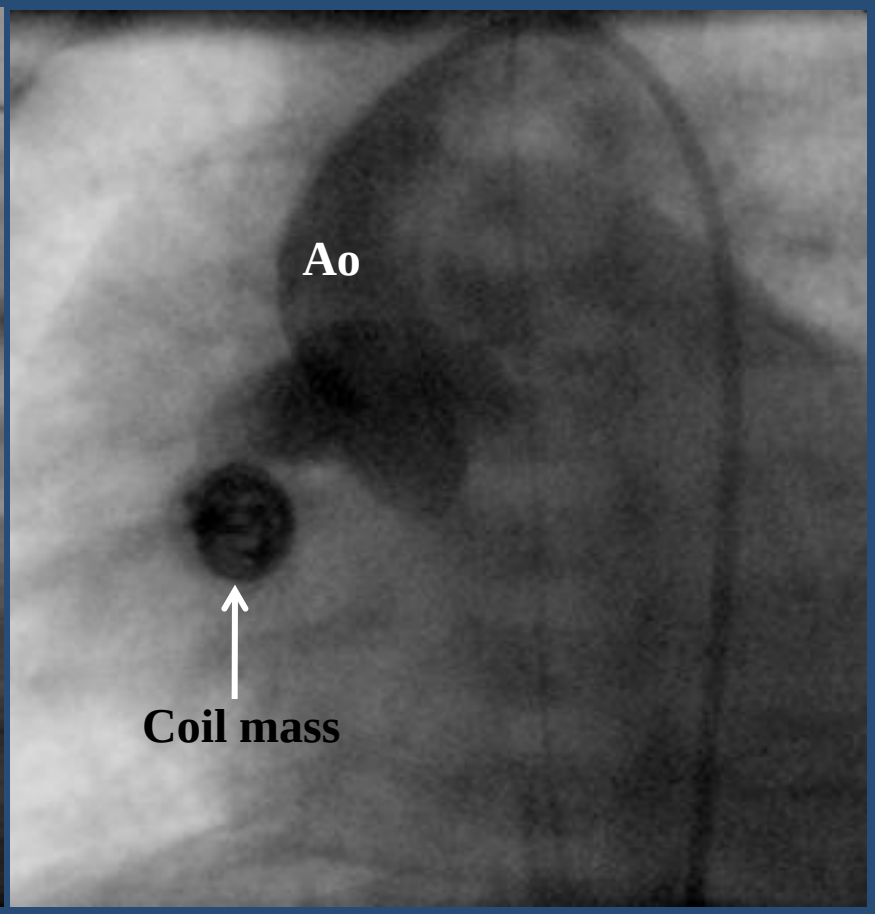


Day of Life #3



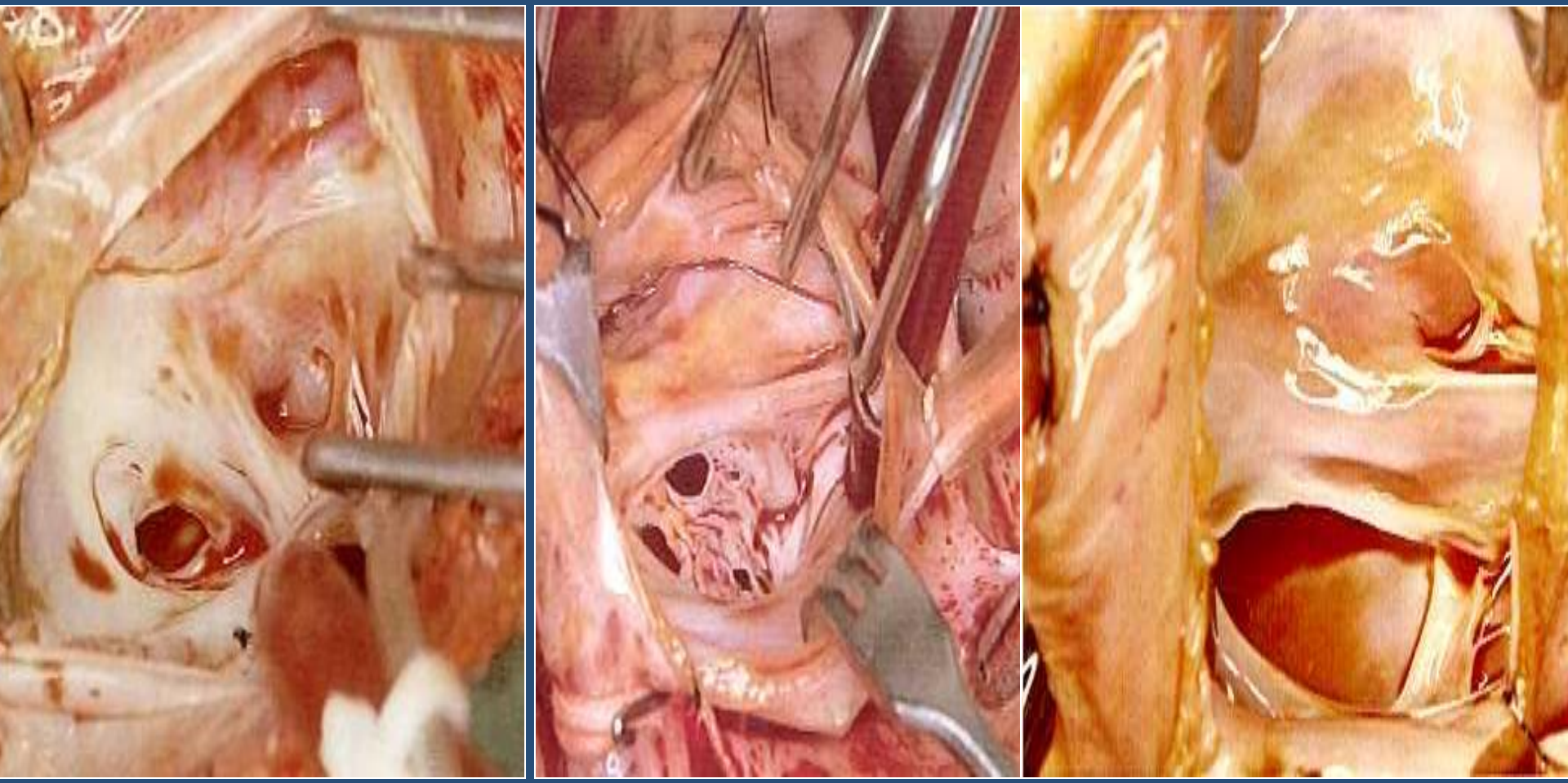
Angiographic demonstration of the AO-RA communication and separate origin of the RCA



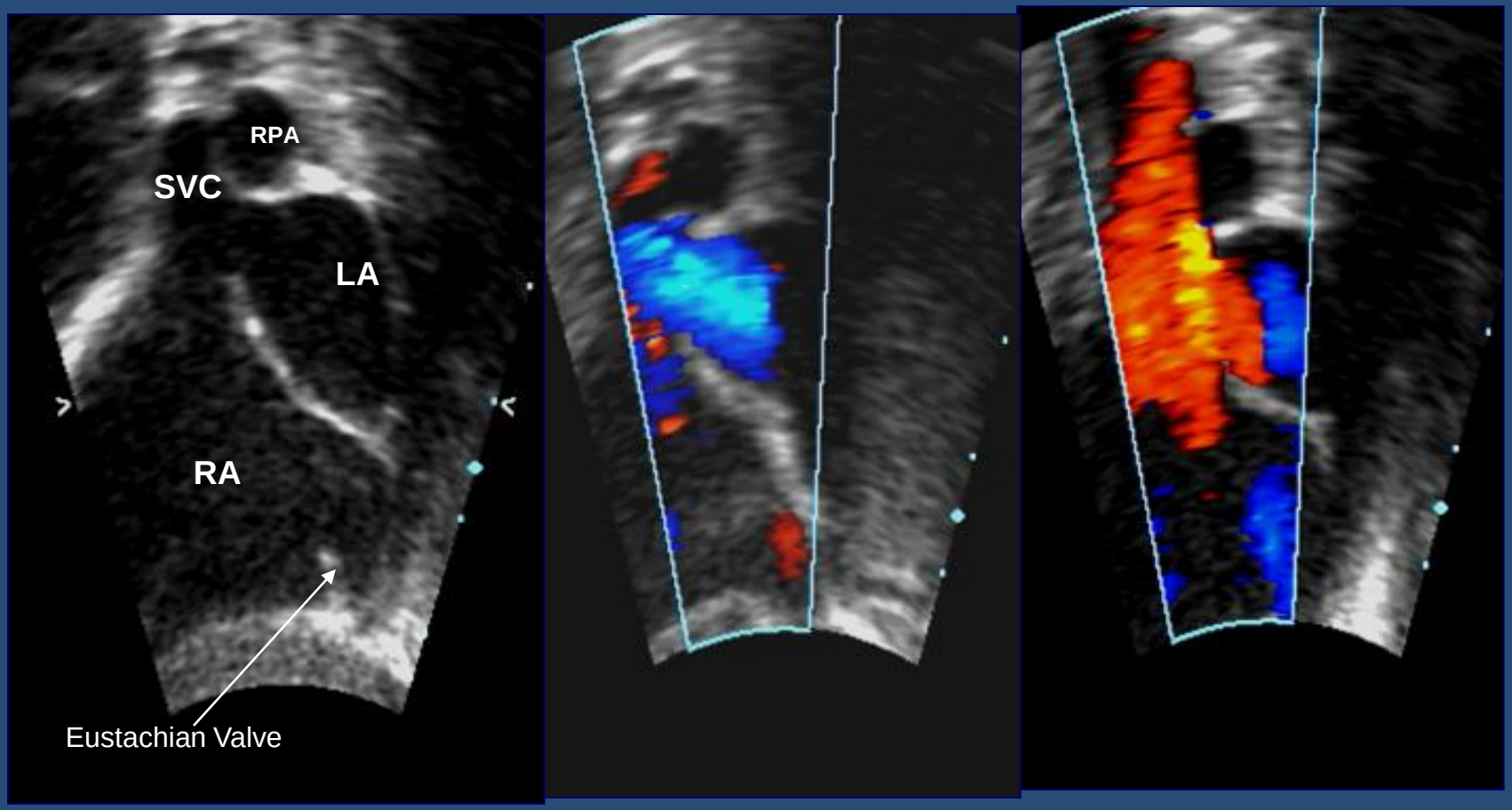


Coil occlusion using bioptome assistance: Two coils have been simultaneously delivered

