



# **Interventional Echo Guidance of PFO and ASD closure : From TEE to ICE**

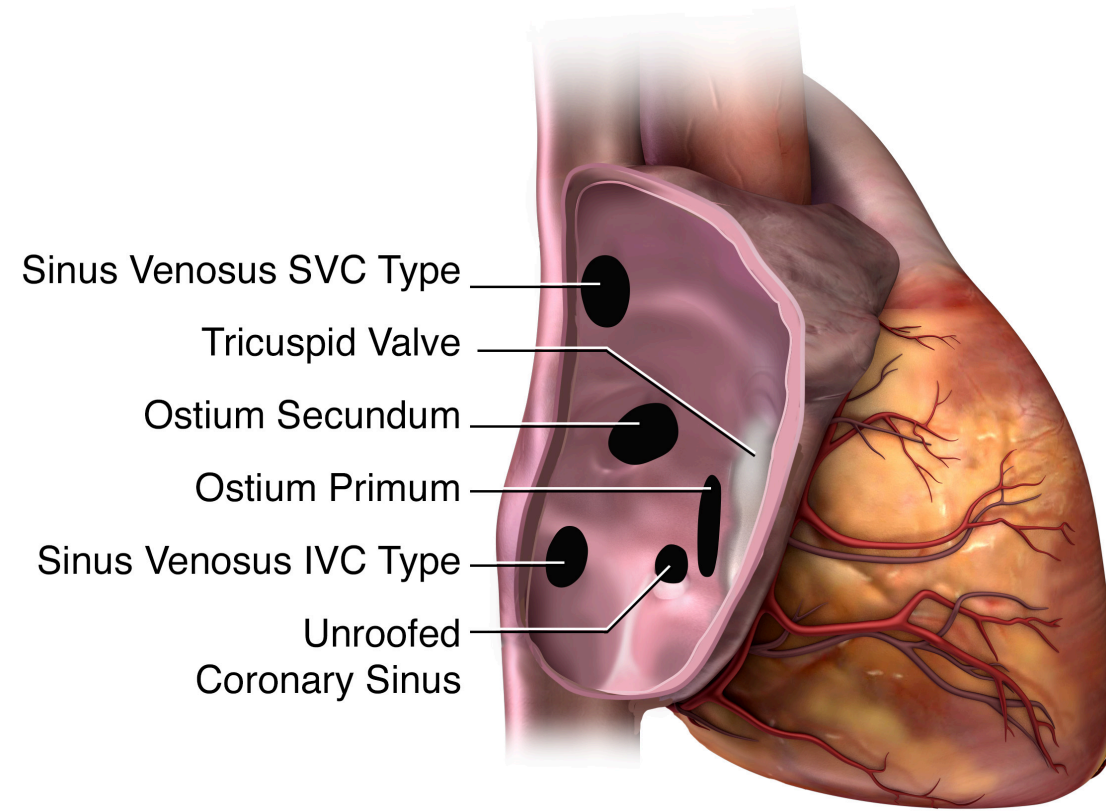
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University of Pennsylvania School of  
Medicine*

**May 2016**

# Introduction

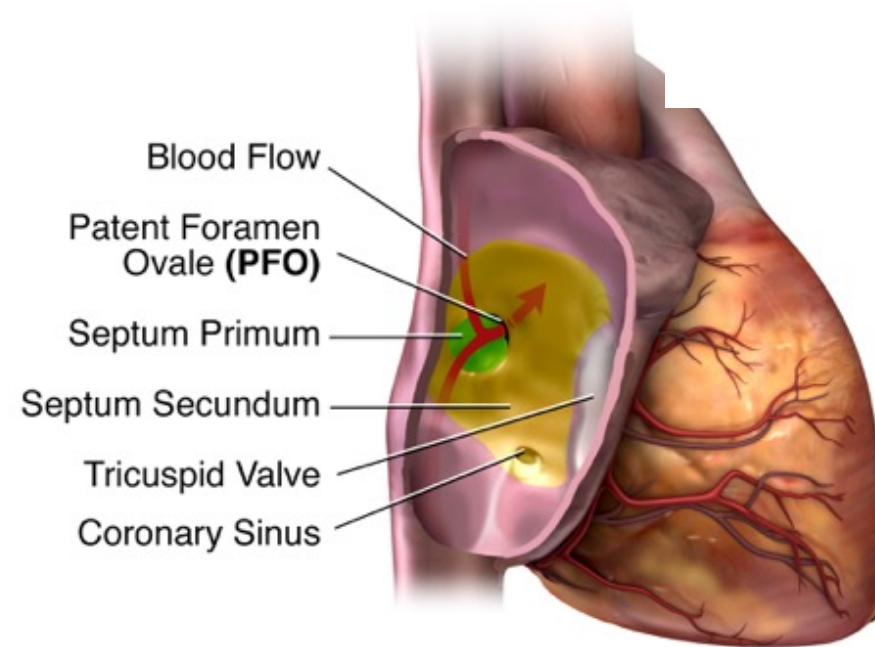
- Increasing number of procedures rely upon precise echocardiographic imaging
- Echo paramount to appropriate *patient selection, procedural guidance, and assessment of results*
  - *No one echo modality is “right”*
  - Balance need for highly specific imaging targets and goals with need for interventionalist autonomy
    - TTE and TEE require additional echo support
    - Intracardiac echo can be performed independently by operator during percutaneous procedure

# Types of Septal Defects



Sub-types of atrial septal communications when viewed from RA. PFO not illustrated.

# Patent Foramen Ovale



Patent foramen ovale: The septum primum is dark green and the septum secundum is light green. A PFO typically exists at the anterior superior border adjacent to the aortic root. The arrows denote the passage of blood through the PFO from the right to left atrium.



## ASD Characteristics That Should be Routinely Measured and Reported

ASD type—PFO, primum ASD, secundum ASD, or other atrial communication (sinus venosus defect, unroofed coronary sinus, anomalous pulmonary vein drainage)

Doppler flow—presence of left to right, right to left or bidirectional flow

Presence or absence of ASA

Associated findings—eustachian valve or Chiari network

ASD size—maximal and minimal diameters (optimally measured from 3D volume data sets), ASD area

ASD location in septum (i.e., high secundum ASD, sinus venosus defect SVC or IVC type)

Measurement of all rims— aortic, RUPV, superior, posterior, inferior, AV septal

Shape of ASD—round, oval, irregular

Presence of multiple fenestrations

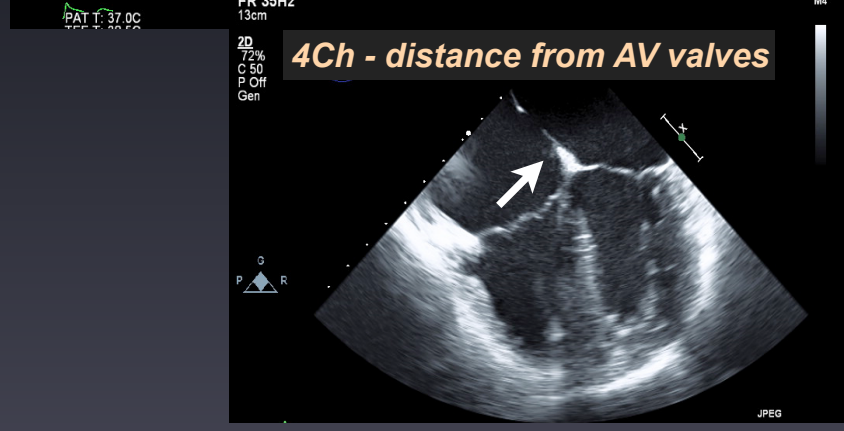
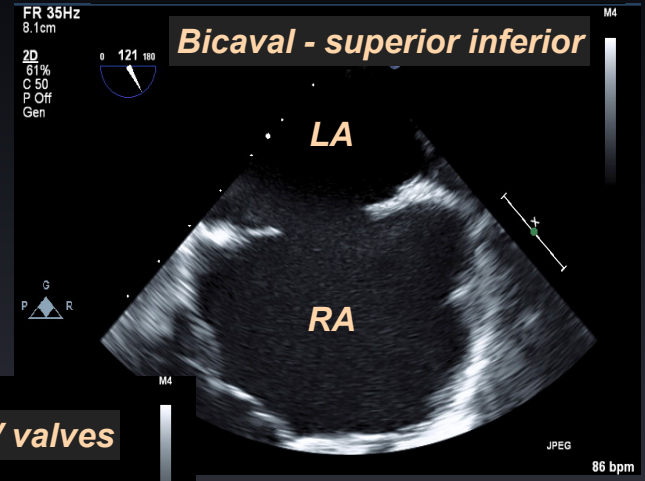
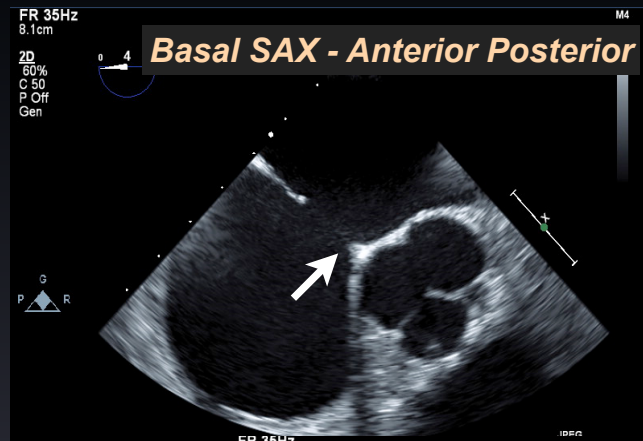
Dynamic nature of ASD—measurement of area and maximum/minimal diameters in end-systole and end-diastole

Stop-flow diameter of ASD (when balloon sizing is used for percutaneous transcatheter closure)

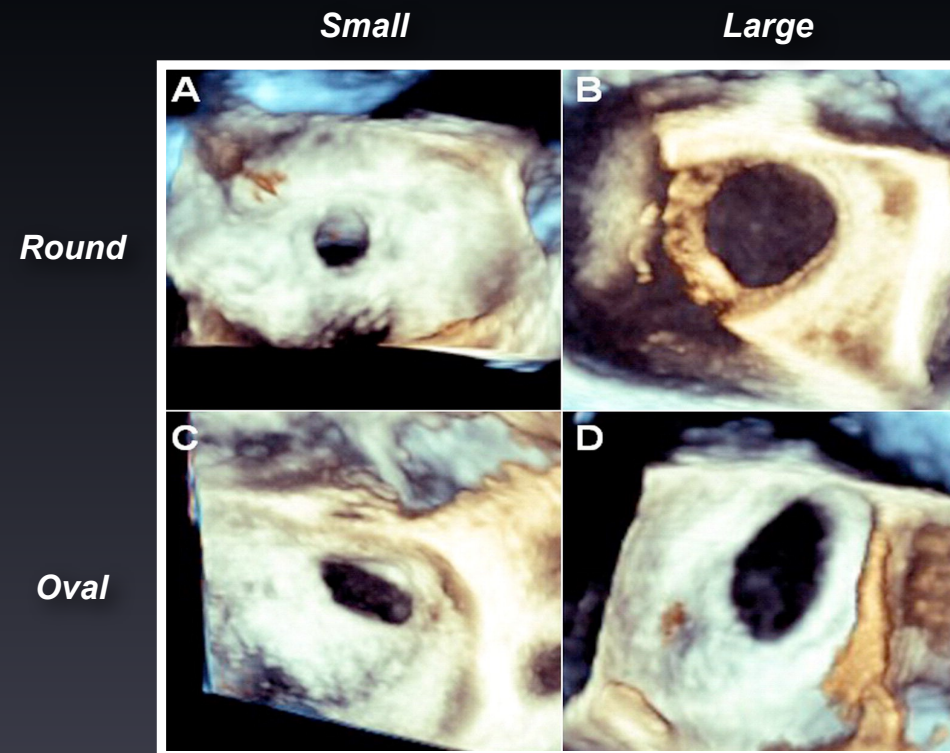
# TEE Guidance of Interventional Procedures

- **Advantages**
  - Superior image quality to TTE in adult patients
  - RT3D TEE widely available
  - Able to evaluate anatomic inclusions, exclude LA and LAA thrombus, evaluate device position and residual shunting
- **Disadvantages**
  - Requires esophageal (+/- endotracheal) intubation
  - Requires additional sedation
  - Risks include esophageal trauma, aspiration
  - Patient discomfort
  - Additional support required

