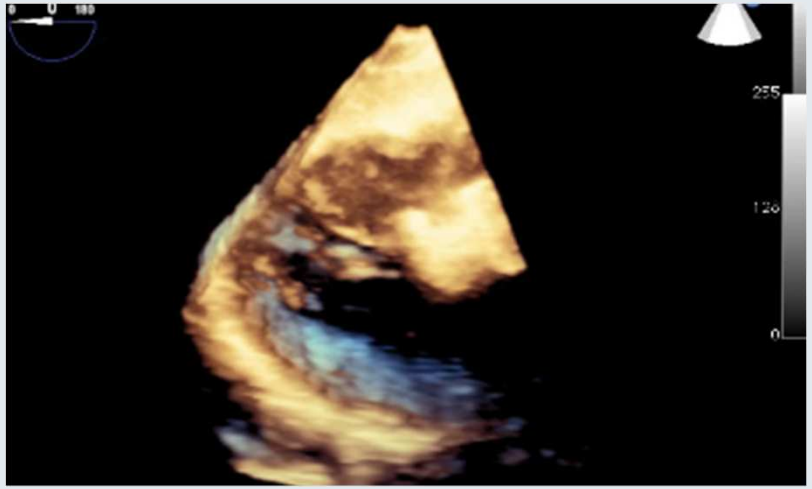
The Restrictive Conoventricular VSD (But with High Qp: Qs) That Won't Spontaneously Close



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Active Materials Lab

UCLA

Disclosure Information

The Restrictive Conoventricular VSD (But with High Qp: Qs) That Won't Spontaneously Close

Daniel S Levi, *MD, FSCAI*

As a faculty member for this program, I disclose the following relationships with industry:

(GRS): Grant/Research Support (C): Consultant (SB): Speaker's Bureau
(MSH): Major Stock Holder (AB): Advisory Board (E): Employment
(O):Other Financial or Material Support

pfm Medical, Edwards, Medtronic, Abbott: C
Atrium Medical: C
Neurosigma Vascular: AB
NIH Challenge Grant, AHA Innovative Research Grant

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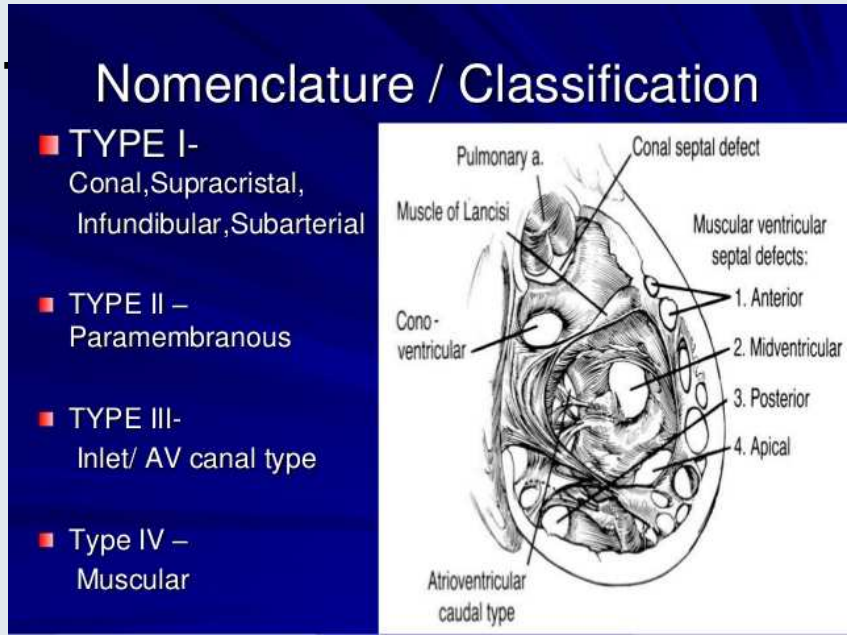
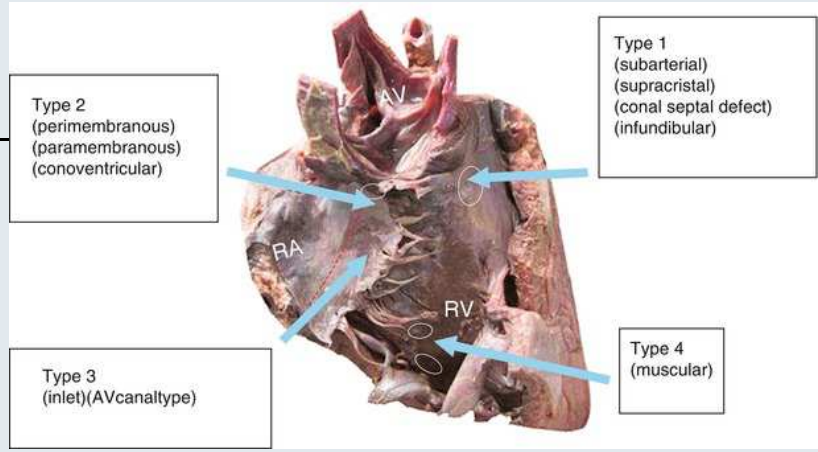
Conoventricular VSDs: PDAs on steroids!!

- Very common congenital defect (20%)
- Up to 50/1000 live births (echo exam)
- 80% of surgical VSD series
- If unrepaired, VSD is the most frequent CHD associated with IE
- Need to weigh risk of closure against long term risk….
- Adult Congenital Heart Program data is key
  - Endocarditis
  - Impact of left to right shunt older in life…
- Untreated pmVSD are not benign*
  - 220 patients followed 4-28 yrs, median 6 yrs
  - 2 (1%) cardiac related death
  - 8 (4%) endocarditis
  - 1 (0.5%) pacemaker, 1 (0.5%) ICD
  - 15 (7%) closing procedure



*Soufflet V, Van de Bruaene A, Troost E. et al. Am J Cardiol 2010
*Di Filippo et al, Archives of Cardiovascular Disease (2012) **105**, 454—

What/who are we talking about…...



- Non-newborns > 1-2 years and > 5-7 kg
- Totally without symptoms and without AR/DCRV
- pmVSDs with a “more than trivial shunt”
  - Qp:Qs > 1.5:1 or 2:1 or so
  - Left atrial or ventricular enlargement
- Average diameter >2-3mm (area >13 mm^2)
- Usually <6 mm and highly restrictive
- With or Without Tricuspid Valve aneurysmal closure
- Feltes et al “no recommendation RE pmVSD clsoure”

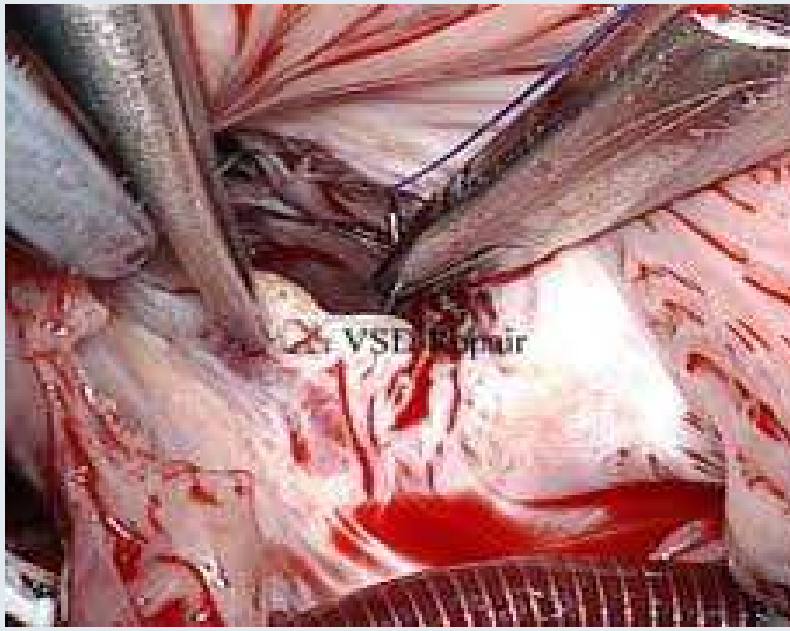
Indications for Cardiac Catheterization and Intervention in Pediatric Cardiac Disease

A Scientific Statement From the American Heart Association

Endorsed by the American Academy of Pediatrics and Society for Cardiovascular Angiography and Intervention

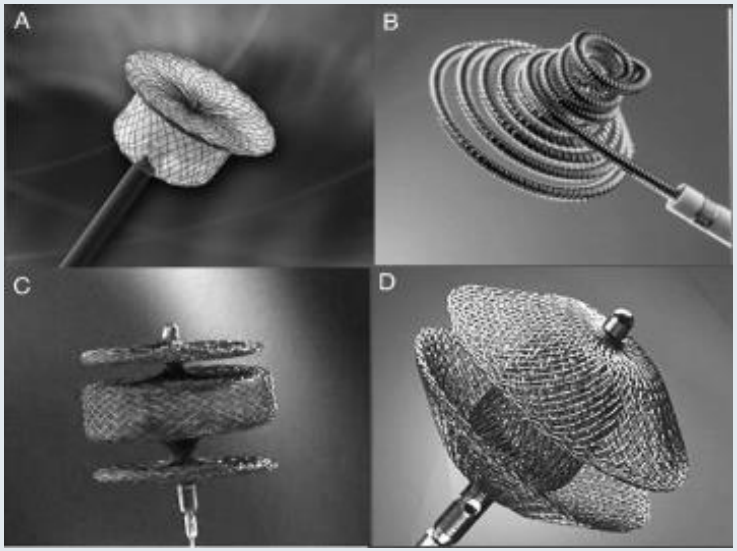
Surgical VSD Repair

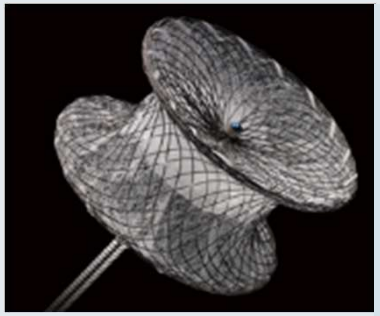
- Direct visualization during CPB from right atrium, pulmonary artery or aorta…high technical success
- Obvious cosmetic issues
- Mortality risk has steadily declined: 3-5% 10-20 years ago* to 0.5 - 1%
- Heart block risk also improved over time: 4,432 children: 1.1% and 0.8% who met criteria transcatheter closure**
- Hospital LOS: ICU 2d, 5-8 total days
- VSD closure in adults: 2% CHB, 15% residual VSDs***



*Hannan EL, Racz M, Kavey R-E, et al. Pediatrics 1998
**Tucker EM, Pyles LE, Bass JL, et al. JACC 2007
***Mongeon FP, Burkhart HM, Ammash NM, et al. JACC Cardiovasc Interv 2010

Transcatheter Device Closure of annoying conoventricular VSDs?



