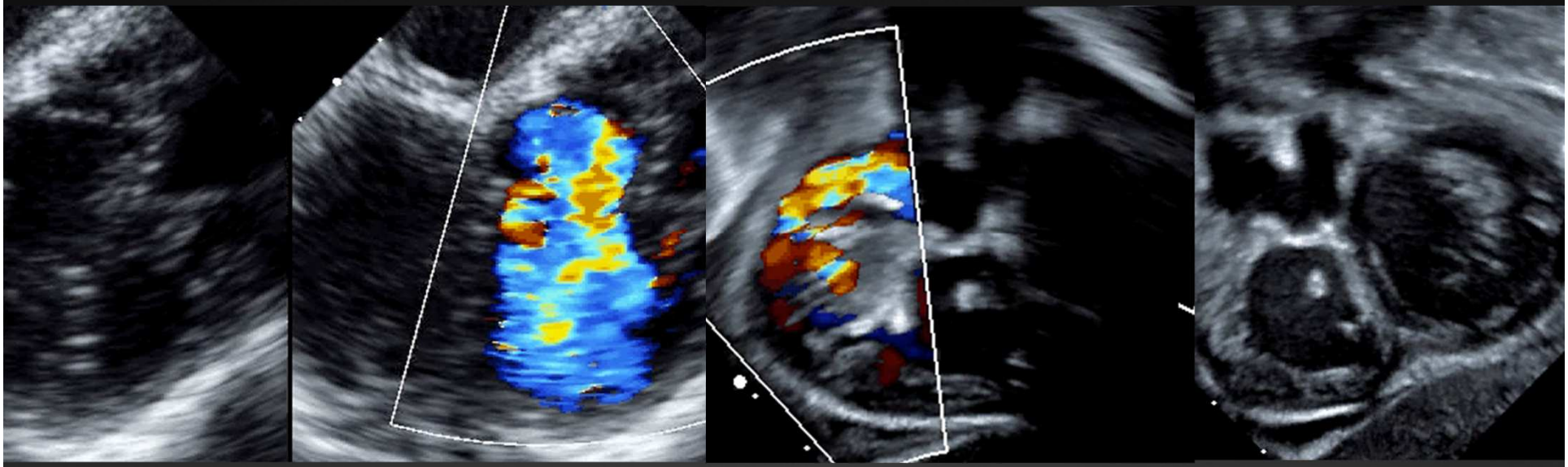
Cardiology 2018, Scottsdale, AZ

Characterizing and Deciding the Significance of a Postoperative Residual VSD



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No Conflicts or Disclosures

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

Braun Scully B et al. Ann Thorac Surg 2010

VSD Surgery

- Residual VSD is common after repair
  - Isolated VSD surgery (33-51%)
  - Conotruncal defects (58%)
- Causes include:
  - Patch dehiscence
  - Incomplete closure
  - 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

Impact of Residual VSD

- Depends on:
  - Type
  - Size
  - Location
  - Preoperative diagnosis
    - e.g. VSD versus TOF
  - Other residual lesions
  - Can cause significant morbidity
    - Prolonged ICU stay
    - Heart failure
    - Poor growth
    - PHN

Residual VSD after TOF

- Cause of significant morbidity and mortality in early reports
- In contrast to isolated VSD, those with TOF have not been exposed to a volume load
- More likely to be a type that is difficult to access
  - Muscular previously not recognized
  - Intramural

