Updates on Minimally Invasive Surgery: Valvular Heart Disease, Repair or Replace?

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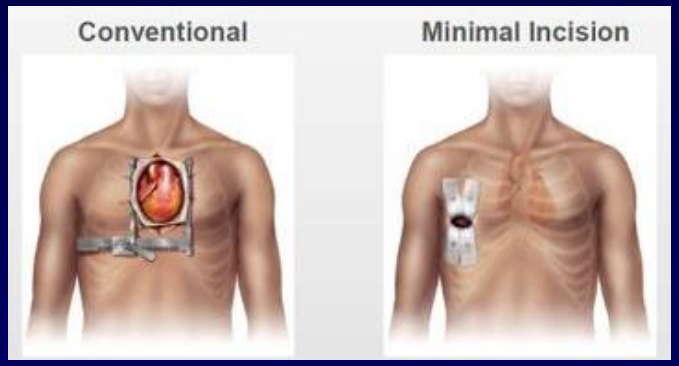
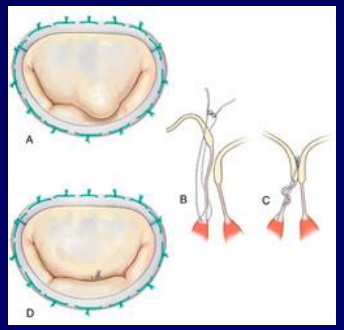
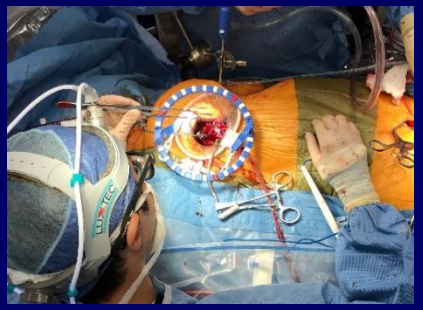
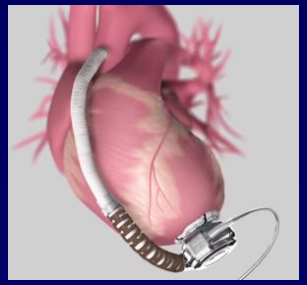


Spring Update in Cardiology Symposium May 4th 2018. Hyatt Regency Hotel. Tulsa, OK.







Presenter Disclosure Information

Updates on Minimally Invasive Surgery: Valvular Heart Disease, Repair or Replace?

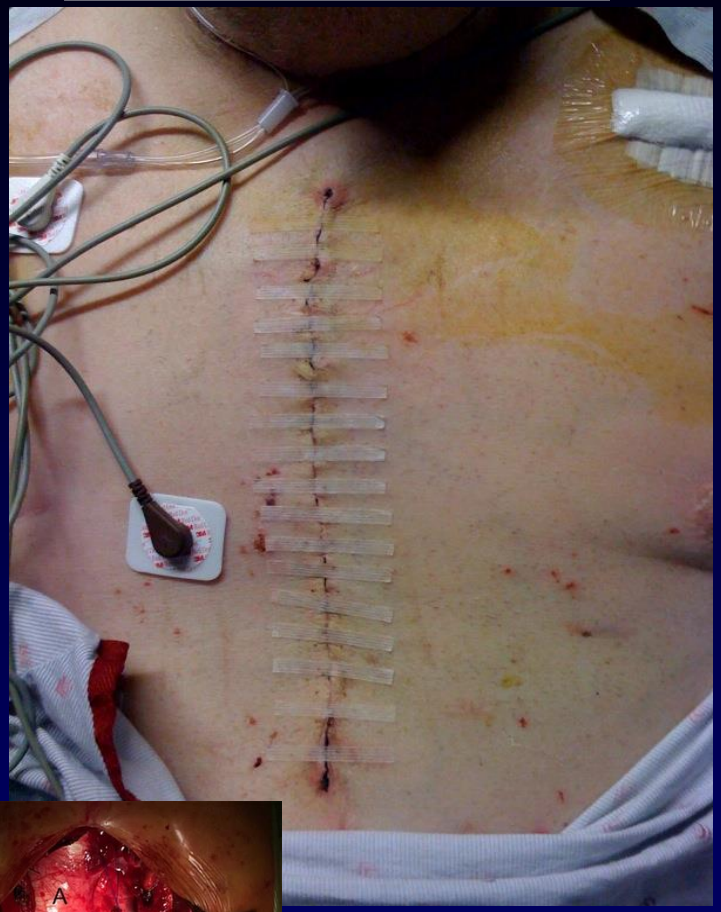
DISCLOSURE INFORMATION:

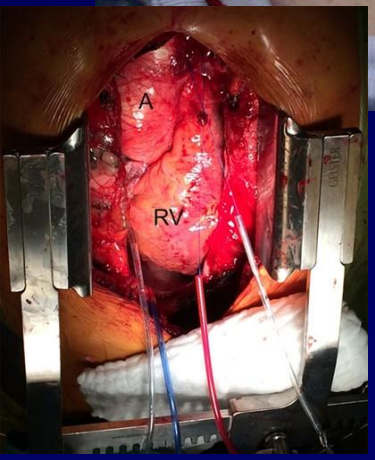
The following relationships exist related to this presentation:

Allen Cheng	**- Presenter for Thoratec and Heartware**
	- No financial relationship disclosure

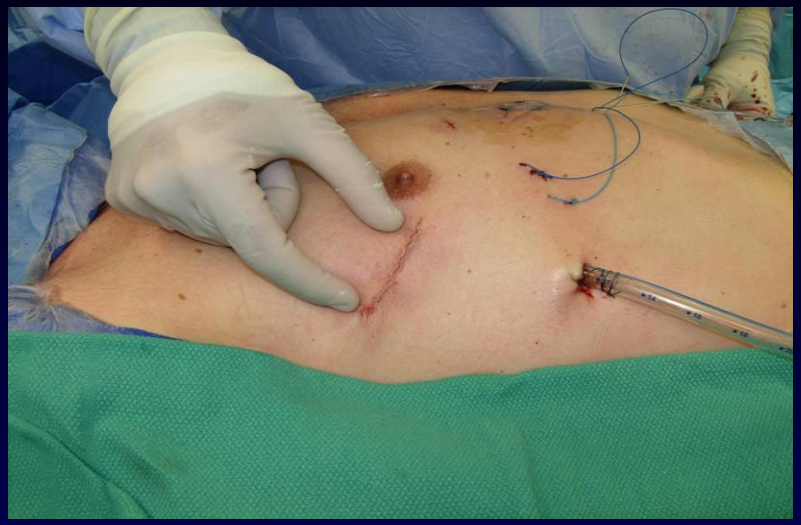
Which would you prefer?

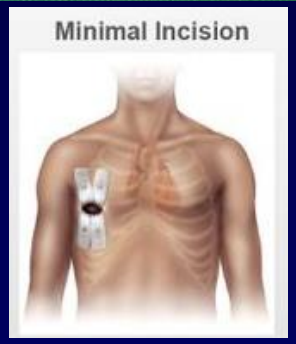
Sternotomy





Minimally invasive



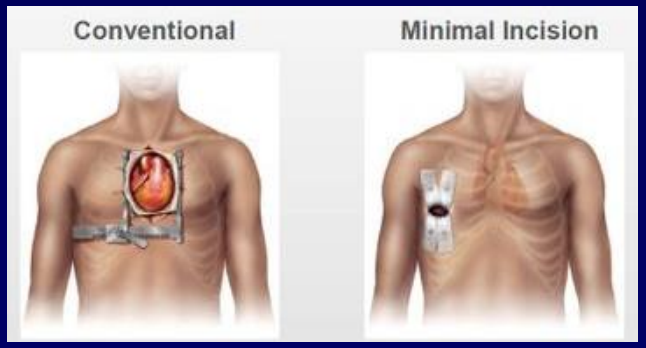


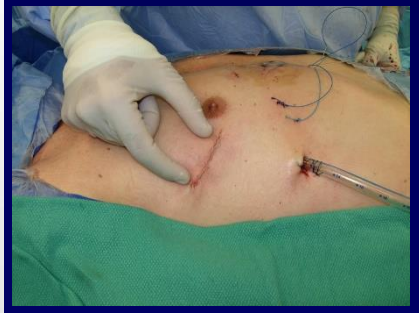
Minimally Invasive Heart Surgery (Key hole surgery)

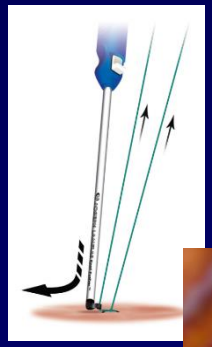
In minimally invasive heart surgery (MIS), aka keyhole surgery, the surgeon performs heart surgery through a smaller incisions without splitting the breastbone (sternotomy) or making a long incision.

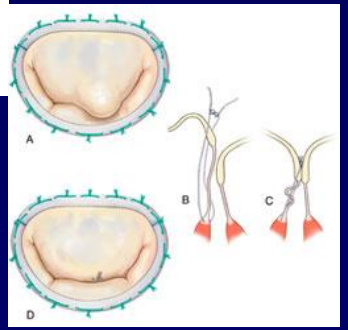
Rather, the surgeon operates through small incisions with specialized instruments, which will result in less pain and trauma and a much quicker recovery for many patients.

This approach will also allow the surgeon to have a better view of certain parts of the heart, and therefore provide a better and more comprehensive operation.



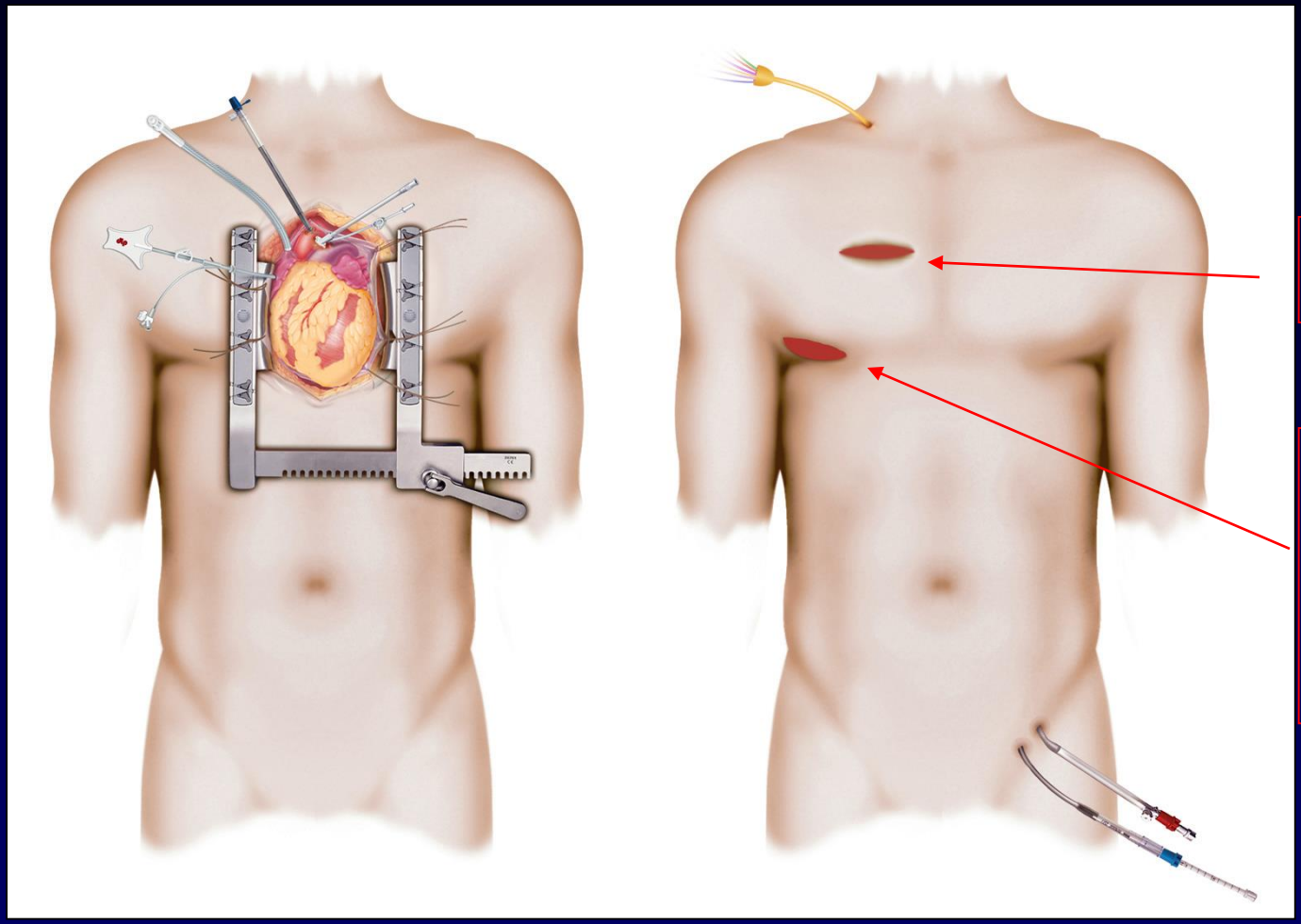






Full Sternotomy

MIS

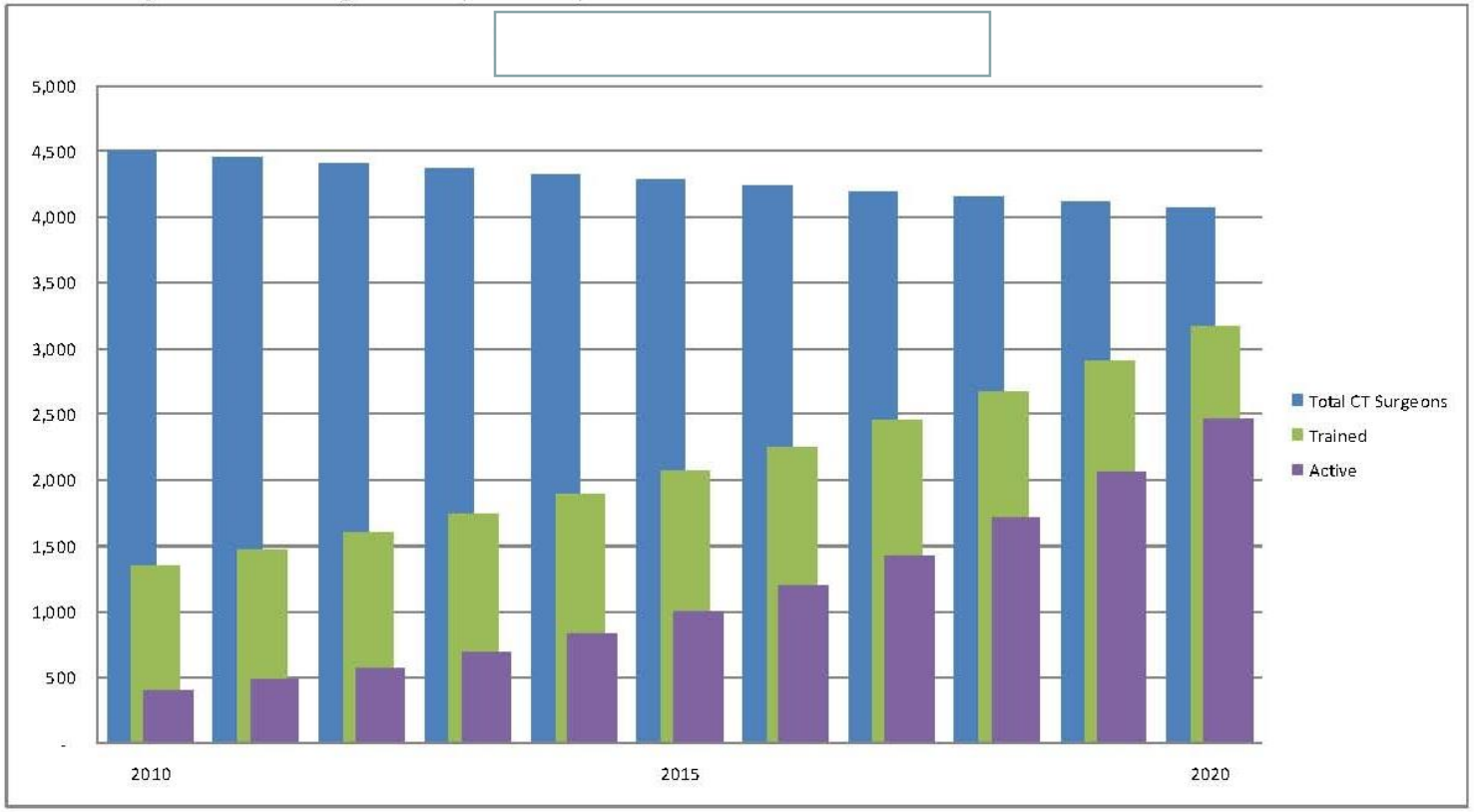


Aorta and Aortic Valve

Mitral Valve
Tricuspid Valve
Congenital Defect
Atrial Fibrillation
Coronary Artery Disease
Cardiac Tumor

Minimally Invasive Heart Surgery

Figure 11: Projected MICS growth (level –I) trend United States.



Source: Report Estimate.

A Decade of Minimally Invasive Mitral Repair: Long-Term Outcomes

Aubrey C. Galloway, MD, Charles F. Schwartz, MD, Greg H. Ribakove, MD, Gregory A. Crooke, MD, George Gogoladze, MD, Patricia Ursomanno, PhD, Margaret Mirabella, MSN, Alfred T. Culliford, MD, and Eugene A. Grossi, MD

Department of Cardiothoracic Surgery, New York University Medical Center, New York, New York

NYU

N = 1601

MICS: 10-yr freedom from reoperation is 95%±1%

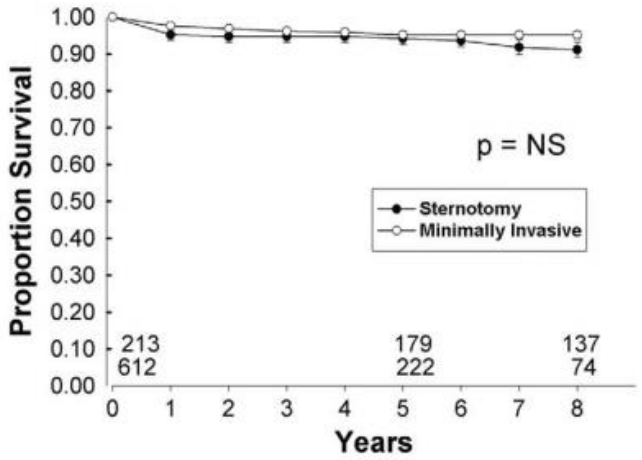


Fig 2. Comparison of standard sternotomy (solid circles) and minimally invasive approach (open circles) for freedom from reoperation in isolated mitral valve repairs. (NS = not significant.)

Survival

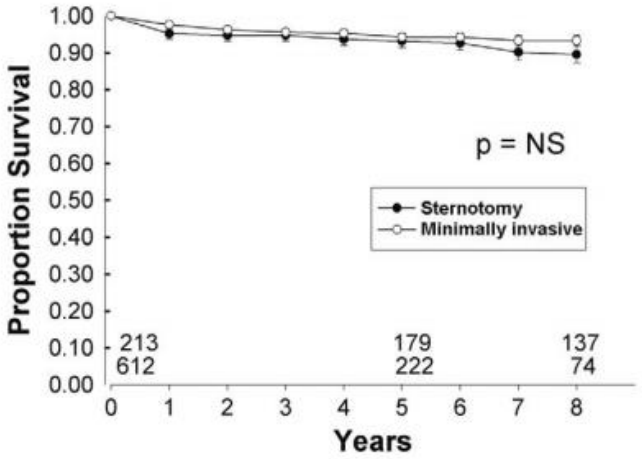


Fig 3. Comparison of standard sternotomy (solid circles) and minimally invasive approach (open circles) for freedom from reoperation or severe mitral insufficiency in isolated mitral valve repairs. (NS = not significant.)

Freedom from Reoperation

Galloway AC, Schwartz CF, Ribakove GH, et al. A decade of minimally invasive mitral repair: long-term outcomes. Ann Thorac Surg 2009;88:1180–4.

J Thorac Cardiovasc Surg 2011;142:1507-14

Less post-op complications

Shorter hospital stay: Average length of stay 9.8 (ST) vs 7.7 (MIS) days (p=0.0043)

A higher proportion of MIS patients discharge home (p=0.018) instead of rehab

A lower readmission rate within 1 year (p=0.023)

Lower Transfusion Rate

TABLE 6. In-hospital complications, short-term survival, discharge location, and readmissions

	ST (n = 217)	MI (n = 217)	*P* value
Complications			
Gastrointestinal bleed	1 (0.46%)	1 (0.46%)	1.0
Intubation > 72 h	18 (8.3%)	6 (2.8%)	.019
Renal failure	6 (2.8%)	2 (0.92%)	.284
Reoperation for bleeding	7 (3.2%)	4 (1.8%)	.544
Sepsis	2 (0.92%)	3 (1.4%)	1.0
Stroke (< 24 h)	3 (1.4%)	1 (0.46%)	.623
Stroke (≥ 24 h)	4 (1.8%)	2 (0.92%)	.685
Transmural myocardial infarction	0	0	1.0
Mortality			
Thirty-day mortality	3 (1.4%)	6 (2.8%)	.503
One-year mortality	12 (5.5%)	10 (4.6%)	.827
Discharge location	(n = 204)	(n = 202)	
Home with no nursing services	111 (54.4%)	135 (66.8%)	.018
Home with nursing aide	63 (30.9%)	52 (25.7%)	
Skilled nursing facility	16 (7.8%)	5 (2.5%)	
Short-term, acute rehabilitation	2 (0.98%)	0	
Other rehabilitation facility	12 (5.9%)	10 (5.0%)	
Readmission	(n = 205)	(n = 207)	
No readmissions within 1 y	177 (86.3%)	193 (93.2%)	.023
≥ 1 readmission within 1 y	28 (13.7%)	14 (6.8%)	
Cardiac surgery	3 (10.7%)	2 (14.3%)	
Pacemaker insertion	4 (14.3%)	3 (21.4%)	
PCI	4 (14.3%)	1 (7.1%)	
Arrhythmia	6 (21.4%)	4 (28.6%)	
Chest pain or CHF	6 (21.4%)	1 (7.1%)	
CVA/TIA	2 (7.1%)	1 (7.1%)	
Pleural effusion	3 (10.7%)	2 (14.3%)	

Comparative effectiveness of minimally invasive versus traditional sternotomy mitral valve surgery in elderly patients

Columbia U

Alexander Iribarne, MD, MS,[a] Rachel Easterwood, BA,[a] Mark J. Russo, MD, MS,[b] Edward Y. Chan, MD,[a] Craig R. Smith, MD,[a] and Michael Argenziano, MD[a]

J Thorac Cardiovasc Surg 2012;143:S86-90

Pt > 75 y/o

N = 1005 patients

Less post-op complications (p=0.01) and long-term survival (p = 0.6)

3.1 day shorter hospital stay (p=0.033)

MIS approach has more pt discharge to home than rehab (p=0.021)

ADULT CARDIAC

What Is the Role of Minimally Invasive Mitral Valve Surgery in High-Risk Patients? A Meta-Analysis of Observational Studies

Marco Moscarelli, MD, Khalil Fattouch, MD, PhD, Roberto Casula, MD, Giuseppe Speziale, MD, PhD, Patrizio Lancellotti, MD, PhD, and Thanos Athanasiou, MD, PhD

National Heart and Lung Institute and Department of Surgery and Cancer, Imperial College London, London, United Kingdom; GVM Care and Research, Villa Maria Eleonora, Palermo; GVM Care, Anthea Hospital, Bari, Italy; Department of Cardiology, University of Liège Hospital, Liege, Belgium; and the GVM Care and Research Group

Ann Thorac Surg 2016;101:981-9.

Meta Analysis

N = 1254 patients

Table 5. Results of High-Quality Studies (More Than 7 EuroSCORE II Risk Factors or Quality Score > 7)

Outcome	N		Mean Difference	Overall Effect			Heterogeneity		
	Studies = 4	MIMVS	ST	Odds Ratio	95% CI	*p* Value	χ^2	*p* Value	I^2
Primary outcome									
Early mortality		325	366	0.97	0.45 to 2.10	0.93	4.25	0.24	29%
Secondary outcomes									
~~CPB time~~	~~325~~	~~366~~	~~33.45~~		~~19.58 to 86.48~~	~~0.22~~	~~854.36~~	~~<0.00001~~	~~99%~~
Number of units PRC transfused[a]		255	261	−1.57	−3.04 to −0.10	0.04	7.55	0.02	74%
~~Inotropes~~	~~325~~	~~366~~		~~1.07~~	~~0.68 to 1.68~~	~~0.78~~	~~3.78~~	~~0.15~~	~~47%~~
Stroke[a]		303	338	0.35	0.15 to 0.82	0.02	1.67	0.43	0%
~~Reopening for bleeding~~	~~325~~	~~366~~		~~1.19~~	~~0.65 to 2.18~~	~~0.58~~	~~4.67~~	~~0.20~~	~~36%~~
~~Prolonged intubation[b]~~	~~325~~	~~366~~		~~0.68~~	~~0.43 to 1.08~~	~~0.11~~	~~3.21~~	~~0.36~~	~~8%~~
AF[ab]		255	261	0.49	0.32 to 0.74	0.0007	0.52	0.77	0%
~~Acute renal failure[b]~~	~~303~~	~~338~~		~~0.66~~	~~0.28 to 1.25~~	~~0.17~~	~~2.86~~	~~0.24~~	~~30%~~
AV block requiring PM implant[b]		255	261	0.53	0.24 to 1.20	0.13	2.93	0.23	32%

[a] Denotes significance. [b] High-sensitivity studies already part of the overall meta-analysis results.

AF = atrial fibrillation; AV = atrioventricular; CI = confidence interval; CPB = cardiopulmonary bypass; MIMVS = minimally invasive mitral valve surgery; PM = pacemaker; PRC = packed red cells; ST = sternotomy.

Minimally Invasive patients (including high risks patients) has better postoperative outcomes:

Lower unit of blood transfusion needed (p=0.0006)

Lower Stroke rate (p=0.02)

Lower Atrial fibrillation rate (p=0.0007)

Incidence of postoperative atrial fibrillation in patients undergoing minimally invasive versus median sternotomy valve surgery

Christos G. Mihos, DO,[a] Orlando Santana, MD,[a] Gervasio A. Lamas, MD,[a] and Joseph Lamelas, MD[b]

Miami

Ann Thorac Surg 2016;101:981-9.

N = 571 (413 MIS vs 158 open)

Post-op A.fib (MIS vs open; 25% vs. 37%, p=0.002)

Shorter intubation time (>24 hrs) (12% vs. 20%, p=0.008)

Hospital/ICU Stay Duration (5 vs 8 days, p=0.008)

TABLE 3. Operative results and clinical outcomes

Variables	Minimally invasive (n = 413)	Median sternotomy (n = 158)	*P* value
Mortality	4 (0.9%)	1 (0.6%)	.7
Bleeding requiring reoperation	7 (1.7%)	4 (2.5%)	.52
Deep wound infection	0	1 (0.6%)	.11
Stroke	4 (0.9%)	1 (0.6%)	.7
Prolonged intubation (>24 h)	48 (12%)	32 (20%)	.008
Intensive care unit length of stay (h, median, IQR)	45 (28-66)	53 (45-91)	<.001
Intensive care unit readmission	10 (2%)	10 (6%)	.02
Hospital length of stay (d, median, IQR)	5 (4-7)	8 (6-11)	<.001
Postoperative AF	101 (25%)	59 (37%)	.002

SD, Standard deviation, *IQR*, interquartile range; *AF*, atrial fibrillation.

Outcomes of Minimally Invasive Triple Valve Surgery Performed Via a Right Anterior Thoracotomy Approach

Hany M. Elmahdy[1], Francisco O. Nascimento[2], Orlando Santana[2], Joseph Lamelas[3]

[1]Department of Internal Medicine, Mount Sinai Medical Center, [2]Columbia University Division of Cardiology, [3]Department of Cardiac Surgery, Mount Sinai Heart Institute, Miami Beach, Florida, USA.