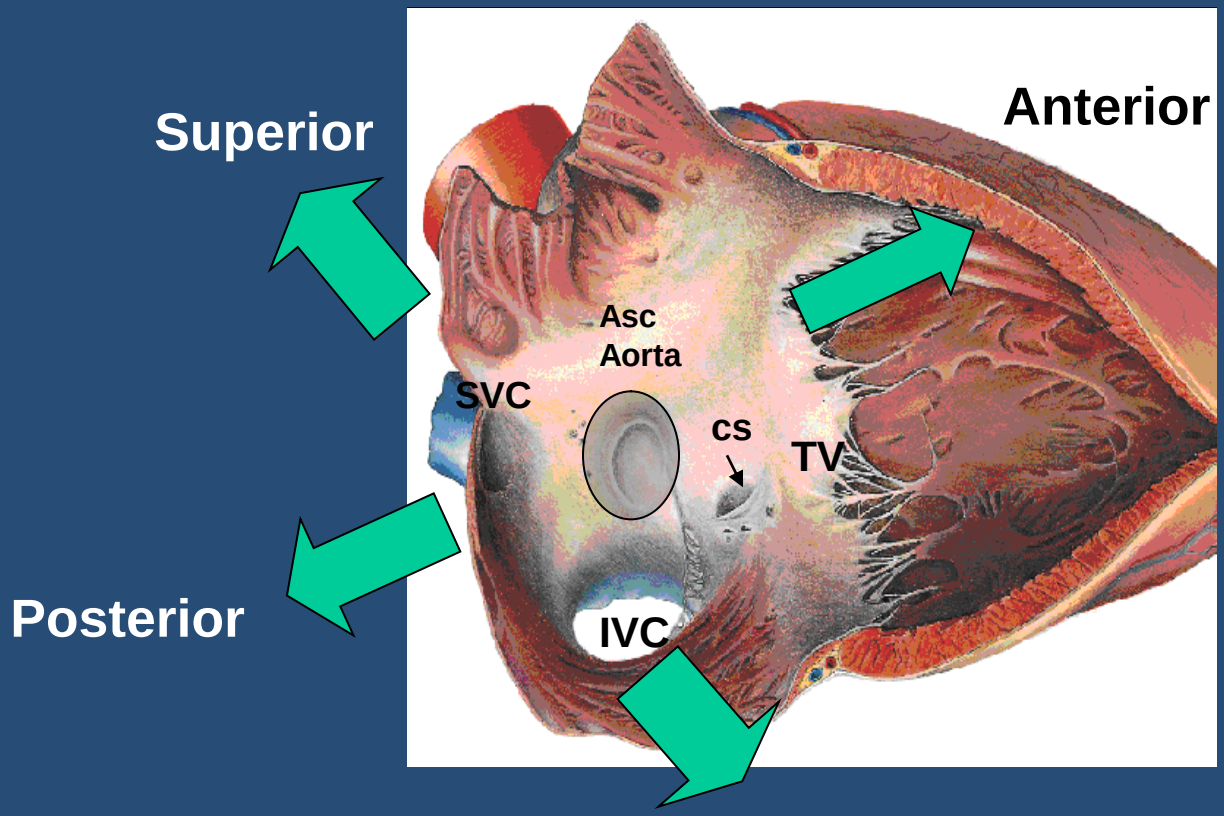
Suitability for Intervention: ASD



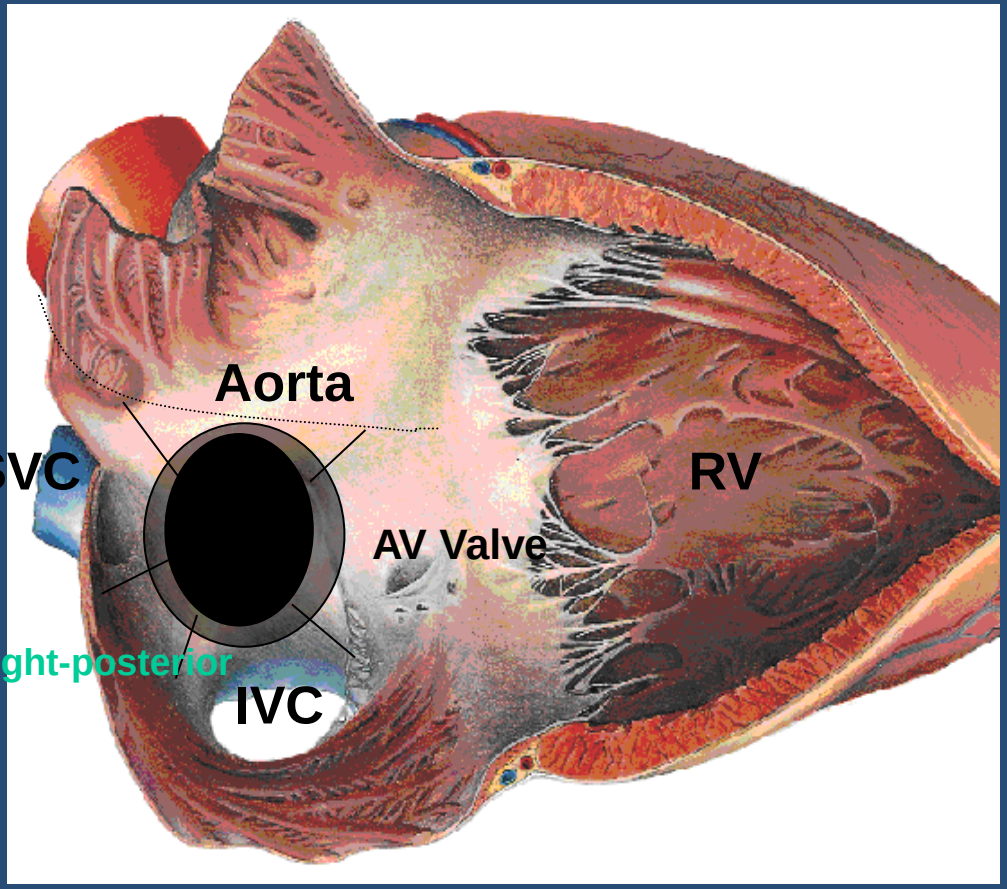
Sinus Venosus ASD



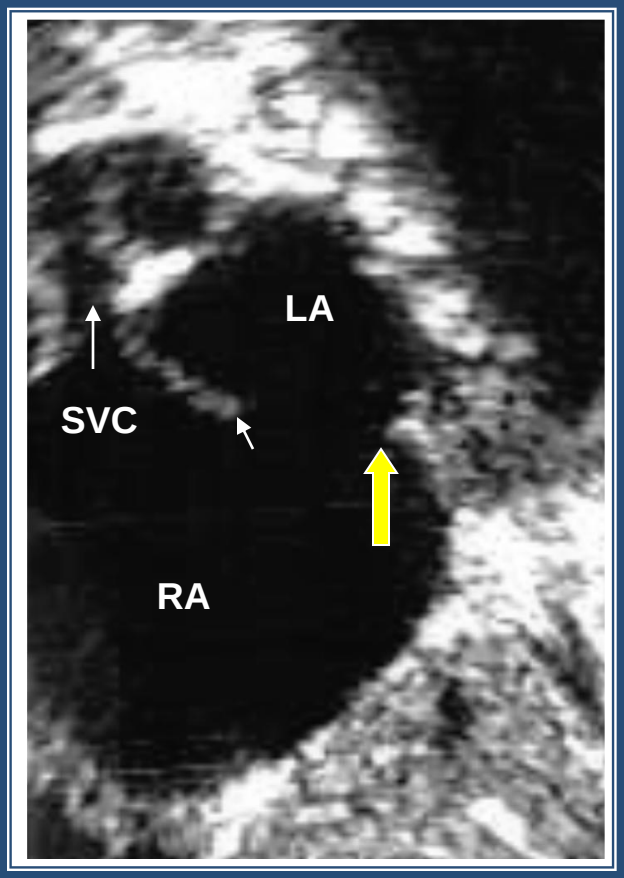
ASD Margins

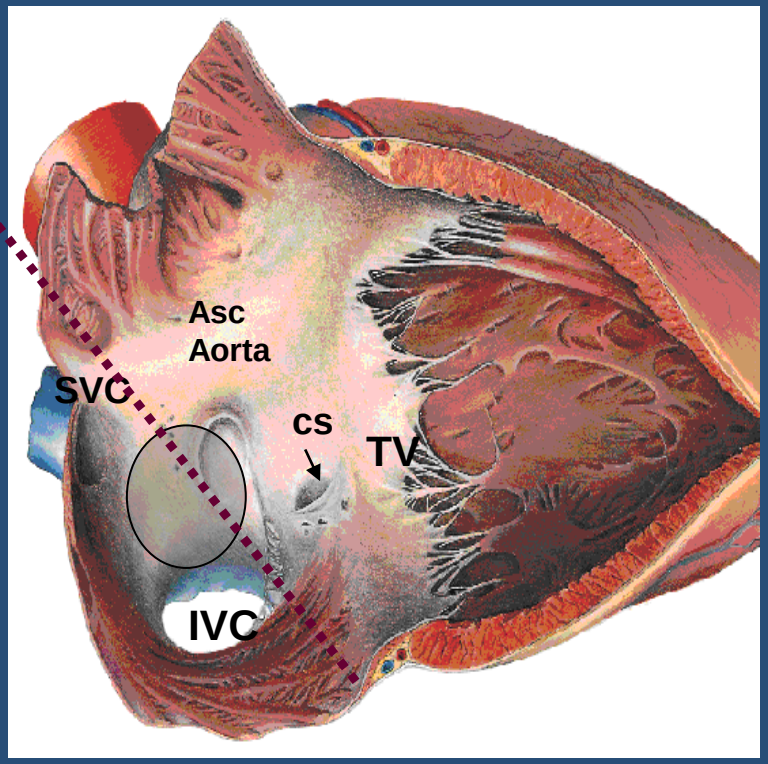

Superior
Anterior
Asc
Aorta
SVC
CS
TV
Posterior
IVC
Inferior

Margins

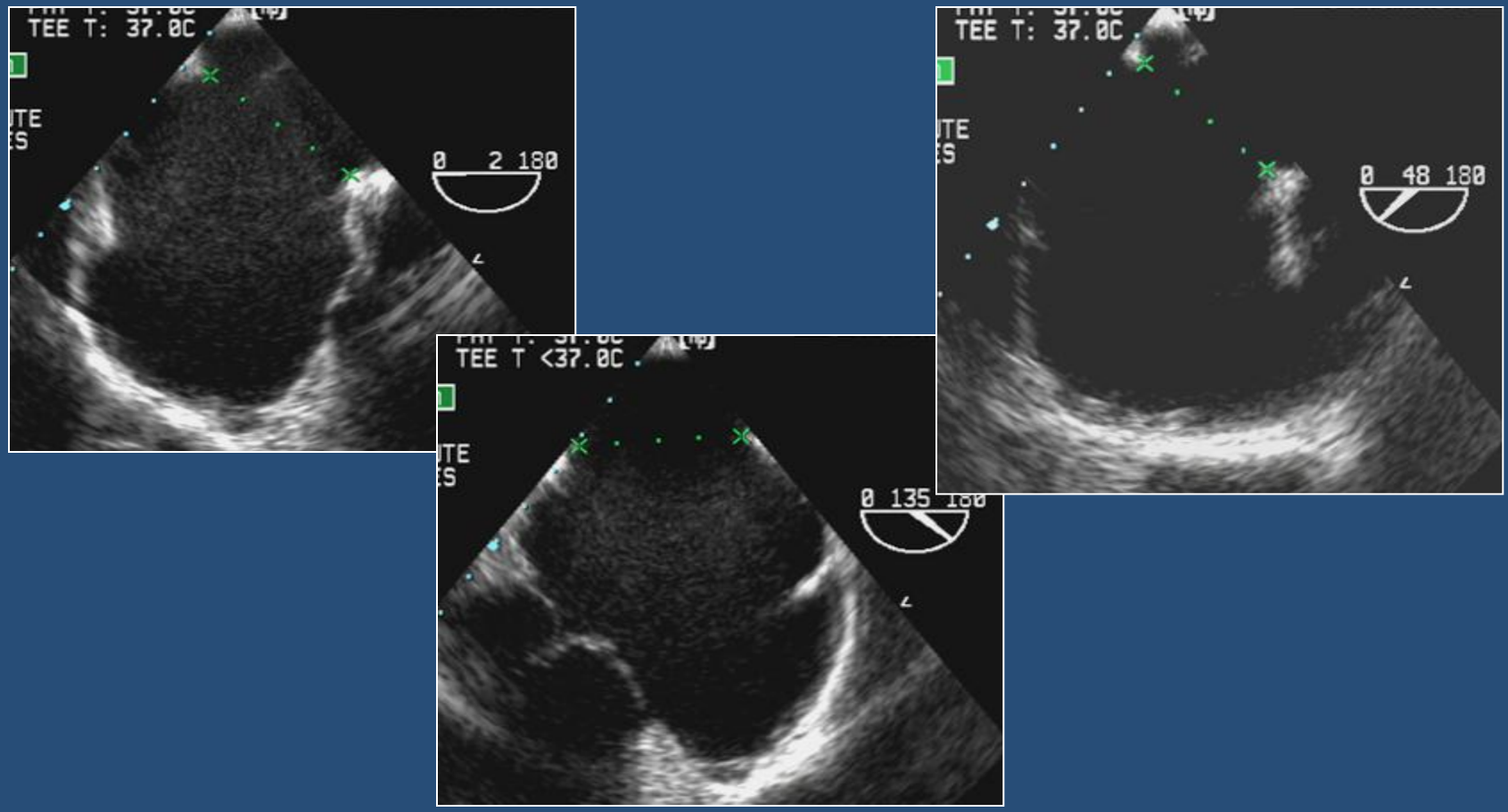


Secundum ASD: Deficient Posterior-Inferior Rim



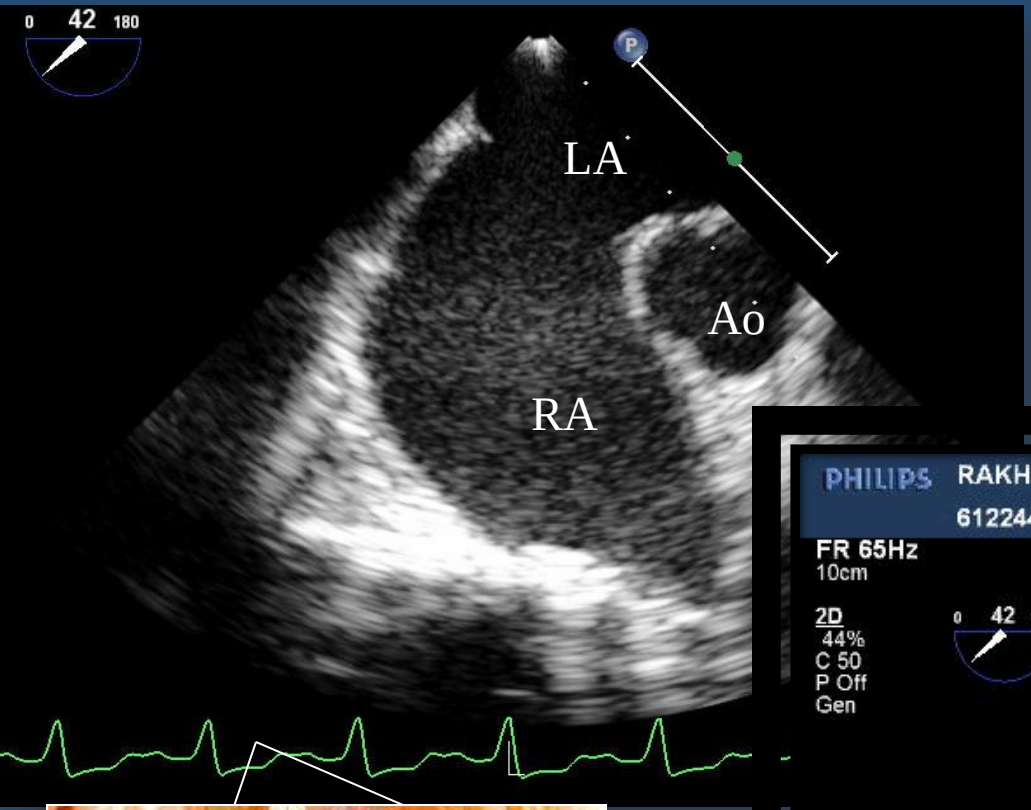


ASD for Device Closure

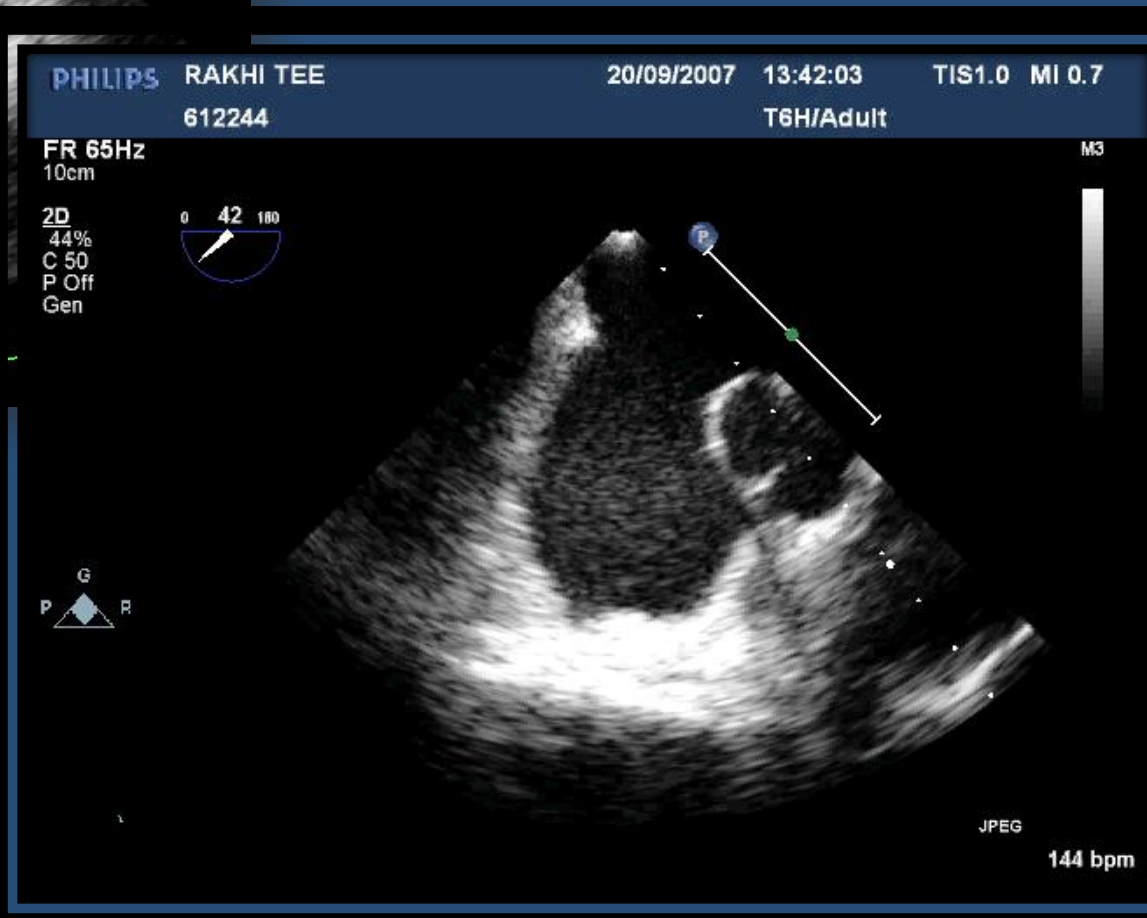


Large ASD with deficient anterior as well as the posterior rims