Uretzky G et al. Circulation 1982

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%

Dodge-Khatami A et al. Ann Thorac Surg 2007

Residual VSD Over Time

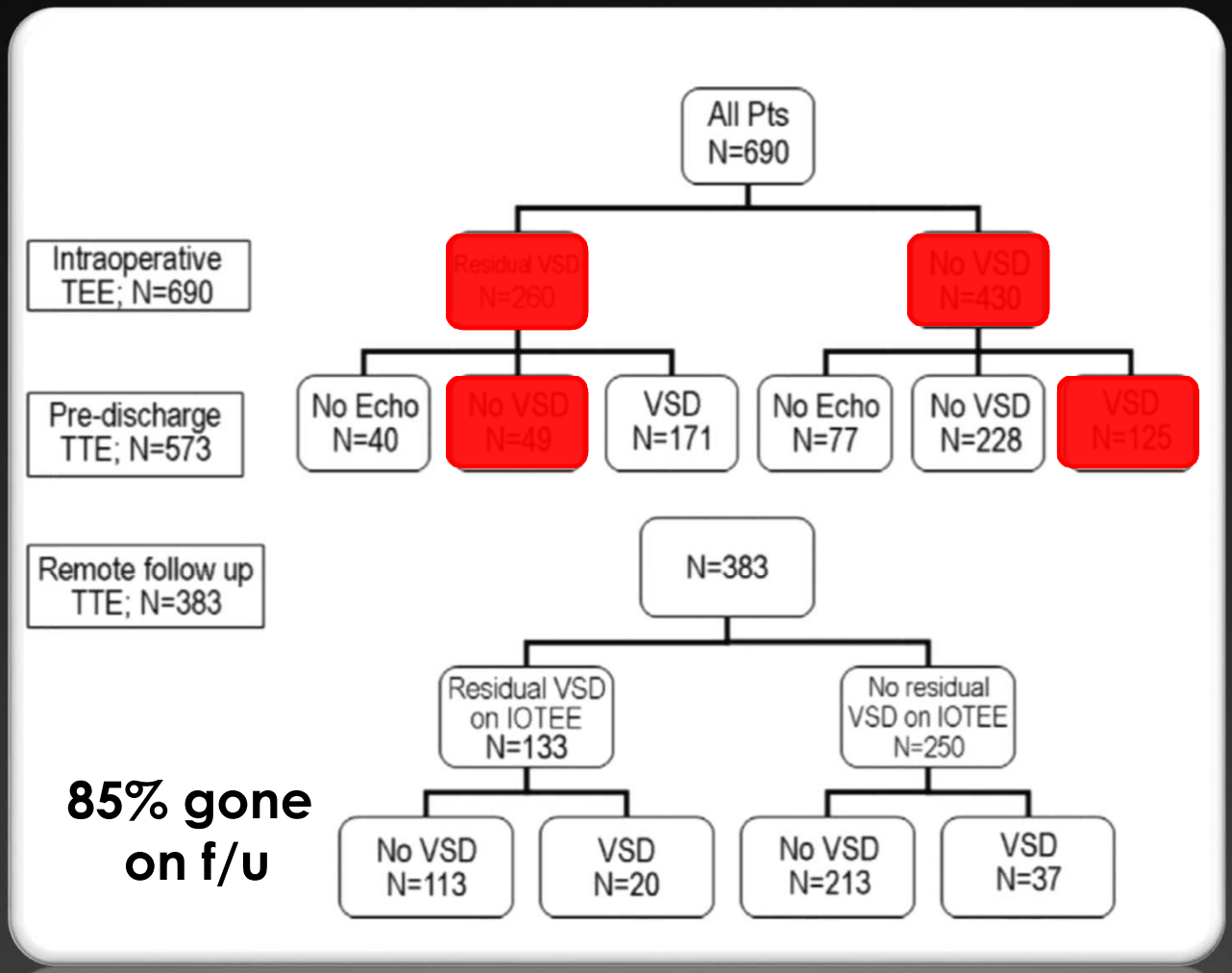
- VSD after AV Canal highly likely to close
- In TOF and isolated VSD, a third will remain open
- Defects <2mm will close spontaneously
- Defects >2mm will not close but are generally not hemodynamically significant over time

Dodge-Khatami A et al. Ann Thorac Surg 2007

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

Detection by TEE



85% gone on f/u

Hanna BM et al. Ann Thorac Surg 2010

Measure of Qp/Qs

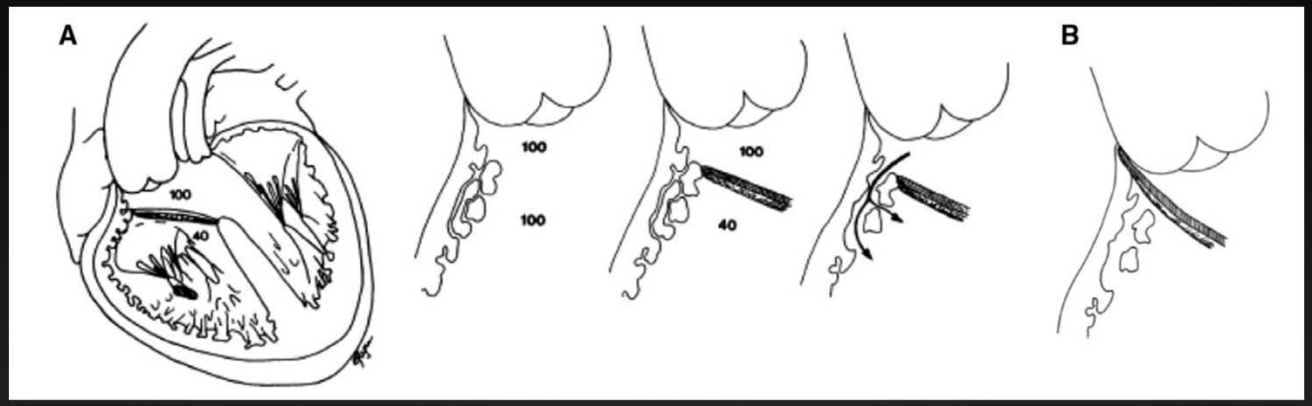
- TEE derived Qp/Qs = $\frac{(PAD^2 \times PA\text{-}VTI)}{LVOTD^2 \times LVOT\text{-}VTI}$

- TEE derived Qp/Qs is inaccurate in the majority of patients
  - Error in measurement
  - Output changes as pt comes off bypass
  - Rhythm may not be normal

