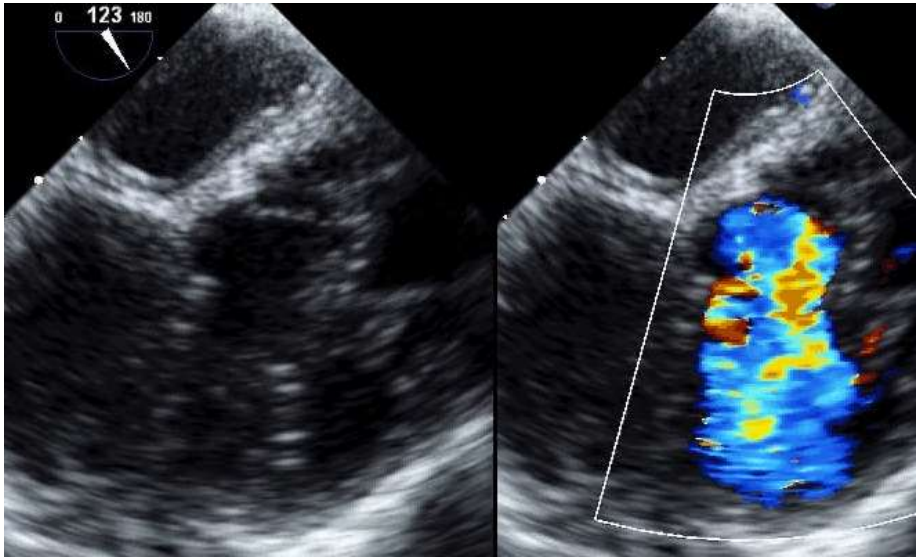
# IMAGING EVALUATION OF A POORLY PLACED INTRACARDIAC PATCH/PATCH LEAK: THIS IS HOW I DO IT

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# NO CONFLICTS OR DISCLOSURES

# WHO IS AT RISK FOR PATCH LEAK?

- Conotruncal repairs
  - TOF, truncus arteriosus
- Complex biventricular repair
  - DORV, CC-TGA with VSD, superior inferior ventricles
- Atrial septation in LV hypoplasia
  - Right dominant unbalanced AV canal
- Complex ASD
  - Unusual sinus venosus defects, common atrium, deviated septum 1$^{o}$
- Endocarditis

# HOW DO “WE” DO IT?

## In the OR

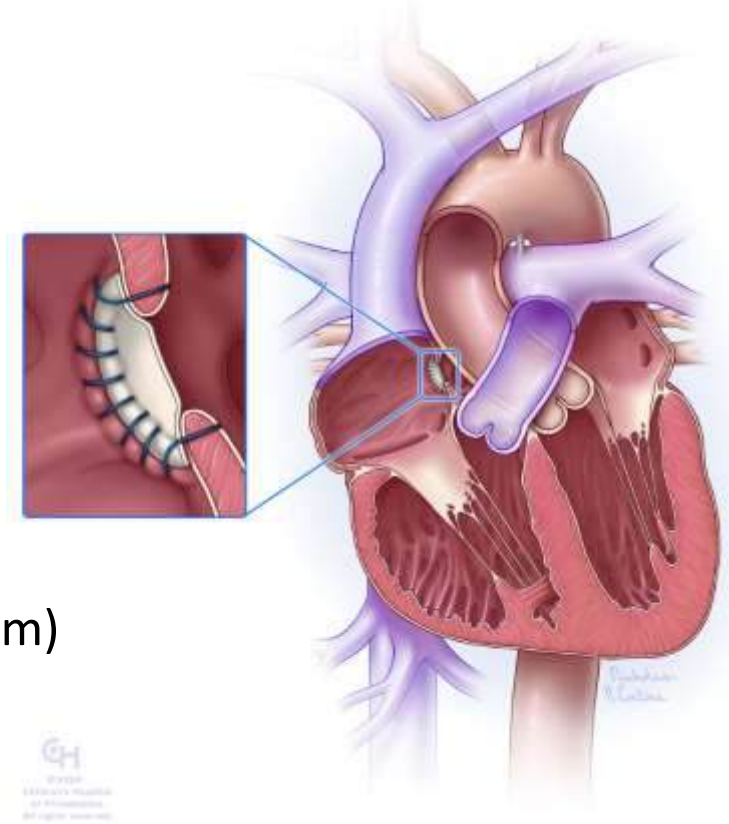
- Understand the anatomy of the pt
- Know the operation
  - What is surgeon is concerned about
- Full sweeps on TEE
- Call for help if unsure of findings
- Use additional data if needed:
  - Direct RVp measurement
  - Saturation run
  - Contrast injection

## In the CICU

- Understand the anatomy of the pt
- Know the operation
- Image early if there are concerns
  - Can’t wean inotropic support
  - Can’t get off respiratory support
- Full sweeps on TTE
- Use additional data if needed:
  - RVp estimate
  - Contrast injection
  - Additional modality

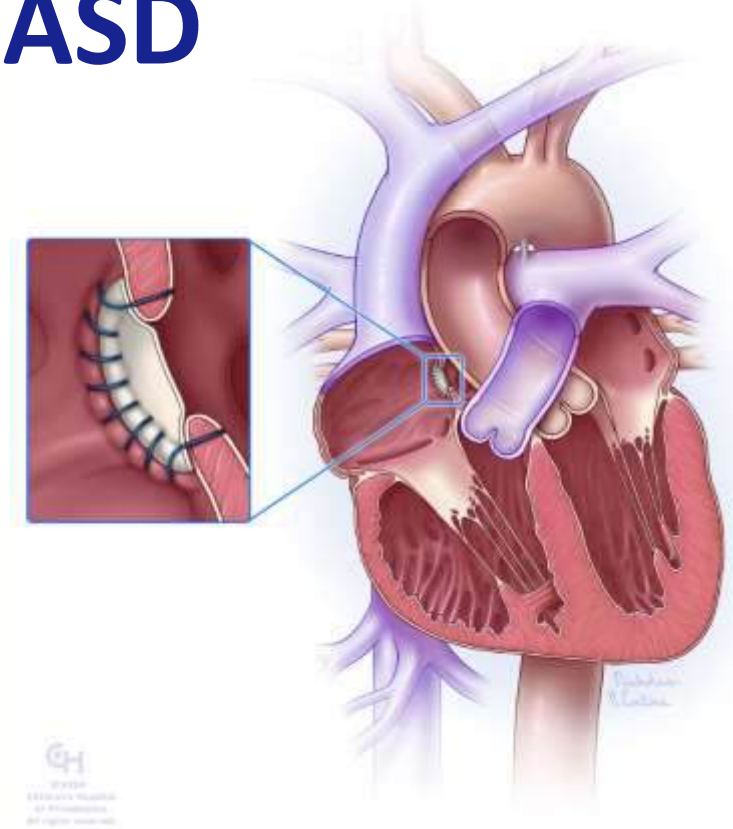
# ASD SURGERY

- Common component of CHD surgery
- Low risk procedure
- Generally well visualized
- Minimal risk to injure other structures
- **But leaks may happen anyway:**
  - Patch may be under tension (LA HTN)
  - Placed perpendicular to wall (common atrium)
  - Defect near the IVC (Atrial switch)
  - Eustachian valve mistaken for atrial septum