# ASD Key views: TEE



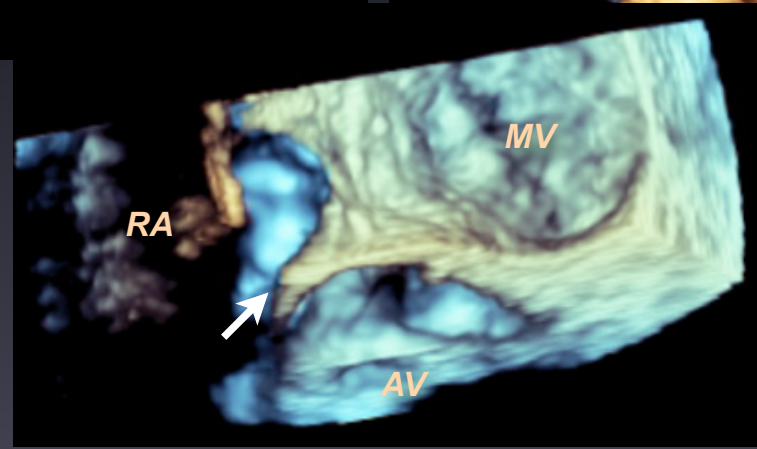
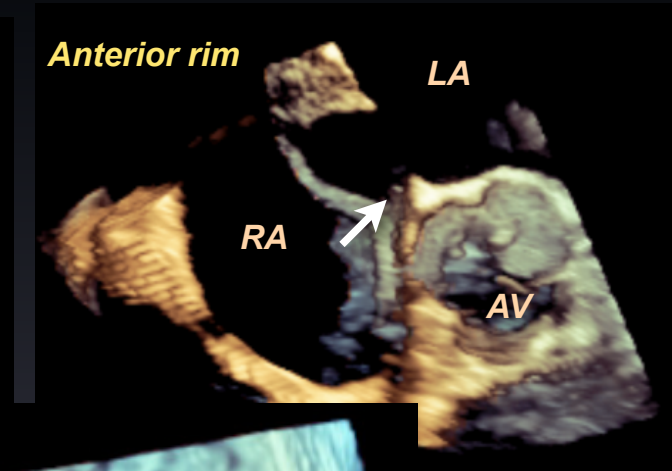
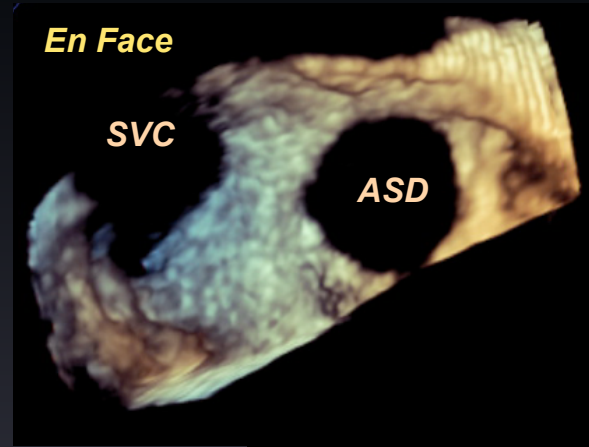
**Defect size and shape helps predicts implanted device size**

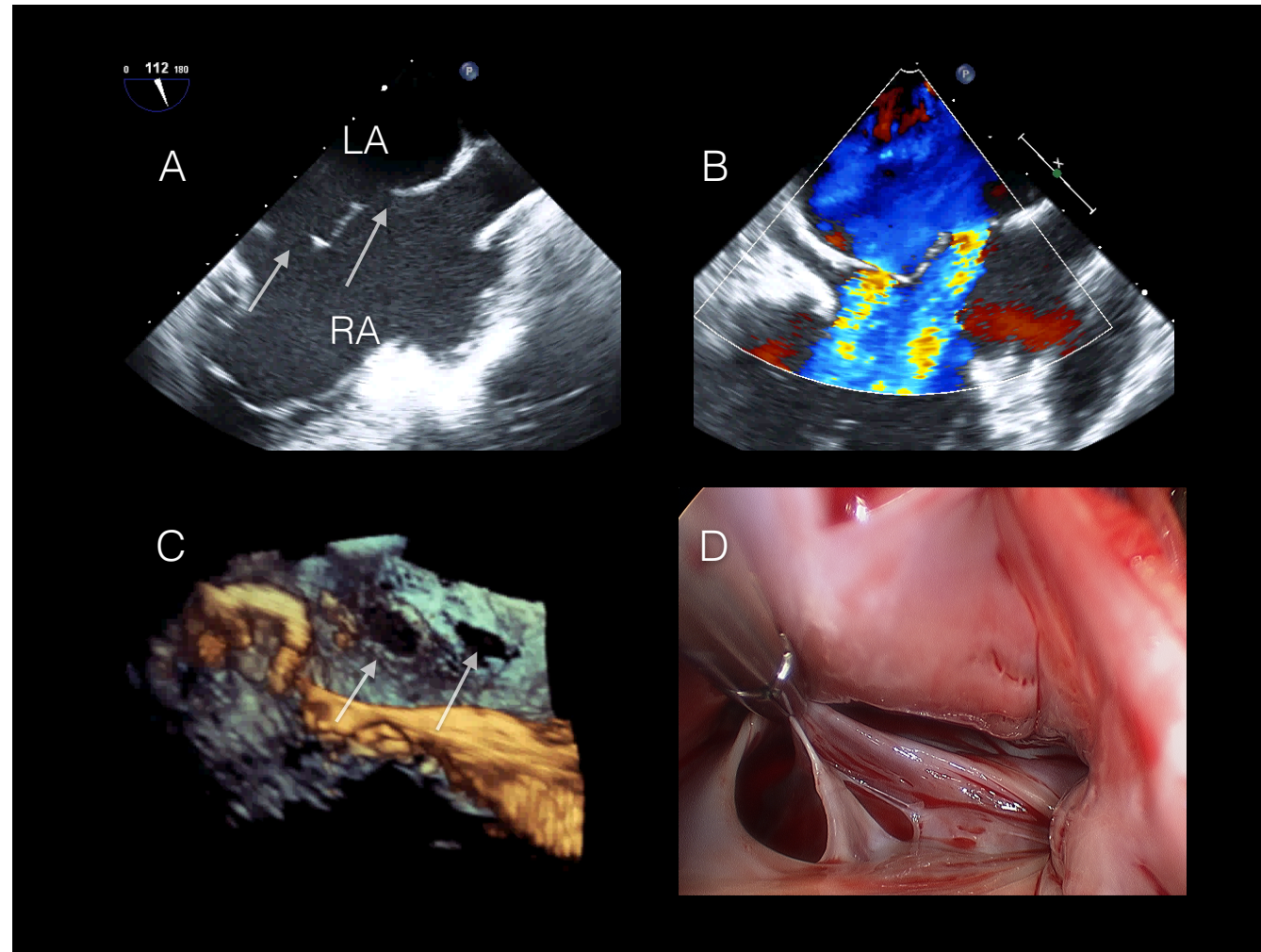


Source: Journal of the American Society of Echocardiography 2012; 25:1031-1040  
(DOI:10.1016/j.echo.2012.07.017 )

Representative examples of (A) RD, small, (B) RD, large, (C) OV, small, and (D) OV, large ASDs.

# RT3D imaging

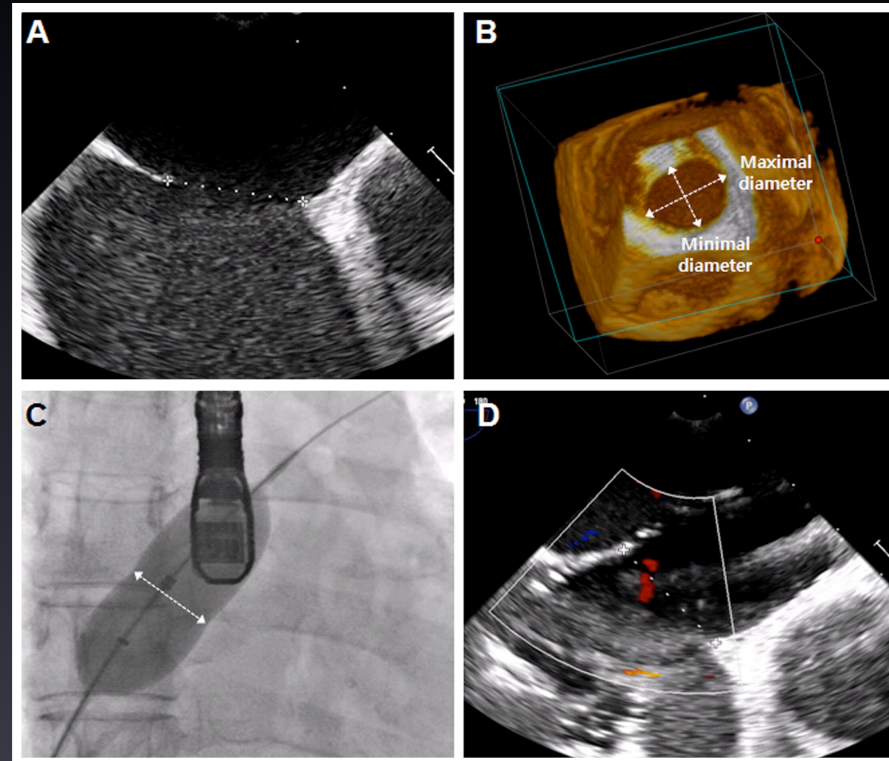




3D TEE of 1 medium and 1 small sized ostium secundum ASDs - A) Bicaval view demonstrating 2 discrete ASDs. B) Bicaval view with Color Doppler demonstrating 2 discrete L to R shunts. C) Zoom acquisition of both ASDs en face from RA perspective. D. Minimally invasive surgical repair demonstrating identical pathology to 3D TEE. White arrow ASDs. RA- right atrium, LA-left atrium



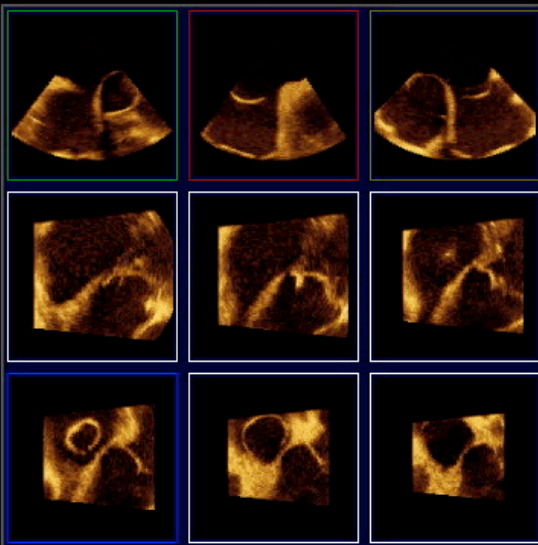
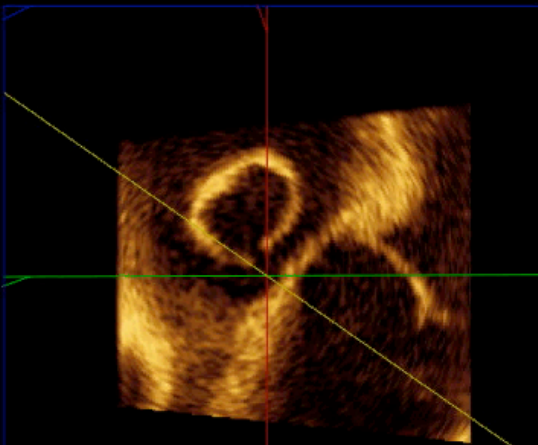
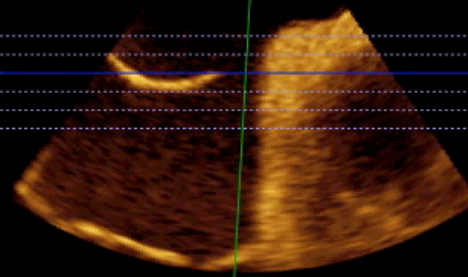
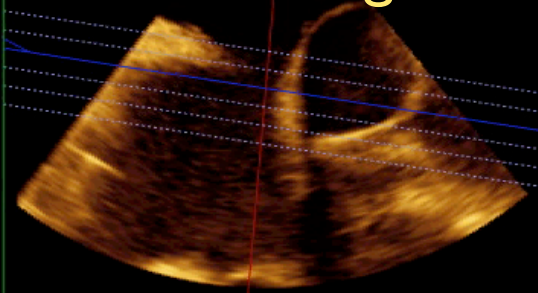
## Multiple measures of ASD size 2D, 3D, BSD on Flouro, BSD on Echo



Source: Journal of the American Society of Echocardiography 2012; 25:1031-1040  
(DOI:10.1016/j.echo.2012.07.017 )

