Perimembranous VSD:

When Do We Ask For A Surgical Closure?

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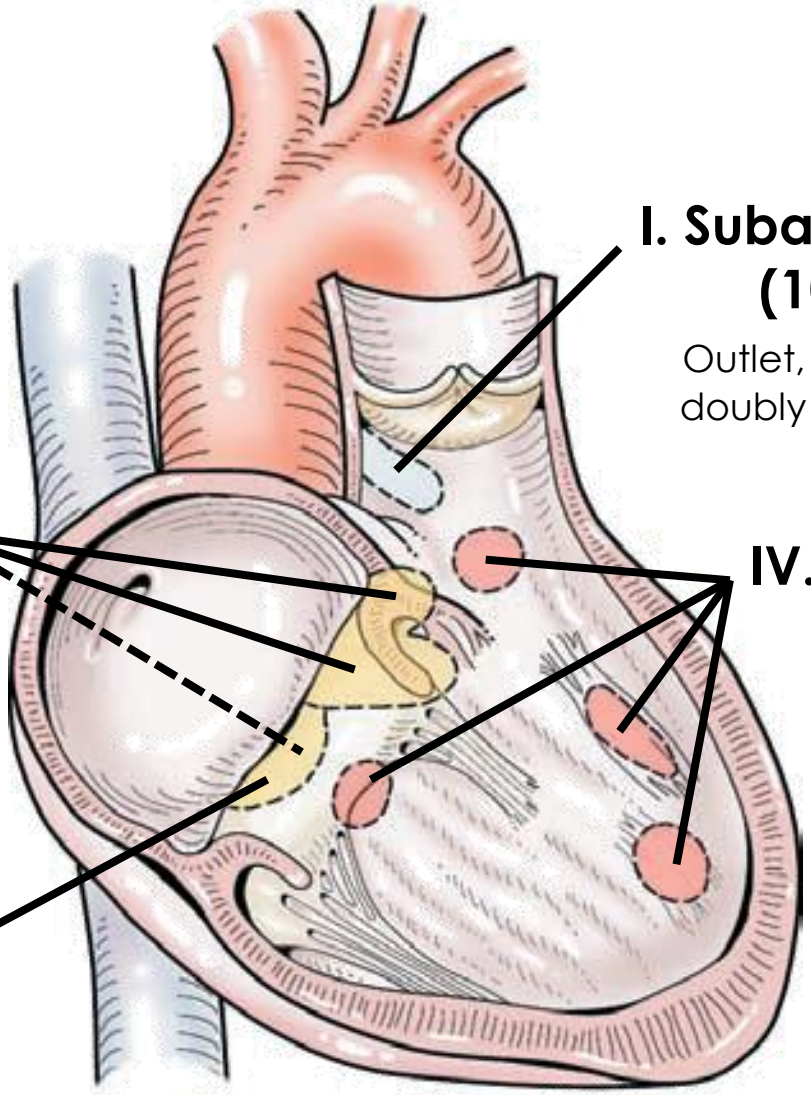
Classification (by Kirklin)



I. Subarterial (10%)

Outlet, conal, supracristal, doubly committed

II. Perimembranous (80%)

Outlet, trabecular, inlet*

IV. Muscular (5-10%)

Outlet, trabecular, inlet

III. *AV canal type (<5%)

Inlet

Associated Lesions

- Patent ductus arteriosus = 6%
- Coarctation = 5-10%
- Aortic stenosis = 2-3%
- Subvalvular / valvular AS
- etc.

Surgical Closure of VSD

- Standard Method of Treatment

1954

Dr. Lillehei (University of Minnesota)

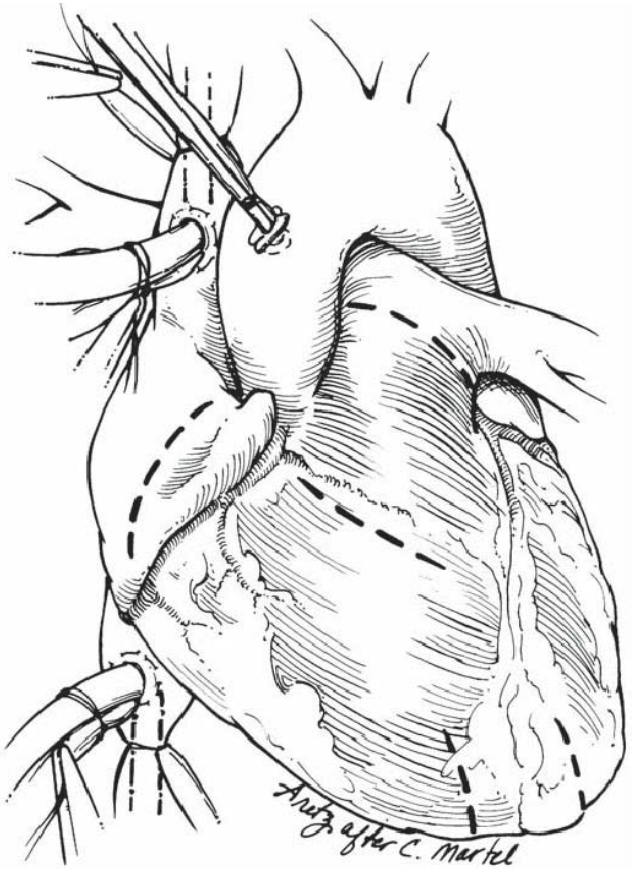
Using controlled cross-circulation with another person serving as pump and oxygenator