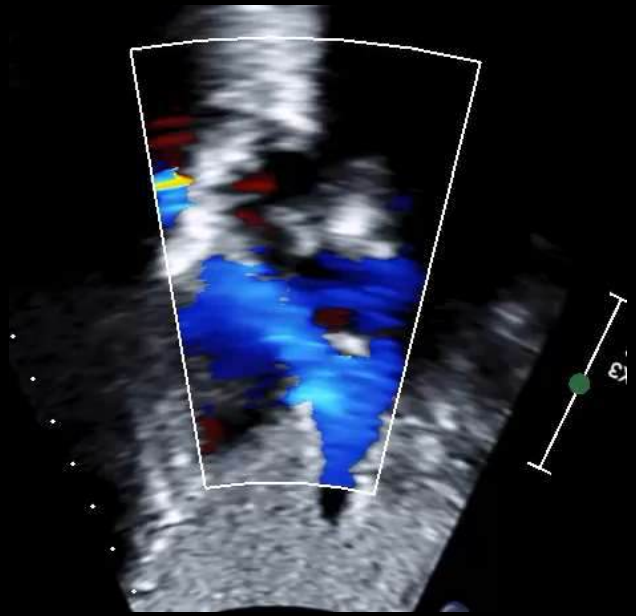
# IMPACT OF RESIDUAL ASD

- Size
- Type, Location
- Significant morbidity
  - RV dilation
  - Pulmonary hypertension
  - Heart failure
  - Obstruction of pulmonary veins or venae cavae

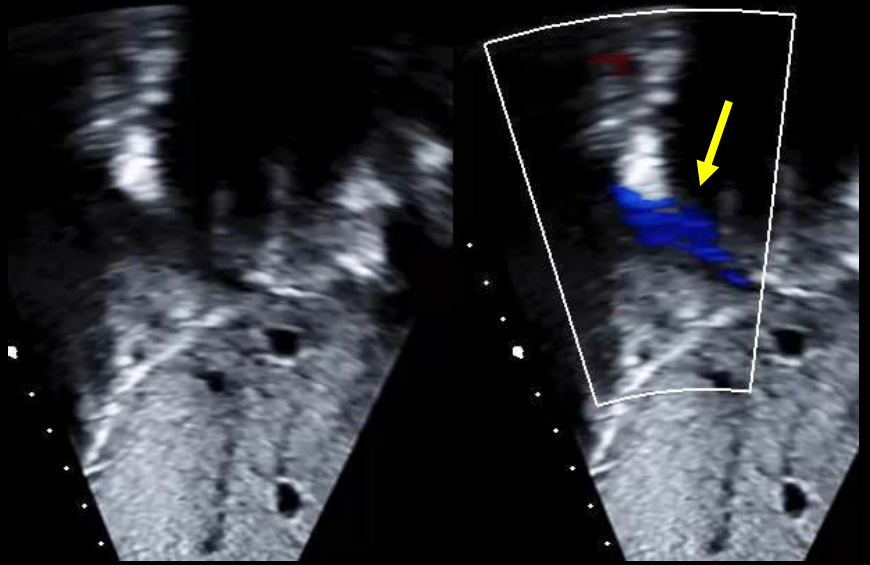


# COMPLEX SINUS VENOSUS DEFECT

- Pulm vein type sinus venosus defect: Postop study



Not a full sweep



Full sweep: Residual ASD

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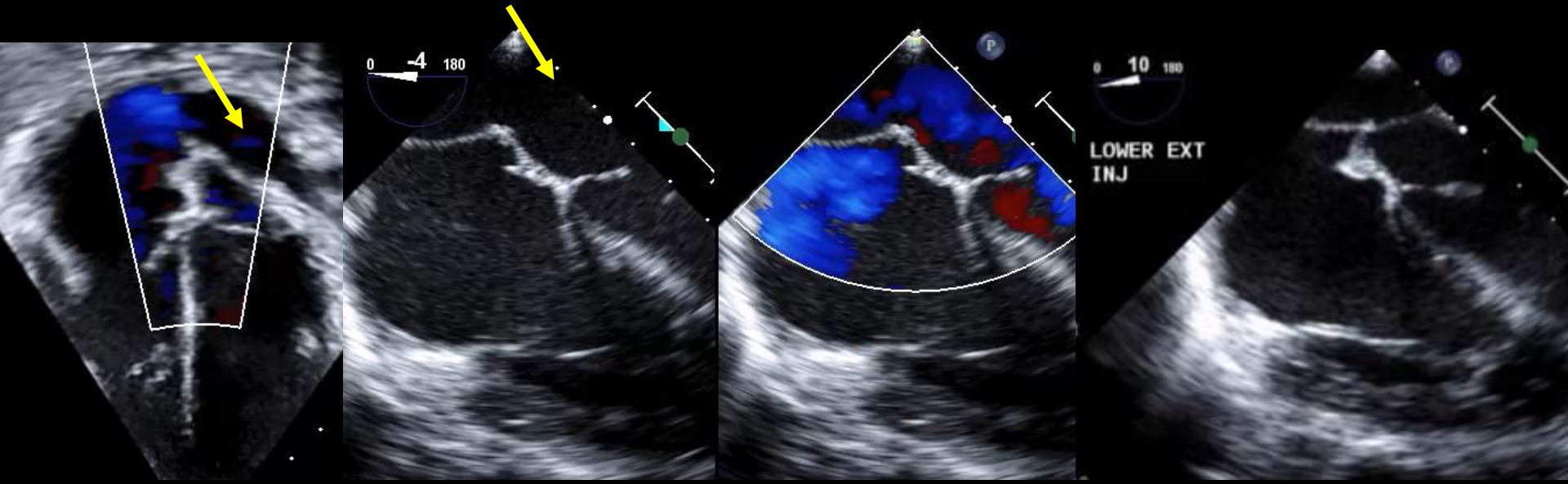
# COMPLEX SINUS VENOSUS DEFECT