- Even measurement by blood gas may not be accurate

Kurokawa S et al. J Anesth 2010

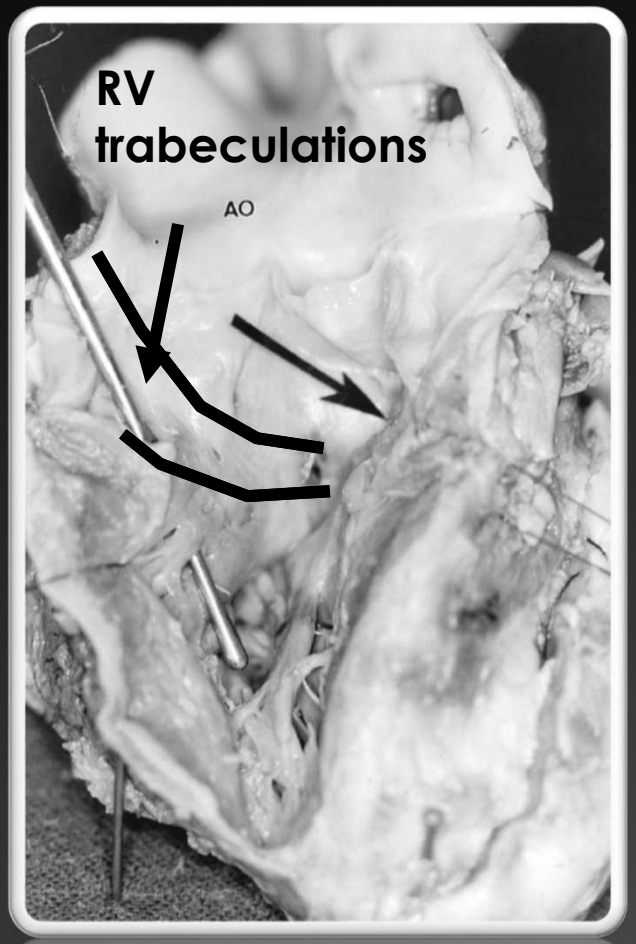
Intramural VSD

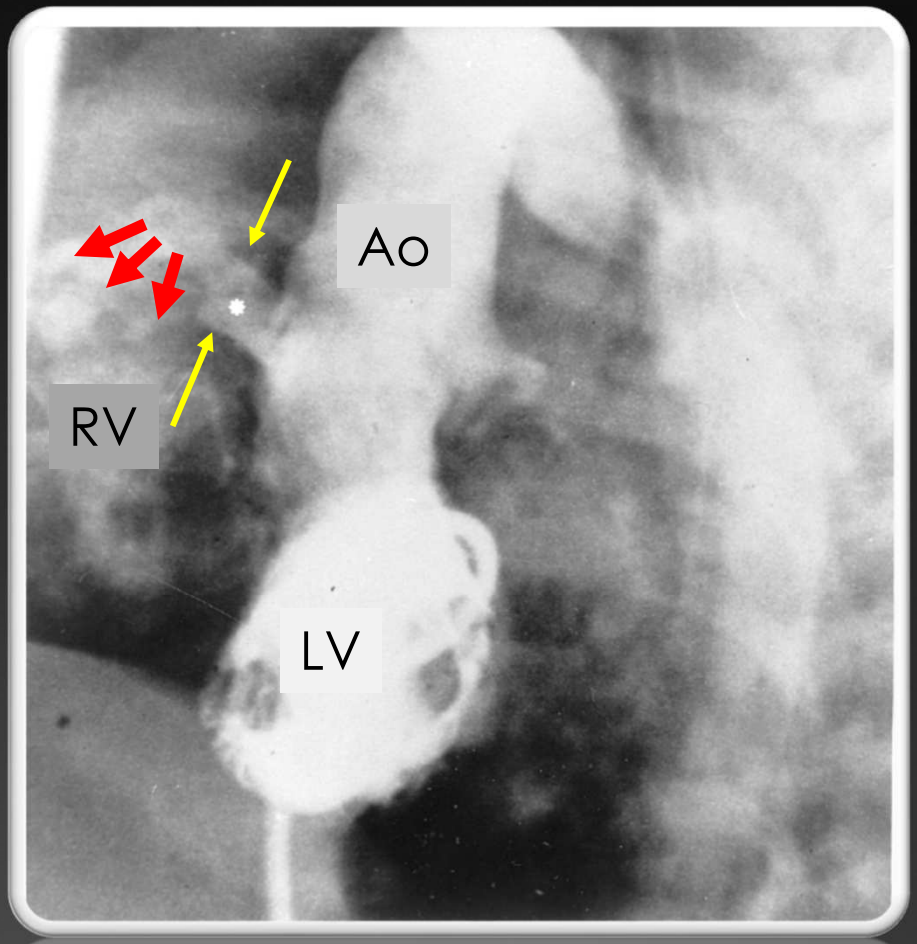


- Occurs in conotruncal defects where LV is baffled to a great artery
  - Patch should attach at ventriculoinfundibular fold
  - Misplaced VSD patch on hypertrophied RV free wall
- Complex communication between the "neo-LV" and the RV body