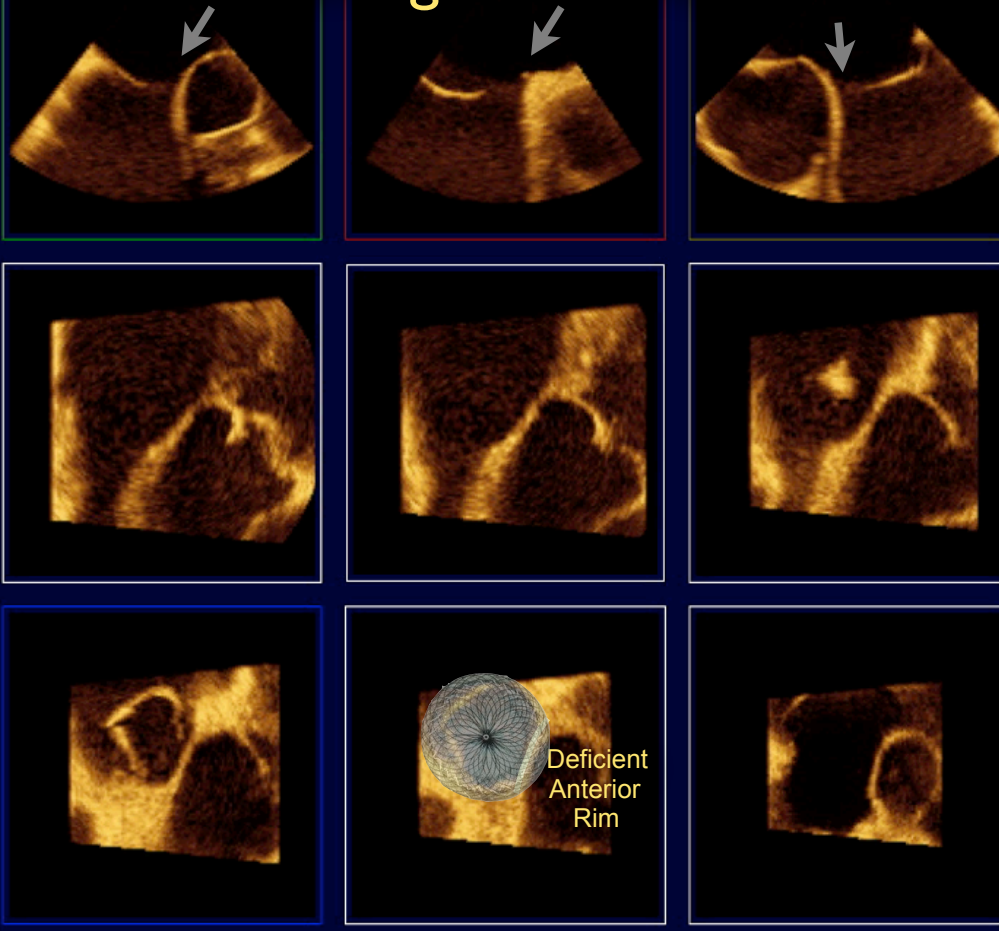
Representative measurements of ASD diameter on (A) 2D-TEE images, (B) maximal and minimal diameters on 3D-TEE images, and SBD using (C) fluoroscopy and (D) 2D-TEE images.

# Challenge of a Deficient Rim



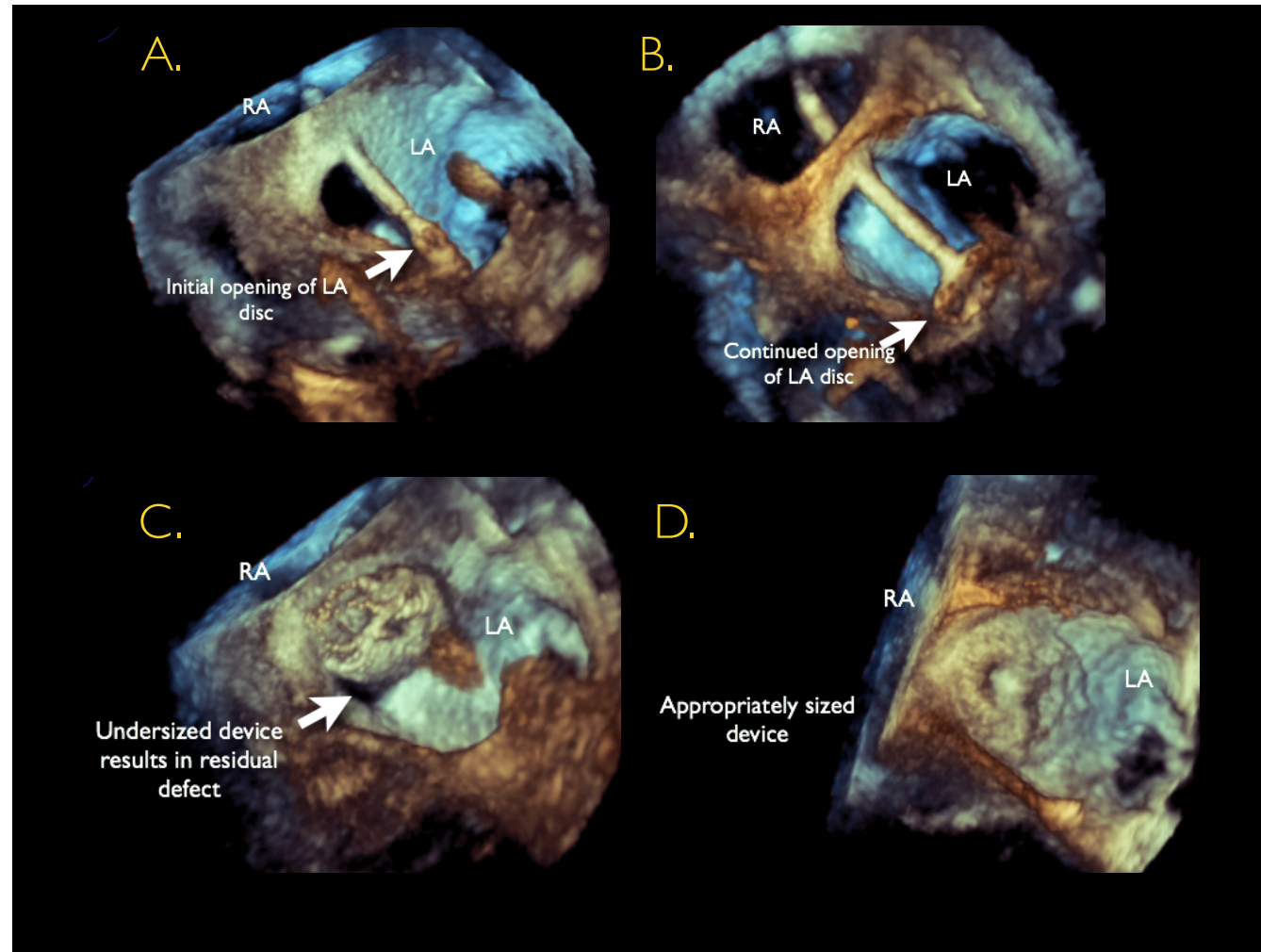


# Challenge of a Deficient Rim



En face  
3D imaging  
allows for  
quantification  
of the rim  
deficiency  
and  
appropriate  
sizing of  
device

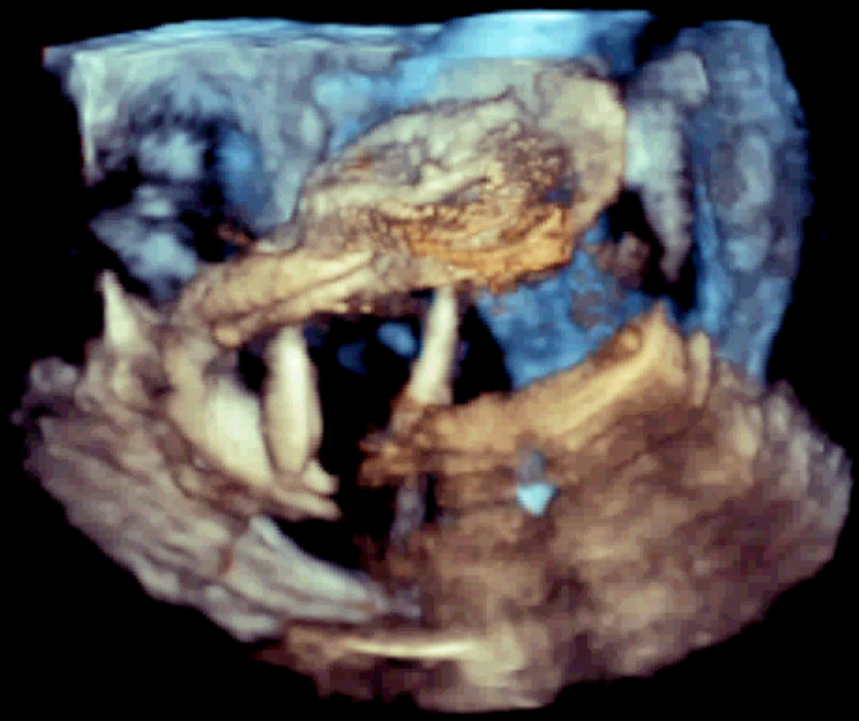
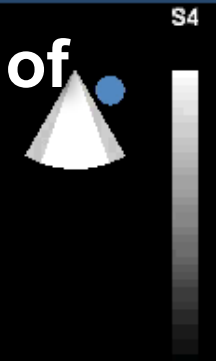




Intra procedural real-time 3D TEE provides superior visualization of wires, catheters and devices, and their relationships to neighboring structures in a format that is generally more intuitively comprehended by the interventional cardiologist than 2D echo. Here an ostium secundum ASD is closed with an Amplatzer device under RT3D TEE guidance. All views are shown from the LA perspective. Panel A demonstrates the LA disc of the device opening in the LA. Panel B demonstrates continued opening of the device. Panel C demonstrates an undersized device with a residual defect. This device was removed and a larger closure device used (panel D).

RA - right atrium, LA - left atrium

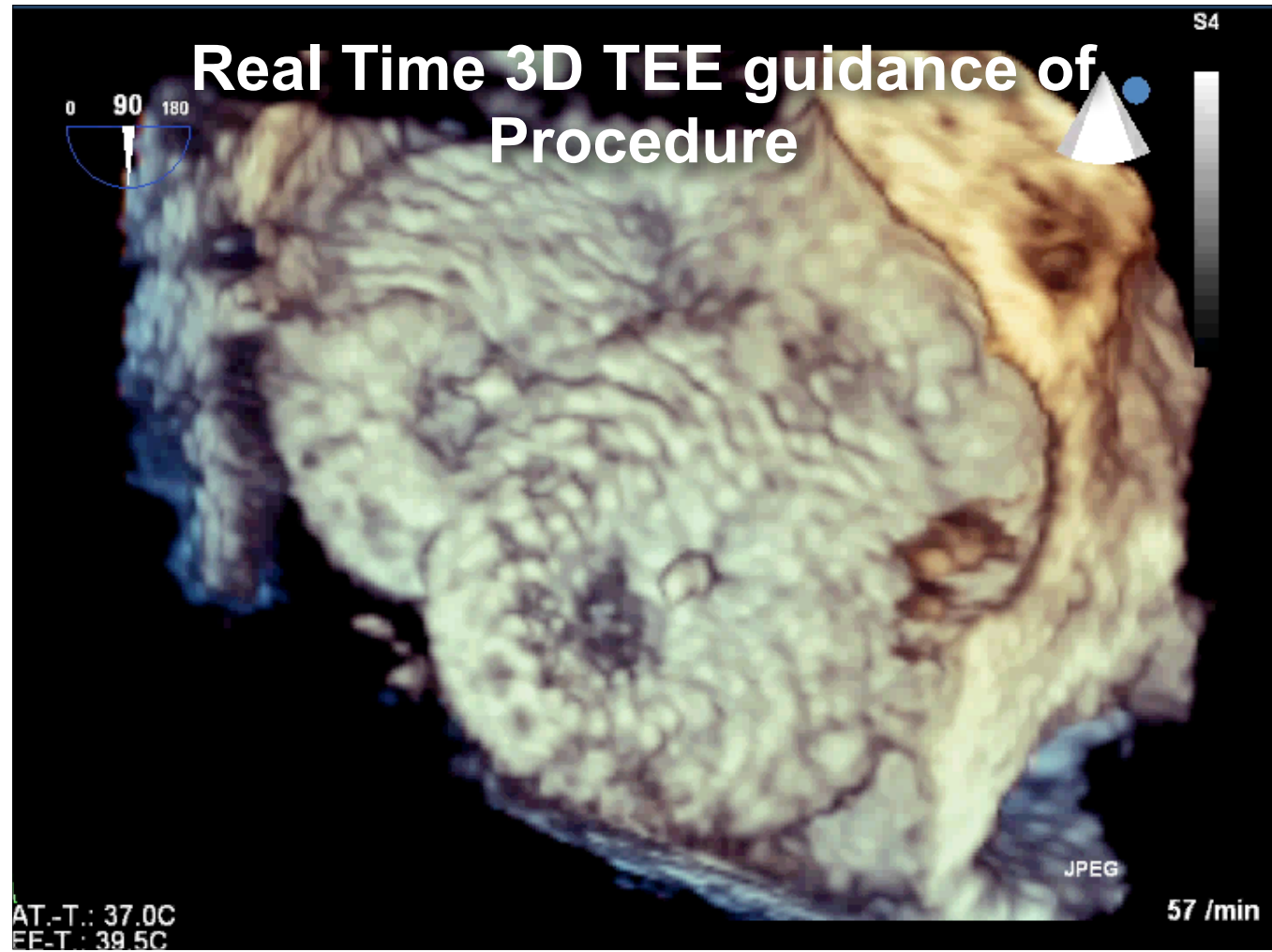
# Real Time 3D TEE guidance of Procedure