- Inferior portion of patch placed in LA along coronary sinus

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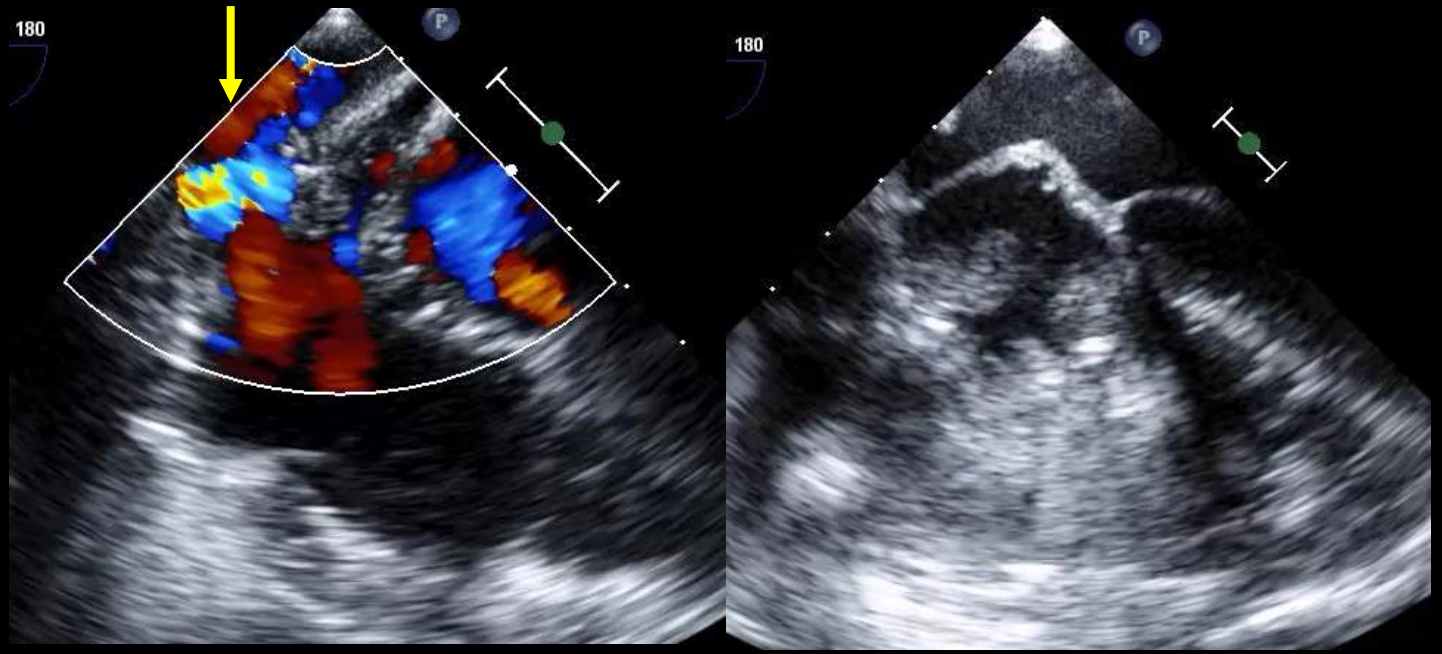
# COMPLEX SINUS VENOSUS DEFECT

- Patch replaced in proper position

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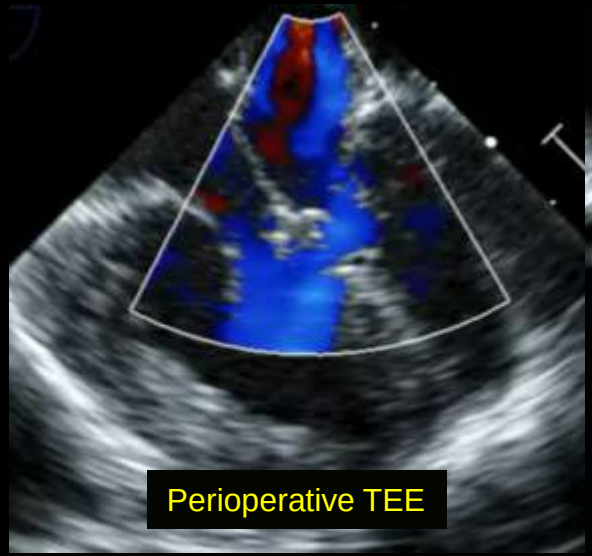
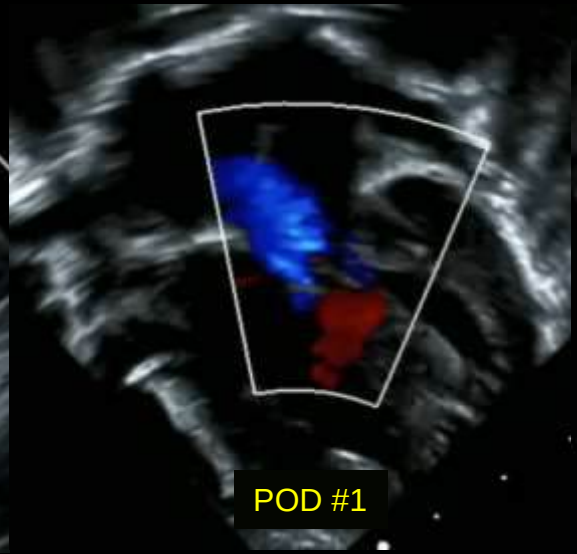
# ATRIAL SEPTATION IN R UNBAL AVC

- Unbal AVC with severe AV valve regurgitation, LVOT obstruction
- Fenestrated ASD patch, LVOT resection, PA band





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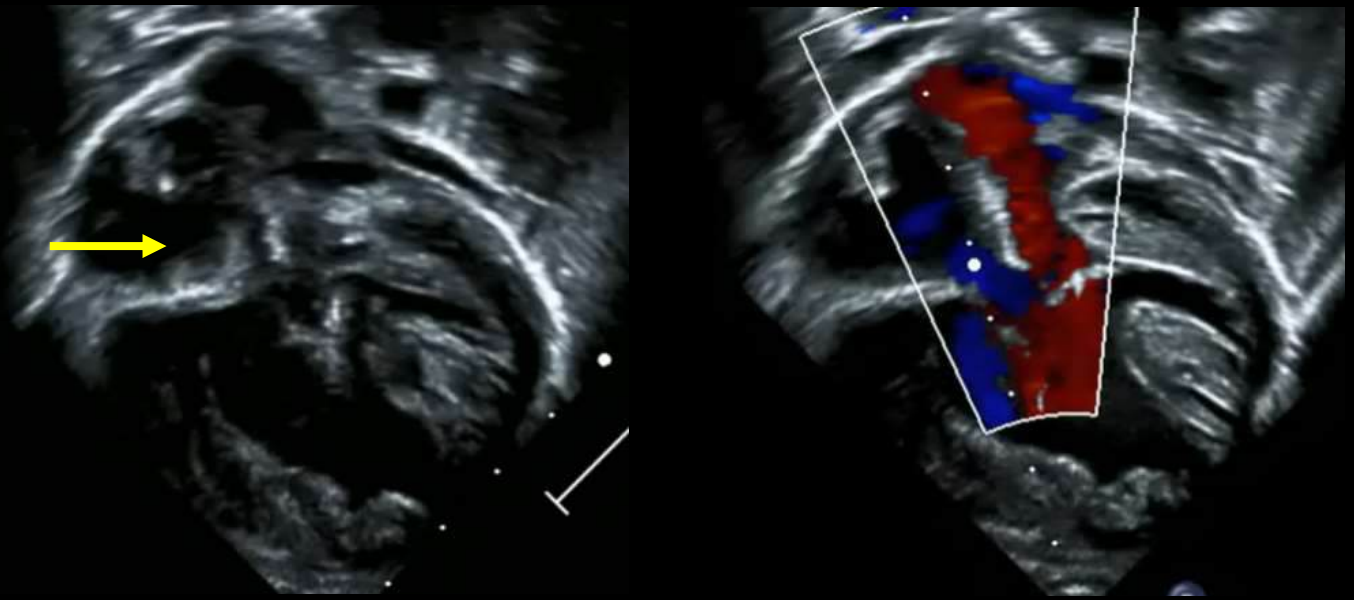
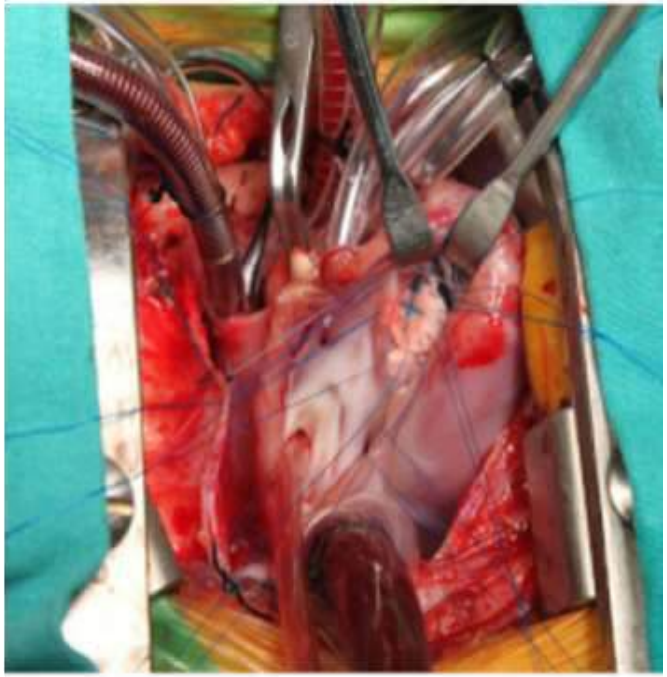
# ATRIAL SEPTATION IN R UNBAL AVC