Preminger TJ et al. Circulation 1994

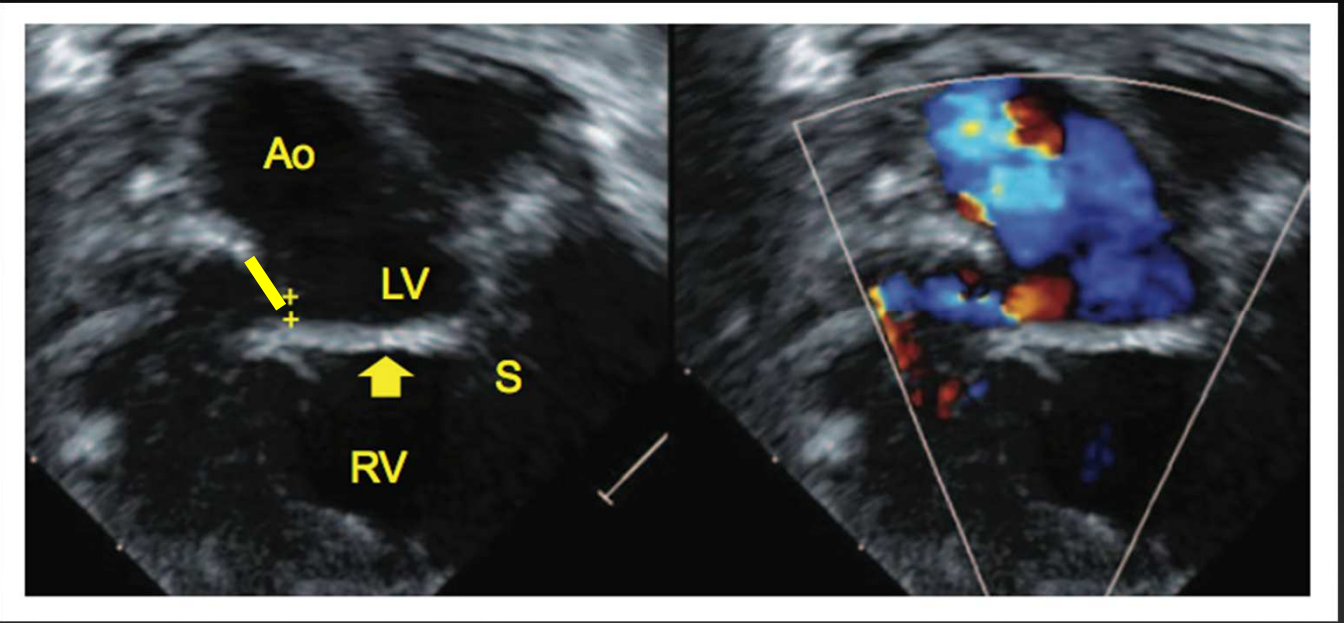
Intramural VSD





Belli E et al. Ann Thorac Surg 2000

Intramural VSD



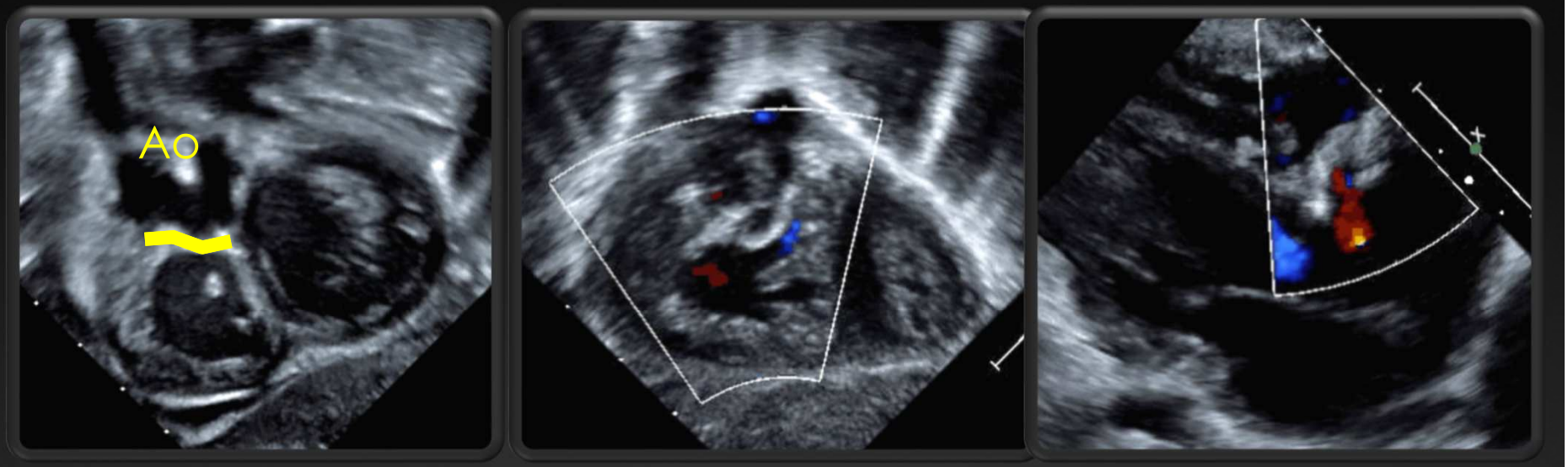
- Can enlarge over time
  - As RV hypertrophy regresses, channels get bigger
- Surgeons has difficulty visualizing them
  - Often anterior without clear-cut rims
  - Multiple channels
  - Typical RA or RV surgical approach may not work