Perimembranous VSD:
Indications For Closure

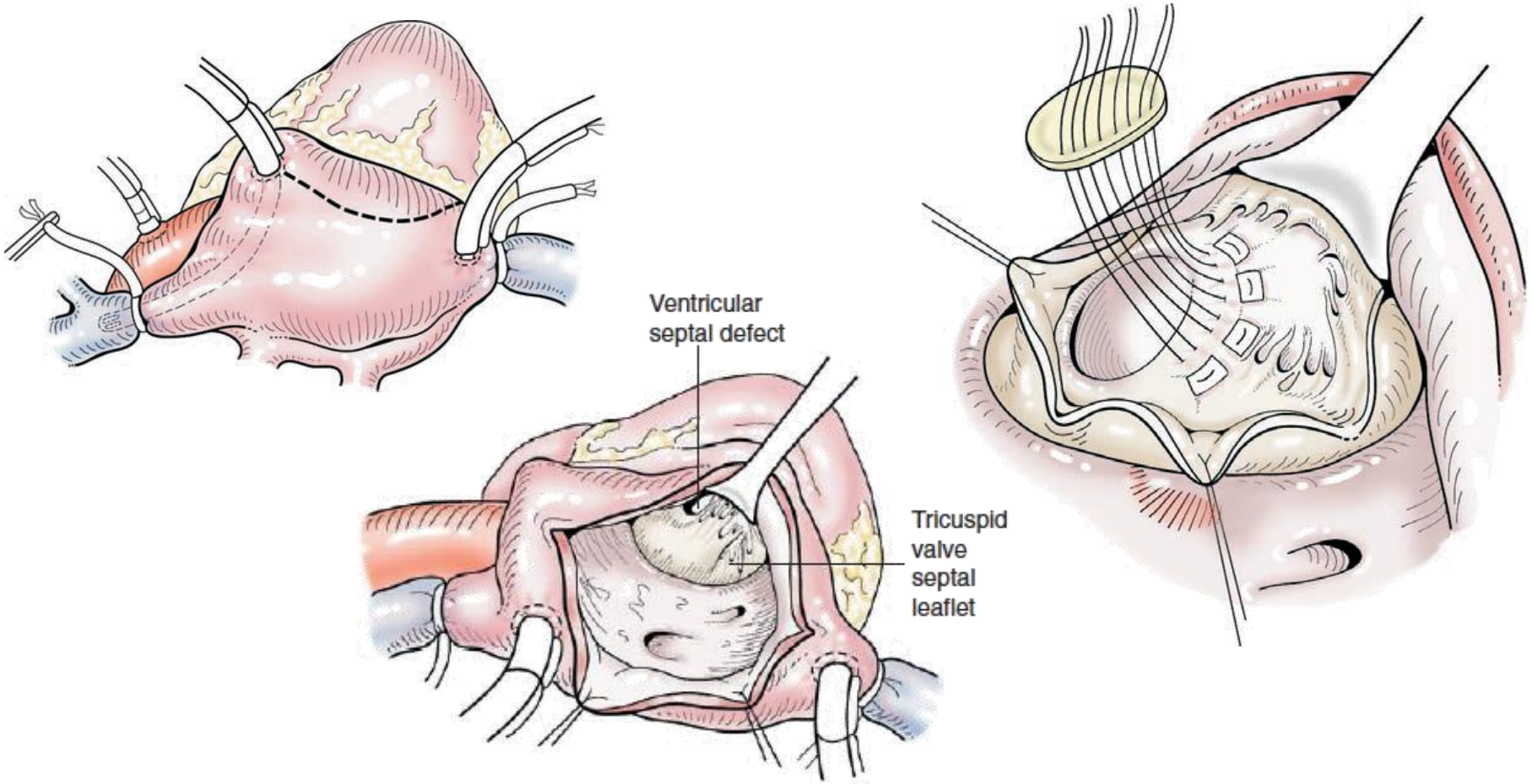
- *ANY* large VSD ⟹ **early operation**: <6m ⟹ <3m
- Moderate sized VSD (Qp/Qs > 1.5:1)
  - Asymptomatic: **elective closure** until 3~5y
  - Symptomatic, heart failure, ↑PA pressure: **early closure**
- Small VSD, if history of infective endocarditis
- *ANY* aortic regurgitation / prolapse

Technical Considerations

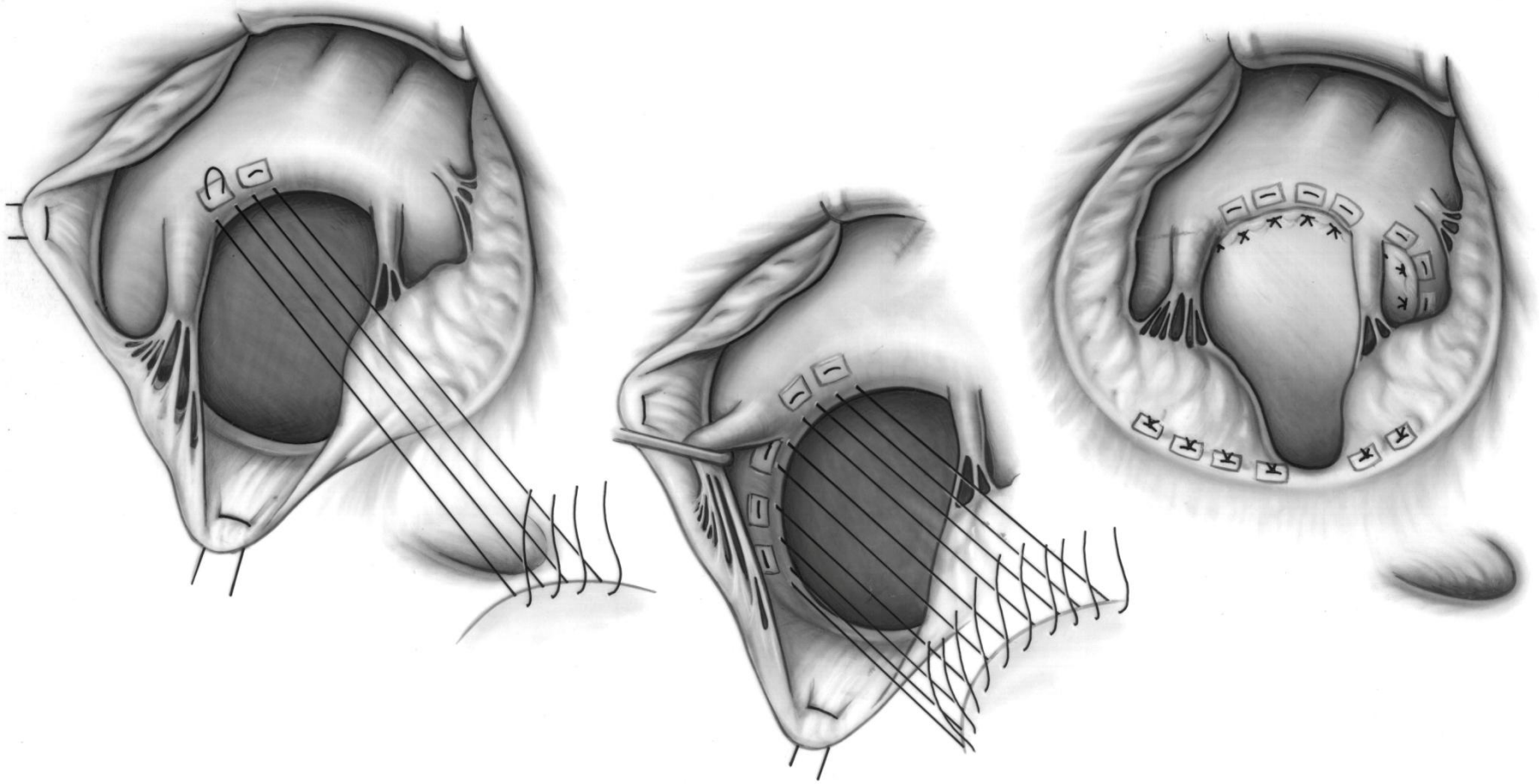
- PDA present - ligate prior to CPB
- Close defect with **patch**
- Avoid **conduction bundles**
- Protect the **aortic** and **tricuspid valves**
- **Avoid ventriculotomy** whenever possible