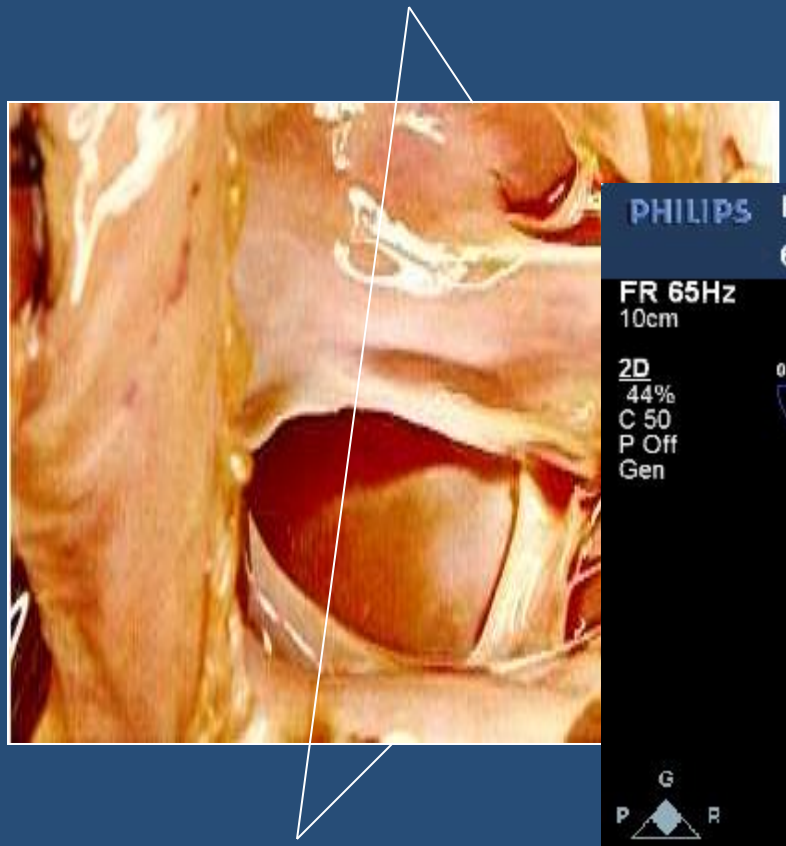
ASD for Device Closure

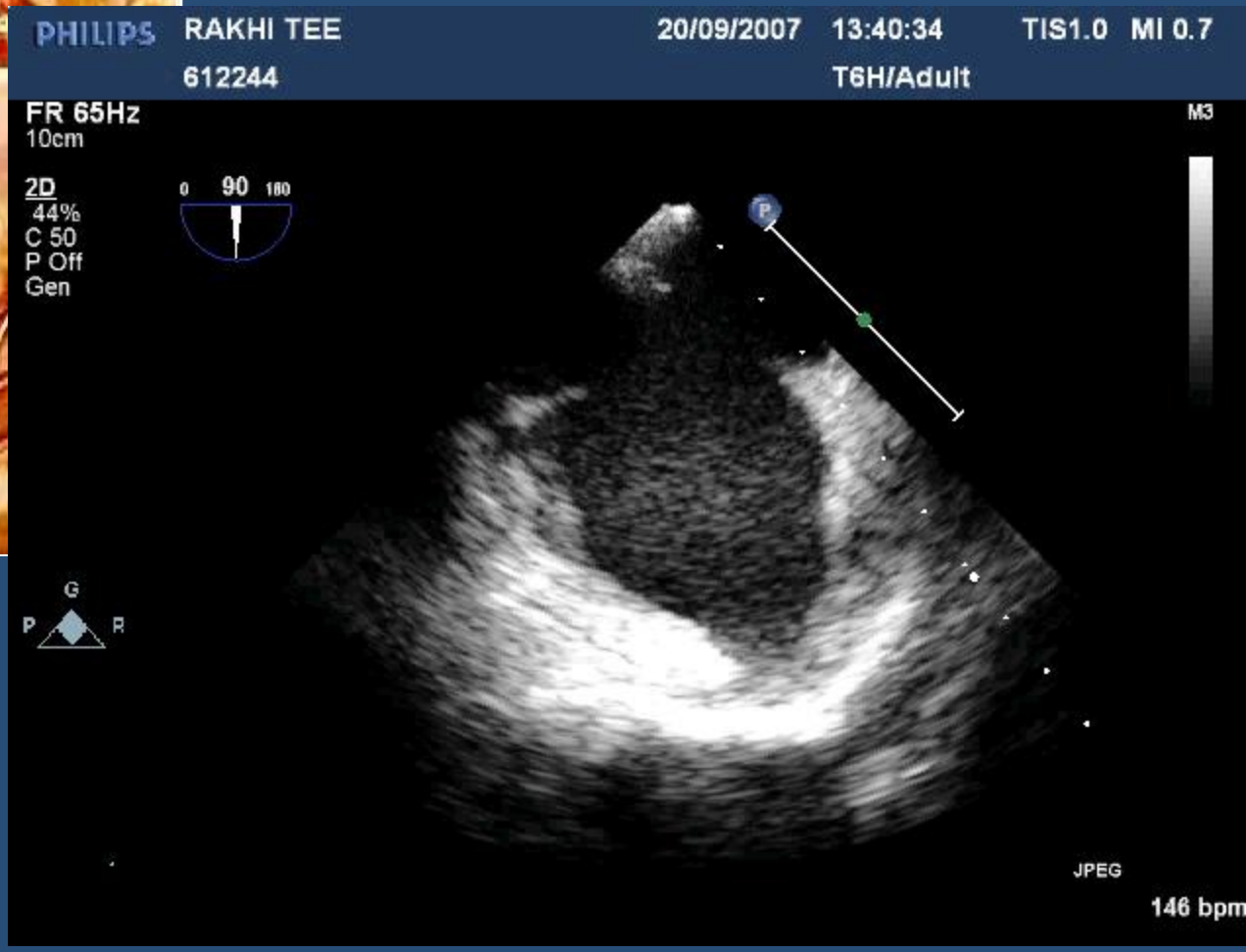


These images can discourage some from trying to close the defect in the cath lab. However, closure is feasible with some technical challenges



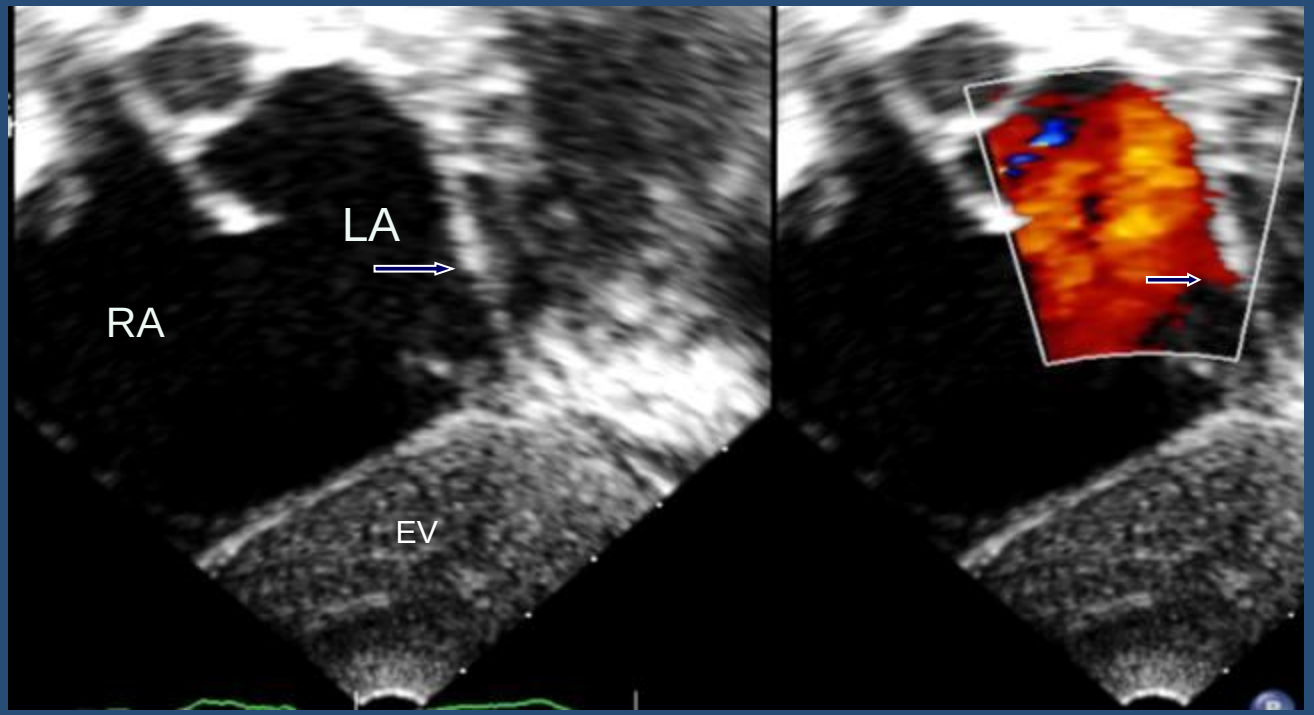
ASD for Device Closure





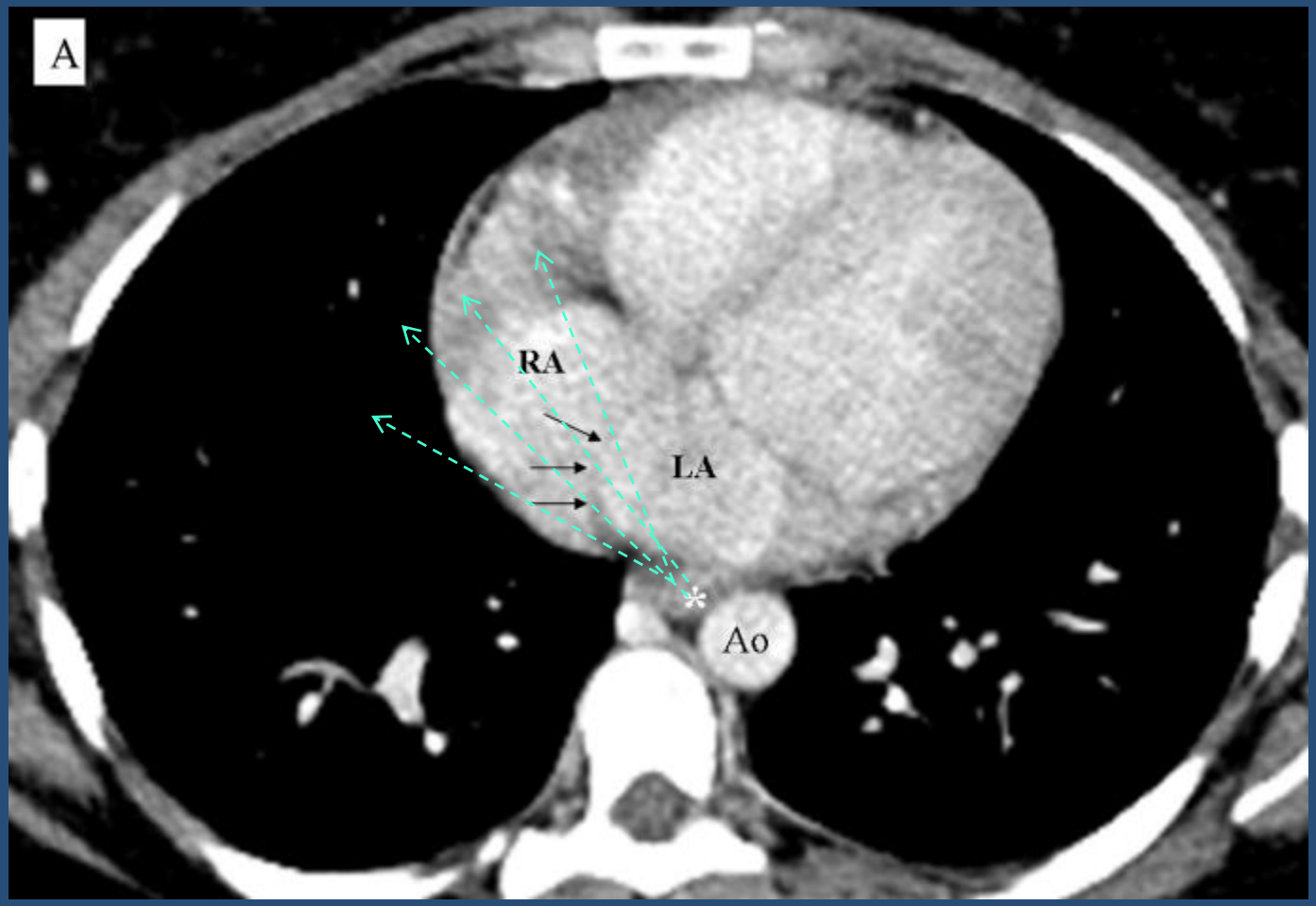
Imaging the IVC Margin

- Best imaged using intracardiac echocardiography (ICE)
- Sub-xiphoid views are also very useful provided there are good acoustic windows
- Imaging through TEE requires special maneuvers



