Complex Decision Making in Interventional Cardiology and Cardiac Surgery

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Chronic Total Occlusion Percutaneous Coronary Intervention (CTO PCI) and an Argument for Complete Percutaneous Revascularization

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Disclosures

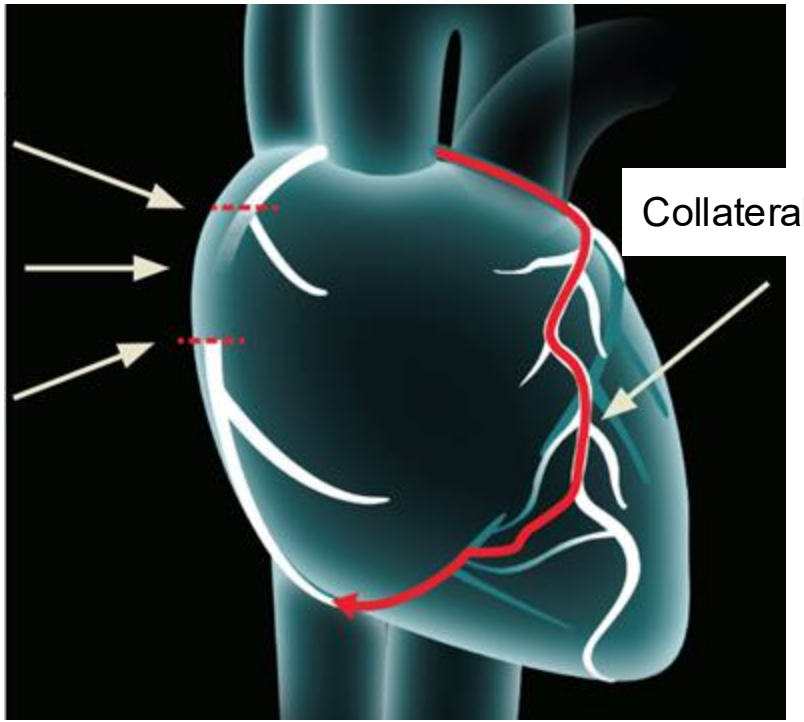
- No relevant disclosures

CTO PCI: Background

Proximal cap

Lesion length

Distal cap



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CTO Definition and Epidemiology

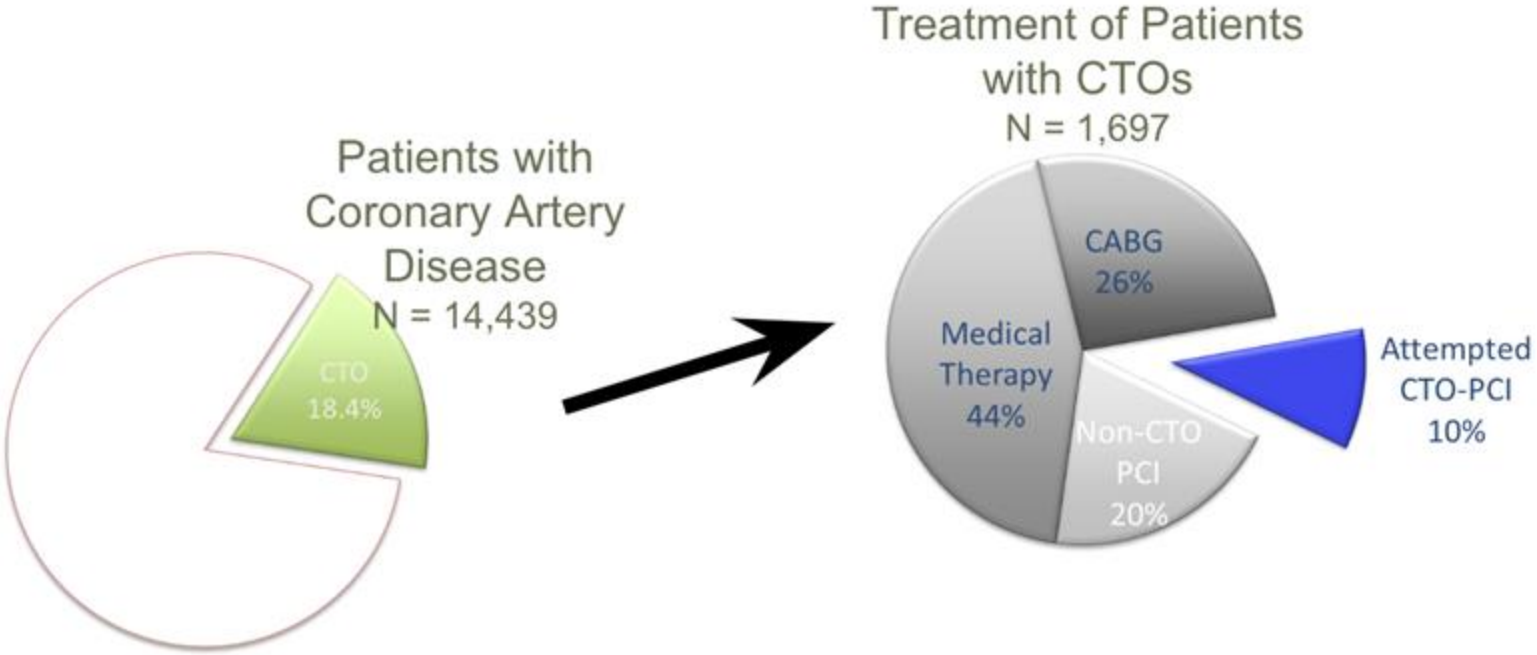
Chronic Total Occlusion: 100% occlusion of a coronary artery with TIMI 0 anterograde flow of at least three months' duration

- Duration can be estimated by symptom length, time of prior myocardial infarct

From a multicenter Canadian CTO registry (1):

- 18.4% prevalence in pts with significant CAD (>50%) on non-emergent cath
- 54% of prior CABG pts on non-emergent cath
- 10% of all STEMI pts

CTO Prevalence and Treatment



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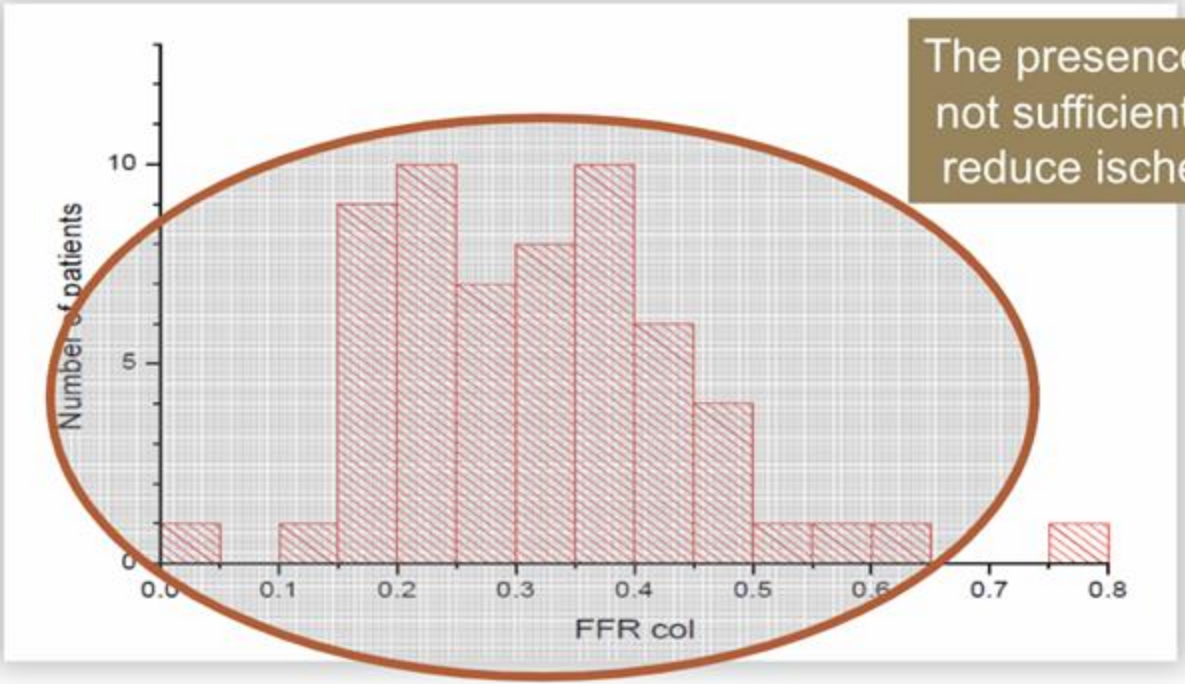
What about Collaterals?



The presence of collaterals is not sufficient to substantially reduce ischemia in CTO (2)

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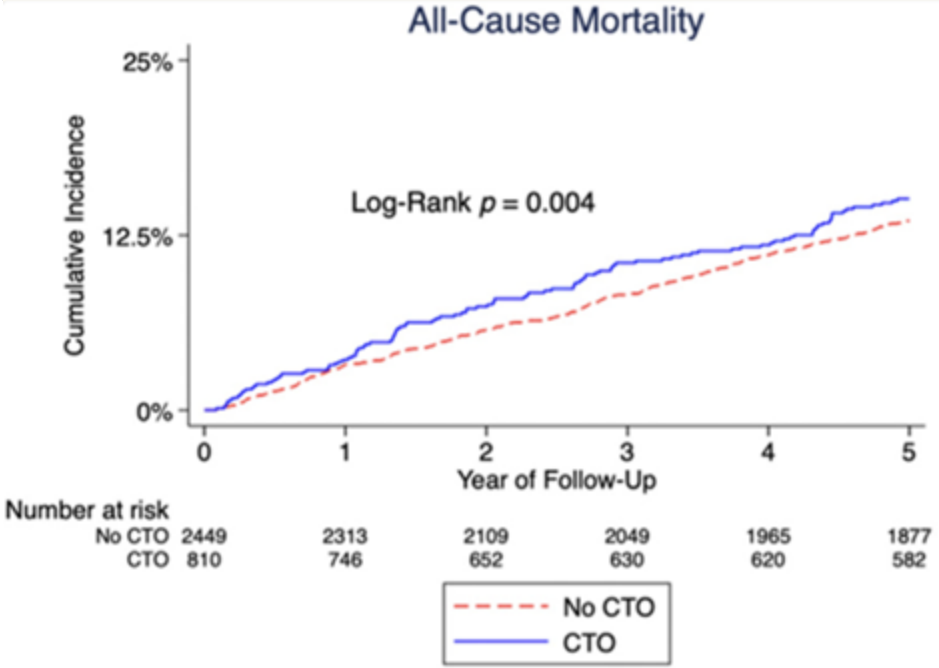
CTO Symptoms and Signs (3)

- Angina, shortness of breath, fatigue, reduced quality of life
- Increased risk of major adverse cardiovascular events (MACE)
  - Myocardial infarction
  - Left ventricular dysfunction
  - Heart failure and related hospitalization
  - Ventricular arrhythmias
- Increased risk of all-cause mortality



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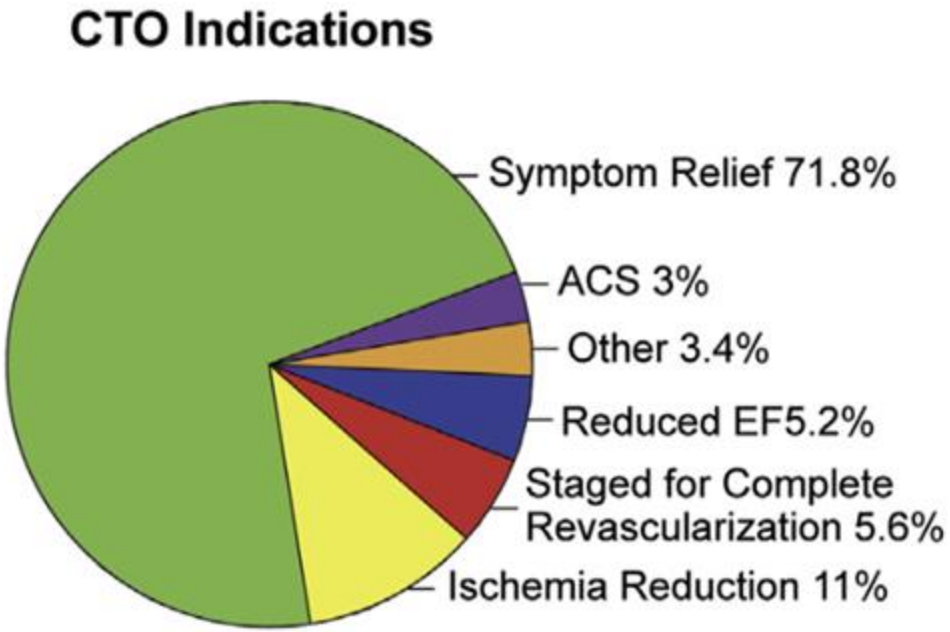
CTO PCI Indications

- Improvement in lifestyle-limiting angina or dyspnea
- Complete revascularization in ACS
- Left ventricular dysfunction
- Ventricular arrhythmias
- Poor suitability for CABG
  - Poor surgical candidate
  - Poor distal targets
  - Patient choice
  - Low-medium SYNTAX score
  - Non-LMCA or proximal LAD disease

OPEN CTO Registry (4)