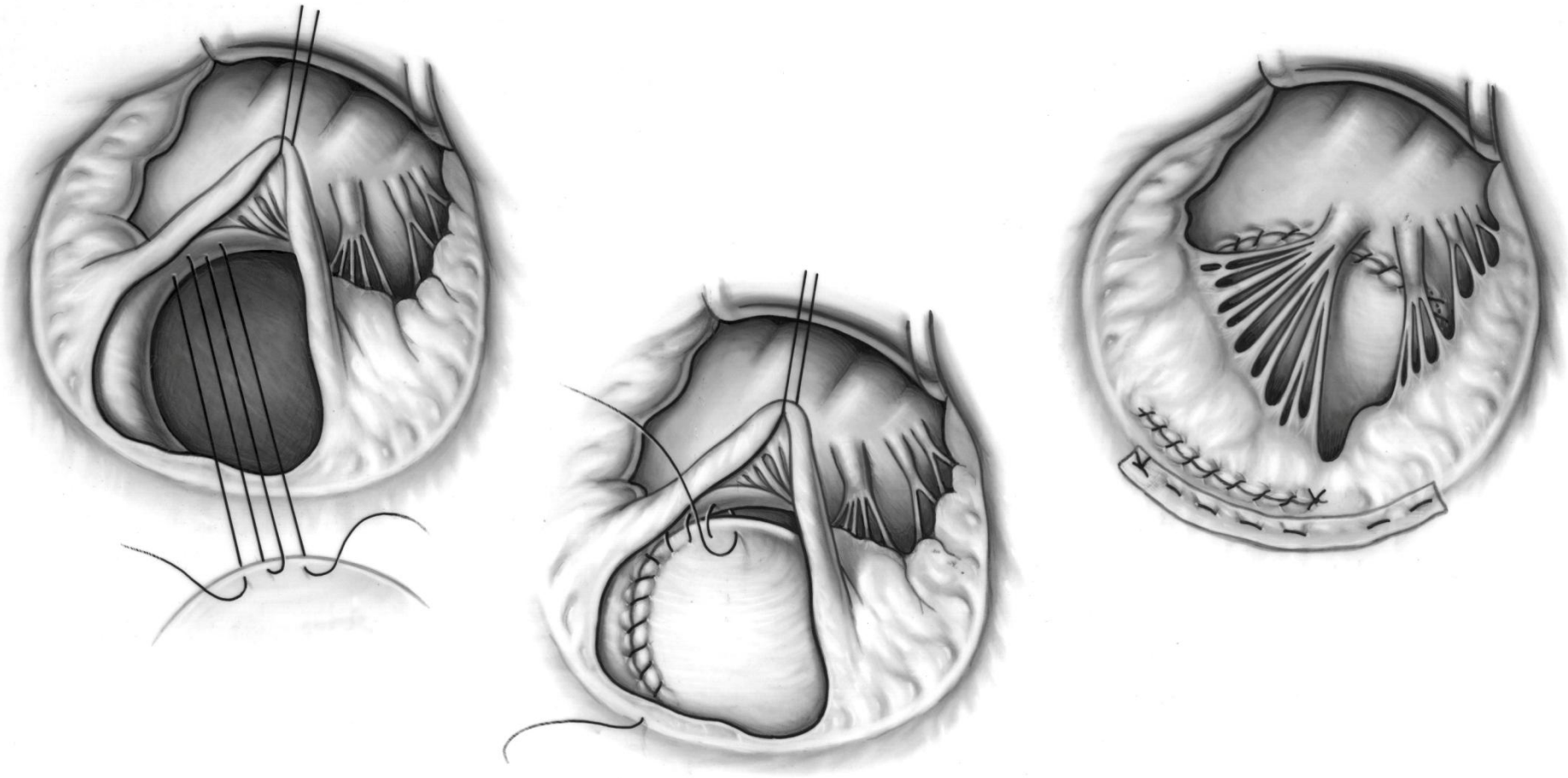
Closure of Perimembranous VSD



Interrupted Suturing Technique



Continuous Suturing Technique



Treatment of Choice in the Current Era

- Surgical repair under cardiopulmonary bypass
- Transcatheter occlusion
  - Percutaneous
  - Per-ventricular (trans-thoracic, hybrid)

Transcatheter VSD Occlusion

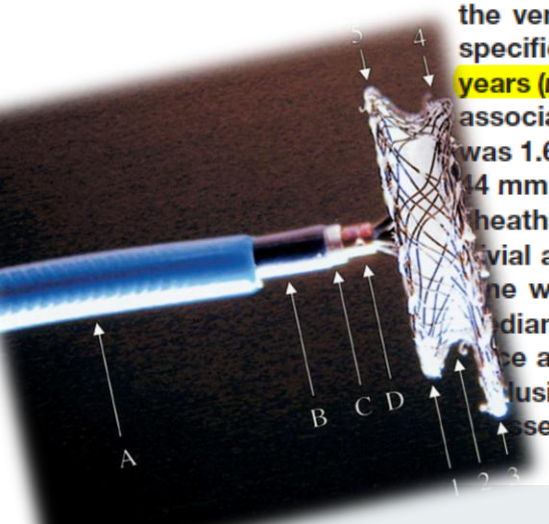
- Started in late 1980s
- Muscular VSDs, especially apical VSD
  - Sufficient margin, away from important structure
  - Surgical difficulty, **avoid ventriculotomy**, **avoid CPB**
- Undiagnosed VSDs after surgical repair of a large defect
- Surgically fenestrated VSD