AT-T: 37.0C  
EF-T: 38.9C

JPEG  
\*\*\* /min

# Real Time 3D TEE guidance of Procedure



# Intracardiac Echo Guidance

- **Advantages**

- **Comparable imaging to TEE**
- **Single operator without additional echo support**
- **Shorter procedure and fluoroscopy times**
- **Avoids general anesthesia or additional sedation**
- **No risk of aspiration or esophageal trauma**
- **Patient comfort**

- **Disadvantages**

- **Cost**
- **Vascular risk associated with 8-10F catheters**
- **Single plane imaging on 2D systems**
- **True long and short axis views difficult to achieve in some patients on 2D systems**
- **3D ICE only recently introduced - role needs to be defined**

## Potential Risks Due to ICE

- **Vascular**
  - Hematoma
  - Retroperitoneal bleed
  - Perforation of venous structures
- **Perforation**
  - Pericardial effusion
  - Tamponade
- **Arrhythmia**
  - PAC's
  - Atrial fibrillation
  - Heart block

# Available ICE Systems

- **Boston Scientific - Atantis® (AKA UltraICE®)**
  - Radial cross sectional imaging (15° forward)
  - 9 MHz, 9 Fr catheter based
  - ~ 5-7 cm radial imaging depth
  - *2D Imaging only*
- **Siemens Biosense Webster - AcuNav®**
  - Side Viewing sector scanning (Phased Array)
  - 8 and 10 Fr, 5.5-10 MHz\*, deflectable catheters
  - ~ 12-15 cm imaging depth
  - Full Doppler, and color flow imaging
  - **Newly introduced 3D system AcuNav V - 10F catheter**
- **Phillips (EP Medsystems - ViewMate®)**
  - 9 Fr catheter with and 2D, color, spectral Doppler
  - Newer CX50 Matrix system ICE compatible



## ACUSON AcuNav V™ Ultrasound Catheter

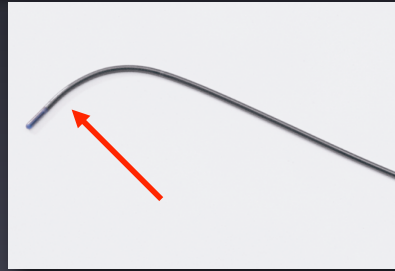
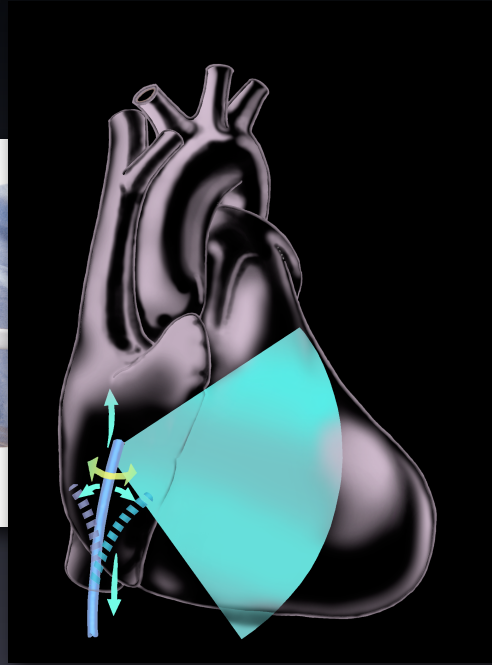
- *10F, 90 cm, 22°x 90° volume, real-time 3D imaging - images at 6 and 8 Mhz*
- *Powered by ACUSON SC2000 system – 16X speed of standard ultrasound*
- *Real-time 3D and 3D with color*
- *Potential to add incremental improvement to EP and structural heart disease interventions*





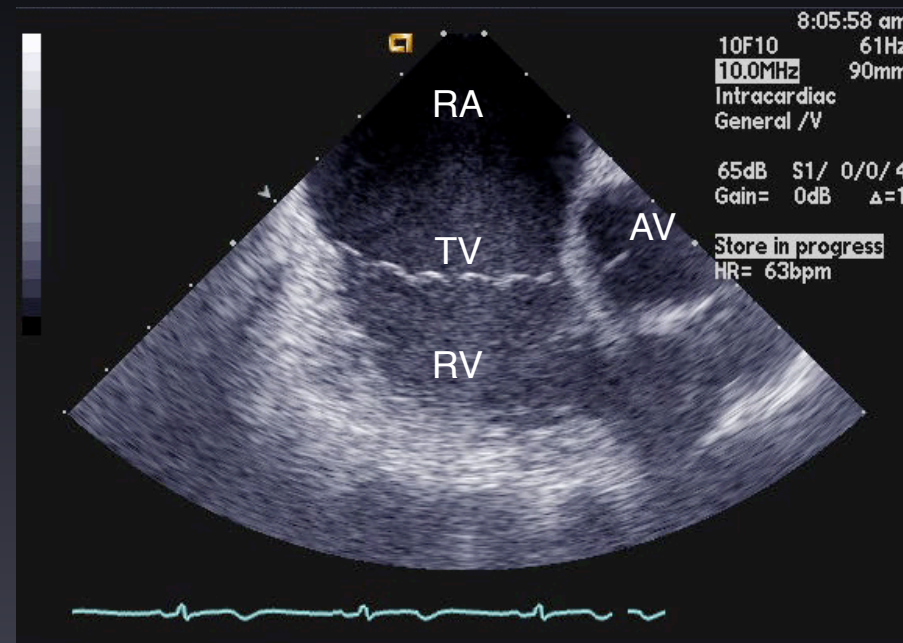
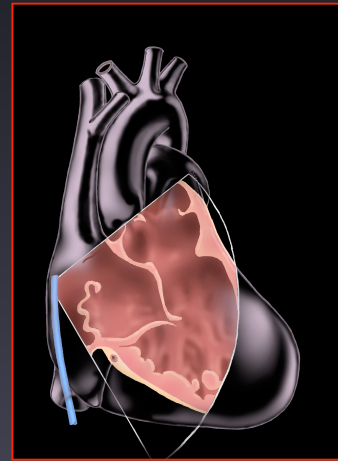


# AcuNav Steering



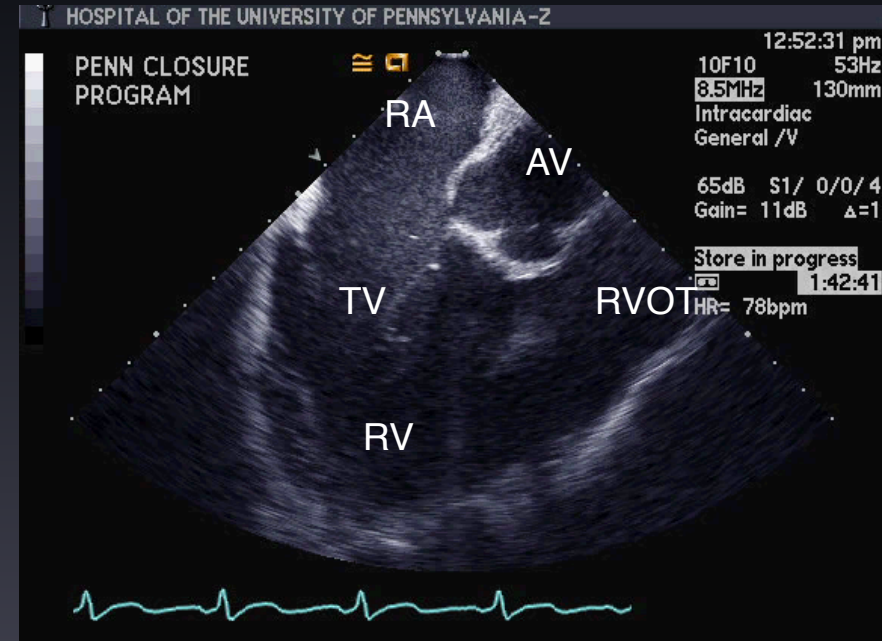
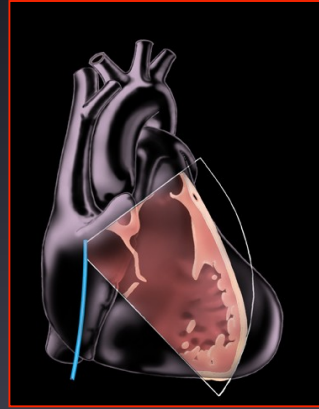
# ICE Image Review (Home)

- RA/Tricuspid/RV
- Neutral Position
- Mid RA
- 10-15° CW rotation
- "Home"



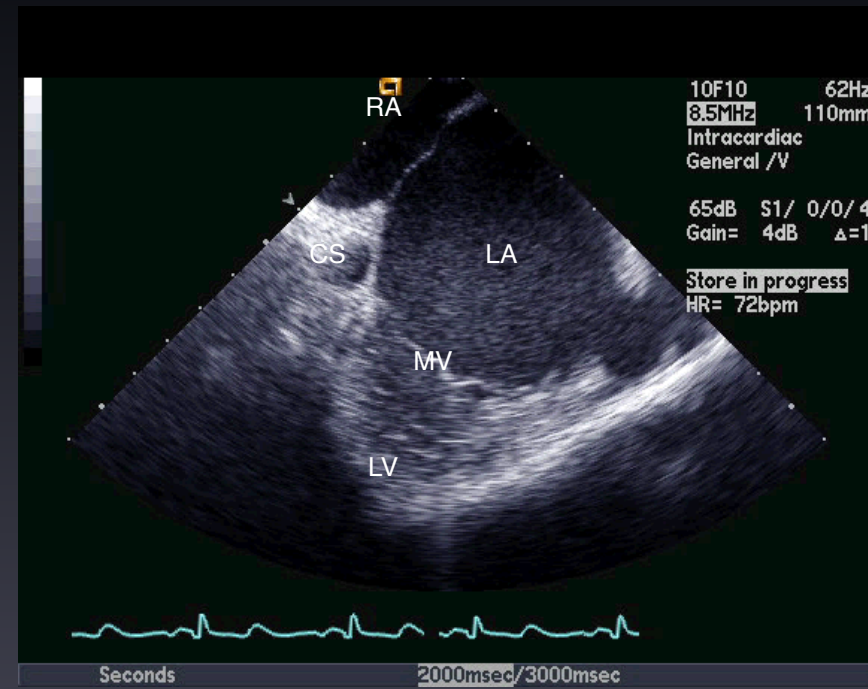
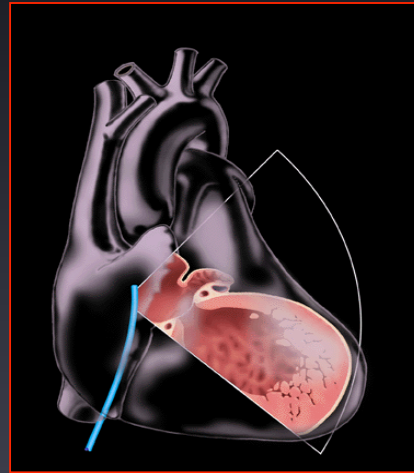
# ICE Image Review (RVOT)