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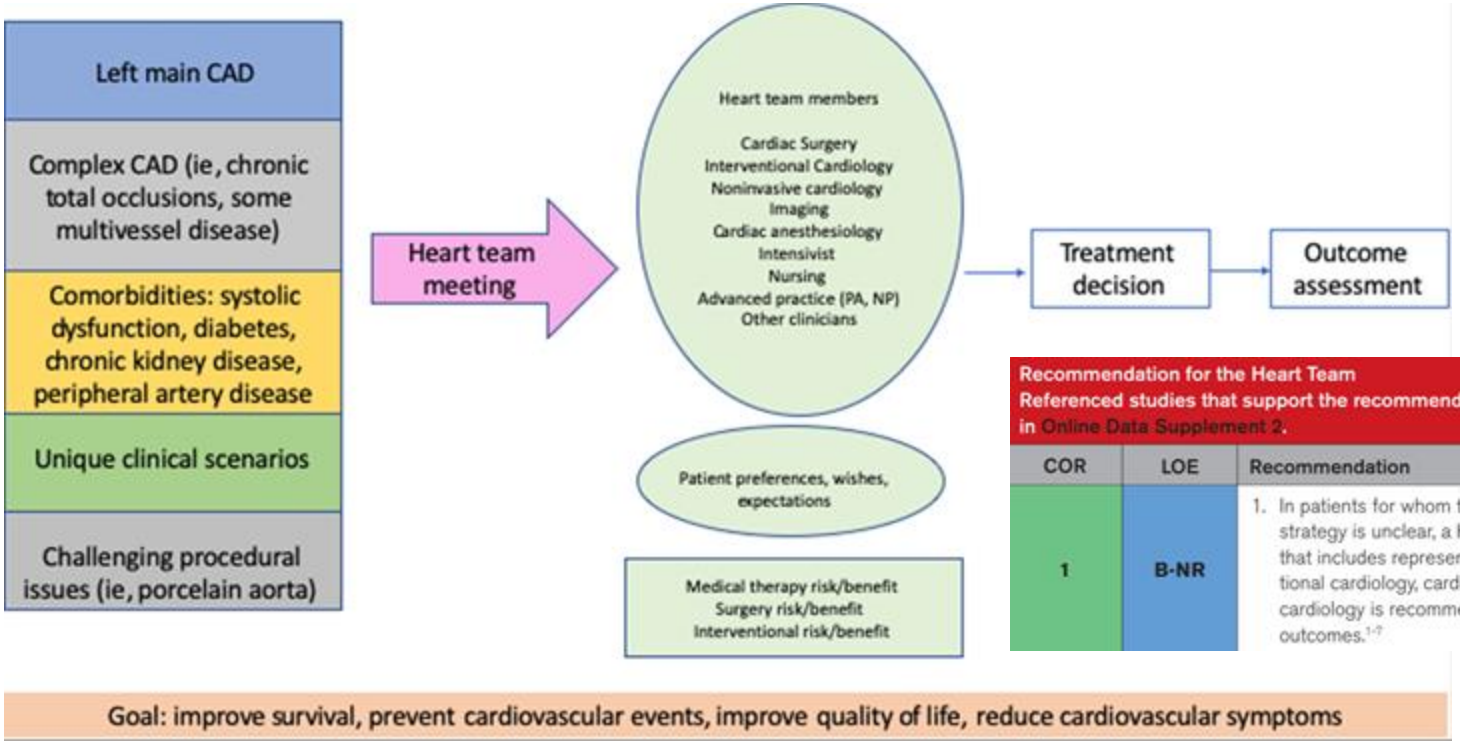
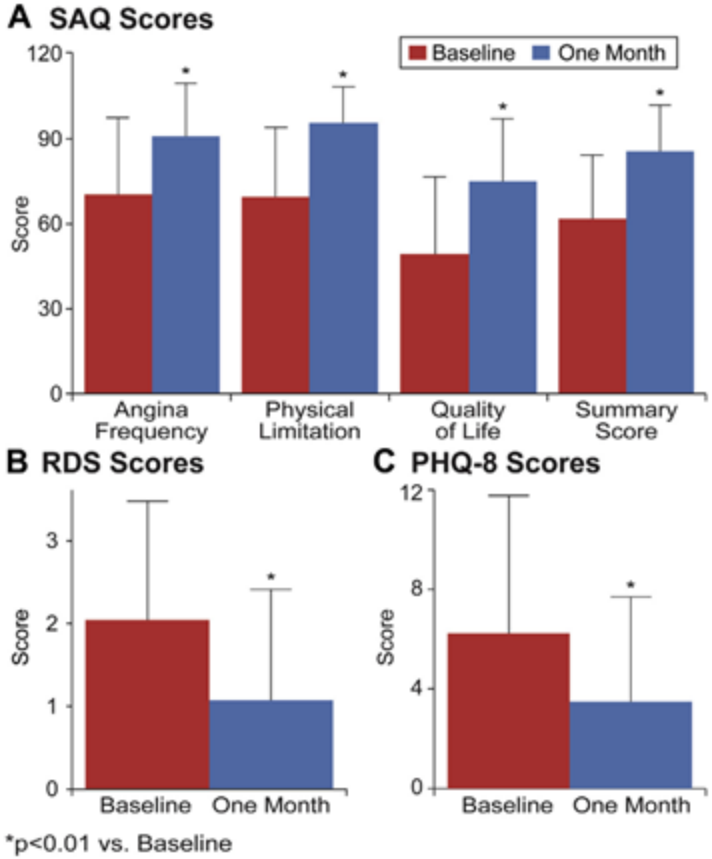
What about CABG (4)?



Health Status Outcomes after CTO PCI (5)



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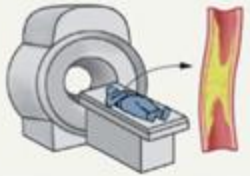
Health Status Outcomes after CTO PCI (6)

CENTRAL ILLUSTRATION: Effect of INV vs CON on Clinical and QoL Outcomes in Patients With CCTA-Determined CTO in the ISCHEMIA Trial

1,470 patients from the ISCHEMIA trial with coronary computed tomography angiography (CCTA)-determined chronic total occlusions (CTO) (Moderate or severe ischemia demonstrated via stress testing)



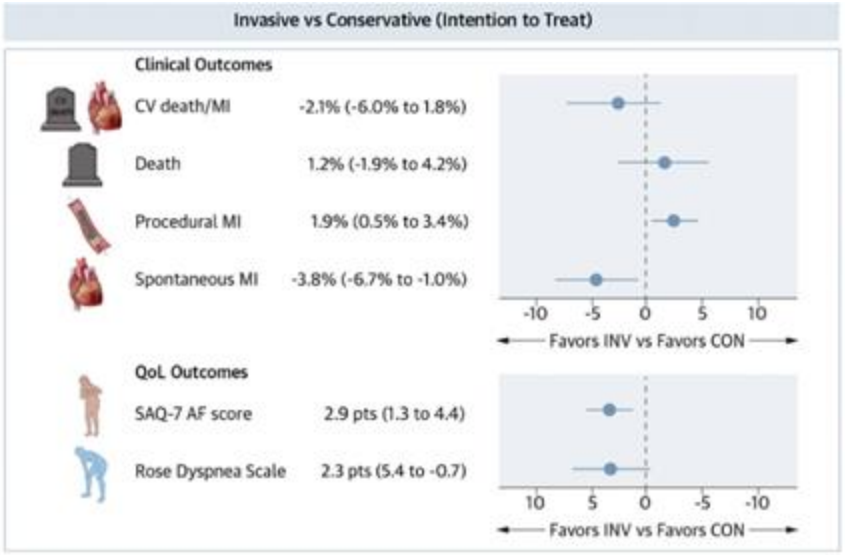
Initial invasive strategy (INV) n=752

vs

Initial conservative strategy (CON) n=718

ISCHEMIA trial exclusions:

- Left main disease
- Estimated glomerular filtration rate <30
- Dialysis
- Recent acute coronary syndrome
- Heart failure hospitalization
- Intolerable angina despite optimal medical therapy



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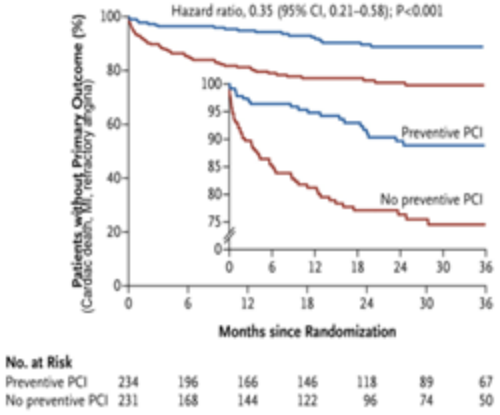
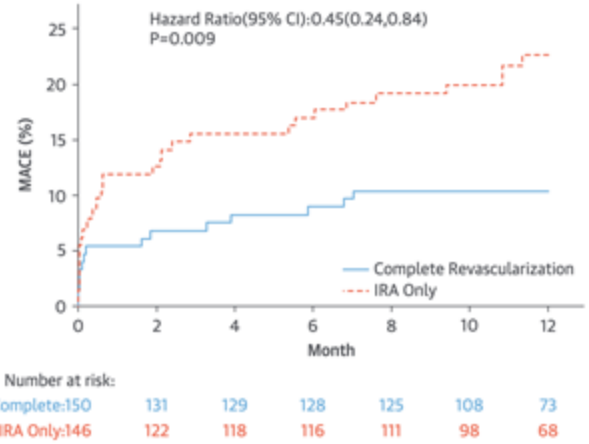
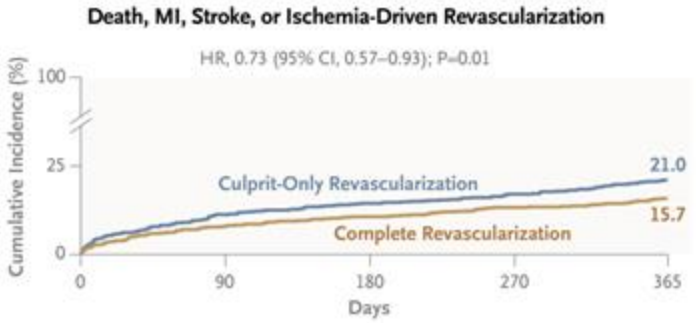
Complete Revascularization in ACS



PRAMI TRIAL (7) - STEMI



CVLPRIT TRIAL (8) - STEMI



FIRE TRIAL (9) - NSTEMI, age > 75

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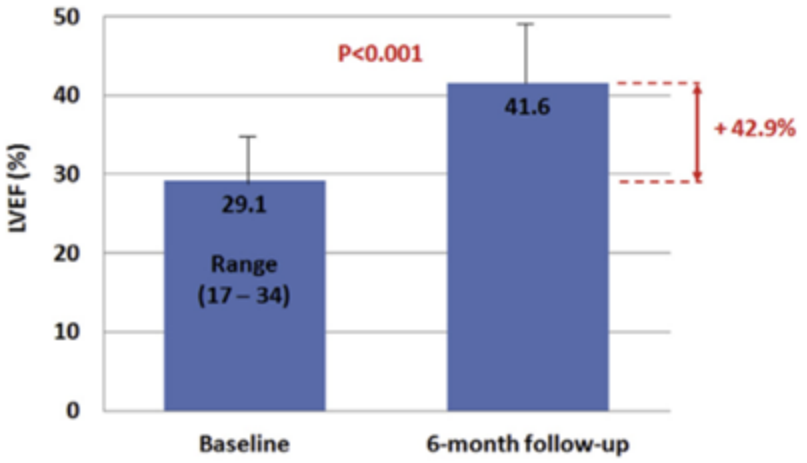
CTO PCI in Heart Failure

- Prospective longitudinal multicenter (10) study of patients undergoing CTO PCI
- LVEF as measured by echo
- Viability performed in all segments considered to be akinetic or dyskinetic by baseline echo

FIGURE 7 Improvement of LVEF After Successful of CTO PCI in Patients With Low LVEF ≤35%



In CTO patients with low LVEF, successful CTO PCI resulted in LVEF improvement from 29.1 ± 3.4% to 41.6 ± 7.9% (+42.9%; $p < 0.001$) at 6-month follow-up. Abbreviations as in Figure 1.