Perimembranous VSD Occlusion

Catheter Closure of Perimembranous Ventricular Septal Defects Using the New Amplatzer Membranous VSD Occluder: Initial Clinical Experience

Ziyad M. Hijazi,[1*†] MD, Fakhri Hakim,[2] MD, A. Abu Haweleh,[2] MD, Awni Madani,[2] MD, Walid Tarawna,[3] MD, Aktham Hiari,[2] MD, and Qi-Ling Cao,[1] MD,

The surgical closure of membranous ventricular septal defects (VSDs) is associated with morbidity and low mortality. Six patients with VSDs located in the membranous part of the ventricular septum underwent an attempt of catheter closure using a new device specifically designed for the membranous septum. Patients ranged in age from 3.5 to 19 years (median, 10.5 years) and in weight from 15 to 45 kg (median, 29 kg). One patient with associated pulmonary valve stenosis had shortness of breath. The median Qp/Qs ratio was 1.6 (range, 1.1–3) and the median left ventricle end-diastolic dimension (LVEDD) was 44 mm (range, 38–52 mm). The devices were deployed via the femoral vein using 7–8 Fr sheaths. There was immediate complete closure in all patients. One patient developed trivial aortic regurgitation. There were no other complications. The median fluoroscopy time was 15.5 min (range, 10.3–53.4 min). At 24 hr, all patients were doing well. The median LVEDD decreased to 38 mm (range, 34–47 mm). One patient continued to have trace aortic regurgitation. All patients were discharged home after 24 hr. Transcatheter occlusion of membranous VSDs is safe and effective. Further clinical trials are underway to assess the long-term safety and results. *Cathet Cardiovasc Intervent* 2002;56:508–515.



Perimembranous VSD Occlusion:

Limitations & Complications

- Technically challenging in the young, large VSDs, and complicated anatomies
- Complications
  - Significant residual shunts
  - Complete heart block
  - New-onset valvular regurgitation
  - Device malposition, migration, embolization
  - LVOT gradient
  - Vascular complications, hemothorax
  - Need for early / urgent surgery

Complete Heart Block

The Journal of Thoracic and Cardiovascular Surgery 2008;136(5):1223-8

Complete heart block associated with device closure of perimembranous ventricular septal defects

Dragos Predescu, MD, Rajiv R. Chaturvedi, MD, PhD, Mark K. Friedberg, MD, Lee N. Benson, MD, Akira Ozawa, MD, and Kyong-Jin Lee, MD The Hospital For sick Children, Toronto

Results: Acute complete shunt occlusion was achieved in all patients. There were no acute procedural complications. The median follow-up time was 23.1 months (range, 1–37.8 months). Four (22%) had complete heart block at 17 days, 4.2 months, 8.8 months, and 37.5 months after implantation, respectively. No risk factors were identified for development of complete heart block, including age, weight, trisomy 21, preceding conduction abnormalities, perimembranous ventricular septal defect size related to body surface area or device size, and progressive device flattening.

Conclusions: Device closure of large perimembranous ventricular septal defects in infants and children with the Amplatzer Membranous VSD Occluder resulted in excellent closure rates but an unacceptably high rate of complete heart block.

Transcatheter Closure of Perimembranous Ventricular Septal Defects

Early and Long-Term Results

Gianfranco Butera, MD, PhD, Mario Carminati, MD, Massimo Chessa, MD, PhD, Luciane Piazza, MD, Angelo Micheletti, MD, Diana Gabriella Negura, MD, Raul Abella, MD, Alessandro Giamberti, MD, Alessandro Frigiola, MD