- Respiratory distress 10 days later



# VSD SURGERY

- VSD is a component of many CHDs
  - Isolated
  - Conotruncal anomalies
  - Arch obstruction
  - AV canal defect
- Isolated VSD surgery is low risk
  - 0.05% mortality
  - Low risk of complete heart block
  - Median LOS is 5 days
  - 3% reoperation rate



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*Braun Scully B et al. Ann Thorac Surg 2010*

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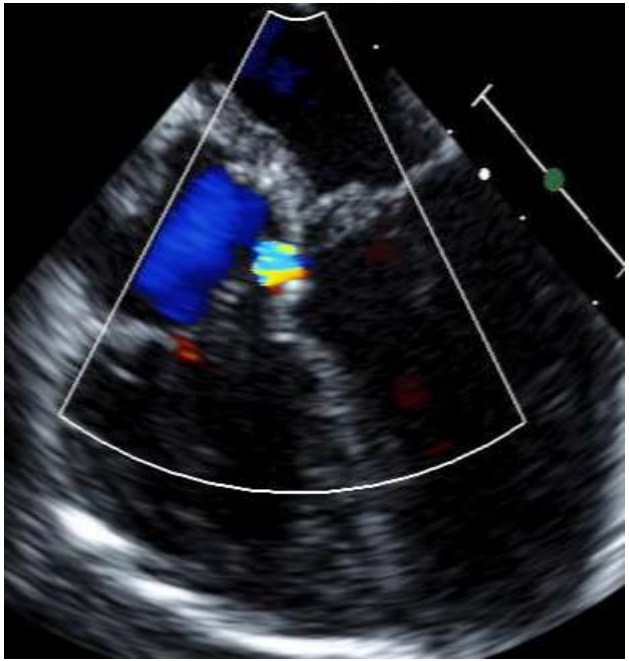
# VSD SURGERY

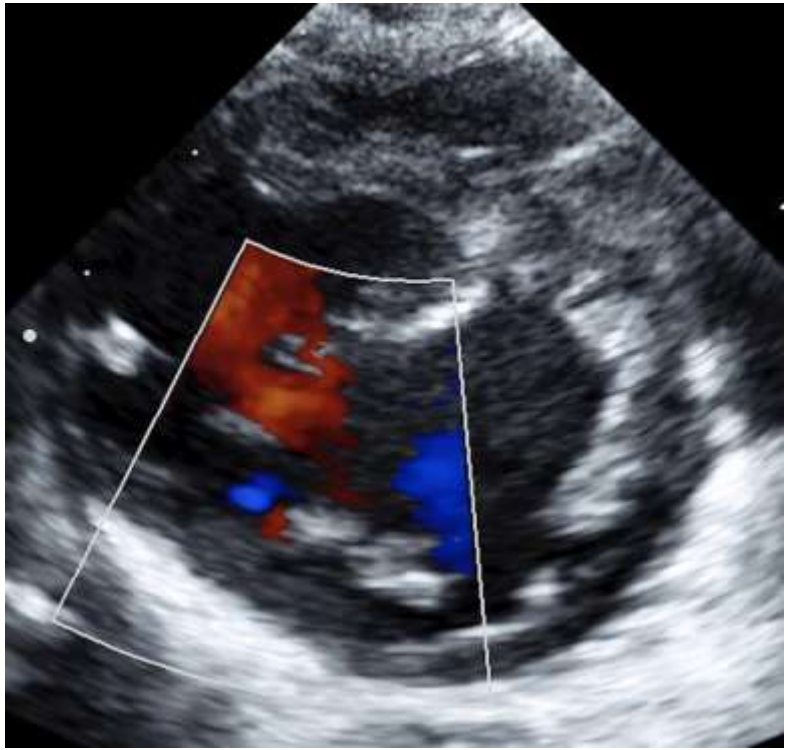
- Residual VSD is common
  - Isolated VSD surgery (33-51%)
  - Conotruncal defects (58%)
- Causes:
  - Peripatch leak
  - Patch dehiscence
  - Incomplete closure (poor exposure)
  - Previously unrecognized additional defect
  - **Intramural defect**
- Majority are small; close spontaneously

*Dodge-Khatami A et al. Ann Thorac Surg 2006*
*Schipper M et al. Pediatr Cardiol 2016*
*Patel J et al. Circ 2015*
*Deng X et al. Pediatr Cardiol 2020*



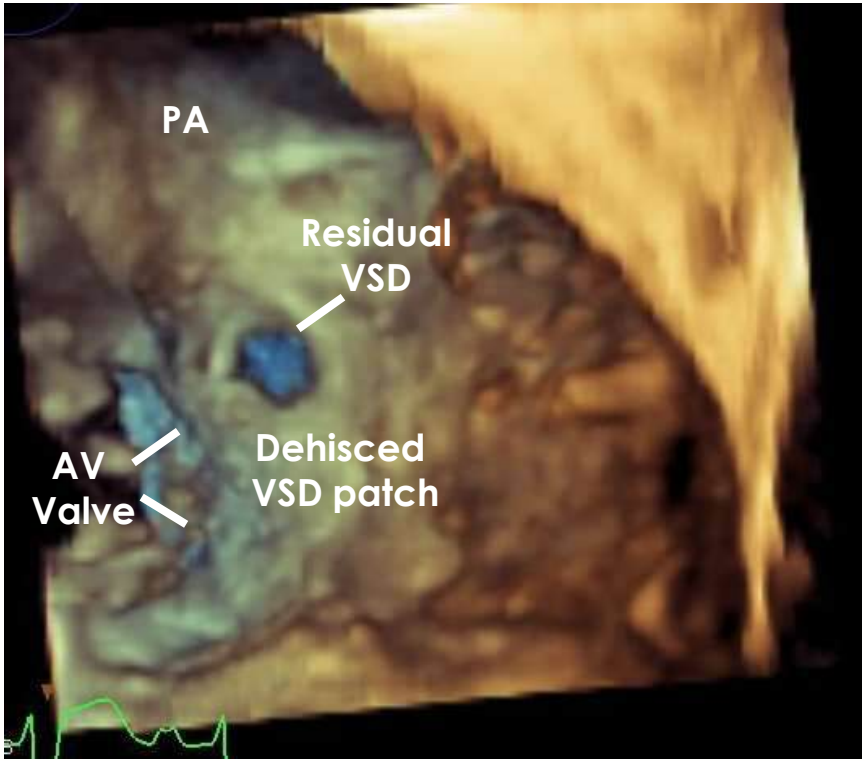
# WHO IS AT RISK?