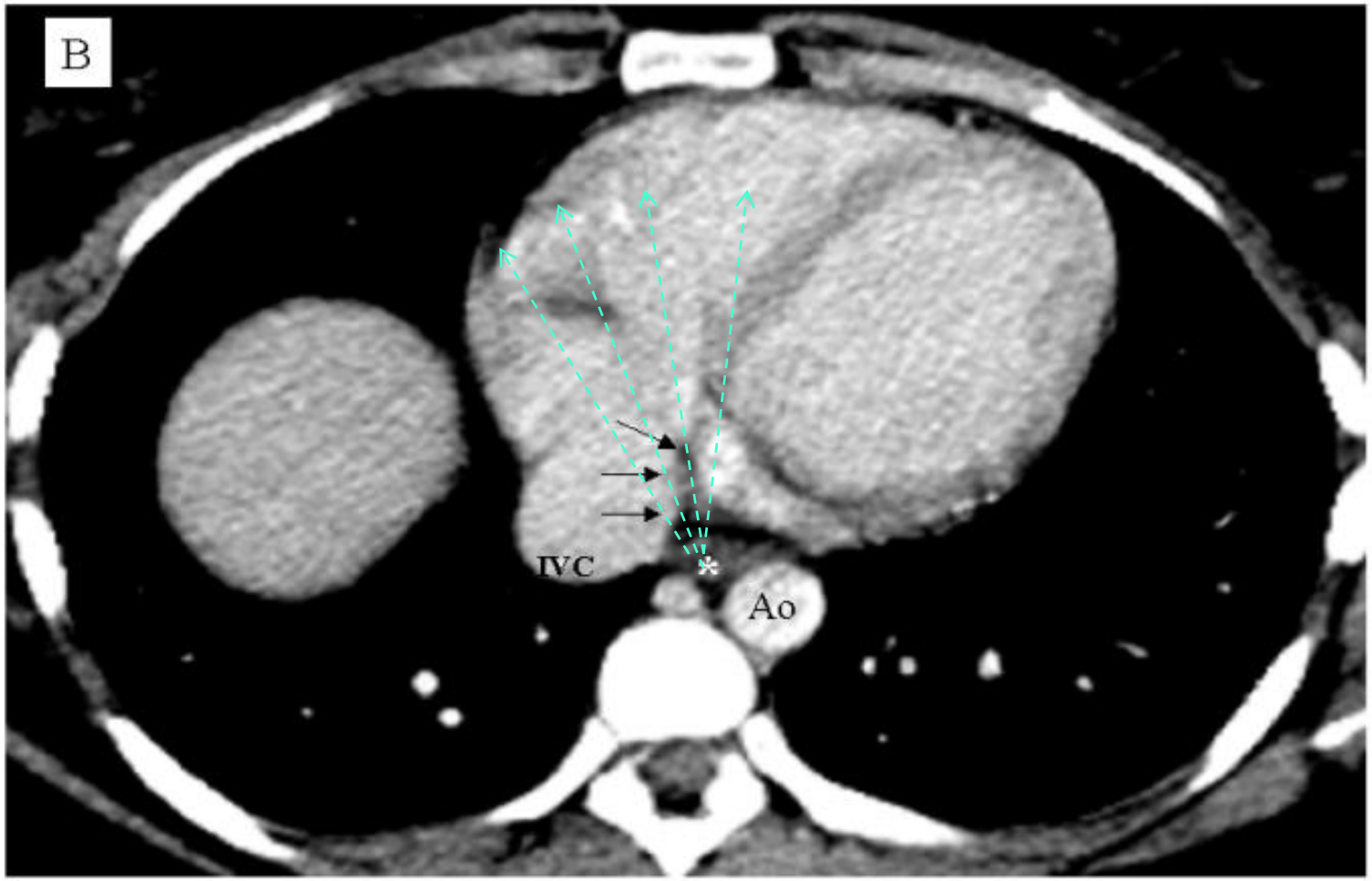
Remadevi KS, Francis E, Kumar RK, Catheter closure of atrial septal defects with deficient inferior vena cava rim under transesophageal echo guidance, Cathet Cardiovasc. Interven. 2009, 73:90-96

Imaging the IVC Margin through conventional TEE: Why is it difficult?

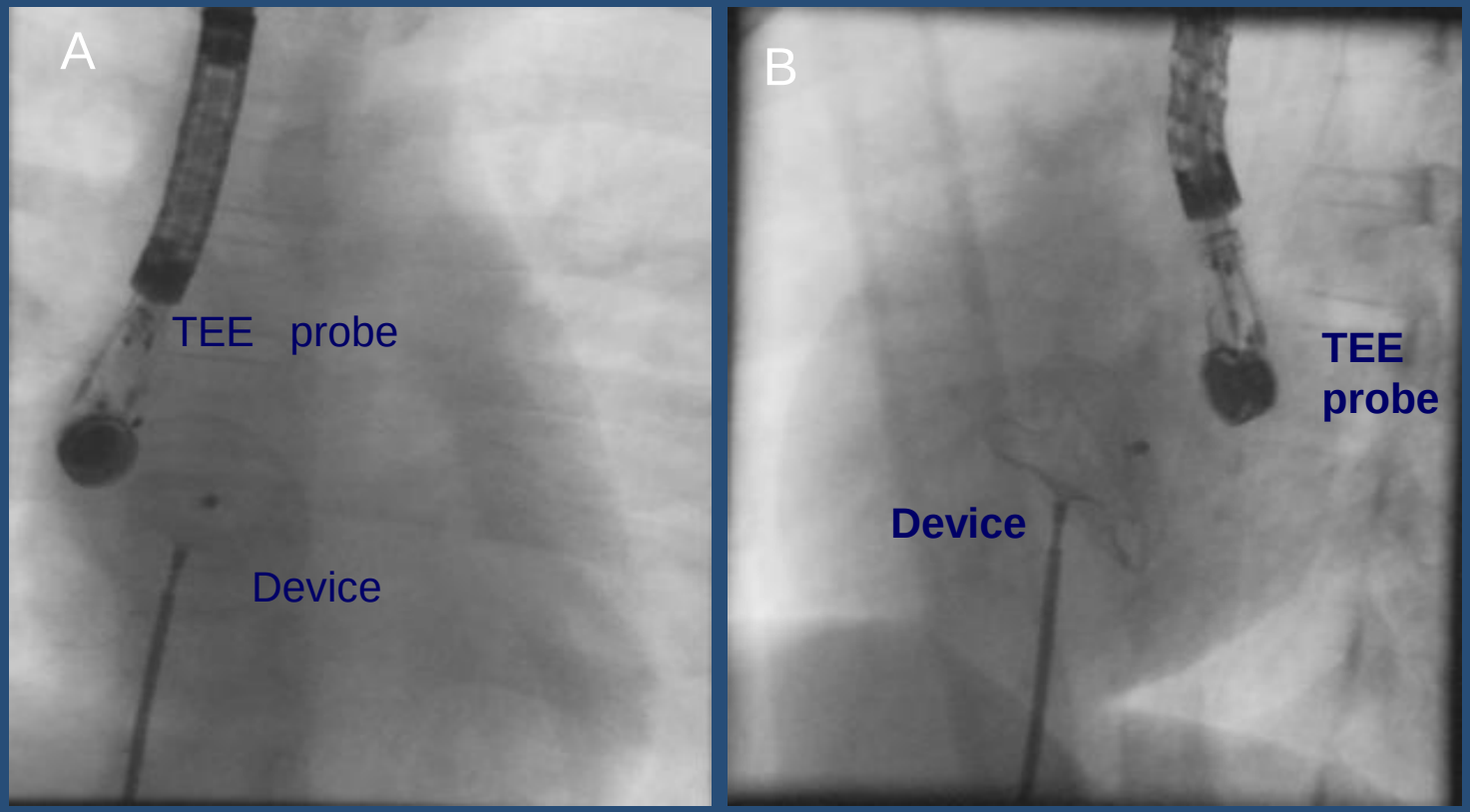


CT chest: Mid-thoracic

Imaging the IVC Margin through conventional TEE: Why is it difficult?

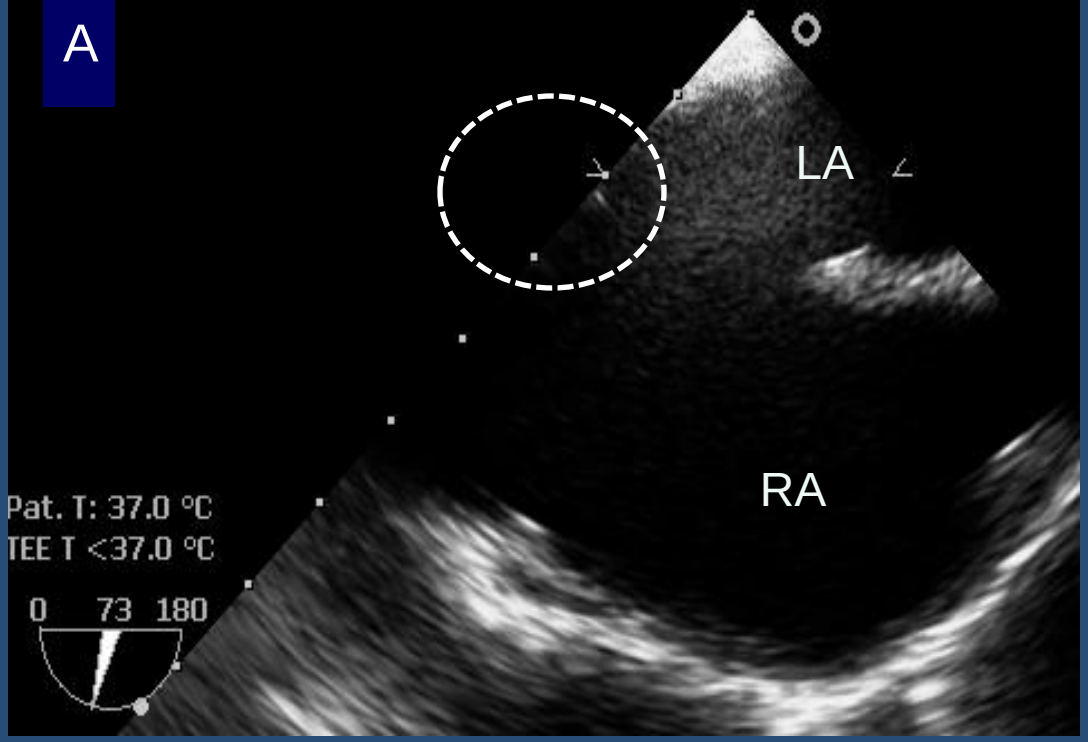


Imaging the IVC Margin through TEE: The modified retroflexed view

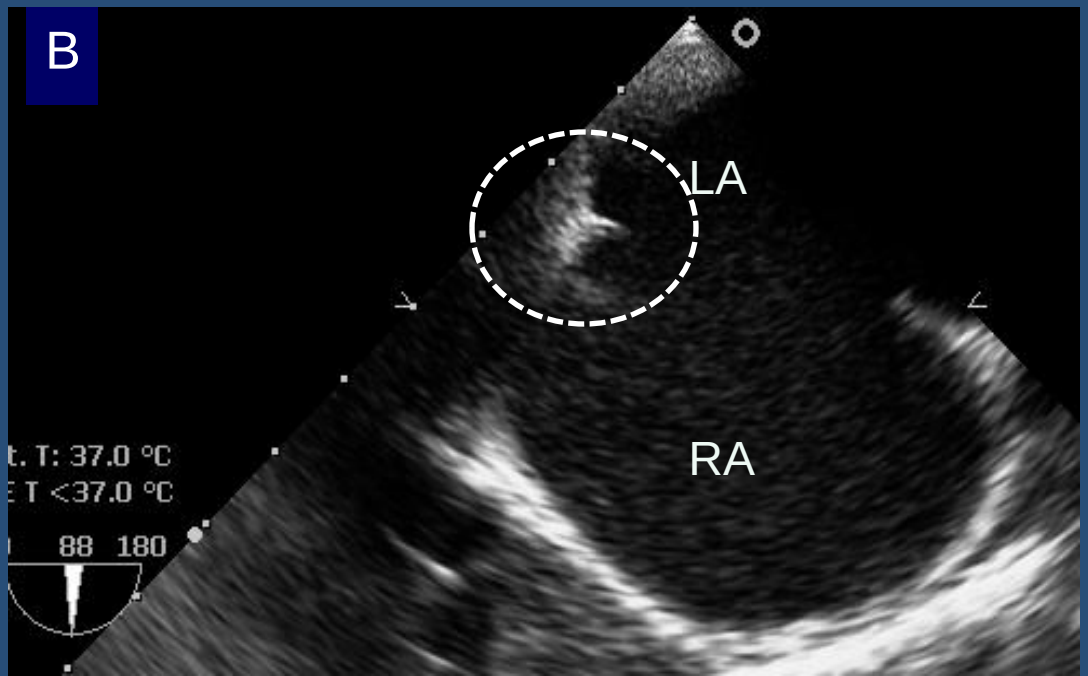


Retroflexion moves probe away from heart and eliminates the parallel orientation of the ultrasound beams to the atrial septum

