Catheter Based Cardiac Surgery: Anesthesia in the Hybrid Suite and Cath Lab

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Learning Objectives:

At the Conclusion of this lecture, participants should be able to:

1) List the key risk factors for patients undergoing interventional cardiac procedures;

2) Differentiate among critical monitoring techniques based on interventional procedure type;

3) List the advantages or disadvantages for general anesthesia in electrophysiology procedures;

4) Describe the challenges of providing anesthetic care for cardiac patients in off site locations;

Disclosures

- Editor in Chief Seminars in Cardiothoracic and Vascular Anesthesiology – SAGE Publications
- Editor - Manual Clinical Anesthesiology – LWW publications
- Haemonetics: Research Reagent Support

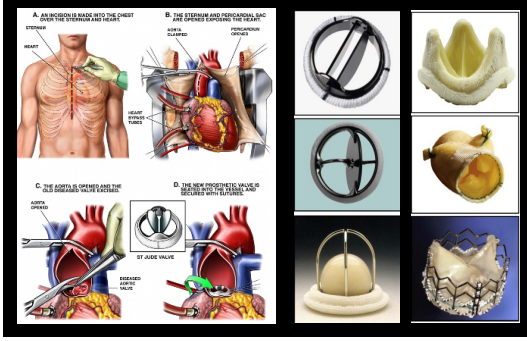
Interventional Cardiology

- Interventional Cardiology has evolved significantly over past 70 years beginning with central catheterization and PCI.
- Topics Covered Today:
  - TAVR
  - AFIB interventions – Lariat
  - Lead Extractions
  - ASD closures
  - Mitra-clip

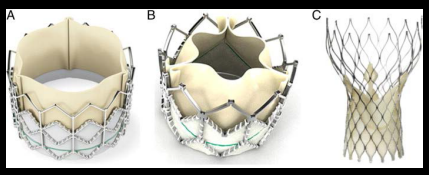
TAVR

- Total Aortic Valve Replacement
- TAVI: Total Aortic Valve Implantation

Aortic Valve Replacement

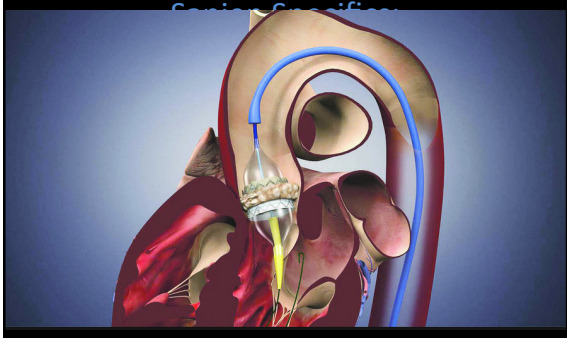


Currently Available Transcatheter Valves

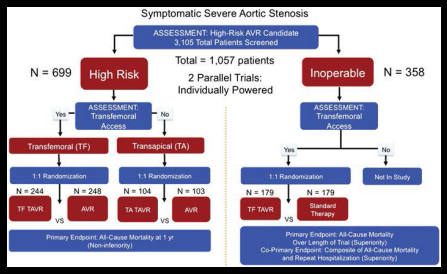


(A)The Edwards SAPIEN THV balloon-expandable valve (incorporates a stainless steel frame, bovine pericardial leaflets,x and a fabric sealing cuff.
(B) The SAPIEN XT THV utilizes a cobalt chromium alloy frame and is compatible with lower profile delivery catheters.
((C) The Medtronic CoreValve (incorporates a self-expandable frame, porcine pericardial leaflets, and a pericardial seal.