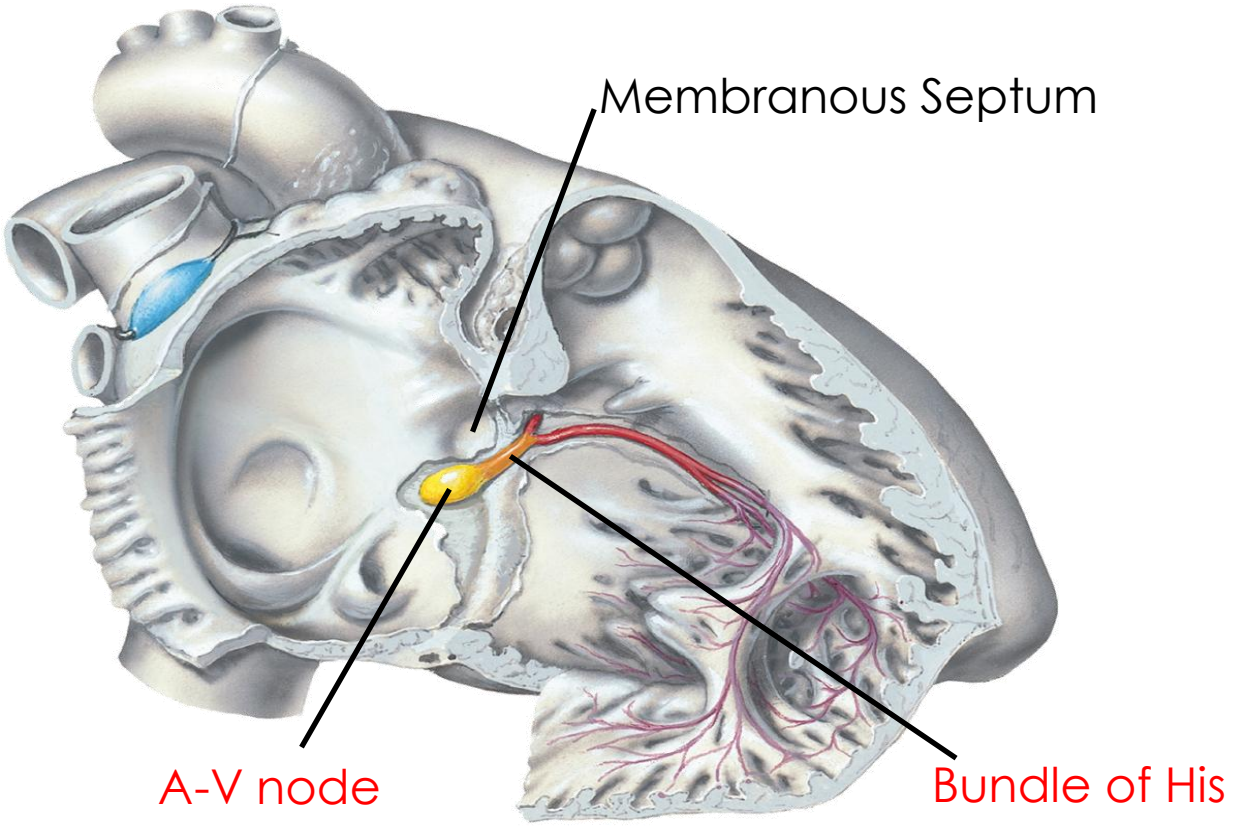
San Donato Milanese, Italy

Methods Between January 1999 and June 2006, 104 patients underwent percutaneous closure of a pmVSD at our institution. An Amplatzer VSD device (muscular or eccentric) (AGA Medical Corp., Golden Valley, Minnesota) was used in all subjects.

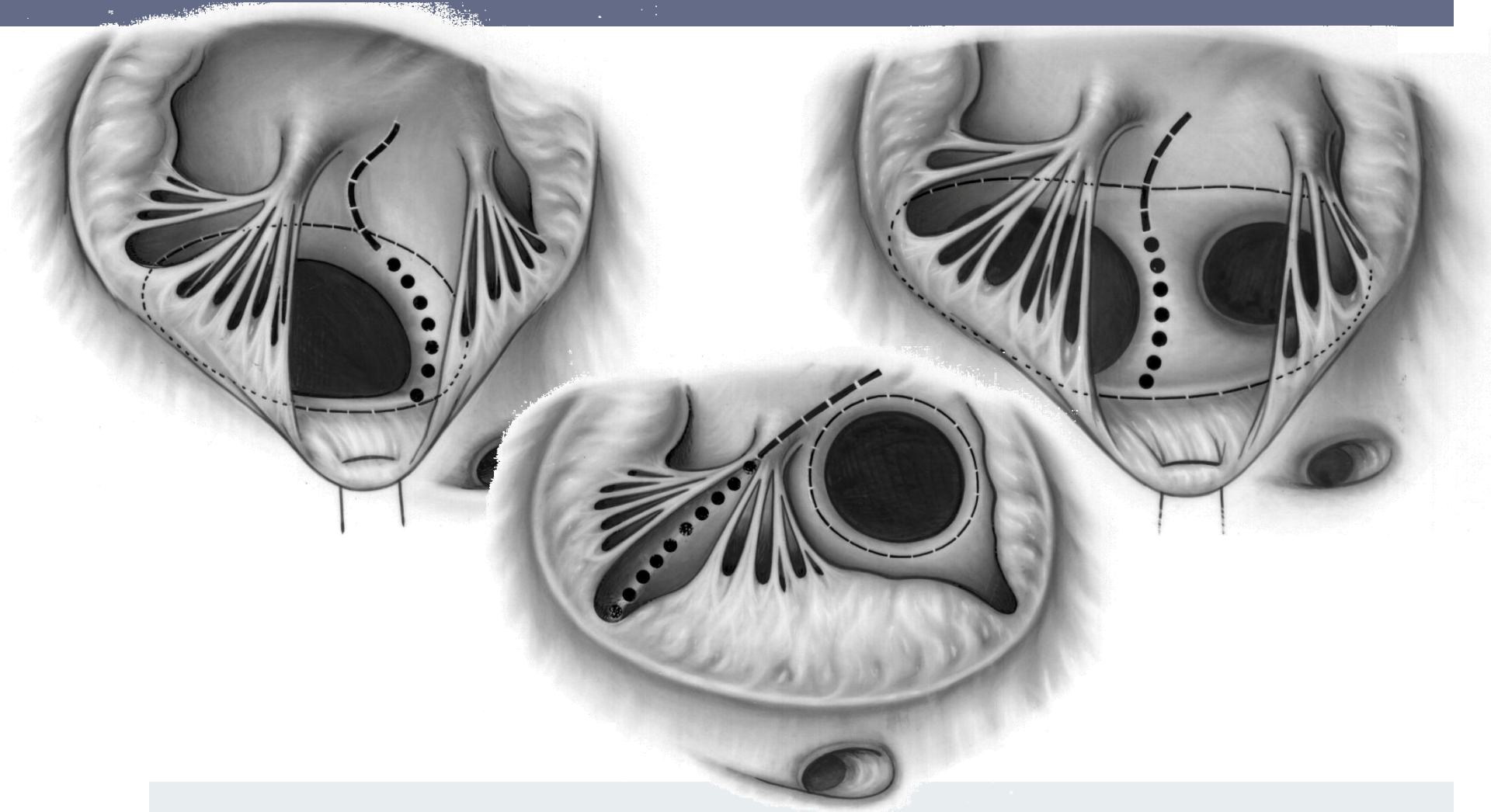
Results The mean age at closure was 14 years (range 0.6 to 63 years). The attempt to place a device was successful in 100 patients (96.2%). The median device size used was 8 mm (range 4 to 16 mm). No deaths occurred. Total occlusion rate was 47% at completion of the procedure, rising to 84% at discharge and 99% during the follow-up. A total of 13 early complications occurred (11.5%), but in all but 2 subjects (1.9%) these were transient. The median follow-up was 38.5 months. The most significant complication was complete atrioventricular block (cAVB), which required pacemaker implantation in 6 subjects (5.7%; 2 in the early phase and 4 during the follow-up). Cox proportional hazards regression analysis showed that the only variable significantly associated with the occurrence of this complication was age at the time of the procedure ($p = 0.028$; relative risk 0.25). All subjects experiencing this problem were <6 years old.