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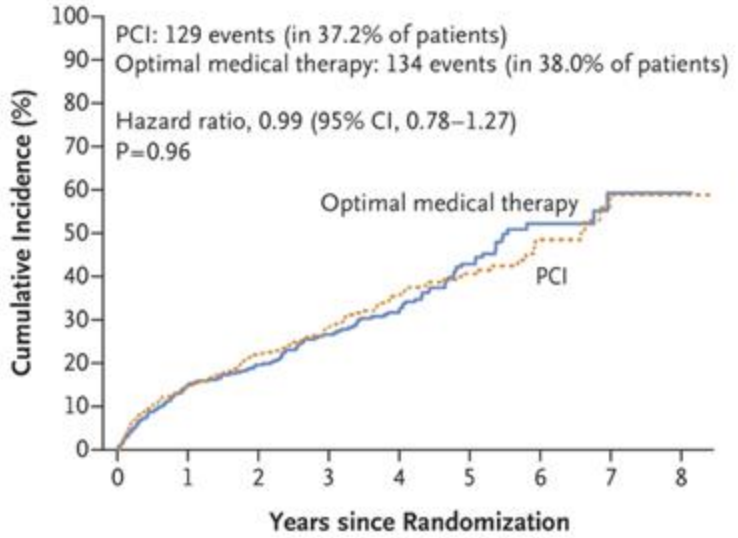
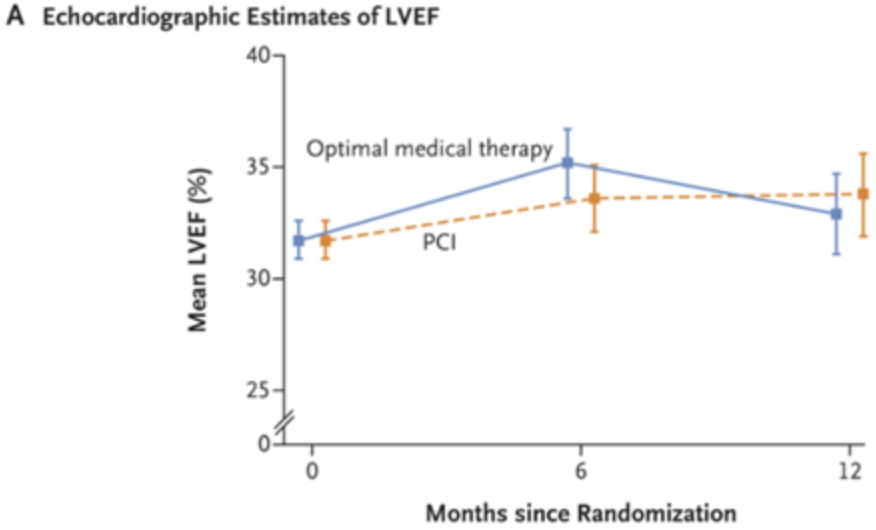
PCI in Heart Failure

REVIVED-BCIS2 Trial (11):
Primary Outcome of Death from Any Cause or Hospitalization for Heart Failure.



No. at Risk									
PCI	347	295	262	179	130	80	32	14	3
Optimal medical therapy	353	299	276	191	142	82	33	10	1



No. of Patients			
PCI	264	276	262
Optimal medical therapy	276	264	267

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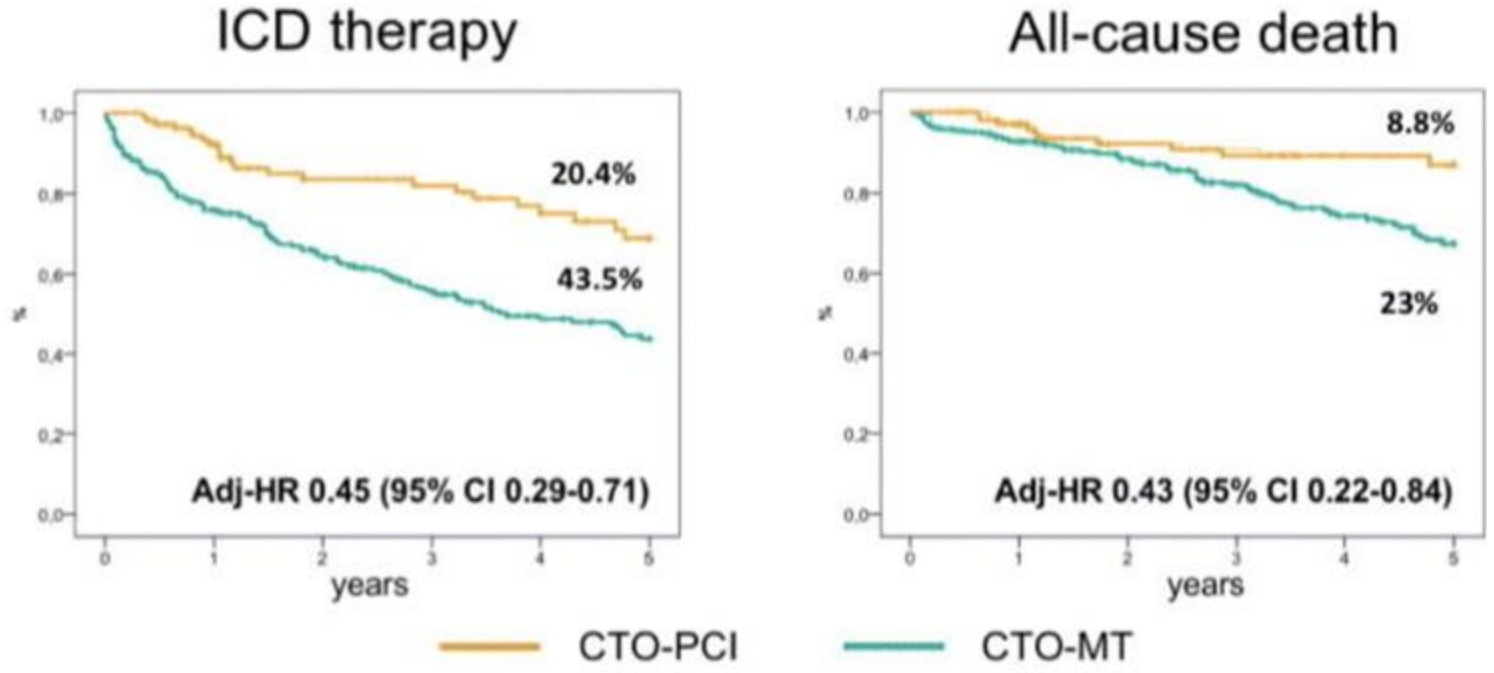
PCI in Heart Failure

- Medical therapy remains the foundation of heart failure treatment
- CTO PCI may be adjunctive
- Role for viability testing is unclear

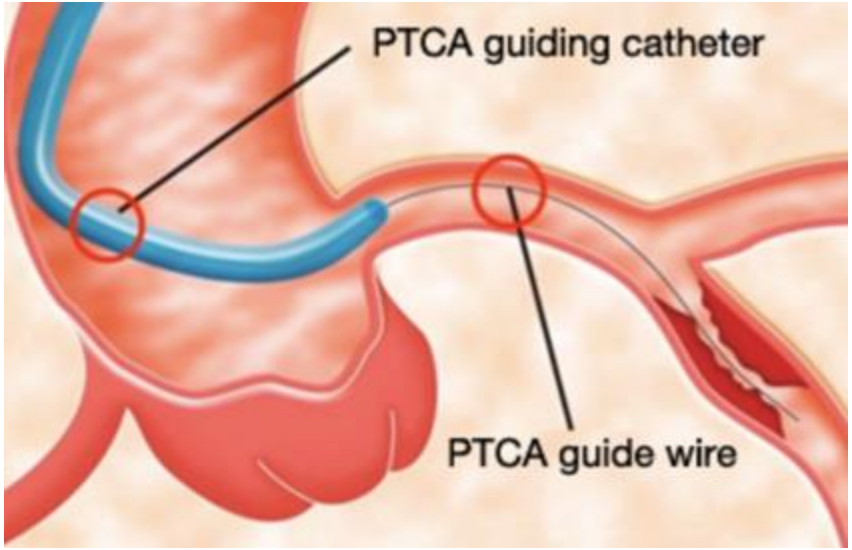
CTO PCI in VT/VF - VACTO PCI Study (12)

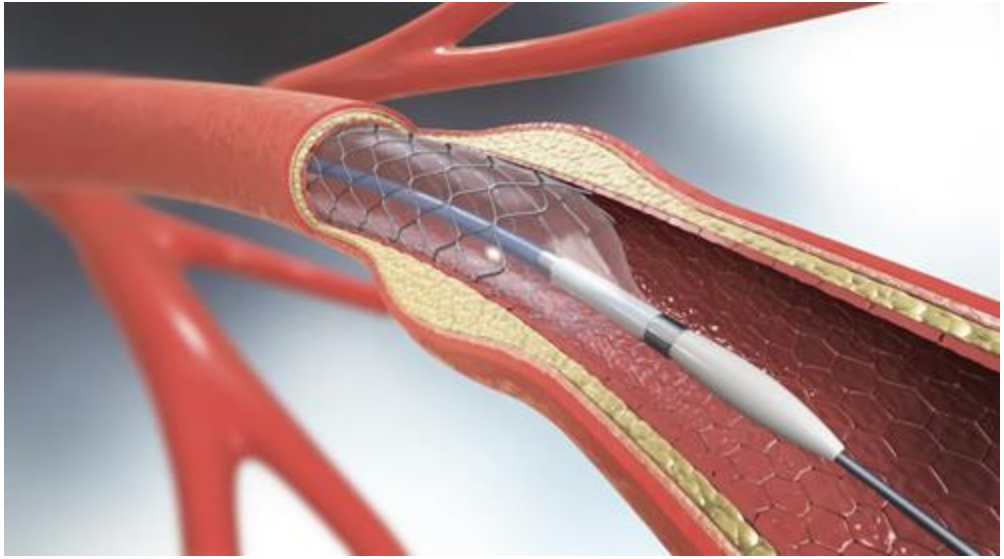


CTO PCI is Rare. Why?

- 3.8% of all PCIs performed in US are for CTO intervention (13)

Step 1 in PCI: Lesion Crossing with Guidewire





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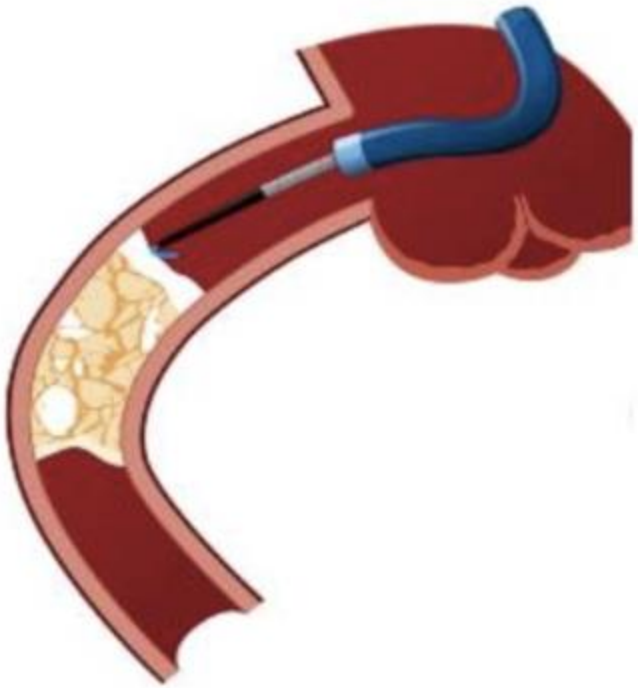
Wire Passage is the Challenge



- Historically long procedural time with low success rates
  - Lack of standardized approaches
  - Lack of specialized equipment
- High complication rates
  - Perforation
  - Dissection
  - Contrast nephropathy

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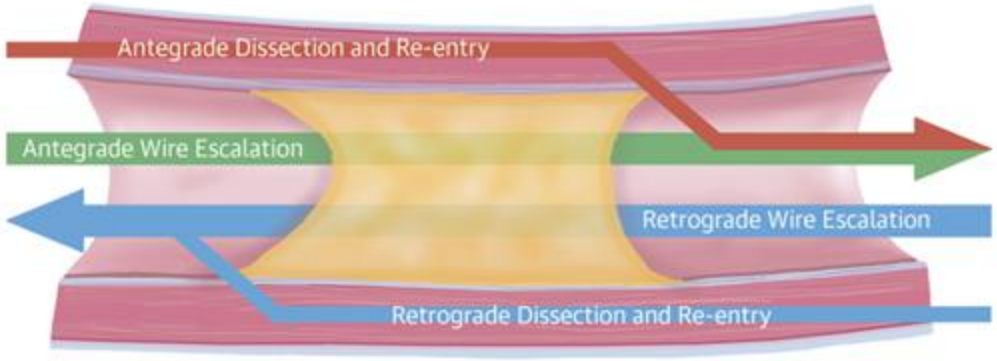
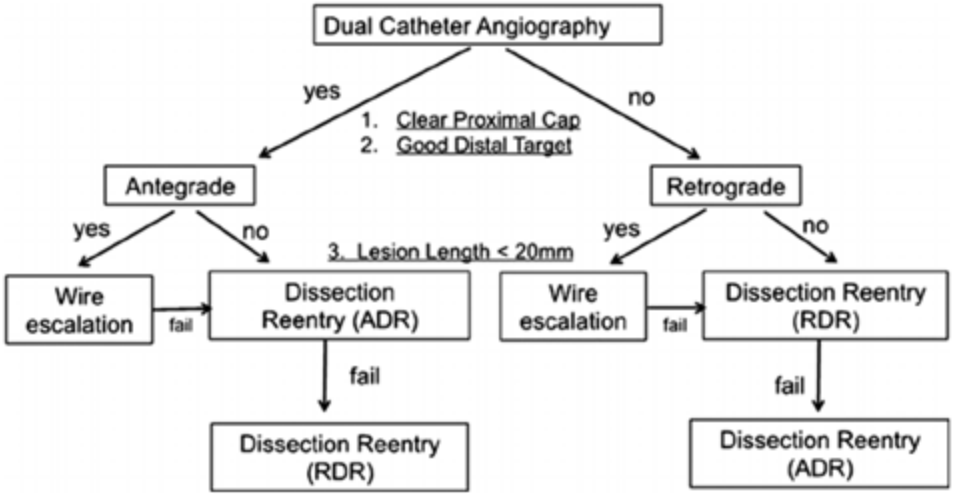
The Hybrid Algorithm (14)





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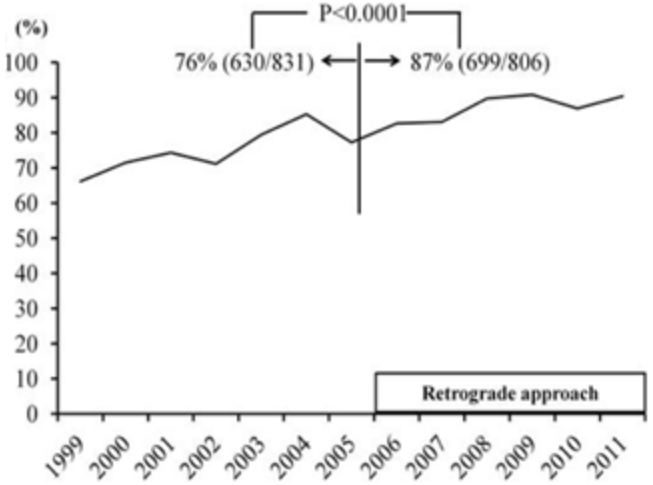
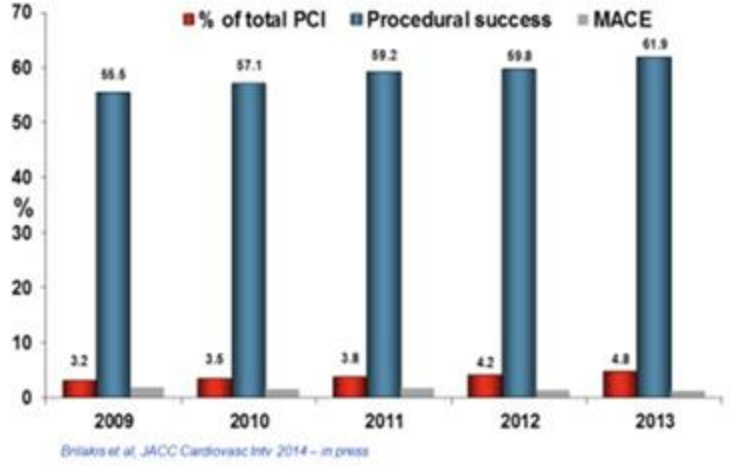
Temporal Trends in Success





89% Success Rate in OPEN CTO Registry with mean procedural time of 121 minutes!