- Underlying patient factors
  - Premature or small infants
  - Children with genetic syndromes
  - Critically ill patients with poor tissue quality
- Underlying anatomic factors
  - Multiple VSDs
  - Defects in poorly exposed regions
  - Large defects in conotruncal anomalies
  - Associated defects

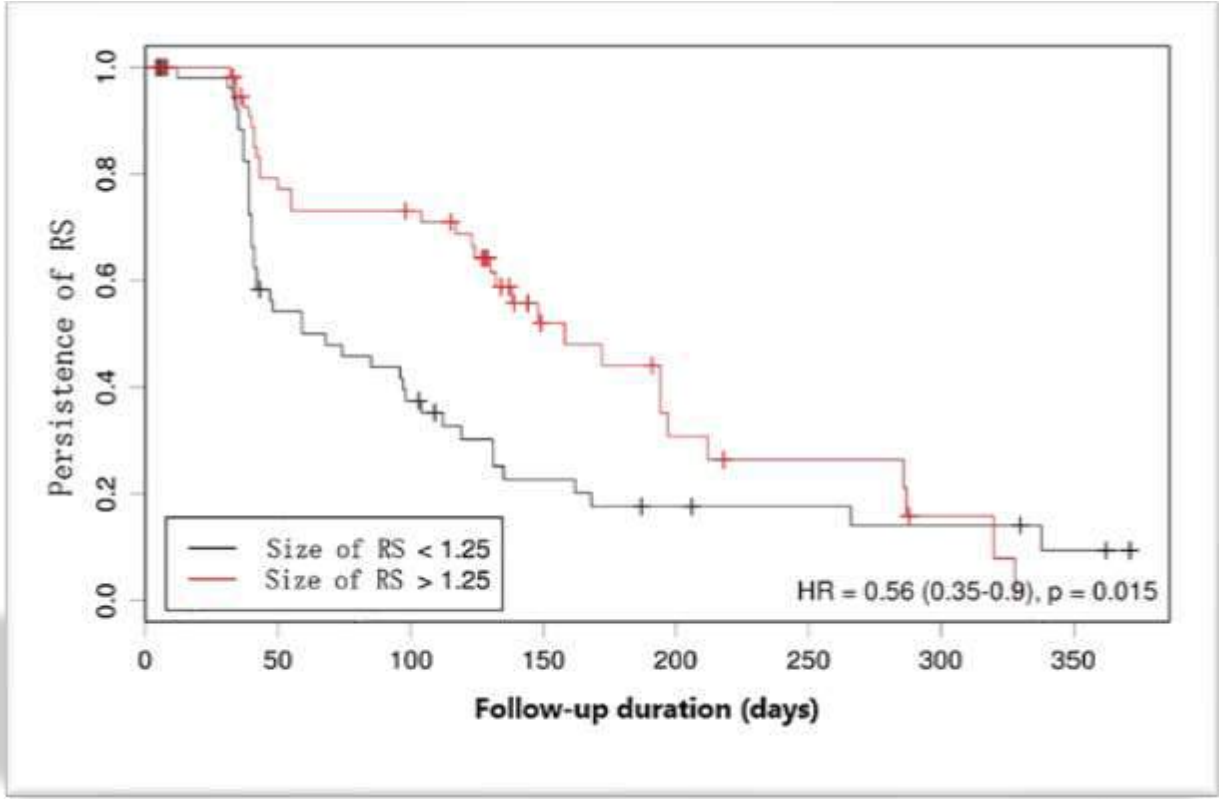


# IMPACT OF RESIDUAL VSD

- Size
- Type, Location
- Preoperative diagnosis
- Other residual lesions
- Significant morbidity
  - Prolonged ICU stay
  - Heart failure
  - Poor growth
  - Pulmonary hypertension



# SIZE OF RESIDUAL VSD

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*Deng X et al. Pediatr Cardiol 2020*

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# RESIDUAL VSD OVER TIME

| Diagnosis | Size | TEE | ICU | Follow-Up |
|---|---|---|---|---|
| *AV Canal* | No | 37 | 32 | 45 |
| | <2mm | 9 | 13 | 1 |
| | >2mm | 0 | 1 | 0 |
| | | 20% | 30% | 2% |
| *TOF* | No | 44 | 28 | 45 |
| | <2mm | 6 | 19 | 4 |
| | >2mm | 2 | 5 | 3 |
| | | 15% | 46% | 13% |
| *Isolated VSD* | No | 75 | 70 | 91 |
| | <2mm | 19 | 27 | 6 |
| | >2mm | 6 | 3 | 3 |
| | | 25% | 30% | 9% |
| Total | | 21% | 34% | 9% |

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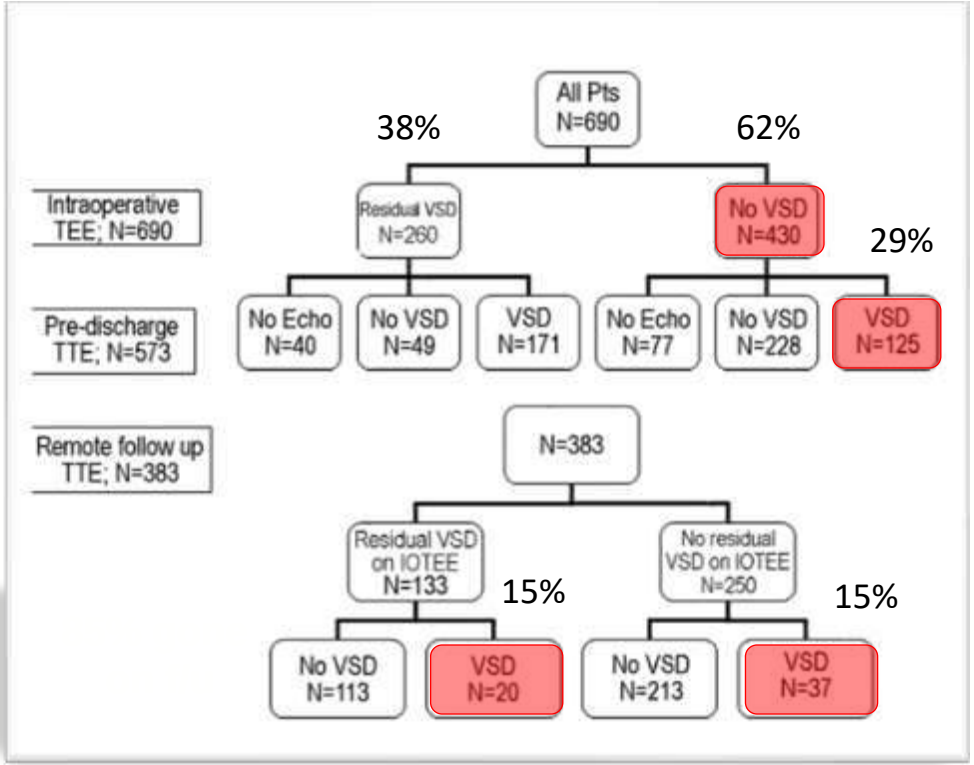
*Dodge-Khatami A et al. Ann Thorac Surg 2007*