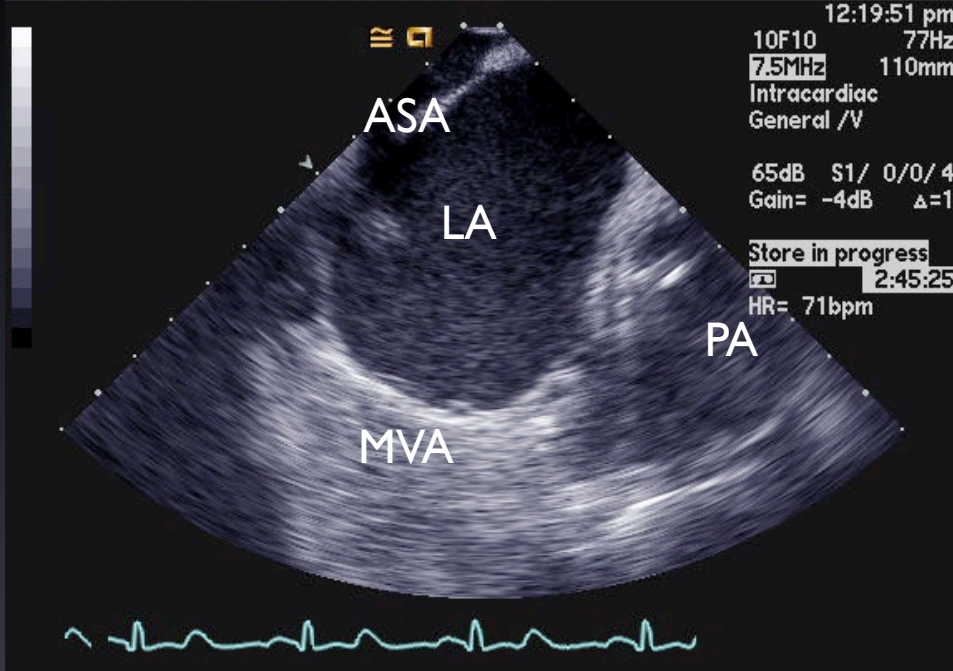
- Tricuspid valve/  
RVOT
- Neutral Position
- Mid RA
- 30° CW rotation



# ICE Image Review MV and LAA

- Lower rim/MV
- Neutral Position
- Mid to high RA
- 70-80° CW rotation

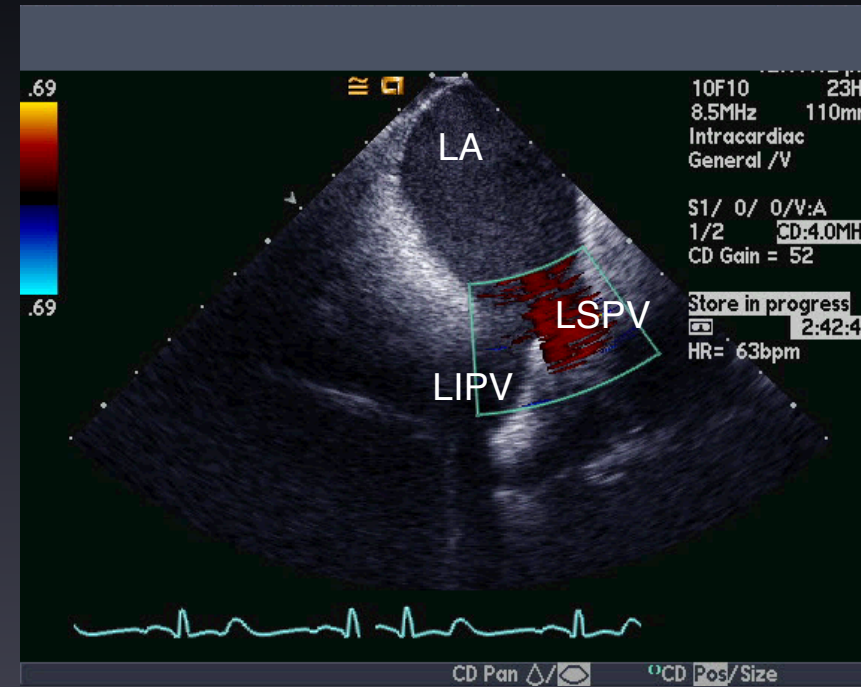
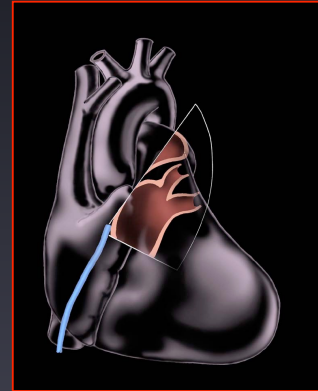






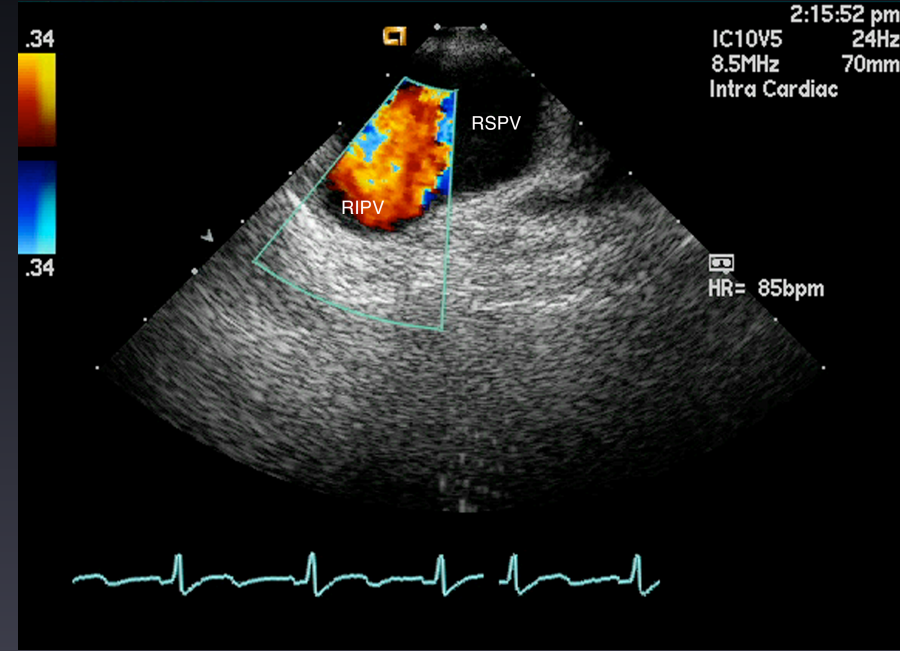
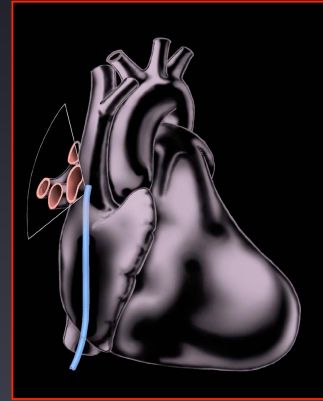
# ICE Image Review (Left PV)

- L Pulm Veins Color Flow
- Neutral Position
- Mid RA
- 90-100° CW rotation
- Superb angle for Doppler



- R Pulm Veins
- +/- Posterior Tilt
- Mid RA
- 150-180° CW rotation
- Color Flow in right veins

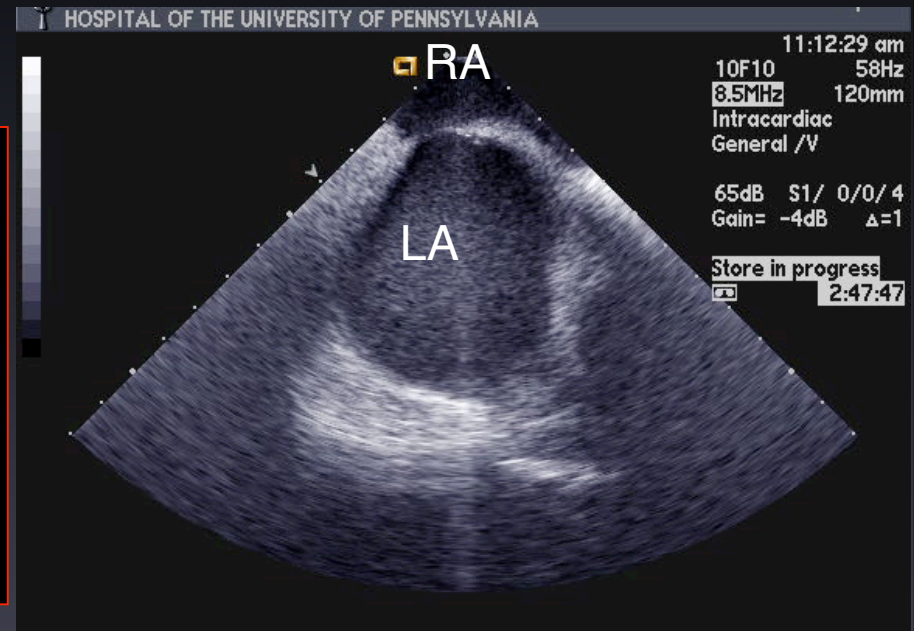
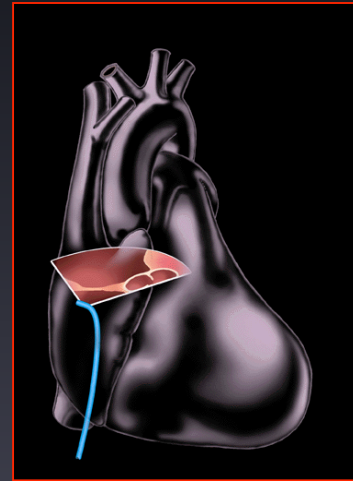
# ICE Image Review (R PV)



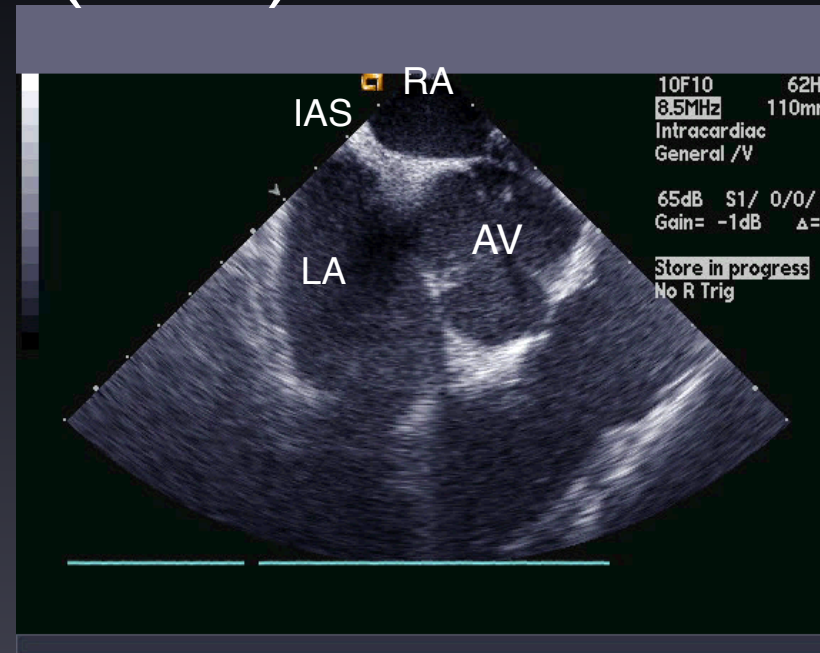
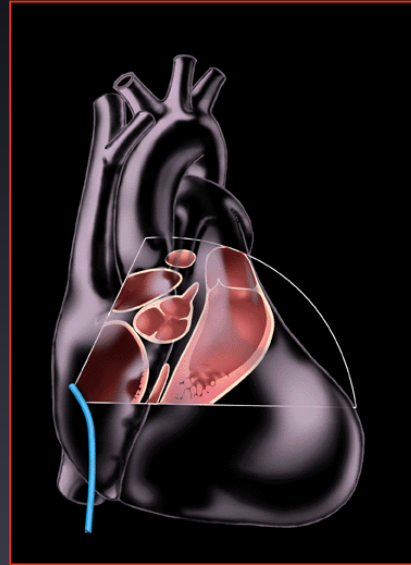