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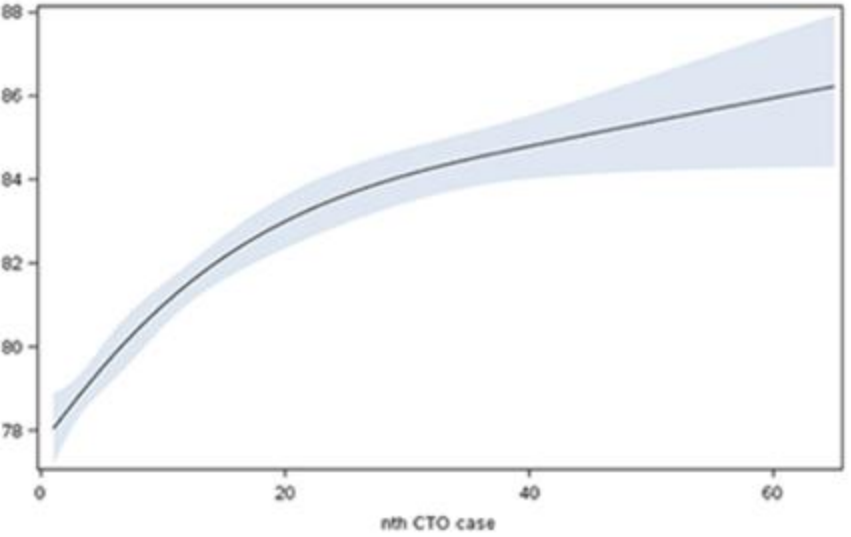
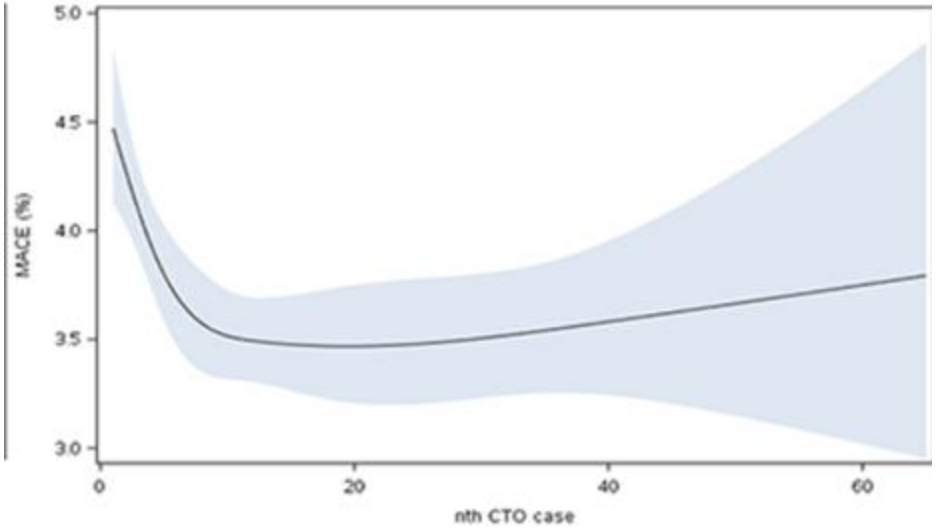
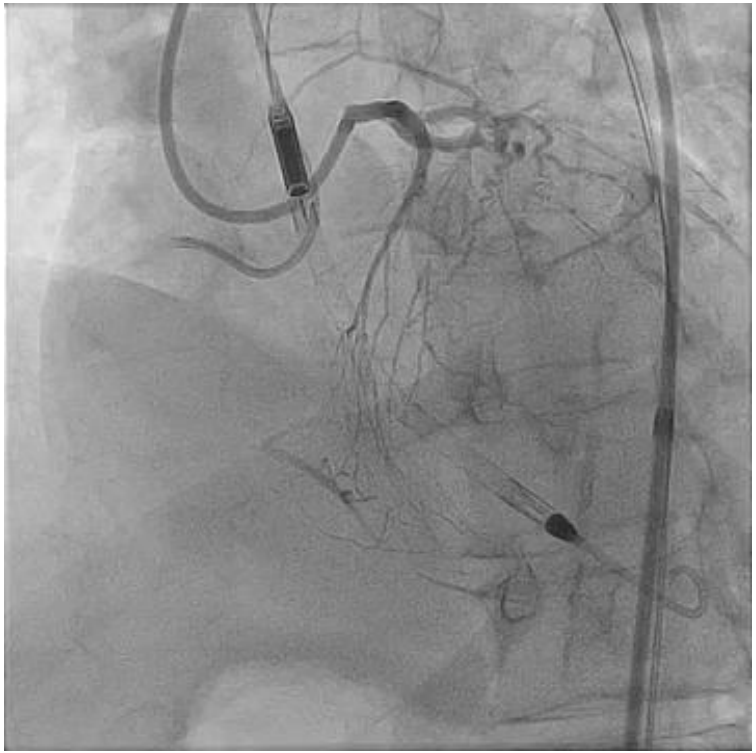
Experience Matters (15)

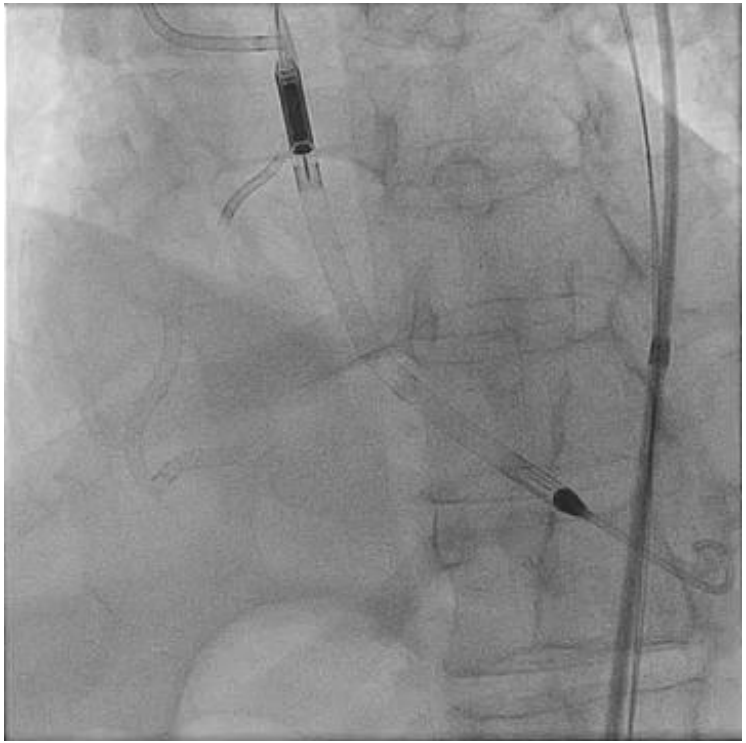
Procedural Success



Composite MACE







Take Home Points

- Revascularization is Indicated:
  - Highly symptomatic patients with medical refractory angina
  - Complete revascularization after myocardial infarction
  - Heart failure
  - Ventricular arrhythmias
- CTO PCI is highly successful with low complication rates when performed by experienced operators

Citations

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Grafting Strategies for Real World Practice

Charles Anderson, MD

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CABG Goals

- Relief of angina
- Decrease MACE
- Improve survival
  - Particularly beneficial in subset of patients with DM and LV dysfunction
  - Shows improved long term outcomes over PCI

CABG Considerations

- Must weigh pt specific factors like age, CKD, chronic lung disease and frailty
- ACC and AHA guidelines emphasize shared decision making with a heart team approach

“The right operation for the right pt at the right time”

CABG Indications

- Anatomic - Severe coronary artery stenosis
  - LM >50%
  - >/= 70% in multiple major epicardial vessels
  - Proximal LAD stenosis >/= 70%
- Angina
  - Despite OMT
- NSTEMI or UA with high risk features
- STEMI
  - When PCI not feasible or after failed PCI
  - Mechanical complications post MI
  - VSD or severe MR with papillary muscle rupture

CABG Indications

- High risk findings on stress test
  - Significant reversible ischemia in large territory, especially with reduced LV function
- Complex coronary anatomy
  - CTO, diffuse disease with heavy calcification not amenable to stenting
- Need for concomitant cardiac surgery like AS, AI or MR

Complete Revascularization

- Syntax trial and Freedom trial showed complete revascularization of all major territories with significant ischemia improves outcomes
  - CABG had a significant advantage over PCI for complete vs incomplete revascularization and in lower MACCE and repeat interventions
- But grafting every minor blockage did not improve outcomes and may worsen outcomes from increased complexity

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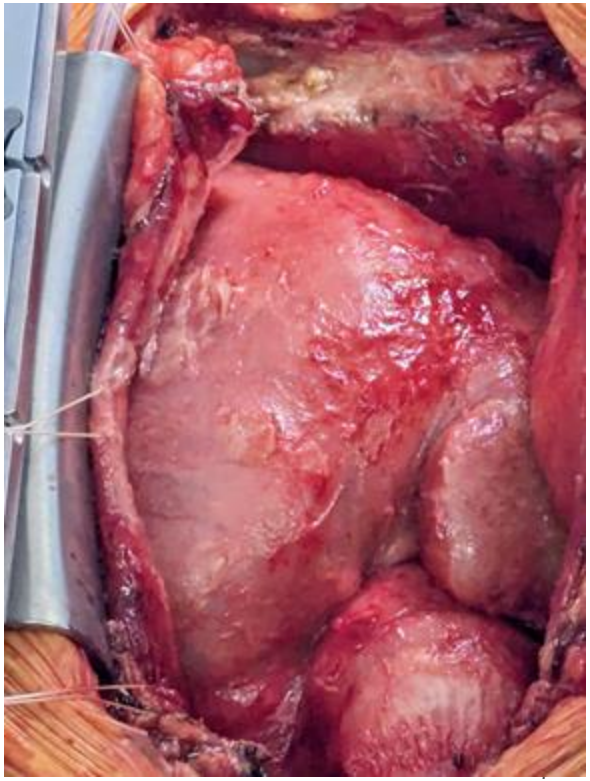
My Approach

- **What are the target vessels or target territories**
- **Conduit options**
- **Potential pitfalls**
  - Extensive scarring
  - Intramyocardial vessels
  - Heavily calcified vessels

Bailout plan: secondary targets, endarterectomy or hybrid approach



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Target Strategy

- Complete vs Incomplete Revascularization
- ACC and AHA emphasize grafting territories with:
  - 70% or greater stenosis in a major epicardial artery
    - LM exception at 50%
  - Evidence of ischemia or viable myocardium
  - Large territory at risk
- Grafting stenoses less than 50% or non-ischemic territories does not improve survival or symptom relief while increasing surgical risk
- Particularly true for the RCA with 50-69% stenosis or if supplying a small territory or with diffuse distal disease

Optimizing Efficiency and Safety

- **“Functionally complete revascularization” focusing on territories**
- Minimize operative risk
  - Avoid excessive operative time
  - Avoid multiple targets in single territory (selective)
    - Increased risk without proportional benefit
- Focusing on territories (anterior, lateral and inferior) with significant ischemia is functionally “complete revascularization” while balancing efficacy with safety

Exceptions to Strict Territory Approach

- Multiple large targets with separation in same territory
  - Multiple grafts in single territory
    - PDA and RPL, two large OMs or Diag and LAD
  - Quality conduit
    - If really good conduit, more likely to pick up additional targets
  - Inability to graft adjacent territories

