Intermediate and long term outcome following device closure of ASD

Dr. Masood Sadiq

Tamgha-e-Imtiaz

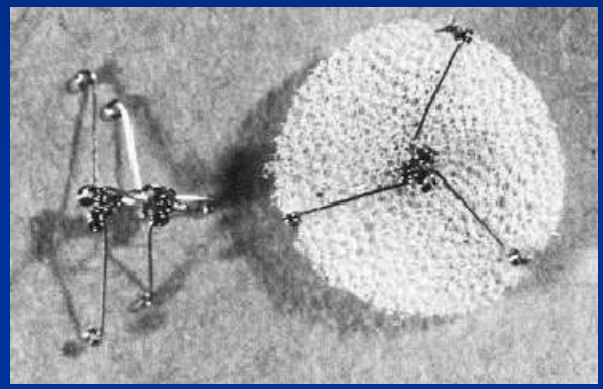
Professor & Head of Paediatric Cardiology

The Children's hospital and Punjab Institute of Cardiology

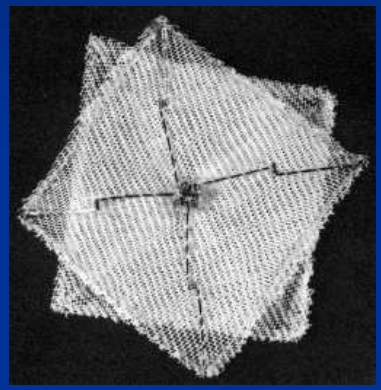
Lahore

Occluders for atrial septal defects

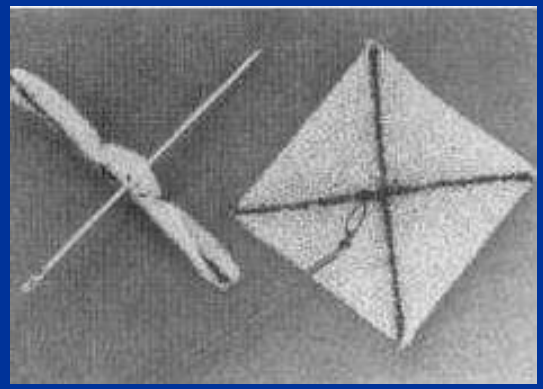
•1974: First successful transcatheter ASD closure by King and Mills



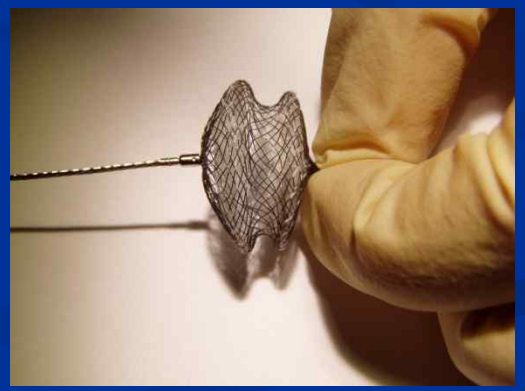
•1983 Rashkind Double Umbrella device



•1990 Lock Clamshell device



•1990: Sideris Buttoned device



•1997: Amplatzer ASD device

Comparison with surgery

- There have been no large, truly randomised comparisons of surgery with transcatheter closure of ASDs as the design of such a study is problematic
- Given a choice between surgery and device closure, parents, patients and PHYSCIANS often prefer device closure
- Nevertheless, surgery is the gold standard against which transcatheter closure of ASDs has been and should be judged.

Surgical or Device closure of ASD
Is it fair to compare?

- **Surgery:** Long term data is available from 1960 onwards
- Results and complications of ASD closure have been evaluated
- **Disadvantage:** In the 1960s,the repair was performed in older patients
- Older age at repair has higher risk of complications

- **Device:** Long term follow up data from 1990s
  - Except for: Mills and King. Long-term...Am J C.2003;92:353-55
- Results and complications of ASD closure have been evaluated
- **Disadvantage:** Repair is performed at much younger age and hence comparison to old surgical data may not be feasible

T/C Closure Vs Surgery

	Device n=442	Surgery N=154	p
Arrhythmia needing Rx	2	0	0.03
Device embolization with surgical removal	3		
Marker band embolism with surgical removal	1		
Cerebral embolism	1	0	1.0
Pericardial effusion with tamponade	0	3	0.017
Pulmonary oedema	0	1	0.26
Repeat surgery	0	2	0.066
Wound complications	0	2	0.066
Total	7 (1.6%)	8 (5.4%)	0.30

Non-randomised study from 29 paediatric cardiology centres

Du ZD, Hijazi ZM, Kleinman CS, *et al. J Am Coll Cardiol* 2002;39:1836–44

Long term outcome of surgery in ASD- Arrhythmias!!

- **1956-1960:** Murphy et al. NEJM 1993;3233:1645-50
  - 30 yr actuarial survival 74 % (controls 85%) Mortality 3.3 %
  - Cardiac failure, stroke and A Fib.
  - Rhythm issues common in older age group
- **1981-1990:** Speechly et al. PGMJ 1993;69(818):912-15
  - One late death (55 pts); 6 patients with A fib
- **1989-1999:** Ghosh et al. Heart;88:485-487
  - 2 late deaths (89 pts), A fib more common in older age group (23.5% vs. 3.3%)
- **2000-2010:** Roos-Hesselink JW *et al. Eur Heart J* 2003;**24**:190–7
  - A longitudinal follow up of 21–33 years (mean 27 years) in 135 patients.
  - Symptomatic supraventricular tachyarrhythmias in 6%, after 15 years and 5% needed pacemaker implantation

Intermediate and long term outcome of device closure of ASD

Have association with..

- Complexity of the defect
- ASD size to device size ratio of the defect
- Experience of the interventionalist/ center
- Type of device used
  - Self-centering device
  - Non self-centering device
- Careful patient selection
- Reports which may have led interventionalist to close a defect that proven to be high risk

Catheter closure of ASD with deficient IVC rim.. CCI 2009;73:90-96

Experience at Punjab Institute of Cardiology (Nov 1999 – October 2008)

- Total Patients = 217
- Unsuitable and not attempted = 12
- Suitable and attempted = 205 pts
- TTE in all & TOE in adults
- Amplatzer Septal Occluder (ASO) in all pts