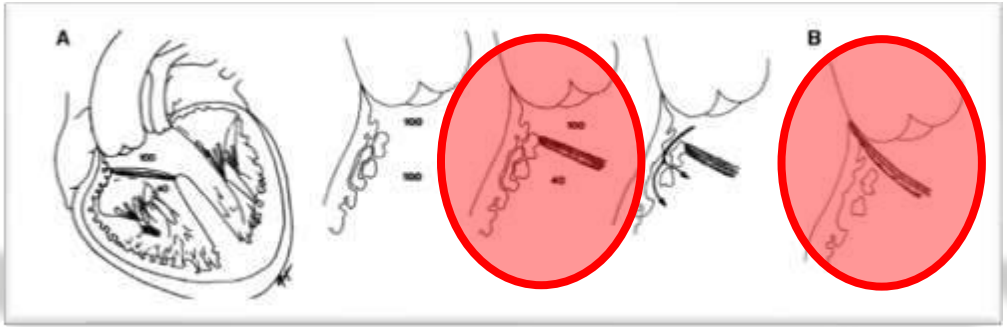
# DETECTION BY INTRAOPERATIVE TEE




*Hanna BM et al. Ann Thorac Surg 2010*

# INTRAMURAL VSD

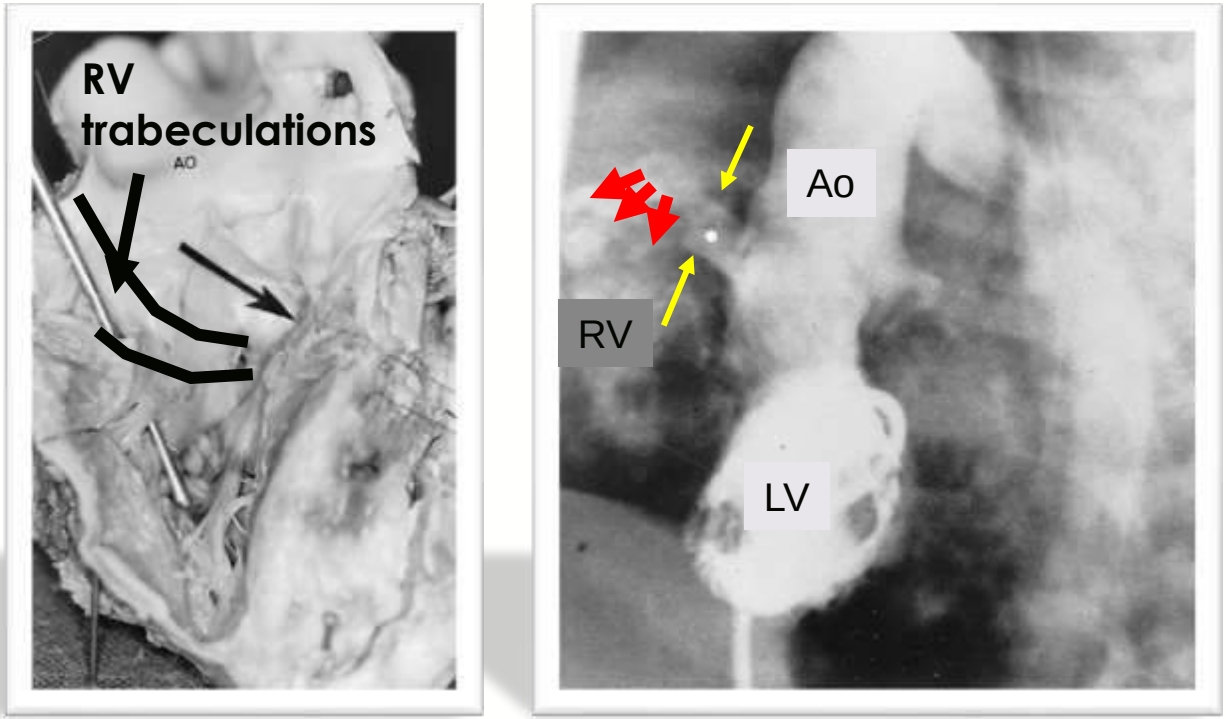
*Preminger TJ et al. Circulation 1994*
*Patel J et al. Circulation 2015*





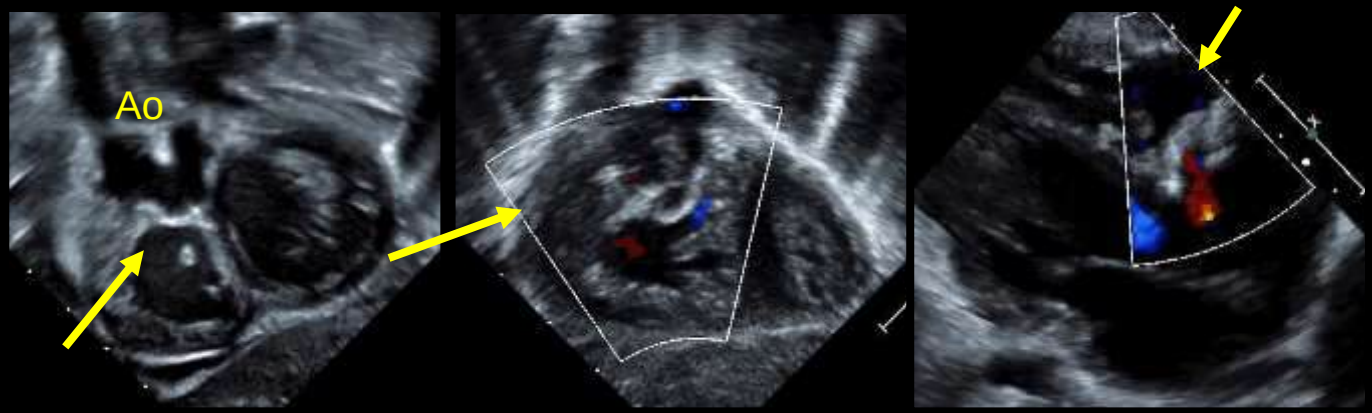
- In conotruncal defects where LV is baffled to a great artery
  - Patch should attach close to semilunar valve annulus
  - Misplaced VSD patch on hypertrophied RV free wall
- Complex communication between the “neo-LV” and RV body
- **Can enlarge over time**
  - As RV hypertrophy regresses, channels get bigger
- Surgeons has difficulty visualizing them
  - Often anterior without clear-cut rims
  - Typical RA or RV surgical approach may not work

# INTRAMURAL VSD




*Belli E et al. Ann Thorac Surg 2000*

# ECHO OF INTRAMURAL VSDS




- Clue is displaced VSD patch along RV free wall
- Must do full sweeps or it can be missed
  - Does not lie in the typical plane of the VSD patch
- Usually very anterior
- Often multiple jets seen on RV side