Tailoring to Patient Specific Factors

- Age, comorbidities and LV function
  - Grafting territories in elderly, high risk patients likely is enough to relieve symptoms and improve survival while minimizing risks
    - Hybrid PCI
    - Optimal medical therapy
      - statins, BB, antiplatelets and nitrates
- FFR </= to 0.80 ensures grafting an ischemic territory and is associated with better graft patency by minimizing risk of competitive flow
  - Particularly true for radial artery grafts (use vein if FFR >/= 0.75)
  - Reasonable to graft large LAD with large territory using LIMA even if FFR is in gray zone

FFR Guided Strategy

- FAME trials
  - FFR guided revascularization (PCI) improved outcomes over angiography guided PCI
  - Reduced stent use by focusing on significant lesions
  - Highlighted risks of incomplete revascularization for functionally significant lesions
- Extrapolating to CABG FFR guided strategy reduces unnecessary grafts without compromising outcomes and with improved graft patency

FFR Guided Strategy

- FFR may be less reliable in diffuse disease or microvascular dysfunction
- Also less reliable in ACS due to altered hemodynamics

- iFR </= 0.89
  - Cutoff value iFR 0.84 to predict graft failure
    - Positive iFR had 7% failure vs 26% failure with negative iFR
- DFR </= 0.89
- FFR </= 0.80

Conduit Strategy

- LIMA - LAD everytime
  - Unless **very** poor target with large diagonal option
  - Exception may be profound cardiogenic shock
    - SVG improves early survival at cost of long term patency
- SVG
  - Less sensitive to competitive flow
  - May remain patent even with FRR > 0.80
    - 50-60% 10 yr patency
    - Good for gray zone RCA or Cx territories

Second Arterial Graft

- Radial vs RIMA
  - RAPCO (RCT)
    - RA patency 89% vs RIMA 80% at 10 yrs
    - RA MACE free survival better than RITA
  - Radial as second arterial graft has 16% lower composite cardiac outcomes at 5 yrs vs SAG/SVG (MACE, angina, re-op and PCI)
  - Longer and larger than RIMA with same or better patency
  - No increase in sternal complications (> DM, Cand obese pts)
  - Simultaneous harvest with LIMA
  - Likely as beneficial for women as for men

When To Avoid Radial

- Major arm trauma or surgery
- Vasculitis
- Raynauds
- Scleroderma
- Advanced CKD
- RA accessed for LHC
- Insufficient ulnar compensation
- Ok to use in > 80 yrs but less likely to realize survival advantage

Conduit Strategy

- Second arterial graft
  - STS data base says 9-11% of isolated CABG cases use MAGs
  - > 93% of CABG pts get a SAG
  - MAGs concentrated among high volume centers (20k of 200K CABG cases)
  - Every pt is considered for MAG but selection is key

Endarterectomy

- Uncommon and often unplanned adjunct to CABG
- Used for diffusely diseased vessels with no distal landing zone
- Mortality 2.6 - 8.6% is slightly higher than routine CABG when adjusted for patient complexity
- Post-op MI 1.5 - 7%
- High early graft patency (92%)
- DAPT 3- 6 months with some starting heparin early post-op when bleeding <100ml/hr and warfarin for 3 months

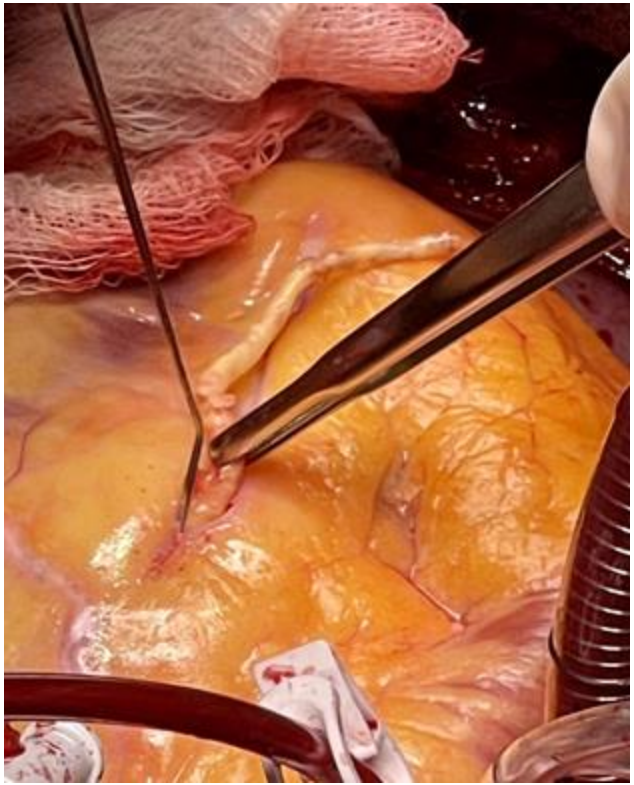
Endarterectomy

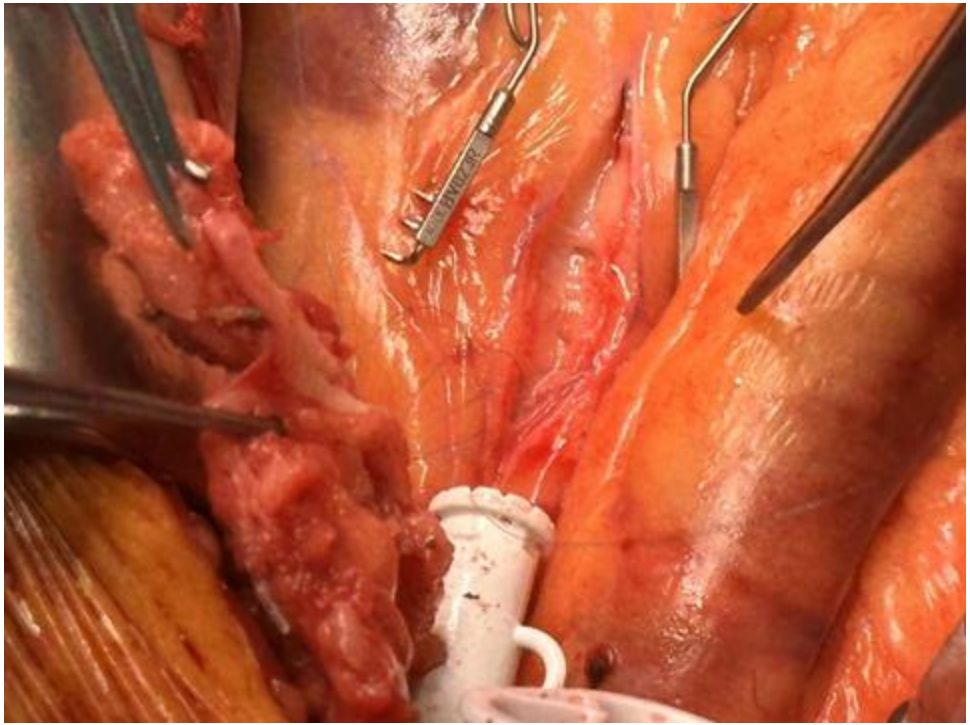
- Open vs closed technique
  - Long arteriotomy
  - shorter arteriotomy with longitudinal traction eversion technique
  - Early graft patency 92% open technique vs 88.6% for closed technique
- Single vessel safer than multiple vessels
  - Single CE 3.3% mortality vs 10.3% for double vessel CE
- Arterial graft to endarterectomy vessel has better patency than SVG
  - 15% arterial graft failure vs 55% with SVG

Endarterectomy

- Favorable survival rates at 74% at 10 yrs in high risk groups
- In diffuse disease, endarterectomy outperforms incomplete revascularization
- Higher risk in LAD than other vessels
  - But vast majority of the time I have to use it is for the LAD
- Open technique with onlay patch
- Closed technique with long hooded anastamosis

Open Endarterectomy





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SVG Patch

Onlay Technique utilizing vein

For large arteriotomies after open CE

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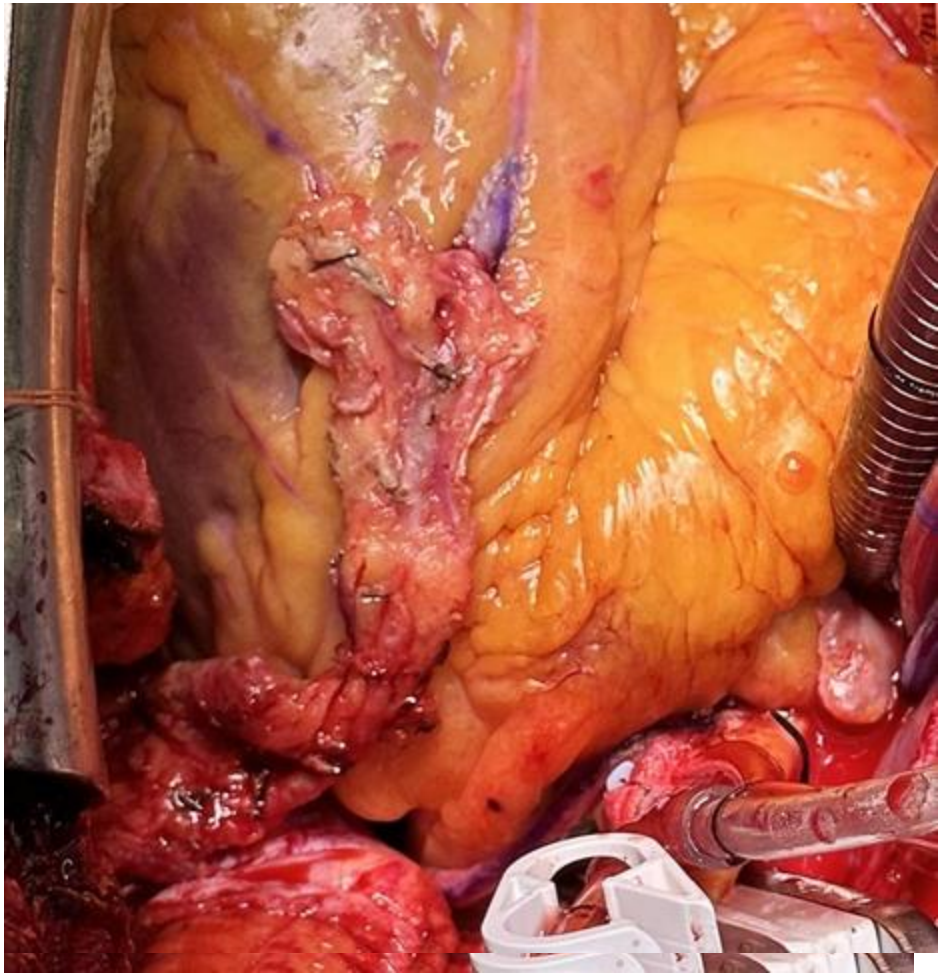
Onlay Technique

Hooded LIMA anastamosis to onlay vein patch



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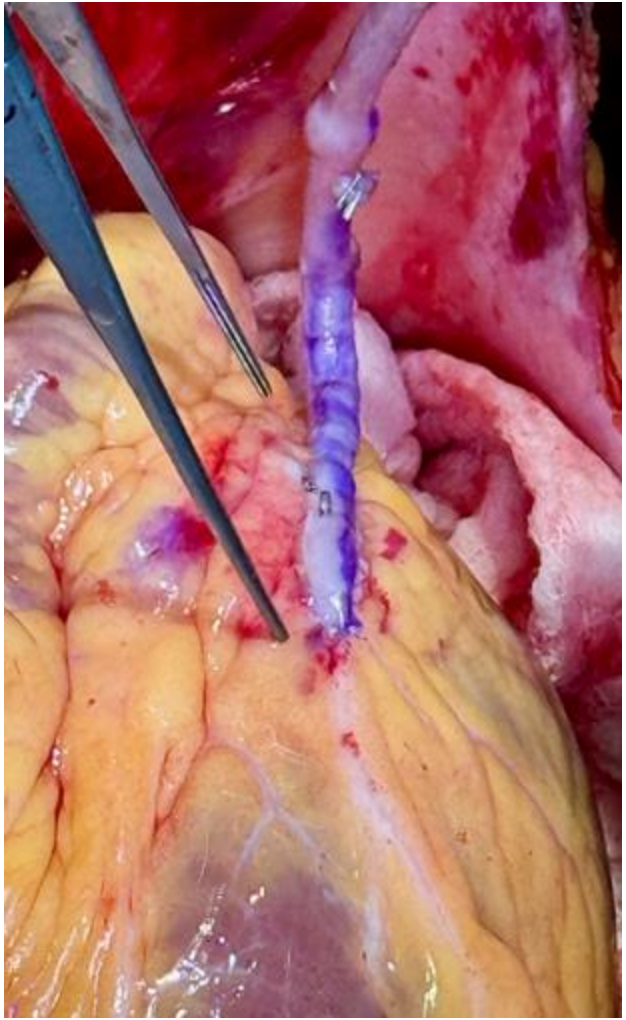
Hooded Anastamosis

Direct long hooded end-to-side anastamosis without onlay patch



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Various Endarterectomy Plaques