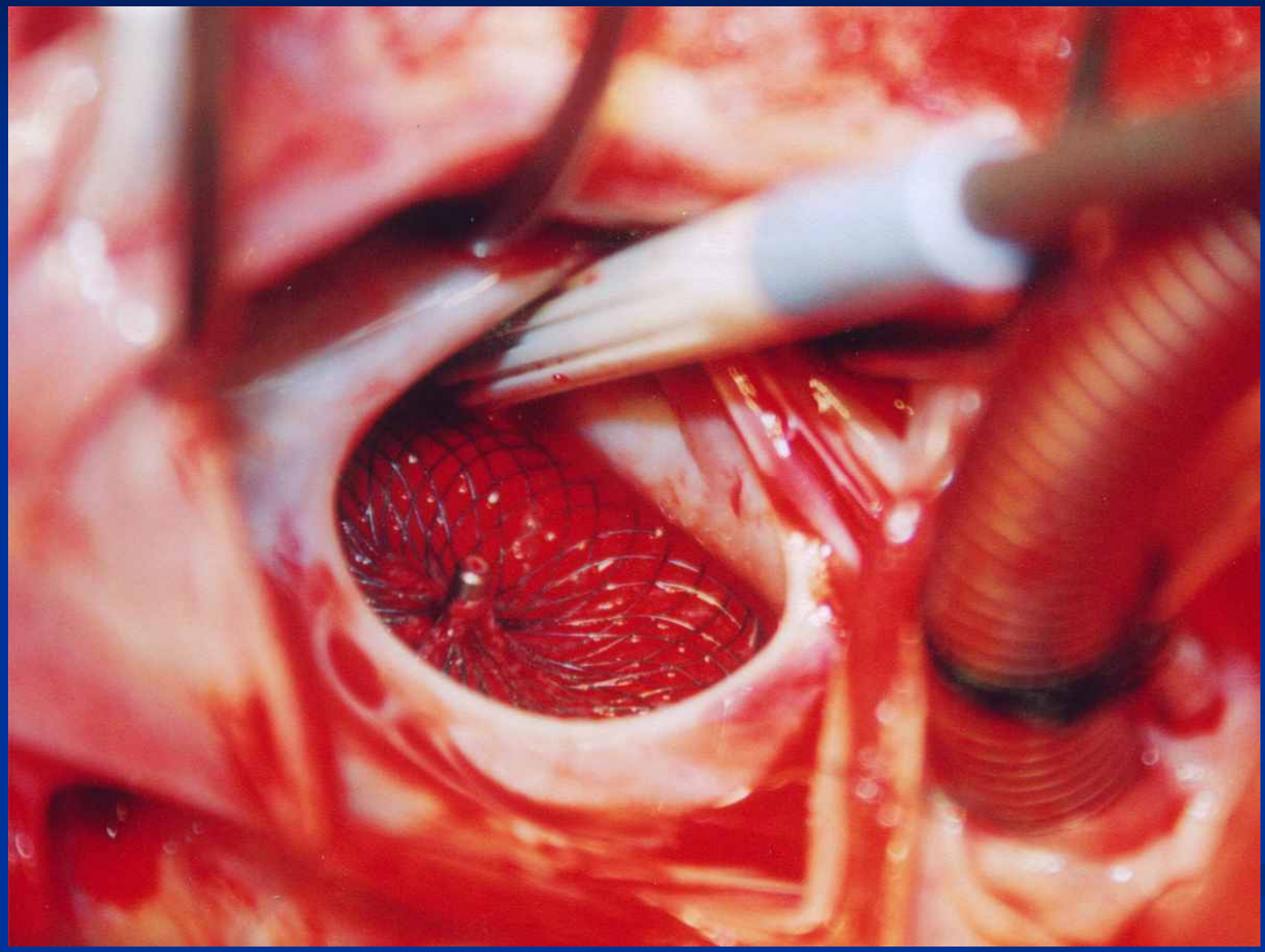
Patients and Methods

- Mean age: 13.5 years (3-55 yrs)
- Mean Weight: 35 Kg (10-107)
- Screening time = 5 – 39 minutes (mean 15 min)
- Procedure time = 25 – 330 (mean 40 min)

- All under TOE control

Immediate Outcome

- Successful in 200 (97.6%) patients
- Unsuccessful despite multiple attempts (2 pts)
- Embolisation:
  - Immediate (2 pt)
  - Within 24 hours (2 pt)
- Residual shunt (6 pts)
- 2nd degree heart block (1 pt)
- Pericardial effusion (1 pt)



Intermediate and long term Complications

- Mean follow up of 4.9 years (median 5.3, range 16 months to 10.5 years)
- No late embolisation
- No thrombus/ stroke
- Residual shunt persistent in 2/6 pts
- ? Late endocarditis – 1 pt

Intermediate and long term Complications

- Mild AR (2 pts- 1%)
- 2nd degree heart block persisted with good chronotropic response (1 pt- 0.5%)
- Other Arrhythmias (4 pts- 2%) all adults:
  - Atrial Fibrillation 3 pts
  - Fib alternating with Flutter (1 pt) – Slowed with long pauses after DC conversion and had a pacemaker

Intermediate and long term issues of device closure of ASD

- Device embolizaion
- Rhythm
- Mechanical issues:
  - Erosions/Perforation
  - Aortic Regurgitation
- Thromoembolism
- Infective endocarditis
- LV diastolic dysfunction
- Blocking access to LA: Interventions on MV, RFA, LA Apend
- Problems with multiple devices
  - New shunts, device malposition, emboli, late fractures

Device embolization

- ASD trials (ASO) 1.1%
- Overall (ASO) 0.9%
- Embolization can occur with any device and is more common in non-self centering devices
  - Undersizing
  - Improper deployment
  - Deficient IVC rim
- Follow up data is not stated in published reports
  - CCI 2005;65:588-592- (no documented fu)
  - JTCVS2006;131:909-910 (documented fu)
- Late embolisation although reported is very uncommon
  - No late embolization in our series

Rhythm

- Immediate AV Block
- Long term issues:
  - Complete heart block
  - Atrial Fibrillation/Flutter

Heart Rhythm Issues

- **Long-Term Outcomes in Individuals With Prolonged PR Interval or First-Degree Atrioventricular Block: Cheng et al. JAMA 2009;301**
  - 7,575 patients who participated in the Framingham study
    - End-points: AF/pacemaker implantation/death
    - Two-fold increase in probability AF; 3-fold in prob. of pacemaker and 40% increase in the risk of death
- **Almost all of us have encountered 1st degree AV block after device implantation, acutely and on late follow up**
  - What significance will 1st degree AVB have in the future ?
  - Fibrosis secondary to the device could extend in to the surrounding atrial tissue and predispose to AF or lead to CHB

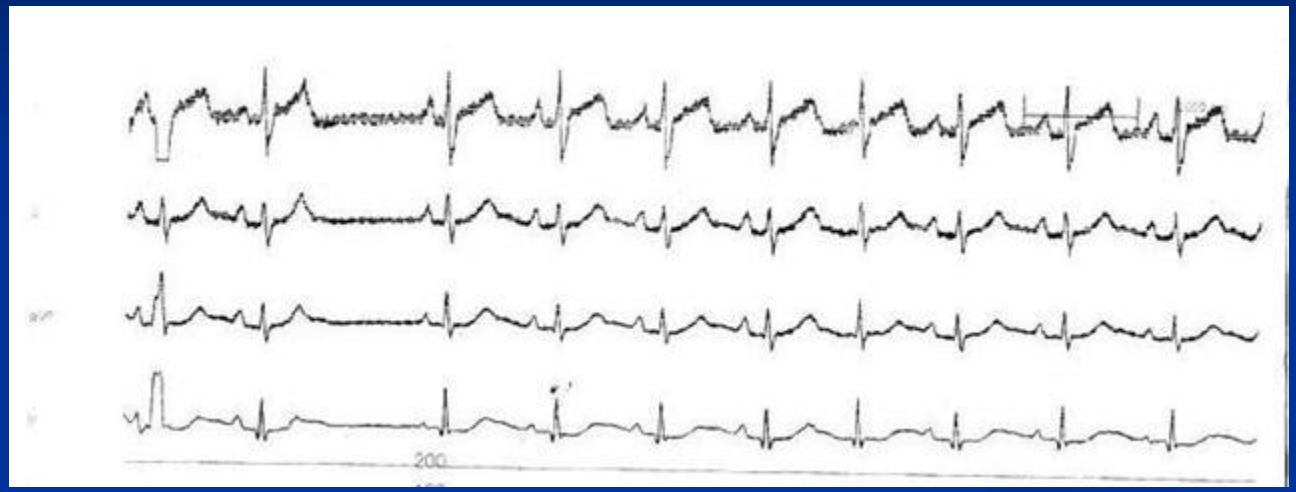
    Majunke et al: AJC: AF was the most common complication
- **Related to size of the device (Suda et al, JACC, 2004)**