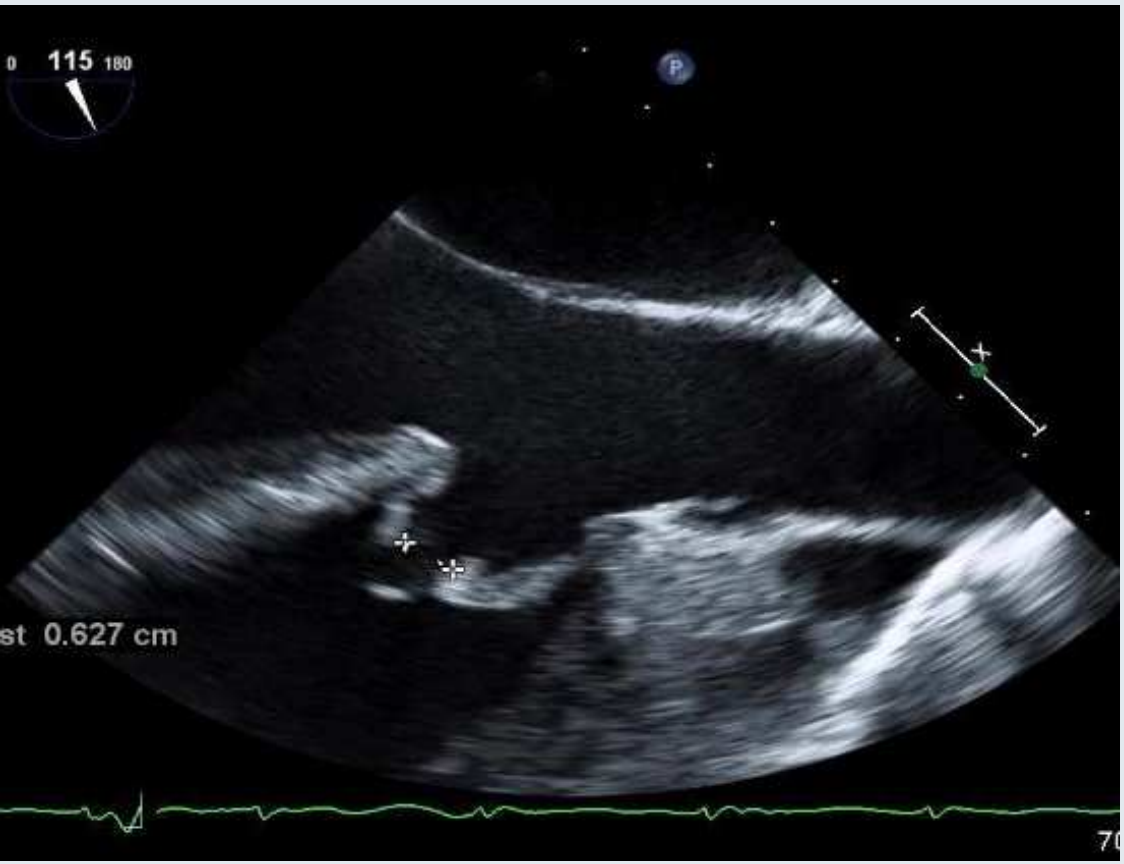


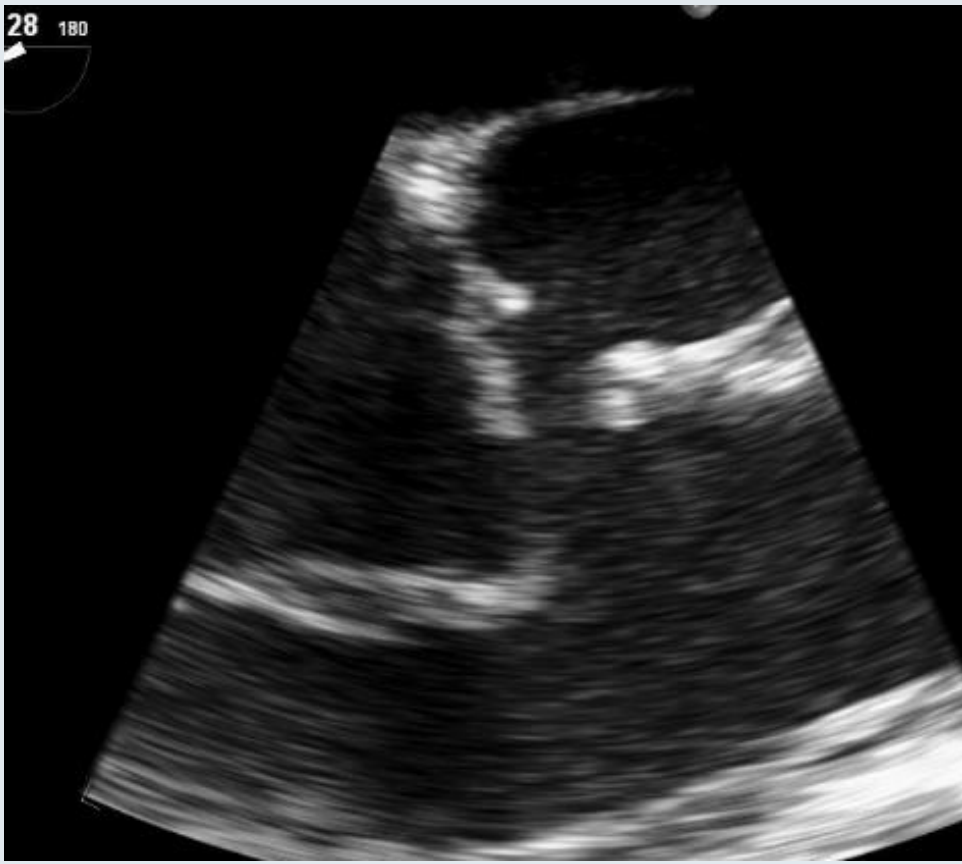
*Knauth AL, Lock JE, Perry SB, et al. Circulation 2004

**Landman G, Kipps A, Moore P, et al. CCI 2013

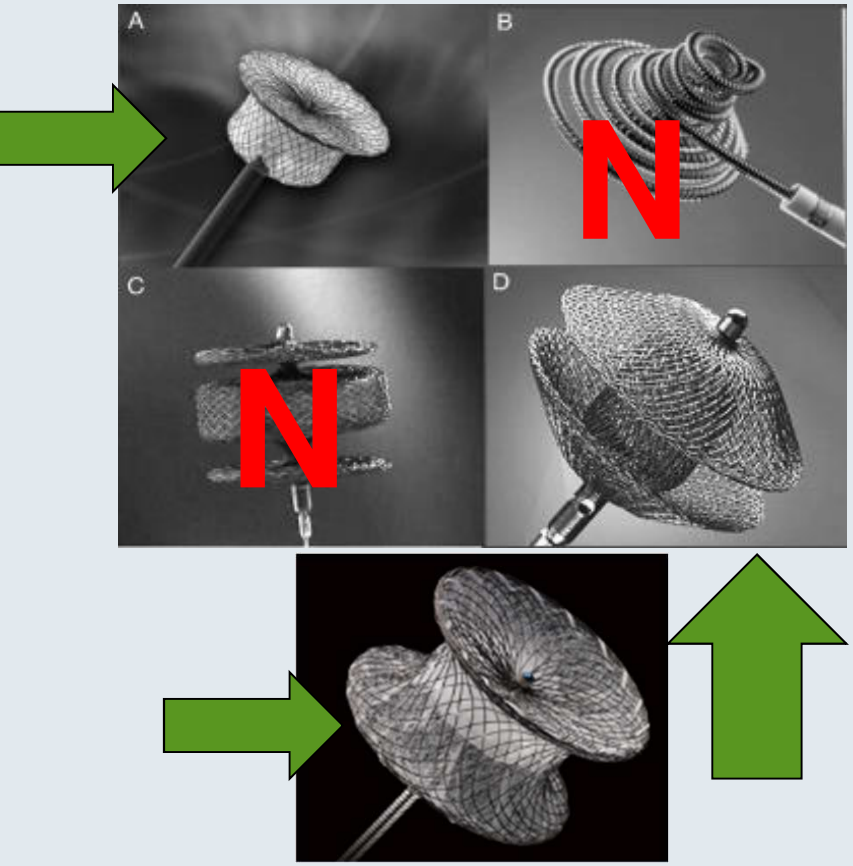
- Catheter based pmVSD closure would solve our annoyance
- **But….. needs to be as safe as surgery**
- Initial focus on muscular VSD and later post-infarct defects beginning in 1987*
- Specific purpose-built occluder, Amplatzer™ mVSD occluder granted FDA approval in 2007 but no pmVSD approval
- Multiple case reports and small series of various occluders used for perimembranous, defects**
- Focus on heart block and efficacy

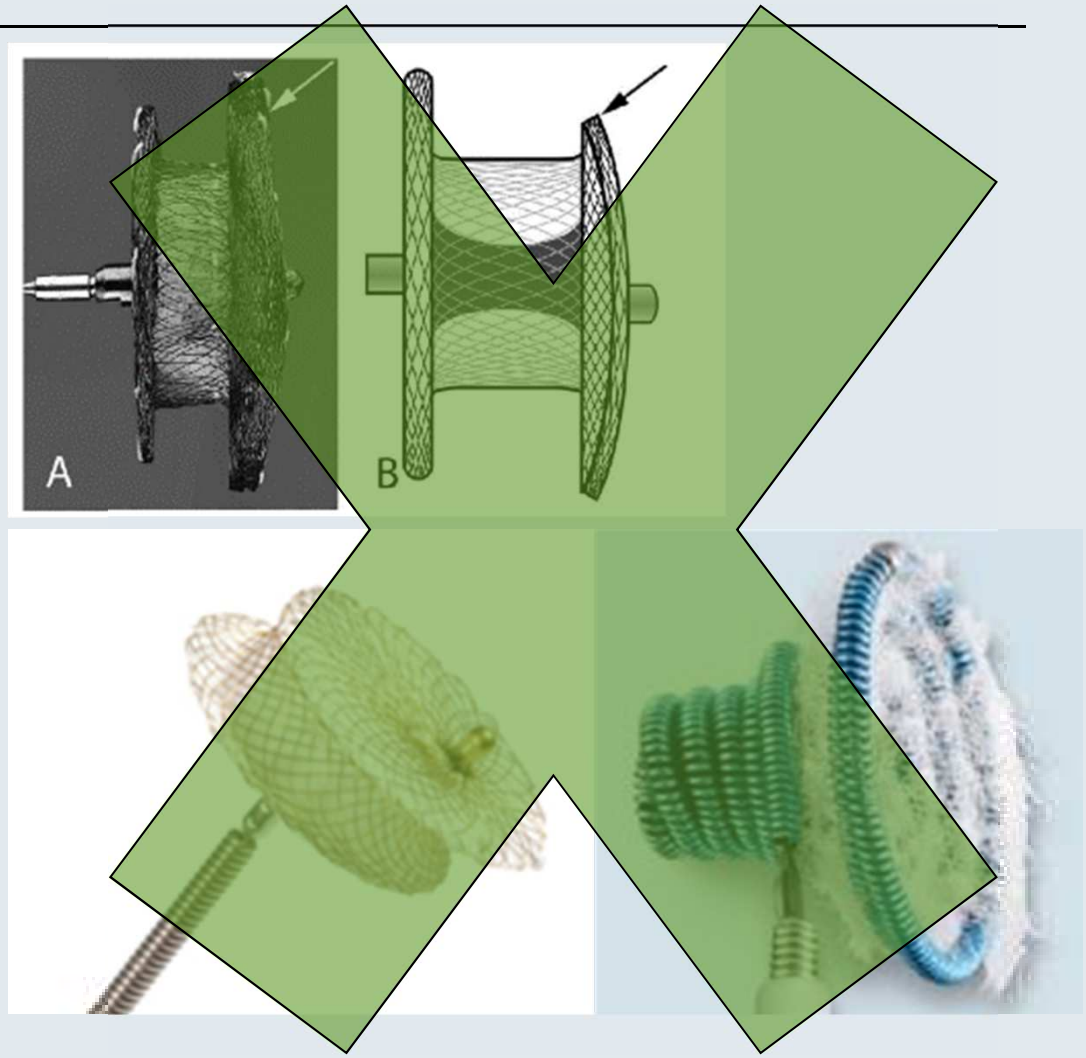
Perimembranous VSD Types: Tunnel/Hole vs Aneurysm