Am Coll Cardiol. 2012;60(6):483-492

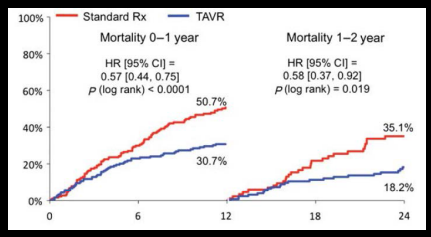


Partner I Trial



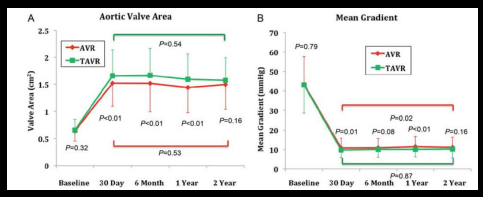
Leon MB N Engl J Med 2010;363:1597–1607

Two-year with 1-year landmark analysis of all-cause mortality Kaplan–Meier curve in PARTNER trial cohort

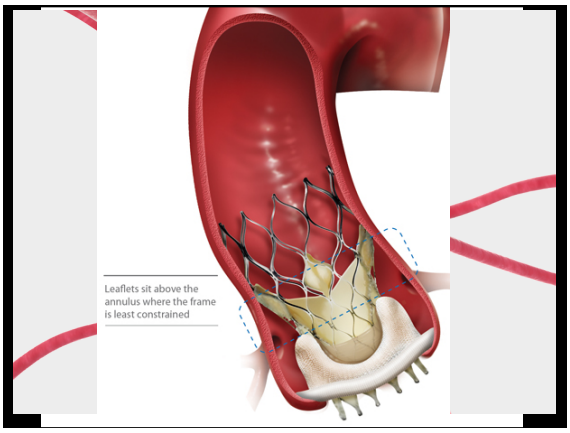


Leon MB N Engl J Med 2010;363:1597–1607

Two-year time trends in hemodynamics after TAVI vs. SAVR



Kodali SK N Engl J Med 2012;366:1686–1695.



The NEW ENGLAND JOURNAL of MEDICINE

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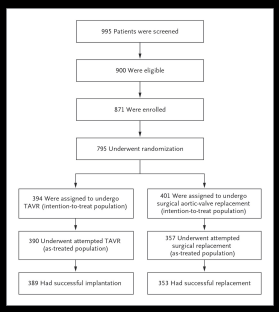
ORIGINAL ARTICLE

Transcatheter Aortic-Valve Replacement with a Self-Expanding Prosthesis

David H. Adams, M.D., Jeffrey J. Popma, M.D., Michael J. Reardon, M.D., Steven J. Yakubov, M.D., Joseph S. Coselli, M.D., G. Michael Deeb, M.D., Thomas G. Gleason, M.D., Maurice Buchbinder, M.D., James Hermiller, Jr., M.D., Neal S. Kleiman, M.D., Stan Chetcuti, M.D., John Heiser, M.D., William Merhi, D.O., George Zorn, M.D., Peter Tadros, M.D., Newell Robinson, M.D., George Petrossian, M.D., G. Chad Hughes, M.D., J. Kevin Harrison, M.D., John Conte, M.D., Brijeshwar Maini, M.D., Mubashir Mumtaz, M.D., Sharla Chenoweth, M.S., and Jae K. Oh, M.D. for the U.S. CoreValve Clinical Investigators

N Engl J Med 2014; 370:1790-1798 | May 8, 2014 | DOI: 10.1056/NEJMoa1400890

Randomization and Analysis Populations.



Adams DH et al. N Engl J Med 2014;370:1790-1798.

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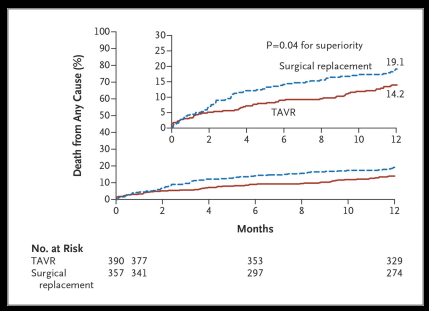
Kaplan–Meier Cumulative Frequency of Death from Any Cause.



Adams DH et al. N Engl J Med 2014;370:1790-1798.