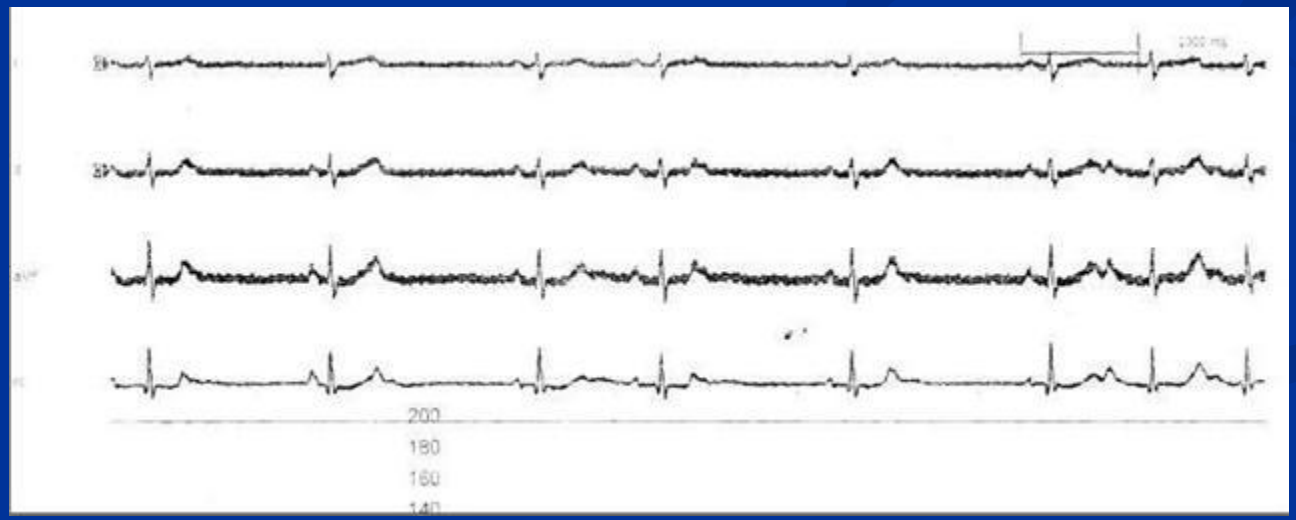
AV Block

- A 6-year-old girl presented with progression of first-degree AV block to symptomatic, complete heart block after ASD closure with an (ASO).
- She received steroids immediately after the procedure when second-degree AV block was seen
- Her AV conduction slowly deteriorated over 4 years, requiring PPM implantation.
- Etiology: Persistent trauma, ischemia, or progressive scarring caused by the ASO on the AV nodal region.
- ??early device removal would have prevented this complication!

Nehgme RA, Huddleston AR, Cheatham JP. Pediatric Cardiol 2008;30-367-70

AV Block





Heart Block

- Rare reports of CHB have been described
- Younger age and large size devices appear to be the culprit
- IVC rim deficiency increases the risk of CHB
- Good news:
  - Risk is lower when compared to surgery patients
  - Chronotropic impairment is less frequent than in surgery patientsbetter exercise capacity

Massin et al. CCI. 2009;73:564-567

Atrial Fibrillation/Flutter

- AGA Post-Market Surveillance Data
  - Total 698
  - Number seen for 5 year follow up 164
  - Arrhythmias 04
- Atrial flutter (2), change in p wave axis (1), atrial arrhythmia, unspecified (1)

Courtsey Zahid Amin

- Risk of arrhythmias after surgery is higher than device closure (6 %). 5 % required pacemaker

Eur Heart J, 2003;24:190-97

Percutaneous ASD Closure: Results in Patients Older than 60 Years

- 96 consecutive patients who underwent percutaneous closure of ASD
- October 1998 - June 2007
- Long-term follow-up (median 33.6 ± 31.2 months), no device-associated complications were observed
- Approximately 20% of patients who did not have atrial fibrillation at baseline went on to develop the complication within 3 months

Jategaonkar S, et al. *Circ Cardiovasc Interv*2009;2:85-89

Device erosion and hemodynamic compromise

- Was published before ASO was in the market

Angel wings was taken off of market after two erosions occurred during the trial

Surgical removal of ASD occlusion system-devices. EHJ 1997;12:869-872

o

oASDOS device perforated the roof of the atrium

Interatrial atrial septal closure devices and aortic perforation. J Invasive Cardiol 2009;21:E39-E41

oCardia devices perforated the roof of the atrium

EROSIONS

- Erosions have been identified by the early or late development of pericardial effusion or even tamponade.
- In all patients who developed hemodynamic compromise after ASO placement, echocardiograms (pre-, intra-, and postprocedure), atrial septal defect (ASD) size (nonstretched, stretched), size of the device used, cineangiograms, and operative records were reviewed by a panel selected by AGA Medical Corporation.
- The findings were compared to the premarket approval data obtained from FDA-approved clinical trials that were conducted in the United States, before the device was approved.

Amin Z, Hijazi ZM, Bass JL, *et al.*. *Catheter Cardiovasc Interv* 2004;63:496–502