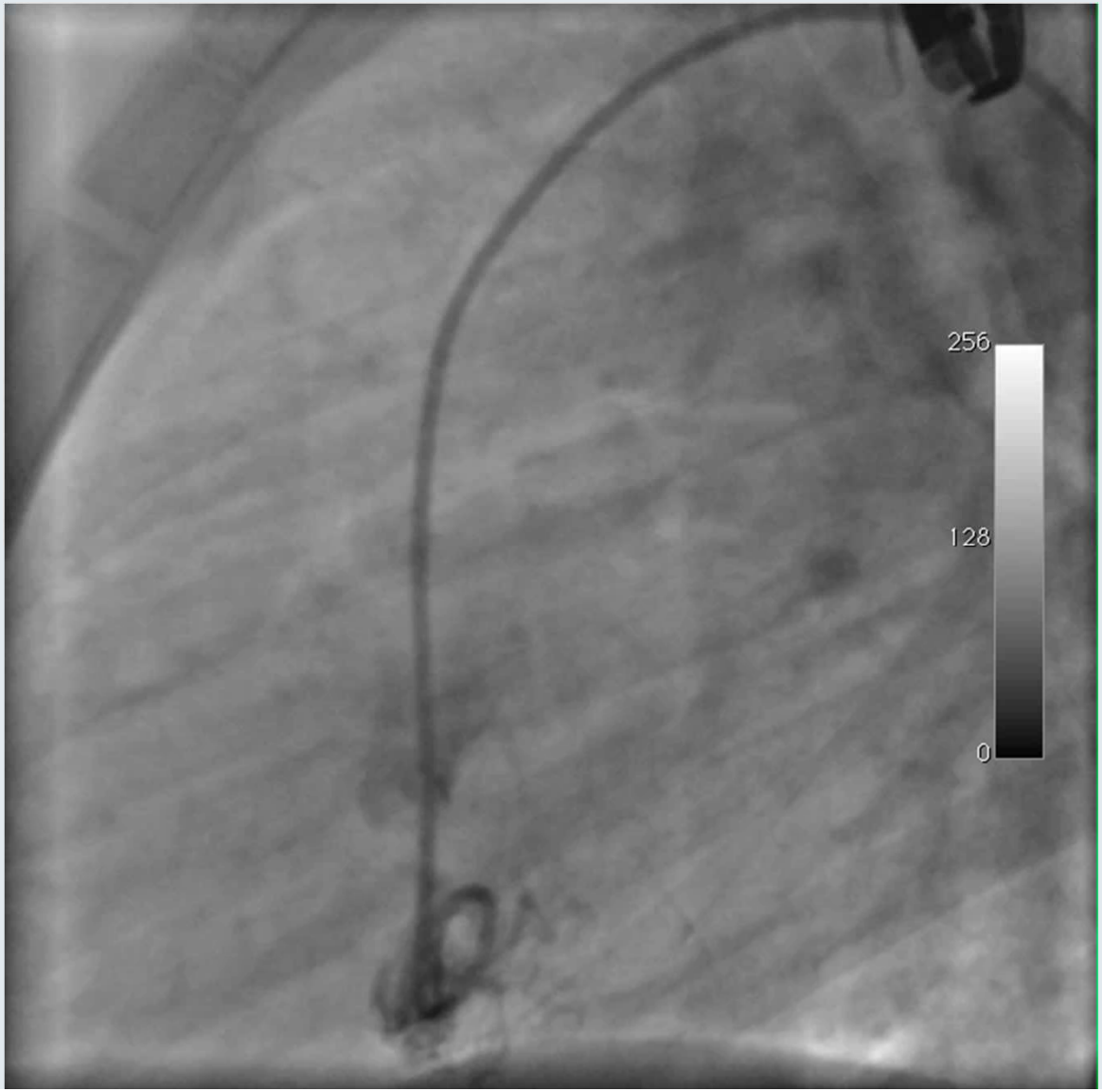
Transcatheter VSD Devices: US options?