Columbia U

Outcomes of minimally invasive double valve surgery

Orlando Santana[1], Steve Xydas[1], Roy F. Williams[1], Angelo LaPietra[1], Maurice Mawad[1], Frederick Hasty[2], Esteban Escolar[1], Christos G. Mihos[3]

[1]Division of Cardiology, Mount Sinai Heart Institute, the Columbia University, Miami Beach, FL, USA; [2]Department of Anesthesia, Mount Sinai Medical Center, Miami Beach, FL, USA; [3]Cardiac Ultrasound Laboratory, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

Contributions: (I) Conception and design: O Santana, CG Mihos; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: O Santana, CG Mihos; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Mount Sinai

Masters of Cardiothoracic Surgery

Concomitant minithoracotomy aortic and mitral valve surgery: the minimally invasive "Miami Method"

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View this article at: http://dx.doi.org/10.3978/j.issn.2225-319X.2014.09.14

Miami

- Mitral + Tricuspid
- Mitral + Aortic
- Mitral + Aortic + Tricuspid
- Aortic + Tricuspid

Journal of Heart Valve Disease 2013;22:735-739
Journal of Thoracic Disease 2017 [ePud]

Minimally Invasive Heart Surgery

Benefits

Less Pain / No bone division / Less tissue trauma

Shorter recovery time and more rapid return to normal activity level

Reduce length of hospital stay

Less blood loss / decreased blood transfusion rate (less tissue trauma)

Lower wound infection rate (smaller incision)

Lower risk for pneumonia (ambulate earlier, cough better with less pain)

Better cosmetics (smaller incision)

Better and direct visualization of valves for better repair and replacement (better visualization than sternotomy)

MICS

Indications:

Mitral Valve Repair and Replacement

Tricuspid Valve Repair and Replacement

Aortic Valve Rapair and Replacement

Coronary Artery Bypass

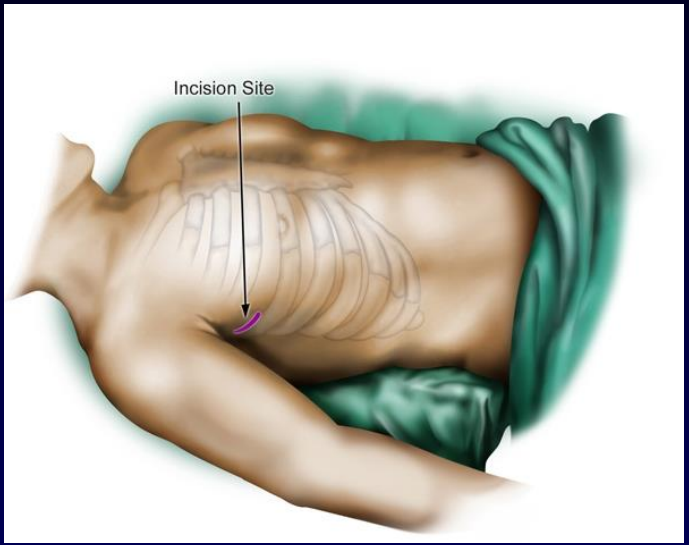
Atrial Fibrillation / MAZE and Left Atrial Appendage Ligation

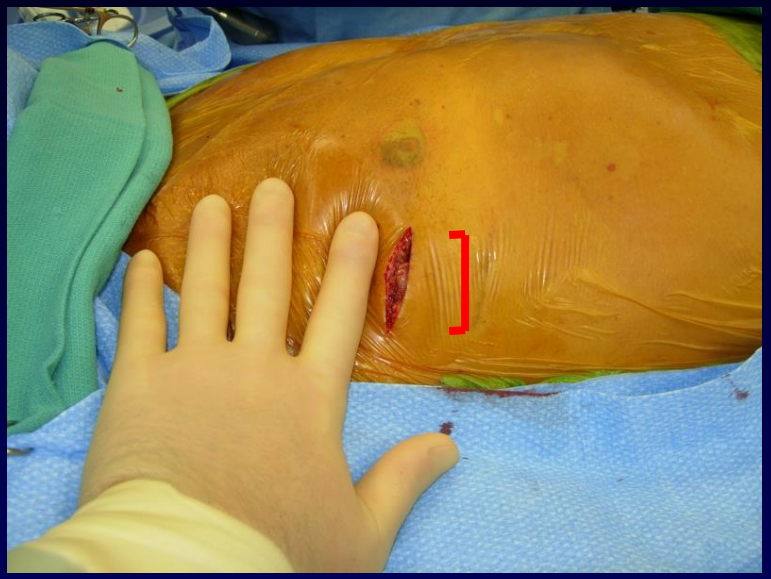
Congenital Heart Defect (Atrial Septal Defect and patent ductus ovale)

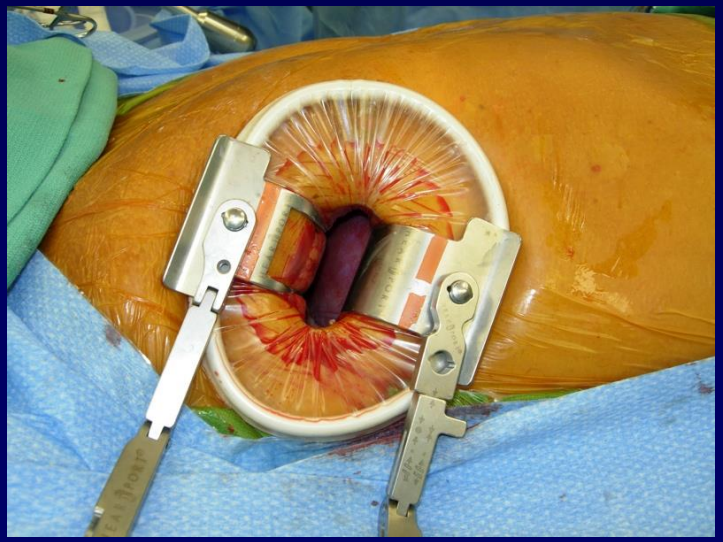
Atrial Myxoma

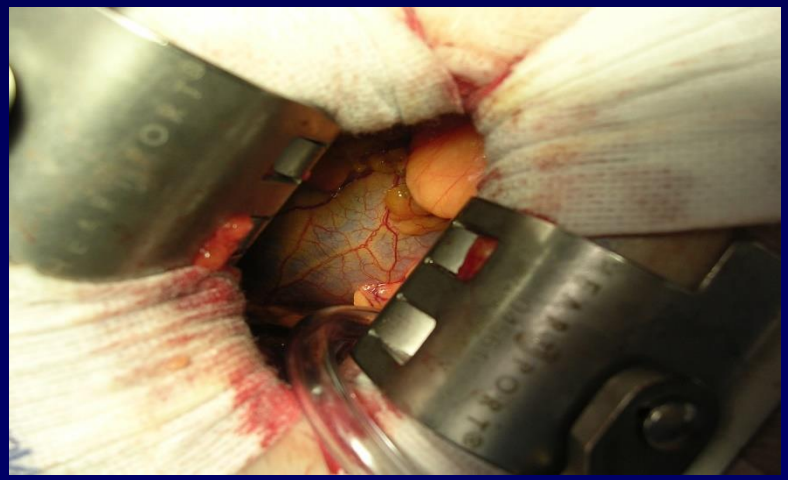
LVAD – Heart Failure

Right mini-thoracotomy for Mitral, Tricuspid, Congeital Defect, A.fib, Myxoma

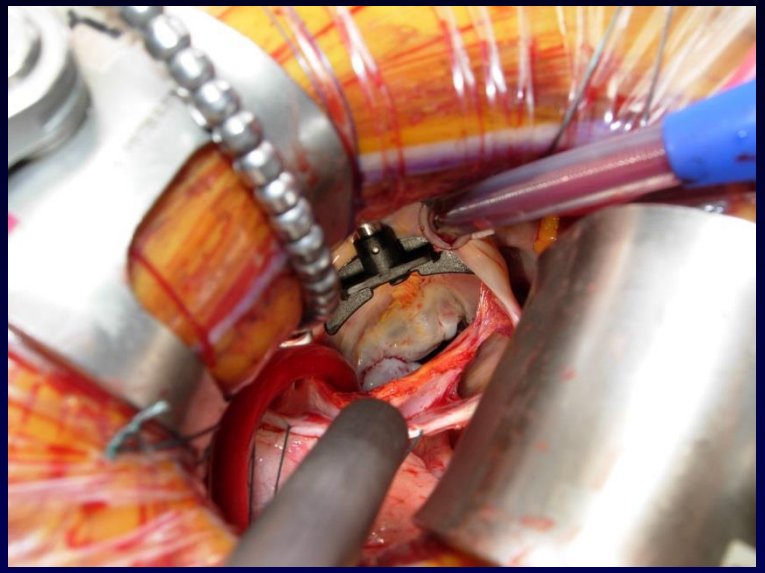


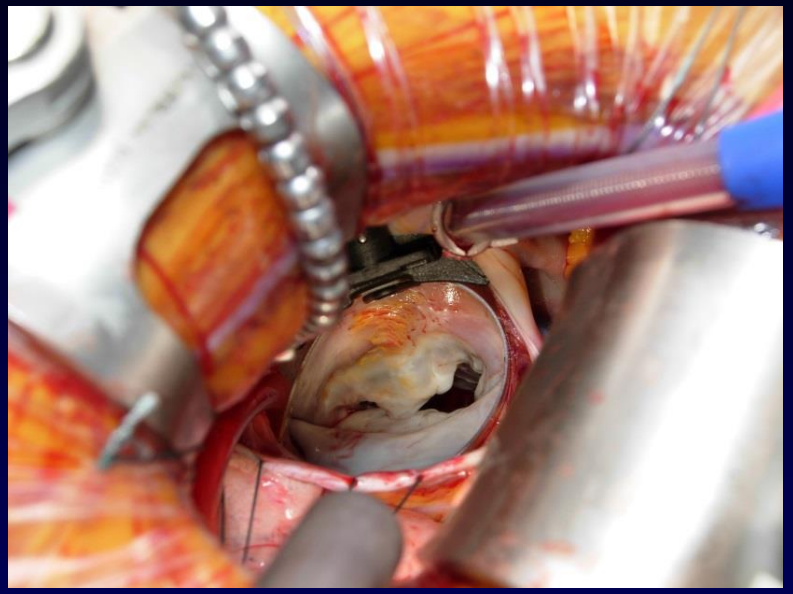


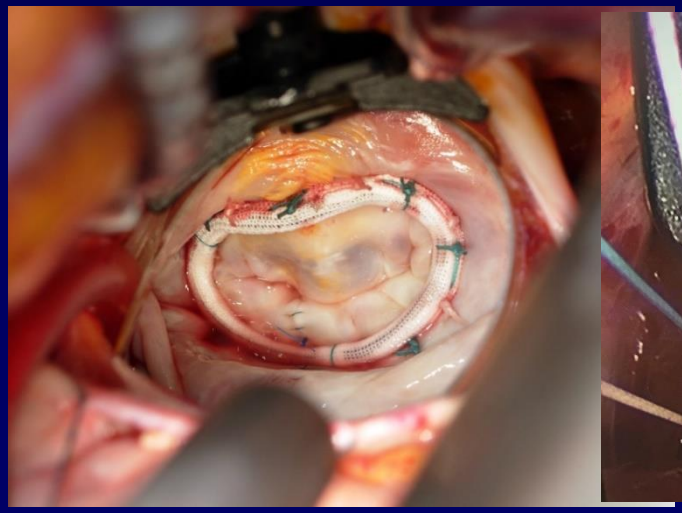


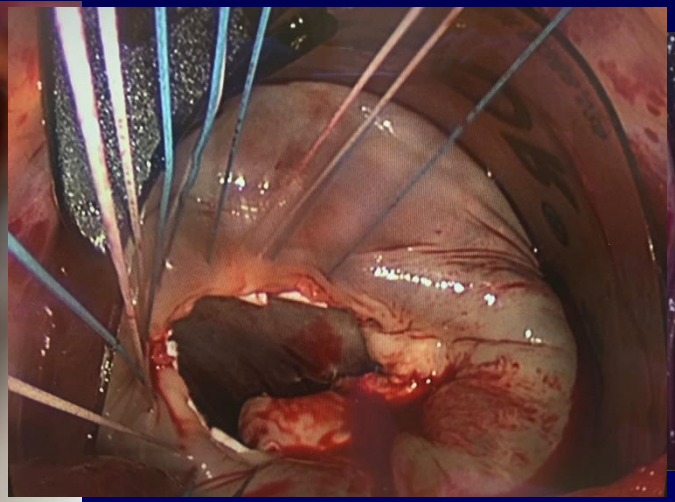


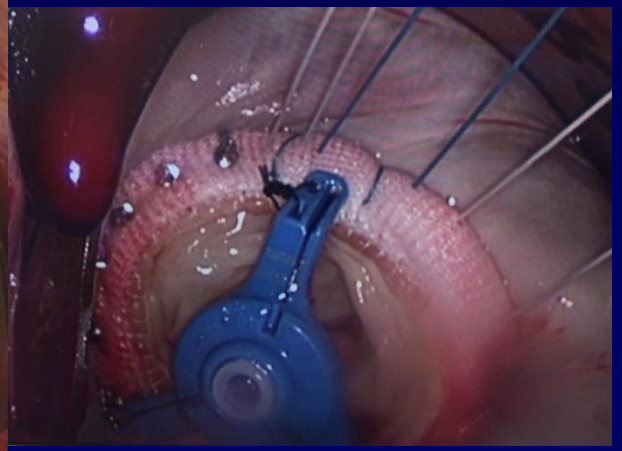
Mitral valve repair and replacement











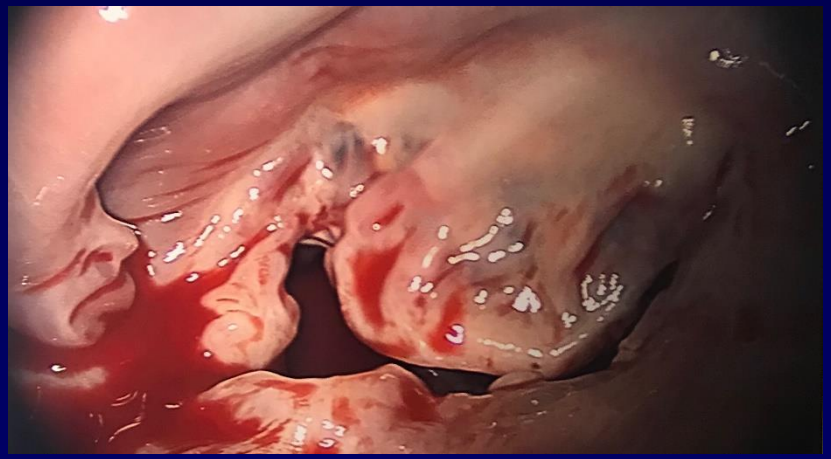
Case Presentations

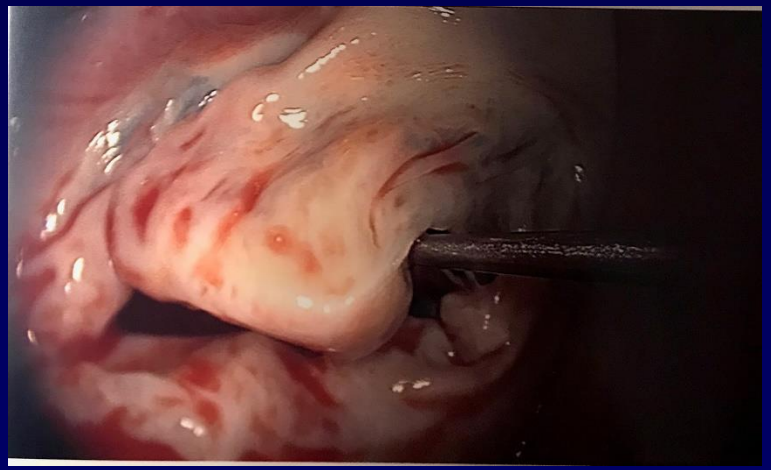
(Recent cases done in Tulsa at OHI/HHS)

1. Minimally Invasive Mitral Valve Replacement

77 y/o lady

Rheumatic
Mitral
Regurgitation



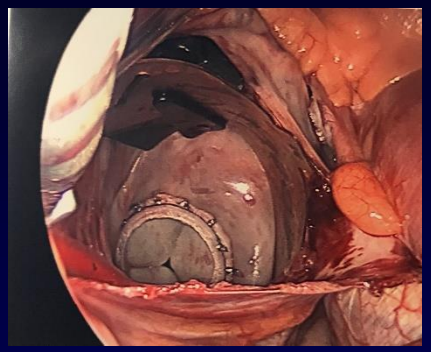


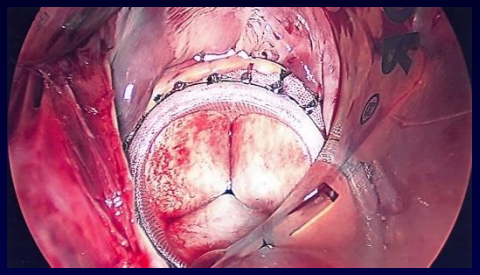
hillcrest Hospital | South

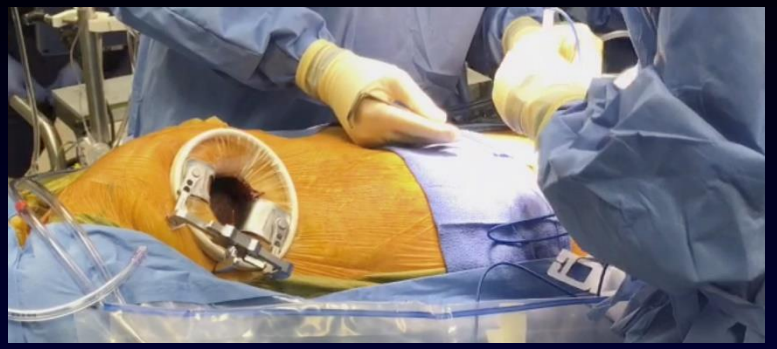
Oklahoma Heart Institute

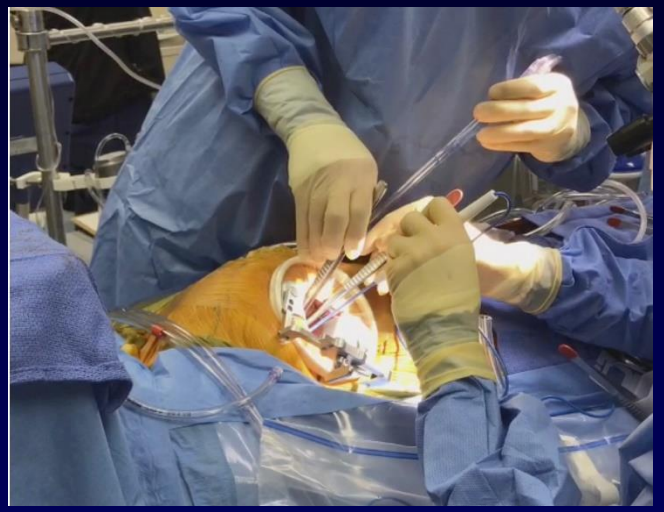
77 y/o lady w/ rheumatic Mitral Regurgitation

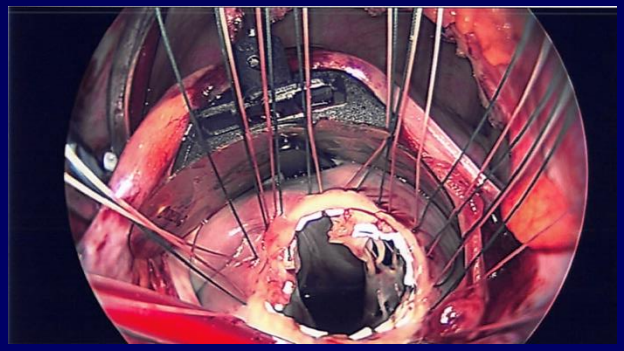
Minimally Invasive Mitral Valve Replacement





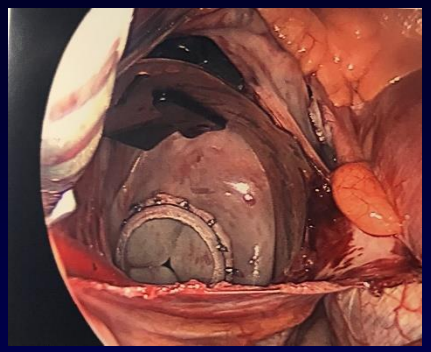


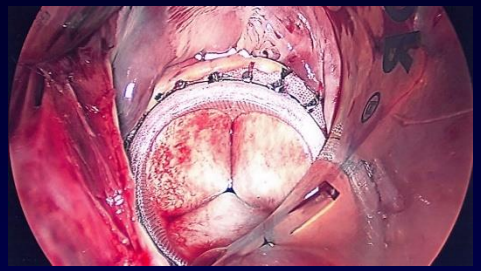


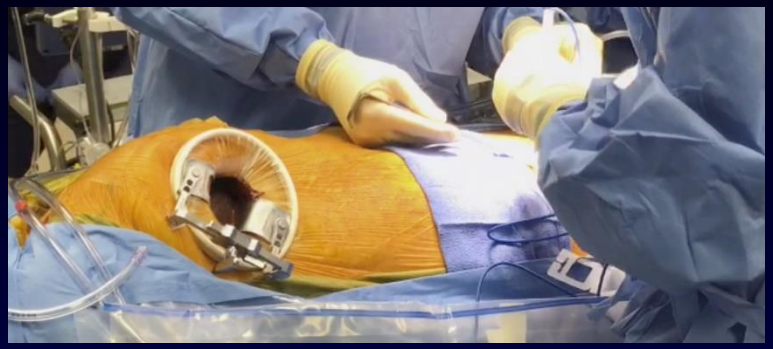


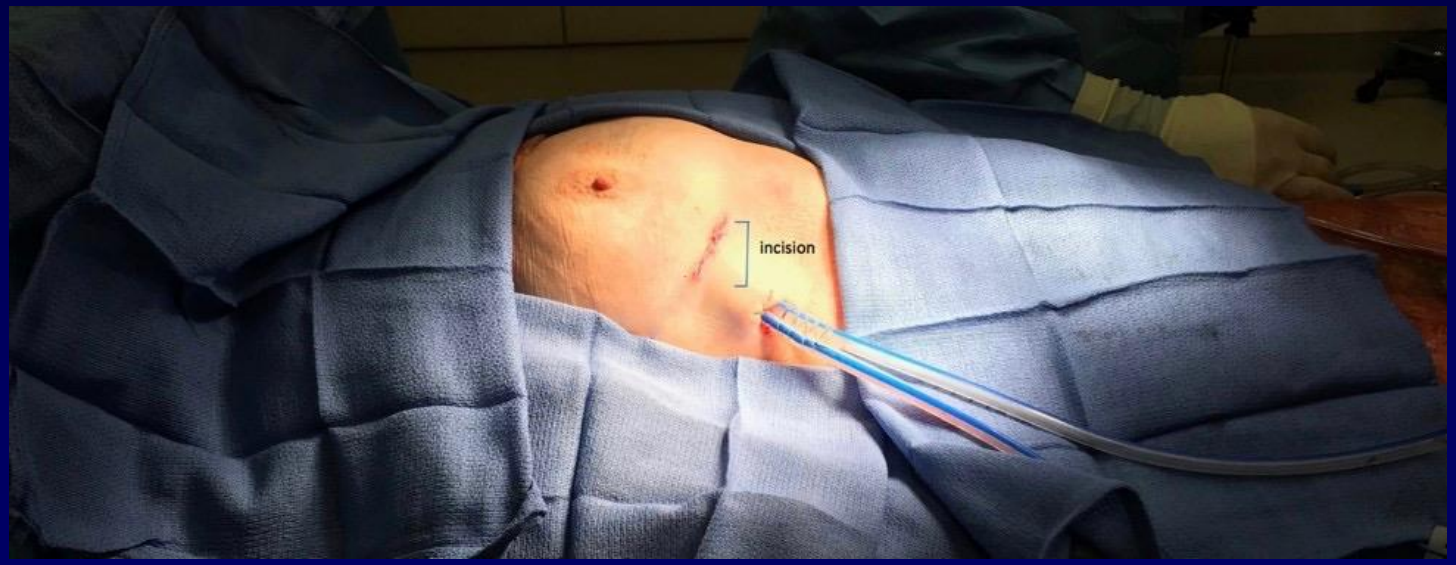
77 y/o lady w/ rheumatic Mitral Regurgitation

Minimally Invasive Mitral Valve Replacement









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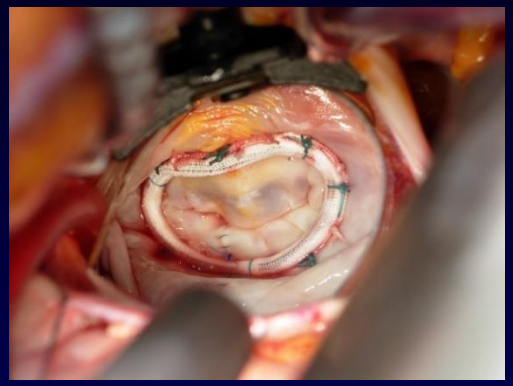
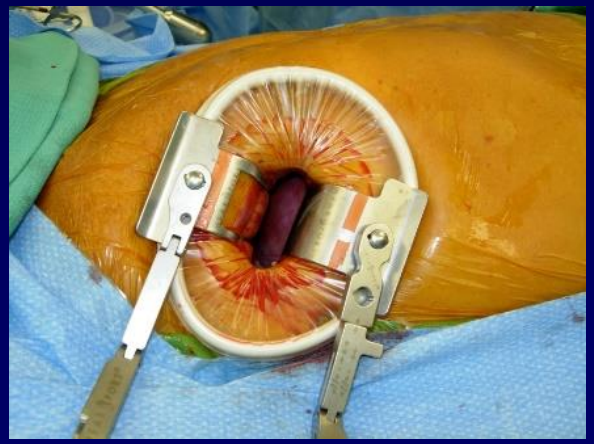
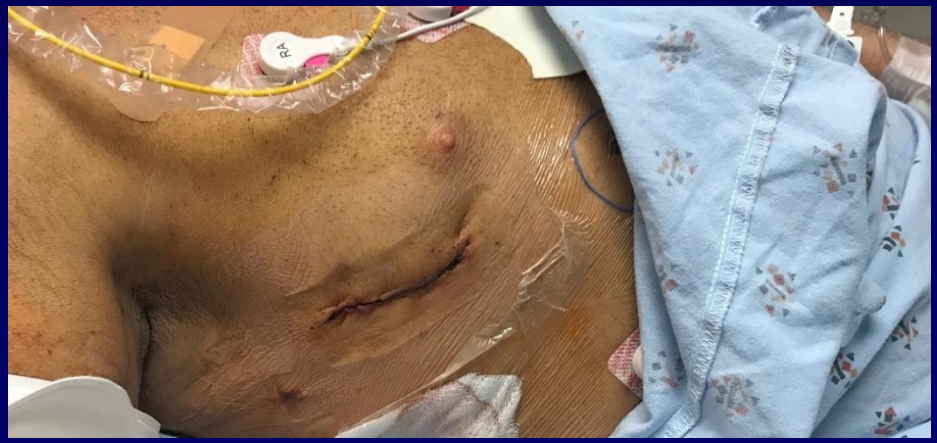
2. Minimally Invasive Mitral Valve Repair

74 y/o gentleman w/ severe mitral regurgitation / Bileaflet prolapse/ Mutliple Regurgitation Jets



Mini Invasive Mitral Valve Repair





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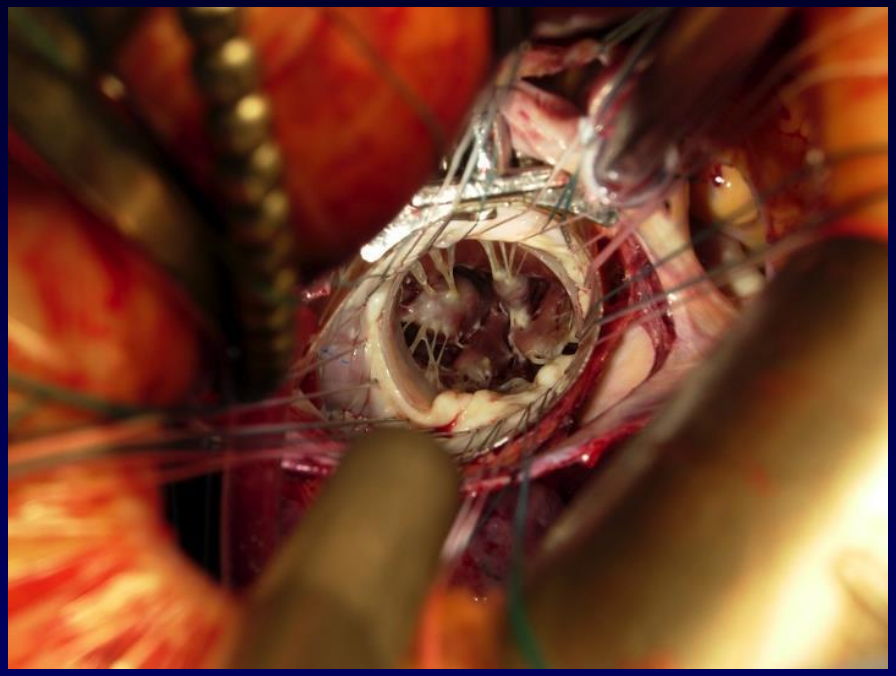
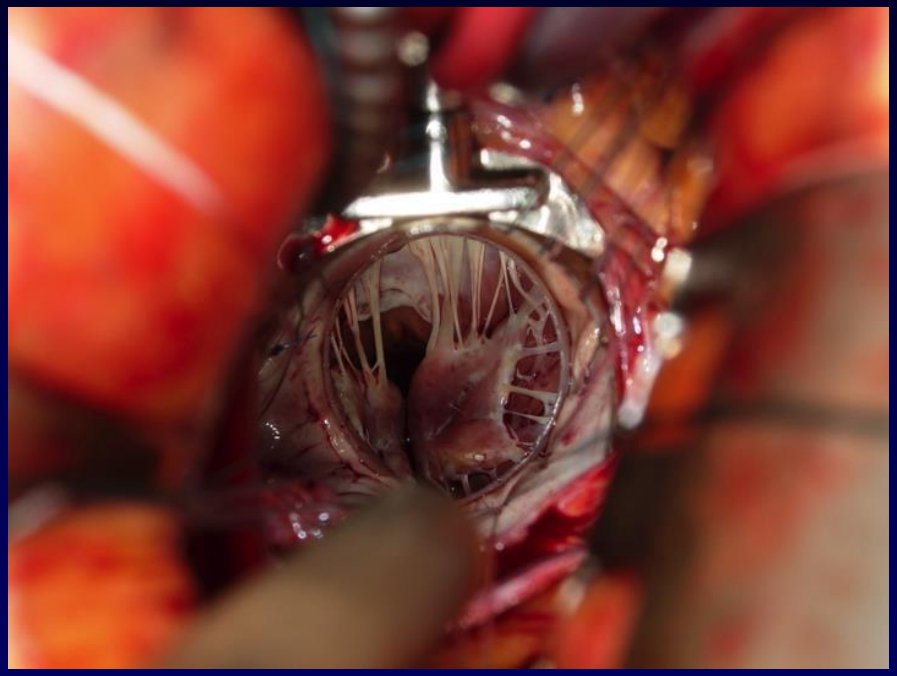
Great visualization of the subvalvular apparatus for mitral valve repair

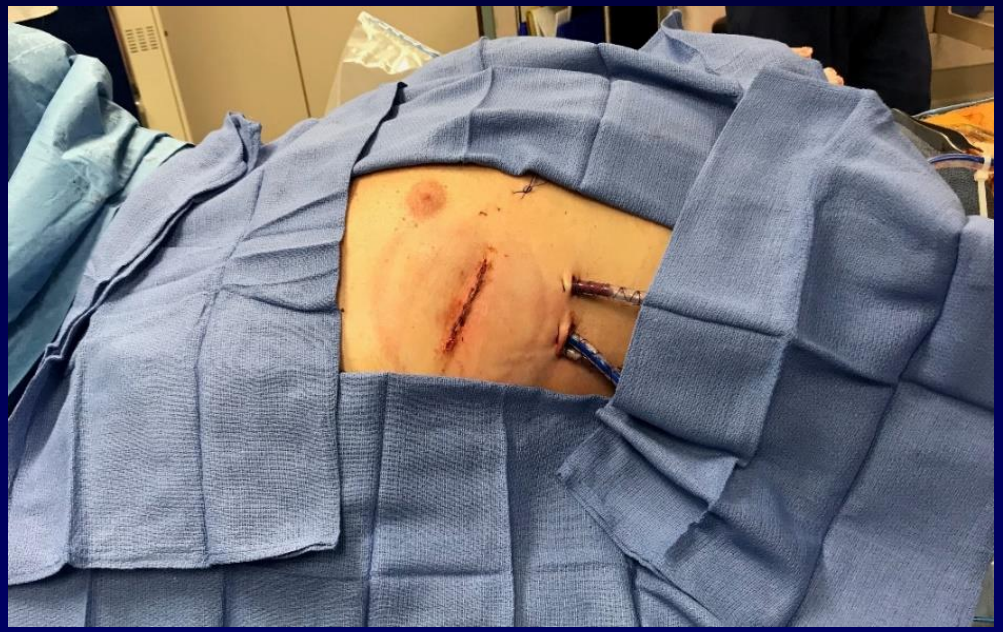


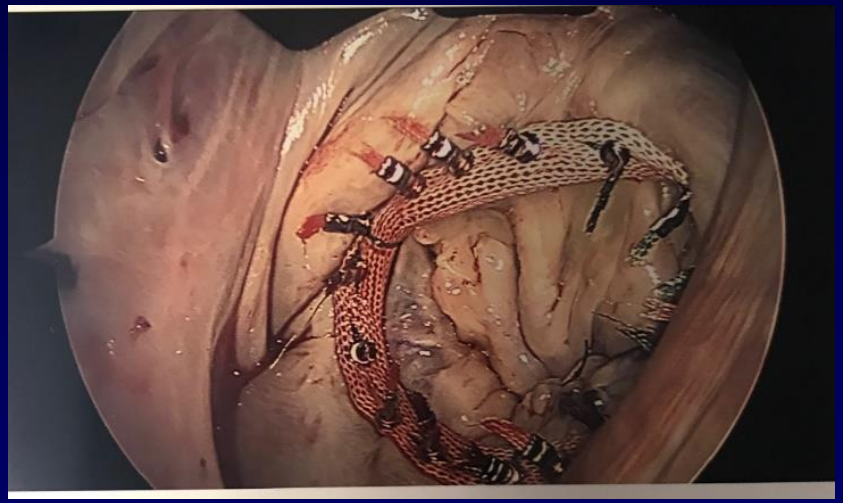


Mitral Valve Repair

60 y/o gentleman w/ mitral regurgitation, posterior leaflet prolapse

Mini Invasive Mitral Valve Repair





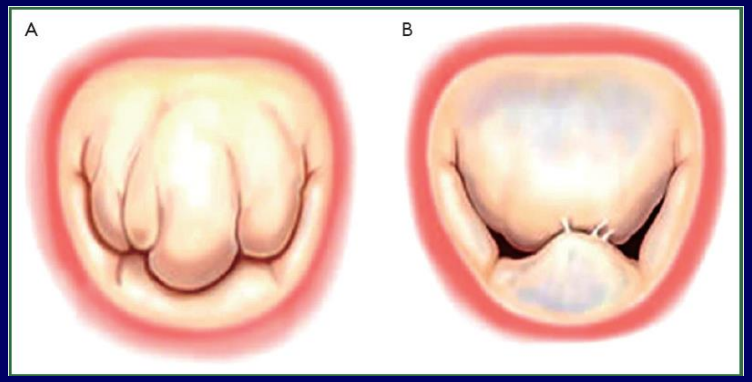
48 y/o gentleman w/ Barlow's mitral regurgitation

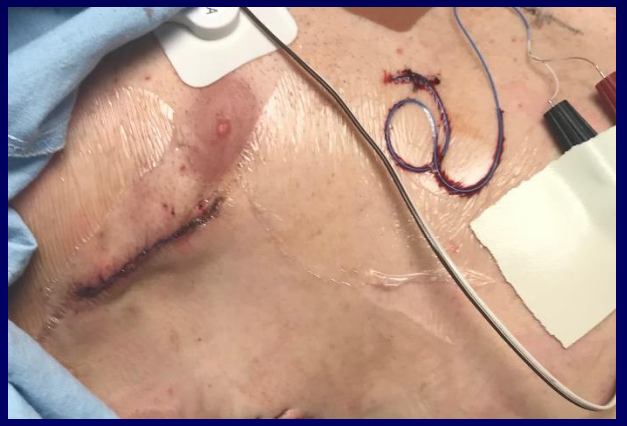
Mini Invasive Mitral Valve Repair

Barlow's mitral regurgitation

Redundant Valve Tissue w/ bi-leaflet prolapse

Experienced, skilled Heart Surgeon





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CLINICAL PRACTICE GUIDELINE: FOCUSED UPDATE

2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines

Developed in Collaboration With the American Association for Thoracic Surgery, American Society of Echocardiography, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

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Recommendations for Chronic Primary MR Intervention

COR	LOE	RECOMMENDATIONS
I	B	Mitral valve surgery is recommended for symptomatic patients with chronic severe primary MR (stage D) and LVEF greater than 30% (73-75).
I	B	Mitral valve surgery is recommended for asymptomatic patients with chronic severe primary MR and LV dysfunction (LVEF 30% to 60% and/or left ventricular end-systolic diameter [LVESD] ≥40 mm, stage C2) (76-82).
I	B	Mitral valve repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR limited to the posterior leaflet (83-99).
I	B	Mitral valve repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR involving the anterior leaflet or both leaflets when a successful and durable repair can be accomplished (84,89,95,100-104).
I	B	Concomitant mitral valve repair or MVR is indicated in patients with chronic severe primary MR undergoing cardiac surgery for other indications (105).