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**

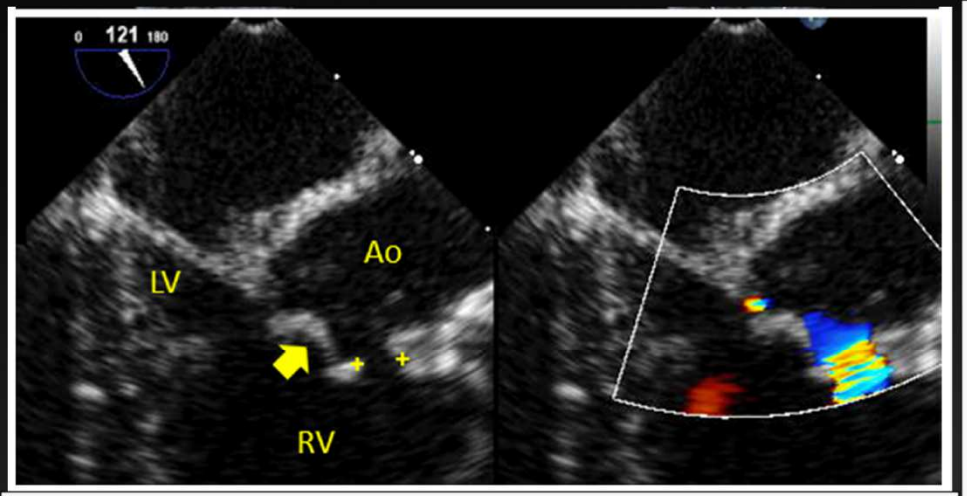
Patel JK et al. Circulation 2015

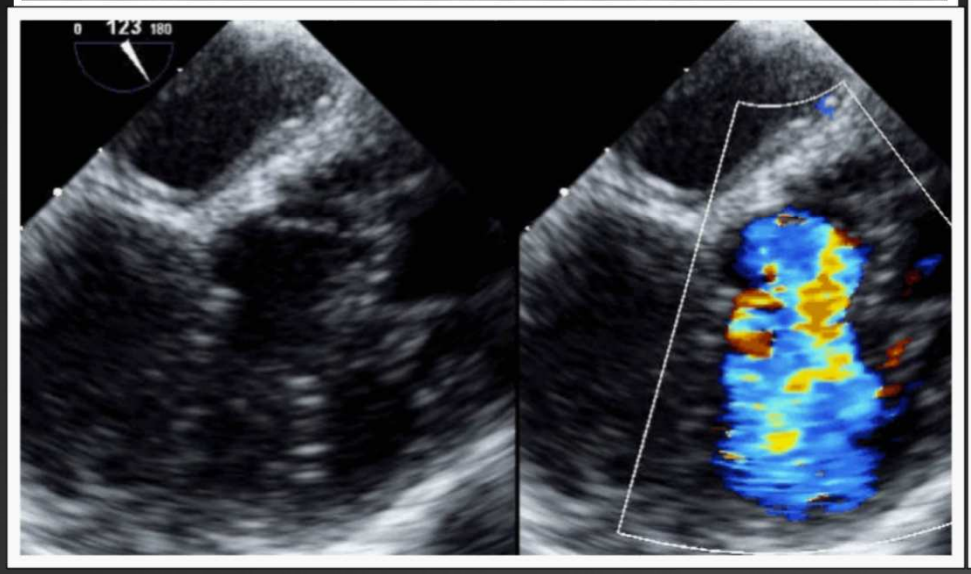
Echo of Intramural VSD

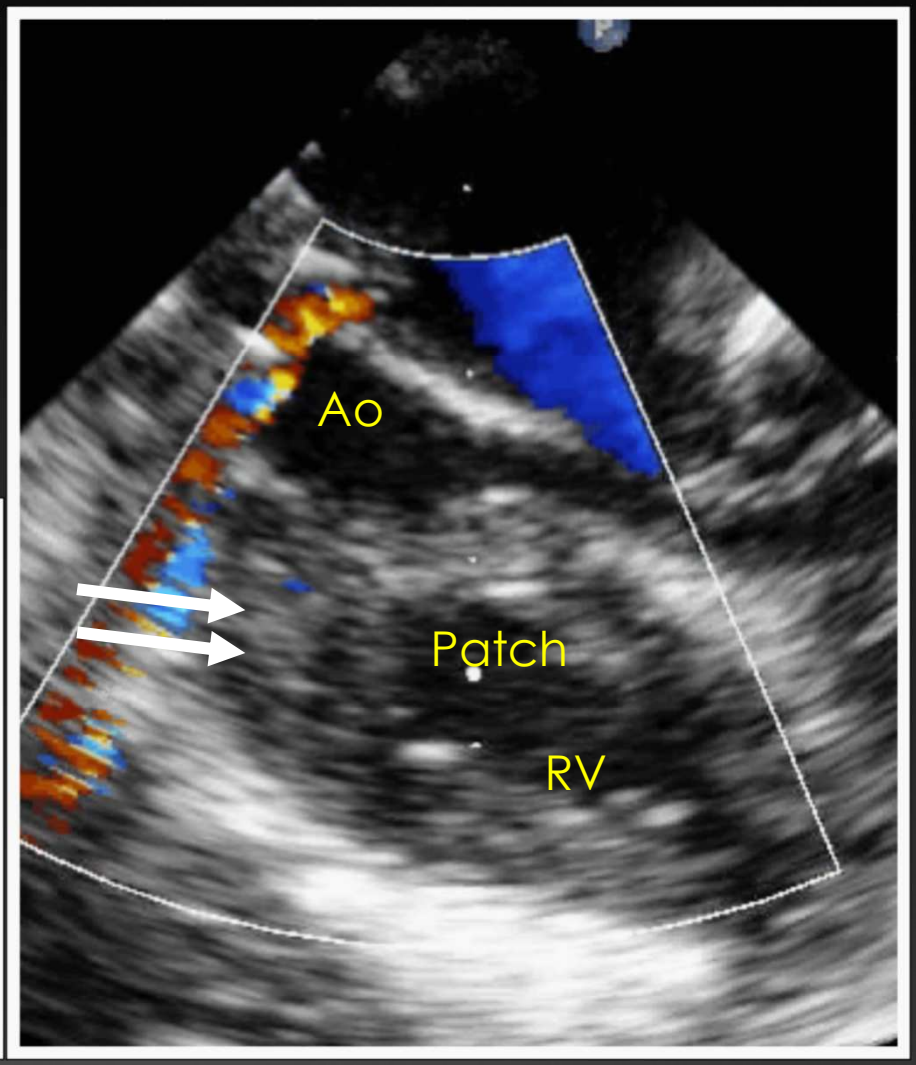


- Clue is displaced VSD patch along RV free wall
- Must do full sweeps or it can be missed
  - Does not lie in the typical plane of the VSD patch
- Usually very anterior
- Often multiple jets seen on RV side