ASO Erosion

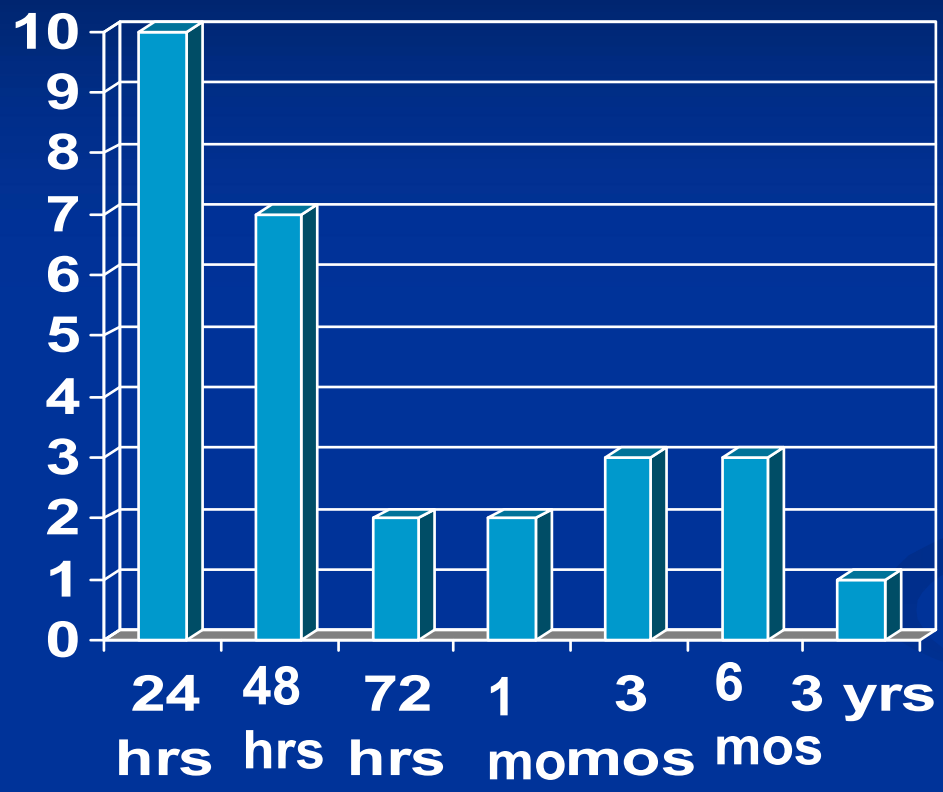
Device-related complications

- Total Cases 28
- Perforations 19
  - *Left atrium* *12*
  - *Right atrium* *6*
  - *Both atria* *1*
- Outcome
  - Surgery 21
    - *Device Removed* *16*
    - *Device NOT Removed* *5*
  - Medical Management 7
    - *Effusion drainage* *5*
    - *Observation* *2*

ASO Erosion
Mortality

- Total 3
  - RUPV perforation 1
    - Device deployed using the RUPV technique
  - Arrhythmia 1
    - The device was in optimal location, without tamponade or erosion
  - Erosion 1
  - *Patient died because of device erosion (panel's view), the pathologist ruled it as catheterization complication*

Appearance of haemodynamic compromise



Time to adverse event in ASD patients only

68% within first 72 hours, 29% between 5 days and 8 months

ASO Erosion

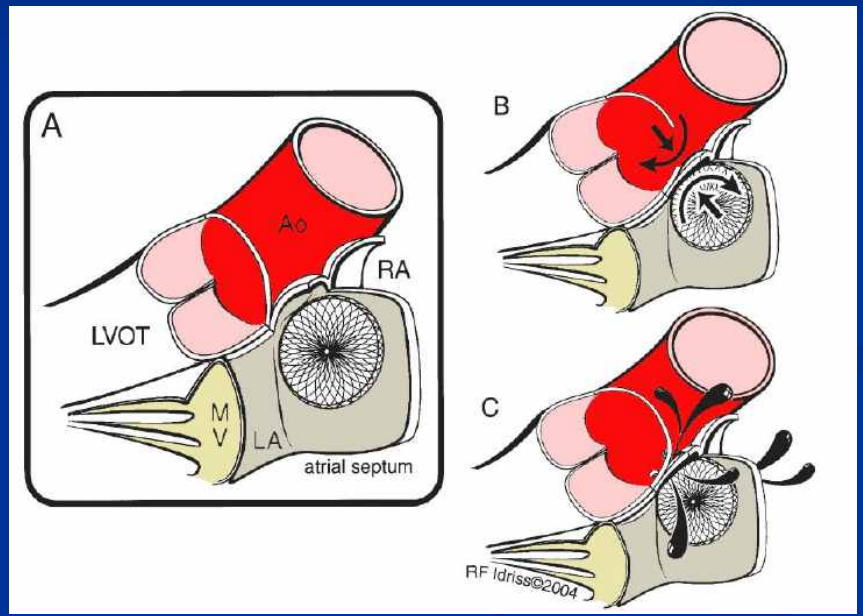
U.S. FDA Approved Trials (device/defect ratio)

- Mean diameter of the device was 4.9 mm (38%) larger than the unstretched ASD size

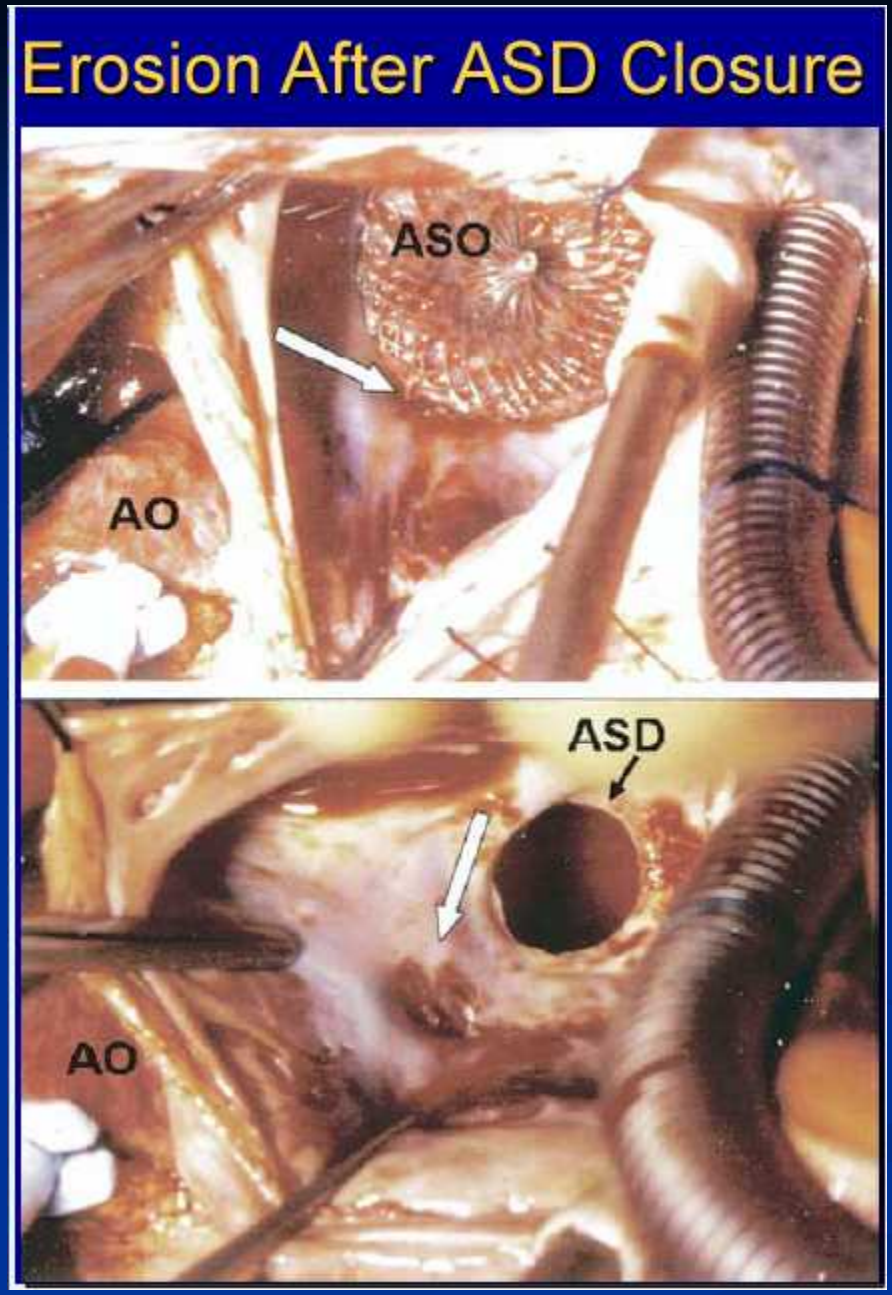
	ASD Diameter	Stretched Diameter	Device Size Implanted	Ratio
Clinical Trial	12.8 mm	17.2 mm	17.7 mm	1.38
Hemodynamic Compromise	12.7 mm	20.9 mm	22.3 mm	1.76