Repair: Posterior mitral leaflet

Repair: Anterior and Posterior mitral leaflet

American Heart Association.

IIa	B

Mitral valve repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is greater than 95% with an expected mortality rate of less than 1% when performed at a Heart Valve Center of Excellence (101,106-112).

Repair: Asymtomatic

IIa	B

Mitral valve repair is reasonable for asymptomatic patients with chronic severe nonrheumatic primary MR (stage C1) and preserved LV function (LVEF >60% and LVESD <40 mm) in whom there is a high likelihood of a successful and durable repair with 1) new onset of AF or 2) resting pulmonary hypertension (pulmonary artery systolic arterial pressure >50 mm Hg) (111,117-123).

IIa	C

Concomitant mitral valve repair is reasonable in patients with chronic moderate primary MR (stage B) when undergoing cardiac surgery for other indications.

Repair: Asymtomatic
1. A.fib
2. PTH (PAP>50)

III: Harm	B

MVR should not be performed for the treatment of isolated severe primary MR limited to less than one half of the posterior leaflet unless mitral valve repair has been attempted and was unsuccessful (84,89,90,95).

Repair: Posterior leaflet

Why MV repair is more superior than replacement (AHA guidelines):

1. Mitral valve repair is performed at a lower operative mortality rate than MVR. Although no RCTs exist, virtually every clinical report, including data from the STS database, indicates that operative risk (30–day mortality) for repair is about half that of MVR.
2. LV function is better preserved following repair preserving the integrity of the mitral valve apparatus versus following MVR.
3. Repair avoids the risks inherent to prosthetic heart valves, that is, thromboembolism or anticoagulant-induced hemorrhage for mechanical valves or structural deterioration for bioprosthetic valves.

Repair vs Replacement:

1. Lower Operative mortality (half)
2. Better LV function
3. Less risk of thromboembolism and bleeding

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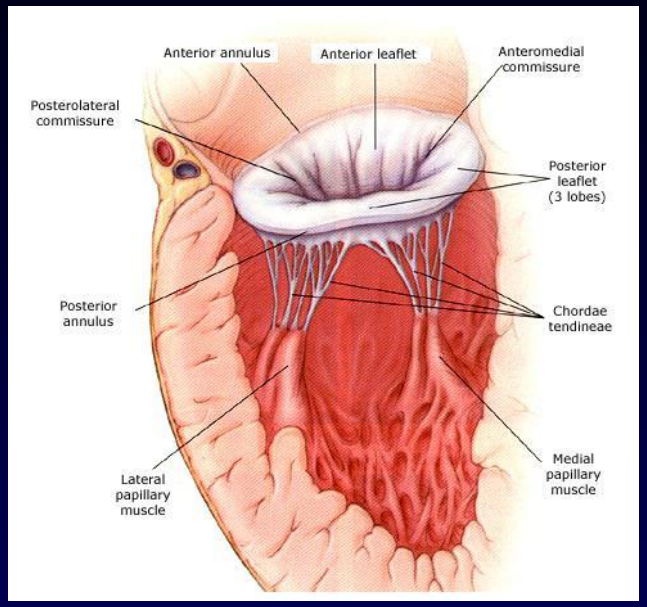
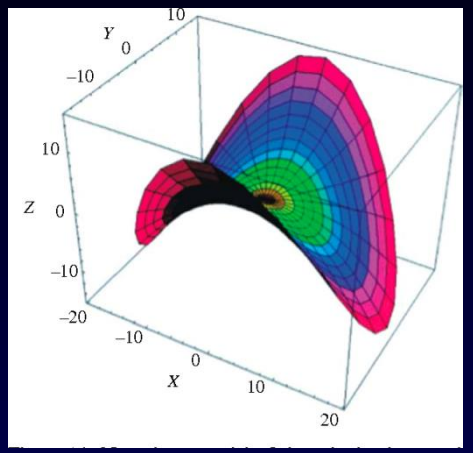
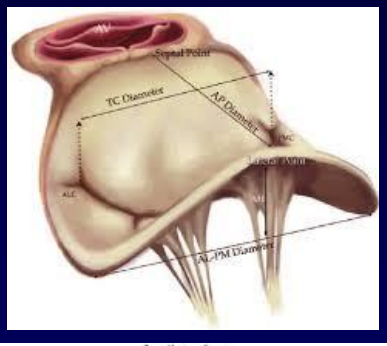
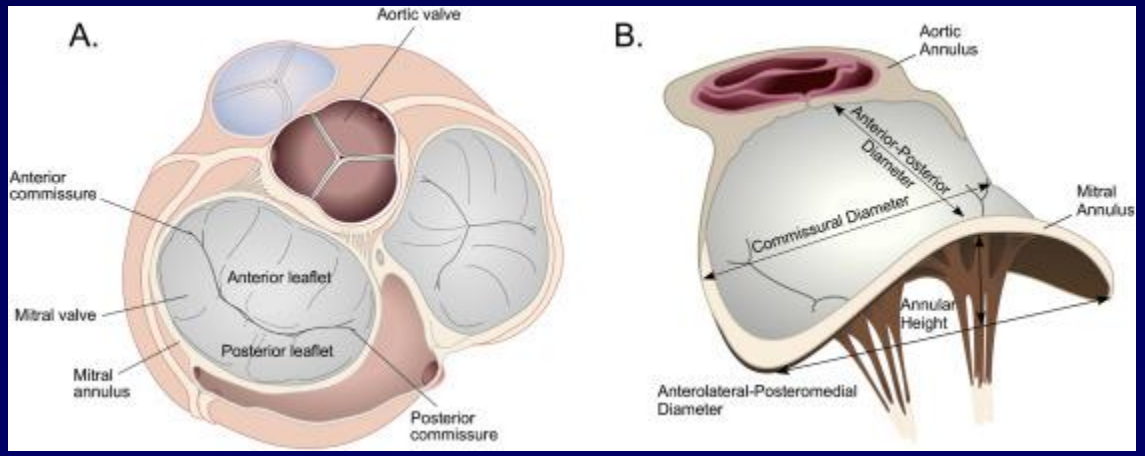
Components of Mitral Valve Apparatus

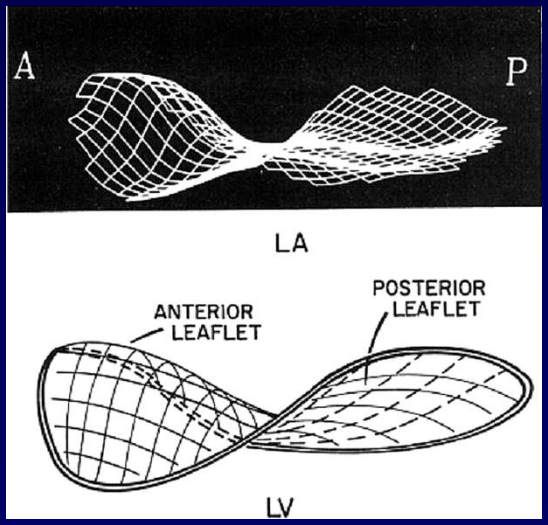
- Mitral annulus
- Anterior and posterior leaflets
- Chordae tendineae
- Lateral and medial papillary Muscles











Effects of Undersized Mitral Annuloplasty on Regional Transmural Left Ventricular Wall Strains and Wall Thickening Mechanisms

Allen Cheng, MD; Tom C. Nguyen, MD; Marcin Malinowski, MD; David Liang, MD, PhD; George T. Daughters, MS; Neil B. Ingels Jr, PhD; D. Craig Miller, MD

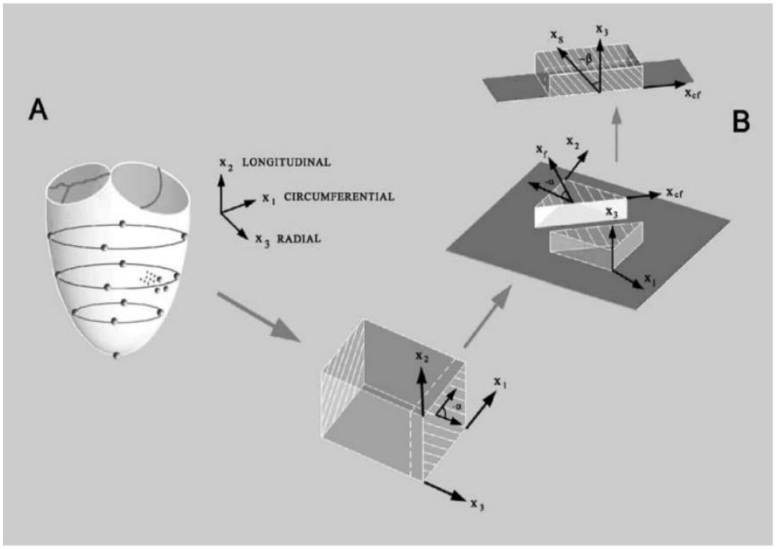


Figure 2. Coordinate orientations and histology method. X_1, X_2, and X_3 define circumferential, longitudinal and radial axes, respectively. X_s, X_f, and X_{cf} define sheet, fiber, and cross-fiber axes, respectively. α and β represent fiber and sheet angles, respectively. A, Markers and beadset array with coordinate orientations. B, Histological methodology to measure fiber and sheet angles directly with preservation of coordinate orientation. At a given transmural depth, measured fiber (α) and sheet (β) angles are used to define local "fiber-sheet" coordinates.

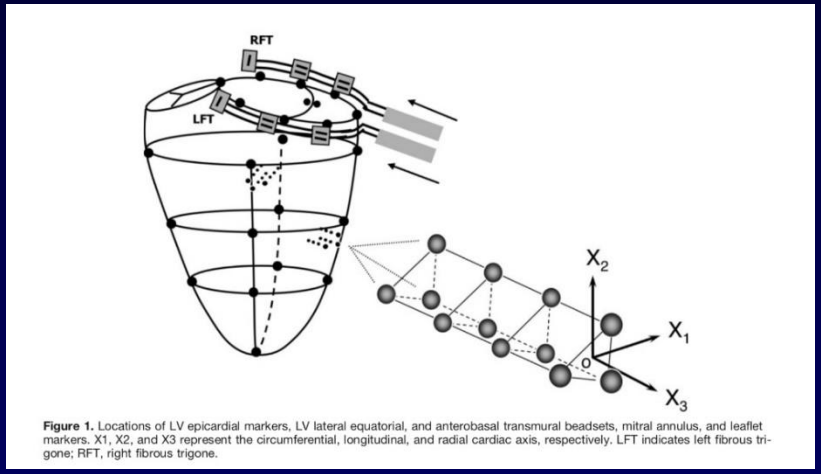


Figure 1. Locations of LV epicardial markers, LV lateral equatorial, and anterobasal transmural beadsets, mitral annulus, and leaflet markers. X1, X2, and X3 represent the circumferential, longitudinal, and radial cardiac axis, respectively. LFT indicates left fibrous trigone; RFT, right fibrous trigone.

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

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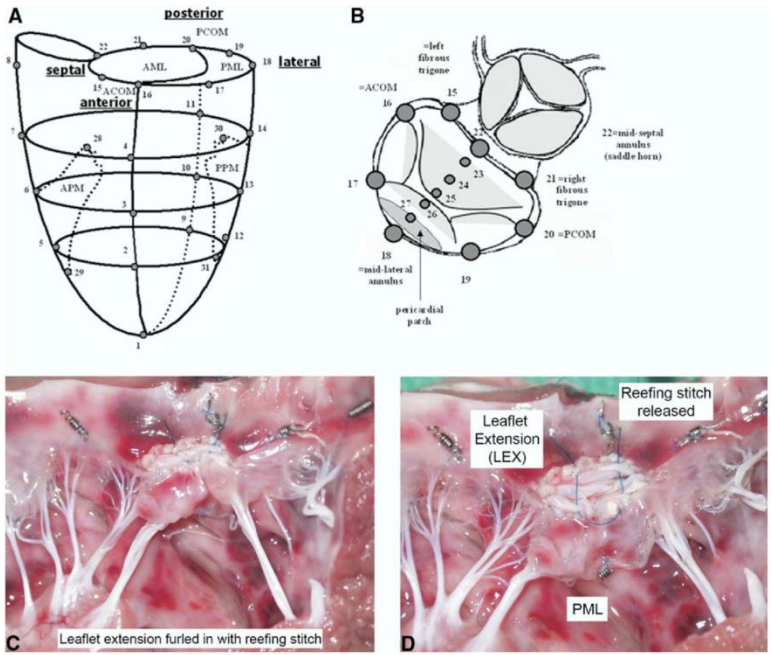
Posterior mitral leaflet extension: An adjunctive repair option for ischemic mitral regurgitation?

Frank Langer, MD,[a] Filiberto Rodriguez, MD,[a] Allen Cheng, MD,[a] Saskia Ortiz,[a] Tom C. Nguyen, MD,[a] Mary K. Zasio, BA,[a] David Liang, MD, PhD,[b] George T. Daughters, MS,[a,c] Neil B. Ingels, PhD,[a,c] and D. Craig Miller, MD[a]



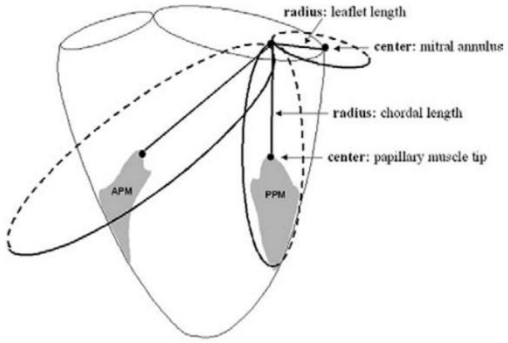


Figure 4. Concept of intersecting spheres with respect to predicted end-systolic leaflet 3-dimensional geometric configuration. Leaflet edge position is determined by 3 intersecting spheres of associated anatomic structures. The papillary muscle tips and the mitral annulus define the centers of the spheres, whereas chordal length and leaflet length define the radii. *APM*, Anterior papillary muscle; *PPM*, posterior papillary muscle.

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EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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Septal-lateral annnular cinching perturbs basal left ventricular transmural strains☆

Tom C. Nguyen [a], Allen Cheng [a], Frederick A. Tibayan [a], David Liang [b], George T. Daughters [a,c], Neil B. Ingels Jr. [a,c], David Craig Miller [a,*]

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[c] *Research Institute of the Palo Alto Medical Foundation, Palo Alto, CA, United States*

Received 21 September 2006; received in revised form 4 December 2006; accepted 14 December 2006; Available online 12 January 2007

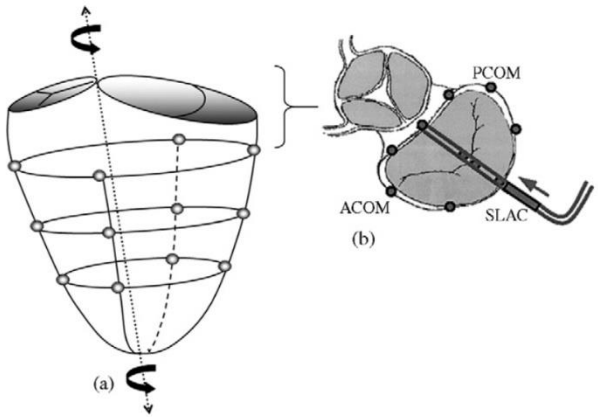

Fig. 1. (a) Locations of LV epicardial markers (shaded circles) surgically implanted to silhouette the LV chamber along four equally spaced longitudinal meridians. (b) Septal-lateral annular cinching (SLAC) showing a prolene suture anchored to the midseptal annulus and externalized to an epicardial tourniquet. ACOM: anterior commissure; PCOM: posterior commissure.

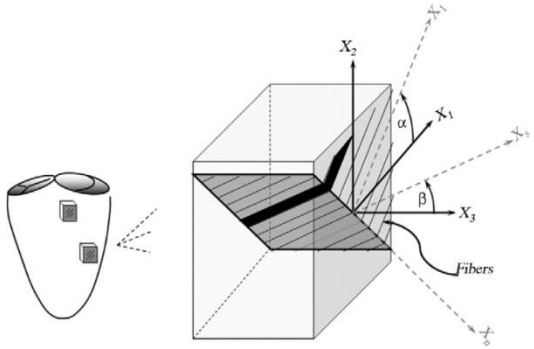

Fig. 2. A transmural tissue block excised from the anterobasal and lateral equatorial free wall of the left ventricle. Edges of the block are cut parallel to the local cardiac coordinates defined by circumferential (X_1), longitudinal (X_2), and radial (X_3) axes. A transmural fiber angle (α) was measured from serial sections cut parallel to the X_1—X_2 plane at varying transmural depths. Measured α and β were then used to define a local 'fiber-sheet' coordinate system with basis vectors of fiber (X_f) axis, sheet axis perpendicular to X_f within sheet plane (X_s), and axis normal to the sheet plane (X_n). The black band illustrates sheet orientation. X_f, X_s, and X_n represent a Cartesian coordinate system. X_f lies in the X_1—X_2 plane; X_s lies in the plane defined by X_3 and the axis normal to the fiber direction.

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Circulation

American Heart Association®

Subvalvular Repair: The Key to Repairing Ischemic Mitral Regurgitation?

Frank Langer, Filiberto Rodriguez, Saskia Ortiz, Allen Cheng, Tom C. Nguyen, Mary K. Zasio, David Liang, George T. Daughters, Neil B. Ingels and D. Craig Miller

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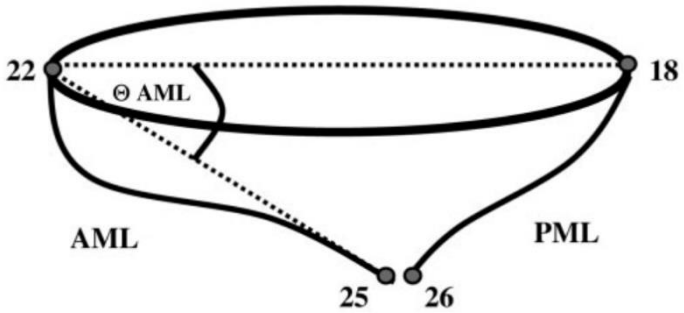
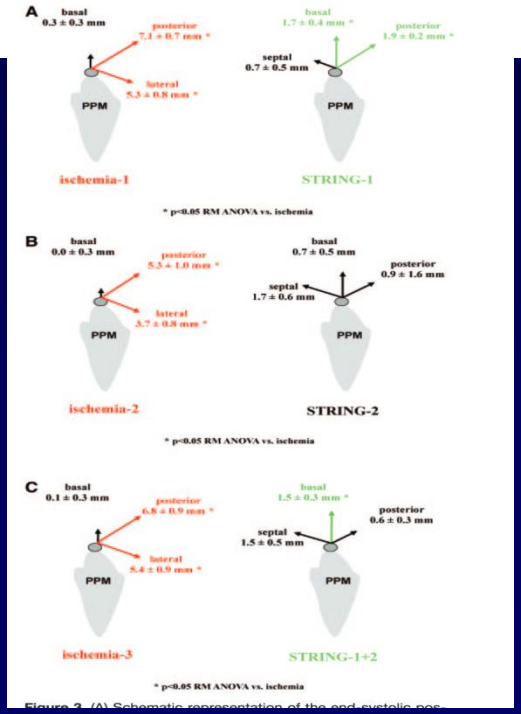


Figure 2. Schematic representation of the radiopaque annular and leaflet markers defining leaflet angle. AML indicates anterior mitral leaflet; PML, posterior mitral leaflet.



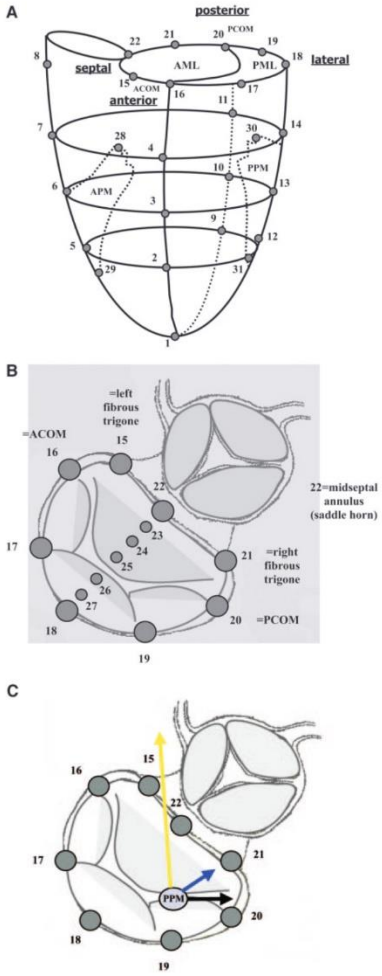


Figure 1. (A) Schematic representation of the radiopaque marker array used in this study. (B) Schematic representation of the radiopaque annular and leaflet markers utilized in this study. (C) Schematic representation of the different repositioning directions. The technique as described by Kron et al[14] is indicated by a black arrow, the STRING-1 suture is indicated by a blue arrow, and STRING-2 by a yellow arrow. (ACOM indicates anterior commissure; PCOM, posterior commissure; APM, anterior papillary muscle; PPM, posterior papillary muscle).

Stanford University

Circulation

American Heart Association®

Importance of Mitral Valve Second-Order Chordae for Left Ventricular Geometry, Wall Thickening Mechanics, and Global Systolic Function

Filiberto Rodriguez, Frank Langer, Katherine B. Harrington, Frederick A. Tibayan, Mary K. Zasio, Allen Cheng, David Liang, George T. Daughters, James W. Covell, John C. Criscione, Neil B. Ingels and D. Craig Miller

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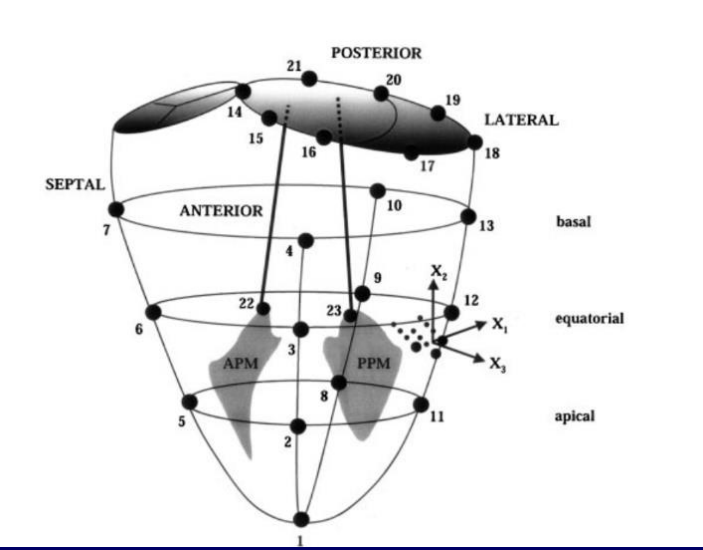
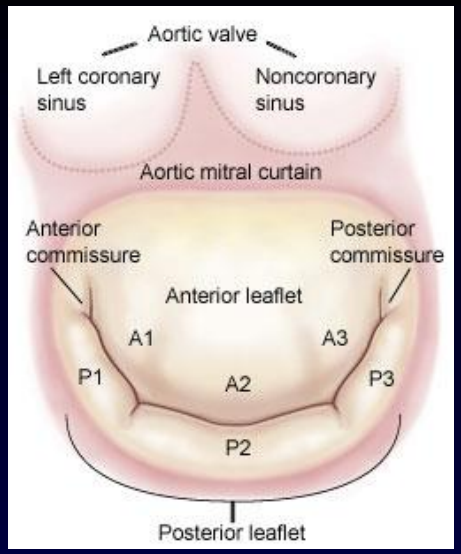
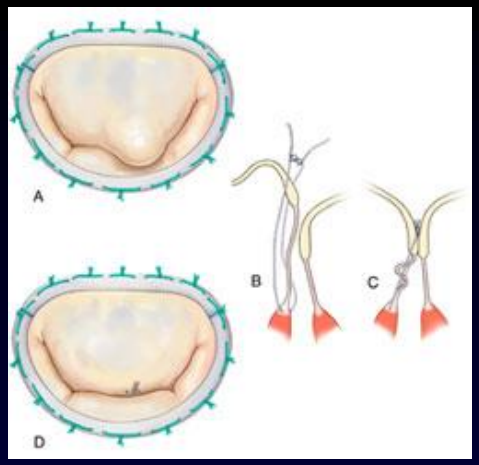
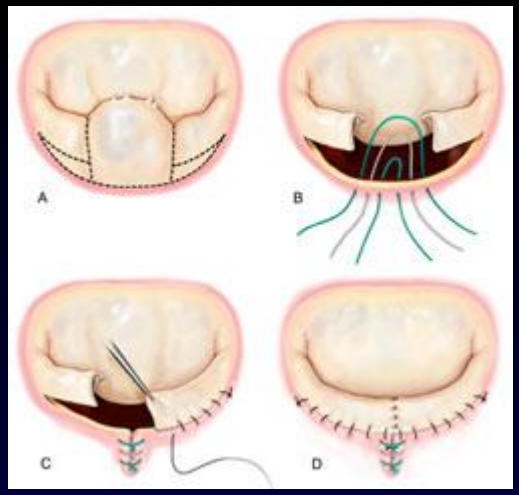


Importance of Chordal Sparing in Mitral Surgery

Stanford University







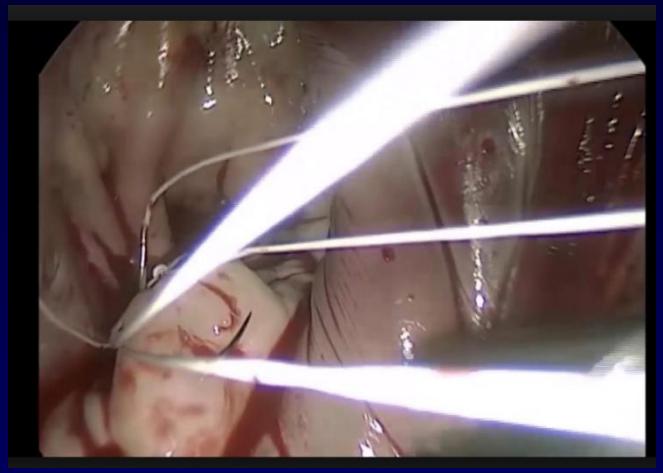
Mitral Valve Repair

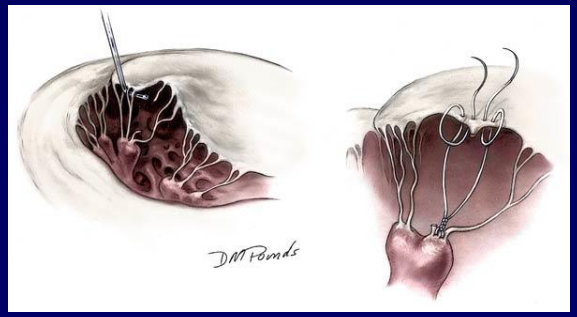
Can be surgically demanding

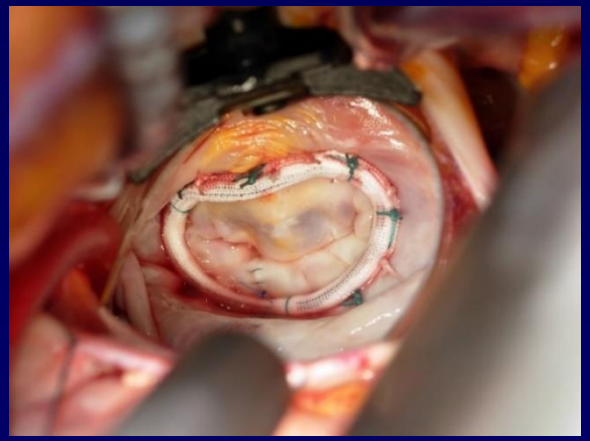
Experienced, Skilled Heart Surgeon

Minimally Invasive

Mitral Repair







Technique:

1. Sliding Annuloplasty
2. Artificial Cords
3. Anterior and Posterior partial leaflets resection and reconstruction
4. Chordal Translocation
5. Leaflet Extension
6. Chordal division and relocation

Etc……

more surgically demanding. The Heart Valve Team should assign complex repairs to more experienced mitral valve surgeons with established outcomes, including acute success rate as well as long-term durability. The probability of

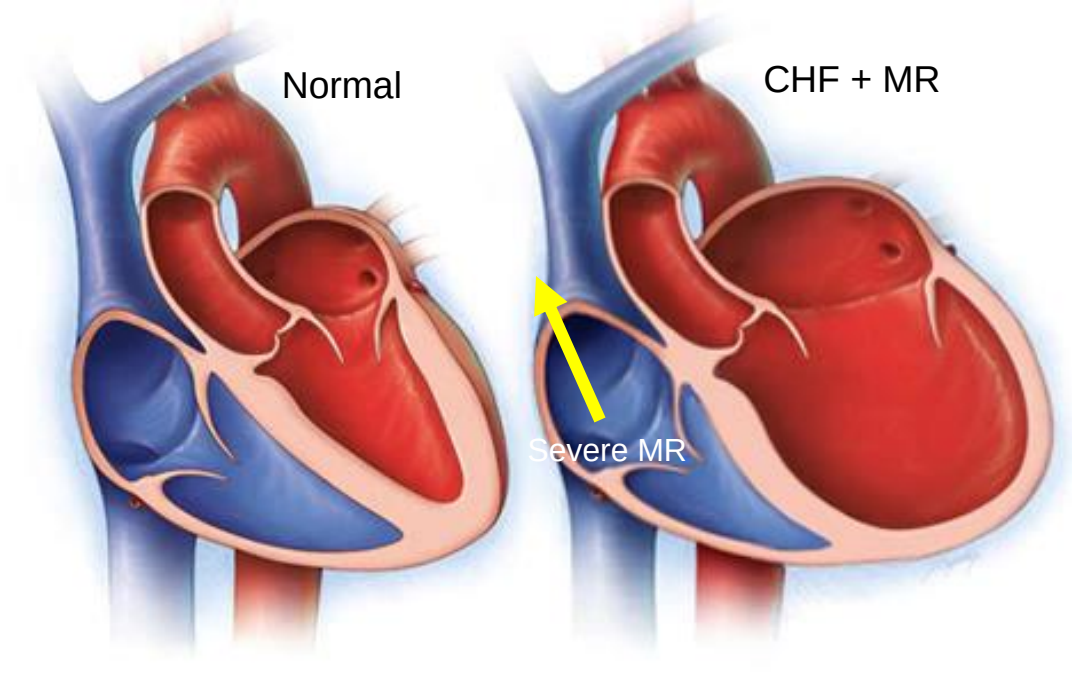
Mitral valve repair is surgical demanding, it is not for all cardiac surgeon, patients with MR should be referred to surgeon who specialize in mitral valve repair.