ASD for Device

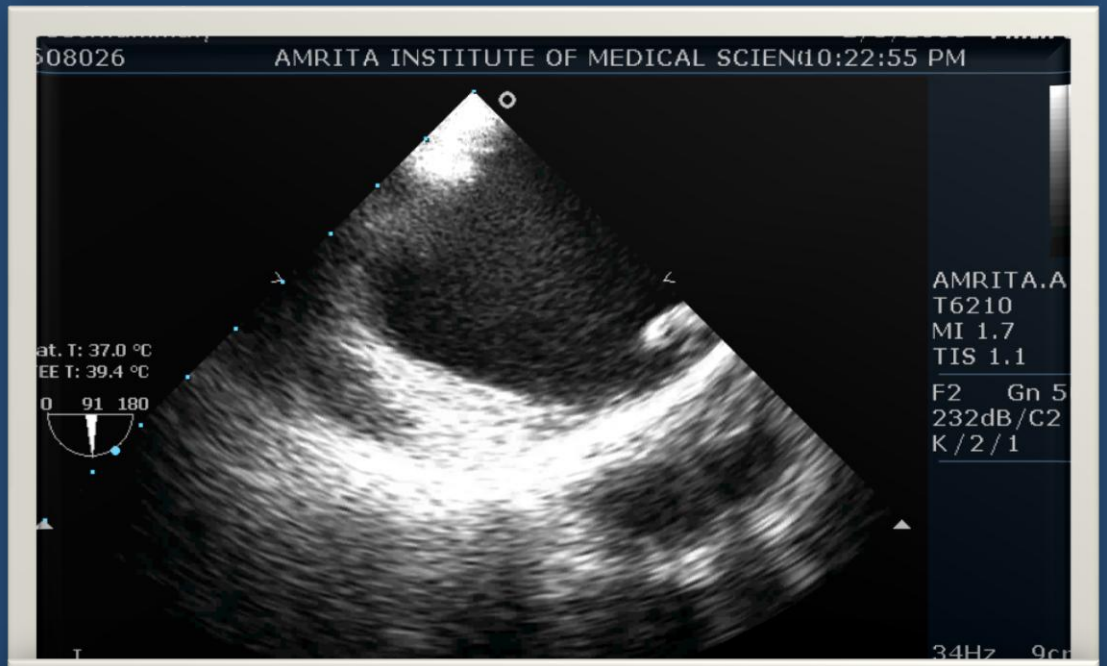


Conventional

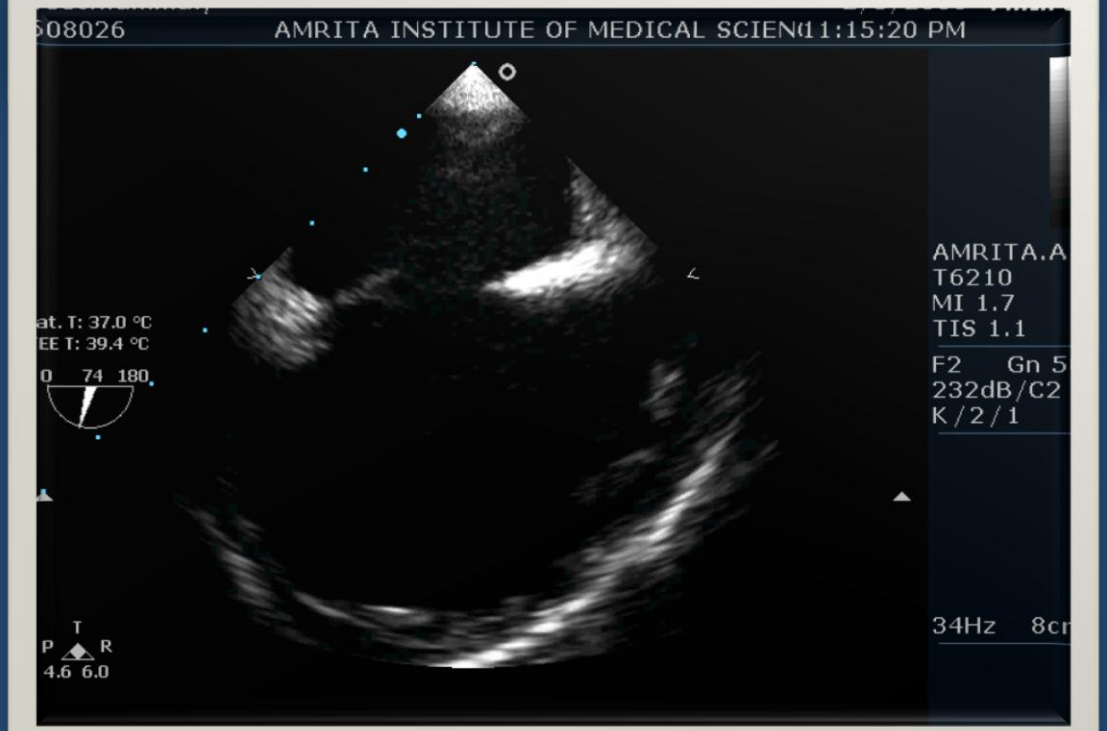


Retroflexed

ASD for

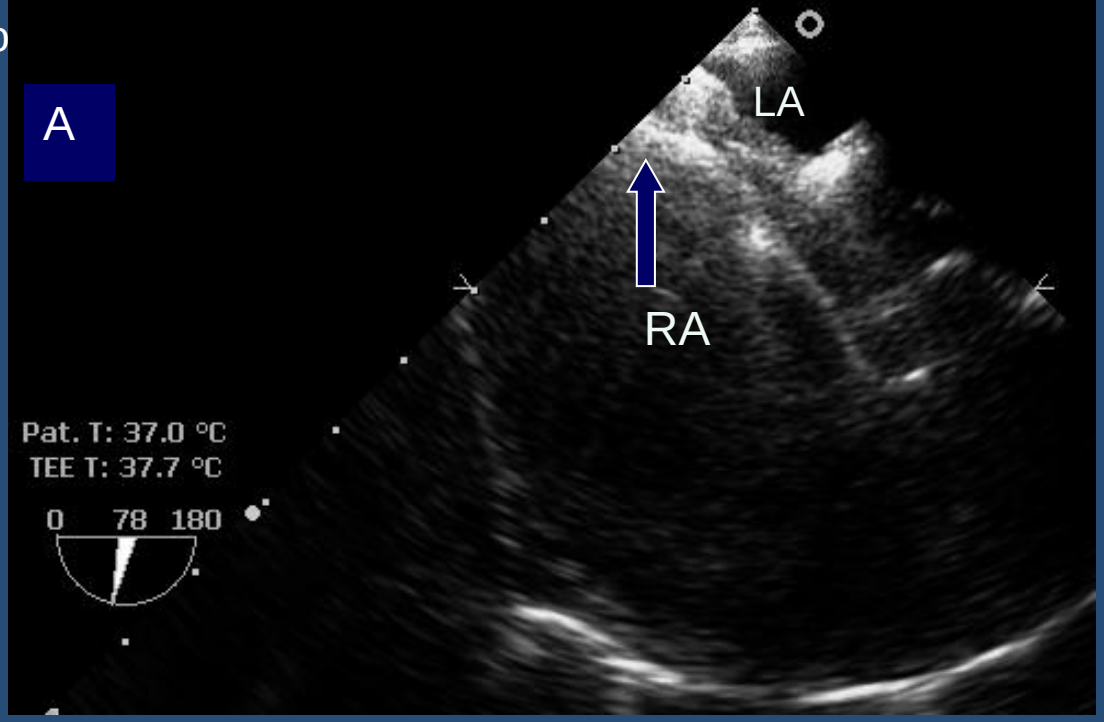


Conventional

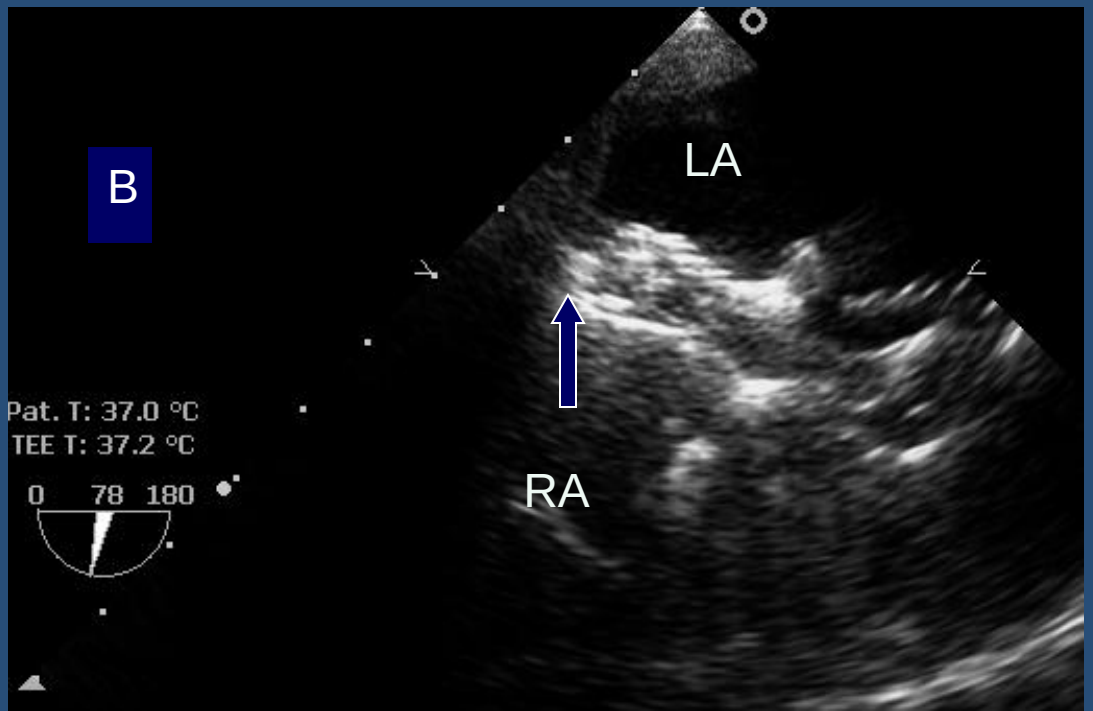


Retroflexed

ASD for Device Clo



Conventional



Retroflexed

Deficient IVC rim: Results from the AIMS database

- Apr 2007 – May 2008, 195 patients, 12 had deficient IVC rims
- Median age: 5.5 (2.5 - 27) yrs.
- Weight 19.5 (9 -65) Kg.
- Defect size 21.5 (16-32) mm
- One residual defect after surgery
- Fluoroscopic time: 13.1 (4.2 -32.7)min

Deficient IVC rim: Results from AIMS

- Four required size revision
- One embolization: 32 mm defect, 34 mm device embolized a few minutes after release (‘good’ position, no residual flows), 36 mm device successfully deployed
- Small residual flows in two at IVC margin, disappeared on follow up in one
- All remain well on follow-up (1-12 months)

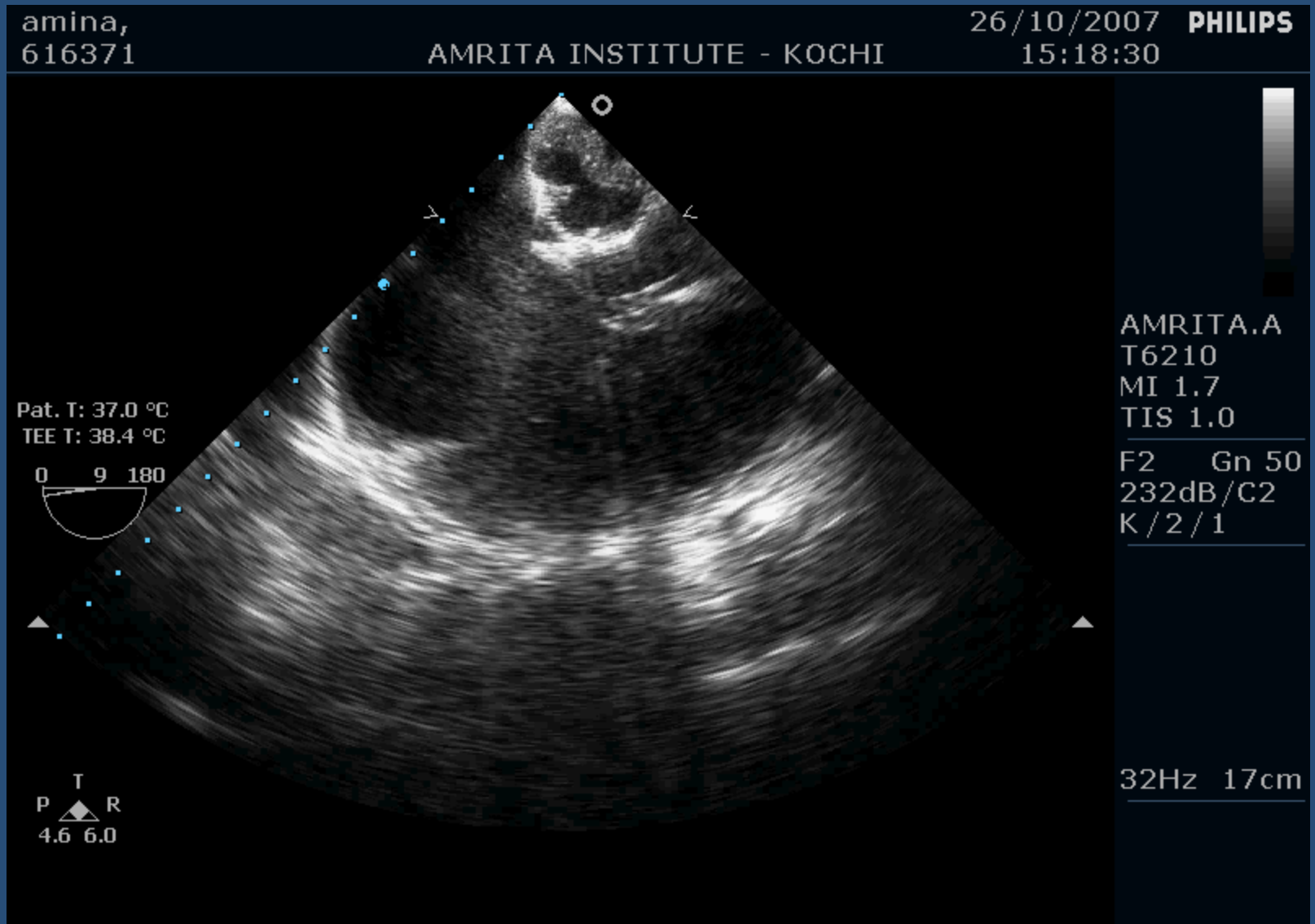
Echo-guided deployment

- Echocardiography (unlike flouro) does not give information of the entire catheter at the touch of a foot switch
- Keeping the image focused on as much of the catheter as possible requires expert echocardiography
- Completely different hand–eye coordination skills for the operator using echo guidance
- Practice deployment under TEE without fluoroscopy!