# ICE Image Review (Fossa)

- Fossa view
- Posterior/right tilt
- Mid RA
- 90-100° CW rotation

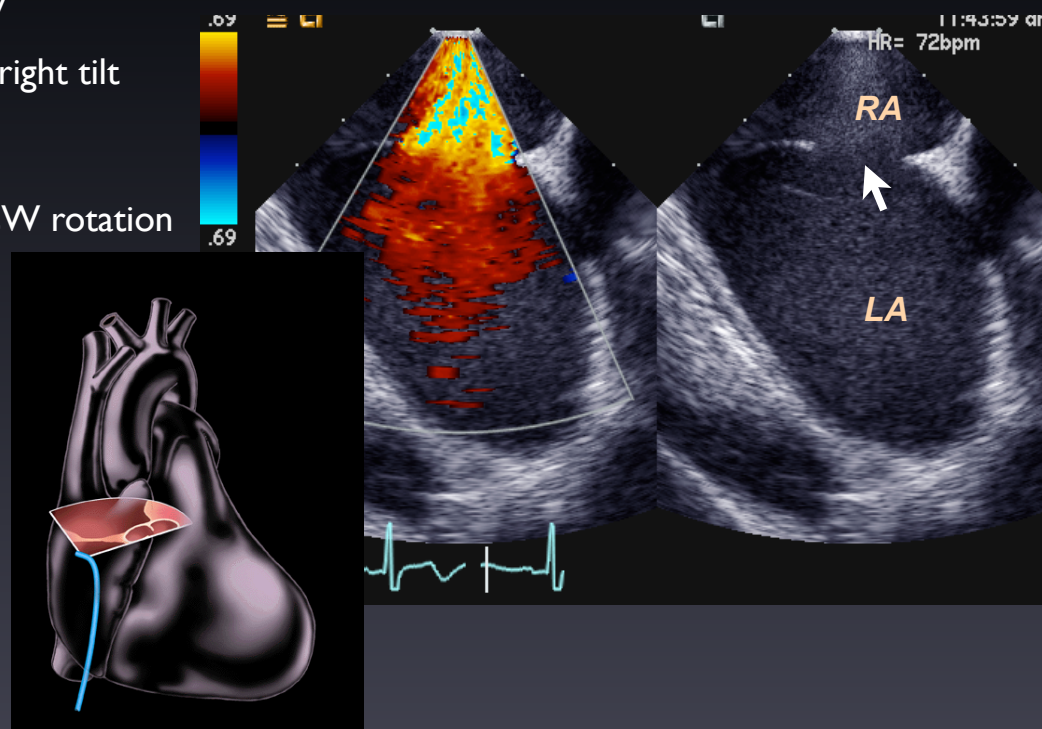


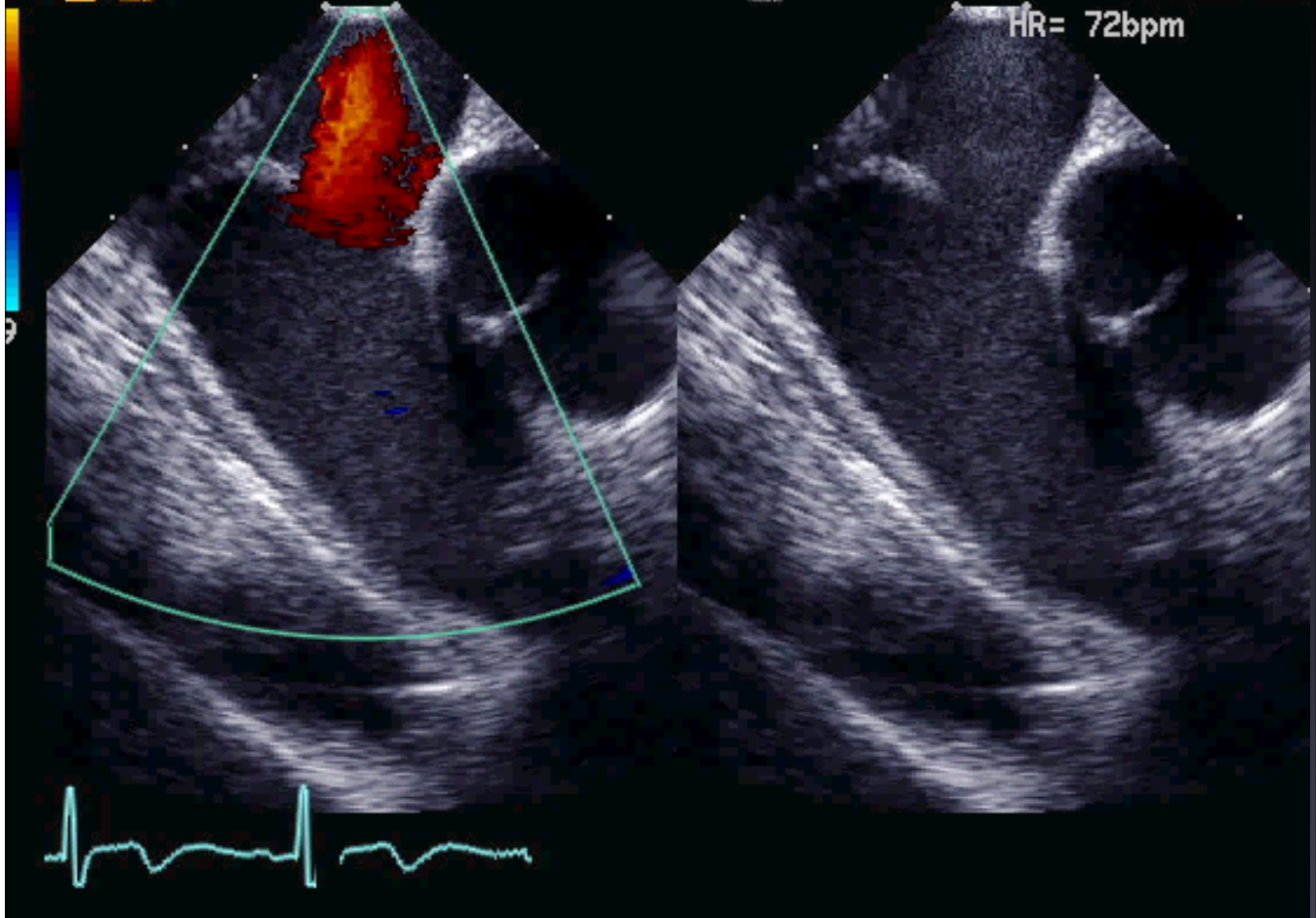
# Superior Aortic Rim (SAX)



# ICE Imaging of Fossa

- Fossa view
- Posterior/right tilt
- Mid RA
- 90-100° CW rotation

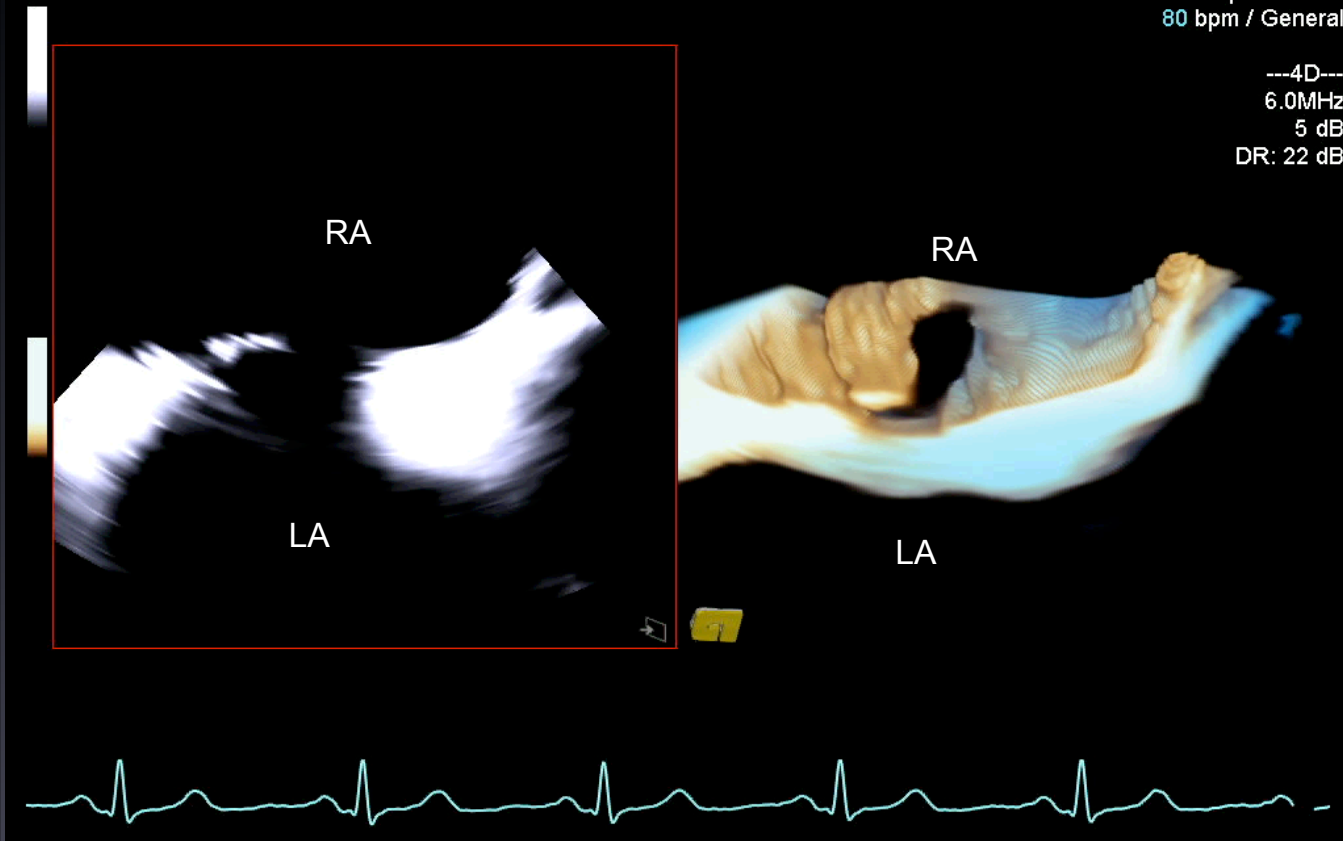




# 3D ICE Guided ASD Closure

67 vps / 60 mm  
80 bpm / General

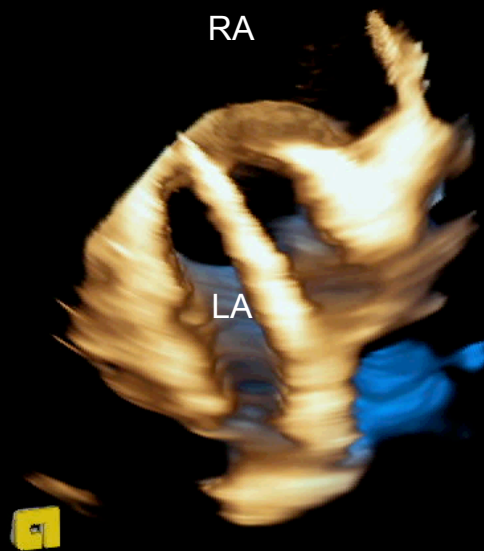
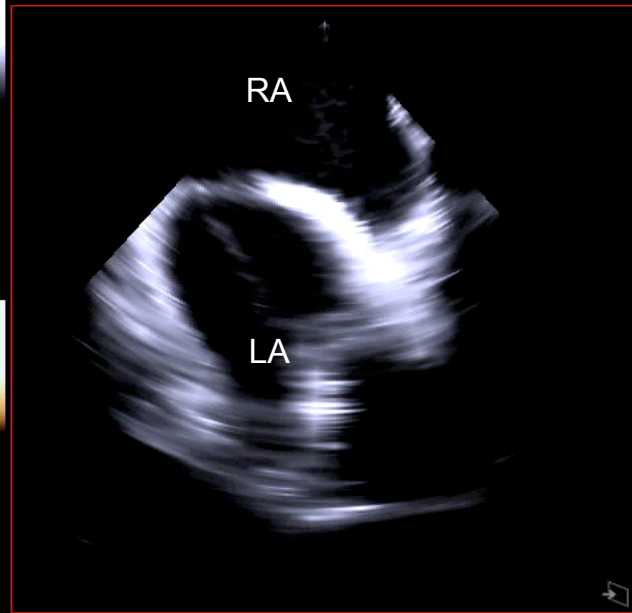
---4D---  
6.0MHz  
5 dB  
DR: 22 dB