TEE of Intramural VSDs







Patel JK et al. JTCVS 2016

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 Predicitve Value: 95%

Patel JK et al. JTCVS 2016

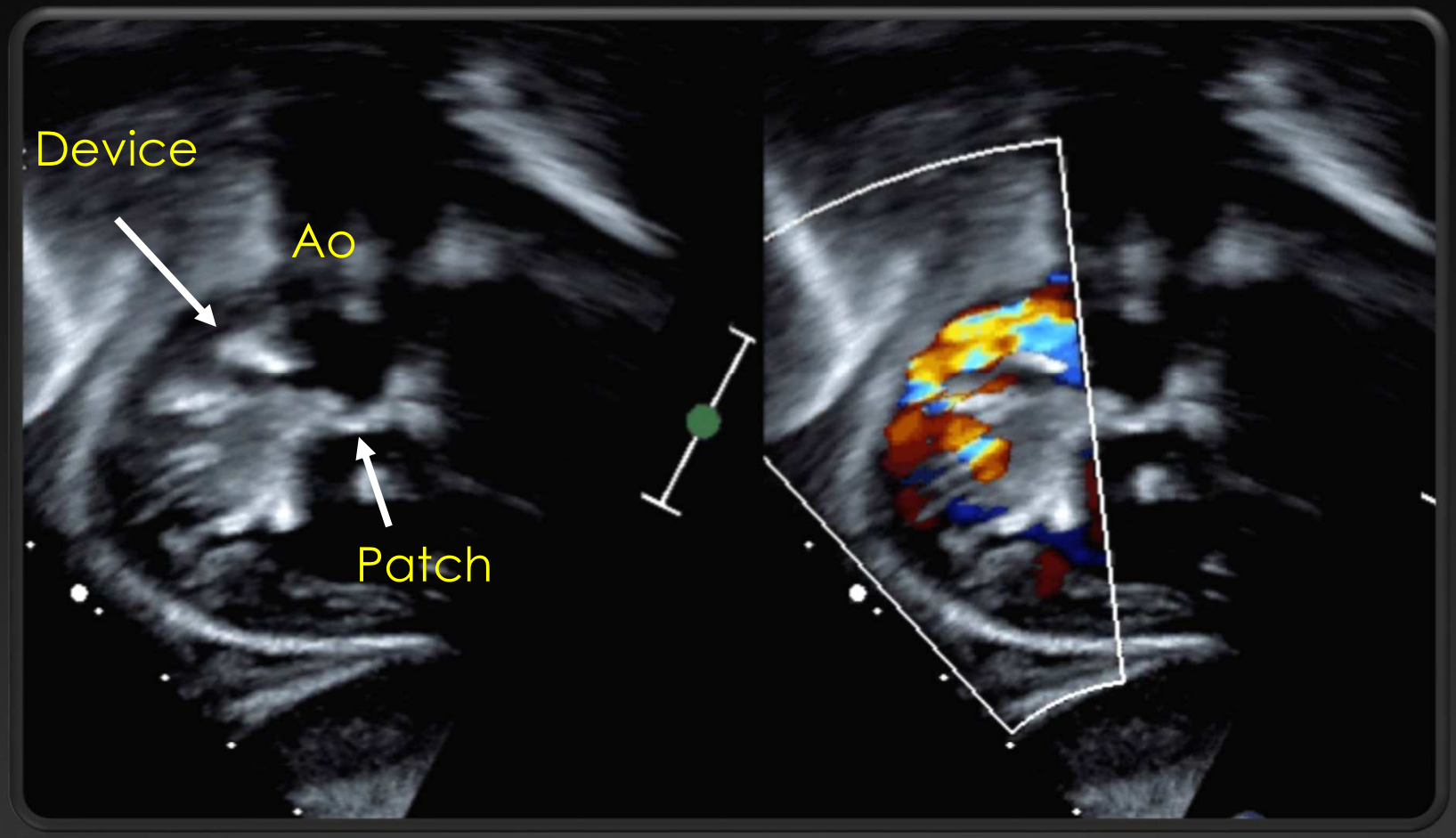
Residual VSD Strategy

- If pt not taking typical postoperative course, think residual VSD
  - Difficult to extubate
  - Rhythm problems
  - Ventricular dysfunction
- Early catheterization to assess hemodynamics
- Consider reoperation or device closure if Qp/Qs is high
  - Generally greater than 2:1

How to Approach Intramural VSD

- If identified in the OR, reoperation is recommended
  - Will likely get larger and cause morbidity
  - May consider reanchor of the patch
- If found later, best approached through:
  - The aorta (*Belli E et al Ann Thorac Surg 2000*)
  - The RVOT
- 3D printing may be helpful