Echo Guided Interventions

- Developing Hand-eye coordination by looking at echo images
  - ASD device closure
  - Balloon atrial septostomy
  - Trans-septal puncture
  - VSD device closure

Echo guided deployment



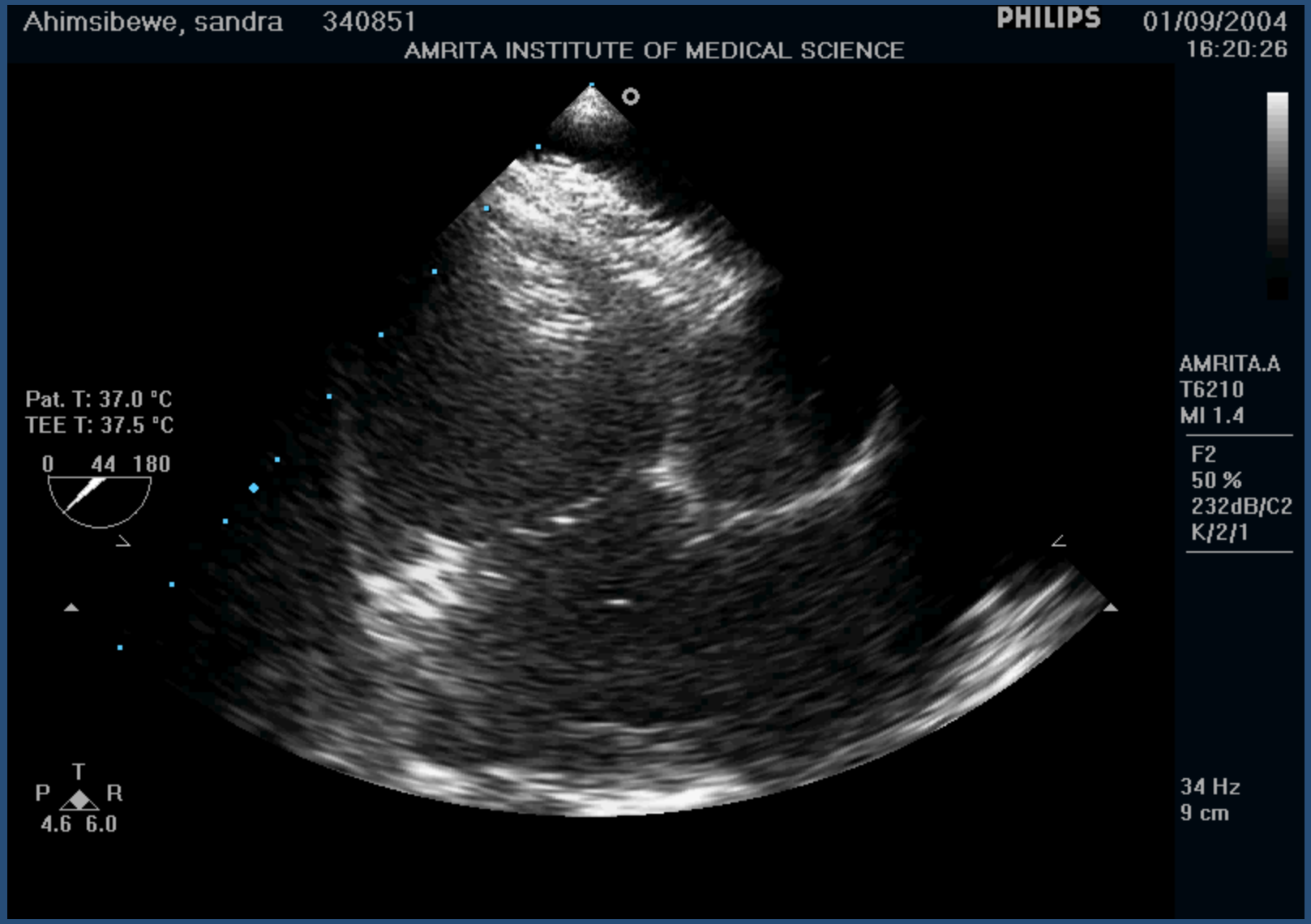
Echo guided procedures

- Keeping the image focused on as much of the catheter as possible requires expertise
- Angiography gives information on all planes at the touch of a foot switch
- Different hand –eye coordination skills
- Some devices scatter ultrasound
- Window dependant →TEE → anesthesia

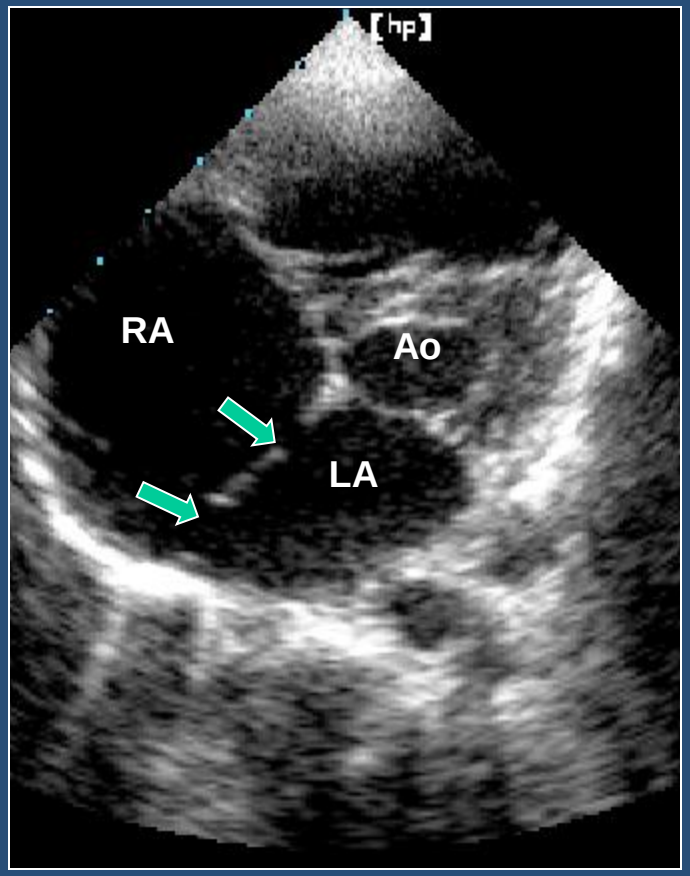
Potential Downsides of Echo as a Sole Guide to Interventions

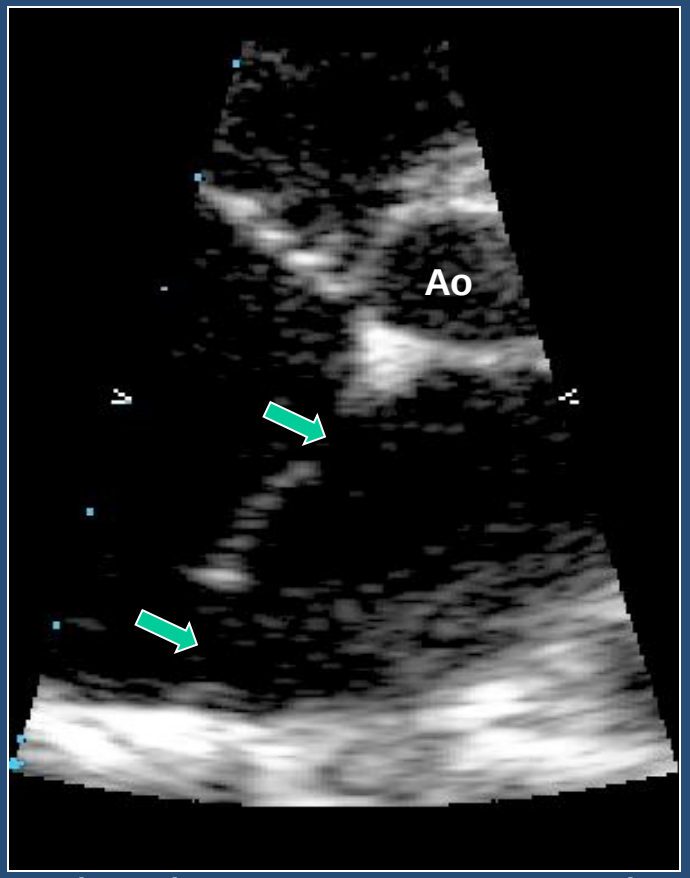
- Considerable expertise in imaging
- Imaging plane has to be same as the plane of the catheter/delivery system
- The catheter often needs to be ‘chased’
- One may advance the catheter too far

Testing device stability



Multifenestrated ASD

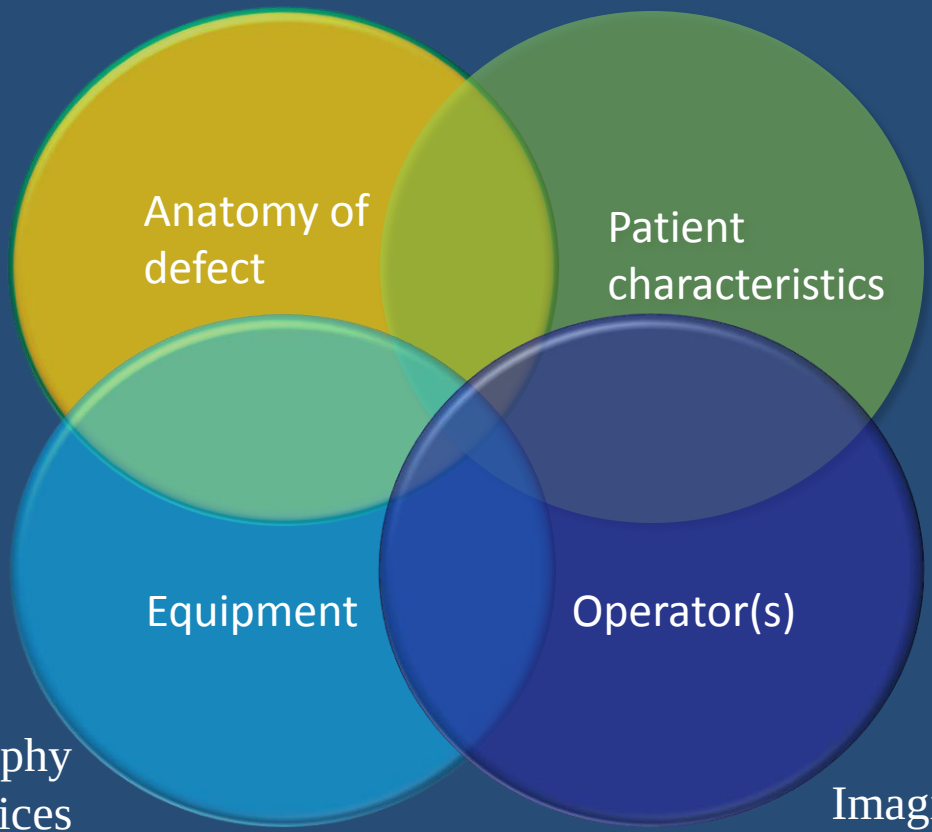




This parasternal short-axis view shows that there are two ASDs. The posterior defect is larger of the two and has no posterior margin

What Determines Results of Catheter Closure of ASD?