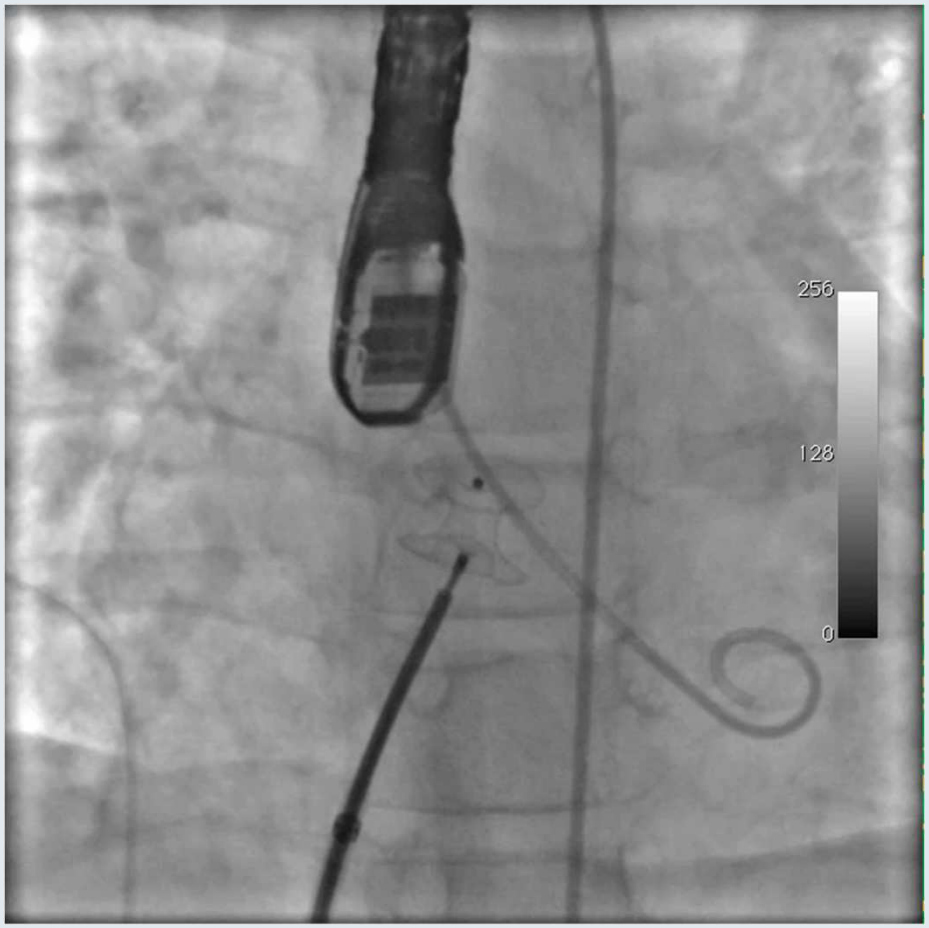


pmVSD + aneurysm Device Closure: Hemodynamic Cath and Angiography

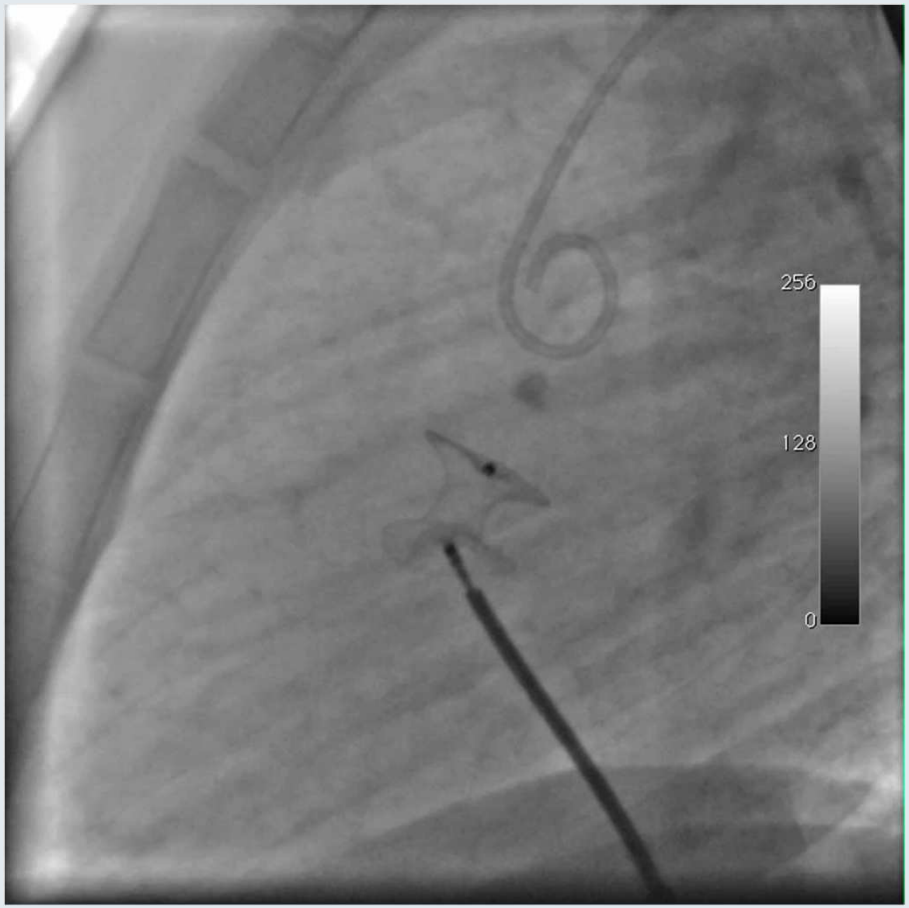
Mattel Children's Hospital at UCLA



pmVSD + aneurysm Device Closure: mVSD device



pmVSD + aneurysm Device Closure : mVSD Device

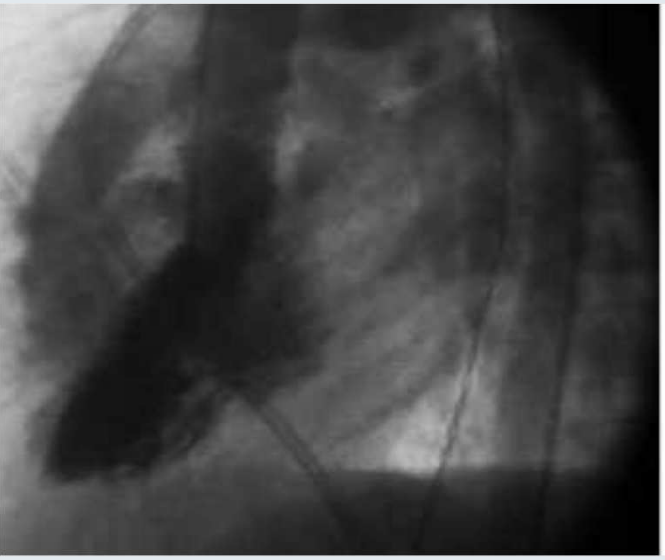


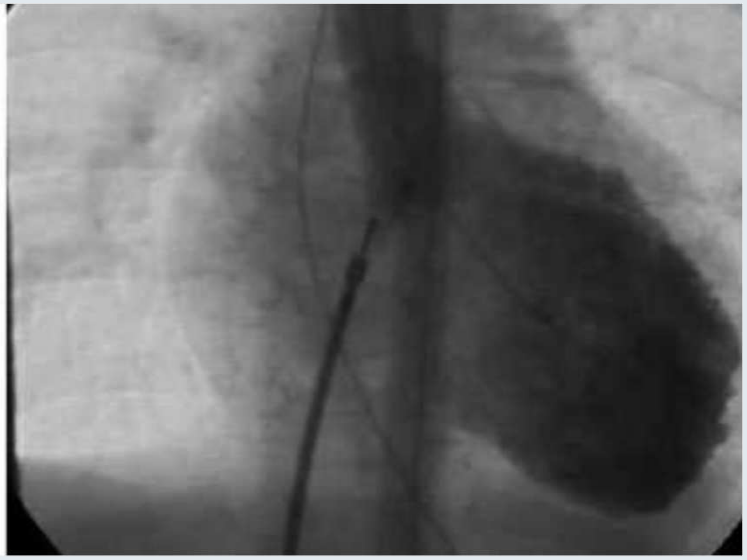
Catheterization and Cardiovascular Interventions 66:427–431 (2005)

Not So Annoying pmVSDs…..

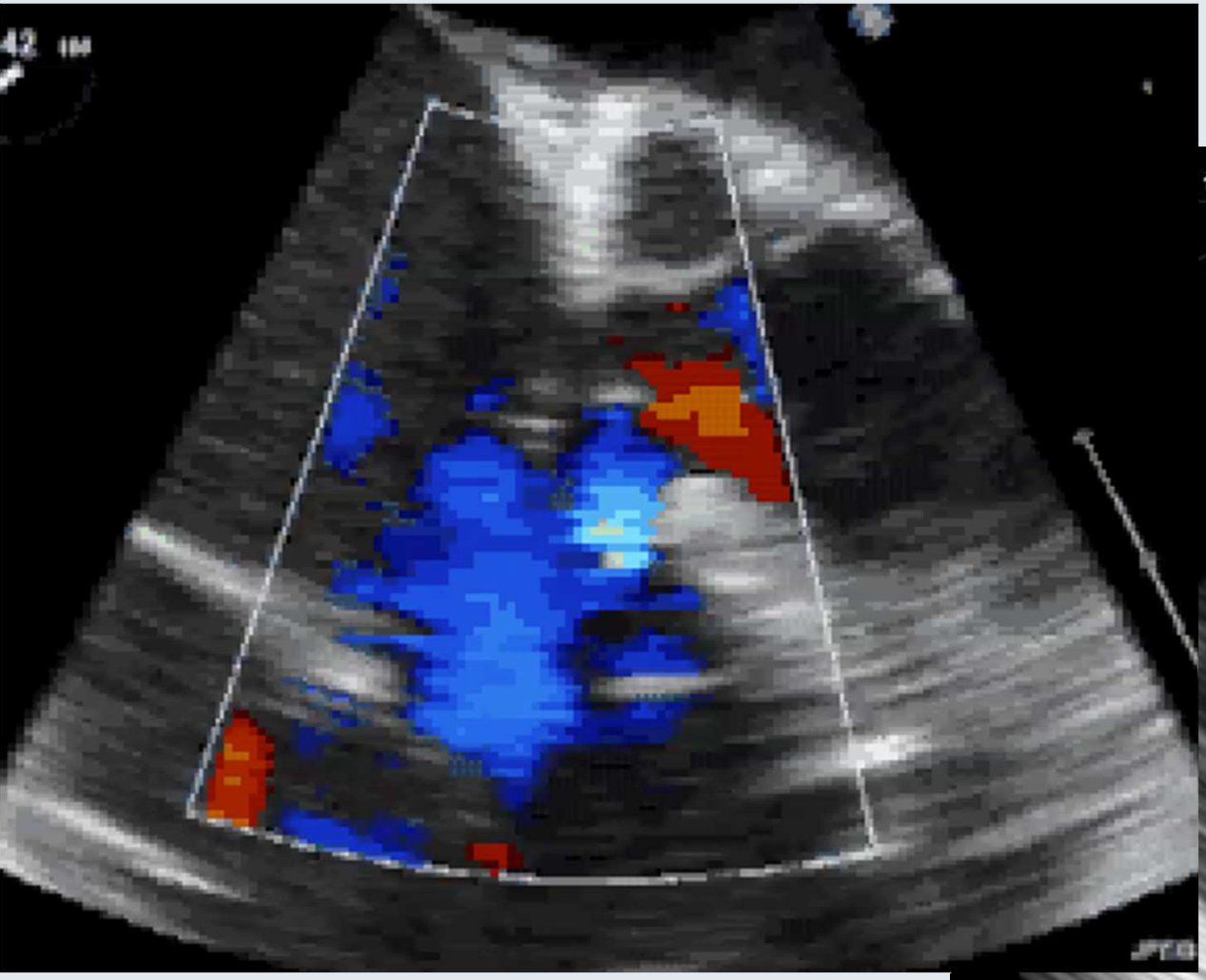
Percutaneous Closure of Perimembranous Ventricular Septal Defect Associated With a Ventricular Septal Aneurysm Using the Amplatzer Ductal Occluder