Mechanism of Erosions

- Deficiency of aortic rim/superior rim
- Oversizing
- Edge of RA or LA disc eroded through free atrial wall
- If extended to aorta, tamponade was rapid



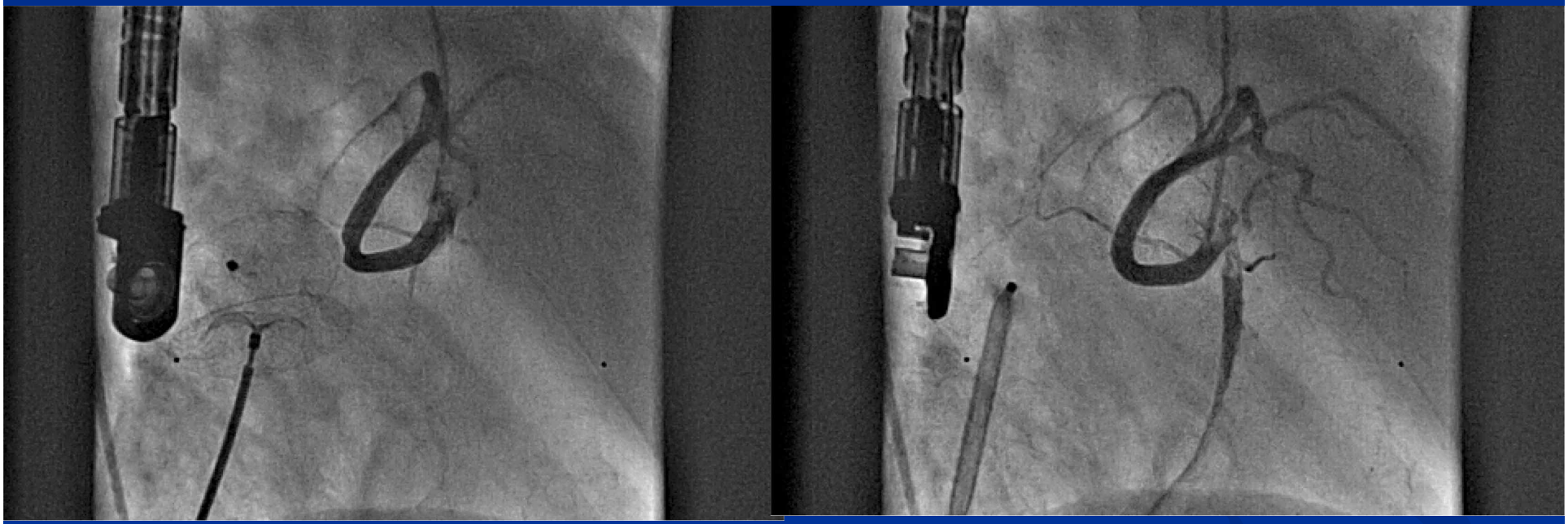
Erosion After ASD Closure



Divekar et al J Am Coll of Cardiol

Inference between the ASD and LCA originating from the right sinus of Valsalva (right anterior oblique cranial view)

After retrieval of the Amplatzer septal occluder back into the sheath, the compression of the LCA disappears



Scholtz, W. et al. Circulation 2008;117:e181–e183

Aortic valve, Aortic root, Aortic rim

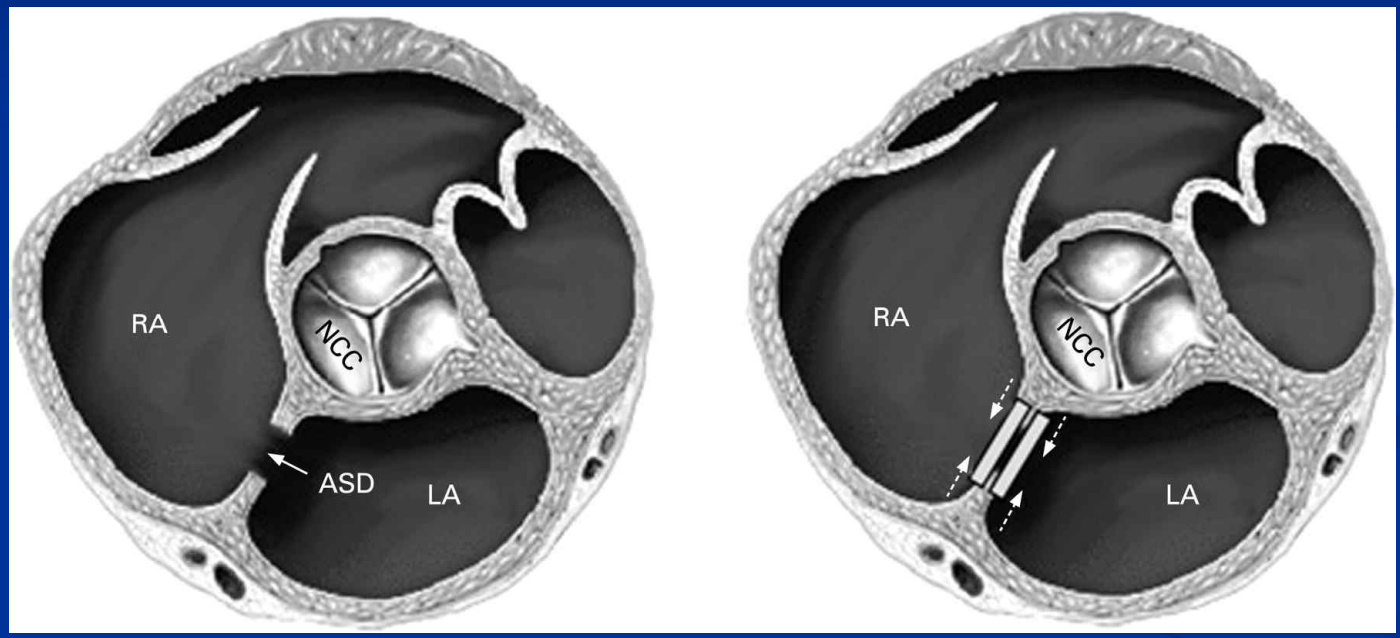
- ASD and PFO are very close to the aorta/aortic root
- This association remains the same regardless of the type of device used
- The close proximity may cause distortion of the aortic frame work and have impact on the non-coronary cusp
  - Aortic insufficiency
  - Aortic to atrial fistulae
  - Disruption of the aorta through the atrial wall-erosion

Aortic valve regurgitation

- Aortic valve regurgitation after closure of ASD and PFO
- ASD 70
  - ASO 40 , Cardia 30
- PFO 170
  - ASO 3, Cardia 167
- AI (newly developed or worsening) developed in 9 % of ASD and 10 % PFO cases
  - Independent of age, size, gender
  - No augmented splaying, device size used,

Schoen, S P et al. Heart 2008;94:844-847

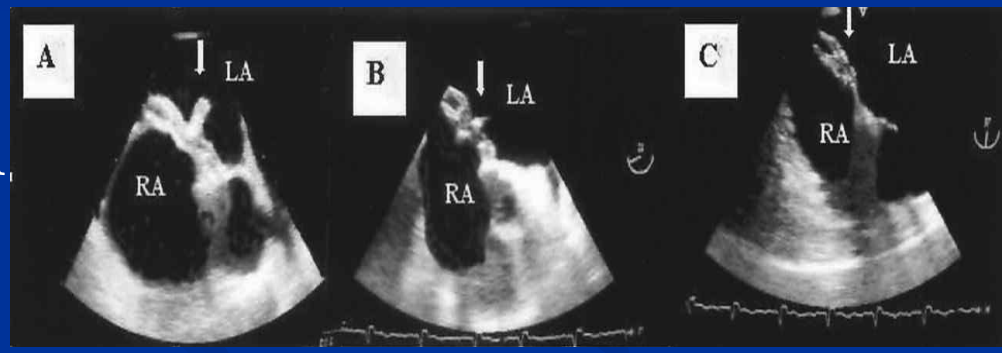
The position of an ASD occluder and--indicated by arrows--shrinking of the interatrial septum owing to tissue overgrowth on the device, leading to traction on the aortic non-coronary cusp (NCC) as one hypothesis of the mechanism of aortic valve regurgitation.