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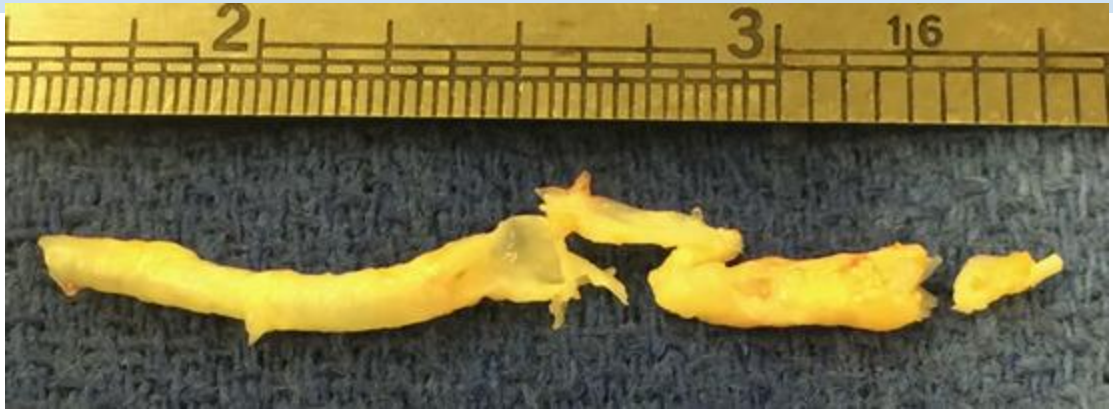
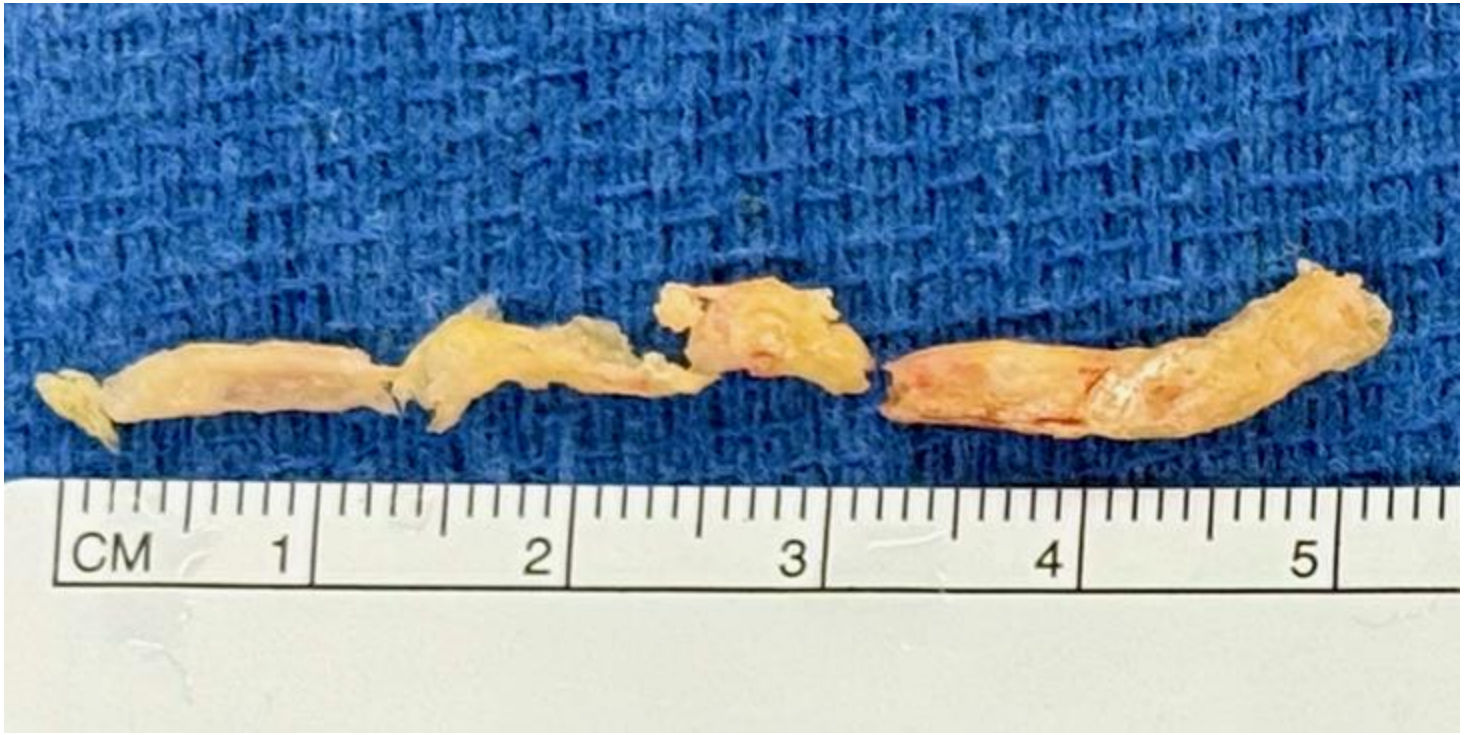
Various Endarterectomy Plaques



Various Endarterectomy Plaques

Recent Case

Recent Case



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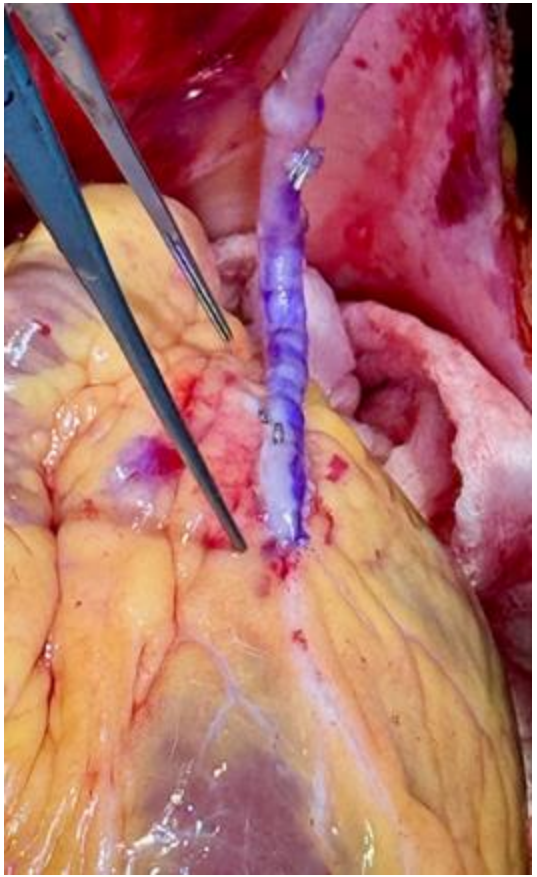
Recent Case



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Sequential Grafting

- Useful in situations with limited conduit
- Superior patency but needs technical expertise
- Parallel side-to-side has less distortion than diamond anastamosis
  - Better flow dynamics and avoids gull wing deformity
- Needs significant disease between vessels grafted (competitive flow)
- Avoid acute angles
- End on most critical target (tightest lesion supplying largest territory)

Hybrid Approach

- Good option for patients with limited conduit or to minimize pump time
- Typically utilizes LIMA to LAD
- May include additional grafts depending on targets and conduit
  - CTO vessel
- PCI typically staged
  - Prior to D/C for critical / symptomatic lesions
- Non-LAD lesions need to be suitable for PCI
  - Focal RCA or CX lesions with low SYNTAX score (<22)
- Outcomes similar to CABG based on LIMA but reinterventions for PCI vessels may be needed

Thank You

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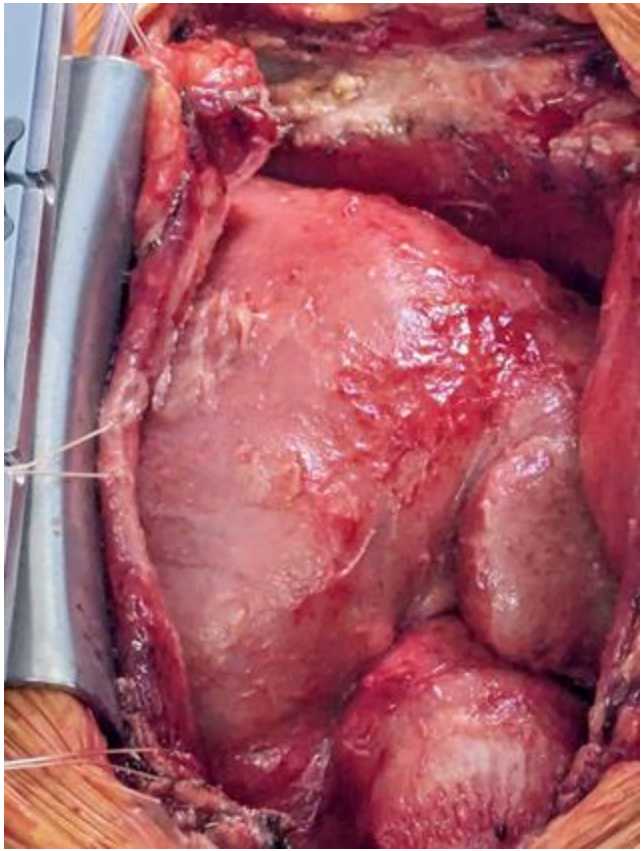
My Approach

- What are the **target vessels** or **target territories**
- Conduit options
- Potential pitfalls
  - Extensive scarring, intramyocardial vessels, heavily calcified vessels
  - Have a bailout plan like secondary targets, coronary endarterectomy or hybrid approach



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My Approach

- What are the **target vessels** or **target territories**
- Conduit options
- Potential pitfalls
  - Extensive scarring, intramyocardial vessels, heavily calcified vessels

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ISCHEMIA WITH NON OBSTRUCTIVE CORONARY ARTERY DISEASE

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DISCLOSURES

- No relevant disclosures.

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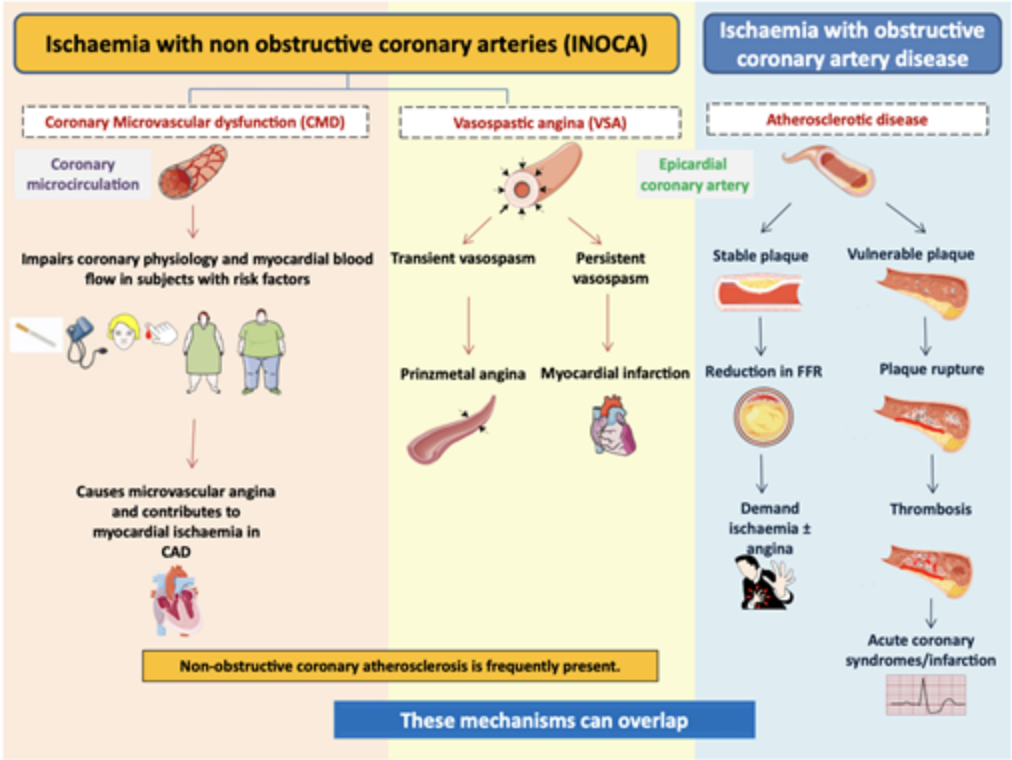
Incidence ~50% in women, and, ~30% in men.