Christopher A. Tan, MD, Daniel S. Levi, MD, and John W. Moore,*† MD, MPH, FSCAI

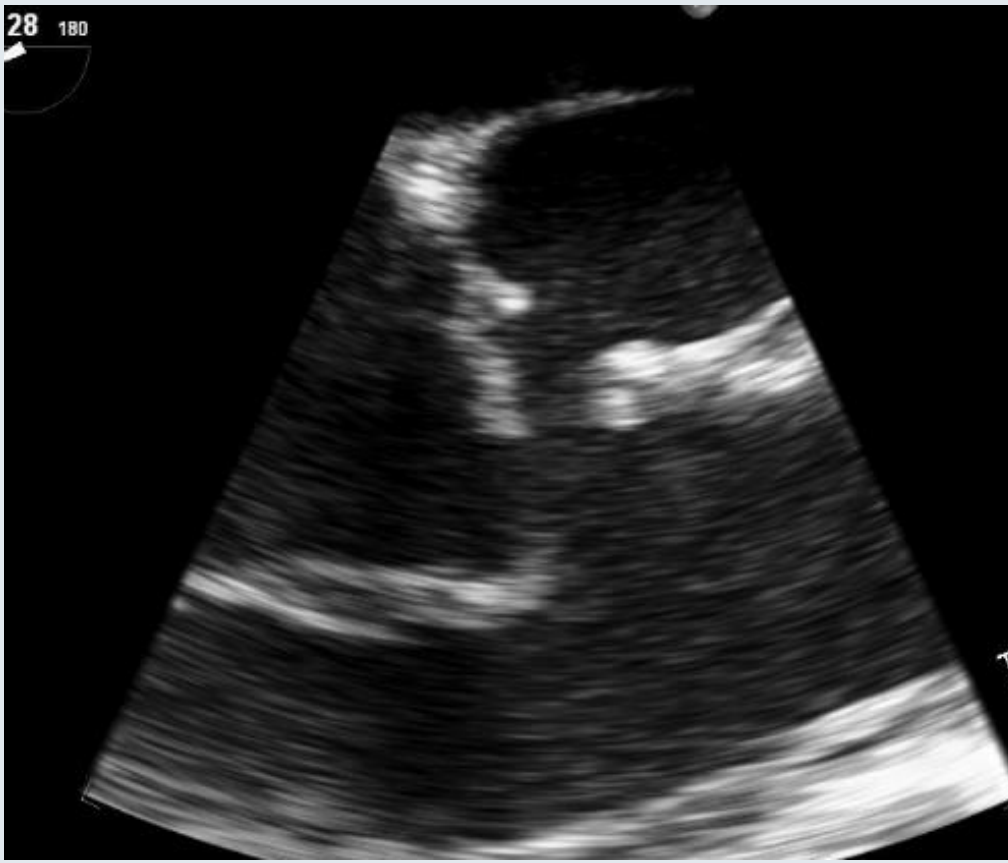




Perimembranous VSD without a TV Aneurysm

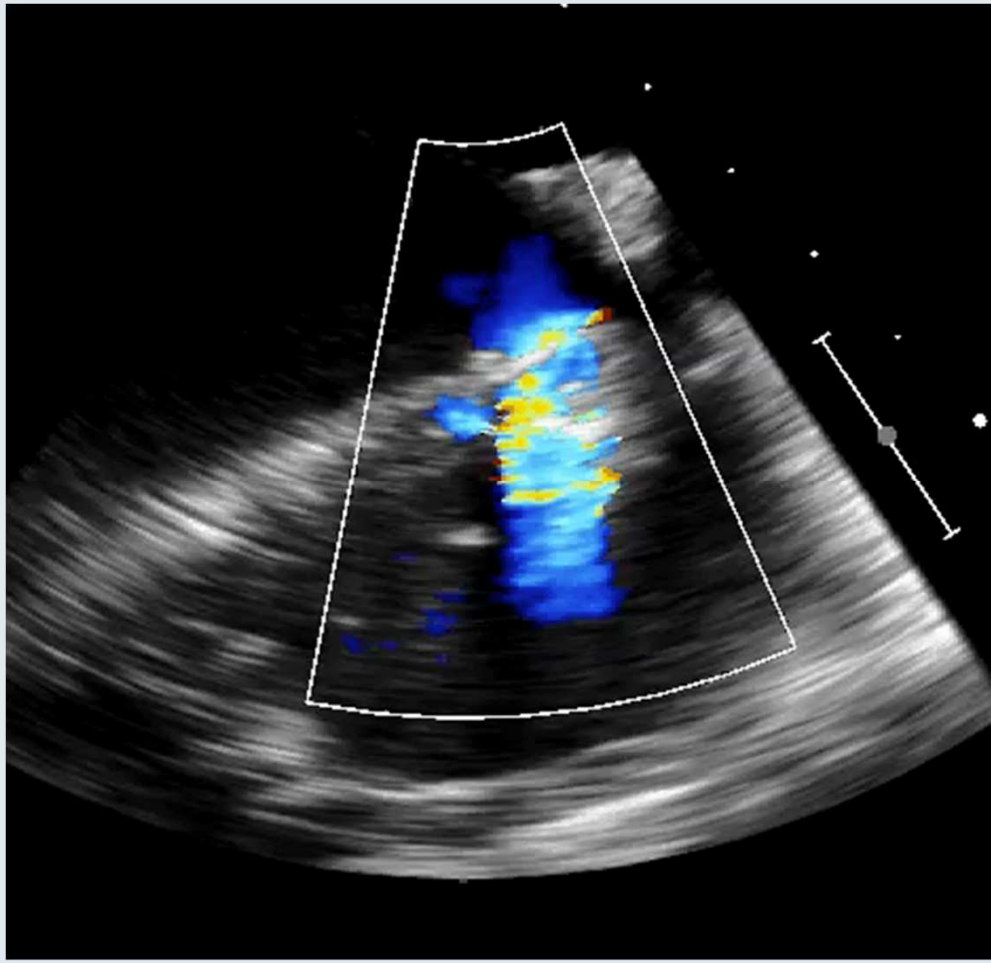


Perimembranous VSD without a TV Aneurysm

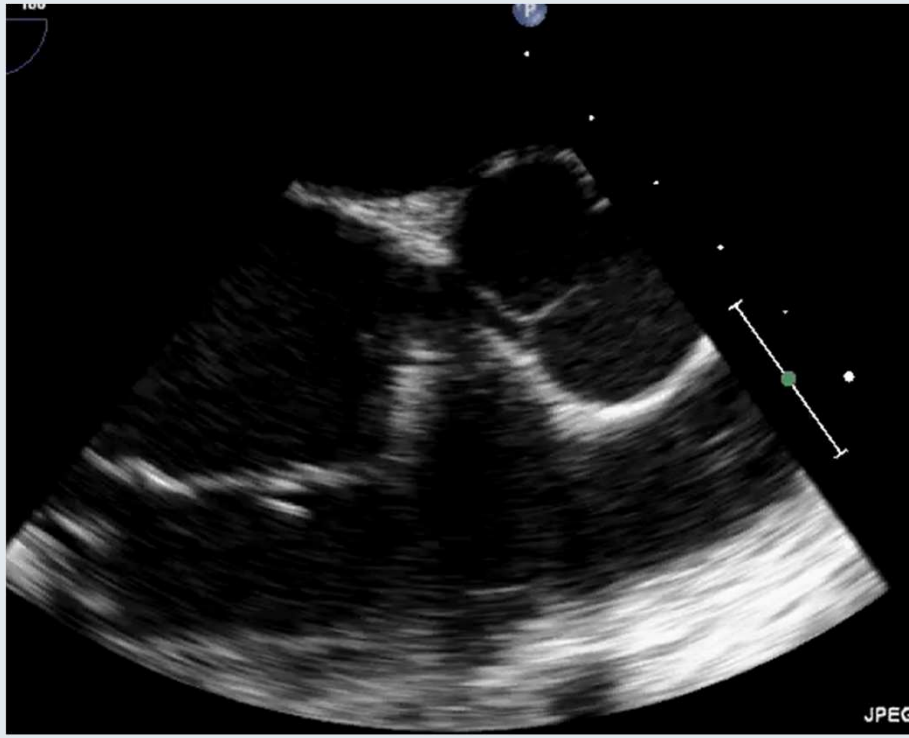


Perimembranous VSD without a TV Aneurysm

Perimembranous VSD without a TV Aneurysm



Perimembranous VSD without a TV Aneurysm



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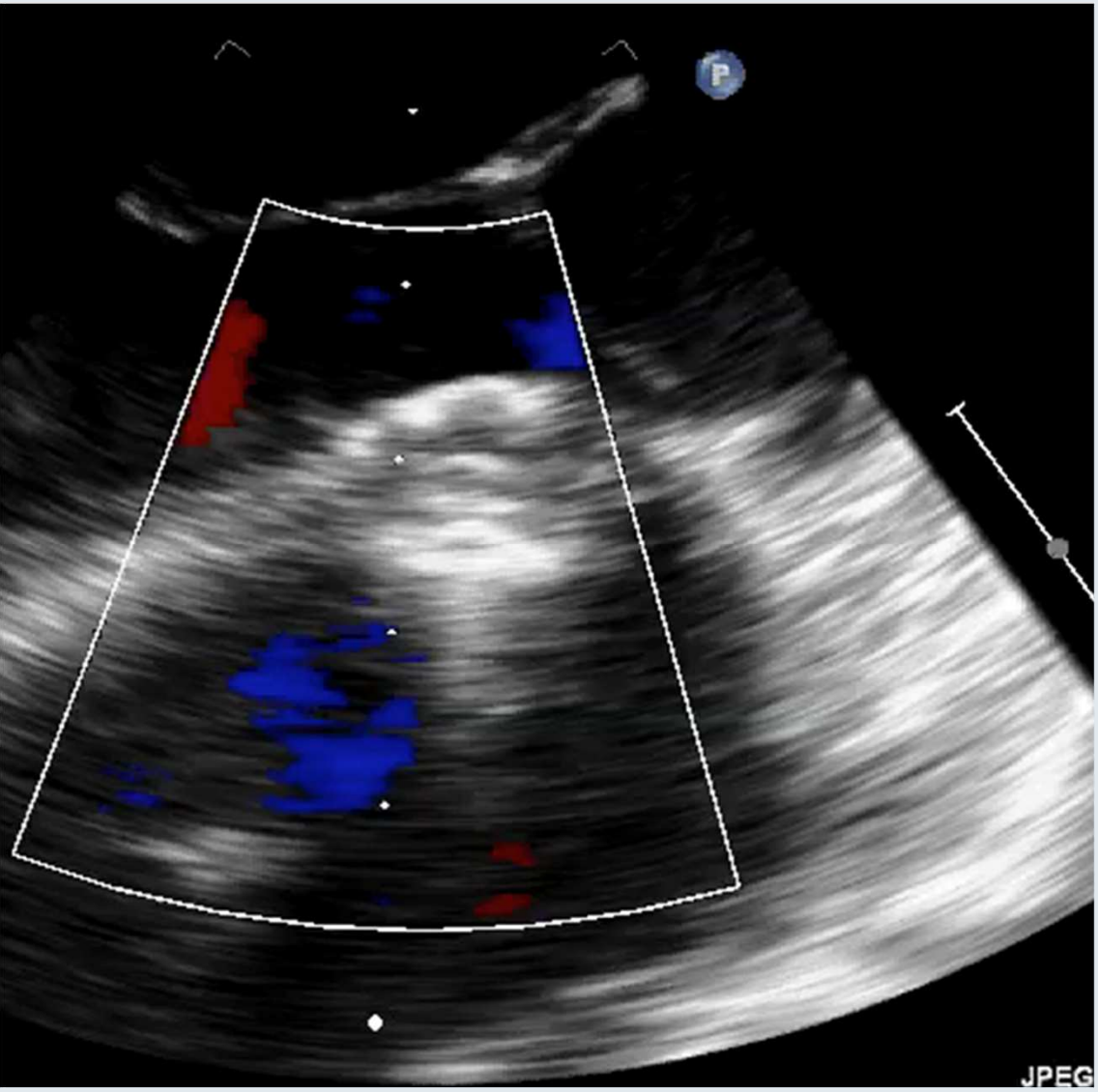
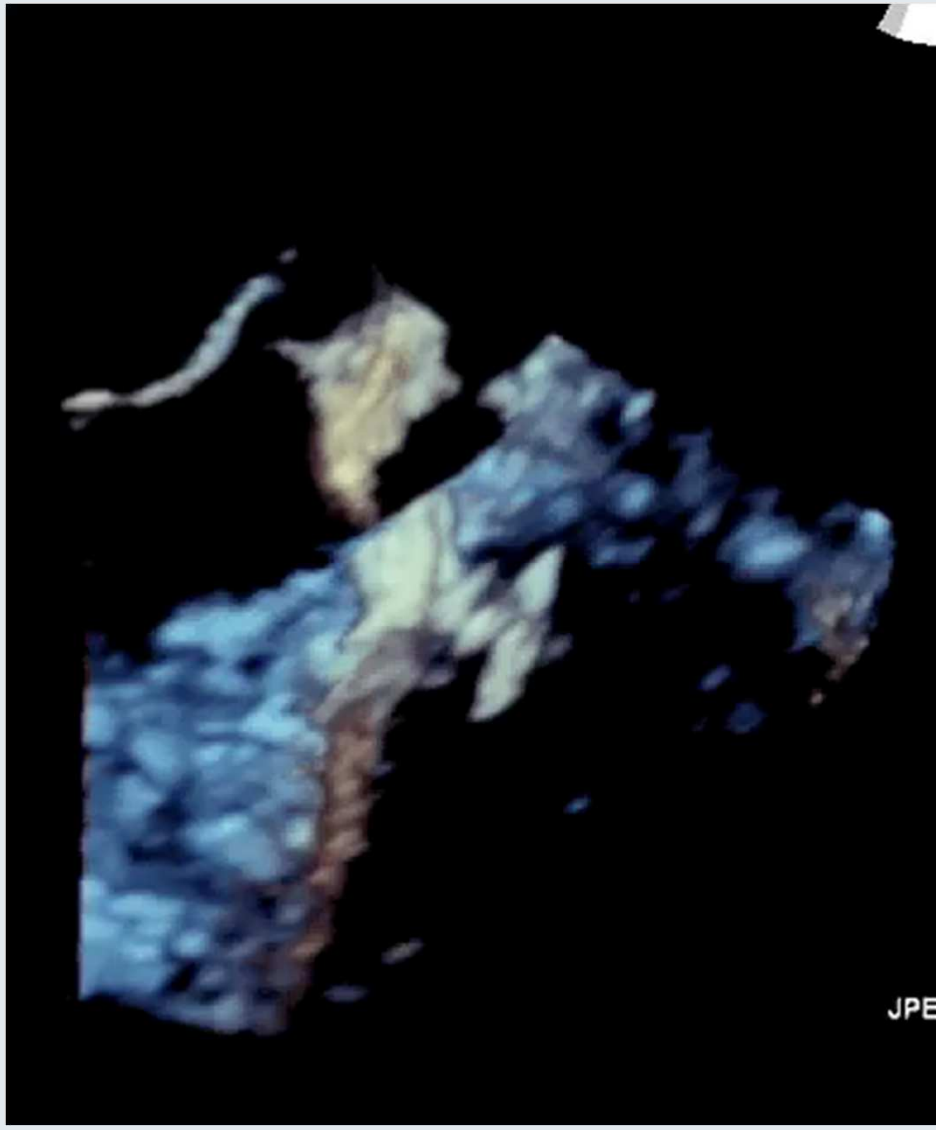
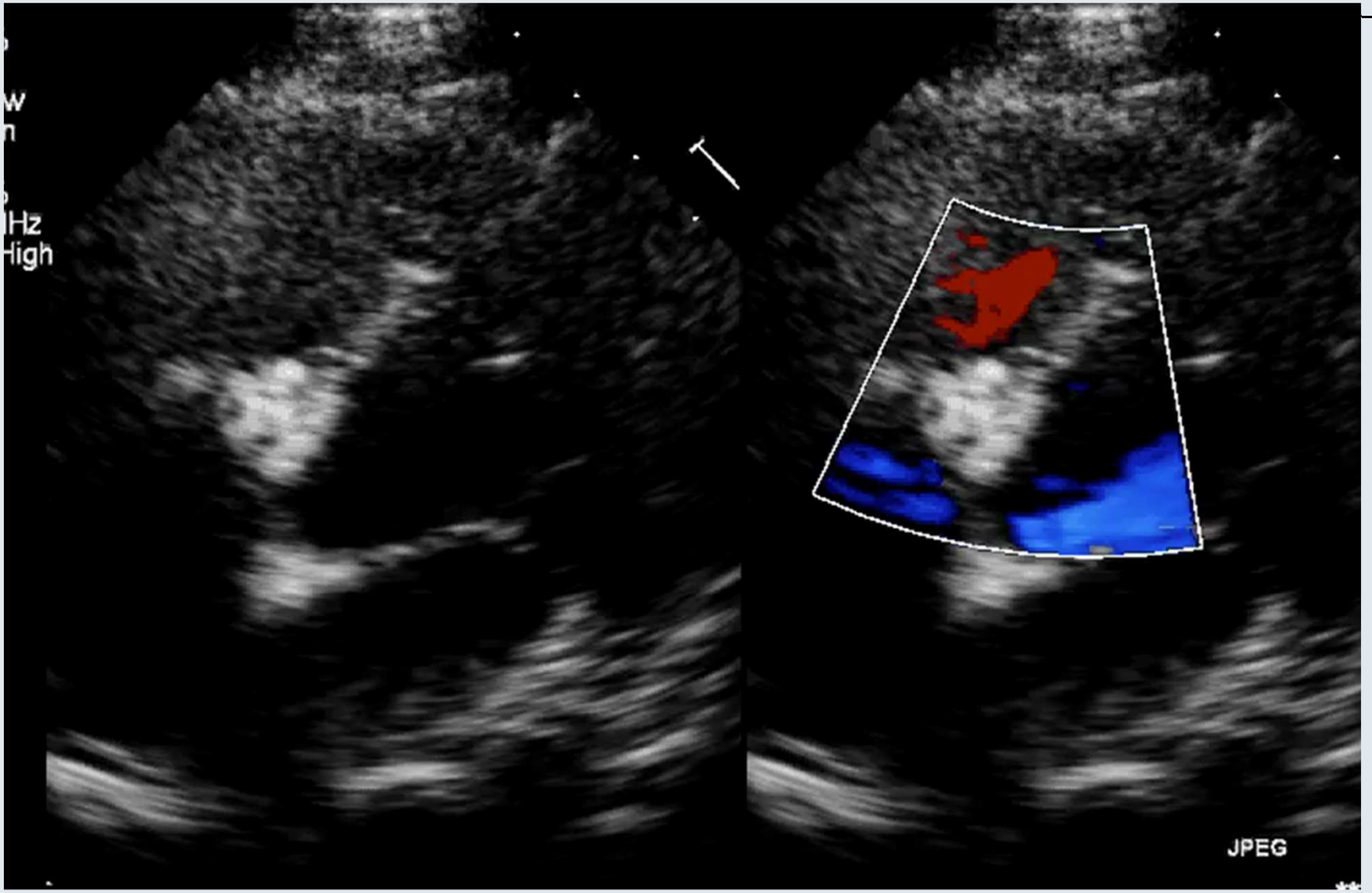
Perimembranous VSD without a TV Aneurysm