Schoen, S P et al. Heart 2008;94:844-847

Thrombus formation

- Has occurred after surgical ASD closure, but is rare
- Was more common with ASDOS and NMT devices
- Higher risk in patients with abnormal coagulation
- Has occurred on every available device
- The Helex and Amplazter devices have the lowest risk of thrombus formation



Chessa, M. et al. J Am Coll Cardiol 2002;39:1061-1065

Thrombus formation

- A total of 1,000 consecutive patients were investigated after
  - Patent foramen ovale (PFO) (n = 593)
  - Atrial septal defect (ASD) (n = 407) closure.
- TEE was done after 4 weeks, 6 m and as clinically indicated.
- Thrombus formation was found:
  - 5 of the 407 (1.2%) ASD patients
  - 15 of the 593 (2.5%) PFO patients (p = NS)
- In 17 of the 20 pts, the thrombus resolved under anticoagulation. In three patients, the thrombus was removed surgically
- LA = 11, RA = 6, both = 3

Krumsdorf U, Sievert H et al. J Am Coll Cardiol. 2004 Jan 21;43(2):302-9

Risk Factors for Thrombus formation

Risk Factors	No Thrombus	Thrombus	p Value
Atrial fibrillation	66/980 (6.2%)	4/20 (20%)	<0.05
Residual shunt	287/980 (29%)	3/20 (15%)	NS
Persistent ASA	13/980 (1.3%)	4/20 (20%)	<0.01
Wire fracture	47/980 (4.8%)	3/20 (15%)	NS
Protein S deficiency	8/456 (1.8%)	0/20 (0%)	NS
Protein C deficiency	9/456 (2%)	0/20 (0%)	NS
Resistance to act. pr. C	25/456 (5.5%)	0/20 (0%)	NS
Mean age	47 yrs	48 yrs	NS
Male	412/980 (42%)	9/20 (45%)	NS
Hypertension	228/980 (23%)	3/20 (15%)	NS
Coronary artery disease	51/980 (5%)	0/20 (0%)	NS
Diabetes	37/980 (4%)	0/20 (0%)	NS
Warfarin	95/980 (10%)	3/20 (15%)	NS
Aspirin	505/980 (52%)	6/20 (30%)	NS
Aspirin + clopidogrel	380/980 (39%)	11/20 (55%)	NS
Protamin	798/980 (81%)	19/20 (95%)	NS

Septal closure and thrombus formation

		TEE Due (n)		TEE Performed (%)		Thrombus (%, n)
Occluder	n	6 months	4 weeks	6 months	4 weeks	6 months
Rashkind	1	1	100%	100%	0%	0%
Buttoned Device	52	52	67%	69%	0%	0%
ASDOS	42	42	66%	83%	3.6% (n=1)	0%
Angel Wings	30	30	0%	97%	0%	3.3% (n=1)
CardioSEAL	27	27	52%	93%	7.1% (n=1)*	0%
StarFLEX	142	111	74%	70%	5.7% (n=6)*	0%
Amplatzer	418	375	78%	70%	0%*	0.3% (n=1)
PFO-Star	127	127	60%	66%	6.6% (n=5)*	1.5% (n=1)
Helex	161	138	76%	80%	0.8% (n=1)	0%
Total	1000	903	71%	71%	2% (n=14)	0.6% (3)

**The difference between Amplatzer against CardioSEAL, StarFLEX , and PFO-Star was significant ($p<0.05$)*

Krumsdorf et al, J Am Coll Cardiol 2004;43:302–9

Embolic Stroke

- 29 yr old woman had Amplatzer ASD device presented with altered sensorium 2 years post implant
- TEE revealed a large thrombus attached to the LA surface of the disc

A. Raghu, D. Kawalsky, M. Feldman *Am J Cardiol 2008;*98 (9):1294-1296

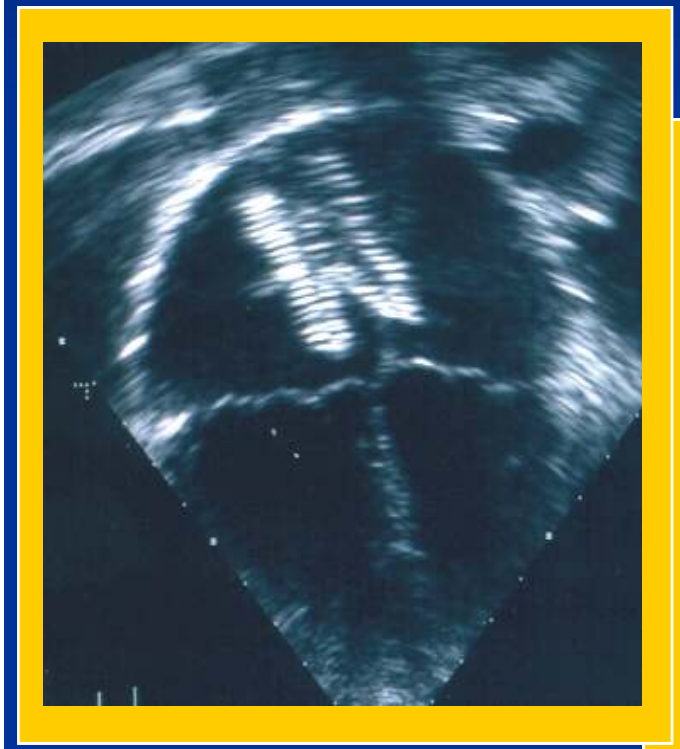
- Stroke and peripheral embolism from an Amplatzer septal occluder 5 years after implantation