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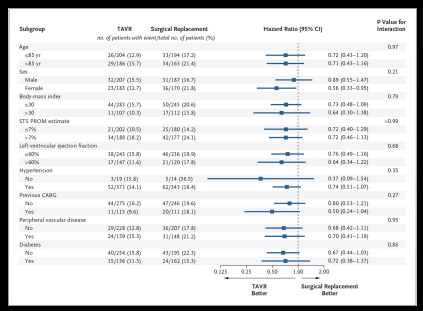
Subgroup Analysis for the Rate of Death from Any Cause at 1 Year.



Subgroup	TAVR	Surgical Replacement	Hazard Ratio (95% CI)	P Value for Interaction
	no. of patients with event/total no. of patients (%)			
Age				0.97
<85 yr	26/204 (12.9)	33/194 (17.2)	0.72 (0.43–1.20)	
≥85 yr	29/186 (15.7)	34/163 (21.4)	0.71 (0.43–1.16)	
Sex				0.21
Male	32/207 (15.5)	31/187 (16.7)	0.89 (0.55–1.47)	
Female	23/183 (12.7)	36/170 (21.8)	0.56 (0.33–0.95)	
Body mass index				0.79
≤30	44/283 (15.7)	50/245 (20.6)	0.73 (0.48–1.09)	
>30	11/107 (10.3)	17/112 (15.8)	0.64 (0.30–1.38)	
STS PROM estimate				>0.99
<7%	21/202 (10.5)	25/180 (14.2)	0.72 (0.40–1.29)	
>7%	34/188 (18.2)	42/177 (24.1)	0.72 (0.46–1.13)	
Left ventricular ejection fraction				0.68
≤40%	38/243 (15.8)	46/236 (19.9)	0.76 (0.49–1.16)	
>40%	17/147 (11.6)	21/120 (17.8)	0.64 (0.34–1.22)	
Hypertension				0.35
No	3/19 (15.8)	3/14 (36.5)	0.37 (0.09–1.54)	
Yes	52/371 (14.1)	62/343 (18.4)	0.74 (0.51–1.07)	
Previous CABG				0.27
No	44/275 (16.2)	47/246 (19.6)	0.80 (0.53–1.21)	
Yes	11/115 (9.6)	20/111 (18.1)	0.50 (0.24–1.04)	
Peripheral vascular disease				0.95
No	29/228 (12.8)	36/207 (17.8)	0.68 (0.42–1.11)	
Yes	24/159 (15.3)	31/148 (21.2)	0.70 (0.41–1.19)	
Diabetes				0.86
No	40/254 (13.8)	43/195 (22.5)	0.67 (0.44–1.03)	
Yes	15/136 (11.3)	24/162 (15.3)	0.72 (0.38–1.37)	

Adams DH et al. N Engl J Med 2014;370:1790-1798.

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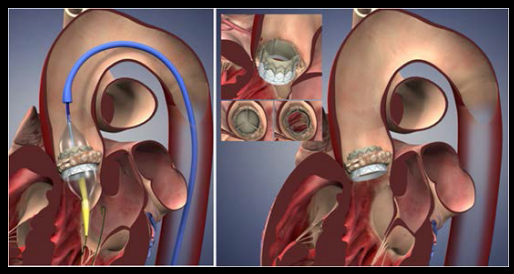
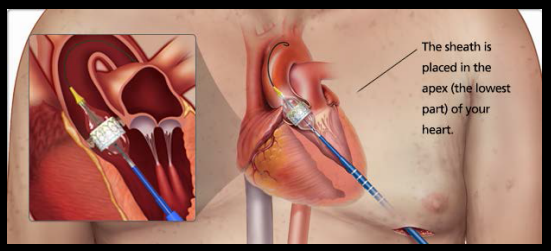
Anesthetic Management

- GETA typically employed**
- Slow, gentle induction tailored for AS
- Anticipate extubation at conclusion
- Pre-induction Arterial Line
- Central Access following induction
  - PAC in higher risk patients (PHTN, RV failure)
- TEE
- Temporary pacing

Trans-femoral TAVR



Trans-apical TAVR



Complications

- Peripheral Vascular Injury
- Stroke (3-4%)

Grading criteria for paravalvular insufficiency based on the percentage of circumferential extent