# OUTCOME EVENTS DURING HOSPITALIZATION

| | Intramural VSD N=49 | Other VSD N=207 | No VSD N=186 | P-value |
|---|---|---|---|---|
| *Primary Outcome (%)* | | | | |
| *Composite* | 14(29) | 15(7) | 6(3) | **<0.001** |
| *Catheter Closure* | 3(6) | 2(1) | 0 | **0.001** |
| *Surgical Closure* | 7(14) | 7(3) | 0 | **<0.001** |
| *ECMO* | 8(16) | 7(3) | 3(2) | **<0.001** |
| *Mortality* | 5(10) | 4(2) | 4(2) | **0.006** |
| *Secondary Outcome* | | | | |
| *Postop LOS* | 20(11-42) | 7(5-14) | 6(4-11) | **0.001** |
| *Cardiac Arrest* | 8(16) | 9(4) | 10(5) | **0.007** |
| *Treated Arrhythmia* | 23(47) | 67(33) | 51(28) | **0.03** |
| *Days Intubated* | 7(1-23) | 1(0-4) | 1(0-3) | **0.001** |

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*Patel JK et al. Circulation 2015*

# TEE OF INTRAMURAL VSDS

| Imaging Modality | TTE: Intramural Present | TTE: Intramural Absent |
|---|---|---|
| TEE: Intramural Present | 19 | 0 |
| TEE: Intramural Absent | 15 | 303 |

Sensitivity: 56%;
Specificity:100%
Positive Predictive Value: 100%
Negative Predictive Value: 95%

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*Patel JK et al. JTCVS 2016*

# BACK ON BYPASS OR NOT?

## YES

- When residual VSD > 3 mm
- More than ½ systemic RV pressure without other cause
  - Or high Qp/Qs by $O_2$ sat
- Easy for surgeon to access
- Intramural VSD

## NO

- Defect < or = 2 mm
- Low RVp on direct measure
- Multiple bypass runs
- Difficult for surgeon to visualize
- High risk of heart block

**There is an in-between where the surgeon ultimately must decide whether to try to repair a residual VSD**

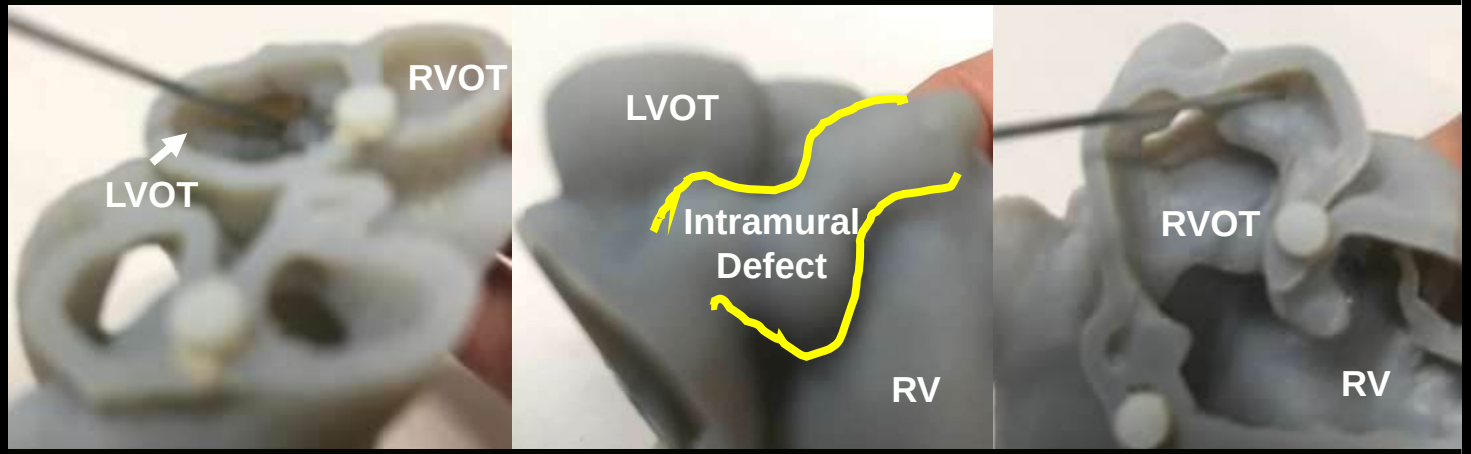
# REOPERATE OR NOT?

- If pt not taking typical postoperative course, think residual VSD
  - Difficult to extubate
  - Heart failure
  - Rhythm problems
  - Ventricular dysfunction
- Early catheterization to assess hemodynamics
- Careful imaging to determine precise location
- Consider reoperation or device closure if Qp/Qs is high
  - > than 2:1 shunt

# INTRAMURAL VSD

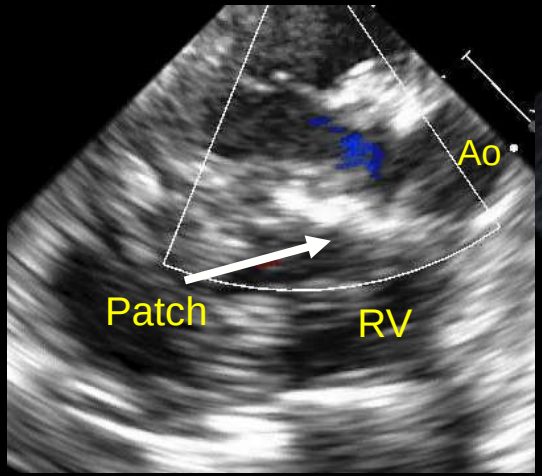
- Taussig-Bing DORV
- Intramural VSD detected, long bypass run
- Cath showed $Q_p/Q_S$ 2.4:1, systemic PA pressure