2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease

American Heart Association.

Severe mitral regurgitation + severe congestive heart failure (EF < 25%)

- Sometimes MV repair or replacement may not be enough,
- advanced heart failure therapy may be needed.



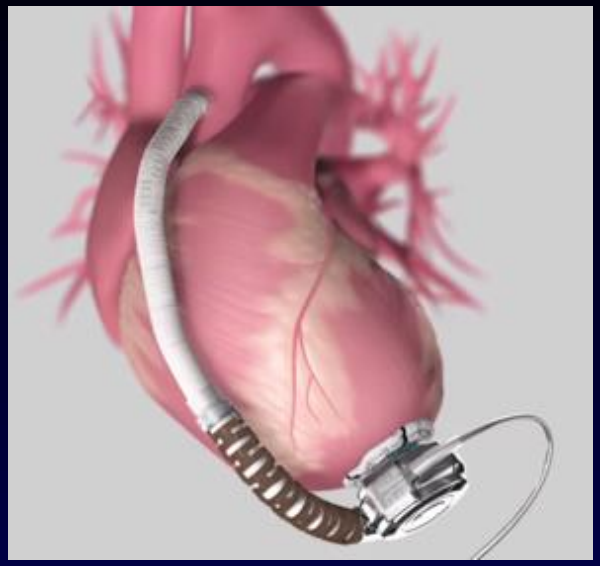
LVAD (Left Ventricular Assist Device)

Heart support device for patients with severe congestive heart failure

Provides ventricular unloading of the failing heart while supporting circulation

- Improves Quality of Life
- Improves Survival

End-stage heart failure is a surgical disease



Oklahoma Heart Institute

Original Article on Cardiac Surgery

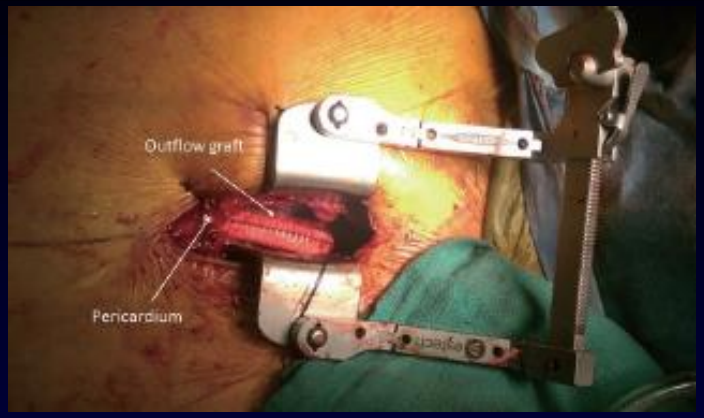
Minimally invasive left ventricular assist device placement

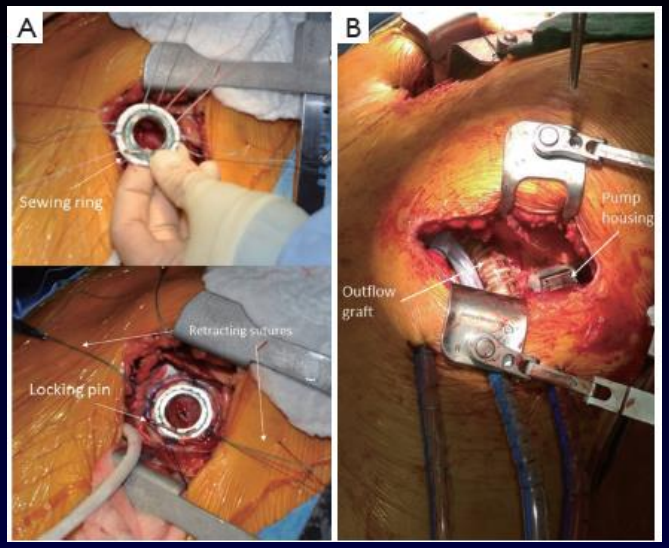
Allen Cheng

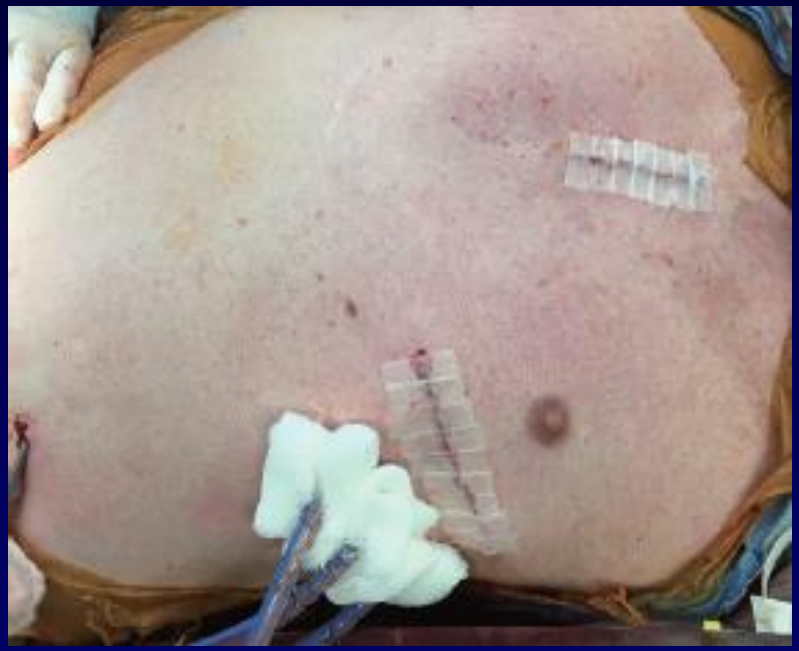
Department of Cardiovascular and Thoracic Surgery, University of Louisville, Louisville, USA

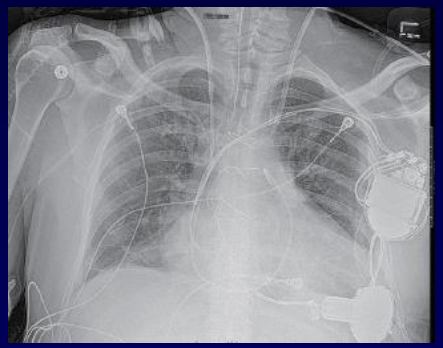
Correspondence to: Allen Cheng, MD. Department of Cardiovascular and Thoracic Surgery, University of Louisville, 201 Abraham Flexner Way, Suite 1200, Louisville, KY 40202, USA. Email: allenchengcs@gmail.com.

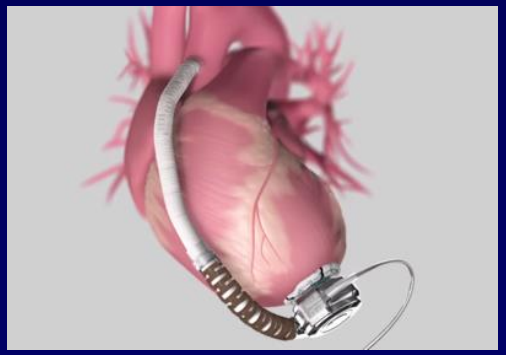
Minimally Invasive LVAD placement





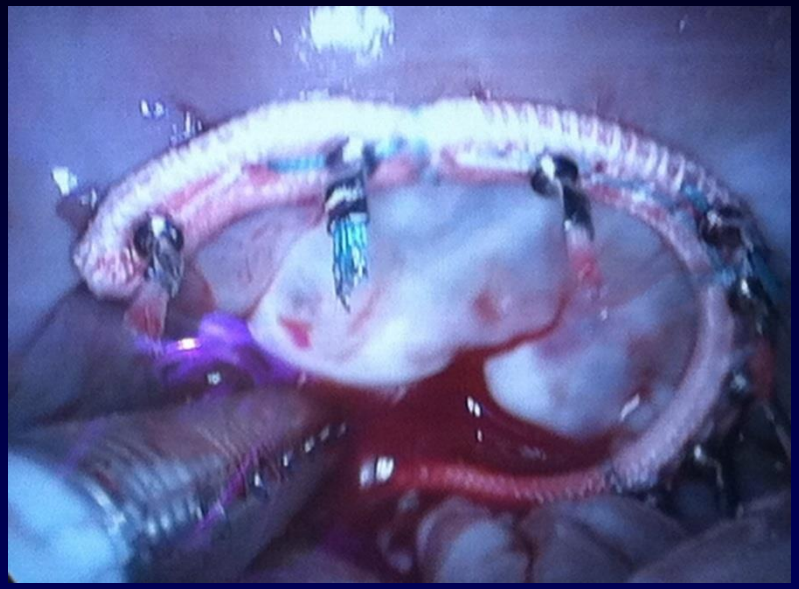




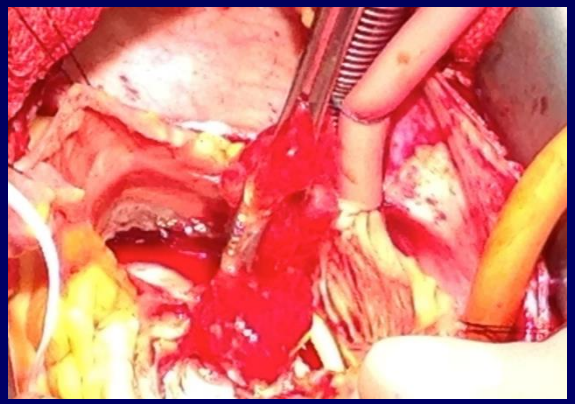


Minimally Invasive LVAD placement

Tricuspid Repair, Congenital Heart Defect, Myxoma

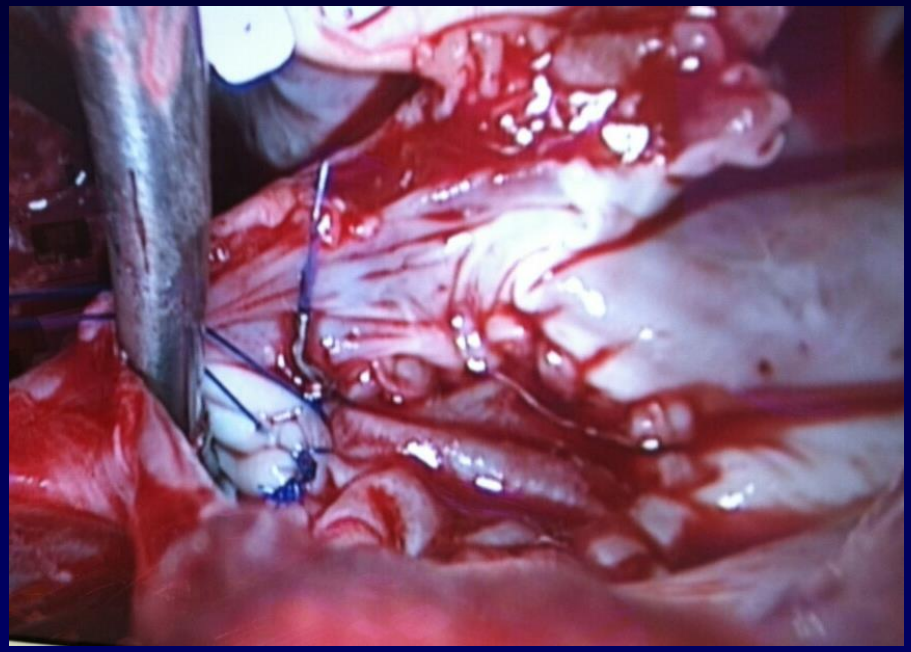


Tricuspid Repair



Myxoma

Minimally Invasive Heart Surgery



Sinus Venosus ASD

Tricuspid Regurgitation

Symptomatic:
- Absites
- LE swelling
- SOB
- Fatigue
- Liver failure

Asymptomatic:
1. Progressive RV dysfunction
2. PHTN
3. Annulus dilation (>40mm)

TV Repair

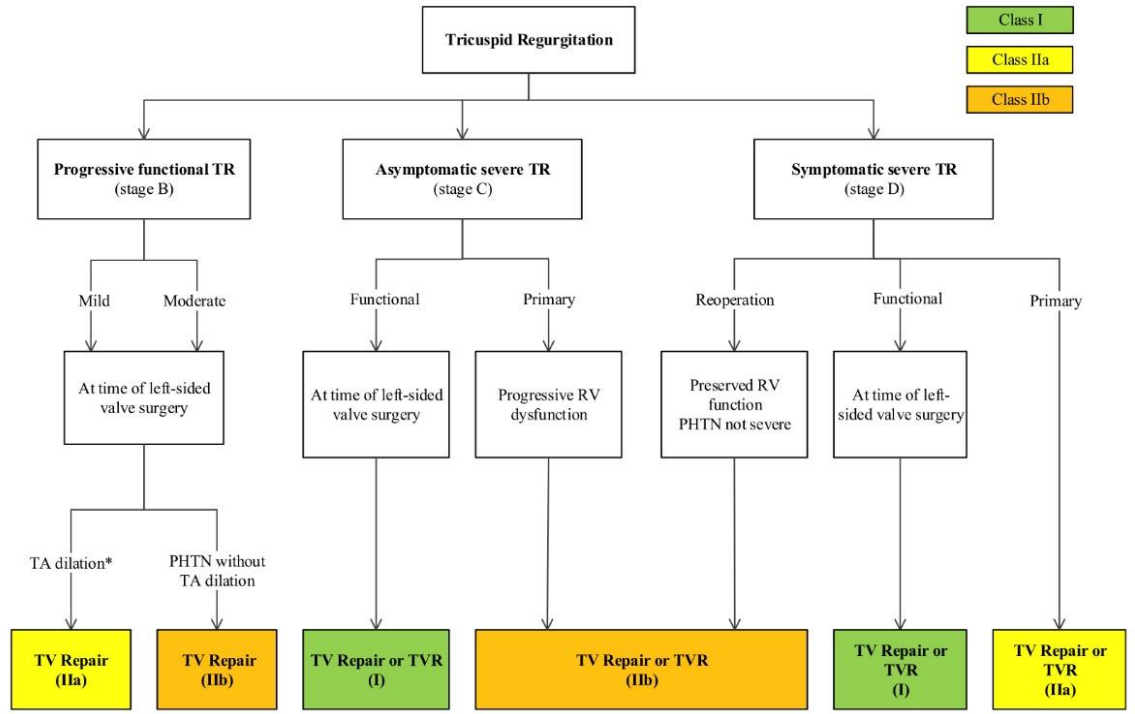


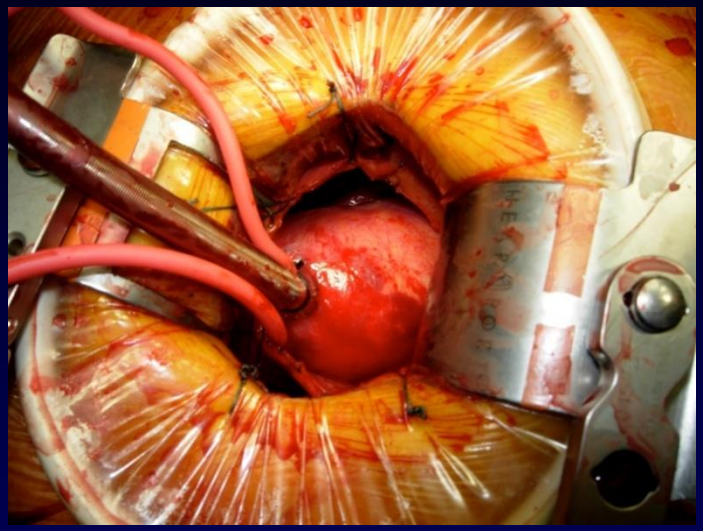
Figure 5. Indications for Surgery

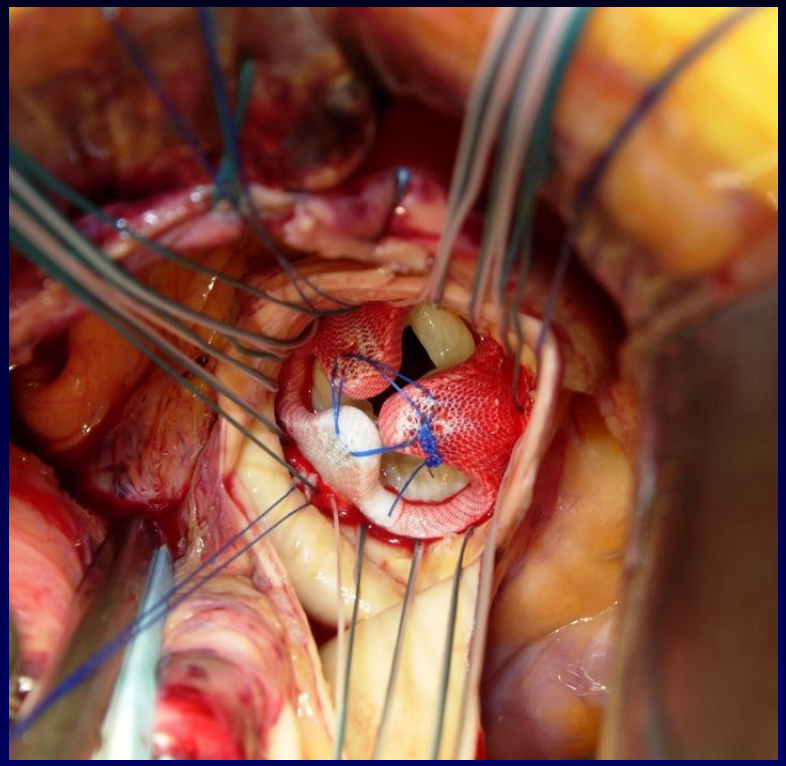
*See Table 19 for definition of stages. TA dilation is defined by >40 mm on TTE (>21 mm/m^2) or >70 mm on direct intraoperative measurement.
LV indicates left ventricular; PHTN, pulmonary hypertension; RV, right ventricular; TA, tricuspid annular; TR, tricuspid regurgitation; TTE, transthoracic echocardiogram; TV, tricuspid valve; and TVR, tricuspid valve replacement.

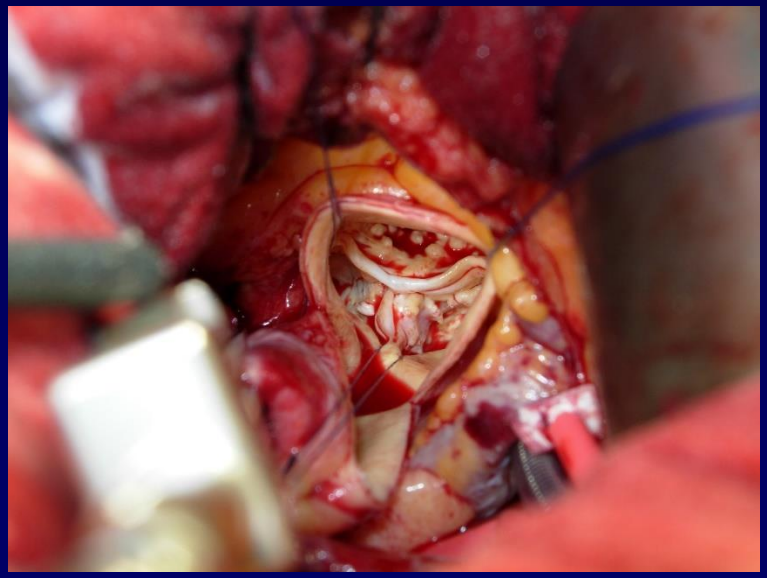
2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease

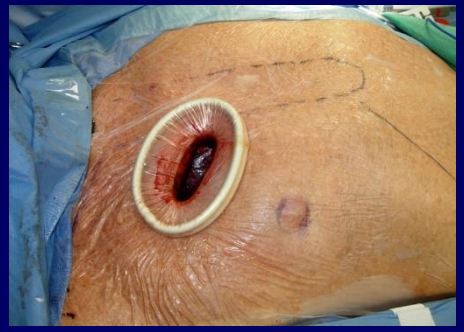
American Heart Association.

Minimally Invasive Aortic Valve Replacement for Aortic stenosis

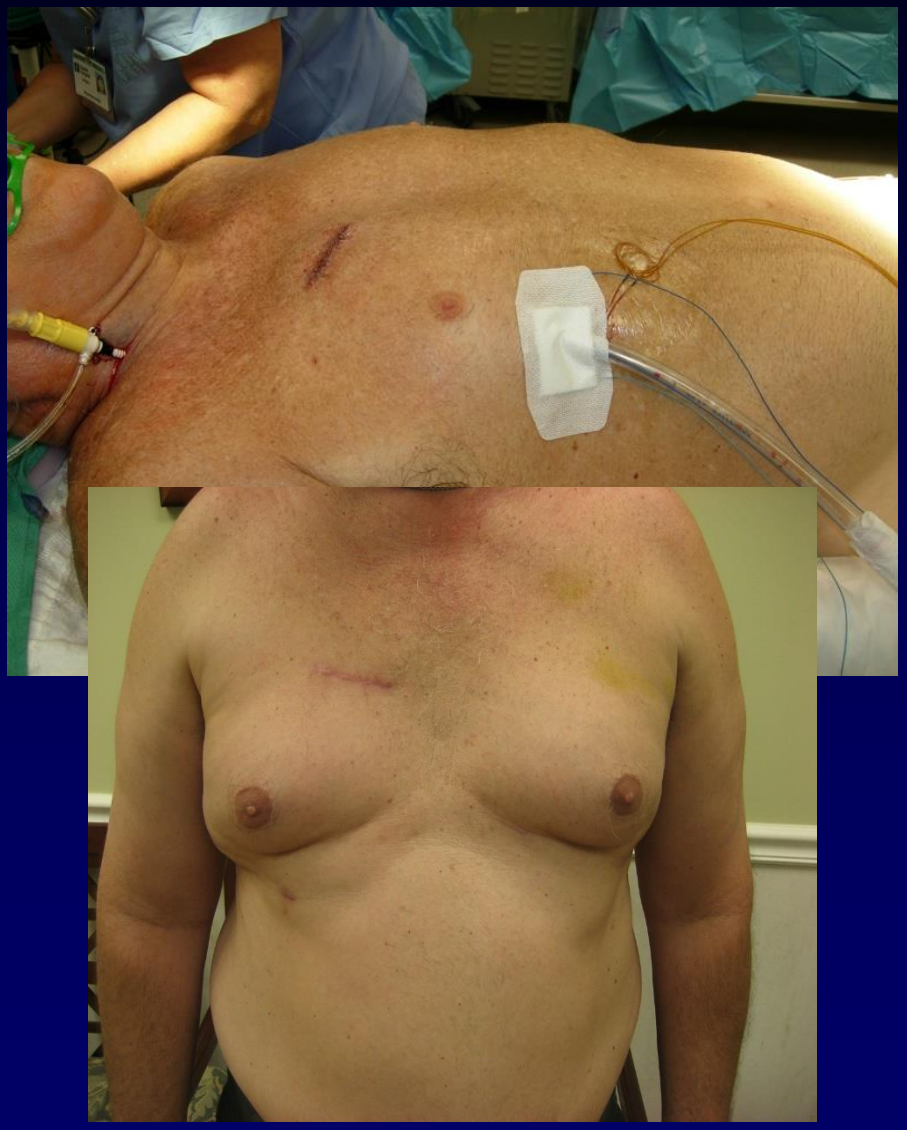


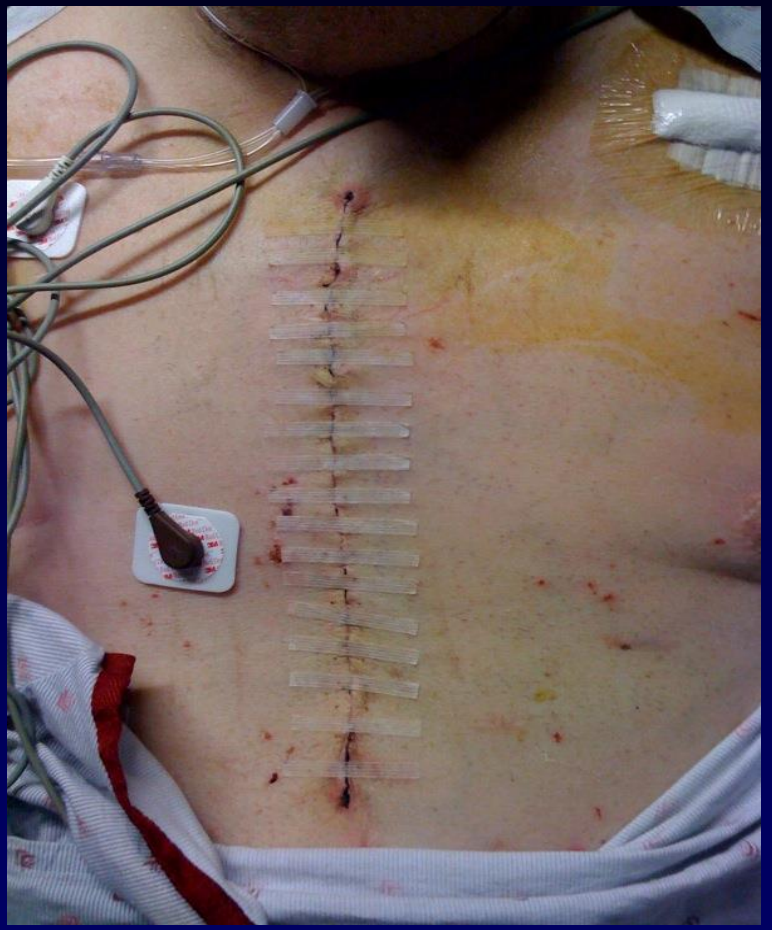






Small Incision for Aortic Valve Replacement

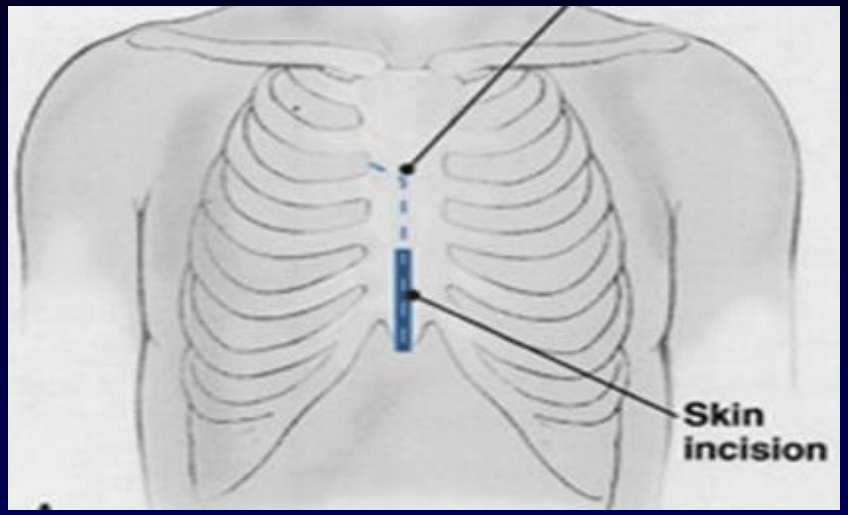


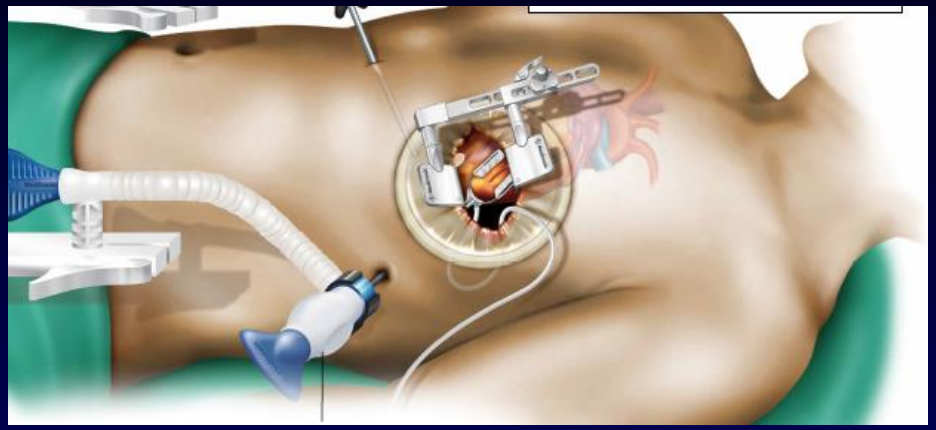


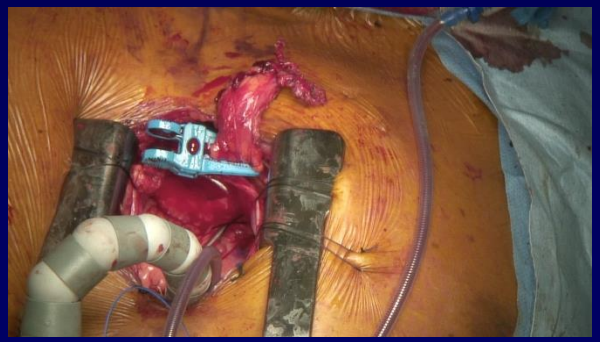
Other minimally invasive heart surgery:

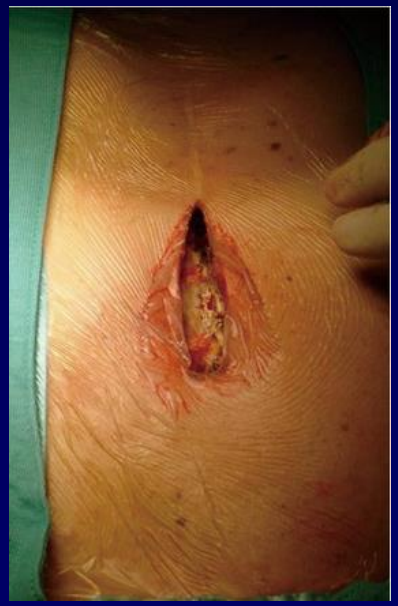
CABG / MIDCAB
Atrial Fibrillation Ablation / Mini- Maze
Heart Failure / MIS LVAD placement

MICAB – Off-pump Minimally Invasive Coronary Bypass Surgery ± Hybrid Procedure









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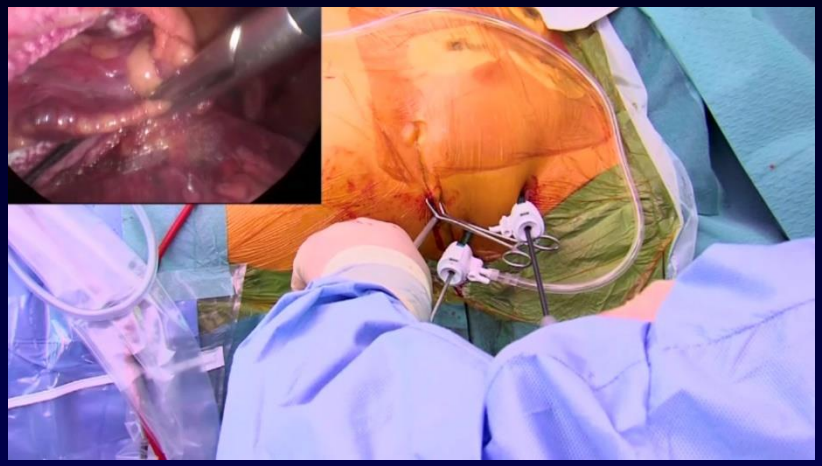
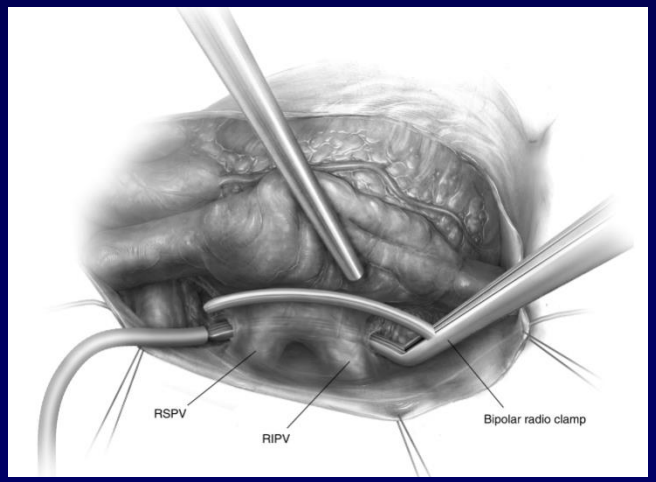
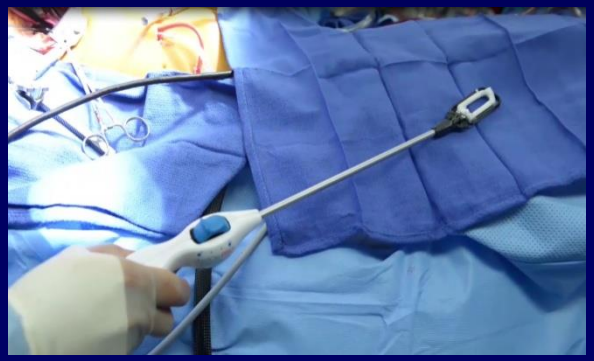
Atrial Fibrillation Ablation / mini MAZE
Thorascopic left atrial appendage ligation