# Guide wire in left atrium

44 vps / 100 mm  
96 bpm / Genera

---4D--  
6.0MHz  
5 dB  
DR: 34 dB

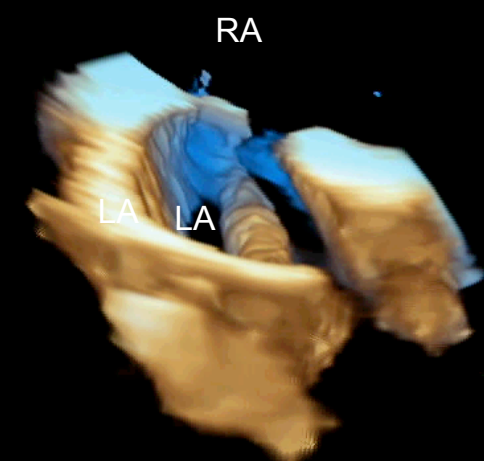
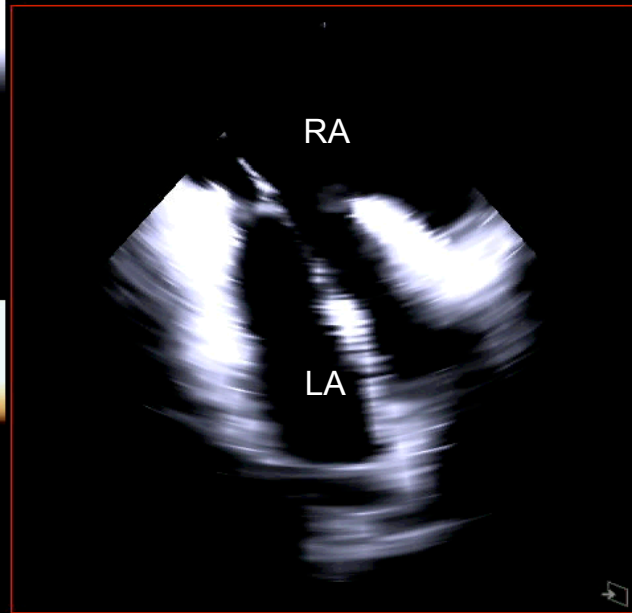


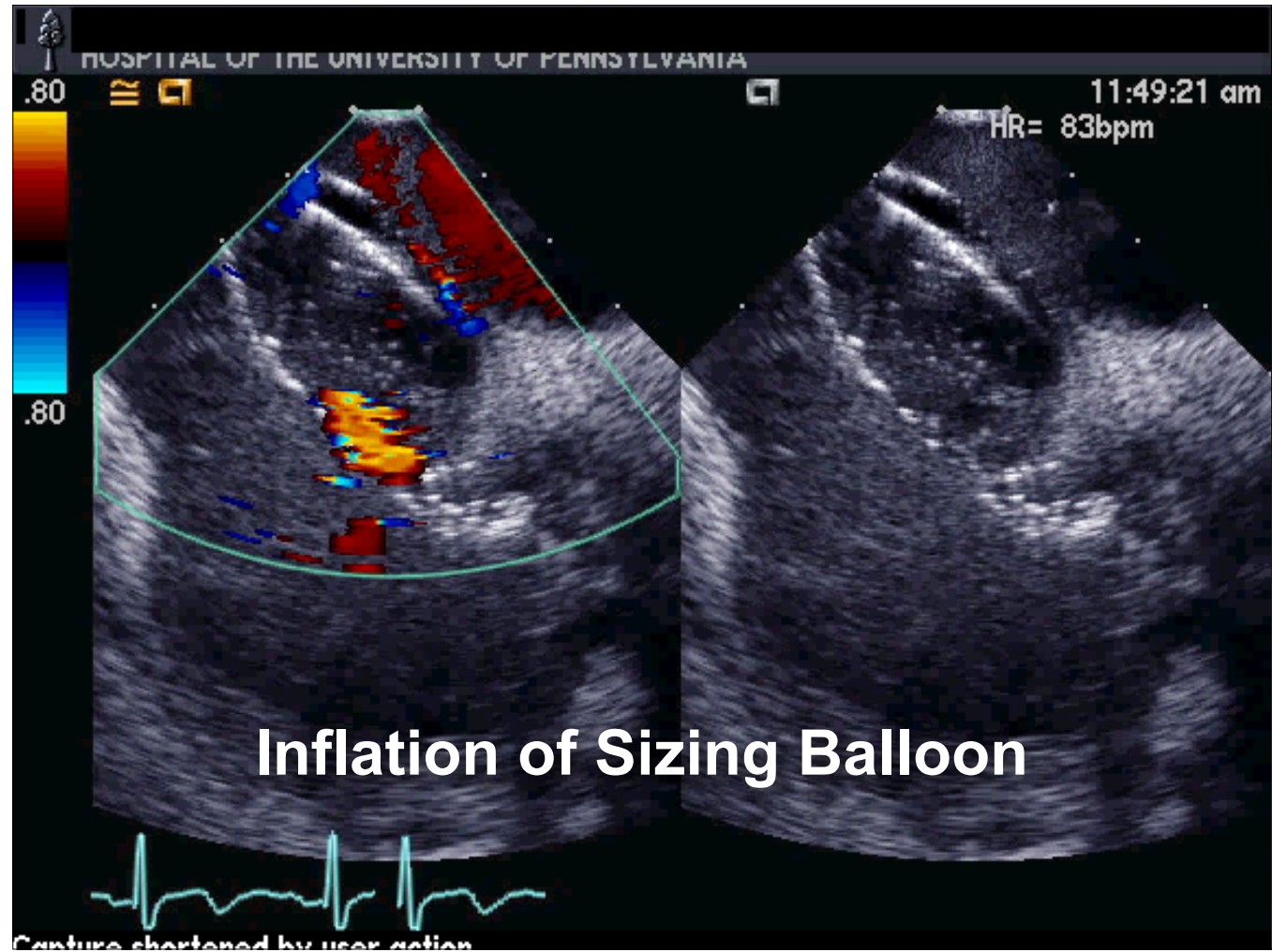


# Guide wire in left atrium

47 vps / 90 mm  
92 bpm / Genera

---4D---  
6.0MHz  
5 dB  
DR: 26 dB

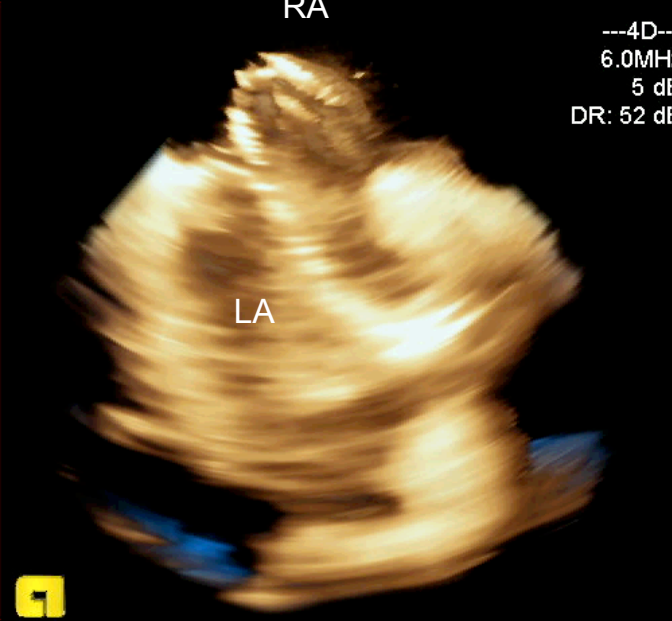
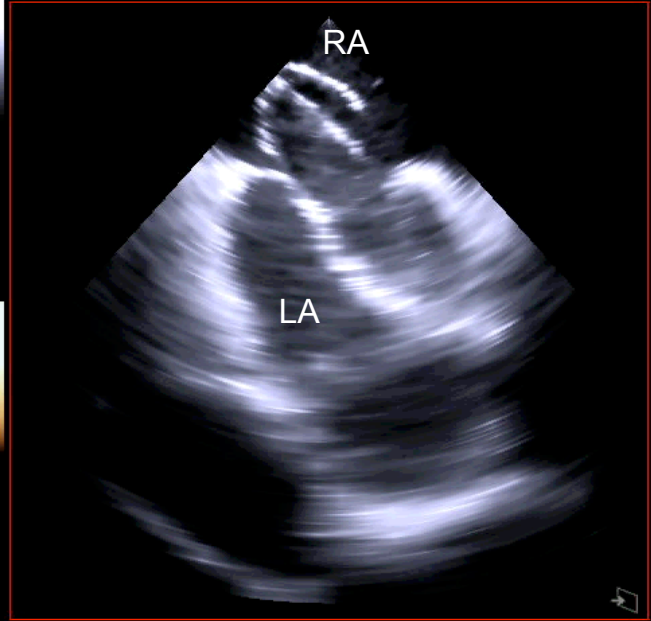




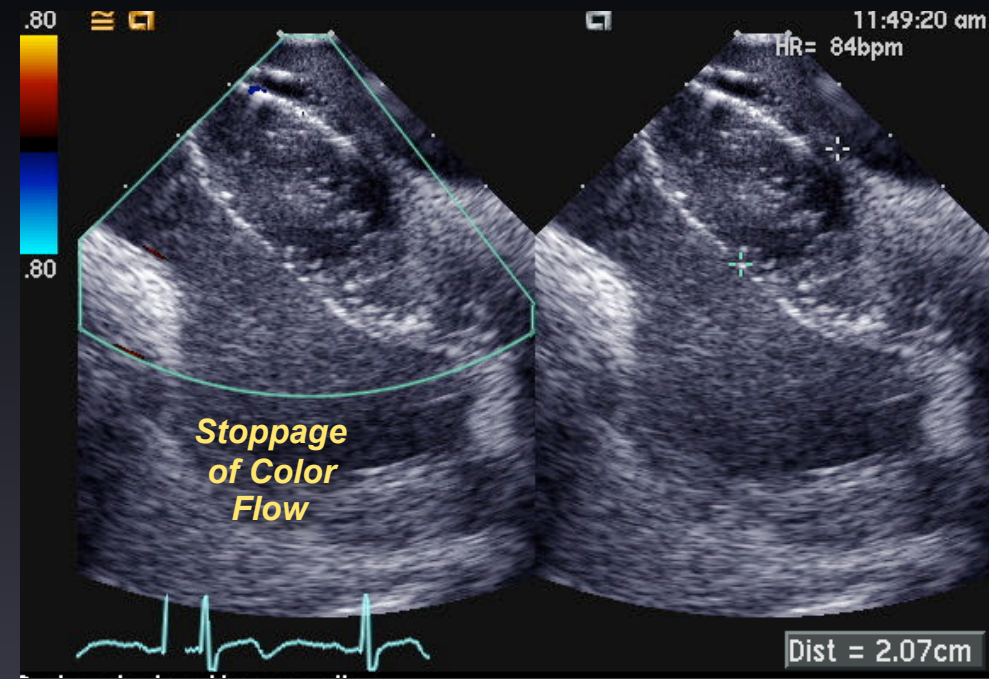


# 3D ICE Sizing Balloon

44 vps / 100 mm  
89 bpm / Genera  
---4D---  
6.0MHz  
5 dB  
DR: 52 dB



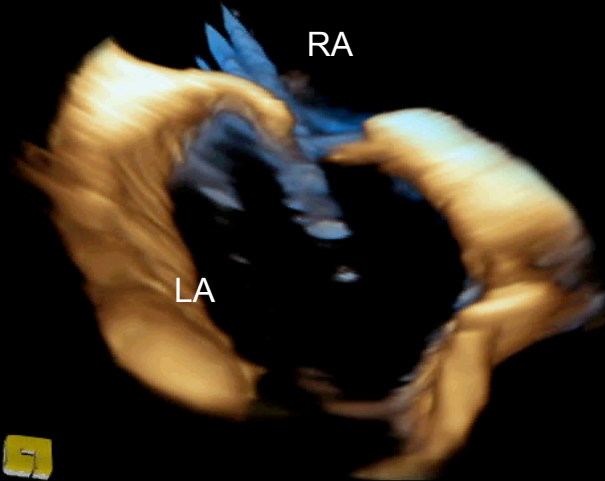
# Balloon Waist Sizing



# Tip of Guide by 3D ICE

52 vps / 80 mm  
96 bpm / General

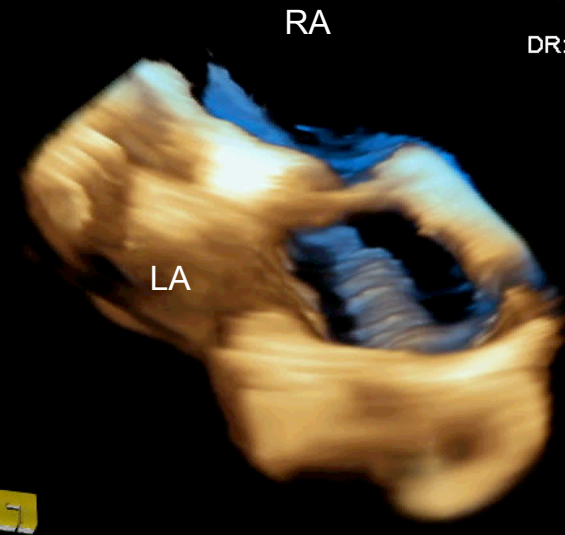
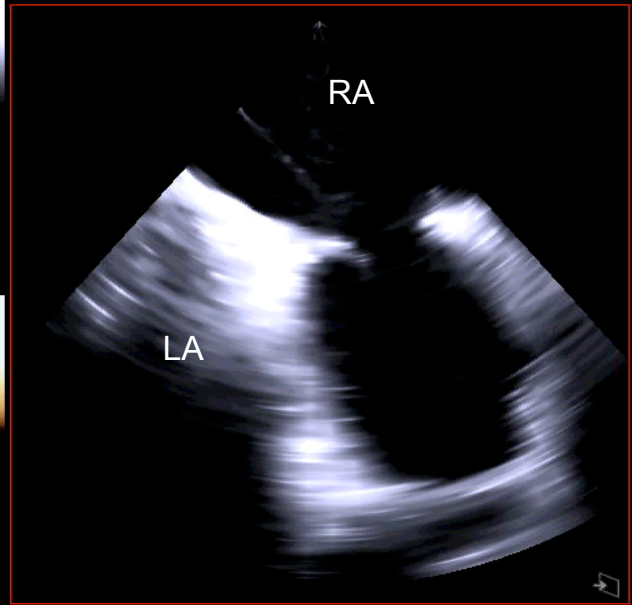
---4D---  
6.0MHz  
5 dB  
DR: 40 dB