Perimembranous VSD without a TV Aneurysm: TTE Next Week



UCLA Experience (no TVA n = 22, TVA n = 33)

Table 1 Demographics (N=26)		Number	Percentage
ADO II Devices Used	4/6	2	7.7%
	6/4	17	65.4%
	6/6	7	26.9%
Gender	Male	11	42.3%
	Female	15	57.7%
Aneurysm Present		14	53.8%
		Mean	**Range**
Age (in years)		14	1.7-69
Weight (in kg)		36.7	8.7-79.2
VSD LV Side Size (largest in mm)		8.1	4-15
VSD RV Side Size (largest in mm)		3.7	2-7
Distance from aortic valve (in mm)		5.2	3-13
Qp:Qs		1.24:1	0.75:1 - 2.7:1
LVEDP (in mmHg)		12	3-20
Length of Hospital Stay (in days)		1.2	0-8

Table 2 Other Devices (N=29)	Number	Percentage
ADO I Devices Used	9	31.0%
Muscular VSD Devices Used	19	65.5%
AVP Device	1	3.5%
Aneurysm Present	27	93.1%
	Mean	**Range**
Age (in years)	16	1.25-64
Weight (in kg)	41.7	7.2-96.7
VSD LV Side Size (largest in mm)	10.2	2-15
VSD RV Side Size (largest in mm)	4.4	2-7.1
Distance from aortic valve (in mm)	5.4	1-13
Qp:Qs	1.7:1	1:1 -3.33:1
LVEDP (in mmHg)	13	5-25

Abbreviations: ADO II - Amplatzer Ductal Occluder II, AVP - Amplatzer Vascular Plug, VSD - Ventricular Septal Defect, LV - Left Ventricle, RV - Right Ventricle, Qp:Qs - Ratio of Pulmonary blood flow to Systemic blood flow, LVEDP - Left Ventricle End Diastolic Pressure.

ADO II Heart Block? Literature Review (n=146).....

Table II: Published Literature

Study	Devendran *et al.* 2012	Gao *et al.* 2014	Zhao *et al.* 2017	Kanaan *et al.* 2014	Ebeid *et al.* 2016	Koneti *et al.* 2011	Mahimarangaiah *et al.* 2014	Ergene *et al.* 2015	Narin *et al.* 2015	Polat *et al.* 2016	El-Sisi *et al.* 2017
Study type	Case Report	Case Report	Case Report	Retrospective Chart Review	Retrospective Chart Review	Prospective Study	Prospective Study	Prospective Study	Prospective Study	Prospective Study	Prospective Study
Country	India	China	China	Germany	USA	India	India	Turkey	Turkey	Turkey	Egypt
Age	12 years	4 years	3-6 years	1->20 years	2-29years	1-6 years	1-41 years	>18 years	4 months-18 years	13 days-16 years	1-13 years
# Perimembranous VSDs	1	1	4	20	20	7	126	11	19	21	30
# Muscular VSDs	-	-	-	10	0	4	-	-	2	3	0
# Postsurgical VSDs	-	-	-	-	-	-	-	-	-	2	-
Devices used	ADO II	ADO II	2 ADO II 6 pmVSDOs	ADO II	11 ADO II 9 AVP II	ADO II	45 ADO II 81 PDA occluders	2 ADO II 1 ADO I 4 pmVSDOs 4mVSDOs	ADO II	ADO II	17 ADO II 13 ADO I
New immediate post-procedural aortic insufficiency	-	-	-	0 patients	4 patients	0 patients	0 patients	0 patients	0 patients	2 patients	-
Residual post-procedure aortic insufficiency at follow-up	-	-	-	-	3 patients	-	-	-	-	Improved	-
New post-procedural tricuspid regurgitation	0 patients	-	-	0 patients	3 patients	0 patients	0 patients	0 patients	-	5 patients	-
Residual post-procedure tricuspid regurgitation at follow-up	-	-	-	-	3 patients (all AVP II)	-	-	-	-	Improved	-
Residual flow through VSD on follow-up	0 patients	0 patients	1 (closed by pmVSDO device)	2 patients	3 patients	2 patients	2 patients	0 patients	0 patients	-	2 patients
Complete heart block	0 patients	0 patients	0 patients	0 patients	0 patients	0 patients	1 patient (4/6 PDA occluder), 1 patient 15 months later (8/10 PDA occluder)	0 patients	0 patients	0 patients	0 patients
Transient ECG changes	-	-	2 patients with pmVSDO devices only(1 transient junctional rhythm, 1 transient incomplete RBBB)	2 patients (1 SVT, 1 AV rhythm, both resolved within 24 hr of device implantation), 1 patient isolated ventricular and supraventricular extrasystoles on holter	Junctional rhythm alternating with sinus rhythm in 1 patient. Accelerated junctional rhythm in 1 patient.	-	2 patients with transient isoarrhythmic AV dissociation	0 patients	-	-	-
Permanent ECG changes	-	-	-	-	-	-	-	-	-	-	-
Device embolization	-	0 patients	-	1 patient	1 patient	0 patients	1 patient	0 patients	0 patients	-	0 patients
Hemolysis	-	-	-	-	0 patients	0 patients	-	-	0 patients	-	-

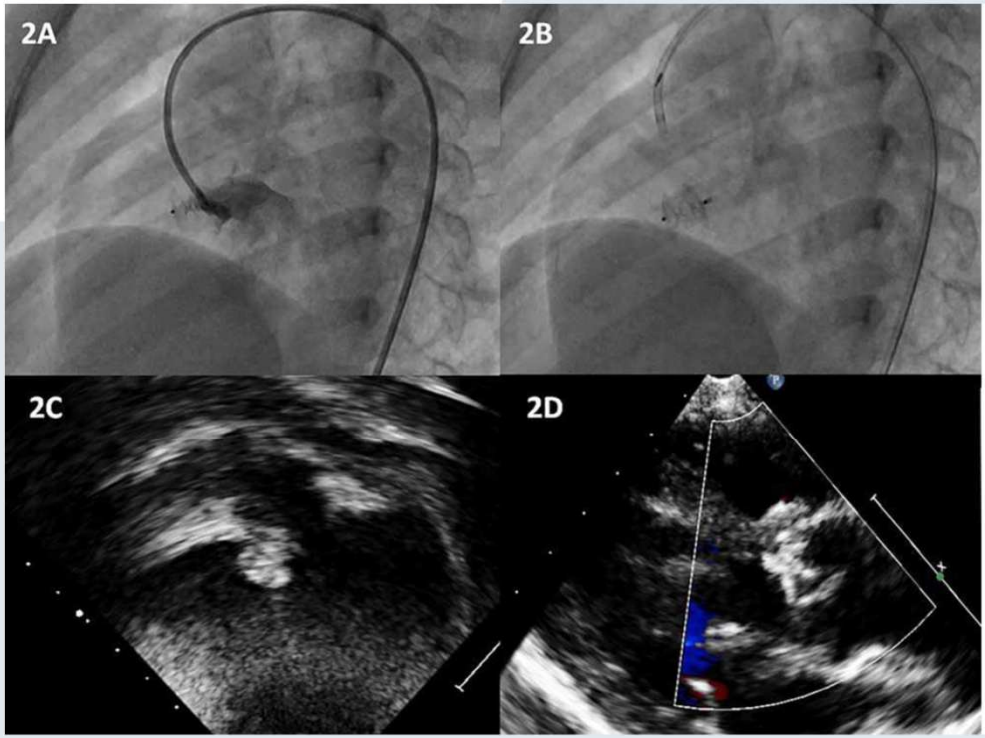
Table II: Summary of Literature Review. A (-) denotes no data available.