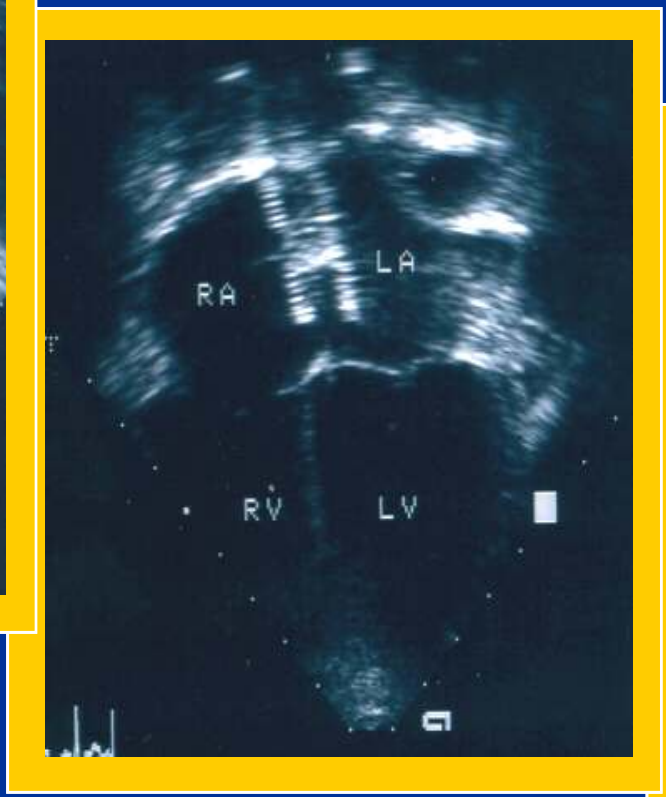
Journal of Neurology (Online) 2008,255:1432-1459

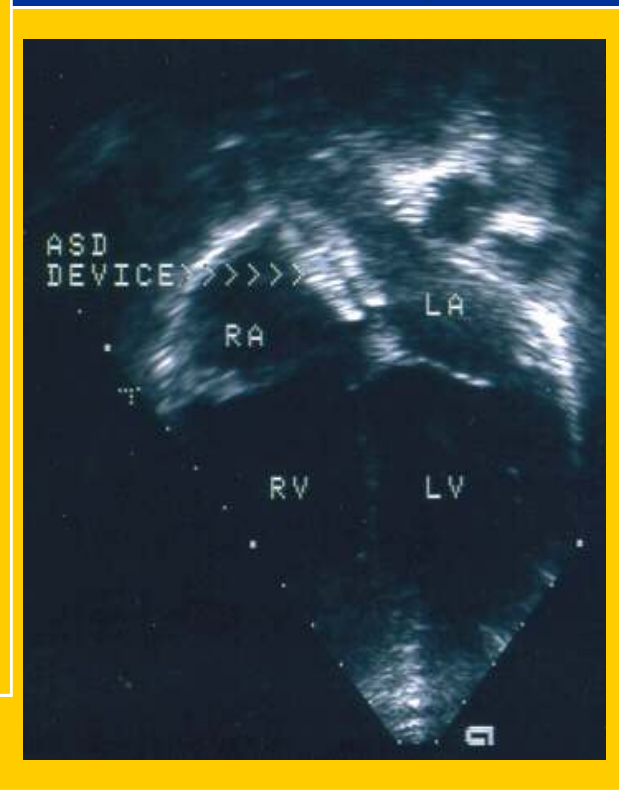
Other Questions

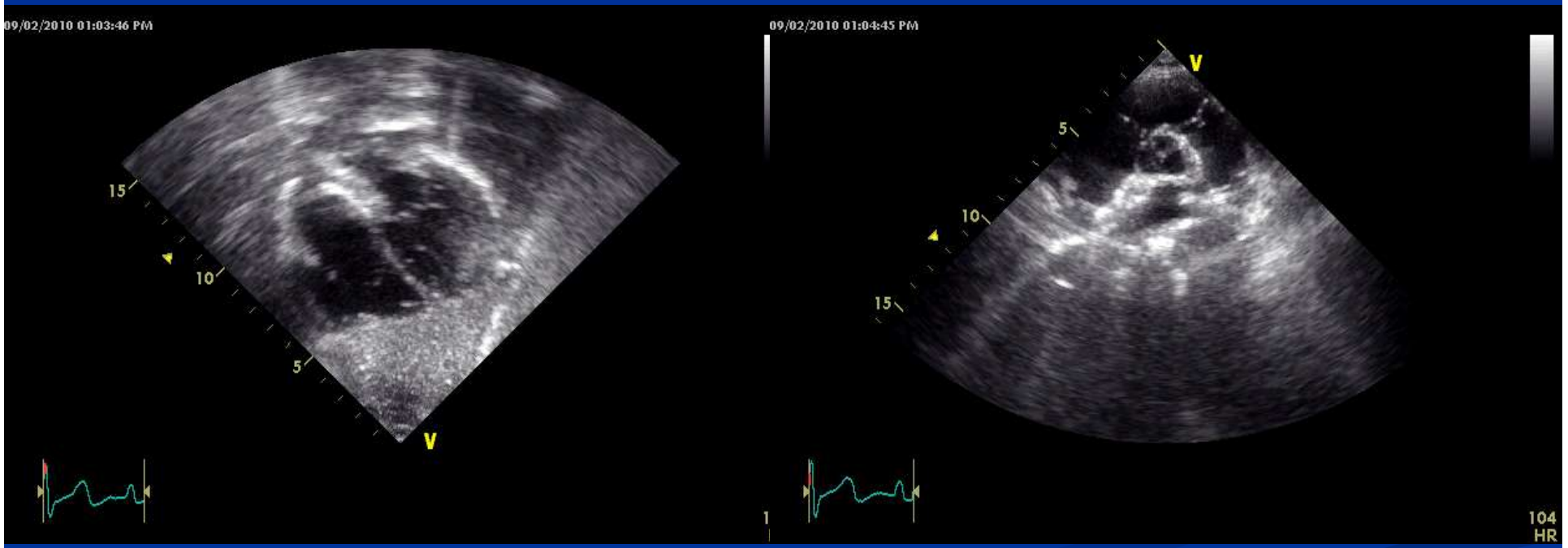
- Does it endothelialise fully?
- Is it unacceptably ‘bulky’?

Bulkiness?