Paravalvular Insufficiency Based on Circumferential Extent

Mild	Moderate	Severe
<10%	10%–29%	≥30%

- Post-TAVR aortic insufficiency (> 60%)

Lead Extractions:

- Class I indications:
  INFX
  - Definite CIED system infection
  - Pocket infection, abscess, erosion through skin
  - Endocarditis
  - Occult Gram + bacteremia

  Lead issues:
  - Arrhythmias secondary to retained leads
  - Interference of retained leads with CIED
  - Interference with treatment for malignancy

  Thrombosis:
  - Thrombotic events associated with lead
  - SVC occlusion and need for additional lead placement
  - Lead presence with planned stent deployment

2014 Consensus Statement

Heart Rhythm Society Expert Consensus Statement on Electrophysiology Laboratory Standards: Process, Protocols, Equipment, Personnel, and Safety

David E. Haines, MD, FHRS, (Chair)[1] Salwa Beheiry, MSN, CCRN, (Chair)[2]
Joseph G. Akar, MD, PhD,[3] Janice L. Baker, MSN, CCRN, CEPS, FHRS,[4] Doug Beinborn, RN, MA,[5]
John F. Beshai, MD, FHRS, FACC,[6*] Neil Brysiewicz, MS,[7] Christine Chiu-Man, MS, CEPS, CCDS, FHRS,[8]
Kathryn K. Collins, MD, FHRS,[9†] Matthew Dare, CEPS,[10] Kenneth Fetterly, PhD,[11] John D. Fisher, MD,
FHRS,[12] Richard Hongo, MD, FHRS,[13] Samuel Irefin, MD,[14] John Lopez, RN,[14]
John M. Miller, MD, FHRS,[15] James C. Perry, MD, FHRS,[16] David J. Slotwiner, MD,[17]
Gery F. Tomassoni, MD, FHRS, FACC,[18] Esther Weiss, APN, CNS, MSN, CCDS, CEPS[19]

Heart Rhythm, Vol 11, No 8, August 2014

Recommendations:

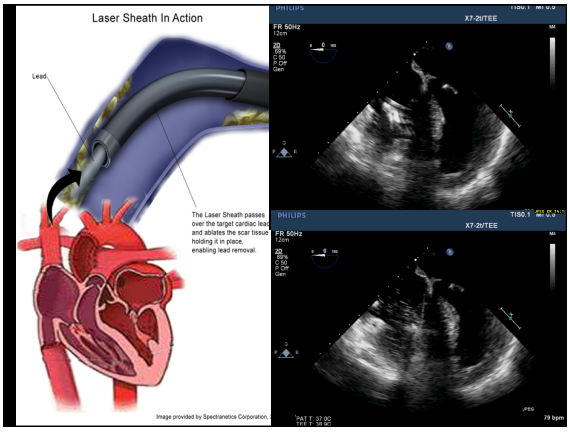
- Highly complex procedures or procedures on patients with certain conditions and comorbidities that are associated with higher procedural risk should not be performed in a freestanding laboratory
- Emergency cardiovascular surgical support should be immediately available extraction of chronic device leads and complex mapping/ ablation procedures, particularly those requiring pericardial access

Recommendations:

- High-risk procedures in critically ill patients, such as ablation of ventricular tachycardia in patients requiring extracorporeal hemodynamic support, can only be safely performed in institutions offering comprehensive programs with active engagement from electrophysiologists, surgeons, intensivists, and anesthesiologists.