Uh Oh!!

Catheter Cardiovasc Interv. 2017;1–4.

Complete heart block following transcatheter closure of perimembranous VSD using amplatzer duct occluder II

Sanjiban Ghosh, MD | Anuradha Sridhar, DNB, FNB
Muthukumaran Sivaprakasam, MRCPCH, CCST



- Large experience in India
- "146 cases of pmVSD closure with ADO II"
- 5/4 and 6/4 ADO II devices for 3-5 mm cvVSDs
- Both within 24 hrs and both retrograde
- **Literature + UCLA experience with ADO II CHB rate about 0.6%**

	Age (Yrs)	Weight	Indication of VSD closure	Size of the defect (By Echocardiography)	Device size	Device appearance after closure	Time of heart block	Outcome
Patient 1	8	17 kg	Aortic valve prolapse	3.8 mm	6/4 ADO-II	Stable	24 hr after procedure	Sinus rhythm after surgical removal of device
Patient 2	9	21 kg	Aortic valve prolapse	4 mm	6/4 ADO-II	Stable	24 hr after procedure	Sinus rhythm after surgical removal of device

A meta-analysis of transcatheter device closure of perimembranous ventricular septal defect

Haripriya Santhanam [a,b,*,1], LinQi Yang [a,b,1], Zhaojin Chen [c,1], Bee-Choo Tai [d,1], Dimple D. Rajgor [a,b,1], Swee-Chye Quek [a,b,1]

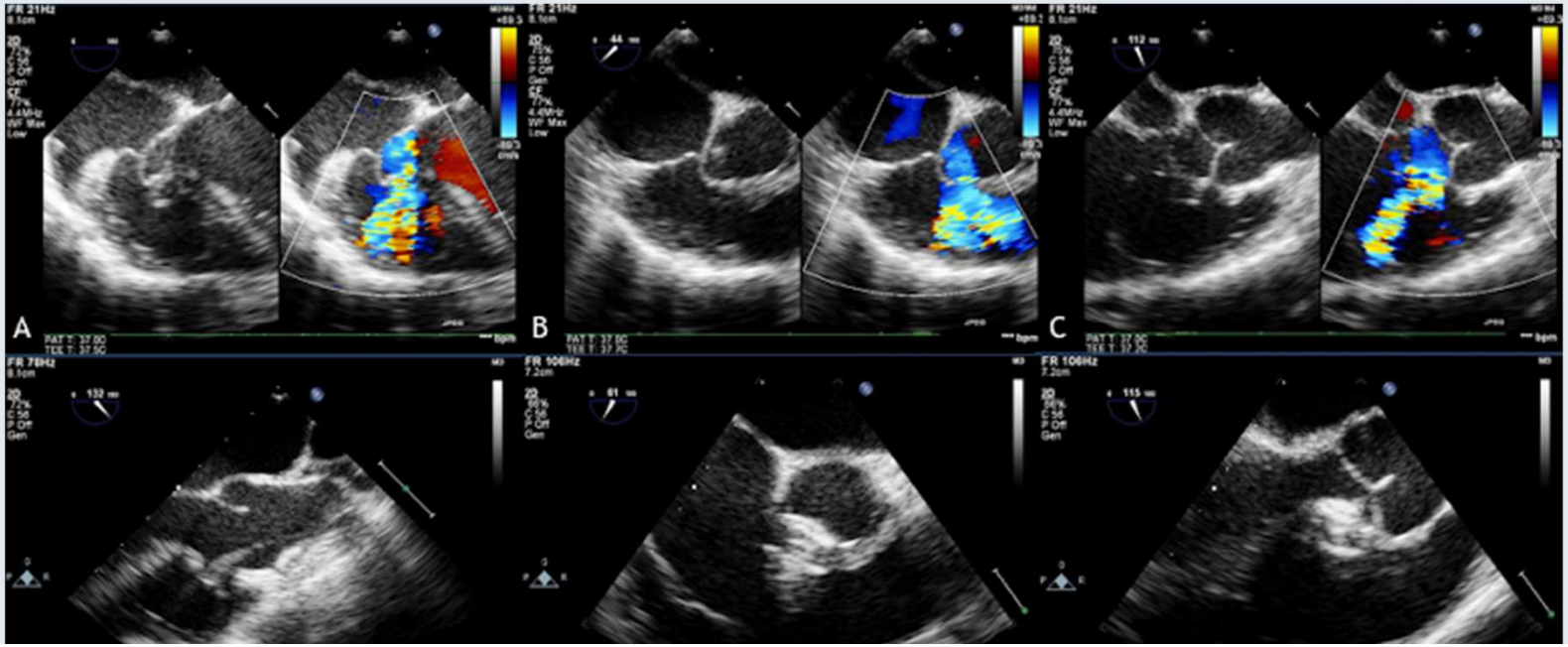
International Journal of Cardiology 254 (2018) 75–83

-54 publications comprising 6762 patients with pmVSDs

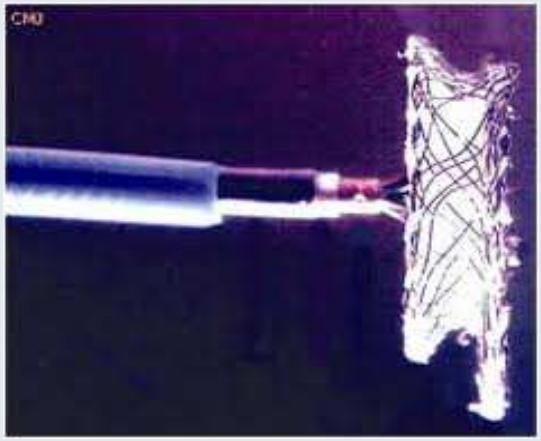
-Successful device implantation is 97.8%

-Residual shunt (15.9%; 95% CI: 10.9 to 21.5)

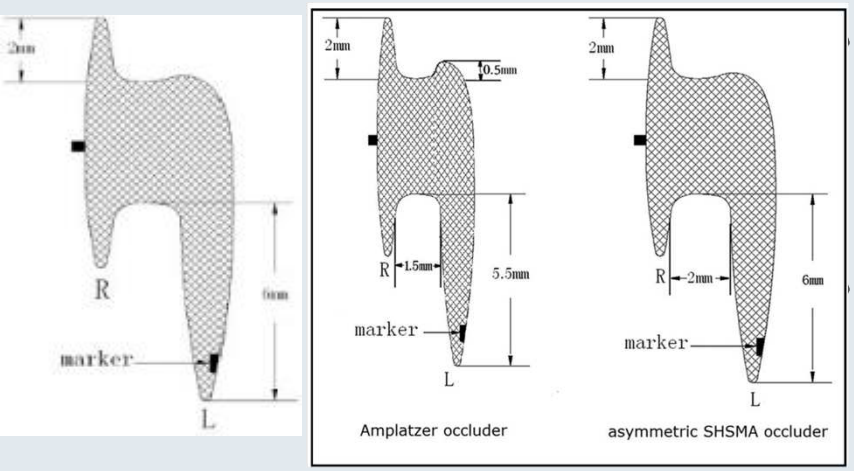
-complete atrioventricular block (cAVB) 1.1%



Amplatzer™ pVSD Occluder, first generation



Amplatzer pVSDO



Lepu Medical Shanghai Occluder

- First, purpose built occluder designed specifically for treatment of pVSD
- Clinical trial initiated in U.S. in 2002
- Asymmetric device with short waist and reduced left sided disk facing aortic valve

Several international studies and US clinical trial showed high closure rates and minimal aortic valve impingement

Permanent heart block requiring pacemaker in 2.0 - 5.7%*

*Fu YC, Bass JL, Amin Z, et al. JACC 2006,
*Carminati M, Butera G, Chessa M, et al. Eur J Cardiol 2007

Transcatheter Closure of Perimembranous Ventricular Septal Defects

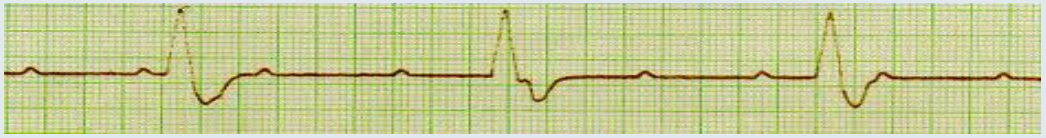
Early and Long-Term Results

JACC Vol. 50, No. 12, 2007
September 18, 2007:1189–95

Gianfranco Butera, MD, PhD, Mario Carminati, MD, Massimo Chessa, MD, PhD,

- 84 pmVSDs, 14 mVSDs, 2 multiple, mean age 14 years (range 0.6 to 63 years)
- Technical successful in 100 of 104 patients (96.2%)
- Amplatzer pmVSD device and mVSD device
- Total occlusion rate was 47% at completion of the procedure, rising to 84% at discharge and 99% during the follow-up
- Median follow-up was 38.5 months
- cAVB which required pacemaker implantation in 6 subjects (5.7%; 2 in the early phase and 4 during the follow-up)
- **pmVSD cAVB = 6/84 = 7.14% cAVB with pacemaker**
- **8/84 = 9.5% cAVB**
- All cAVB in pmVSD occurred in pts that were 6 yrs old

Solving the heart block dilemma



- **Softer Device?**
  - Amplatzer™ PMVSO2
  - Nitinol woven occluder with polyester fabric
  - 75% reduction in radial force, 45% reduction in clamping force with increased stability
  - Animal data and FIM encouraging with no CHB*
  - Amplatzer ADO II?