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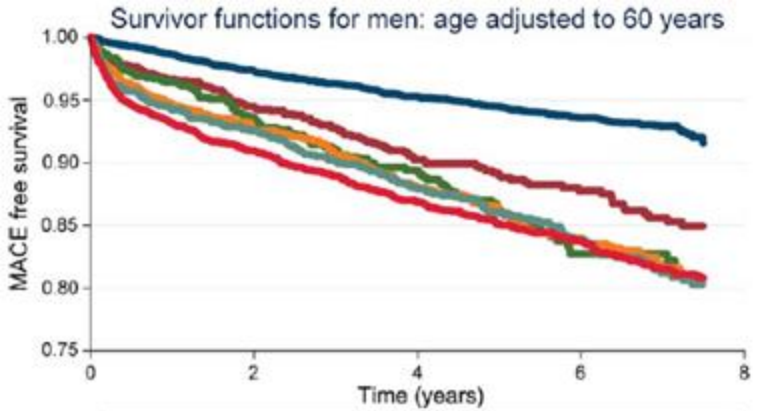
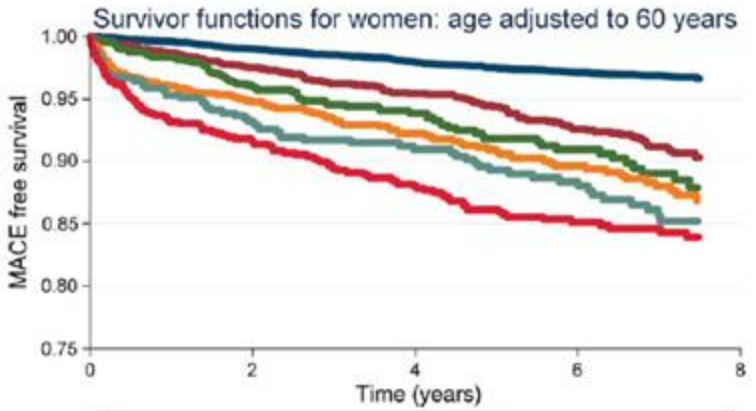
V. Kunadian et al. European Heart Journal (2020); 41: 3504-20

INOCA



Numbers at risk	0	2	4	6
Asymptomatic	2359	2231	2101	1738
Normal CA	1214	854	597	367
Dif. non-obstr. CAD	869	557	362	174
1VD	1475	1072	783	474
2VD	1105	806	583	342
3VD	1783	1312	984	632



Numbers at risk	0	2	4	6
Asymptomatic	3346	3213	3044	2600
Normal CA	2237	1597	1155	721
Dif. non-obstr. CAD	809	527	336	187
1VD	777	567	411	252
2VD	377	274	209	143
3VD	471	333	256	161

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L. Jespersen et al. European Heart Journal (2012) 33: 734-44

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Table 2 Hazard ratios (95% confidence interval) for patients with no obstructive coronary artery disease compared with asymptomatic women and men, respectively, in successively adjusted models

MACE	Events, *n*	Model 1[a]		Model 2[b]	
Degree of CAD	Women/men	Women	Men	Women	Men
Reference population	302/256	—	—	—	—
Normal coronary arteries	156/127	1.34 (1.08–1.66)	1.50 (1.19–1.89)	1.57 (1.21–2.02)	1.53 (1.18–2.00)
Diffuse non-obstr. CAD	87/132	1.62 (1.25–2.10)	1.79 (1.43–2.25)	1.86 (1.35–2.56)	1.87 (1.43–2.46)
All-cause mortality					
Reference population	356/298	—	—	—	—
Normal coronary arteries	105/103	0.97 (0.77–1.23)	1.30 (1.02–1.65)	1.20 (0.92–1.57)	1.44 (1.11–1.88)
Diffuse non-obstr. CAD	66/95	1.31 (1.00–1.71)	1.33 (1.05–1.69)	1.56 (1.13–2.15)	1.52 (1.15–2.01)

[a]Adjusted for age.
[b]Adjusted for age, BMI, diabetes, smoking status, and use of lipid-lowering and antihypertensive medication.

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L. Jespersen et al. European Heart Journal (2012) 33: 734-44

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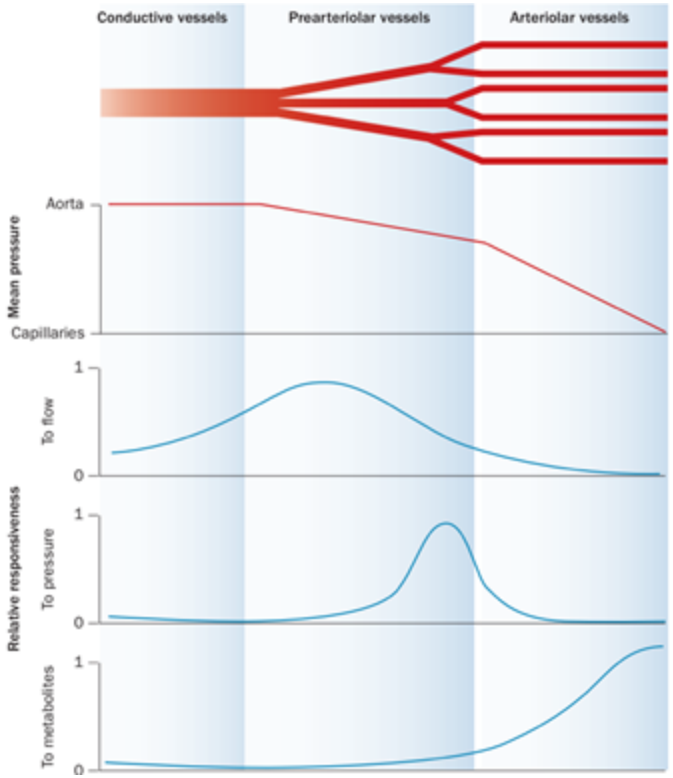

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Camici, P. G. et al. Nat Rev. Cardiol. (2015) 12, 48-62

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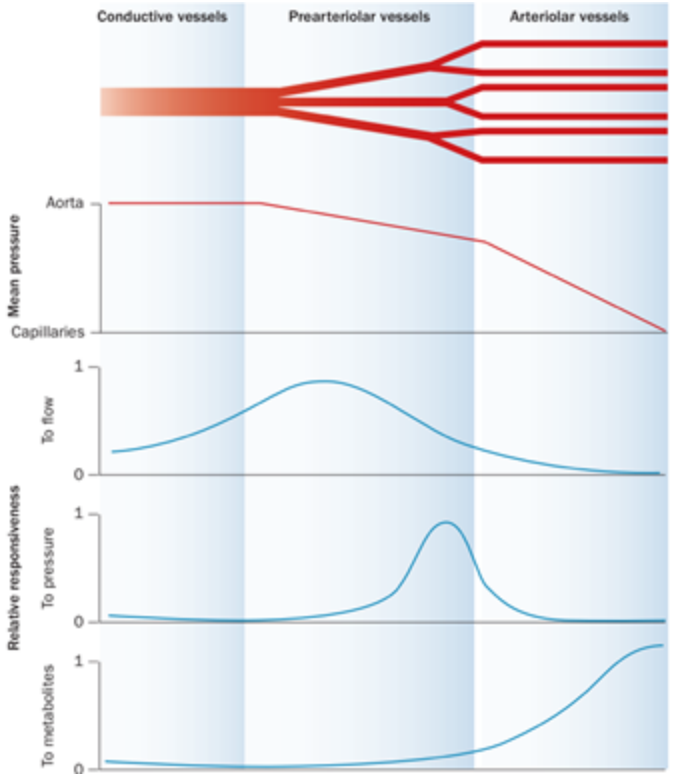

Epicardial vessels

- Visible on coronary angiogram.
- Have a capacitance function.
- Converts elastic energy to kinetic energy.

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Camici, P. G. et al. Nat Rev. Cardiol. (2015) 12, 48-62

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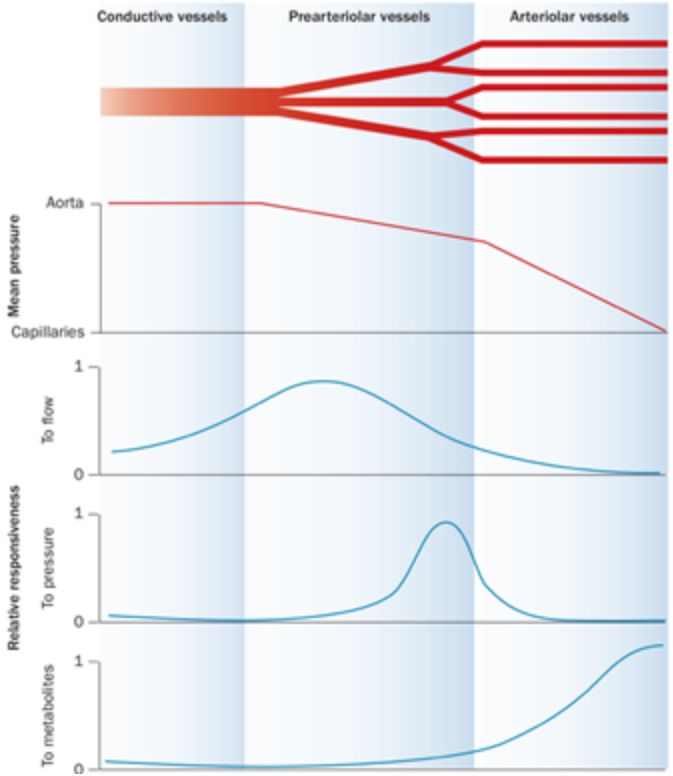

Prearteriolar vessels

- Not visible on coronary angiogram.
- Function to maintain narrow pressure range at the origin of the next compartment.
- Proximally responsive to flow and distally responsive to pressure.

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Camici, P. G. et al. Nat Rev. Cardiol. (2015) 12, 48-62

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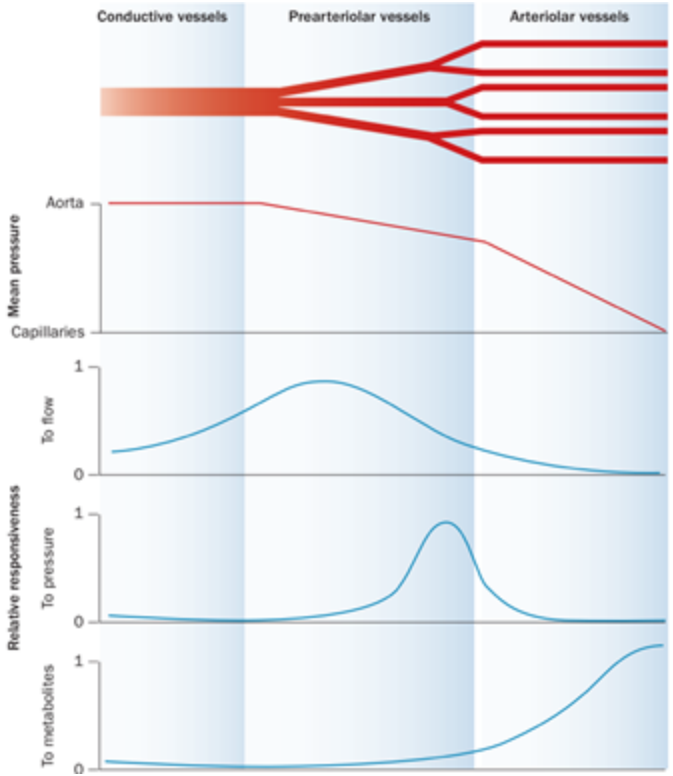

Arteriolar vessels

- Not visible on coronary angiogram.
- Responsive to metabolic substances.
- Function to match myocardial blood and oxygen demand.

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Camici, P. G. et al. Nat Rev. Cardiol. (2015) 12, 48-62

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Box 1 | Pathogenic mechanisms of CMD

Type 1: in the absence of myocardial diseases and obstructive CAD

- Microvascular remodelling
- Endothelial dysfunction
- Smooth muscle dysfunction

Type 2: in myocardial diseases without obstructive CAD

- Microvascular remodelling
- Smooth muscle dysfunction
- Extramural compression
- Reduced diastolic perfusion time (increased intramyocardial pressure or tissue oedema)
- Vascular wall infiltration
- Vascular rarefaction
- Perivascular fibrosis

Type 3: in obstructive CAD

- Endothelial dysfunction
- Smooth muscle dysfunction
- Luminal obstruction (microembolization)

Type 4: iatrogenic

- Luminal obstruction (microembolization by plaque and thrombus debris)
- Autonomic dysfunction

Abbreviations: CAD, coronary artery disease; CMD, coronary microvascular dysfunction.

- These mechanisms lead to disruption of normal coronary physiology, and impair adaptability to changes in myocardial oxygen demand.

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Camici, P. G. et al. Nat Rev. Cardiol. (2015) 12, 48-62

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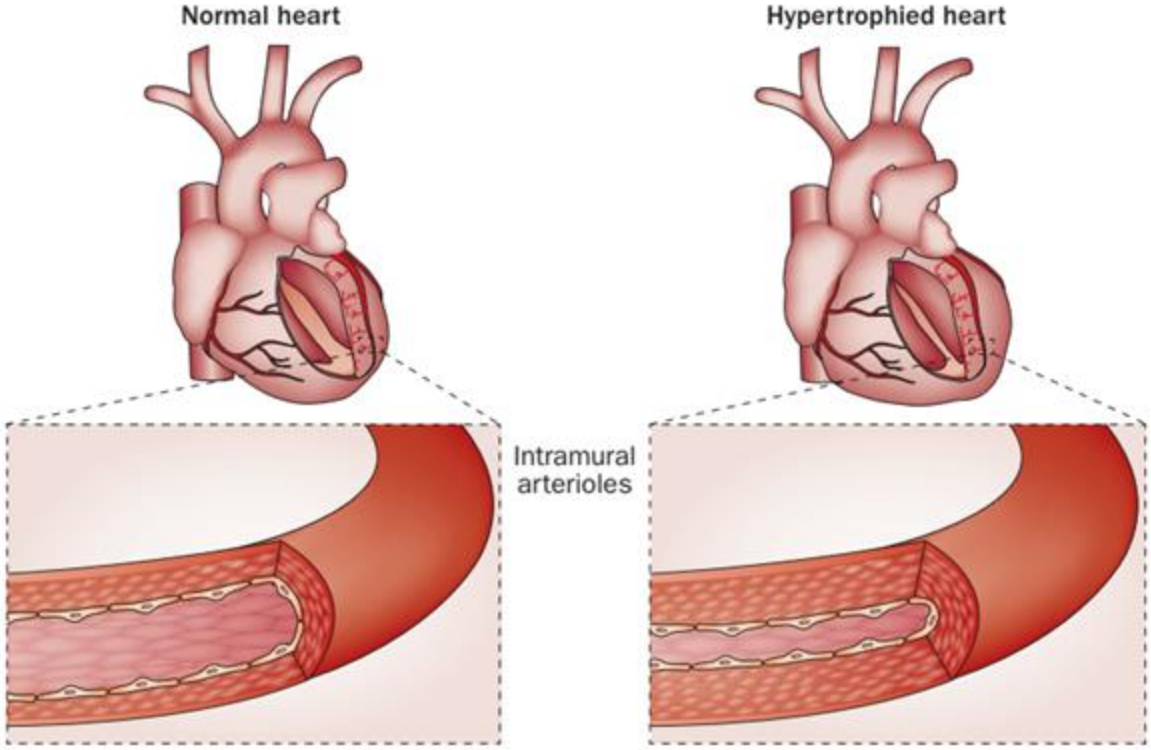