Recommended Personnel

- 1 EP or device-credentialed MD performing the procedure
- 1 Secondary operator (Fellow, NP, PA, and technician performing under the supervision of an MD responsible for the procedure [as approved by the institution])
- 1 AA / CRNA administering anesthesia under the supervision of an MD anesthesiologist, or 1 nurse trained and credentialed in procedural sedation
- 1 CV surgeon to be immediately available (may be required to be in the room for the critical part of the procedure)
- 1 nurse – circulating
- 1 technologist or nurse scrubbing



Lead Extraction Evidence

Clinical predictors of adverse patient outcomes in an experience of more than 5000 chronic endovascular pacemaker and defibrillator lead extractions

Michael P. Brunner, MD,* Edmond M. Cronin, MB, MRCPI,* Valeria E. Duarte, MD,† Changhong Yu, MS,‡ Khaldoun G. Tarakji, MD, MPH, FHRS,* David O. Martin, MD, MPH,* Thomas Callahan, MD, FHRS,* Daniel J. Cantillon, MD, FHRS,* Mark J. Niebauer, MD, PhD, FHRS,* Walid I. Saliba, MD, FHRS,* Mohamed Kanj, MD,* Oussama Wazni, MD,* Bryan Baranowski, MD,* Bruce L. Wilkoff, MD, FHRS*

Heart Rhythm. 2014 May;11(5):799-805.

Table 2 Lead characteristics (n = 5521)

Type of lead [n (% of total leads)]	
Pacemaker	4137 (74.9)
Dual-coil ICD	922 (16.7)
Single-coil ICD	462 (8.4)
Location [n (% of total leads)]	
Right ventricle	3287 (59.5)
Right atrium	1865 (33.8)
Coronary venous system	263 (4.8)
Superior vena cava	106 (1.9)
Leads extracted per procedure	
Median	2.0 (1.0, 2.0)
> 2	556 (18.5)
> 3	162 (5.4)
Implant duration of leads extracted per procedure (years)	
Median	4.7 (2.4, 8.3)
Age of oldest lead	5.1 (2.8, 8.7)
Combined age of leads	7.3 (3.7, 14.6)

ICD = implantable cardioverter-defibrillator.

Multivariate Analysis Results

- Major Complications: (1.8%)
  - Cerebrovascular Dz, reduced EF, low platelets, INR > 1.2, use of mechanical sheath.
- MCVI – (1.1%)
  - Low platelets, combined age of leads > 7 yrs, use of mechanical or powered sheath

Cleveland Clinic TVLE Catastrophes

- 25 patients experience complications required emergent surgical or endovascular intervention. This is 0.8% of their population
- Twenty patients required cardiac surgical intervention
  - Eighteen patients required sternotomy
  - 2 patients required thoractomy
  - There were 15 SVC lacerations, 2 right atrial perforations, 3 ventricular perforations

Cleveland Clinic TVLE Catastrophes

- Two patients required vascular repair at the procedural access site for SCL vein or artery laceration
- Three patients were managed with an endovascular approach for SVC laceration, left axillary laceration and brachiocephalic vein and artery fistula

Cleveland Clinic TVLE Catastrophes

- Six of the 25 died intraoperatively
- Three of the 25 made it out of the operating room but did not survive to hospital discharge

Case:

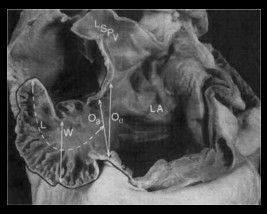
- 34 yo female – developed post partum cardiomyopathy 8 years ago
- CIED placed at that time
- Heart function has since recovered, with near normal LV systolic function
- Plan is to remove leads / device

Anesthesia Recommendations:

- General Anesthesia
- Standard ASA + Arterial line
- Possible Central line
- TEE
- LB IV access – preferably femoral
- Type and Cross
- CPB / CT surgeon standby*
- Stratify low / intermediate vs high risk patients

Left Atrial Appendage (LAA) →Percutaneous Closure

Saady et al. Heart 1999



Fuller et al. Curr Card Rep 2011

Recommendations for LAA closure/occlusion/excision

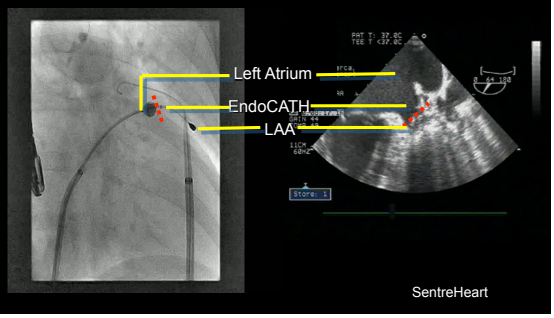
Recommendations	Class[a]	Level[b]	Ref[c]
Interventional, percutaneous LAA closure may be considered in patients with a high stroke risk and contraindications for long-term oral anticoagulation.	IIb	B	115, 118
Surgical excision of the LAA may be considered in patients undergoing open heart surgery.	IIb	C	