Size
Location
Margins
Neighboring structures
Associated lesions

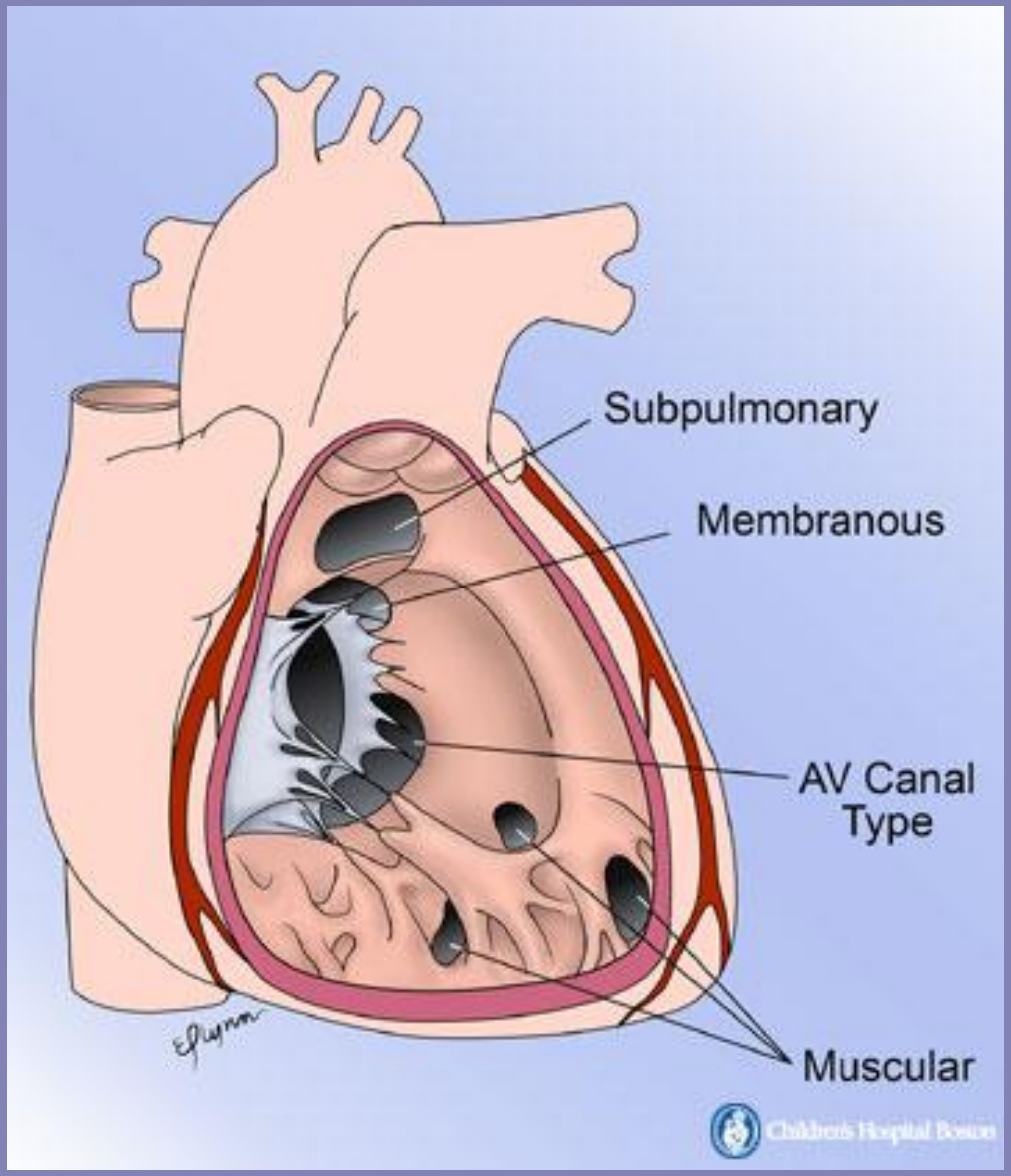


Weight
Age
Co-morbidity

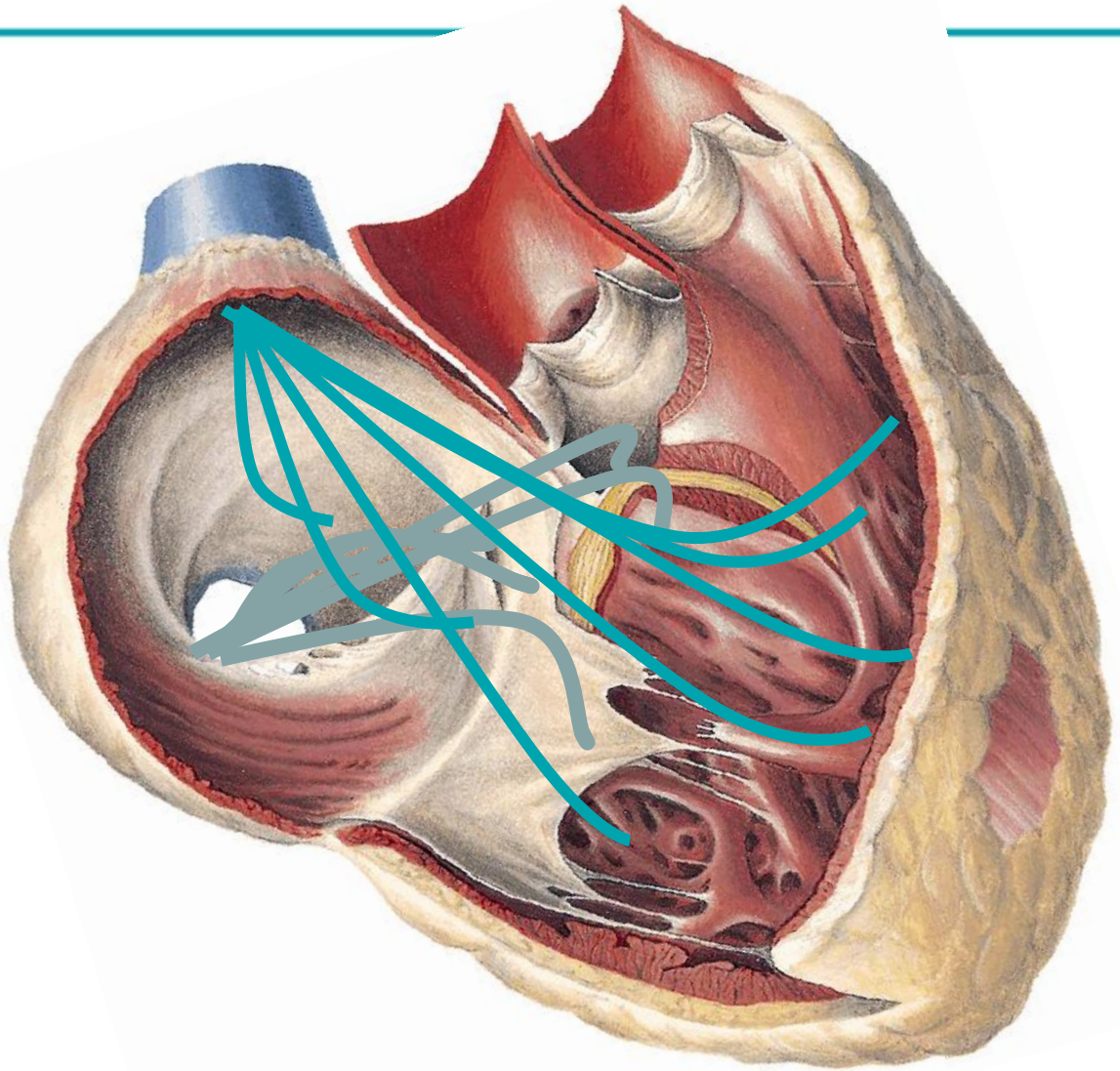
Echocardiography
Devices
Delivery systems