Cryo + RF



CONVERGENT/ Hybrid Atrial Fibrillation Ablation

1. Permanent A.fib
2. Recurrent A.fib

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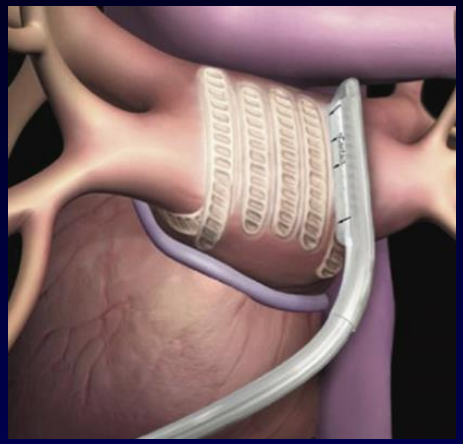
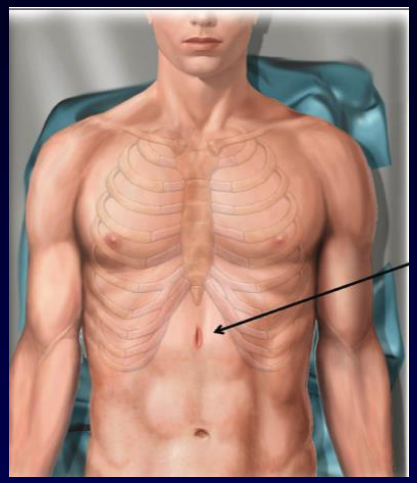
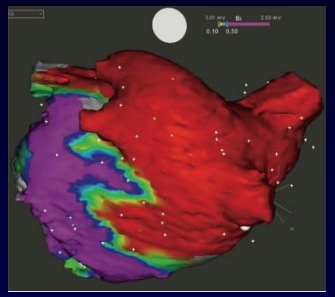
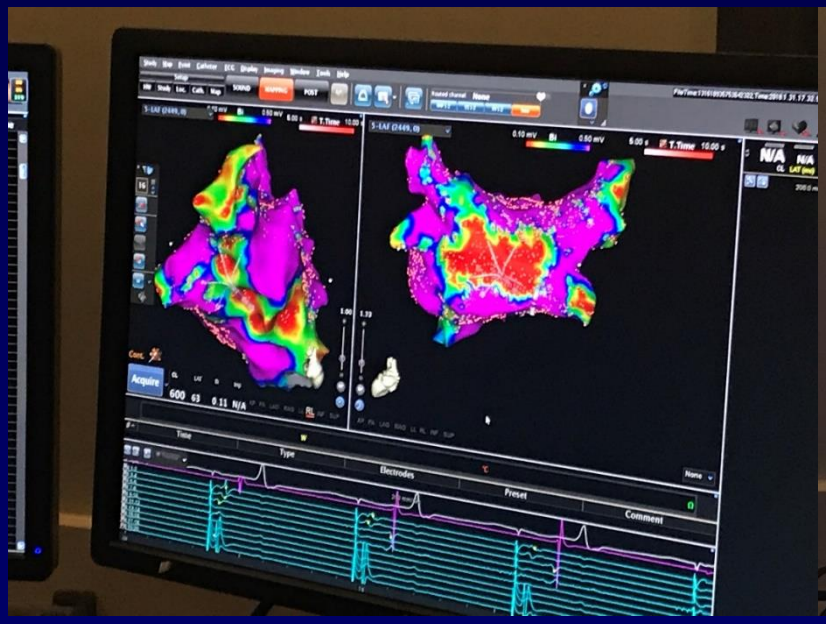
Operating Room

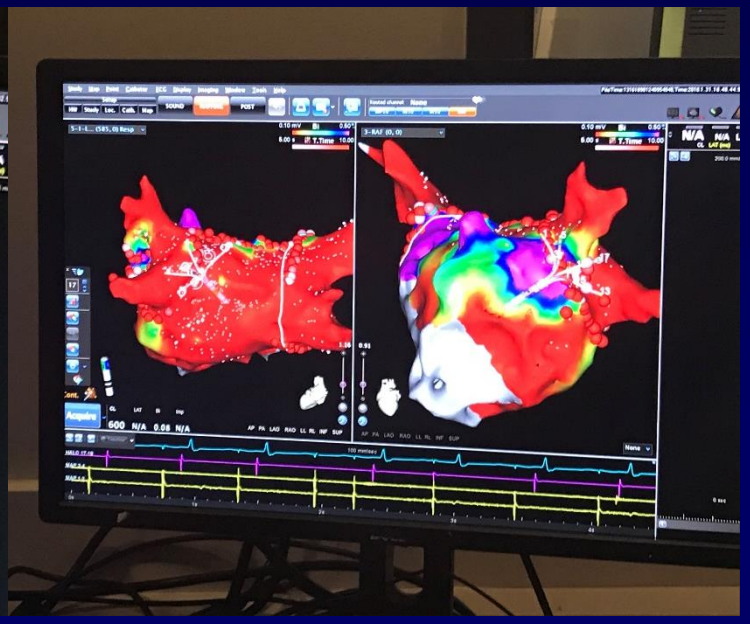






EP lab





Minimally Invasive Heart Surgery

Benefits

Less Pain / No bone division / Less tissue trauma

Shorter recovery time and more rapid return to normal activity level

Reduce length of hospital stay

Less blood loss / decreased blood transfusion rate (less tissue trauma)

Lower wound infection rate (smaller incision)

Lower risk for pneumonia (ambulate earlier, cough better with less pain)

Better cosmetics (smaller incision)

Better and direct visualization of valves for better repair and replacement (better visualization than sternotomy)

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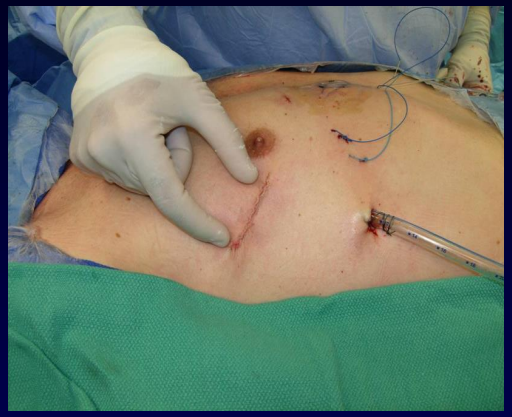


hillcrest
HealthCare System

hillcrest
Hospital | South

Oklahoma Heart Institute is the only center in Tulsa and the State of Oklahoma where Minimally Invasive Heart Surgery is offered.

Oklahoma Heart Institute

hillcrest HealthCare System

Oklahoma Heart Institute / Hillcrest Medical Center is the only center in Tulsa and eastern Oklahoma where LVAD / Advanced Heart Failure Therapy is offered.

OHI/ Hillcrest is one of the only two centers where LVAD therapy is provided in the whole State of Oklahoma.

Minimally Invasive Team

OR Team
Amy Ramsey (CV lead)
Kara Mata
Leisha Madalone (Scrub lead)
Terri Gilbert
Washeem Abdalmalk
et. al.

Anesthesiologists
Brad Christiansen
Dale Dautenhahn
David Lee

Perfusionists

ICU Team and Intensivists

Office nurse
Dana Archibald

Dr. Wayne Leimbach

Oklahoma Heart Institute

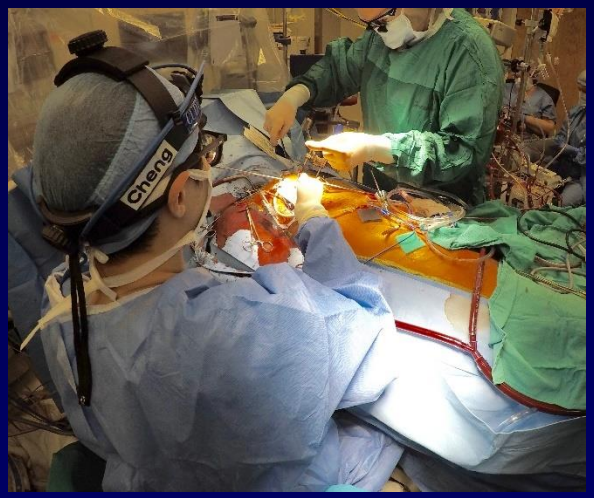
hillcrest Hospital | South

Thank you

Questions:

Allen Cheng, M.D.
Office: 918-749-6400
(Dana Archibald, R.N.)

email: allen.cheng@oklahomaheart.com



More info: www.oklahomaheart.com
www.facebook.com/chengminimallyinvasive

Featured Article

Concomitant tricuspid valve repair in patients with minimally invasive mitral valve surgery

Bettina Pfannmüller, Piroze Davierwala, Gregor Hirnle, Michael A. Borger, Martin Misfeld, Jens Garbade, Joerg Seeburger, Friedrich W. Mohr

Department of Cardiac Surgery, Heart Center, University of Leipzig, Germany

Corresponding to: Dr. med. habil. Bettina Pfannmueller, MD, PhD. Department of Cardiac Surgery, Heart Center, University of Leipzig, Struempellstrasse 39, 04289 Leipzig, Germany. Email: pfab@med.uni-leipzig.de.

Double valves

N = 441 pt with MVR + TVR

Overall 30 days mortality was 4.3%

Freedom from reoperation was 91%

Combine TV surgery can be done safely and routinely with good perioperative results.

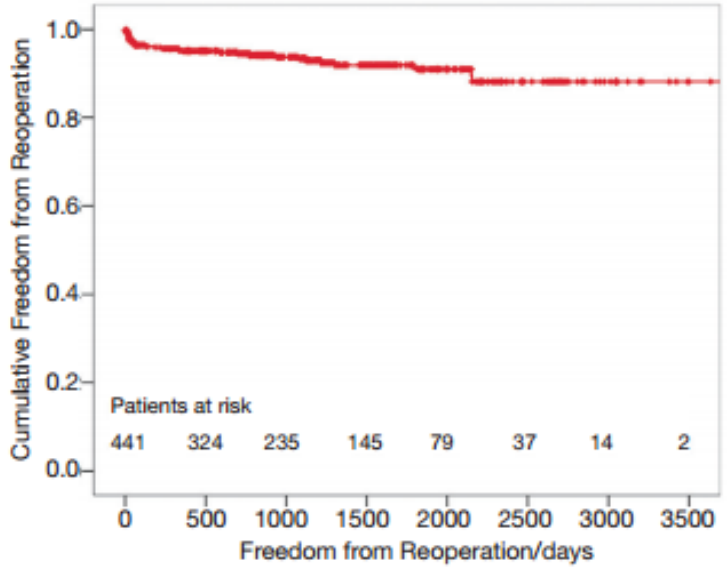
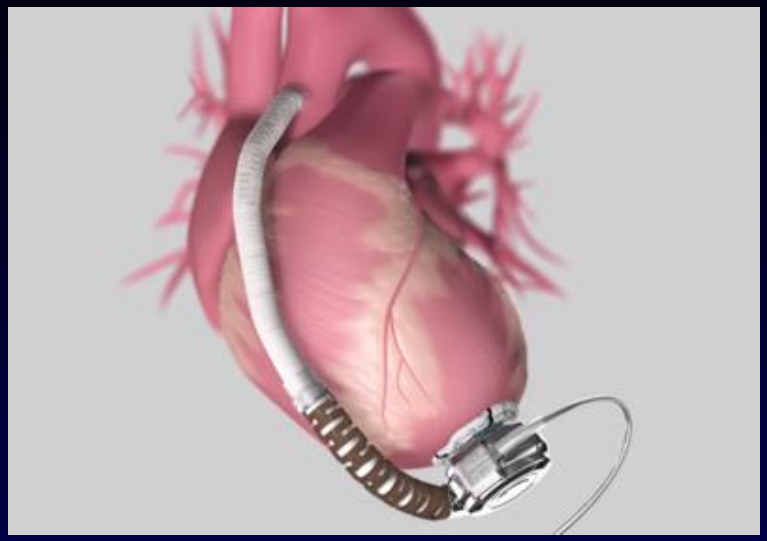


Figure 4 Kaplan-Meier estimated freedom from reoperation.

Uses of LVAD Support

- Provides ventricular unloading of the failing heart while supporting circulation
- Used as a bridge to heart transplant (BTT) until a donor heart is identified
- Permanent support as destination therapy (DT)
- In some patients, supports the heart as a bridge to recovery (BTR)



Basics: Why do we need LVAD?

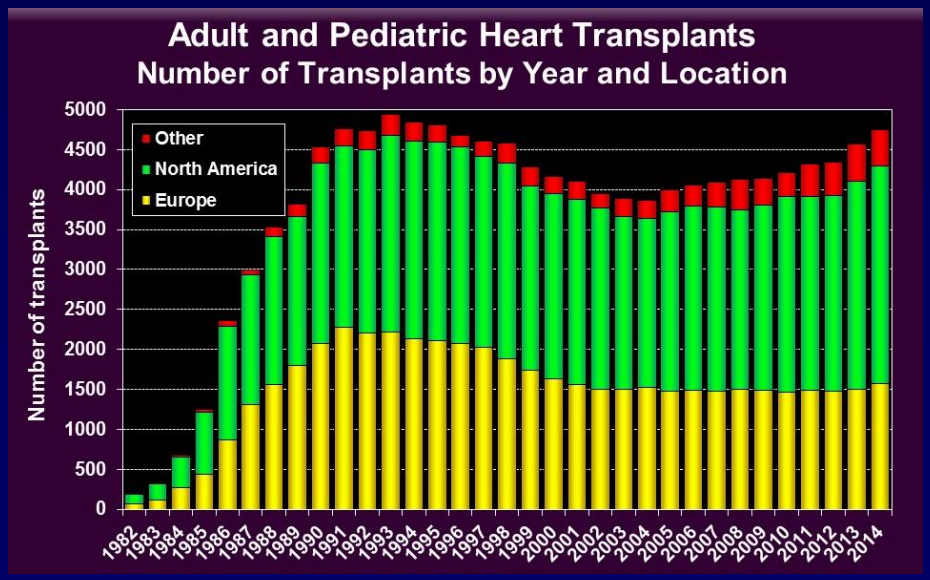
26 millions heart failure patients worldwide (6 millions in the US alone), 2 millions pts qualify for advance HF therapy (600,000 pts in the US alone) each year (American Heart Association estimate 2016)

Along with the aging population, the AHA estimate growth rate of heart failure patients will exceed greater than 30% in the next 10 years* (800,000 pts per year).

*Forecasting the future of cardiovascular disease in the US: A policy statement from the American Heart Association Circulation. 2011 Mar 1;123[8]:933-44

With the limitation of available donor organ, the number of annual heart transplantation in the US and Europe, has remained unchanged in the last two decade with only about 2500 cases a year nation-wide in the US and Europe.

2500 ≠ 800,000



Benefits of Mechanical Circulatory Support

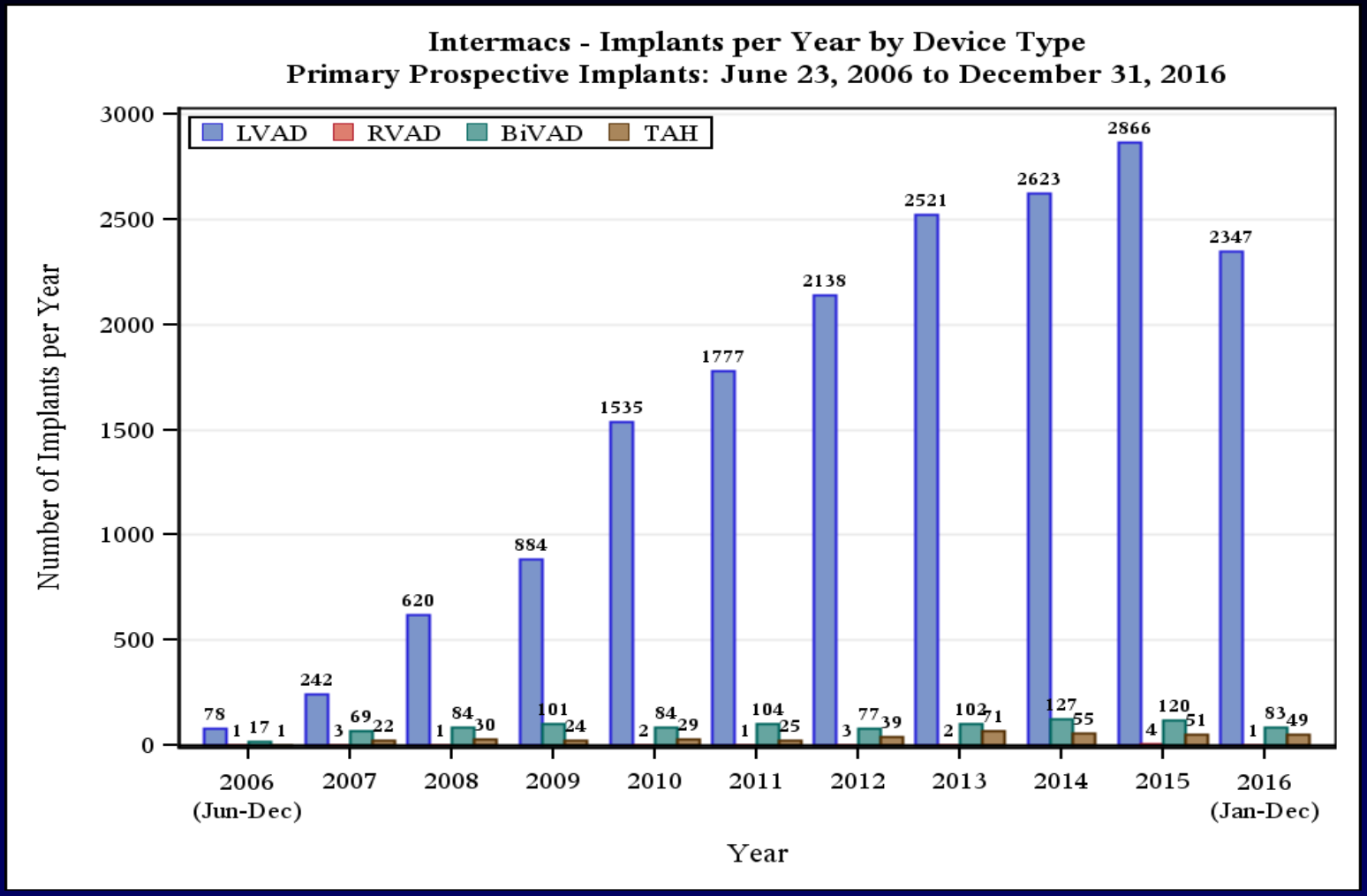
Heart transplantation vs. mechanical circulatory support

	Transplant	MCS
Wait list	Yes	No
Elective procedure	No	Yes
Risk of transmission of infectious agents	Yes	No
Need for immunosuppressive therapy	Yes	No
Monitoring for allograft vasculopathy	Yes	No
Increased malignancy risk	Yes	No
Need for surveillance biopsies	Yes	No
Rejection risk	Yes	No
Minimally invasive implantation	No	Yes
Readily replaceable	No	Yes
Amenable to technologic advancement	No	Yes
Partial support option	No	Yes
Recovery option	No	Yes
Heart transplant option	No	Yes
Lifelong anticoagulation	No	Yes
Driveline required	No	Yes

Frontline Medical News

Source: Joseph Woo, M.D.

INTERMACS Annual Report 2016



>19000 implants
> 170 centers

https://www.uab.edu/medicine/intermacs/reports/public-statistical-reports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European Market (CE Mark)
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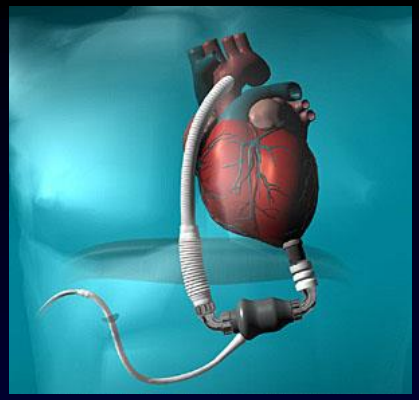
INCOR
Jarvik 2000 FlowMaker
HeartMate XVE
HeartMate II
DuraHeart
HVAD
HeartAssist 5
VentrAssist
U.S. Market (FDA Approval)
Novacor
BTT
HeartMate XVE
BTT
HeartMate XVE
DT
HeartMate II
BTT
HeartMate II
DT
HVAD
BTT

Three FDA approved Devices



Heartmate II

Older pump (> 15 years old pump)
Require a large pump pocket for placement / below diaphragm
Not being use in Europe anymore

Heartmate III

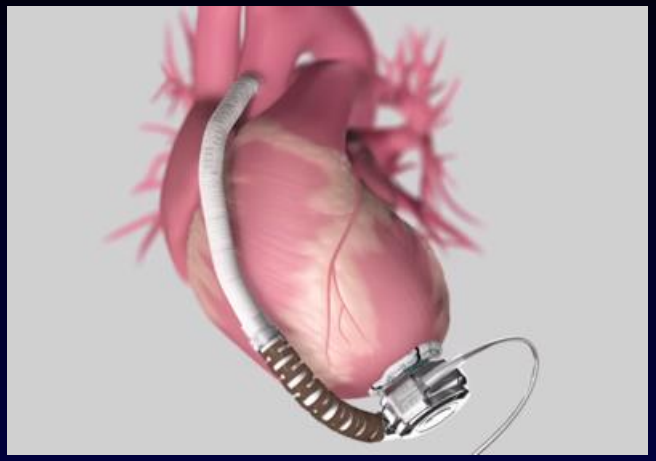
Currently approved only for BTT or short term support

- One of the newest pump
- Third Generation Centrifugal –flow pump
- Smallest /Integrated Inflow Cannula
- 10 Liters of flow/min
- No pump pocket needed for implant /Fit in the pericardial space
- Less pump thrombosis
- Approved for both BTT (bridge-to-transplant) and DT (destination therapy)
- Can be place minimally invasively and off-bypass

- Available only at Hillcrest in the State of Oklahoma

Oklahoma Heart Institute

hillcrest HealthCare System



Heartware HVAD

(Jan-Dec)

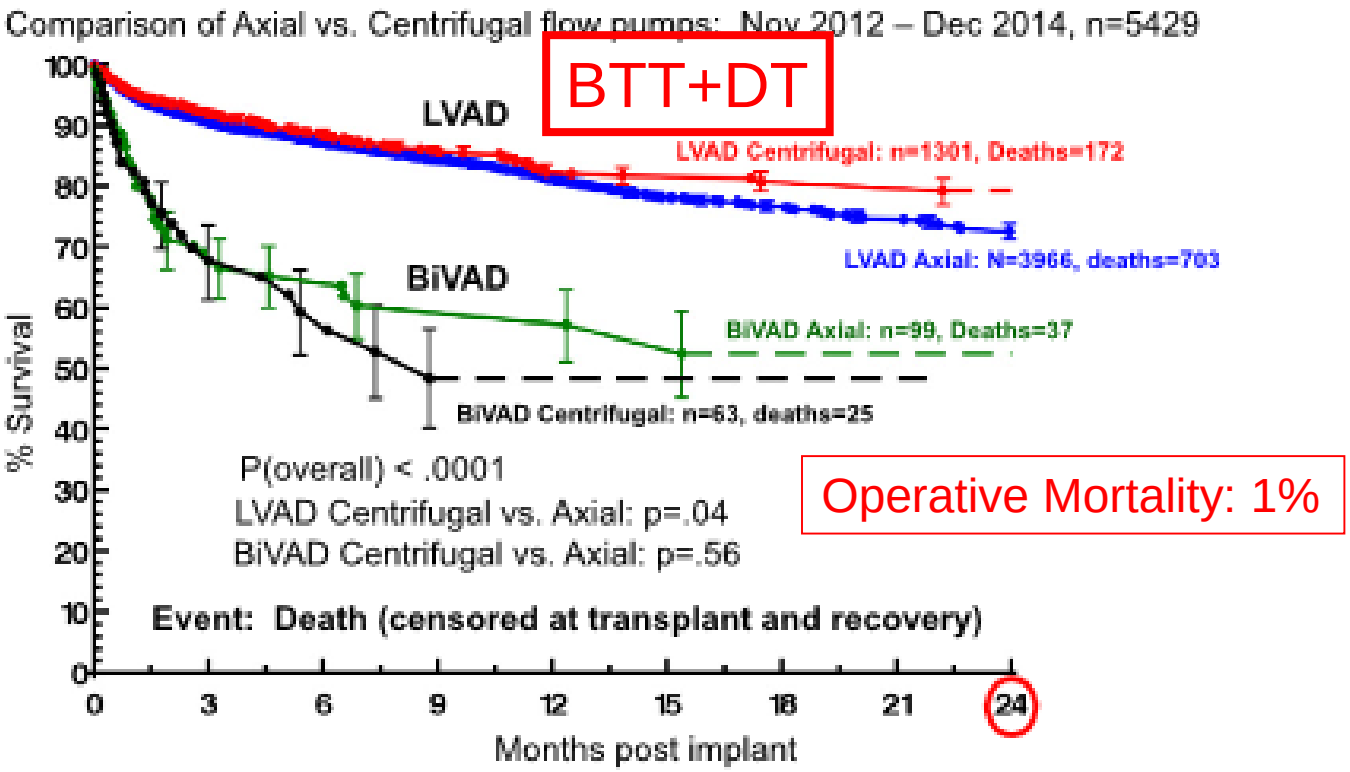


Figure 7 Actuarial survival curve for continuous-flow LVAD and BiVAD patients, stratified by pump type. The depiction is as shown in Figure 6.

Kirklin et al. Seventh INTERMACS annual report. *JHLT*. 2016;34:1495-1504

Long-term mechanical circulatory support (destination therapy): On track to compete with heart transplantation?

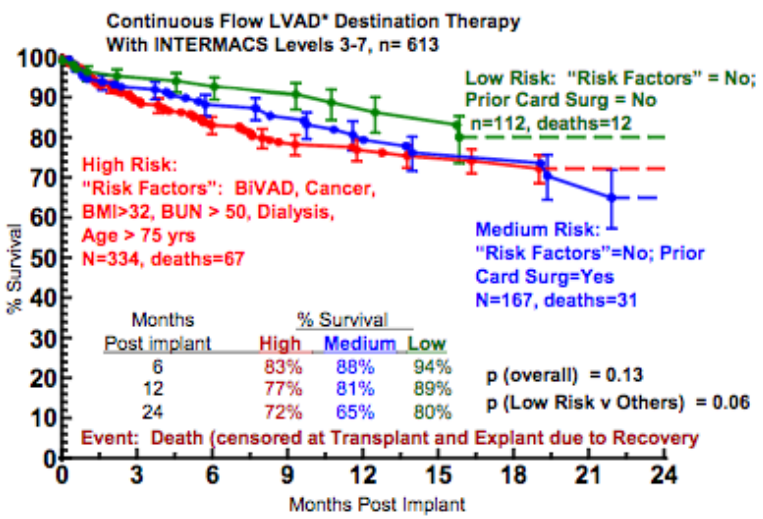
James K. Kirklin, MD,[a] David C. Naftel, PhD,[a] Francis D. Pagani, MD, PhD,[b] Robert L. Kormos, MD,[c] Lynne Stevenson, MD,[d] Marissa Miller, DVM, MPH,[e] and James B. Young, MD[f]

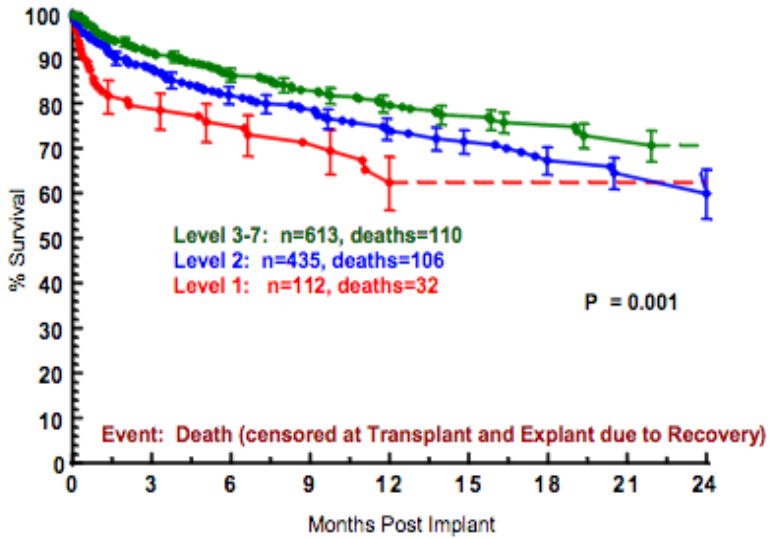
J Thorac Cardiovasc Surg 2013;144:584-603)

INTERMACS database

Results: By multivariable analysis, risk factors ($P < .05$) for mortality after DT included older age, larger body mass index, history of cancer, history of cardiac surgery, INTERMACS level I (cardiogenic shock), dialysis, increased blood urea nitrogen, use of a pulsatile flow device, and use of a right ventricular assist device (RVAD). Among patients with a continuous flow LVAD who were not in cardiogenic shock, a particularly favorable survival was associated with no cancer, patients not in cardiogenic shock, and blood urea nitrogen less than 50 mg/dL, resulting in 1- and 2-year survivals of 88% and 80%.

Conclusions: (1) Evolution from pulsatile to continuous flow technology has dramatically improved 1- and 2-year survivals; (2) DT is not appropriate for patients with rapid hemodynamic deterioration or severe right ventricular failure; (3) important subsets of patients with continuous flow DT now enjoy survival that is competitive with heart transplantation out to about 2 years. (J Thorac Cardiovasc Surg 2012;144:584-603)





ADULT CARDIAC

Survival on the Heart Transplant Waiting List: Impact of Continuous Flow Left Ventricular Assist Device as Bridge to Transplant

Jaimin R. Trivedi, MD, MPH, Allen Cheng, MD, Ramesh Singh, MD, Matthew L. Williams, MD, and Mark S. Slaughter, MD

Division of Thoracic and Cardiovascular Surgery, University of Louisville, Louisville, Kentucky

(Ann Thorac Surg 2014;98:830–4)

UNOS Database
Propensity Match Study
Impact of LVAD on wait list survival

Does Left Ventricular Assist Device Support Improve Survival on the Heart Transplant Waiting List?