Percutaneous LAA Closure

- WATCHMAN
- Amplatzer Cardiac Plug
- ~~PLAATO~~
- LARIAT

LARIAT

HYBRID: ENDOCARDIAL/EPICARDIAL APPROACH



SentreHeart

FindrWIRZ

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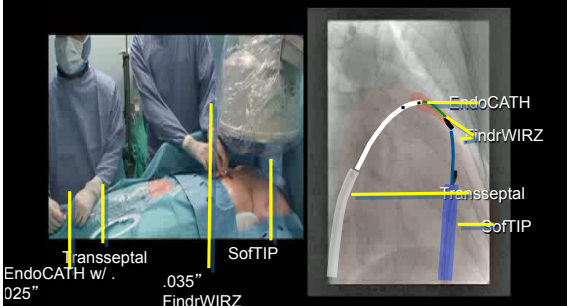

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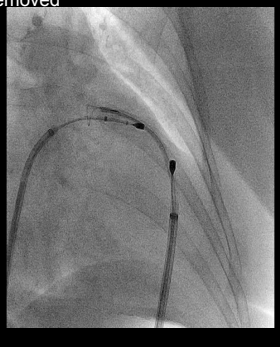
EndoCATH & .025" FindrWIRE removed



CONFIRM

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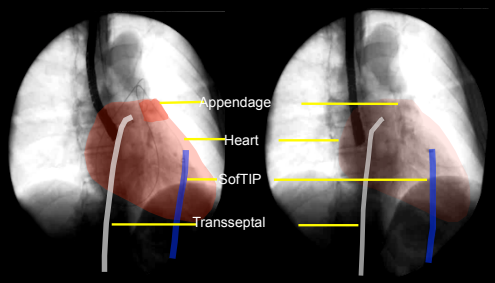
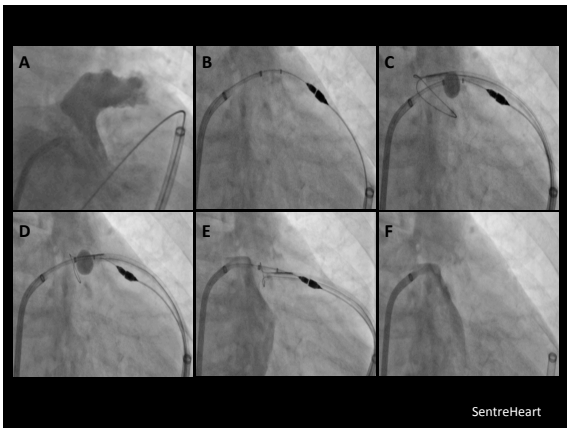
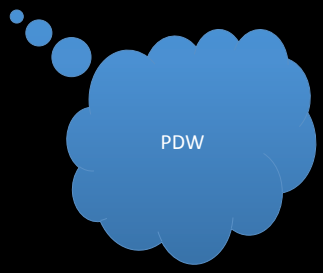
Before | After





SentreHeart

Global Difficulty Rating????



Clinical Exclusion Criteria

- History of Pericarditis
- Hx of Cardiac Surgery
- Pectus Excavatum
- Recent MI (< 3mos)
- Recent embolic event in last 30 days
- Heart Failure NYHA IV
- Systolic HF (EF < 30%)
- Thoracic Radiation

Anatomic Exclusion:

- LAA > 40mm
- Superiorly oriented LAA
- Bilobed LAA

TABLE 2 Major Bleeding Events During Hospitalization in the Study Population (n = 154)*

Major bleed	14 (9.1)
Any transfusion with overt bleeding	7 (4.5)
Overt bleed, hemoglobin drop 3 to <5 g/dl	5 (3.2)
Bleeding requiring vasoactive agents	4 (2.6)
Fatal bleeding	0

Values are n (%). Bleeding Academic Research Consortium type 3A or greater.
*More than 1 bleeding event may have occurred in a single patient.