Imaging guidance
Experience
Hand-eye coordination

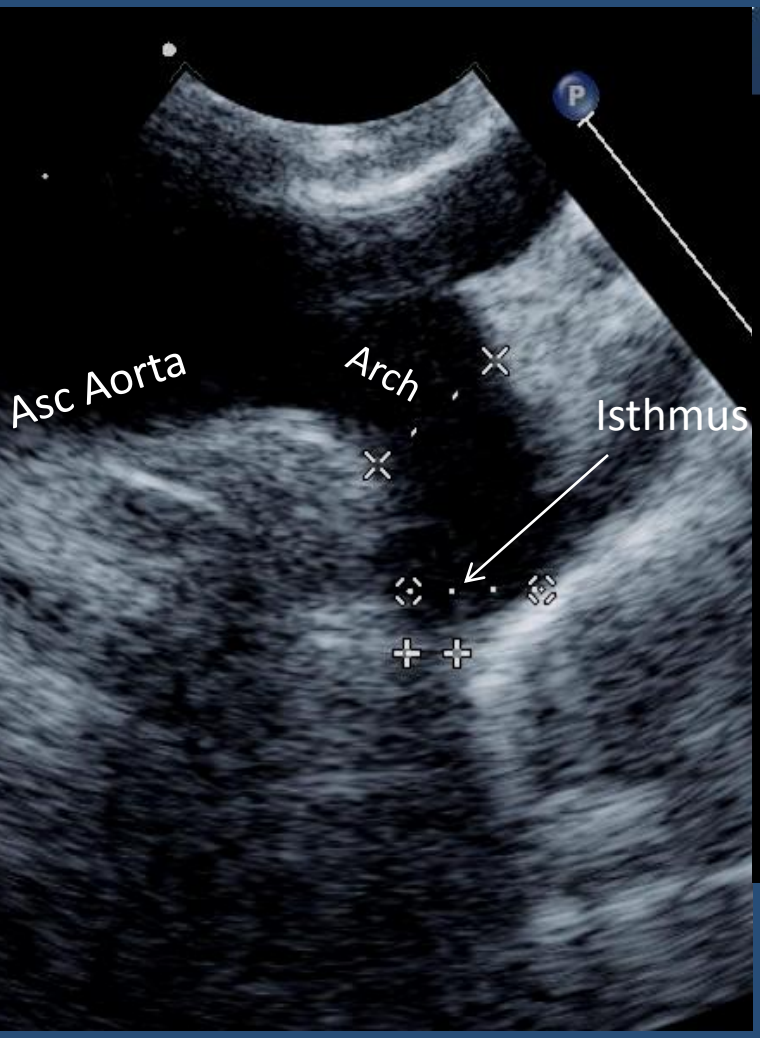
Echo for VSD

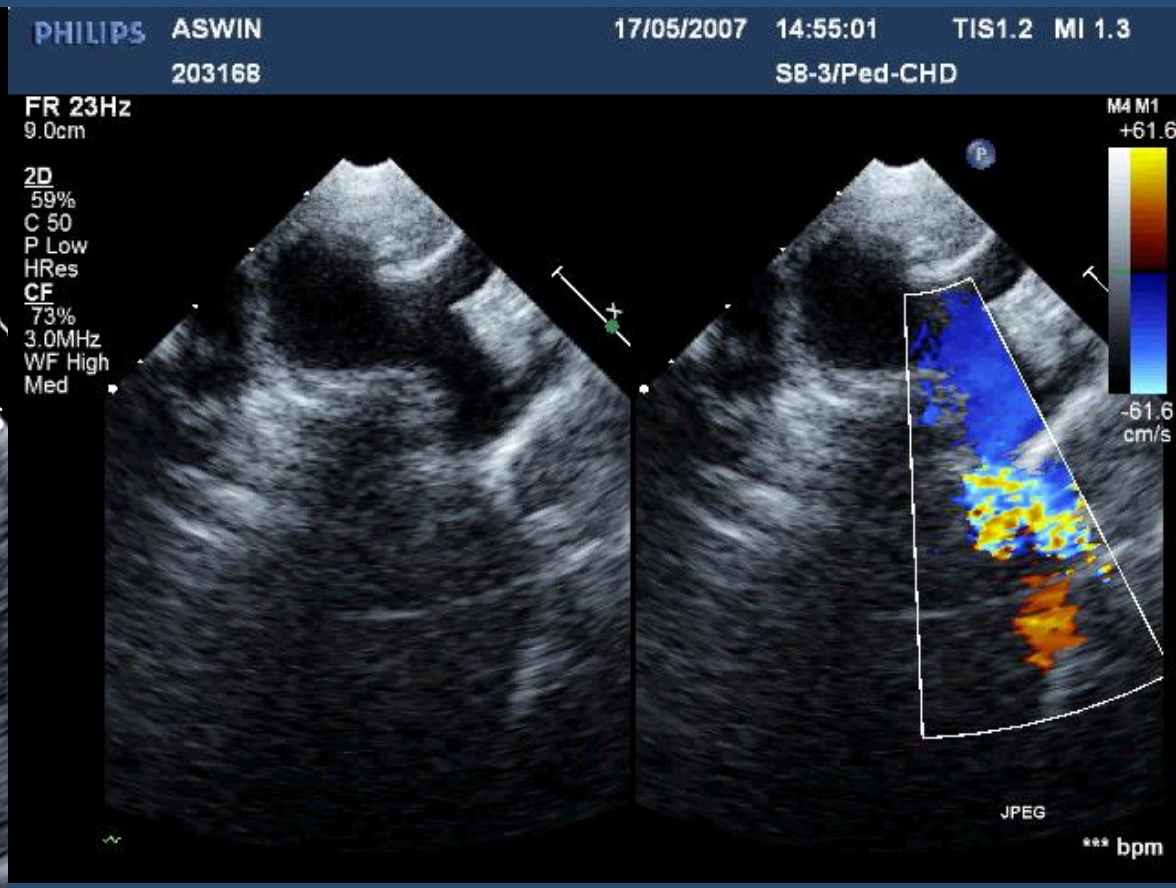

Subpulmonary
Membranous
AV Canal Type
Muscular
Children's Hospital Boston

Muscular VSD: Location

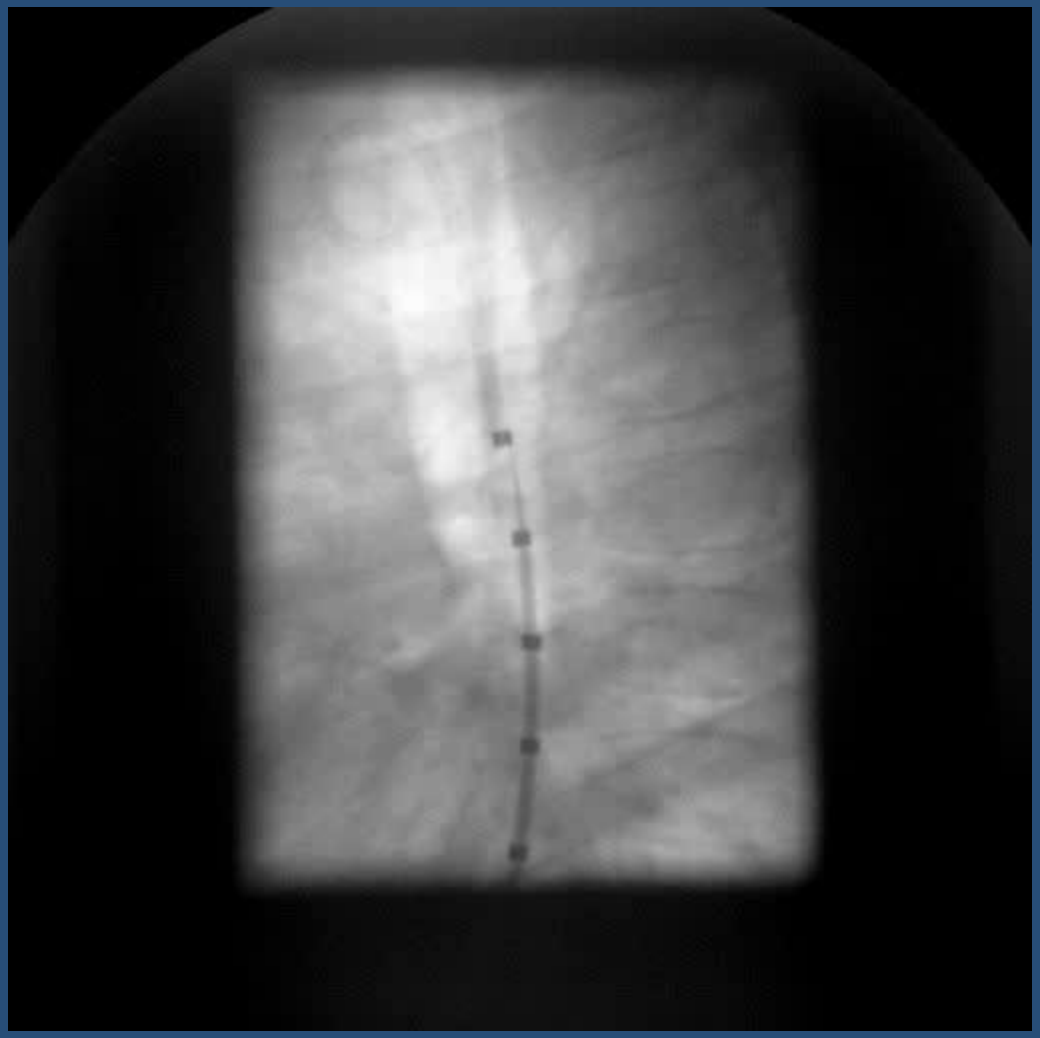


Coarctation: Stent Vs. Balloon

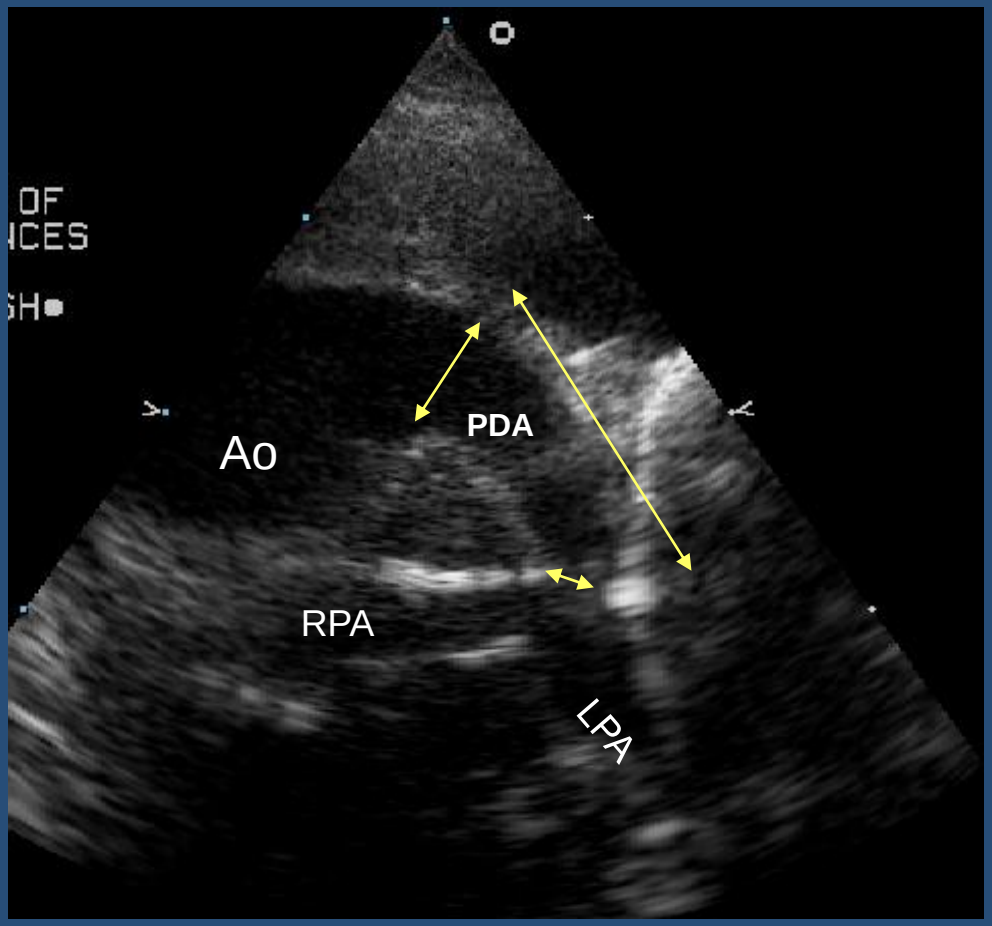




Coarctation: Stent Vs. Balloon



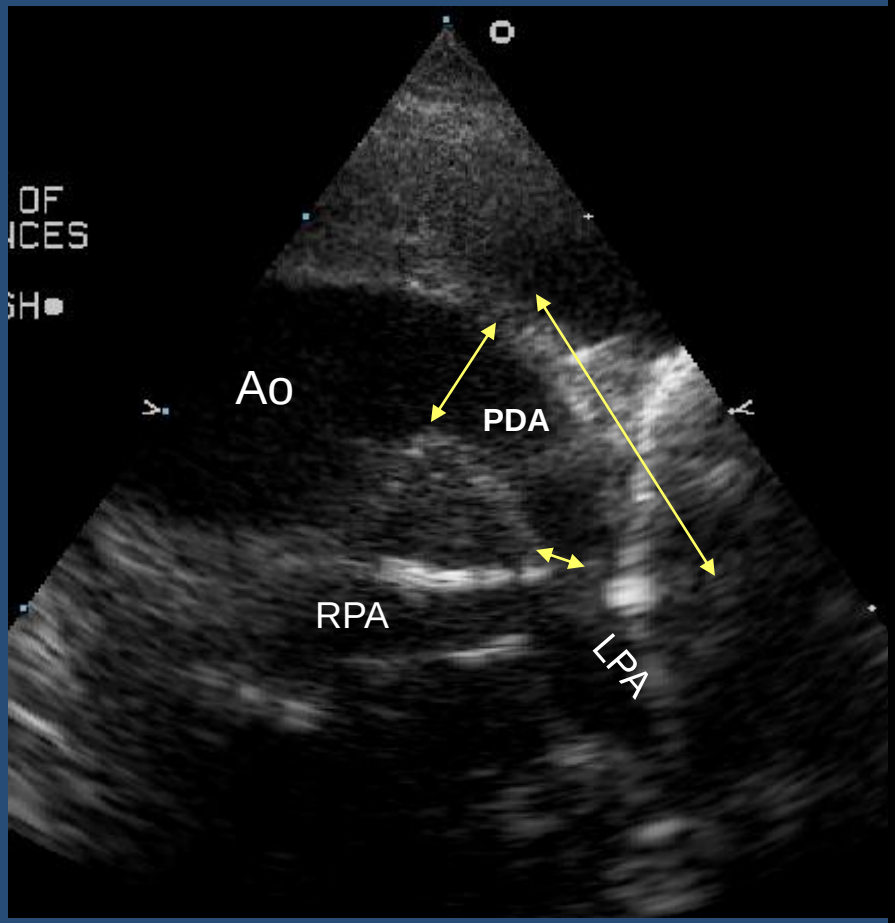
Echocardiogram before ductal stenting

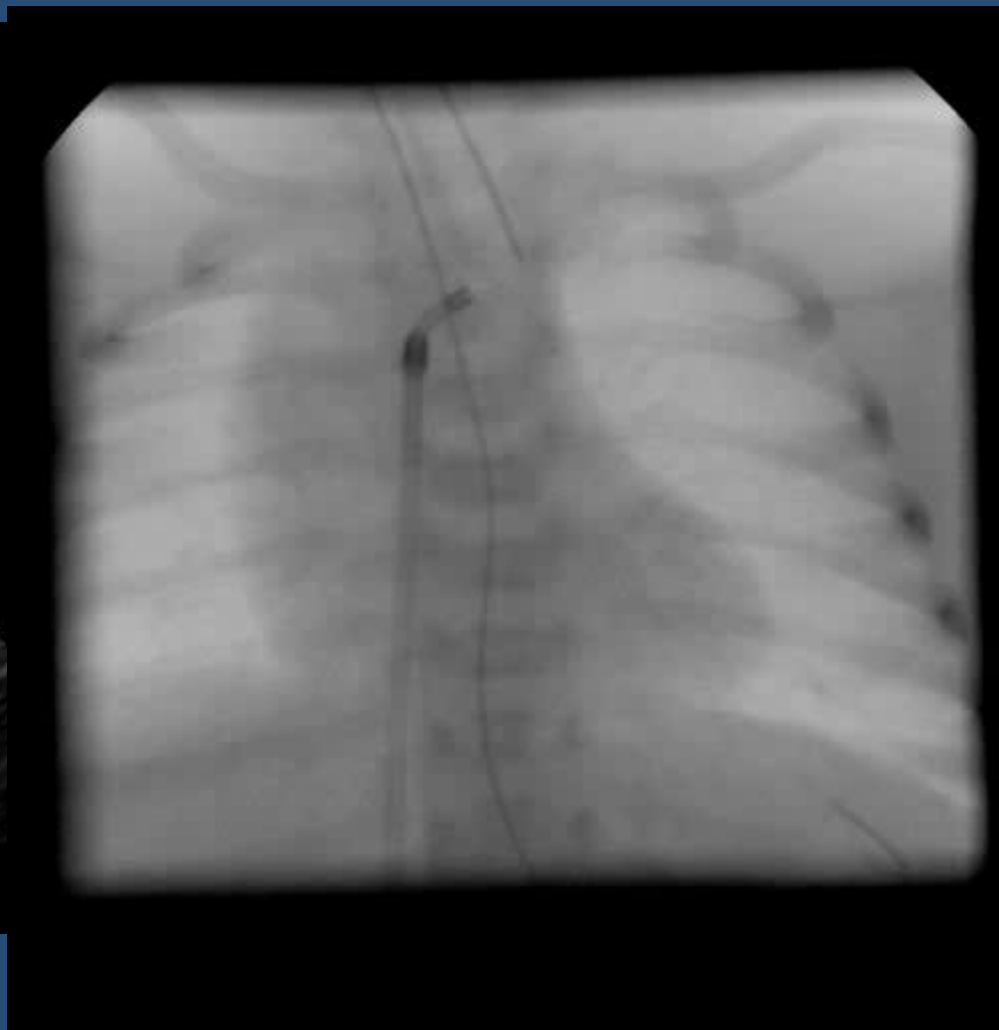


Measurements

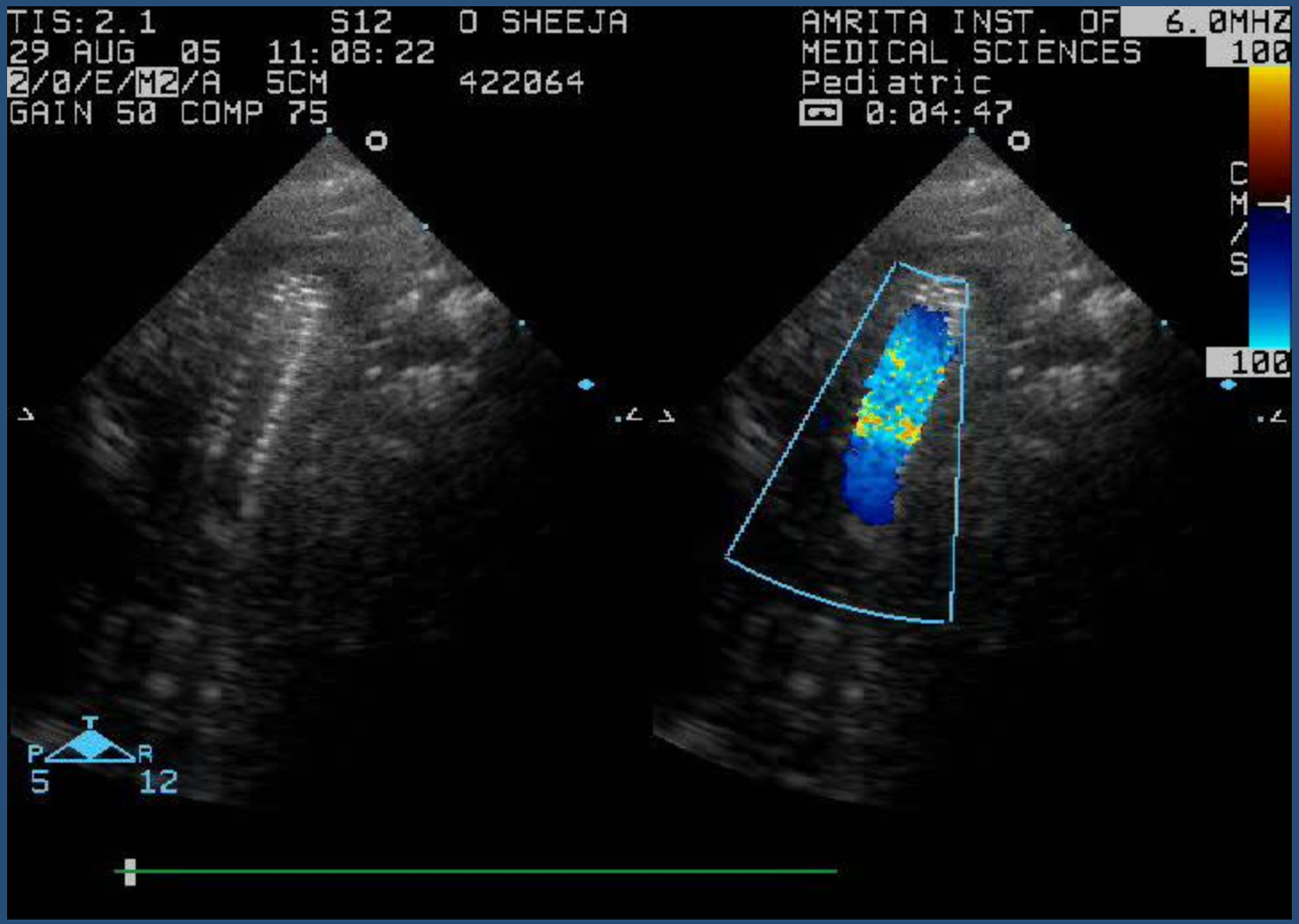
- Narrowest Duct Diameter: 2.1 mm
- Duct Diameter at aortic end: 4.4 mm
- Duct length:13 mm
- Hilar LPA: 4 mm
- Hilar RPA: 3.5 mm
- RPA origin: 2.5 mm

Echocardiogram before ductal stenting

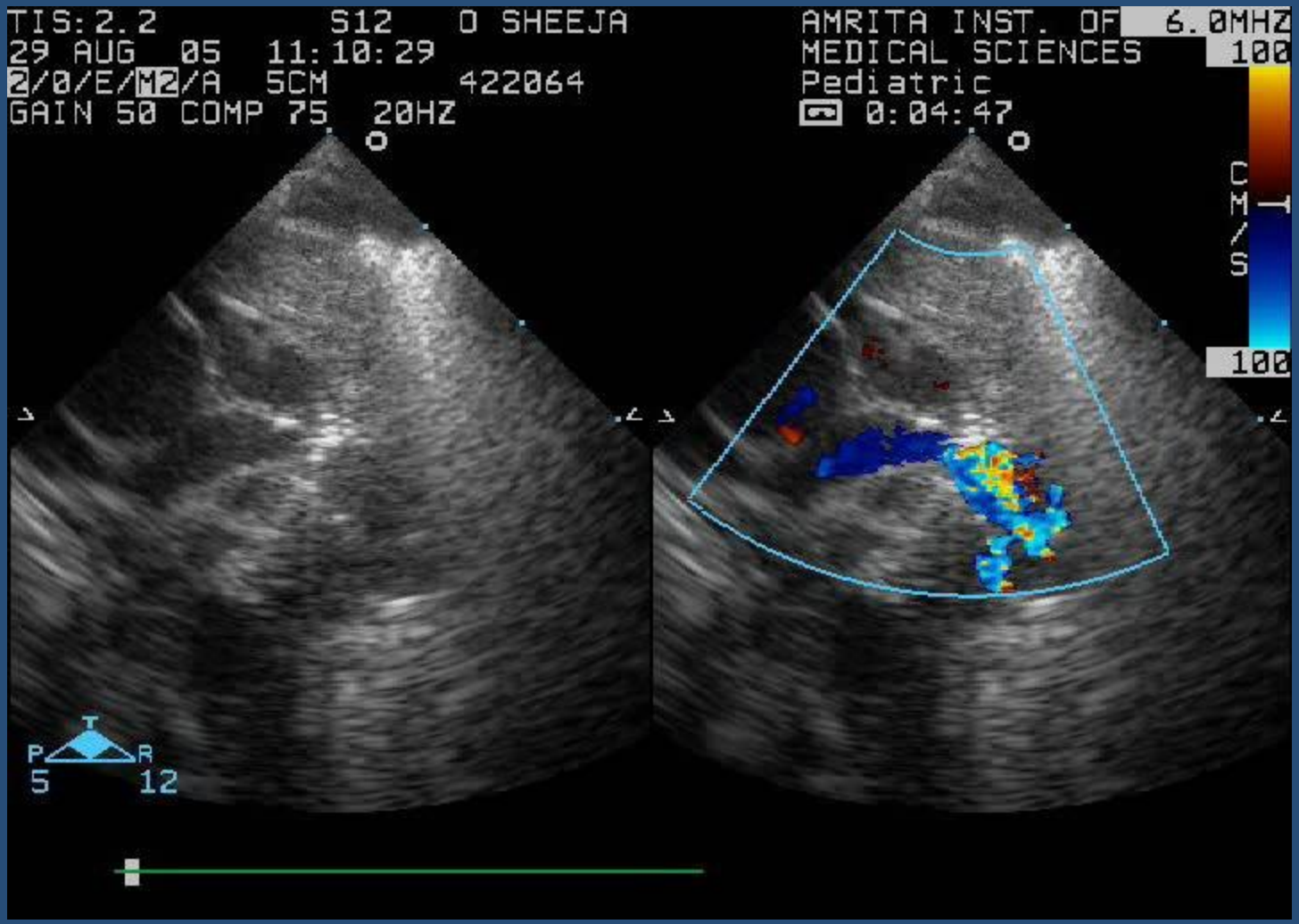




Echo after PDA stent deployment



Echo after PDA stent deployment



Echo after PDA stent deployment