# LA disc delivery 3D ICE

52 vps / 80 mm  
96 bpm / General

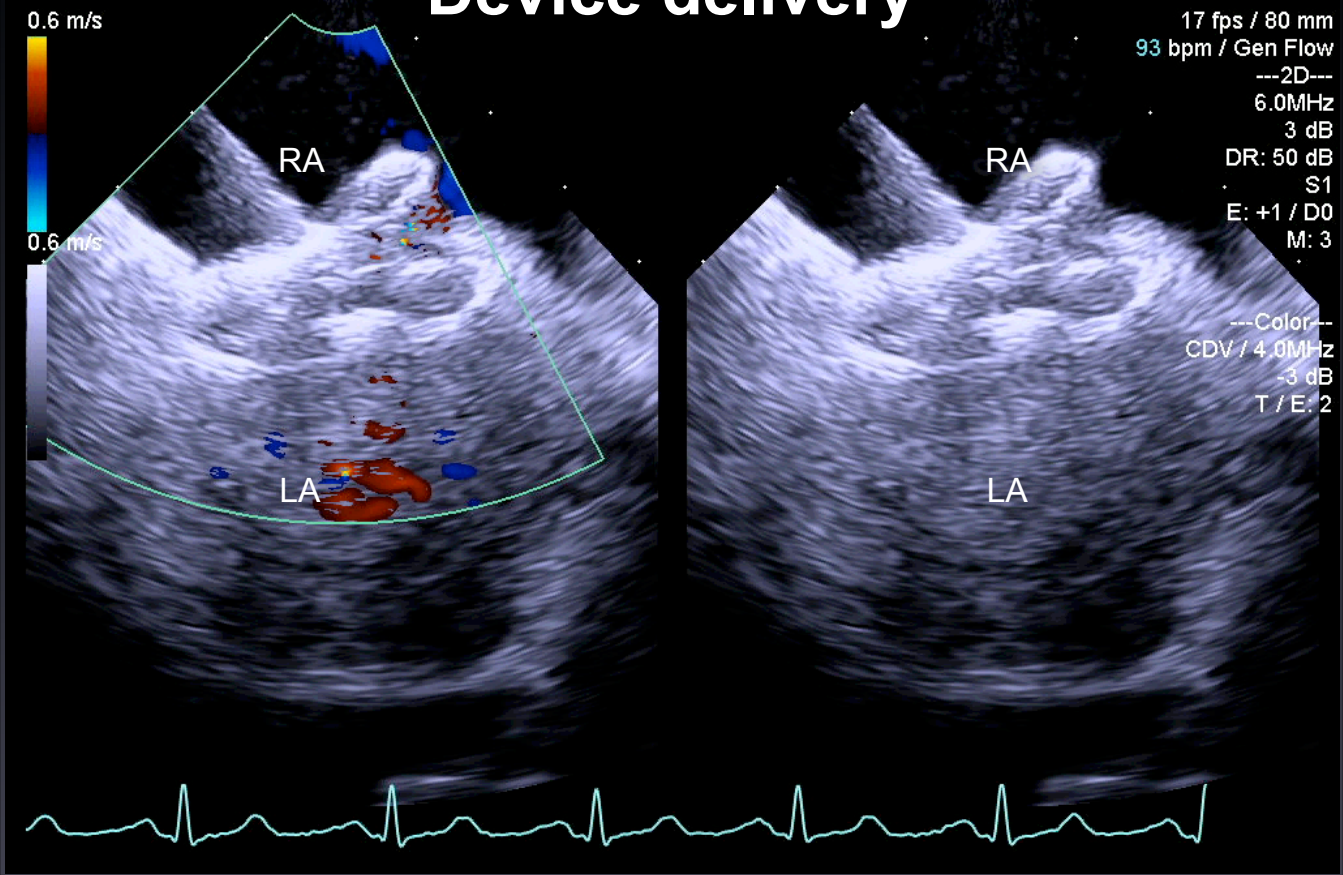
---4D---  
6.0MHz  
5 dB  
DR: 40 dB



08/06/2012 2:35:23 PM

0dB / MI: 0.97 / TIS: 1.25  
Cardiac / IntraCardiac\* / AcuNav V

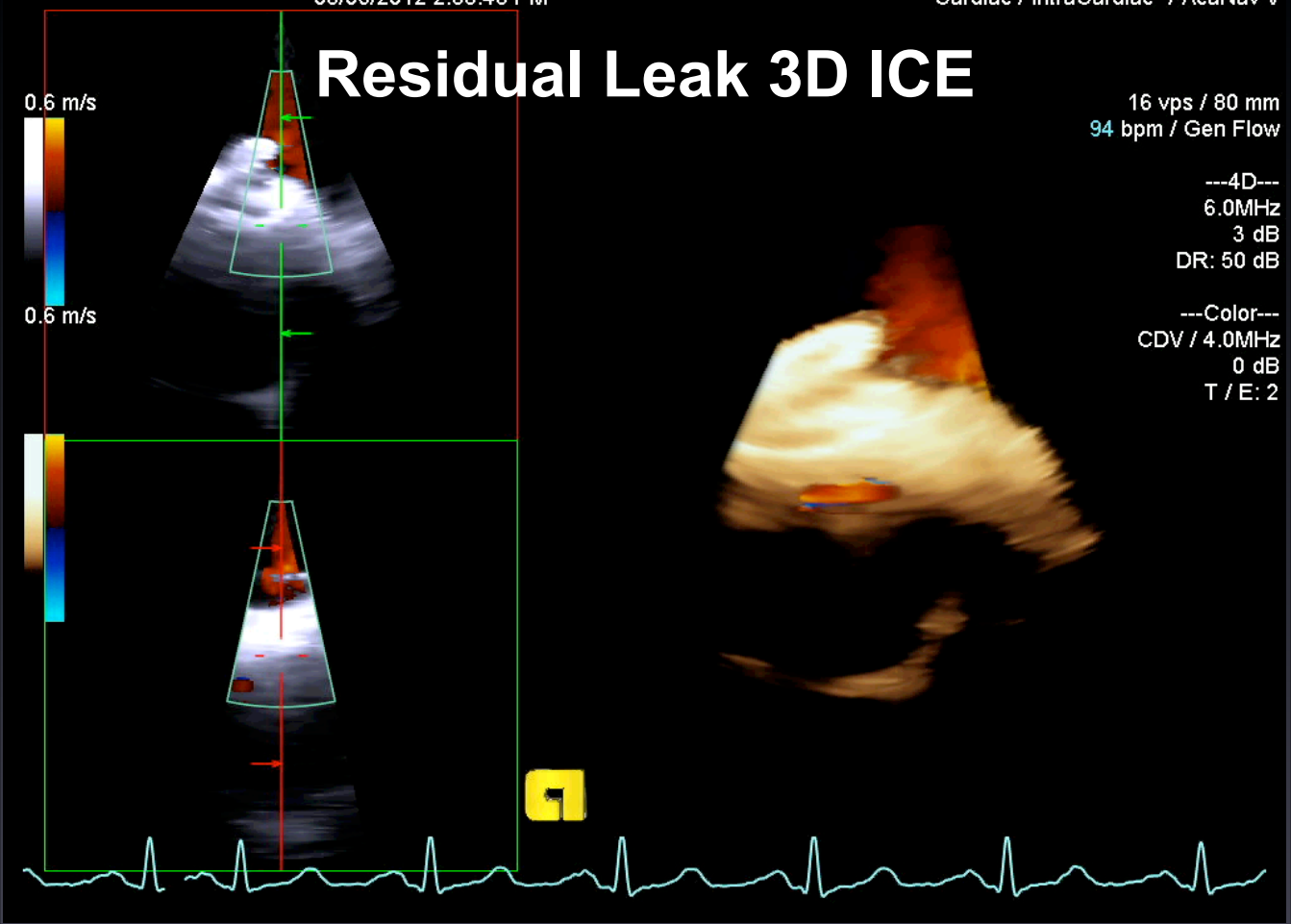
# Device delivery



08/06/2012 2:35:43 PM

0dB / MI: 1.03 / TIS: 0.34  
Cardiac / IntraCardiac<sup>®</sup> / AcuNav V

# Residual Leak 3D ICE

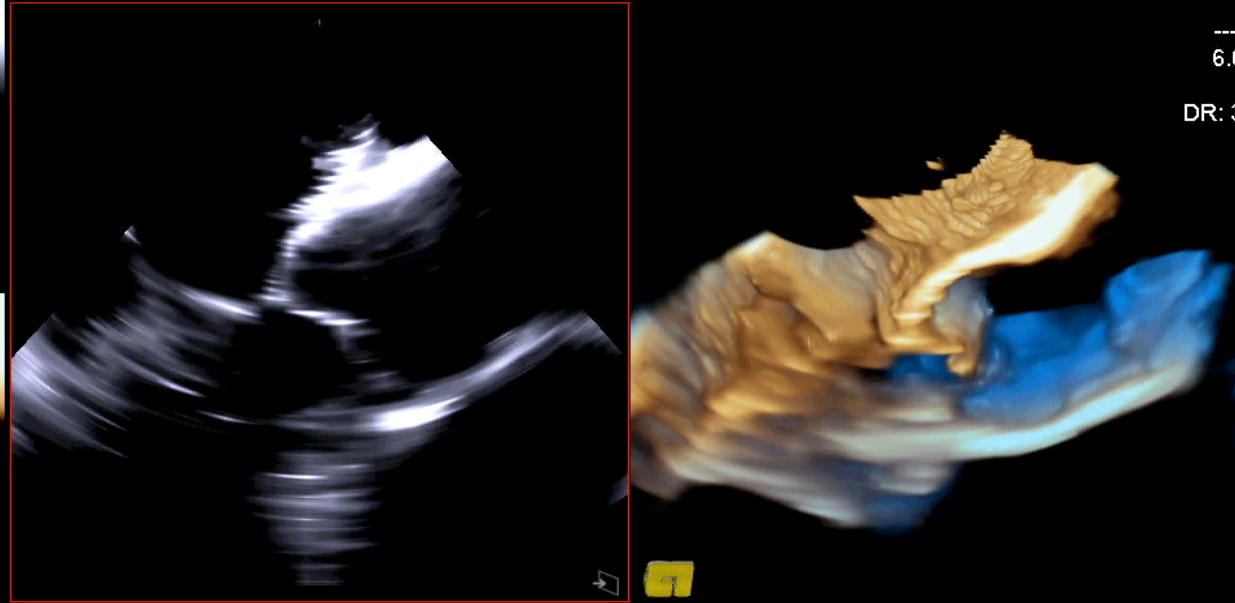




# Relationship of device to Aorta

52 vps / 80 mm  
78 bpm / General

---4D---  
6.0MHz  
3 dB  
DR: 33 dB



## 3D ICE

- **Understand role in interventional (and EP procedures)**
  - **Comparison to 2D ICE imaging**
  - **Comparison to 2D TEE**
  - **Comparison to 3D TEE**
- **Don't just create cool images**
- **Weigh benefits of independent operator performed 3D ICE study against added catheter cost and ability to comparably image targets compared to other modalities**

# Interventional Echo Lessons Learned

- Common anatomically based vocabulary
- Tackle one learning curve at a time
  - Anatomy
  - Devices
  - Imaging (especially ICE and now 3D ICE)
- Know when to NOT percutaneously intervene
  - Caution with very large ASDs and multiple rim deficiencies
    - Especially anterior and posterior
    - Erosion risk must be factored in
  - Multiple small defects with aneurysmal IAS

## Conclusions

- Expert echo imaging *essential* to the success of transcatheter interventions:
  - Patient selection
  - Procedural guidance
- *No one modality (or device) is right for all procedures*
- Interventionalists need to become expert in imaging as percutaneous interventions continue to expand their role