CONCLUSIONS In this initial multicenter experience of LAA ligation with the Lariat device, the rate of acute closure was high, but procedural success was limited by bleeding. A prospective randomized trial is required to adequately define clinical efficacy, optimal post-procedure medical therapy, and the effect of operator experience on procedural safety. (J Am Coll Cardiol 2014;64:565–72) © 2014 by the American College of Cardiology Foundation.

CONCLUSIONS In this initial multicenter experience of LAA ligation with the Lariat device, the rate of acute closure was high, but procedural success was limited by bleeding.

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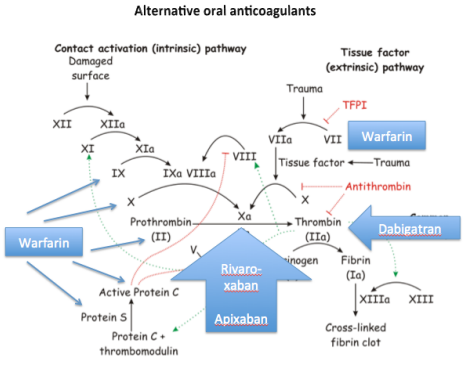
"Given the considerable incidence of complications, the relatively high incidence of incomplete LAA occlusion, and the lack of long-term efficacy data, we agree with the suggestion of the authors that this method should be reserved only for very well-selected patients with substantial thromboembolic and bleeding risk."



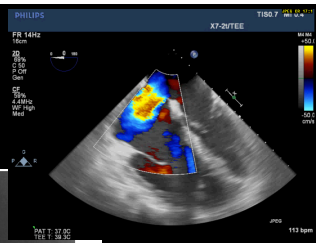
Anesthesia Recommendations

- Arterial Line
- General Anesthesia
- TEE
- Large Bore IV
- CPB / CT surgeon standby**
- Type and Cross

Structural Interventions

- Multiple lesions now being intervened upon
  - ASD closure
  - Mitral valve (regurgitation) → Mitra Clip

ASD

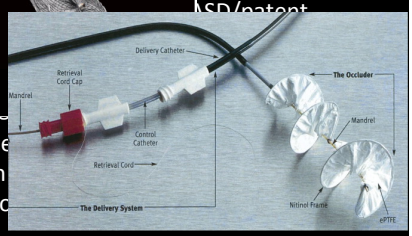


Subtypes of ASD. A: sinus venosus; B: ostium secundum; C: ostium primum; D: unroofed coronary sinus

Mayo Clinic Foundation

ASD closure – how common?

patient Sample
ASD/patent



- ASD device
  secundum
  fenestratio

Moore J, Hegde S, El-Said H, et al. Transcatheter device closure of atrial septal defects: a safety review. JACC Cardiovasc Interv 2013;6:433-42.

Complications

- Typical Anesthesia Management:
  - General Anesthesia following any right heart catheter measurements for Qp:Qs (cardiologist may want to do this on room air)
  - TEE monitoring
  - IV access and standard ASA monitors
  - Arterial line only for patients with severe heart disease
  - Aggressive removal of air from IV lines etc

Mitra – Clip for Mitral Regurgitation

- Percutaneous approach to Alfieri repair (1991) – or the edge to edge repair
- FDA approval for Mitra-clip in 2013
- Indicated for patients with severe MR and high surgical risk
  - Ideally used for Type II and Type IIIb patients with functional MR

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doi:10.1016/j.jacc.2011.08.067

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Acute and 12-Month Results With Catheter-Based Mitral Valve Leaflet Repair