- **Softer Delivery System?**
  - Nit-Occlud coil more flexible with lower profile
  - Able to use smaller, more flexible delivery sheath (6, 7 French)

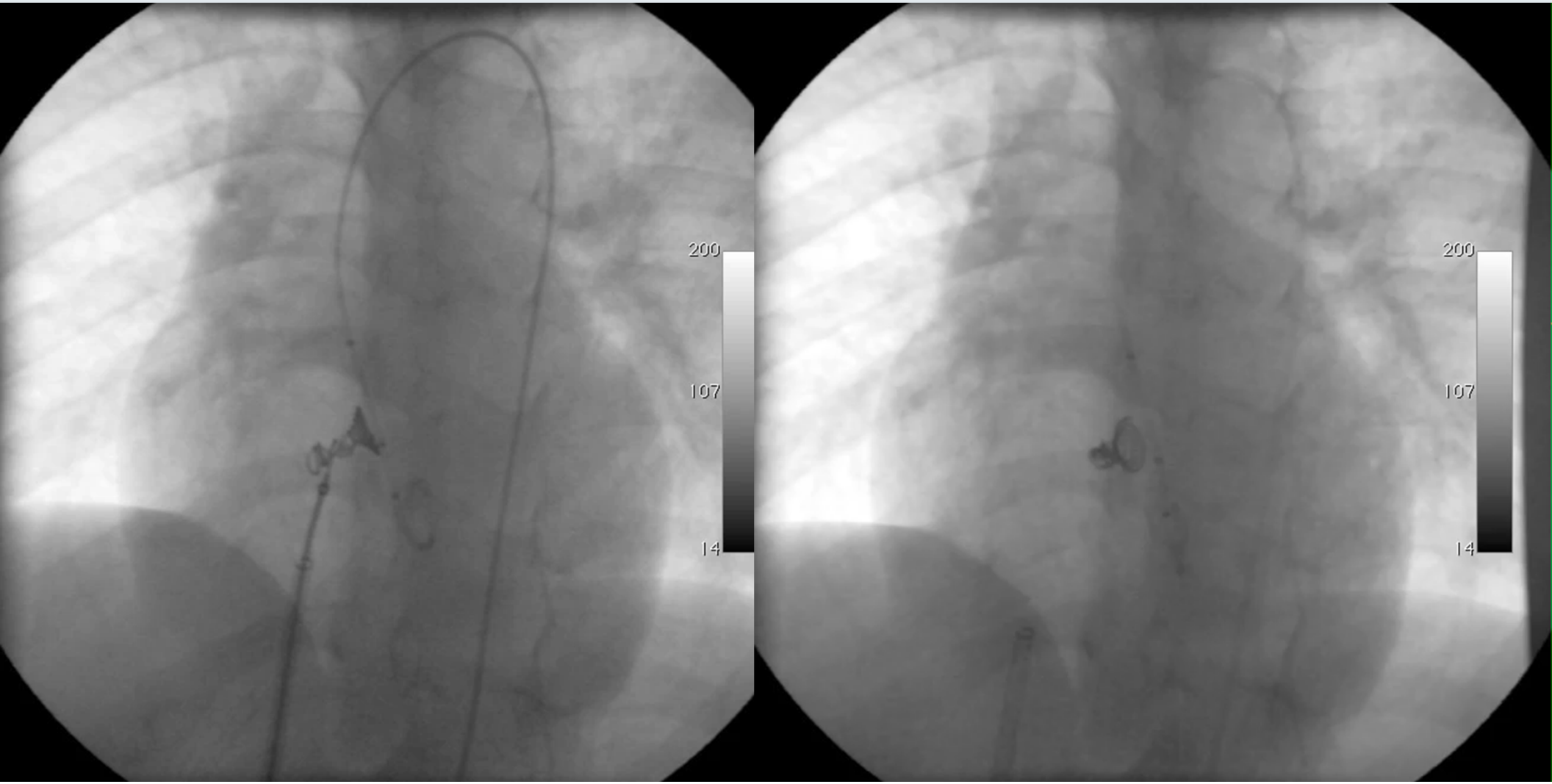
*Bass JL, Gruenstein D. CCI, 2011
*Velasco-Sanchez D, Tzihas A, Ibrahim R, Miro J. CCI, 2012

Nit-Occlud Lê VSD

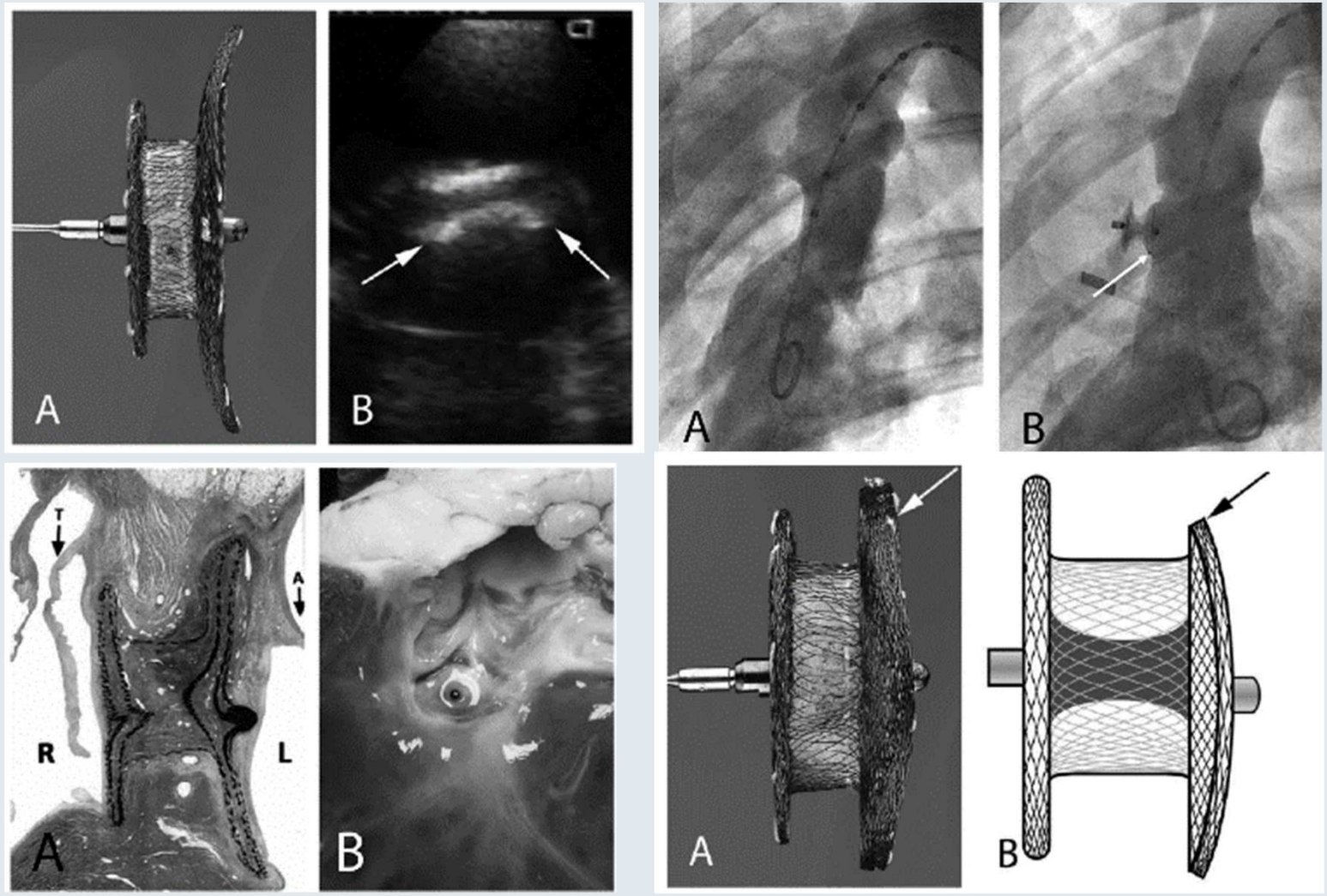
- Nitinol coil shaped to produce a “cone-in-cone” configuration
- Various device sizes and shapes from 10 mm x 6 mm to 18 mm x 8 mm
- Four distal loop sizes: 10, 12, 14, 18 mm
- Premounted in a 6 F delivery catheter
- Delivered prograde through a 6 or 7 F kink-resistant sheath
- Repositionable and retrievable
- Safety clip on handle prevents premature release
- Issues:
  - Low heart block rate
  - Hemolysis?

Nit-Occlud Lê VSD

Device Implantation



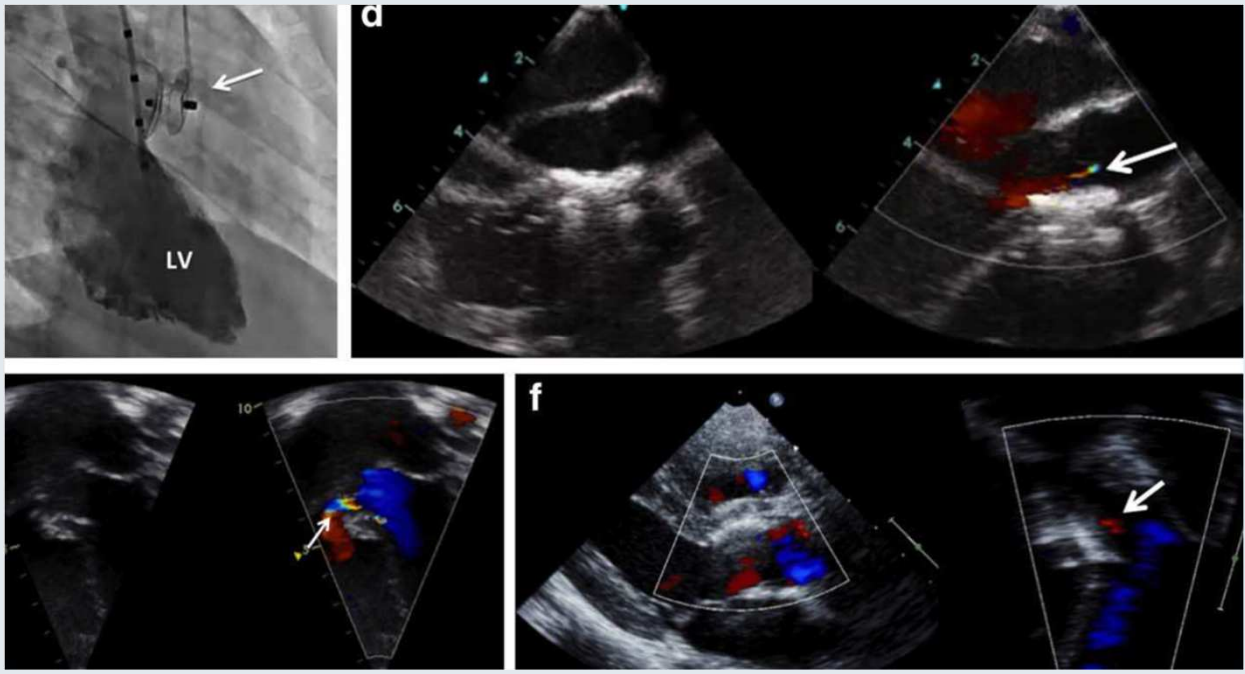
New Amplatzer Device for pmVSD: PMVSO2



Bass JL, Greunstein D. *Catheterization and Cardiovascular Interventions* 79:1153–1160 (2012)

Transcatheter Closure of Perimembranous Ventricular Septal Defect With the Amplatzer® Membranous VSD Occluder 2: Initial World Experience and One-Year Follow-Up

- Nineteen patients, median age 6 years (range 1.4–62 years)
- Median weight was 26 kg (range 9.3–96 kg)
- There were no procedural complications.
- No patient had any degree of AV block
- Holter evaluation, obtained in all patients, was unremarkable in all



Catheterization and Cardiovascular Interventions 83:571–580 (2014)

SUMMARY

- Don’t feel guilty about closing these…. effect of “small” VSDs on adults is significant as LV function declines
- VERY tempting to close the larger “annoying” VSDs definitely if >3-4 mm from AoV or TV aneurysm
- New, soft devices (ADO II) are making the risks of this procedure comparable to surgery
- STILL very questionable to close very small VSDs - common sense
- Difficult but honest discussion with parents as there are no absolute guidelines and everything is off label