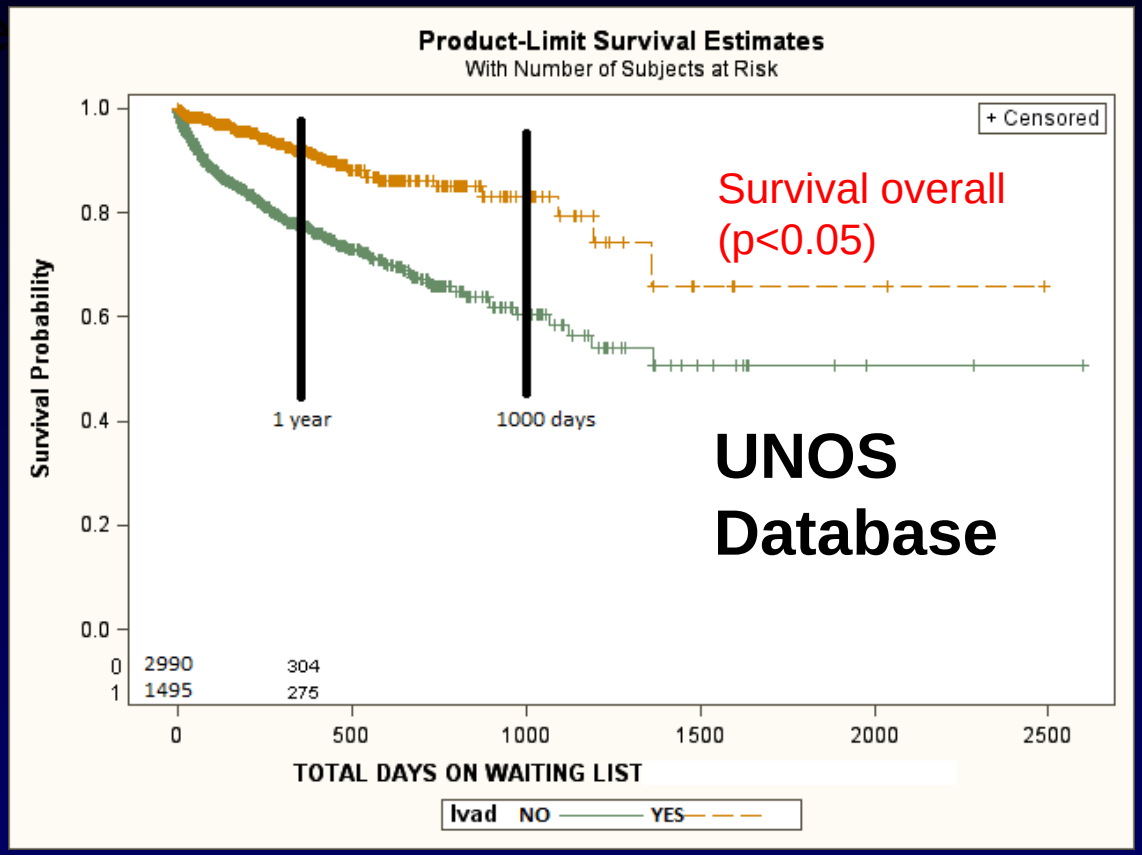
UNOS database Analysis:

Survival in Prope

Patients supported with HM II LVAD for BTT demonstrated an improved survival in patients on waiting list

Potential additional benefits

- Improved survival with LVAD could allow improved allocation of donor organs
- Improved quality of life while on waiting list compared non-LVAD patients



Trivedi J., Cheng A, Slaughter MS et al . Presented at STSA Annual Meeting 2013. Annal of Thoracic Surgery 2014;98:830-4.

DOI 10.1111/jocs.12823

TRANSPLANTATION AND MECHANICAL SUPPORT
ORIGINAL ARTICLE

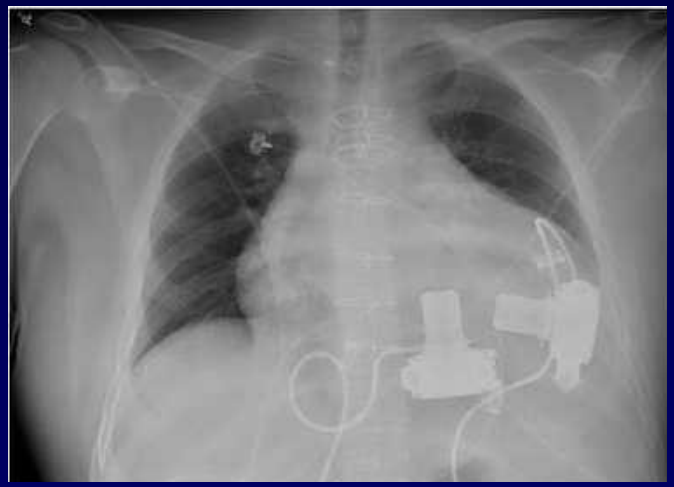
WILEY Journal of Cardiac Surgery

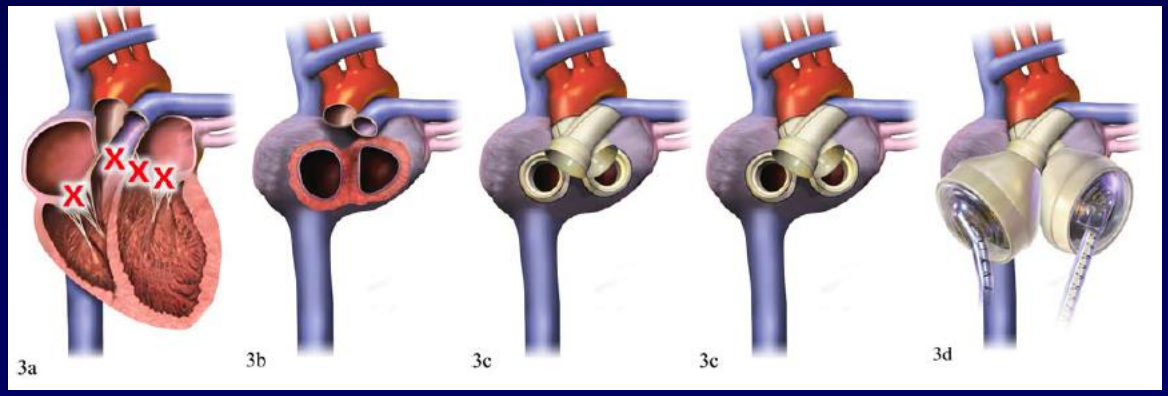
Comparison of total artificial heart and biventricular assist device support as bridge-to-transplantation

Allen Cheng, M.D.* | Jaimin R. Trivedi, M.D., M.P.H. |
Victor H. Van Berkel, M.D., Ph.D. | H. Todd Massey, M.D. | Mark S. Slaughter, M.D.

Cheng et al. *J Card Surg*. 2016 Oct;31(10):648-653

Biventricular Heart failure - BiVAD





Total Artificial Heart

LVAD Bridge to Recovery

- Effects of chronic mechanical unloading with LVAD
  - Decrease myocardial cytokines
  - Decreased neurohormonal activation
  - Up-regulation B-receptor density
  - Normalization Ca transport
  - Decrease wall stress & LVEDP
  - Decrease MR & PCWP
  - Decrease LVEDD
  - Reverse remodeling

Left Ventricular Assist Device as a Bridge to Recovery for Patients With Advanced Heart Failure

Djordje G. Jakovljevic, PhD,[a] Magdi H. Yacoub, MD, PhD,[b] Stephan Schueler, MD, PhD,[c] Guy A. MacGowan, MD,[c] Lazar Velicki, MD, PhD,[d] Petar M. Seferovic, MD, PhD,[e] Sandeep Hothi, PhD,[f] Bing-Hsiean Tzeng, MD, PhD,[g] David A. Brodie, DSci,[h] Emma Birks, MD, PhD,[i] Lip-Bun Tan, DPhil[j]

ABSTRACT

BACKGROUND Left ventricular assist devices (LVADs) have been used as an effective therapeutic option in patients with advanced heart failure, either as a bridge to transplantation, as destination therapy, or in some patients, as a bridge to recovery.

OBJECTIVES This study evaluated whether patients undergoing an LVAD bridge-to-recovery protocol can achieve cardiac and physical functional capacities equivalent to those of healthy controls.

METHODS Fifty-eight male patients—18 implanted with a continuous-flow LVAD, 16 patients with LVAD explanted (recovered patients), and 24 heart transplant candidates (HTx)—and 97 healthy controls performed a maximal graded cardiopulmonary exercise test with continuous measurements of respiratory gas exchange and noninvasive (rebreathing) hemodynamic data. Cardiac function was represented by peak exercise cardiac power output (mean arterial blood pressure × cardiac output) and functional capacity by peak exercise O_2 consumption.

RESULTS All patients demonstrated a significant exertional effort as demonstrated with the mean peak exercise respiratory exchange ratio >1.10. Peak exercise cardiac power output was significantly higher in healthy controls and explanted LVAD patients compared with other patients (healthy 5.35 ± 0.95 W; explanted 3.45 ± 0.72 W; LVAD implanted 2.37 ± 0.68 W; and HTx 1.31 ± 0.31 W; $p < 0.05$), as was peak O_2 consumption (healthy 36.4 ± 10.3 ml/kg/min; explanted 29.8 ± 5.9 ml/kg/min; implanted 20.5 ± 4.3 ml/kg/min; and HTx 12.0 ± 2.2 ml/kg/min; $p < 0.05$). In the LVAD explanted group, 38% of the patients achieved peak cardiac power output and 69% achieved peak O_2 consumption within the ranges of healthy controls.

CONCLUSIONS The authors have shown that a substantial number of patients who recovered sufficiently to allow explantation of their LVAD can even achieve cardiac and physical functional capacities nearly equivalent to those of healthy controls. (J Am Coll Cardiol 2017;69:1924–33)

JACC 2017;69:1924-33

Conclusion:

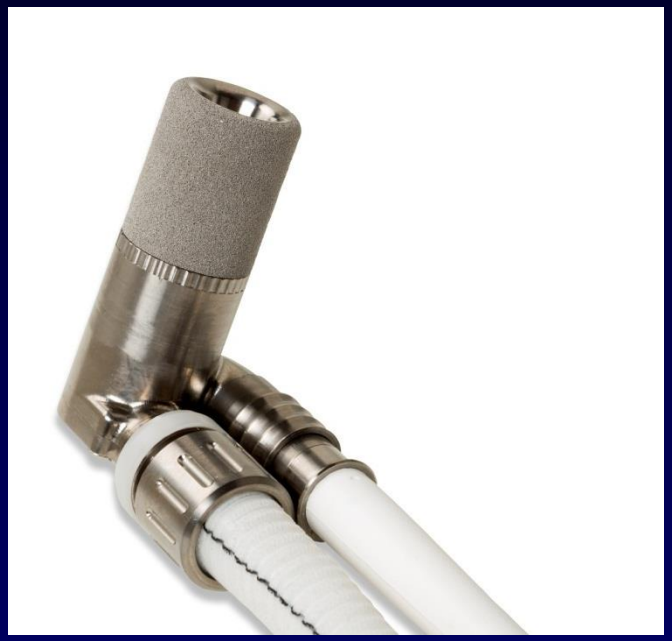
With specific bridge-to-recovery protocol, recovered patients with LVAD explanted can achieve the same cardiac and physical function capacities when compared to the healthy subjects.

The future of artificial device / left ventricular assist device for heart failure

CARDIOVASCULAR INNOVATION • INSTITUTE

HeartMate X

Ultra-Compact, Highly Versatile VAD = New patient populations



Features

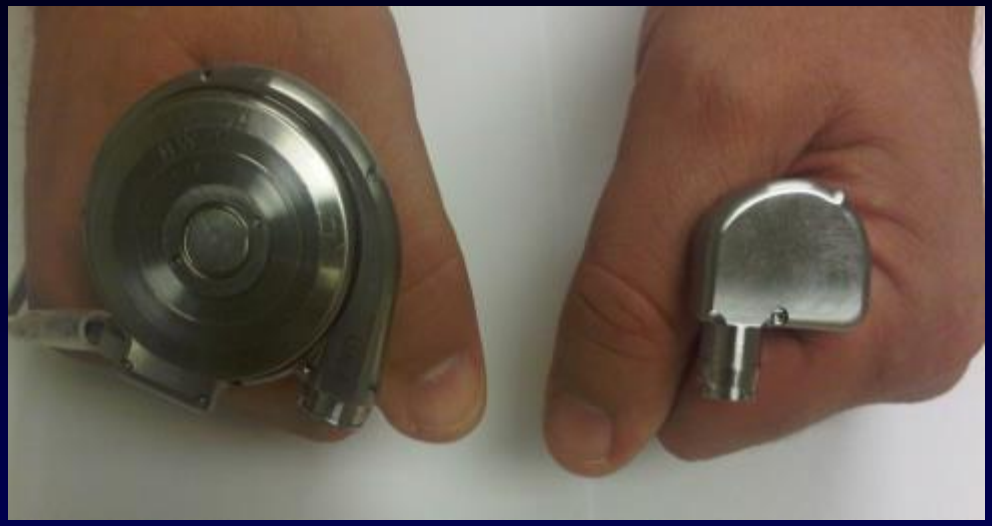
- Utilizes proven HeartMate II bearing technology
- Partial to Full support (8 L/min) in ultra-compact size
- Highly energy efficient
- Miniaturized patient peripherals
- Left and/or right side assistance

Expected Benefits

- Potential to meet the needs of earlier stage patients
- Potential for minimally invasive implantation
- Potential for multiple configurations (LVAD, RVAD, BiVAD)
- Very small, full support pump, can be use in various configuration, including as a RVAD and BiVAD, and will allow minimally invasive approaches.

*In development. Not approved for clinical use.

Heartware HVAD® and MVAD® Pump: Side-by-Side Comparison



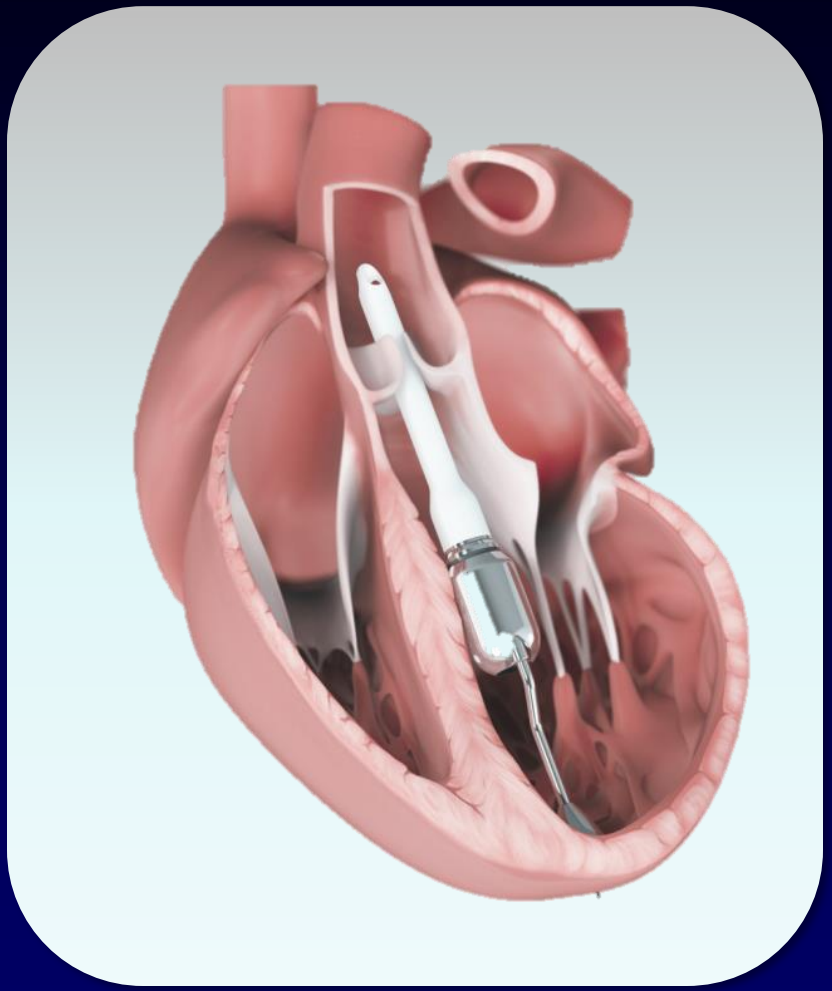
- Significantly smaller in size (Half the size of HVAD)
- Able to provide Full support
- Trial started in Europe –Increase in thromboembolic events, but sources found per Medtronics
- Trial in US soon

Parameter	HVAD	MVAD
Pump Type	Centrifugal	Axial
Weight	160 g	58 g
Pericardial Volume	50 cc	15 cc
Priming Volume	15 cc	5 cc
Inflow OD	Same	Same

CAUTION – Investigational Device. Limited by United States law to investigational use. Exclusively for Clinical Investigations.

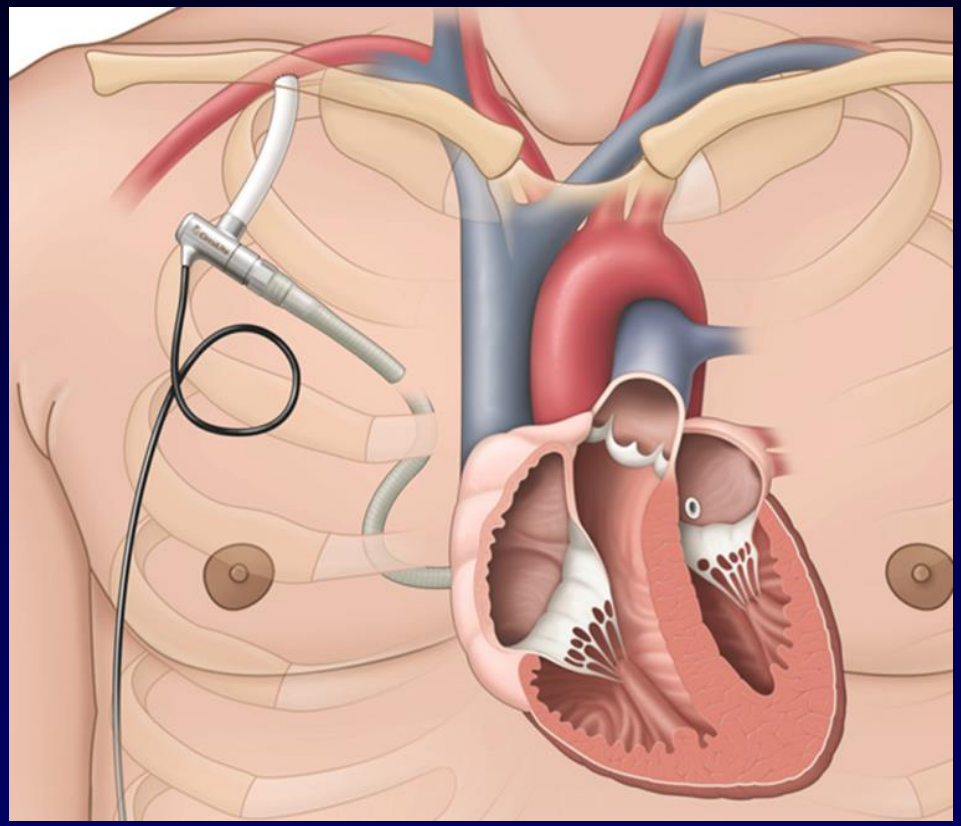
Transapical Cardiac Assist (Longhorn)

- Design based on MVAD Pump platform
- Transapical placement, pump cannula sits across aortic valve
- Axial design, continuous flow
- In vitro studies demonstrate no intraventricular or aortic valve thrombus
- Aortic valve seals around cannula with minimal to no regurgitation



- A variation of MVAD. Implant through the LV apex, pump rest in the left ventricle.
- No outflow anastomosis needed.
- Small Thoracotomy and off-pump.

CircuLite Surgical System



Partial support pump

Pump in subcutaneous pacemaker-like pocket

Inflow cannula done via small right sided mini-thoracotomy into the PV

ideal for less sick pts.

- Reduce Left Atrial and ventricular pressure - offloading
- Reverse end-organ dysfunction, BTT.
- Off-pump procedure
- Extubation in OR possible

Energy Source

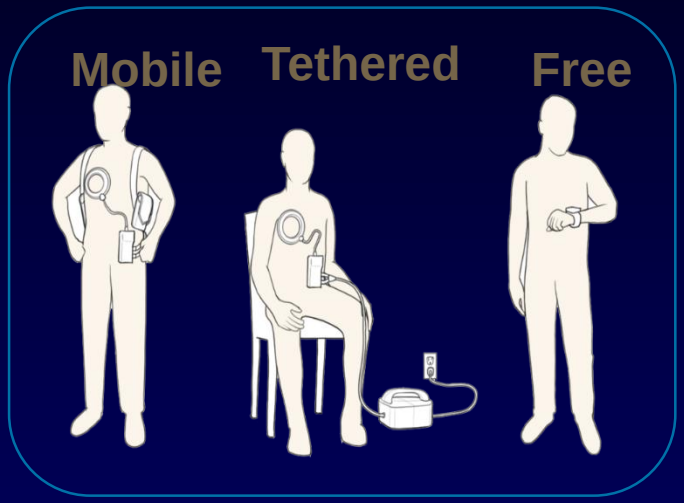
Current:

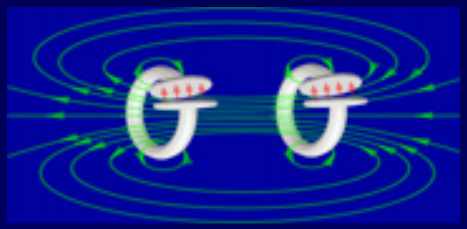
- Lithium ion batteries
- External driveline
- System controller
- “tethered” at all times
- Affect quality of life and not ideal

Fully Implantable System*

Breakthrough technology to advance mechanical circulatory support.

HeartMate





Forgiving Energy Transfer

- High-efficiency, user-friendly wireless energy transfer across a distance.
- Eliminates the driveline and "around the clock" worn equipment.

HeartWare

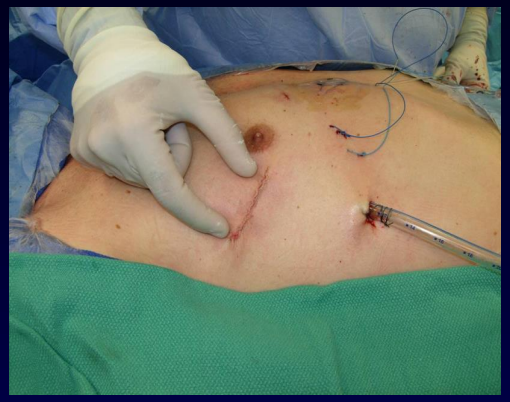
- Partnership with Dualis MedTech GmbH, a spin-off of the German Aerospace Centre (DLR)
- Competency in coil designs, biocompatible materials, and RF telemetry systems complement internal development effort
- Configuring technology for HVAD/MVAD

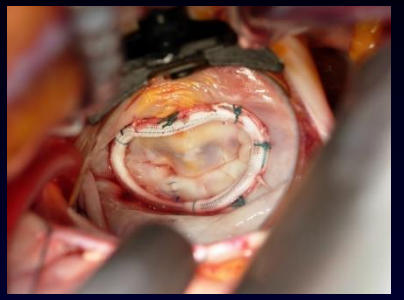
Pt happier without external battery, system controller, risk of driveline infection, fracture driveline, frequent visit to hospital.

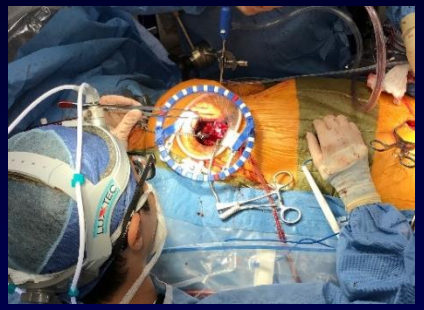
- **WREL (Wireless Resonant Energy Link)**

Other option. A home system. Energy transmit at home. At least untether at home. Do daily activity freely at home.

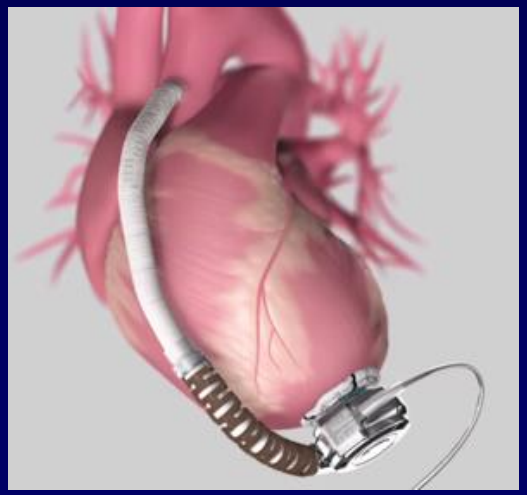
Minimally Invasive Heart Surgery (Key Hole Heart Surgery)

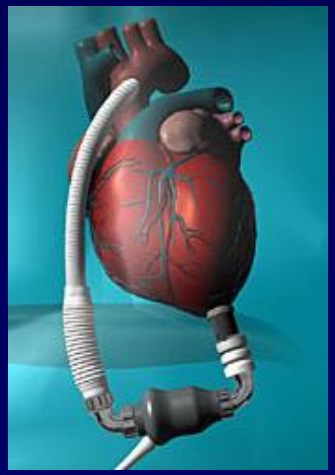




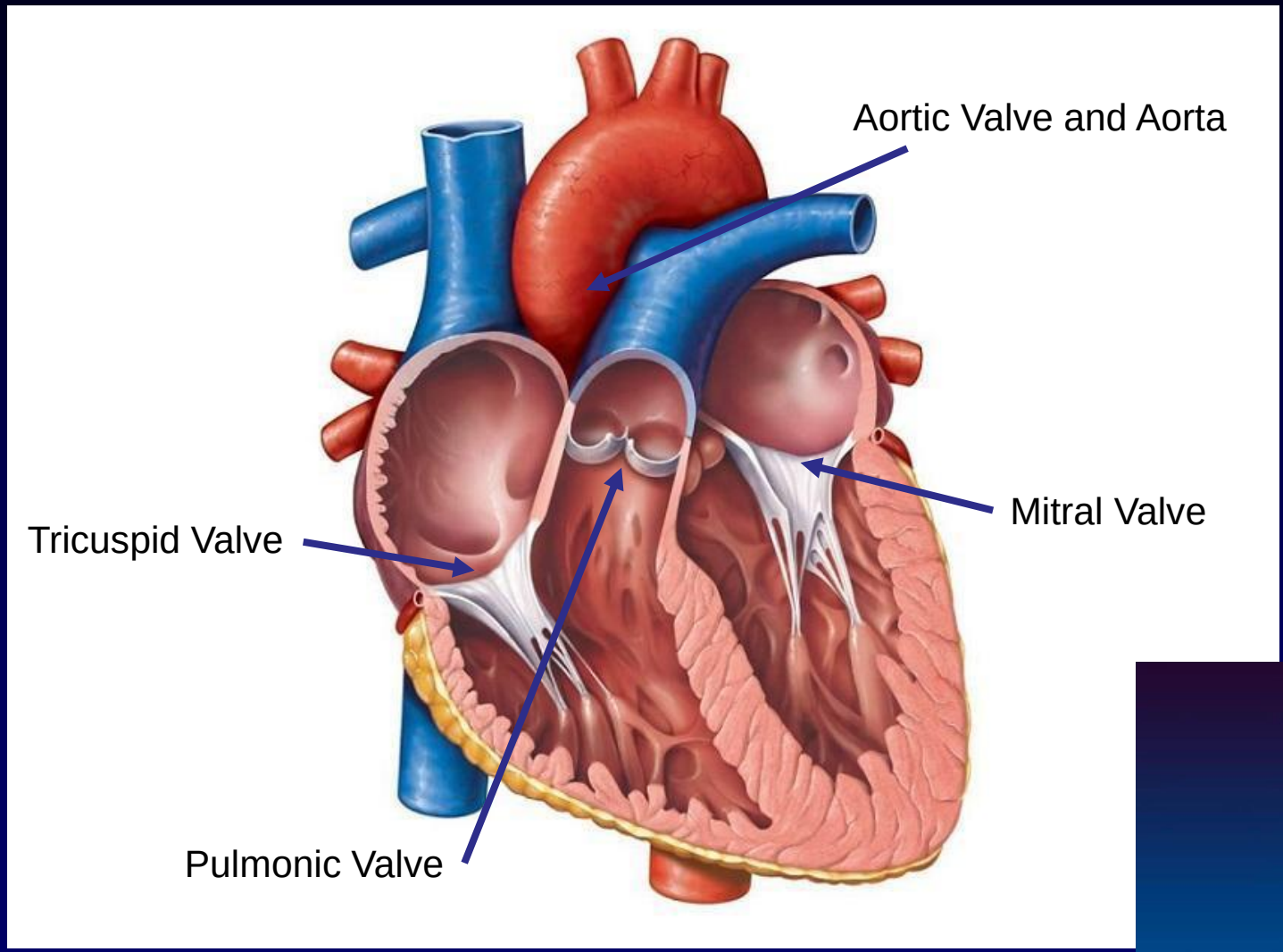


Artificial Heart / Left Ventricular Assist Device for Heart Failure

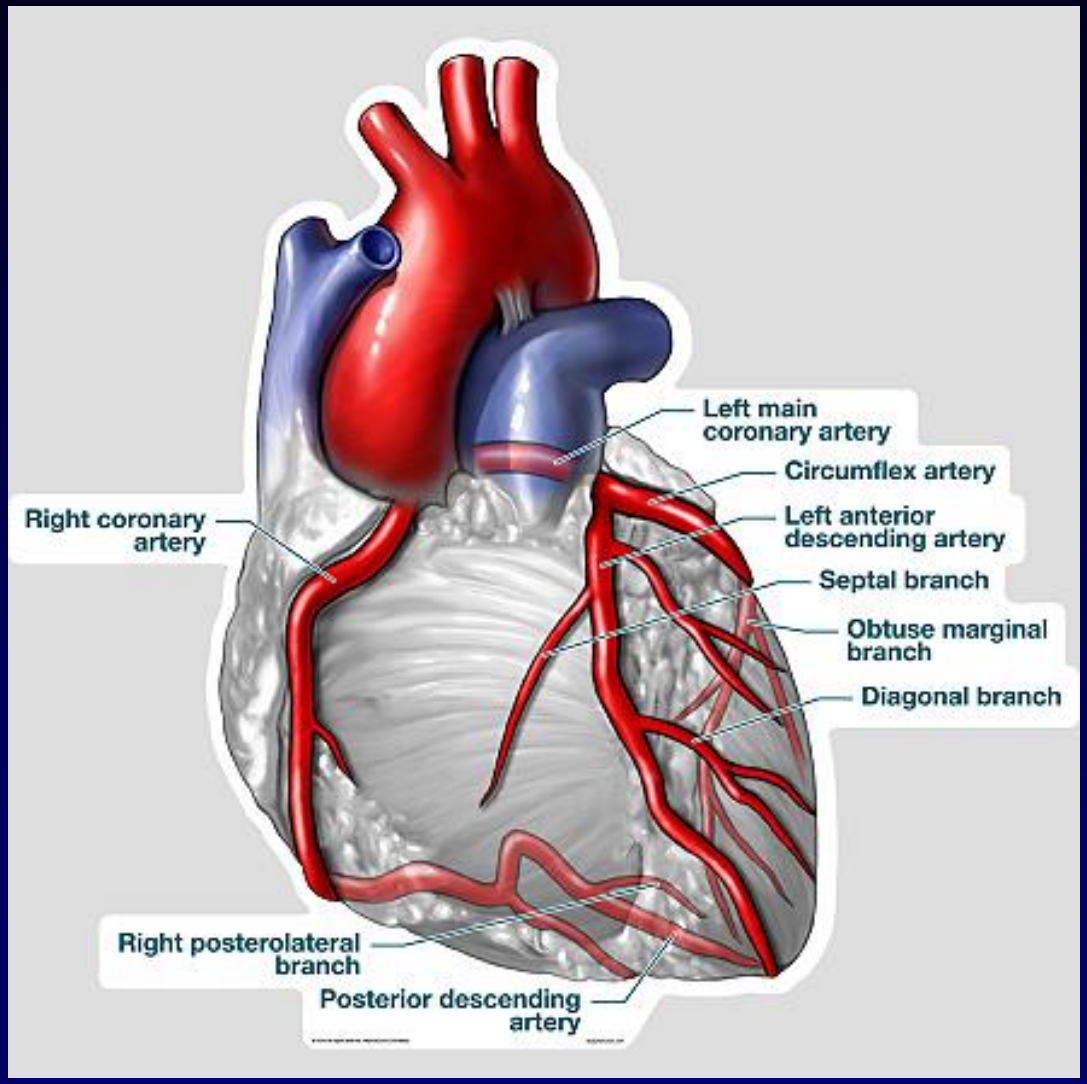




Heart Anatomy



Coronary Artery Anatomy



What Is the Role of Minimally Invasive Mitral Valve Surgery in High-Risk Patients? A Meta-Analysis of Observational Studies

Marco Moscarelli, MD, Khalil Fattouch, MD, PhD, Roberto Casula, MD, Giuseppe Speziale, MD, PhD, Patrizio Lancellotti, MD, PhD, and Thanos Athanasiou, MD, PhD

National Heart and Lung Institute and Department of Surgery and Cancer, Imperial College London, London, United Kingdom; GVM Care and Research, Villa Maria Eleonora, Palermo; GVM Care, Anthea Hospital, Bari, Italy; Department of Cardiology, University of Liège Hospital, Liege, Belgium; and the GVM Care and Research Group

Background. Minimally invasive valve surgery is related to certain better postoperative outcomes. We aimed to assess the role of minimally invasive mitral valve surgery in high-risk patients.