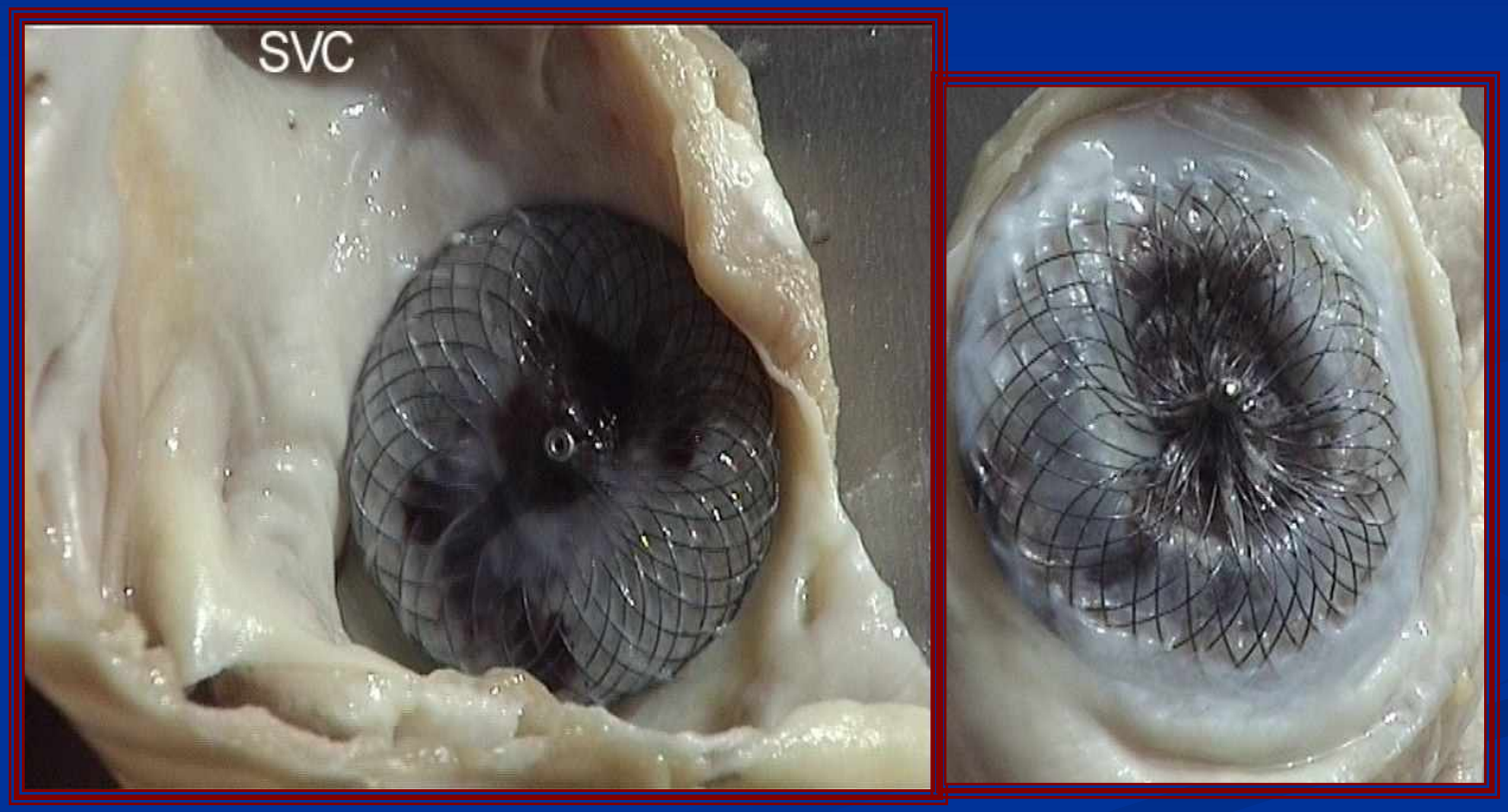






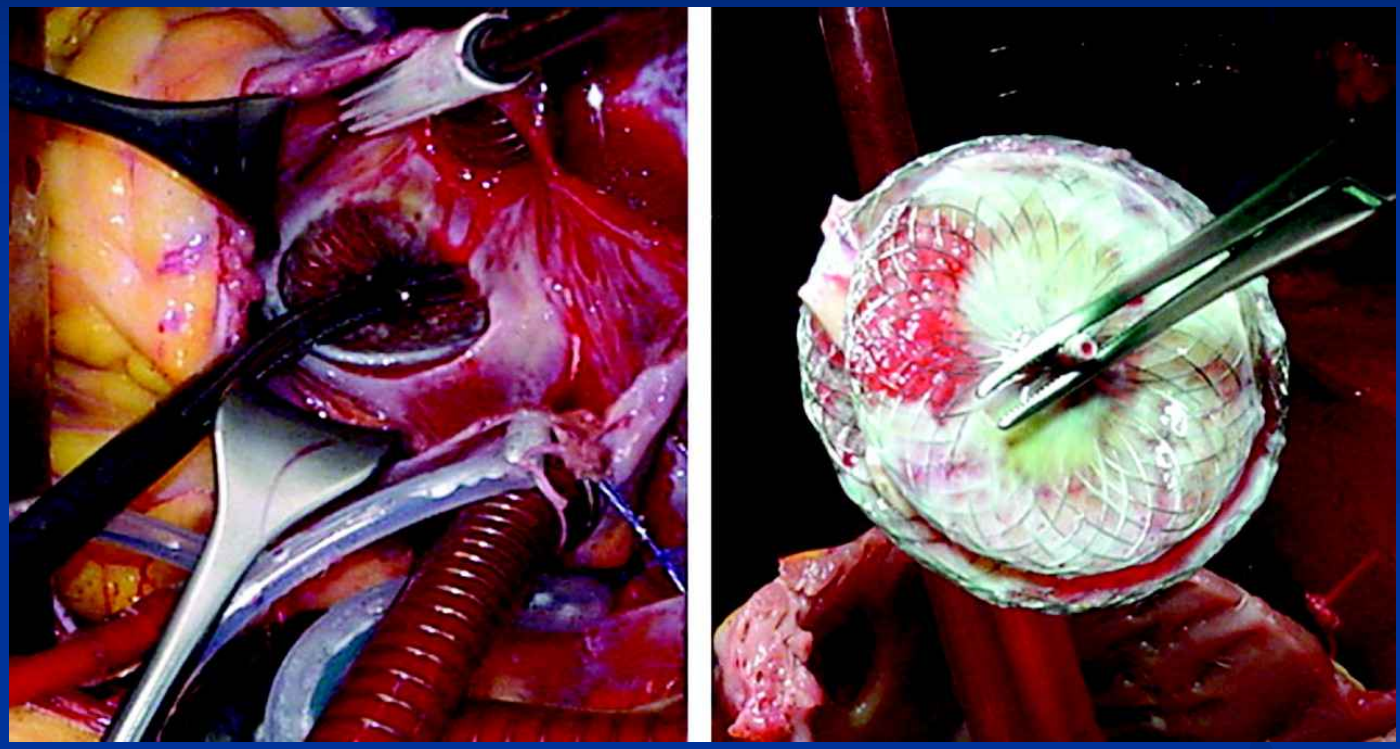

09/02/2010 01:03:46 PM
15
10
5
V
09/02/2010 01:04:45 PM
V
5
10
15
1
104
HR

Endothelialisation?



Eighteen months post implant

Intraoperative situs with an Amplatzer occlude 1 year after implantation. Almost complete tissue overgrowth is apparent.



Schoen, S P et al. Heart 2008;94:844-847

Erosion after Percutaneous ASD Closure

What we have learned?

- Don't overstretch while sizing, Use stop-flow technique
- Don't overdo Minnesota wiggle
- Aortic rim absence alone without over-sizing will not result in erosion. wedging the device between the aortic and posterior rim is detrimental and may result in erosion
- Identify high risk patients
  - ASO > 150% ASD on TEE
  - Small pericardial effusion at 24 hrs.
  - Deformation of ASO
  - High ASD with minimal aortic and FLAIL/MOBILE superior rim
  - Mandatory 24 hr F/U
  - Patient education

What we have learned so far

- **Rhythm:** The risks can be minimized by:
  - avoiding defects that may increase the risk of future arrhythmias and by using proper defect to device size ratio
- **Thrombus formation:**
  - Use higher dose of ASA
  - Go beyond the recommended 6 months, in patients who have undergone large sized devices or when the device appears bulky and in adults
- **Aortic Regurgitation:**
  - Avoid significant splaying
  - Anticipate that the size of the heart will decrease over time, after device closure
  - Avoid over-sizing of the device

CONCLUSIONS

- Device closure of ASD is now a standard procedure for majority of Secundum ASD's
- Complications although infrequent, can be potentially serious but majority are preventable and treatable
- Intermediate and long term results are promising and results are comparable with surgery

CONCLUSION

- We can improve upon the available devices to make long-term outcomes more favorable and more devices will become available
- There are definite known and some unknown risks involved with the closure
- We do not follow patients as eagerly as we pursue them for the procedure