Conclusions In the current era and in experienced hands, pmVSD closure can be performed safely and successfully. The major concern is the occurrence of cAVB; therefore, very careful monitoring of rhythm is mandatory during follow-up. (J Am Coll Cardiol 2007;50:1189–95)

Conduction System



Conduction System *vs* VSDs



Controversies - Device Occlusion

Unacceptable high rate of **complete heart block** (especially in large defect or inlet VSD)

- Average rate 5%
- Intraop, postop, late-onset

X Older age

- Percutaneous >2~3y, perventricular >3mo

X Large unrestrictive VSD

X With aortic valve regurgitation / prolapse

X With major concomitant lesions

? Ambiguous indication for VSD closure

Perimembranous VSD:

Roles of Surgical Repair

- Large VSD in infancy
  - Heart failure
  - Failure to growth
  - Pulmonary hypertension

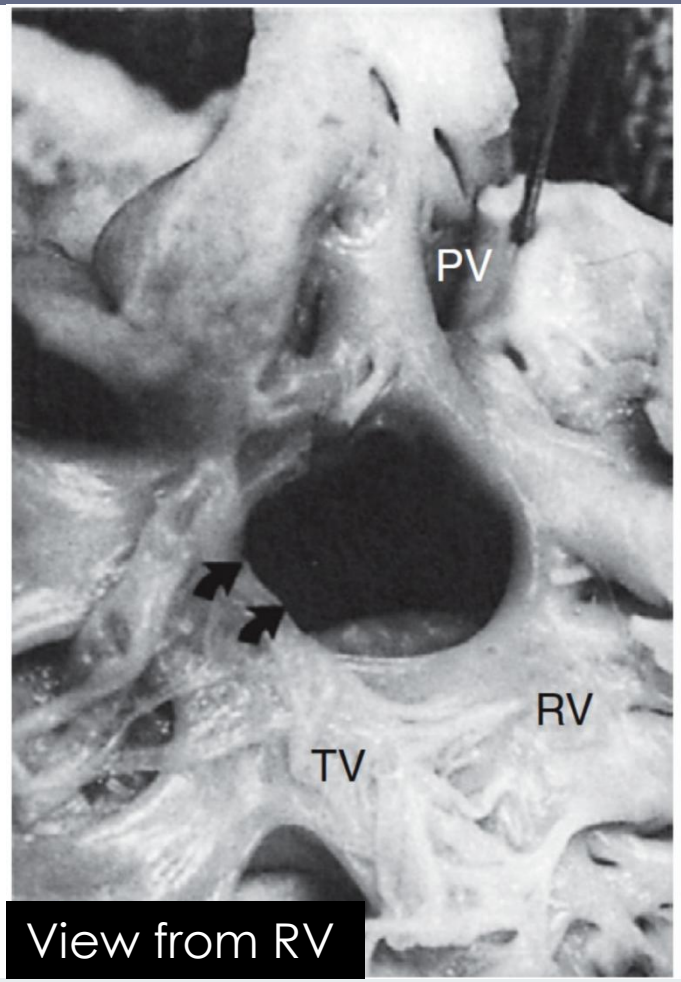
➠ Need to be closed early

Perimembranous VSD:

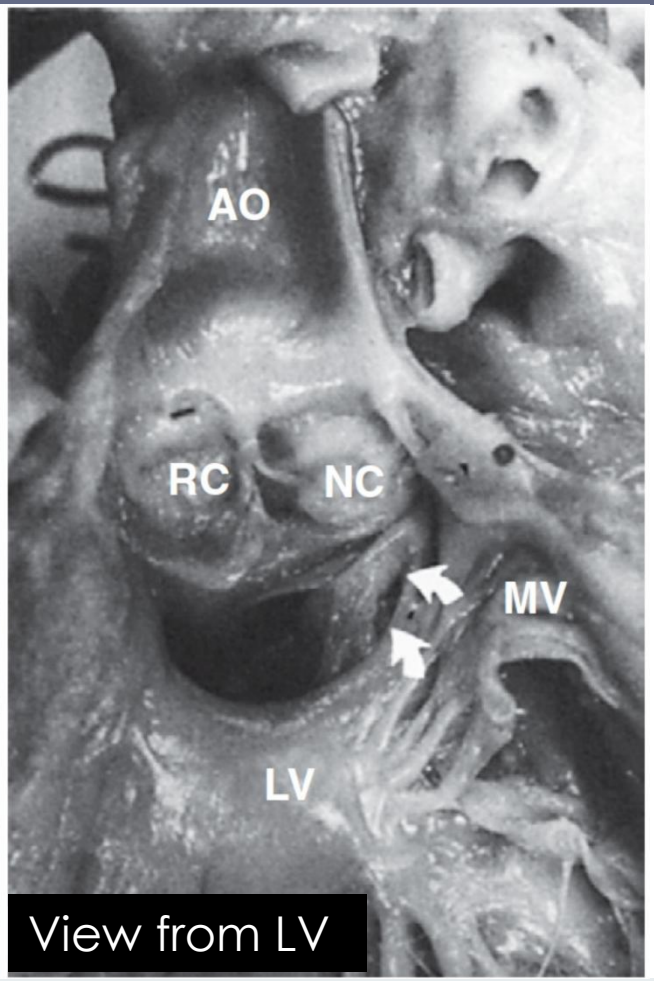
Roles of Surgical Repair

- Protect the important surrounding structures
  - Conduction axis
  - Aortic valve
  - Tricuspid valve