Methods. A systematic literature review identified eight studies of which seven fulfilled criteria for meta-analysis. Outcomes for a total of 1,254 patients (731 were conventional standard sternotomy and 523 were minimally invasive mitral valve surgery) were submitted to meta-analysis using random effects modeling. Heterogeneity and subgroup analysis with quality scoring were assessed. The primary end point was early mortality. Secondary end points were intraoperative and postoperative outcomes and long-term follow-up.

Results. Minimally invasive mitral valve surgery conferred comparable early mortality to standard sternotomy ($p = 0.19$); it was also associated with a lower number of units of blood transfused (weighted mean difference, −1.93; 95% confidence interval [CI], −3.04 to −0.82; $p = 0.0006$) and atrial fibrillation rate (odds ratio, 0.49; 95% CI, 0.32 to 0.74; $p = 0.0007$); however, cardiopulmonary bypass time was longer (weighted mean difference, 20.88; 95% CI, −1.90 to 43.65; $p = 0.07$). There was no difference in terms of valve repair rate (odds ratio, 1.51; 95% CI, 0.89 to 2.54; $p = 0.12$), and the incidence of stroke was significantly lower in the high-quality analysis with no heterogeneity (odds ratio, 0.35; 95% CI, 0.15 to 0.82; $p = 0.02$; χ^2, 1.67; I^2, 0%; $p = 0.43$).

Conclusions. Minimally invasive mitral valve surgery is a safe and comparable alternative to standard sternotomy in patients at high risk, with similar early mortality and repair rate and better postoperative outcomes, although a longer cardiopulmonary bypass time is required.

(Ann Thorac Surg 2016;101:981–9)

Table 5. Results of High-Quality Studies (More Than 7 EuroSCORE II Risk Factors or Quality Score > 7)

Outcome	N			Mean Difference	Overall Effect			Heterogeneity		
	Studies = 4	MIMVS	ST		Odds Ratio	95% CI	*p* Value	χ^2	*p* Value	I^2
Primary outcome										
Early mortality		325	366		0.97	0.45 to 2.10	0.93	4.25	0.24	29%
Secondary outcomes										
CPB time		325	366	33.45		−19.58 to 86.48	0.22	354.36	<0.00001	99%
Number of units PRC transfused[a]		255	261	−1.57		−3.04 to −0.10	0.04	7.55	0.02	74%
Repair		325	366		1.07	0.68 to 1.69	0.76	5.76	0.12	48%
Stroke[a]		303	338		0.35	0.15 to 0.82	0.02	1.67	0.43	0%
Reopening for bleeding		325	366		1.19	0.65 to 2.18	0.58	4.67	0.20	36%
Prolonged intubation[b]		325	366		0.68	0.43 to 1.08	0.11	3.24	0.36	8%
AF[ab]		255	261		0.49	0.32 to 0.74	0.0007	0.52	0.77	0%
Acute renal failure[b]		303	338		0.60	0.28 to 1.25	0.17	2.86	0.24	30%
AV block requiring PM implant[b]		255	261		0.53	0.24 to 1.20	0.13	2.93	0.23	32%

[a] Denotes significance. [b] High-sensitivity studies already part of the overall meta-analysis results.

AF = atrial fibrillation; AV = atrioventricular; CI = confidence interval; CPB = cardiopulmonary bypass; MIMVS = minimally invasive mitral valve surgery; PM = pacemaker; PRC = packed red cells; ST = sternotomy.

Ann Thorac Surg 2016;101:981–9

Meta Analysis

N = 1254 patients

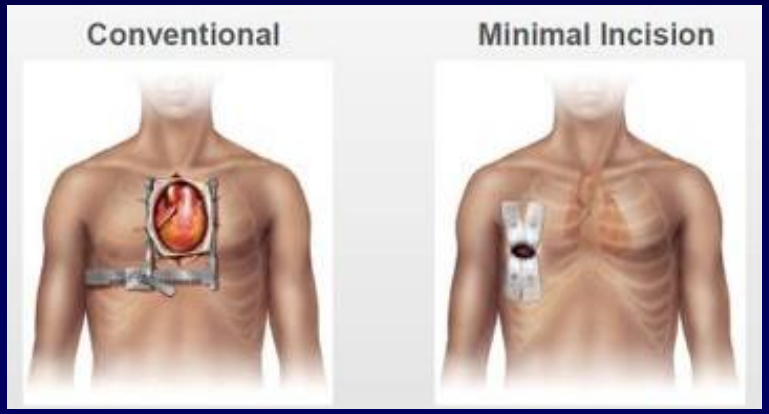
Minimally Invasive patients (including high risks patients) has better postoperative outcomes:

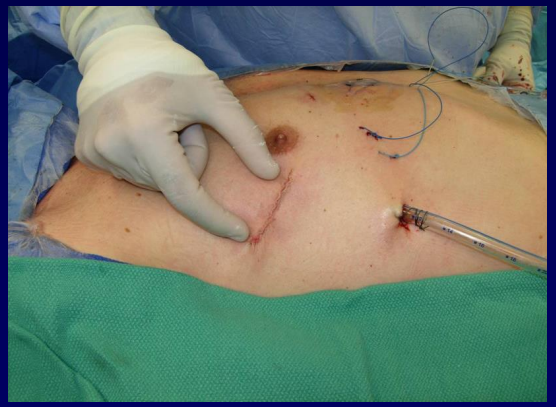
Lower unit of blood transfusion needed (p=0.0006)

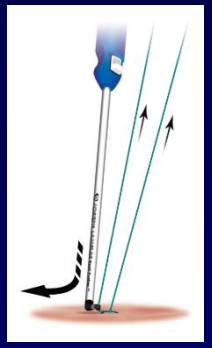
Lower Stroke rate (p=0.02)

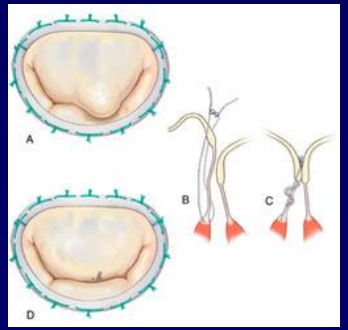
Lower Atrial fibrillation rate (p=0.0007)

Minimally Invasive Heart Surgery (Key Hole Surgery









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Marco Moscarelli, MD, Khalil Fattouch, MD, PhD, Roberto Casula, MD, Giuseppe Speziale, MD, PhD, Patrizio Lancellotti, MD, PhD, and Thanos Athanasiou, MD, PhD

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Minimally Invasive patients (including high risks patients) has better postoperative outcomes:

Lower unit of blood transfusion needed (p=0.0006)

Lower Stroke rate (p=0.02)

Lower Atrial fibrillation rate (p=0.0007)

Incidence of postoperative atrial fibrillation in patients undergoing minimally invasive versus median sternotomy valve surgery

Christos G. Mihos, DO,[a] Orlando Santana, MD,[a] Gervasio A. Lamas, MD,[a] and Joseph Lamelas, MD[b]

Background: Atrial fibrillation (AF) after cardiac surgery is associated with increased morbidity and hospital length of stay. Our objective was to determine whether a minimally invasive approach to isolated valve surgery reduced the incidence of postoperative AF.

Methods: Patients without a history of arrhythmia, who underwent isolated aortic or mitral valve surgery between January 2005 and August 2011, were included. The incidence of postoperative AF in those who underwent a minimally invasive approach was compared with that of patients undergoing median sternotomy surgery. Resource utilization was approximated on the basis of intensive care unit and total hospital lengths of stay.

Results: A total of 571 patients were identified (413 minimally invasive and 158 median sternotomy). No significant differences in baseline characteristics existed between groups. The incidence of postoperative AF (25% vs 37%; $P = .002$), use of intraoperative blood products (52% vs 83%; $P < .001$), and prolonged intubation (≥24 hours) (12% vs 20%; $P = .008$) were significantly less in the minimally invasive group. The intensive care unit and hospital lengths of stay were 45 hours (interquartile range [IQR], 28-66 hours) versus 53 hours (IQR, 45-91 hours) ($P < .001$), and 5 days (IQR, 4-7 days) versus 8 days (IQR, 6-11 days) ($P < .001$) for the minimally invasive and median sternotomy groups, respectively. Multivariable analysis revealed a decreased risk of postoperative AF in patients undergoing minimally invasive surgery (odds ratio, 0.4; 95% confidence intervals, 0.24-0.66; $P < .001$).

Conclusions: A minimally invasive approach for isolated valve surgery reduces postoperative AF and resource use when compared with median sternotomy. (J Thorac Cardiovasc Surg 2013;146:1436-41)

TABLE 5. Postoperative outcomes in patients with AF

Variables	AF (n = 160)	AF (n = 411)	*P* value
In-hospital mortality	0	5 (1%)	.16
Bleeding necessitating reoperation	5 (3%)	6 (2%)	.19
Deep wound infection	0	1 (0.2%)	.53
Prolonged intubation	38 (24%)	42 (10%)	<.001
Acute renal failure	6 (4%)	5 (1%)	.05
Sepsis	5 (3%)	5 (1%)	.12
Pneumonia	11 (7%)	10 (2%)	.01
Reintubation	17 (11%)	13 (3%)	<.001
Stroke	1 (0.6%)	4 (1%)	.69
Intensive care unit length of stay (h, median, IQR)	46 (29-64)	53 (44-98)	<.001
Hospital length of stay (d, median, IQR)	5 (4-7)	8 (6-11)	<.001

AF, Atrial fibrillation; *IQR*, interquartile range.

Ann Thorac Surg 2016;101:981-9.

N = 571 (413 MIS vs 158 open)

Post-op A.fib (MIS vs open; 25% vs. 37%, p=0.002)

Prolong intubation (>24 hrs) (12% vs. 20%, p=0.008)

Hospital Stay Duration (5 vs 8 days, p=0.008)

TABLE 3. Operative results and clinical outcomes

Variables	Minimally invasive (n = 413)	Median sternotomy (n = 158)	*P* value
Mortality	4 (0.9%)	1 (0.6%)	.7
Bleeding requiring reoperation	7 (1.7%)	4 (2.5%)	.52
Deep wound infection	0	1 (0.6%)	.11
Stroke	4 (0.9%)	1 (0.6%)	.7
Prolonged intubation (>24 h)	48 (12%)	32 (20%)	.008
Intensive care unit length of stay (h, median, IQR)	45 (28-66)	53 (45-91)	<.001
Intensive care unit readmission	10 (2%)	10 (6%)	.02
Hospital length of stay (d, median, IQR)	5 (4-7)	8 (6-11)	<.001
Postoperative AF	101 (25%)	59 (37%)	.002

SD, Standard deviation, *IQR*, interquartile range; *AF*, atrial fibrillation.

Masters of Cardiothoracic Surgery

Concomitant minithoracotomy aortic and mitral valve surgery: the minimally invasive "Miami Method"

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Background and aim of the study: The feasibility of minimally invasive triple valve surgery performed via a right anterior thoracotomy approach was evaluated.

Methods: A retrospective analysis was conducted on all patients who underwent minimally invasive triple valve surgery via a right anterior thoracotomy approach at the authors' institution between December 2009 and February 2013. The operative times and intensive care unit and hospital lengths of stay, postoperative complications, and mortality were analyzed.

Results: Six patients (three males, three females; mean age 76.7 ± 5.4 years) were identified. Five patients had a prosthetic aortic valve, and one patient had an aortic valve repaired by commissuroplasty. In four patients the mitral valve repair was effected with an annuloplasty ring, while in two patients a transaortic edge-to-ed performed. All patient with a ring annulopla clamp time was 136 mi median cardiopulmona (IQR: 145-231 min). Th and hospital lengths of and 12 days (IQR: 7- were no postoperativ myocardial infarctions patients developed po and two died at 30 day

Conclusion: In patients a minimally invasive a anterior thoracotomy these high-risk patient

Outcomes of minimally invasive double valve surgery

Orlando Santana[1], Steve Xydas[1], Roy F. Williams[1], Angelo LaPietra[1], Maurice Mawad[1], Frederick Hasty[2], Esteban Escolar[1], Christos G. Mihos[3]

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Contributions: (I) Conception and design: O Santana, CG Mihos; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: O Santana, CG Mihos; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: Double valve surgery is associated with an increased peri-operative morbidity and mortality. A less invasive right thoracotomy approach may be a viable alternative to median sternotomy surgery in these higher-risk patients.

Methods: We retrospectively analyzed the baseline demographics, operative characteristics, and post-operative outcomes of patients who underwent minimally invasive double valve surgery between January 2009 and December 2011 at our institution.

Results: The cohort consisted of 117 patients, of which 68 (58.1%) were female. The mean age was 73±11 years, and the mean left ventricular ejection fraction was 52±11%. There were 43 (36.8%) patients with a history of congestive heart failure, 45 (38.5%) with chronic obstructive pulmonary disease, and 5 (4.3%) had a history of chronic kidney disease. The patients underwent primary (90.6%) or re-operative (9.4%) double valve surgery, which consisted of 50 (42.7%) aortic valve replacement and mitral valve repair, 31 (26.5%) mitral and tricuspid valve repair, 18 (15.4%) aortic and mitral valve replacement, 17 (14.5%) mitral valve replacement with tricuspid valve repair, and 1 (0.9%) aortic valve replacement with tricuspid valve repair. Post-operatively, there were 40 (34.2%) cases of prolonged ventilation, 9 (7.7%) acute kidney injury, 6 (5.1%) re-operations for bleeding, 1 (0.9%) cerebrovascular accident, and 15 (12.8%) cases of atrial fibrillation. The mean total hospital length of stay was 12±12 days, with an in-hospital mortality of 2 (1.7%).

Conclusions: A minimally invasive right thoracotomy approach to primary or re-operative double valve surgery is feasible, may be utilized with acceptable peri-operative morbidity and mortality.

Keywords: Aortic valve replacement; double valve surgery; minimally invasive valve surgery; mitral valve surgery; tricuspid valve repair

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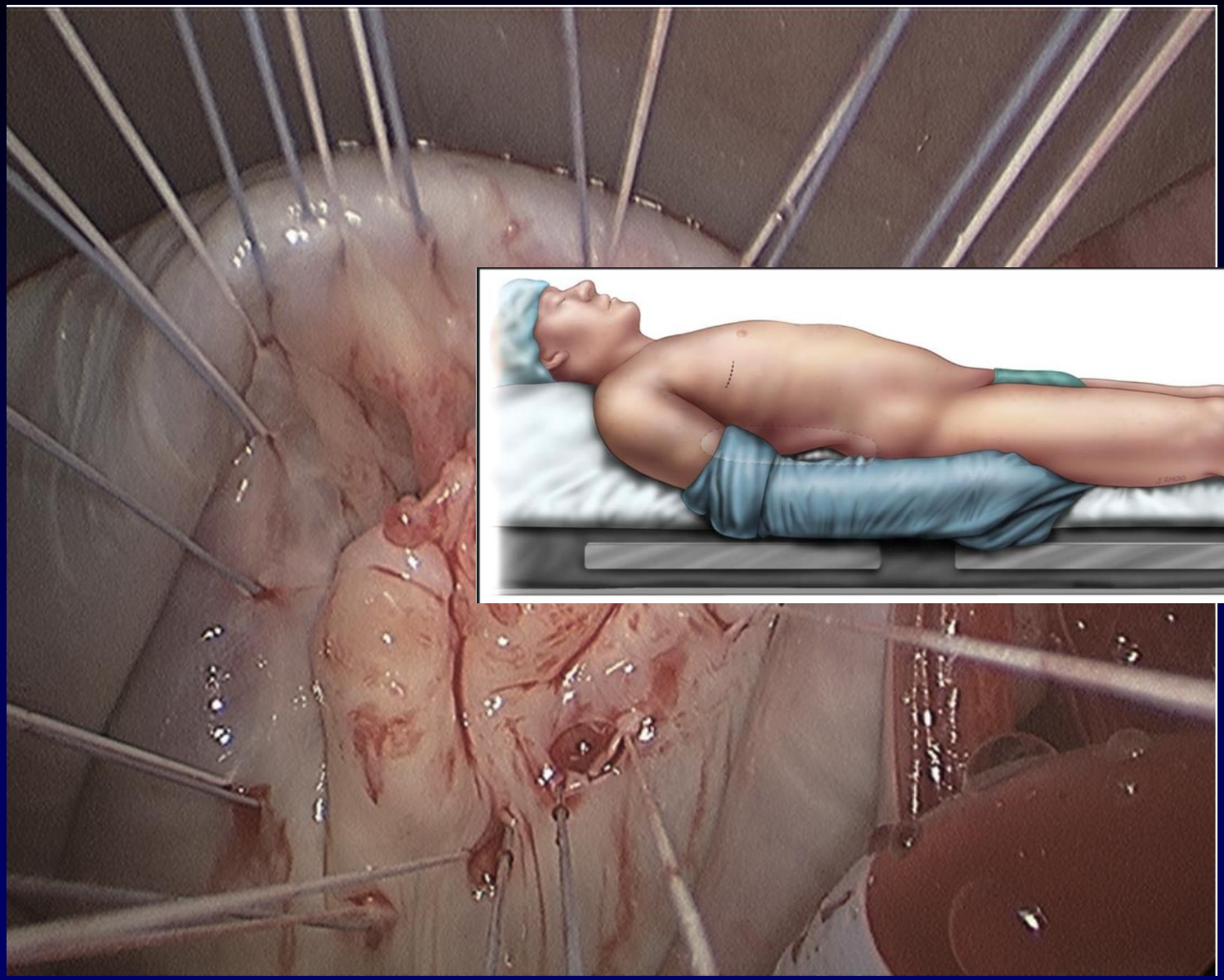
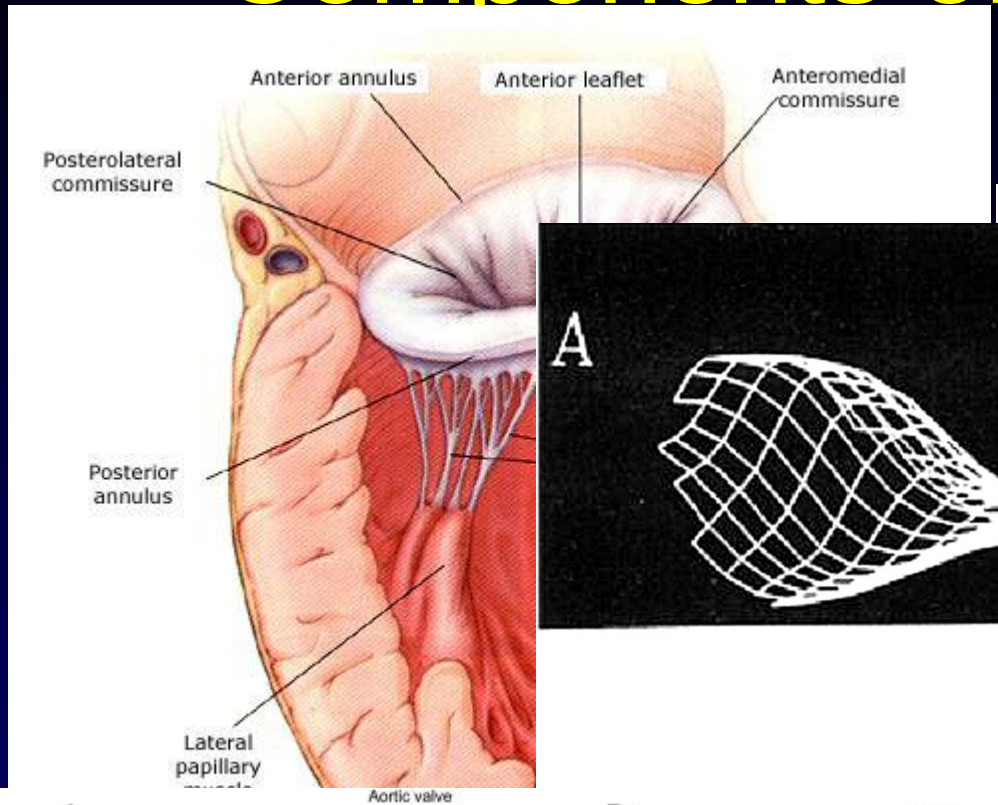
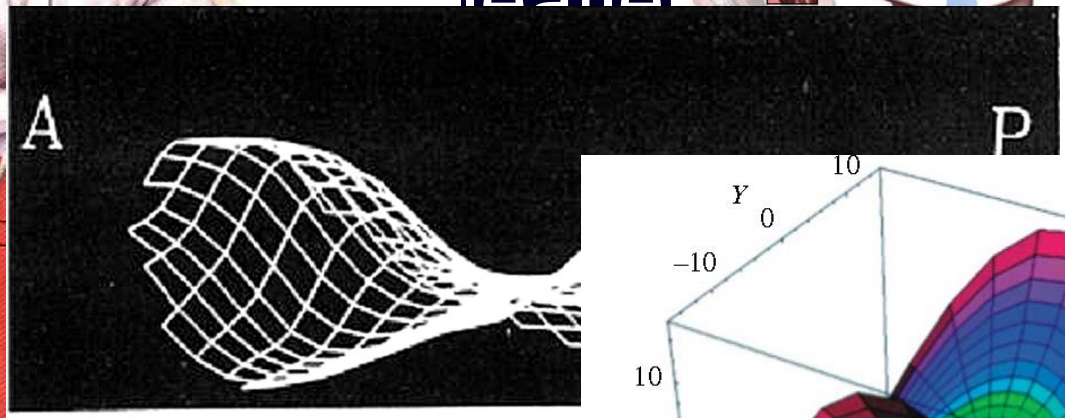
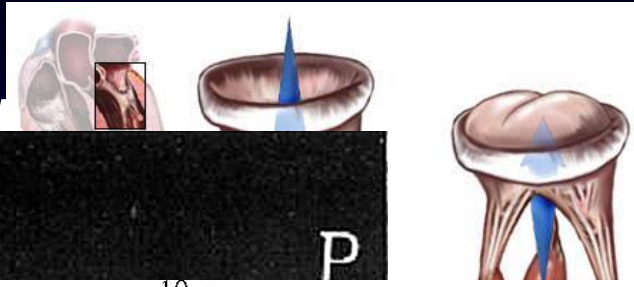
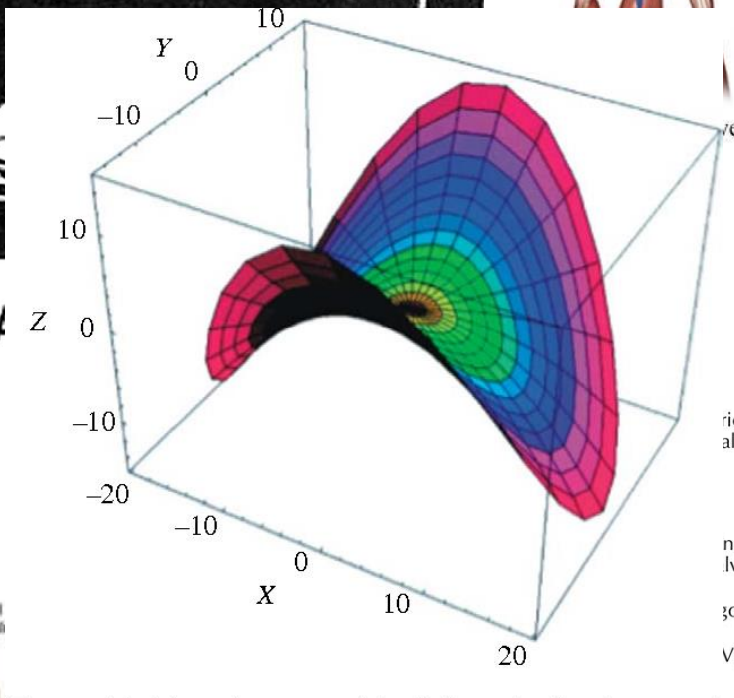


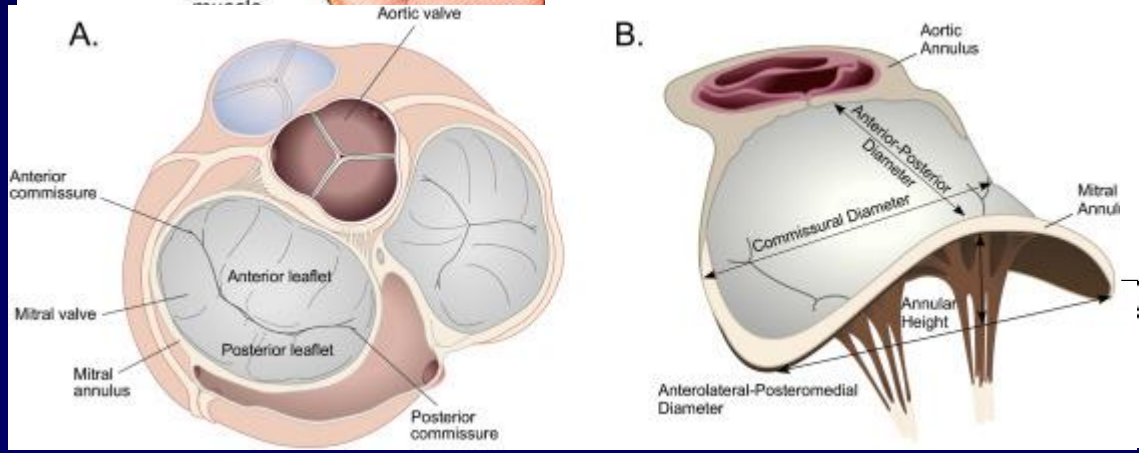
Components of Mitral Valve











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CLINICAL PRACTICE GUIDELINE: FOCUSED UPDATE

2017 AHA/ACC Focused Update of 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines

Developed in Collaboration With the American Association for Thoracic Surgery, American Society of Echocardiography, Society for Cardiovascular Angiography and Interv Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

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TABLE 1 Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care* (Updated August 2015)

CLASS (STRENGTH) OF RECOMMENDATION

CLASS I (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

CLASS IIa (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

CLASS IIb (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well established

CLASS III: No Benefit (MODERATE) — Benefit = Risk
(Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

CLASS III: Harm (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

LEVEL A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

LEVEL B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

LEVEL B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

LEVEL C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

LEVEL C-EO (Expert Opinion)

Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR I and IIa; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

Recommendations fo

COR	LOE
I	B
I	B
I	B
I	B
I	B

(continued)

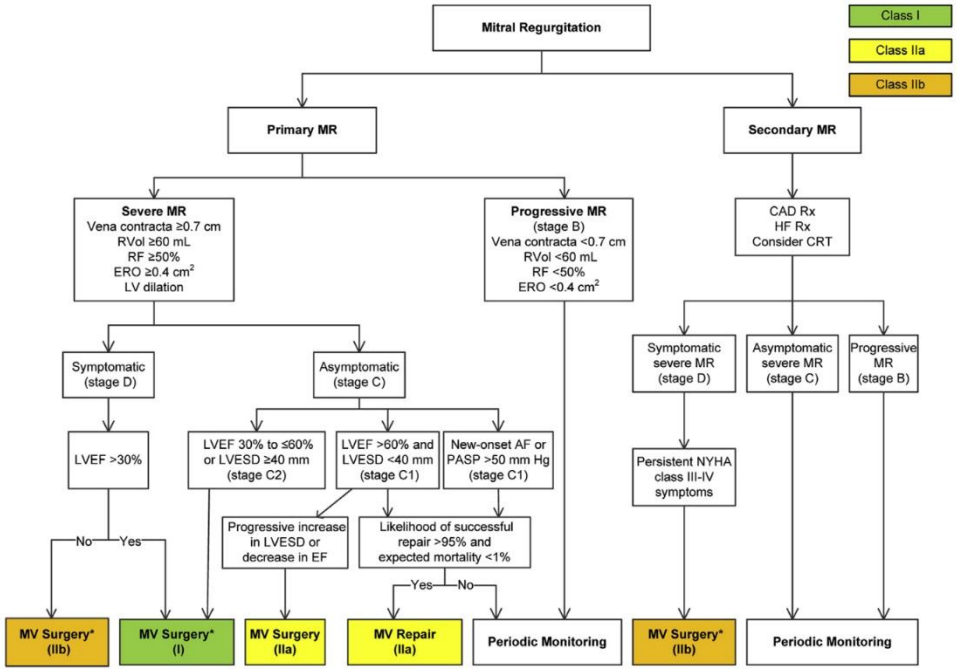
IIa	B	Mitral valve repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is greater than 95% with an expected mortality rate of less than 1% when performed at a Heart Valve Center of Excellence (101,106-112).	2014 recommendation remains current.
IIa	C-LD	Mitral valve surgery is reasonable for asymptomatic patients with chronic severe primary MR (stage C1) and preserved LV function (LVEF >60% and LVESD <40 mm) with a progressive increase in LV size or decrease in ejection fraction (EF) on serial imaging studies (112-115). (Figure 2)	NEW: Patients with severe MR who reach an EF ≤60% or LVESD ≥40 have already developed LV systolic dysfunction, so operating before reaching these parameters, particularly with a progressive increase in LV size or decrease in EF on serial studies, is reasonable.

See Online Data Supplement 17 (Updated From 2014 VHD Guideline)

There is concern that the presence of MR leads to progressively more severe MR ("mitral regurgitation begets mitral regurgitation"). The concept is that the initial level of MR causes LV dilatation, which increases stress on the mitral apparatus, causing further damage to the valve apparatus, more severe MR and further LV dilatation, thus initiating a perpetual cycle of ever-increasing LV volumes and MR. Longstanding volume overload leads to irreversible LV dysfunction and a poorer prognosis. Patients with severe MR who develop an EF ≤60% or LVESD ≥40 have already developed LV systolic dysfunction (112-115). One study has suggested that for LV function and size to return to normal after mitral valve repair, the left ventricular ejection fraction (LVEF) should be >64% and LVESD <37 mm (112). Thus, when longitudinal follow-up demonstrates a progressive decrease of EF toward 60% or a progressive increase in LVESD approaching 40 mm, it is reasonable to consider intervention. Nonetheless, the asymptomatic patient with stable LV dimensions and excellent exercise capacity can be safely observed (116).

IIa	B	Mitral valve repair is reasonable for asymptomatic patients with chronic severe nonrheumatic primary MR (stage C1) and preserved LV function (LVEF >60% and LVESD <40 mm) in whom there is a high likelihood of a successful and durable repair with 1) new onset of AF or 2) resting pulmonary hypertension (pulmonary artery systolic arterial pressure >50 mm Hg) (111,117-123).	2014 recommendation remains current.
IIa	C	Concomitant mitral valve repair is reasonable in patients with chronic moderate primary MR (stage B) when undergoing cardiac surgery for other indications.	2014 recommendation remains current.
IIb	C	Mitral valve surgery may be considered in symptomatic patients with chronic severe primary MR and LVEF less than or equal to 30% (stage D).	2014 recommendation remains current.
IIb	B	Transcatheter mitral valve repair may be considered for severely symptomatic patients (NYHA class III to IV) with chronic severe primary MR (stage D) who have favorable anatomy for the repair procedure and a reasonable life expectancy but who have a prohibitive surgical risk because of severe comorbidities and remain severely symptomatic despite optimal GDMT for heart failure (HF) (124).	2014 recommendation remains current.
III: Harm	B	MVR should not be performed for the treatment of isolated severe primary MR limited to less than one half of the posterior leaflet unless mitral valve repair has been attempted and was unsuccessful (84,89,90,95).	2014 recommendation remains current.