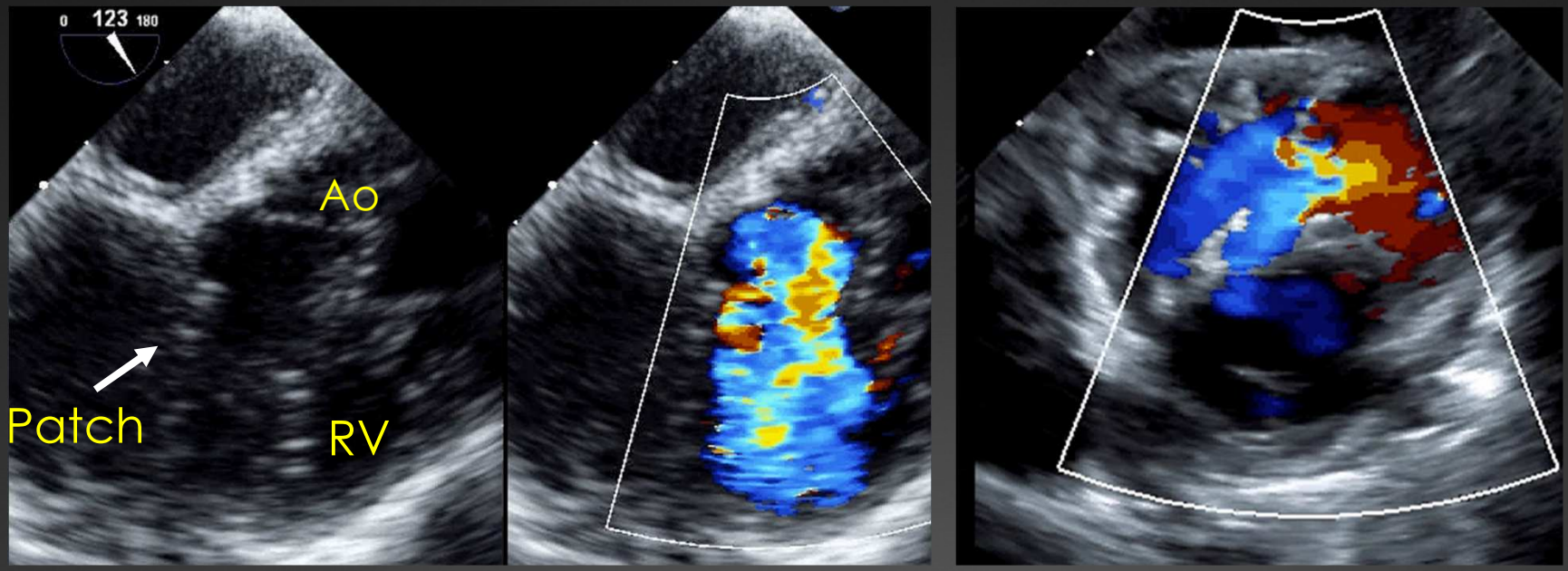
Device Closure



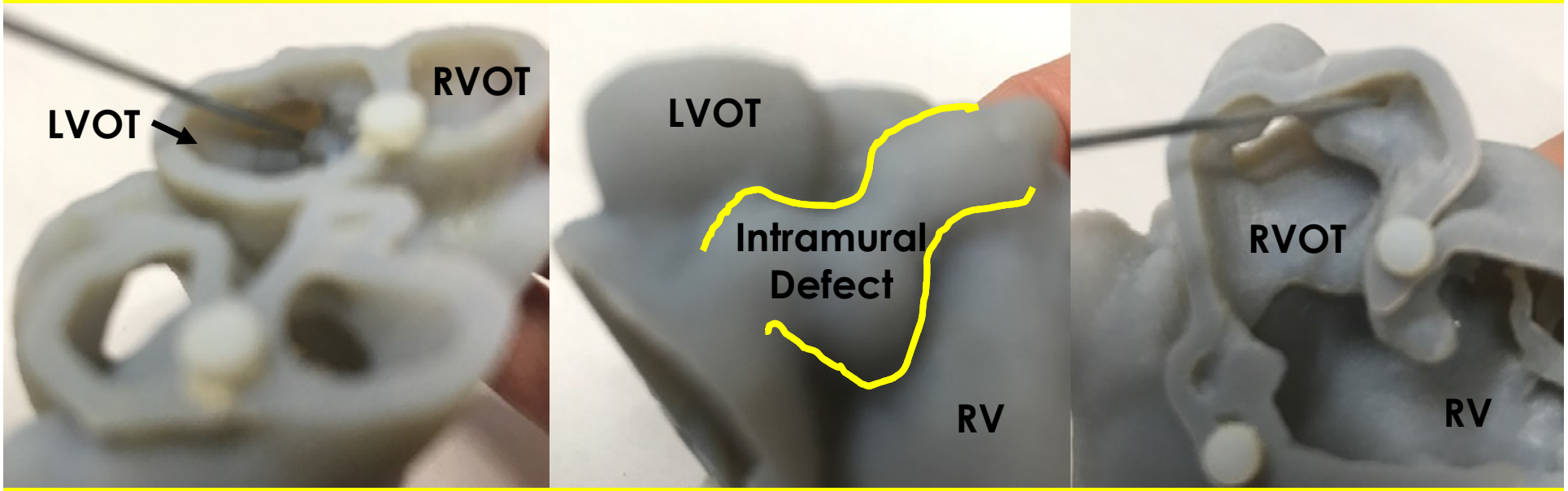
Doesn't always close the entire defect

Before

- Taussig-Bing DORV
- Intramural VSD detected but surgeon decided not to go back on bypass
- Cath showed Qp/QS 2.4:1, systemic PAp

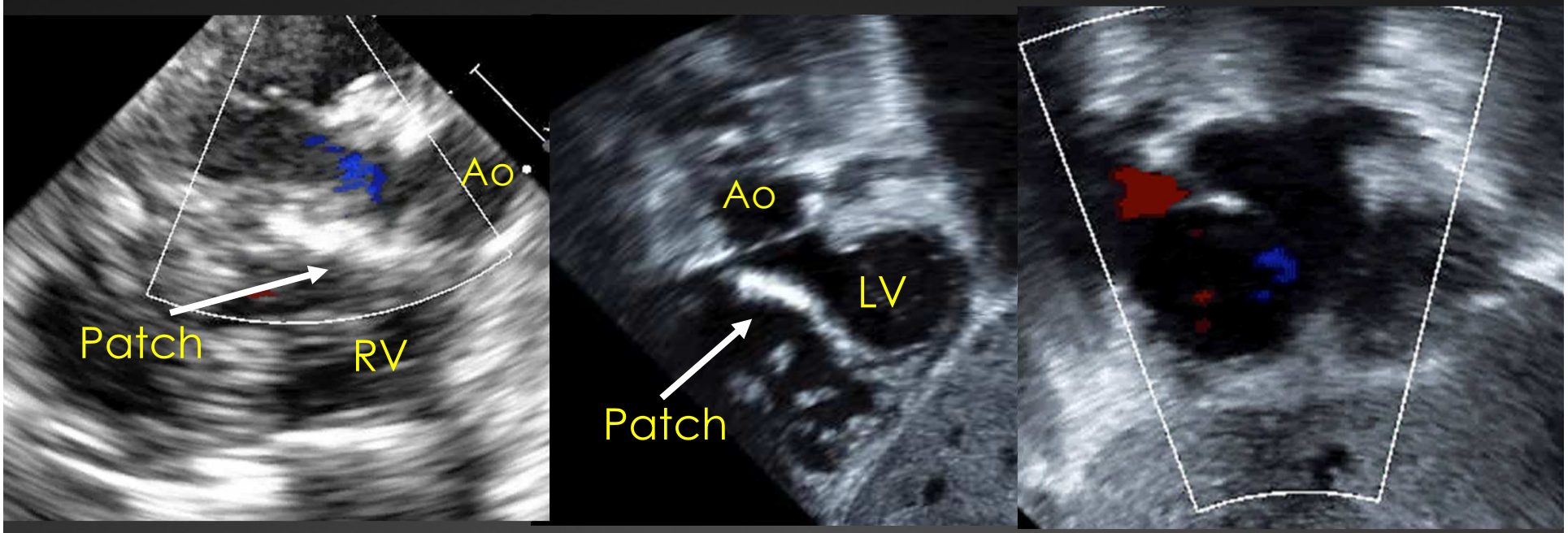


3D Printing



After

- VSD enlarged
- Patch repositioned through RVOT



Residual VSD

- Most are insignificant and resolve
  - Especially if peripatch
- Can be missed on intraoperative TEE
  - Significance can be difficult to determine
  - Usually < 2 mm is not a problem
- Beware the intramural VSD
  - Can enlarge over time
  - Causes morbidity and mortality
  - Difficult for surgeon to visualize and repair

Thank You