Large Perimembranous VSD:
Close Relationship to the Valves

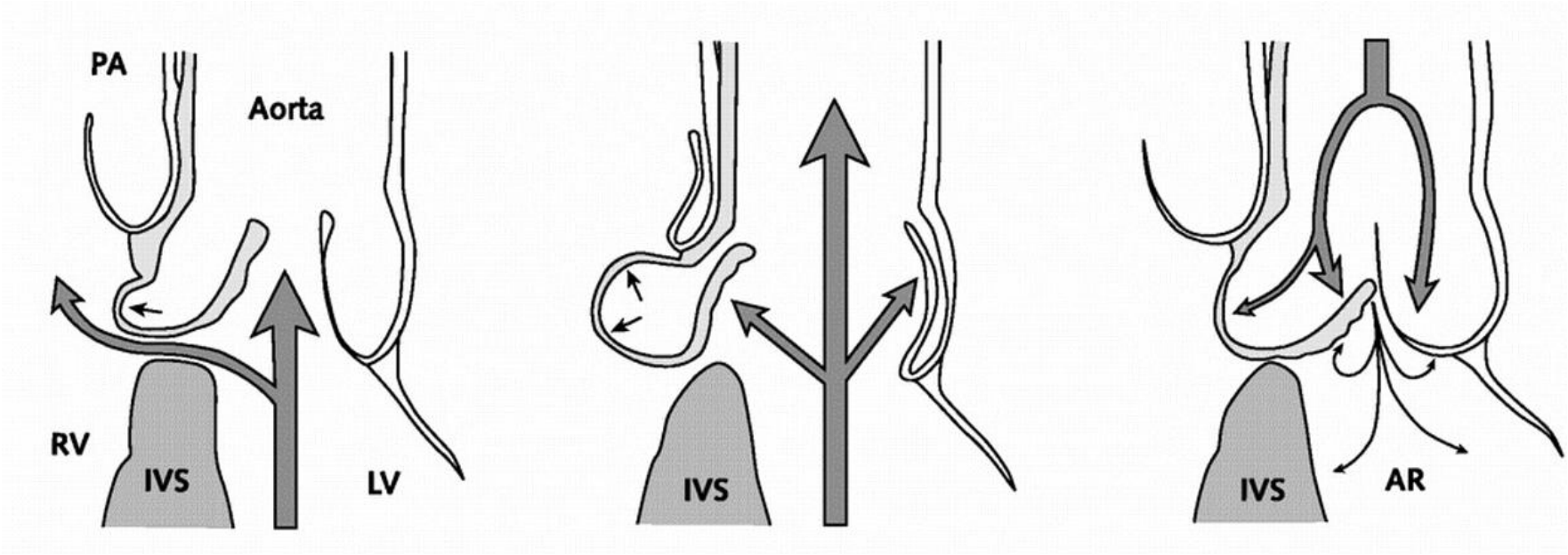


View from RV



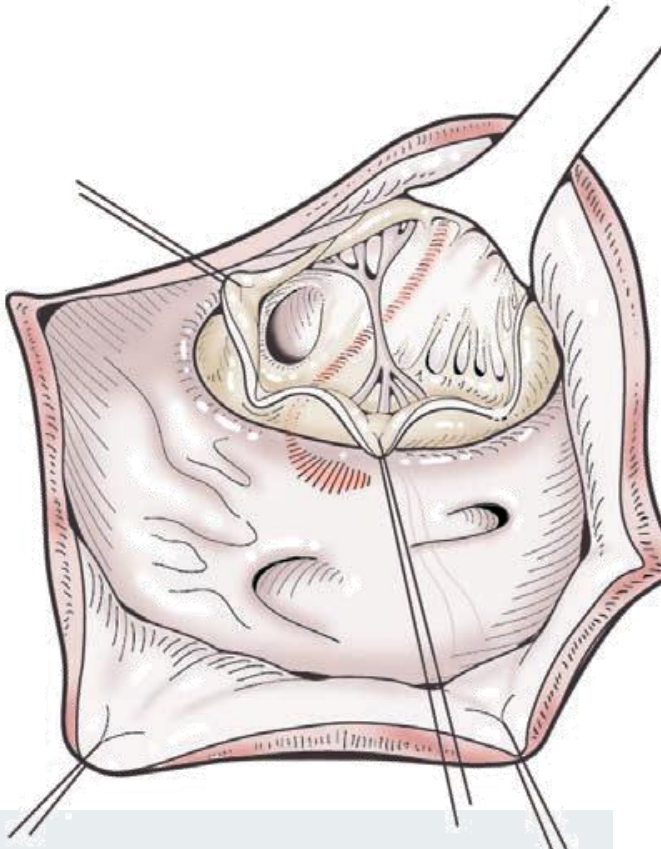
View from LV

VSD with aortic prolapse / regurgitation



Surgical Techniques to Avoid Conduction Injury

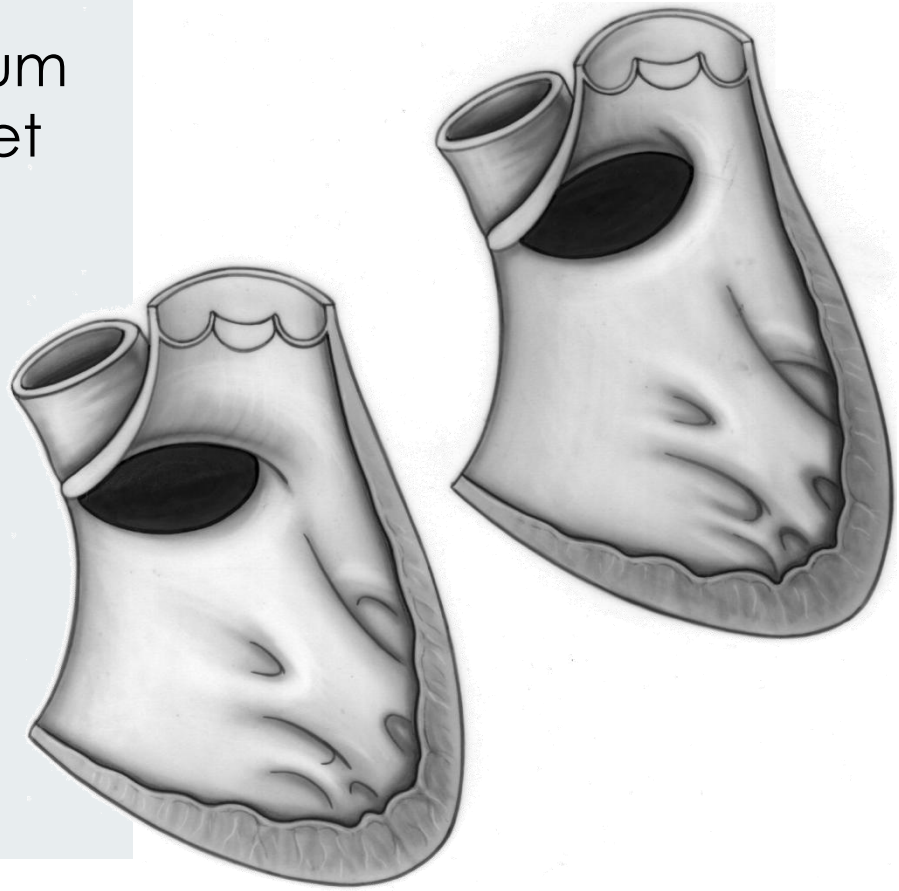
- Suture along RV side of septum
- Avoid posteroinferior rim of defect
  - Placing sutures a few mm from posteroinferior rim, and not penetrating the septum
- Inlet VSD
  - Conduction tissue runs along anterior or superior border of the defect