FIGURE 2 Indications for Surgery for MR (Updated Figure 4 From the 2014 VHD guideline)



*MV repair is preferred over MV replacement when possible.

AF indicates atrial fibrillation; CAD, coronary artery disease; CRT, cardiac resynchronization therapy; EF, ejection fraction; ERO, effective regurgitant orifice; HF, heart failure; LV, left ventricular; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic diameter; MR, mitral regurgitation; MV, mitral valve; NYHA, New York Heart Association; PASP, pulmonary artery systolic pressure; RF, regurgitant fraction; RVol, regurgitant volume; and Rx, therapy.

Recommendations for Secondary MR Intervention

COR	LOE	RECOMMENDATIONS
IIa	C	Mitral valve surgery is reasonable for pa chronic severe secondary MR (stages C a undergoing CABG or AVR.
IIa	B-R	It is reasonable to choose chordal-sparir downsized annuloplasty repair if operati considered for severely symptomatic pa class III to IV) with chronic severe ischer D) and persistent symptoms despite GD (69,70,125,127,130–139).

See Online Data Supplement 18 (Updated From 2014 VHD Guideline)

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JULY 11, 2017:252–89

(continued)

In an RCT of mitral valve repair versus MVR in 251 patients with severe is 23.2% in the replacement group (p=0.39) (70). There was no differenc moderate or severe MR over 2 years was higher in the repair group than higher incidence of HF and repeat hospitalizations in the repair group (poor prognosis of secondary MR. The lack of apparent benefit of valv highlights that primary and secondary MR are 2 different diseases (69,12

IIb	B	Mitral valve repair or replacement may l for severely symptomatic patients (NYH IV) with chronic severe secondary MR (s have persistent symptoms despite optin HF (125,127,130–140).
IIb	B-R	In patients with chronic, moderate, isch (stage B) undergoing CABG, the usefuln valve repair is uncertain (71,72).

See Online Data Supplement 18 (Updated From 2014 VHD Guideline)

In an RCT of 301 patients with moderate ischemic MR undergoing CABG, mortality rate at 2 years was 10.6% in the group undergoing CABG alone and 10.0% in the group undergoing CABG plus mitral valve repair (HR in the combined-procedure group = 0.90; 95% CI: 0.45 to 1.83; p=0.78) (71). There was a higher rate of moderate or severe residual MR in the CABG-alone group (32.3% versus 11.2%; p<0.001), even though LV reverse remodeling was similar in both groups (71). Although rates of hospital readmission and overall serious adverse events were similar in the 2 groups, neurological events and supraventricular arrhythmias were more frequent with combined CABG and mitral valve repair. Thus, only weak evidence to support mitral repair for moderate secondary MR at the time of other cardiac surgery is currently available (71,72).

Table 17. Summary of Recommendations for Chronic *Primary* MR

Recommendations	COR	LOE	References
MV surgery is recommended for symptomatic patients with chronic severe primary MR (stage D) and LVEF >30%	I	B	(365,376)
MV surgery is recommended for asymptomatic patients with chronic severe primary MR and LV dysfunction (LVEF 30%–60% and/or LVESD ≥40 mm, stage C2)	I	B	(359–362, 392–394)
MV repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR limited to the posterior leaflet	I	B	(87,364, 395–409)
MV repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR involving the anterior leaflet or both leaflets when a successful and durable repair can be accomplished	I	B	(86,407–413)
Concomitant MV repair or replacement is indicated in patients with chronic severe primary MR undergoing cardiac surgery for other indications	I	B	(414)
MV repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is >95% with an expected mortality rate of <1% when performed at a Heart Valve Center of Excellence	IIa	B	(39,86, 415–419)
MV repair is reasonable for asymptomatic patients with chronic severe nonrheumatic primary MR (stage C1) and preserved LV function in whom there is a high likelihood of a successful and durable repair with 1) new onset of AF or 2) resting pulmonary hypertension (PA systolic arterial pressure >50 mm Hg)	IIa	B	(363,415, 420–425)
Concomitant MV repair is reasonable in patients with chronic moderate primary MR (stage B) undergoing cardiac surgery for other indications	IIa	C	N/A
MV surgery may be considered in symptomatic patients with chronic severe primary MR and LVEF ≤30% (stage D)	IIb	C	N/A
MV repair may be considered in patients with rheumatic mitral valve disease when surgical treatment is indicated if a durable and successful repair is likely or if the reliability of long-term anticoagulation management is questionable	IIb	B	(86,406,413)
Transcatheter MV repair may be considered for severely symptomatic patients (NYHA class III/IV) with chronic severe primary MR (stage D) who have a reasonable life expectancy but a prohibitive surgical risk because of severe comorbidities	IIb	B	(426)
MVR should not be performed for treatment of isolated severe primary MR limited to less than one half of the posterior leaflet unless MV repair has been attempted and was unsuccessful	III: Harm	B	(87,407–409)

AF indicates atrial fibrillation; COR, Class of Recommendation; LOE, Level of Evidence; LV, left ventricular; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic dimension; MR, mitral regurgitation; MV, mitral valve; MVR, mitral valve replacement; N/A, not applicable; NYHA, New York Heart Association; and PA, pulmonary artery.

increased risk of postoperative complications.

CLASS I

3. **Mitral valve repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR limited to the posterior leaflet (87,364,395–409). *(Level of Evidence: B)***

Mitral competence is only 1 function of the mitral valve apparatus. The mitral valve apparatus is an integral part of the left ventricle. It aids in LV contraction and helps maintain the efficient prolate ellipsoid shape of the left ventricle. Destruction of the mitral apparatus causes immediate LV dysfunction. Mitral valve repair is favored over MVR for 3 reasons:

1. Mitral valve repair is performed at a lower operative mortality rate than MVR. Although no RCTs exist, virtually every clinical report, including data from the STS database, indicates that operative risk (30–day mortality) for repair is about half that of MVR.
2. LV function is better preserved following repair preserving the integrity of the mitral valve apparatus versus following MVR.
3. Repair avoids the risks inherent to prosthetic heart valves, that is, thromboembolism or anticoagulant-induced hemorrhage for mechanical valves or structural deterioration for bioprosthetic valves.

Because the success of repair increases with surgical volume and expertise, repair (which is the preferred treatment) is more likely to be accomplished in centers with surgeons who have expertise in this type of surgery. Mitral valve repair over MVR is indicated even in patients >65 years of age. When in doubt, MVR is preferable to a poor repair. The results of a minimally invasive approach performed via minithoracotomy/port access using direct vision, thoracoscopic, or robotic assistance versus a conventional sternotomy approach may be similar when performed by highly experienced surgeons.

Surgical repair of MR has been remarkably successful in the treatment of primary MR. When leaflet dysfunction is sufficiently limited so that only annuloplasty and repair of the posterior leaflet are necessary, repair of isolated degenerative mitral disease has led to outcomes distinctly superior to biological or mechanical valve replacement: an operative mortality of <1%; long-term survival equivalent to that of the age-matched general population; approximately 95% freedom from reoperation; and >80% freedom from recurrent moderate or severe (≥3+) MR at 15 to 20 years after operation. As much as one half of the posterior leaflet may be excised, plicated, or resuspended. Posterior leaflet repair has become sufficiently standardized so that valve repair rather than valve replacement is the standard of care in this situation. Execution of this procedure with a success rate ≥90% should be the expectation of every

CLASS I

4. **Mitral valve repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR involving the anterior leaflet or both leaflets when a successful and durable repair can be accomplished (86,407–413). *(Level of Evidence: B)***

Degenerative mitral valve disease consisting of more than posterior leaflet disease requires a more complex and extensive repair. When the anterior leaflet or both leaflets require repair, durability of the repair freedom from reoperation of appro freedom from recurrent moderate or 15 to 20 years. These results are sup MVR, even in elderly patients. Re attempted if possible with other causes of severe MR, such as papillary muscle rupture, IE, and cleft mitral valve. As the repair becomes more complex, however, results of very complex repair in younger patients may be matched by results of durable mechanical MVR with careful management of anticoagulation.

More complex repair is not well standardized and is more surgically demanding. The Heart Valve Team should assign complex repairs to more experienced mitral valve surgeons with established outcomes, including acute success rate as well as long-term durability. The probability of mitral valve repair rather than MVR correlates with surgeon-specific mitral volumes. In a 2007 analysis, hospitals that performed <36 mitral operations per year had a 48% repair rate, whereas hospitals that performed >140 mitral operations per year had a 77% repair rate. Hospital mortality was also 50% lower, on average, in the highest-volume hospitals. There was, however, considerable overlap in specific hospital outcomes, with >25% of low-volume hospitals outperforming the median high-volume hospitals. This overlap suggests that hospital or surgeon-specific volumes should not be used as a surrogate for actual surgeon-specific repair rates and outcomes.

Supporting References: (86,407–413)

CLASS I

5. Concomitant mitral valve repair or MVR is indicated in patients with chronic severe primary MR undergoing cardiac surgery for other indications (414). *(Level of Evidence: B)*

During coronary revascularization and in cases of IE or other conditions where multiple valves may be involved, it is prudent to correct severe primary MR at the time of surgery. This is especially true when mitral repair can be performed in conjunction with AVR because operative risk is lower than that of double valve replacement.

Supporting Reference: (414)

CLASS IIa

1. Mitral valve repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is greater than 95% with an expected mortality rate of less than 1% when performed at a Heart Valve Center of Excellence (39,86,415–419). *(Level of Evidence: B)*

The onset of symptoms, LV dysfunction, or pulmonary hypertension worsens the prognosis for MR. Careful intensive surveillance may result in timing of valve surgery before these negative sequelae occur. However, an attractive alternative strategy for treating severe chronic primary MR is to perform early mitral repair before these triggers are reached. Early mitral repair avoids the need for intensive surveillance and also obviates the possibility that patients might become lost to follow-up or delay seeing their clinician until advanced LV dysfunction has already ensued. This strategy requires expertise in clinical evaluation and cardiac imaging to ensure that MR is severe. For

CLASS IIa

2. Mitral valve repair is reasonable for asymptomatic patients with chronic severe nonrheumatic primary MR (stage C1) and preserved LV function (LVEF >60% and LVESD <40 mm) in whom there is a high likelihood of a successful and durable repair with 1) new onset of AF or 2) resting pulmonary hypertension (pulmonary artery systolic arterial pressure >50 mm Hg) (363,415,420–425). *(Level of Evidence: B)*

In nonrheumatic MR, the onset of AF is in part due to enlarging left atrial size, and its presence worsens surgical outcome. Furthermore, the longer AF is present, the more likely it is to persist. Thus, it may be reasonable to restore mitral competence by low-risk repair with the hope that the ensuing reduction in left atrial size will help restore and maintain sinus rhythm. However, restoration of sinus rhythm following valve surgery is uncertain, and concomitant AF abl
14.2.2). This
where active a
sinus rhythm
likelihood of
nary arterial hypertension due to MR is associated with poorer outcome after valve surgery. Thus, it is reasonable to consider surgery in these patients if there is a high likelihood of a successful and durable repair.

increased operative mortality might not be justified in treating moderate MR.

Supporting Reference: (433)

Supporting References: (363,420–425)

CLASS IIa

3. Concomitant mitral valve repair is reasonable in patients with chronic moderate primary MR (stage B) when undergoing cardiac surgery for other indications. *(Level of Evidence: C)*

Because MR is a progressive lesion, it is reasonable to address it at the time of other cardiac surgery. This is especially true if the mitral valve can be repaired. However, the added risk of mitral valve surgery must be weighed against the potential for progression of MR. In such cases,

CLASS III: Harm

1. **MVR should not be performed for the treatment of isolated severe primary MR limited to less than one half of the posterior leaflet unless mitral valve repair has been attempted and was unsuccessful (87,407–409). *(Level of Evidence: B)***

Surgical repair of MR has been remarkably successful, particularly in the treatment of chronic primary MR. Repair of isolated degenerative mitral disease, when leaflet dysfunction is sufficiently limited that only annuloplasty and repair of the posterior leaflet are necessary, has led to outcomes distinctly superior to biological or mechanical MVR: operative mortality of <1%; long-term survival equivalent to that of age-matched general population; approximately 95% freedom from reoperation; and >80% freedom from recurrent moderate or severe (≥3+) MR at 15 to 20 years after operation. As much as one half of the posterior leaflet may be excised, plicated, or resuspended. Posterior leaflet repair has become sufficiently standardized in this situation that repair rather than MVR is the standard of care. Execution of this procedure with a success rate ≥90% should be the expectation of every cardiac surgeon who performs mitral valve procedures.

Supporting References: (87,407–409)

See Online Data Supplements 16 and 17 for more information on intervention.

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Supporting References: (87,364,395–409,427–432)

more surgically demanding. The Heart Valve Team should assign complex repairs to more experienced mitral valve surgeons with established outcomes, including acute success rate as well as long-term durability. The probability of

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CLASS IIa

1. **Mitral valve repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is greater than 95% with an expected mortality rate of less than 1% when performed at a Heart Valve Center of Excellence (39,86,415–419). *(Level of Evidence: B)***

The onset of symptoms, LV dysfunction, or pulmonary hypertension worsens the prognosis for MR. Careful intensive surveillance may result in timing of valve surgery before these negative sequelae occur. However, an attractive alternative strategy for treating severe chronic primary MR is to perform early mitral repair before these triggers are reached. Early mitral repair avoids the need for intensive surveillance and also obviates the possibility that patients might become lost to follow-up or delay seeing their clinician until advanced LV dysfunction has already ensued. This strategy requires expertise in clinical evaluation and cardiac imaging to ensure that MR is severe. For

CLASS IIa

2. **Mitral valve repair is reasonable for asymptomatic patients with chronic severe nonrheumatic primary MR (stage C1) and preserved LV function (LVEF >60% and LVESD <40 mm) in whom there is a high likelihood of a successful and durable repair with 1) new onset of AF or 2) resting pulmonary hypertension (pulmonary artery systolic arterial pressure >50 mm Hg) (363,415,420–425). *(Level of Evidence: B)***

In nonrheumatic MR, the onset of AF is in part due to enlarging left atrial size, and its presence worsens surgical outcome. Furthermore, the longer AF is present, the more likely it is to persist. Thus, it may be reasonable to restore mitral competence by low-risk repair with the hope that the ensuing reduction in left atrial size will help restore and maintain sinus rhythm. However, restoration of sinus rhythm following valve surgery is uncertain, and concomitant AF ablation surgery may be warranted (Section 14.2.2). This strategy does not apply to rheumatic MR, where active atrial inflammation may make restoration of sinus rhythm less likely and valve scarring reduces the likelihood of a successful repair. The presence of pulmonary arterial hypertension due to MR is associated with poorer outcome after valve surgery. Thus, it is reasonable to consider surgery in these patients if there is a high likelihood of a successful and durable repair.

Supporting References: (363,420–425)

CLASS IIa

3. **Concomitant mitral valve repair is reasonable in patients with chronic moderate primary MR (stage B) when undergoing cardiac surgery for other indications. *(Level of Evidence: C)***

Because MR is a progressive lesion, it is reasonable to address it at the time of other cardiac surgery. This is especially true if the mitral valve can be repaired. However, the added risk of mitral valve surgery must be weighed against the potential for progression of MR. In such cases,

CLASS III: Harm

1. **MVR should not be performed for the treatment of isolated severe primary MR limited to less than one half of the posterior leaflet unless mitral valve repair has been attempted and was unsuccessful (87,407–409). *(Level of Evidence: B)***

Surgical repair of MR has been remarkably successful, particularly in the treatment of chronic primary MR. Repair of isolated degenerative mitral disease, when leaflet dysfunction is sufficiently limited that only annuloplasty and repair of the posterior leaflet are necessary, has led to outcomes distinctly superior to biological or mechanical MVR: operative mortality of <1%; long-term survival equivalent to that of age-matched general population; approximately 95% freedom from reoperation; and >80% freedom from recurrent moderate or severe (≥3+) MR at 15 to 20 years after operation. As much as one half of the posterior leaflet may be excised, plicated, or resuspended. Posterior leaflet repair has become sufficiently standardized in this situation that repair rather than MVR is the standard of care. Execution of this procedure with a success rate ≥90% should be the expectation of every cardiac surgeon who performs mitral valve procedures.

Supporting References: (87,407–409)

See Online Data Supplements 16 and 17 for more information on intervention.

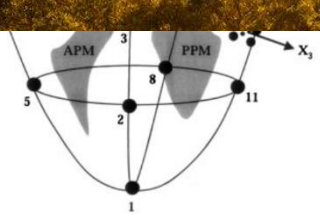
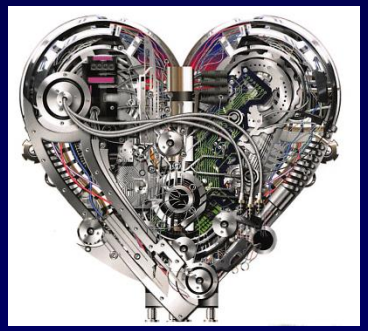
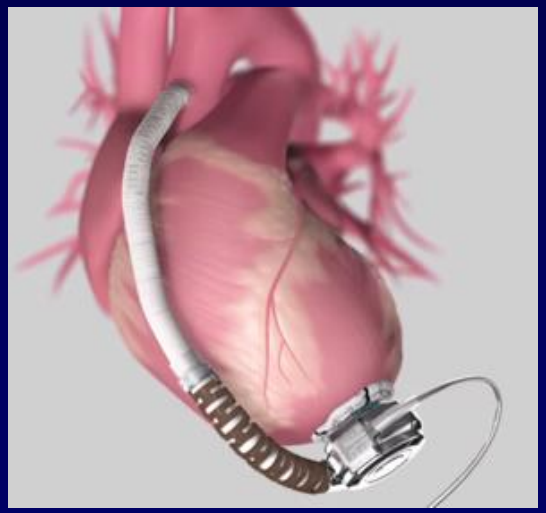


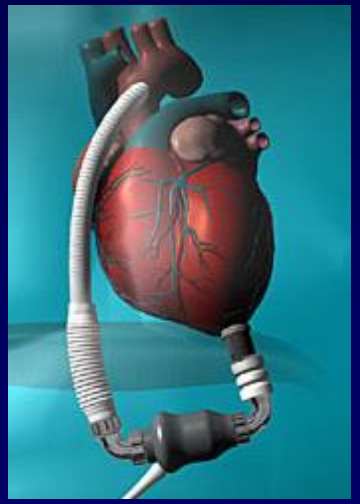
Figure 1. Myocardial marker array. The 2 second-order strut chordae tendineae arising from the APM (22) and PPM (23) tips and inserting into the belly of the anterior mitral valve leaflet are illustrated. Three transmural columns of radiopaque beads were inserted into the mid-lateral LV wall between the papillary muscles to measure myocardial deformations along the cardiac coordinates aligned with the LV circumferential (X_1), longitudinal (X_2), and radial (X_3) axes. APM indicates anterior papillary muscle; PPM, posterior papillary muscle.

Stanford University

Advanced Heart Failure: Artificial Heart / Left Ventricular Assist Device (LVAD)







CLASS I

1. Tricuspid valve surgery is recommended for patients with severe TR (stages C and D) undergoing left-sided valve surgery. *(Level of Evidence: C)*

The indications for surgical correction of TR are most often considered at the time of mitral or aortic valve surgery. Severe TR of either a primary or functional nature may not predictably improve after treatment of the left-sided valve lesion and reduction of RV afterload; as such, severe TR should be addressed as part of the index procedure. Reoperation for severe, isolated TR after left-sided valve surgery is associated with a perioperative mortality rate of 10% to 25%. Tricuspid valve repair does not add appreciably to the risks of surgery and can be accomplished with a clinically insignificant increase in ischemic time. There has been a significant increase in the number of tricuspid valve repairs performed for this indication over the past decade. Tricuspid valve repair is preferable to replacement. When replacement is necessary for primary, uncorrectable tricuspid valve disease, the choice of prosthesis is individualized, with the usual trade-offs between thrombosis/anticoagulation with a mechanical valve and durability with a tissue valve. Meta-analysis has shown no difference in overall survival between mechanical and tissue valves for patients undergoing tricuspid valve replacement. The risks and benefits of tricuspid valve operation should be carefully considered in the presence of severe RV systolic dysfunction or irreversible pulmonary hypertension, due to the possibility of RV failure after operation.

Supporting References: (485–494)

CLASS IIa

1. Tricuspid valve repair can be beneficial for patients with mild, moderate, or greater functional TR (stage B) at the time of left-sided valve surgery with either 1) tricuspid annular dilation or 2) prior evidence of right HF (464–466,495–501). *(Level of Evidence: B)*

Left uncorrected at the time of left-sided valve surgery, mild or moderate degrees of functional TR may progress over time in approximately 25% of patients and result in reduced long-term functional outcome and survival. Risk factors for persistence and/or progression of TR include tricuspid annulus dilation (>40 mm diameter or 21 mm/m^2 diameter indexed to body surface area on preoperative TTE; >70 mm diameter on direct intraoperative measurement); degree of RV dysfunction/remodeling; leaflet tethering height; pulmonary artery hypertension; AF; nonmyxomatous etiology of MR; and intra-annular RV pacemaker or implantable cardioverter-defibrillator leads. The cut-off of >70 mm diameter on direct intraoperative measurement originated from a single center, performed with the patient on cardiopulmonary bypass using a supple ruler, taken from the anteroseptal commissure to the anteroposterior commissure. Echocardiography is usually performed on the beating heart and examines a different plane of the tricuspid annulus. Numerous observational studies and 1 prospective RCT attest to the benefit on several echocardiographic and functional parameters of tricuspid repair at the time of mitral valve surgery for mild-to-moderate TR (stage B) with tricuspid annulus dilation. When surgery is performed for isolated severe primary MR due to a degenerative etiology, less than moderate TR is unlikely to progress if left untreated. A prior recent history of right HF is also an indication for tricuspid valve repair at the time of left-sided valve surgery. A survival benefit with tricuspid repair in this setting has not been demonstrated. Management of indwelling pacemaker or implantable cardioverter-defibrillator leads may require their removal with epicardial placement in selected patients. Other approaches, such as sequestering the leads in a commissure or placing them in an extra-annular position, may be used. Following repair with ring annuloplasty, residual TR is present in approximately 10% of patients at 5 years.

Supporting References: (463–466,495–504)

CLASS IIa

2. Tricuspid valve surgery can be beneficial for patients with symptoms due to severe primary TR that are unresponsive to medical therapy (stage D). *(Level of Evidence: C)*

Correction of symptomatic severe primary TR (stage D) in patients without left-sided valve disease is preferentially performed before onset of significant RV dysfunction. Replacement may be required because of the extent and severity of the underlying pathology (e.g., carcinoid, radiation, Ebstein's anomaly). Reduction or elimination of the regurgitant volume load can alleviate systemic venous and hepatic congestion and decrease reliance on diuretics. Patients with severe congestive hepatopathy may also benefit from surgery to prevent irreversible cirrhosis of the liver. Quality and duration of long-term survival are related to residual RV function.

CLASS IIb

1. Tricuspid valve repair may be considered for patients with moderate functional TR (stage B) and pulmonary artery hypertension at the time of left-sided valve surgery. *(Level of Evidence: C)*

When pulmonary artery hypertension is caused predominantly by left-sided valve disease, effective surgery on the left-sided valve lesions usually leads to a fall in RV afterload and improvement in functional TR, especially in the absence of significant (i.e., >40 mm on TEE) tricuspid annulus dilation. This observation dates to the early years of mitral valve surgery. Prediction rules that account for the relative contributions of pulmonary hypertension and only mild-to-moderate degrees of tricuspid annulus enlargement for the risk of progressive TR are lacking. The benefit of routine tricuspid valve repair in this context is less clear across broad populations but may be considered on an individual basis.

Supporting References: (503,505,506)

CLASS IIb

2. Tricuspid valve surgery may be considered for asymptomatic or minimally symptomatic patients with severe primary TR (stage C) and progressive degrees of moderate or greater RV dilation and/or systolic dysfunction. *(Level of Evidence: C)*

The optimal timing of tricuspid valve surgery for asymptomatic or minimally symptomatic, severe primary TR has not been established. Extrapolation from limited experiences reported for patients with stable carcinoid heart disease and patients with a flail tricuspid leaflet and application of the management principles adopted for patients with severe MR suggest that serial assessments of RV size and function might trigger consideration of

reoperation have influenced decision makin
of functional TR initially at the time of left
surgery. The sobering results seen with tri
repair at reoperation inject a note of cauti
recommendations for its performance and r
age replacement with an age-appropriate (m
biological) prosthesis. The presence of either
uncorrectable pulmonary hypertension or sig
dysfunction constitutes a relative contrain
reoperation.

Supporting References: (485–489,509–512)

See Online Data Supplement 19 for more in
outcomes following tricuspid valve surgery.

rates for isolated tricuspid valve surgery have therefore exceeded those reported for isolated aortic or mitral valve surgery, and this trend has been even more pronounced following reoperative tricuspid surgery late after left-sided valve surgery. This high mortality is likely related to the advanced nature of RV failure encountered at the time of the second procedure, residual pulmonary hypertension, LV dysfunction, and other valve abnormalities. Two Heart Valve Centers of Excellence have reported perioperative mortality rates with tricuspid valve reoperation of 4.2% and 13.2%, respectively. Thus, the hazards imposed by

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June 10, 2014:e57–185

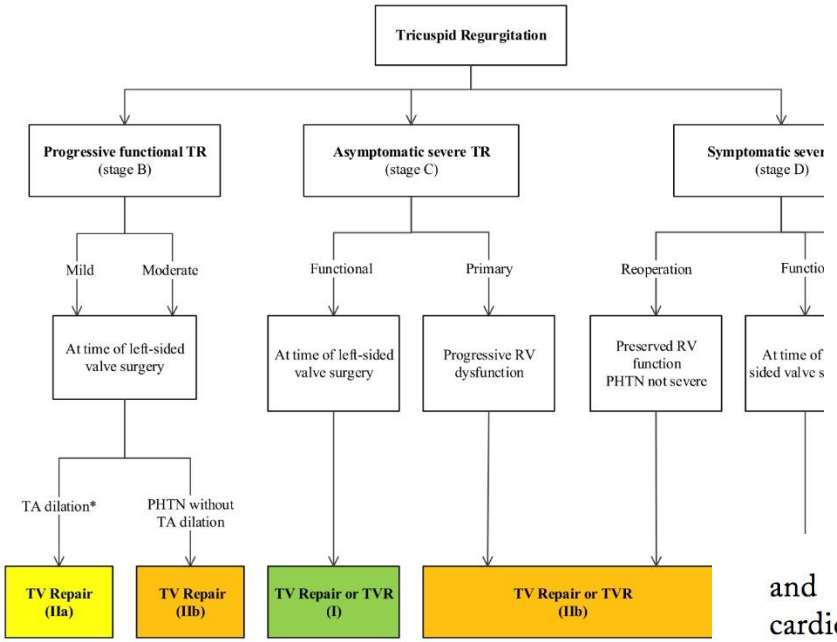

Figure 5. Indications for Surgery

*See Table 19 for definition of stages. TA dilation is defined by >40 mm on TTE (>21 mm/m^2) or >70 mm on direct intra
LV indicates left ventricular; PHTN, pulmonary hypertension; RV, right ventricular; TA, tricuspid annular; TR, tricuspid regu
tricuspid valve; and TVR, tricuspid valve replacement.

Table 19. Stages of TR

Stage	Definition	Valve Anatomy	Valve Hemodynamics*	Hemodynamic Consequences	
A	At risk of TR	**Primary** • Mild rheumatic change • Mild prolapse • Other (e.g., IE with vegetation, early carcinoid deposition, radiation) • Intra-annular RV pacemaker or ICD lead • Postcardiac transplant (biopsy related) **Functional** • Normal • Early annular dilation	• No or trace TR	• None	• None left h pulmo
B	Progressive TR	**Primary** • Progressive leaflet deterioration/destruction • Moderate-to-severe prolapse, limited chordal rupture **Functional** • Early annular dilation	**Mild TR** • Central jet area <5.0 cm^2 • Vena contracta width not defined • CW jet density and contour: soft and parabolic • Hepatic vein flow: systolic dominance	**Mild TR** • RV/RA/IVC size normal **Moderate TR** • No RV enlargement • No or mild RA enlargement • No or mild IVC enlargement with normal respirophasic variation	• None left h pulmo

8. Tricuspid Valve Disease

8.1. Stages of TR

Trace-to-mild degrees of TR of no physiologica
quence are commonly detected on TTE in subje
anatomically normal valves. *Primary* disorders
tricuspid apparatus that can lead to more signifi
grees of TR include rheumatic disease, prolapse, c
disease (Ebstein's), IE, radiation, carcinoid, blu
wall trauma, RV endomyocardial biopsy–related

and intra-annular RV pacemaker or implantable cardioverter-defibrillator leads. Approximately 80% of cases of significant TR are *functional* in nature and related to tricuspid annular dilation and leaflet tethering in the setting of RV remodeling due to pressure and/or volume overload. The tricuspid annulus is a saddle-shaped ellipsoid that becomes planar and circular as it dilates in an anterior-posterior direction and will often not return to its normal size and configuration after relief of RV overload. Table 19 shows the stages (A through D) of *primary* and *functional* TR as defined for other valve lesions. Severe TR (stages C and D) is associated with poor prognosis independent of age, LV and RV function, and RV size. Patients with signs or symptoms of right HF would fit into the stage D category even if they do not meet other hemodynamic or morphological criteria.

Supporting Reference: (460)

Minimally Invasive Cardiac Surgery

Posted On 2018-03-30 16:17:49

This issue, guest edited by Dr. Allen Cheng, aims to increase the community awareness and to provide a comprehensive illustration of the current standard surgical technique in various minimally invasive cardiac surgical and transcatheter approaches. Clinical data will be provided to support the current approaches and their benefits.

Surgical Technique on Cardiac Surgery

Video assisted right mini-thoracotomy for aortic root replacement

Carl A. Johnson Jr, Katherine L. Wood, Amber L. Melvin, Brandon F. Lebow, Peter A. Knight

PDF HTML

Video assisted right mini-thoracotomy for aortic valve replacement

Carl A. Johnson Jr, Amber L. Melvin, Brandon F. Lebow, Amanda Yap, Peter A. Knight

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Awake transcatheter aortic valve replacement—an anesthesiologist's perspective

Jiapeng Huang, Sheng Wang, Jiakai Lu

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More are coming.....

Meet the Professor

James D. Luketich: future for esophageal cancer patients is bright with growing technology and better therapy
Dr. Marco Scarci: never settle for easy life
Dr. Alessandro Brunelli: passion is my motivation
Prof. Robert Cerfolio: we can always do better
Prof. Joel Dunning: the future of thoracic surgery is full of possibilities
Prof. Gianluca Torregrossa: think positive, stay positive, think for your patients
Exploring Da Vinci robotic surgery with Prof. David Rice and Prof. Hecheng Li
Prof. Hiran Fernando: interaction between peers is important
Peter Licht: working hard and making good use of the internet—advices for young surgeons
Prof. Diego Gonzalez-Rivas and Prof. Alan Sihoe: what do we need to think about uniportal video-assisted thoracoscopic

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Allen Cheng, MD

Department of Cardiovascular and Thoracic Surgery, University of Louisville, Louisville, Kentucky, USA

Dr.Cheng is a cardiovascular surgeon who did his general surgery training at UCLA, cardiothoracic surgery fellowship at Massachusetts General Hospital/ Harvard Medical School and cardiac surgery postdoctoral fellowship at Stanford University. He is currently the Surgical Director of Heart Transplantation at Rudd Heart and Lung Center, Jewish Hospital, University of Louisville. His clinical interests include heart and lung transplantation, mechanical circulatory support, minimally invasive cardiac surgery, atrial fibrillation, transcatheter aortic valve replacement and pulmonary thromboendarterectomy. Dr.Cheng is also a principle investigator at Cardiovascular Innovation Institute with research focus in left ventricular assist device and heart transplantation.