The EVEREST II (Endovascular Valve Edge-to-Edge Repair) High Risk Study

Patrick L. Whitlow, MD,* Ted Feldman, MD,† Wes R. Pedersen, MD,‡ D. Scott Lim, MD,§ Robert Kipperman, MD,‖ Richard Smalling, MD, PHD,¶ Tanvir Bajwa, MD,# Howard C. Herrmann, MD,** John Lasala, MD, PHD,†† James T. Maddux, MD,‡‡ Murat Tuzcu, MD,* Samir Kapadia, MD,* Alfredo Trento, MD,§§ Robert J. Siegel, MD,§§ Elyse Foster, MD,‖‖ Donald Glower, MD,¶¶ Laura Mauri, MD,## Saibal Kar, MD,§§ on behalf of the EVEREST II Investigators

Cleveland, Ohio; Chicago, Illinois; Minneapolis, Minnesota; Charlottesville, Virginia; Oklahoma City, Oklahoma; Houston, Texas; West Bend, Wisconsin; Philadelphia, Pennsylvania; Missoula, Montana; Los Angeles and San Francisco, California; Durham, North Carolina; and Boston, Massachusetts

EVEREST SUMMARY

- First arm → 279 patients with 3 or 4+ MR randomized to Mitral clip vs surgical repair
  - 12-month results demonstrated equivalent mortality, improved efficacy with surgery vs Mitral Clip (73% vs 55%), yet reduced adverse events compared to the surgical group.

EVEREST SUMMARY

- Second arm (Everest II trial) → High Risk Study (HRS) which looked at high surgical risk patients (>12% estimated mortality) with grade III/IV MR.
  - Compared retrospectively to "comparator" group
  - Device repair was achieved in in 96% of the 76 patients.
  - 12-month survival rate was 76% for intervention group and 55% for control group. The intervention group also demonstrated reduction in MR severity, LV volume, improvement in NYHA classification, and improved quality of life indicators

Evidence:

Heart. 2013 Jun 27. [Epub ahead of print]

- Surgical Repair probably more durable and effective
- High Risk patients have low procedural mortality and functional improvement after Mitra-clip repair
- Viable option for many high surgical risk patients

MitraClip® System

Anesthetic Management:

- Induction as with any High Risk cardiac patient with Severe MR
- Relative increase in HR, without impairing LV function
- Arterial Line access
- TEE montoring
- +/- Central access

Radiation Safety

- Staff and physician awareness (ALARA)
- Time, Distance, Shielding
- Personal protection tools
  - Lead aprons
  - Thyroid shields
  - Eye protection
  - Hand protection
- Radiation Dose

Radiation risk to Anesthesia

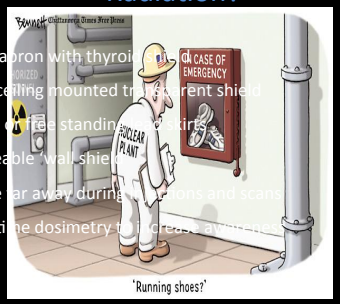
- Radiation
  - Radiation exposure to operating room personnel and patients during endovascular procedures. Mohapatra et al. Journal of Vacular Surgery, 58 (3), 701, 2013.
  - Highest for anesthesia providers!
  - 15x higher than the dose received by the scrub nurse
  - Attributed to the lack of effective shielding, which was available but not utilized due to inconvenience
  - Effective shielding can reduce radiation dose by up to 80%
  - Real time dosimeter increases awareness

Making sense of radiation units

- NY to LA flight 40 µSv
- Chest Xray: 20 µSv
- One EVAR average exposure 38 – 112 µSv
- Anesthesia exposure 268 µSv
- CT spin: up to 5 mSv
- Yearly limit: 50mSv

How to protect ourselves from Radiation?

- Lead apron with thyroid
- Two ceiling mounted tr current shield
- Table coffee standing skirts
- Moveable 'wall shield
- Move far away during ions and scans
- Real time dosimetry to decrease awareness



Structural interventions

- Discuss the plan with Interventional Team
  - Impact when to induce general anesthesia
  - Impact degree of monitoring
- Keep in mind the risk of failure – and the need to mobilize the OR urgently when needed
- Advanced TEE training is needed to help guide many of these procedures.