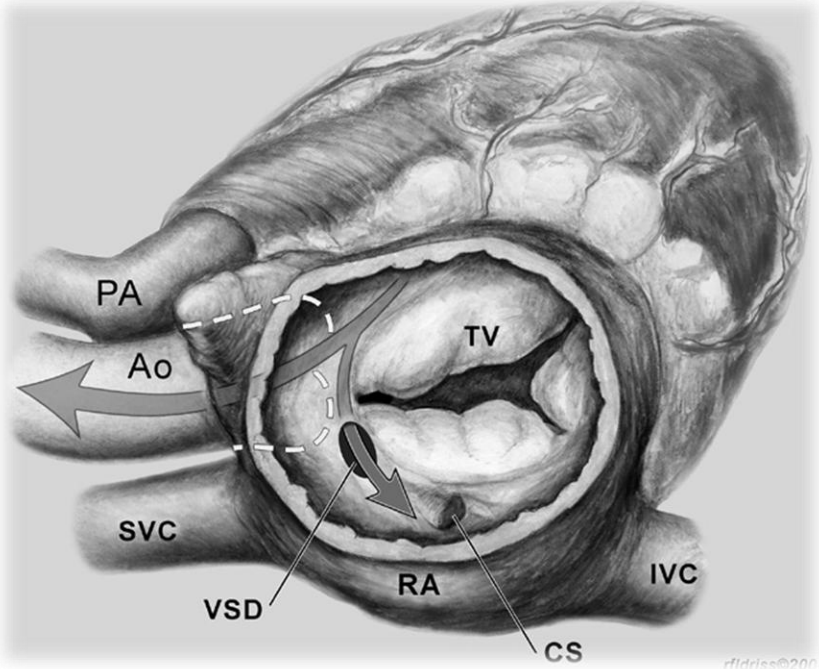
Malalignment VSD

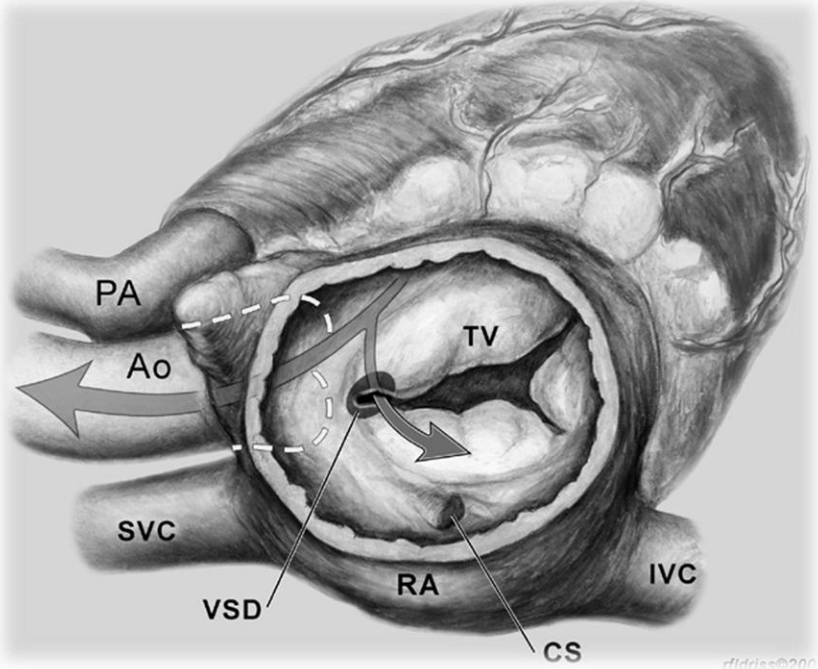
Deviation of the outlet septum in relation to its adjoining inlet and trabecular parts

- Anterior deviation ⇒ TOF
- Posterior deviation ⇒ IAA / CoA-VSD
- Rotational ⇒ Taussig-Bing



LV to RA Shunt





Surgical Results The Children's Memorial Hospital

- 358 infants and children

Table 17.2 Complications of VSD closure during the period from 1990 to 2004 at Children's Memorial Hospital.

Type	Patients	%
Death	0	0
Heart block requiring pacemaker	7*	1.9
Reoperation for bleeding	4	1.0
Significant residual shunting	0	0

Mavroudis C, et al. Pediatric cardiac Surgery 2013; 311-41

Surgical Mortality: International Databases

EACTS Database
(2010 – 2013)

VSD patch repair (n=10,916):
30-day mortality **0.63%**

- Neonates (n=141): 2.86%
- Infants (n=6,441): 0.70%
- Children (n=3,866): 0.47%
- Adults (n=468): 0.43%

Multiple VSDs repair (n=271):
mortality 1.51%

STS Database
(Jul 2009 – Jun 2013)

VSD patch repair (n=6,666):
discharge mortality **0.7%**

- Neonatal VSD patch repair (n=146): 6.2%
- Neonatal CoA+VSD repair (n=396): 5.3%

Surgical Results: Excellent

- The younger the age at repair, the better the chance of normal PVR post-operatively
- Overall mortality <1%
  - Early mortality approach to zero in experienced centres
  - Multiple VSD's, associated anomalies ~ ↑mortality
- Complete heart block ~ 1%
- Residual shunts requiring reoperation < 1-2%

SUMMARY

Perimembranous VSD:
When Do We Ask For A Surgical Closure?

- Surgery remains the mainstay treatment for all hemodynamically significant VSDs
- **Surgical closure**:
  - Young age (exp. <3mo)
  - Larger unrestrictive VSD
  - Malalignment VSD
  - With aortic valve regurgitation / prolapse
  - With major concomitant lesions
- **Transcatheter closure**: gaining increasing acceptance, but require careful patient selection and follow-up