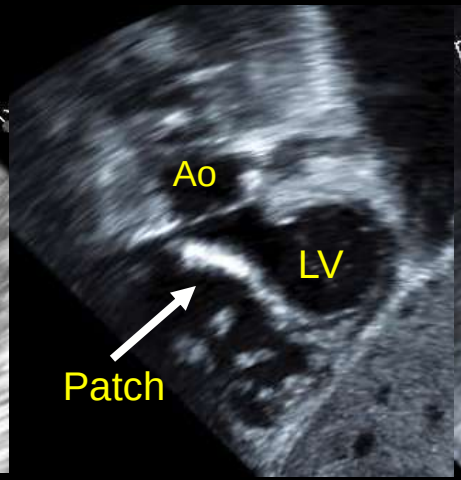
# 3D PRINTING

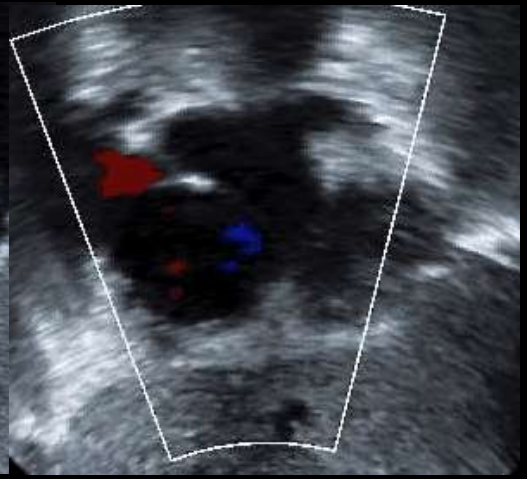


# AFTER

- VSD enlarged
- Patch repositioned through RVOT

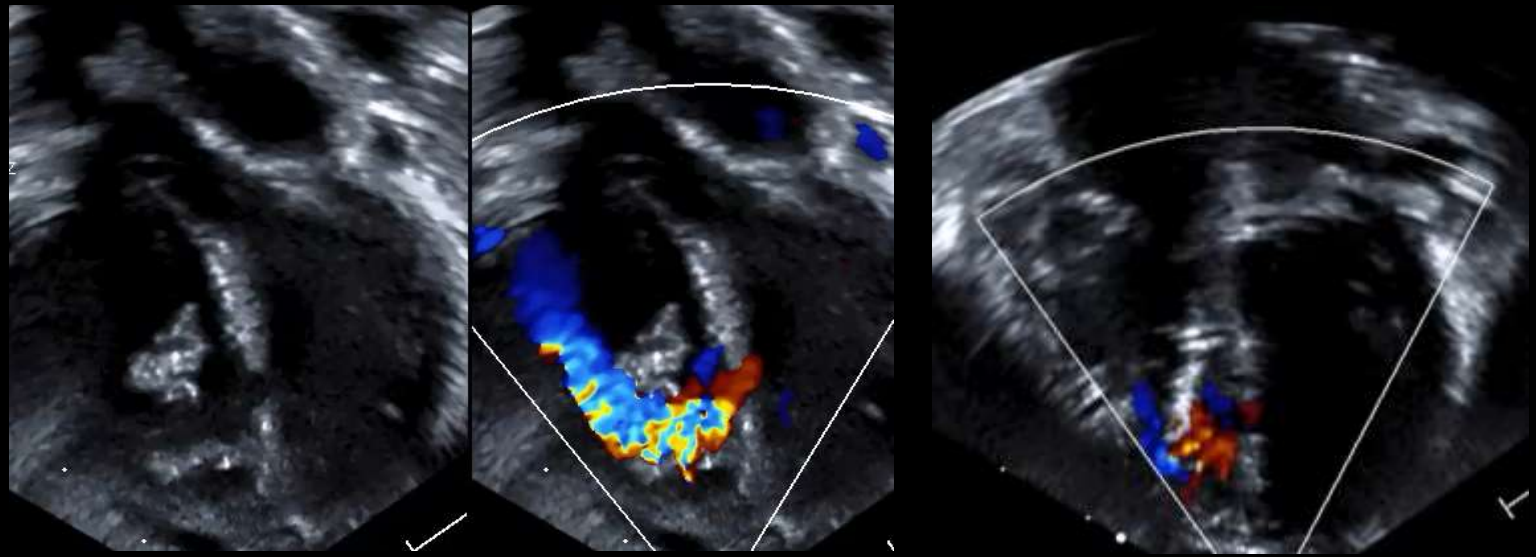


# COMPLEX MUSCULAR VSD

- Attempt at patch placement
- Significant residual flow around patch



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# Standard Pre-operative 2D and 3D Transthoracic Echocardiography

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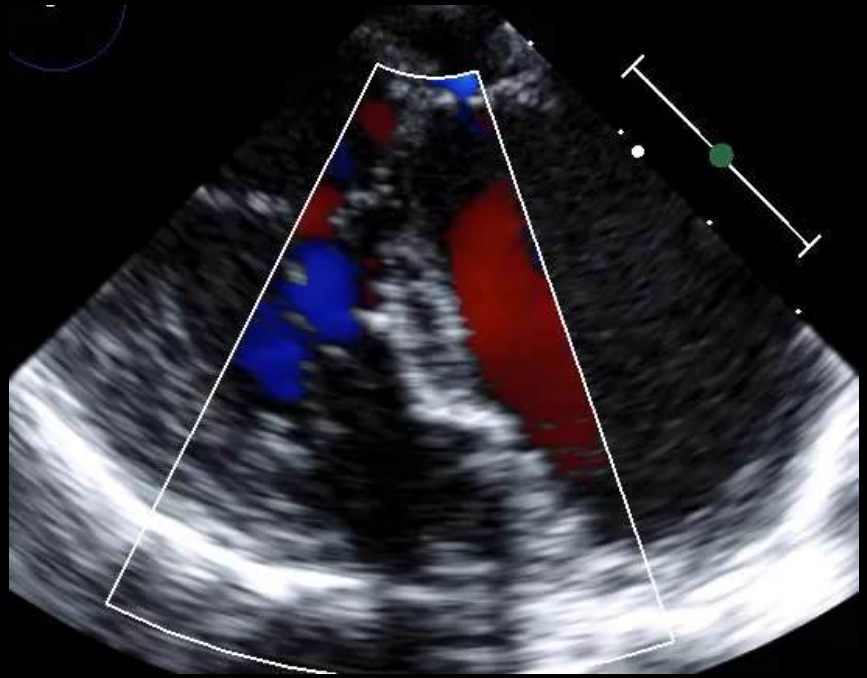
# COMPLEX MUSCULAR VSD

- Patch placed under muscle bundles



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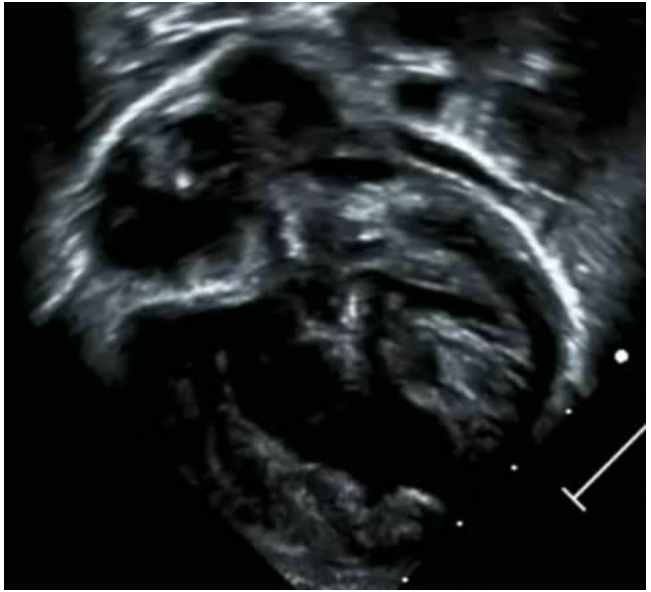
# DETECTING RESIDUAL LEAKS

- Complete echo sweeps
  - Use contrast if diagnosis uncertain
  - Phone a friend
- Suspect when:
  - Acute increase in AV valve regurgitation
  - Acute decrease in ventricular function
  - Unexpected pleural effusion
- Patch abnormality
  - Not aligned properly (intramural)
  - Mobility of patch (dehiscence)



# DETECTING RESIDUAL LEAKS

- Most common time is immediate or in first few postop days
- Most are insignificant and resolve
  - Especially if peripatch
- Residual ASDs and VSDs can cause morbidity
  - **Beware the intramural VSD**
- Can be missed on intraoperative TEE
  - Additional techniques in the OR (RVp, Qp/Qs)
- Look early by postop echo if pt not taking typical course

# Thank You!

# HOW IS RESIDUAL VSD DETECTED?

- Intraoperative TEE
  - High rate of false negatives
  - Size may be underestimated
- Direct measurement of RV pressure
  - Can be elevated for other reasons
- Measurement of Qp/Qs in the OR
  - Not always reliable, particularly by echo
- Postop study is often when it is recognized