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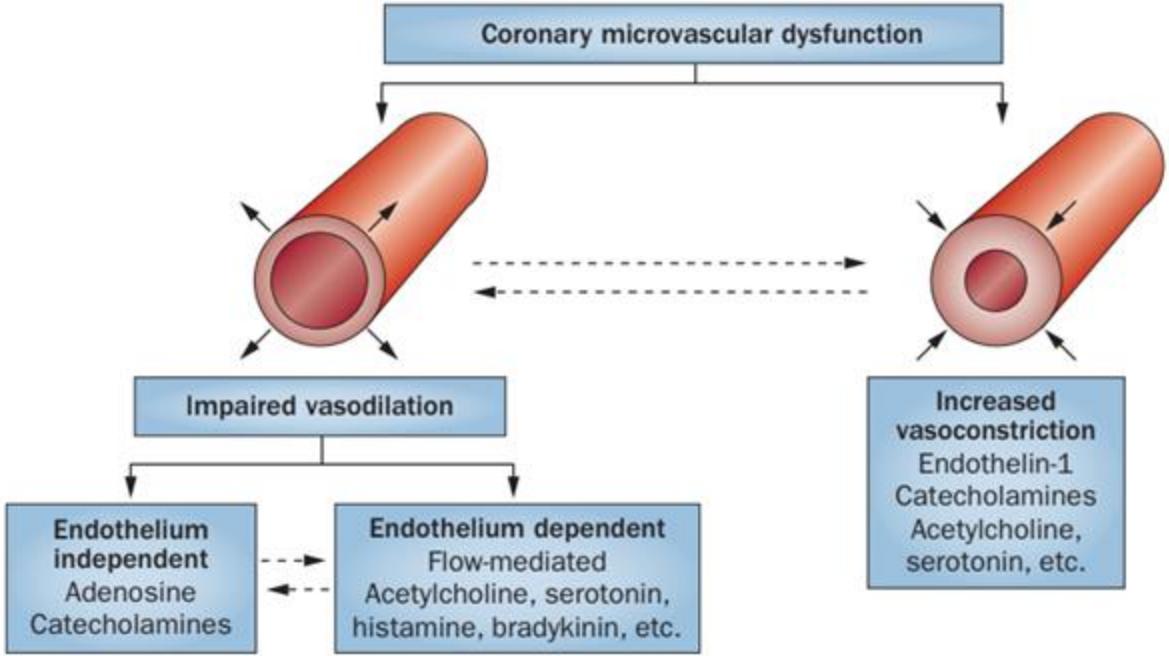

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- In swine diabetes mellitus and familial hypercholesterolemia models, microvascular dysfunction has been shown, prior to progression to macrovascular disease.
- There is impaired coronary microvascular nitric oxide bioavailability.
- Shift toward anaerobic metabolism particularly during exercise.
- Changes lead to generalized impairment in cardiac contractile efficiency.

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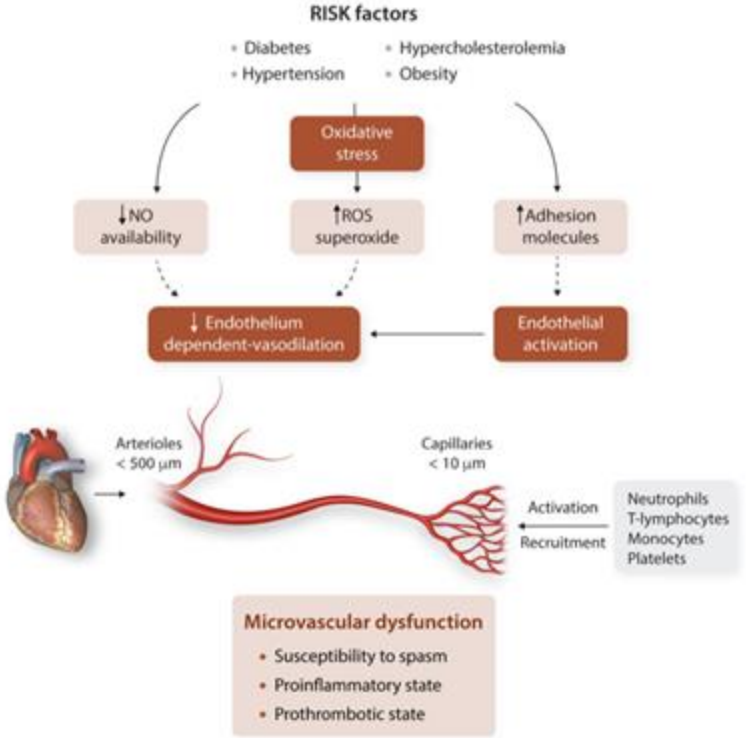

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- Coronary flow reserve is the ratio of hyperemic coronary flow to resting coronary flow - utilized to diagnose microvascular dysfunction.
- Can be measured non-invasively using cardiac PET - Gold standard.
- Invasive measurements can be done using a doppler velocity wire. Flow can be determined by multiplying the velocity by the cross sectional area of the vessel. More commonly, the average peak velocities are used for the calculation.

INOCA

- A thermodilution method can also be used to determine flow.
- The mean transit time of room temperature saline injected into a coronary artery can be determined from a thermodilution curve.
- There is a strong correlation between the inverse of the mean transit time and absolute coronary flow.

INOCA

$$\text{Absolute coronary flow} \approx \frac{1}{\text{Tmn}}$$

$$\text{CFR} = \frac{\text{Coronary flow at hyperemia}}{\text{Coronary flow at rest}} \approx \frac{\frac{1}{\text{TmnHyp}}}{\frac{1}{\text{TmnRest}}} = \frac{\text{TmnRest}}{\text{TmnHyp}}$$

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Circ Cardiovasc Interv. (2017) ;10:e005361

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- Index of microvascular resistance, is another tool to evaluate for microvascular dysfunction.

$$\text{Ohm law}: \mathrm{V} = \mathrm{I} \times \mathrm{R} \rightarrow R = \mathrm{R} = \frac{\mathrm{V}}{\mathrm{I}}$$

$$\left(R = \mathrm{R} = \text{resistance},\ \mathrm{V} = \text{voltage},\ \mathrm{I} = \text{current}\right)$$

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$$IMR = \frac{Pd - Pv}{\frac{1}{Tmn}} \text{ at maximal hyperemia}$$

$$IMR = \frac{Pd}{\frac{1}{TmnHyp}} \qquad IMR = Pd \times TmnHyp$$

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- Coronary artery spasm is a subset of INOCA.
- Endothelial dysfunction and primary hyperreactivity of vascular smooth muscle cells predisposes to coronary artery spasm.
- Smoking is a risk factor for coronary artery spasm - ~75% of patients with coronary artery spasm are active smokers.
- Acetylcholine provocation testing can help assess for coronary artery spasm.

INOCA

	INOCA endotypes	Pathophysiology	Diagnostic criteria
1	Microvascular angina[a]	CMD	Diagnostic guidewire and Adenosine test • FFR > 0.8 • CFR < 2.0 • IMR ≥ 25[b] • HMR ≥ 1.9[b] Vasoreactivity (acetylcholine test) • No or <90% diameter reduction • + angina • + ischaemic ECG changes

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V. Kunadian et al. European Heart Journal (2020); 41: 3504-20

INOCA

2	Vasospastic angina	Epicardial spasm	Diagnostic guidewire and Adenosine test • FFR > 0.8 • CFR ≥ 2.0 • IMR < 25 • HMR < 1.9 Vasoreactivity (acetylcholine test) • ≥ 90% diameter reduction • + angina • + ischaemic ECG changes

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3	Both microvascular and vasospastic angina	Both CMD and epicardial spasm	Diagnostic guidewire and Adenosine test • FFR > 0.8 • CFR < 2.0 • IMR ≥ 25 • HMR ≥ 1.9 Vasoreactivity (acetylcholine test) • No or <90% or ≥90% diameter reduction • + angina • + ischaemic ECG changes

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INOCA

4	Non-cardiac chest pain	None	Diagnostic guidewire and Adenosine test • FFR > 0.8 • CFR ≥ 2.0 • IMR < 25 • HMR < 1.9 Vasoreactivity (acetylcholine test) • No or <90% diameter reduction • No angina • No ischaemic ECG changes

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5	Non-flow-limiting CAD[c]	Diffuse coronary artery atherosclerosis	Diagnostic guidewire and adenosine test • FFR > 0.8 • CFR ≥ 2.0 • IMR < 25 • HMR < 1.9 Vasoreactivity (acetylcholine test) • No or <90% diameter reduction • No angina • No ischaemic ECG changes

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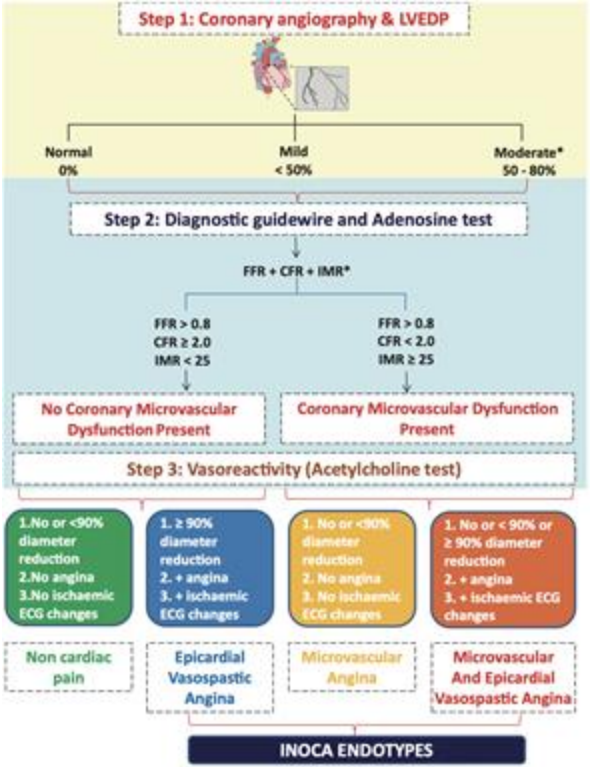

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- The CorMicA trial evaluated the role of medical therapy using invasive coronary function testing in angina.
- 151 patients underwent coronary angiogram with evaluation for microvascular dysfunction and coronary artery spasm, and were then randomized to stratified medical therapy vs standard care.

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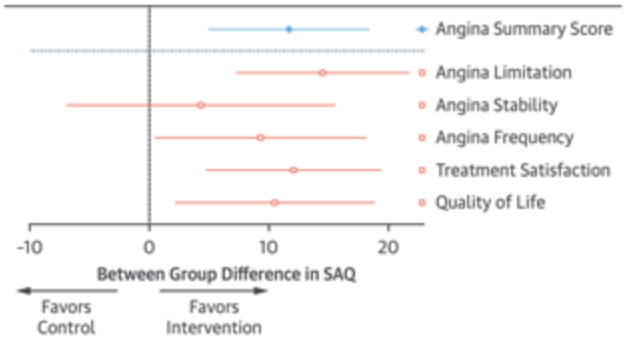
Ford et al. JACC (2018) 72:2841-55

INOCA

FIGURE 3 Primary Efficacy Outcome: Treatment Difference in the 6-Month SAQ Summary Score



Forest plot of mean treatment difference in angina summary score (95% CI) and breakdown of the Seattle Angina Questionnaire (SAQ) score domains. The angina summary score is the mean of 3 angina domains (limitation, frequency, and overall quality of life). The angina summary score was adjusted for baseline variation using a regression model. The overall difference at 6 months was 11.7 U (95% confidence interval: 5.0 to 18.4; $p < 0.001$).

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Ford et al. JACC (2018) 72:2841-55

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Table 2. Treatment approaches based on abnormality identified by functional pathway.

Treatment class	Coronary microvascular dysfunction	Coronary vasospasm, endothelial dysfunction, microvascular spasm
ACEi/ARB	↑ CFR, improves microvasculature remodeling, improves endothelial vasomotor function	
Statins	↑ CFR, improves endothelial function; pleiotropic effects (reduced vascular inflammation)	↑ CFR, improves endothelial function; pleiotropic effects (reduced vascular inflammation)
Beta blocker	↓ myocardial oxygen consumption	(Avoid beta-1 selective BB)
Calcium channel blocker	Vascular smooth muscle relaxation; ↓ myocardial oxygen consumption	↓spontaneous and inducible coronary vasospasm via vascular smooth muscle relaxation ↓ oxygen demand
Nitrates	Limited benefit/avoid use	↓spontaneous and inducible coronary vasospasm via epicardial vasodilation, ↓ oxygen demand
Ranolazine	Improves MPRI in CMD	
Nicorandil[a]	K channel agonist-coronary microvasculature effect	
Exercise training	↑ CFR	
Device-based/ surgical therapy	Coronary sinus reducer redistributes blood flow	

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Toleva et al. JSCAI (2025) 102633

QUESTIONS

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Ford et al. JACC (2018) 72:2841-55

Redo-SAVR vs Valve In Valve TAVR – What's Best?

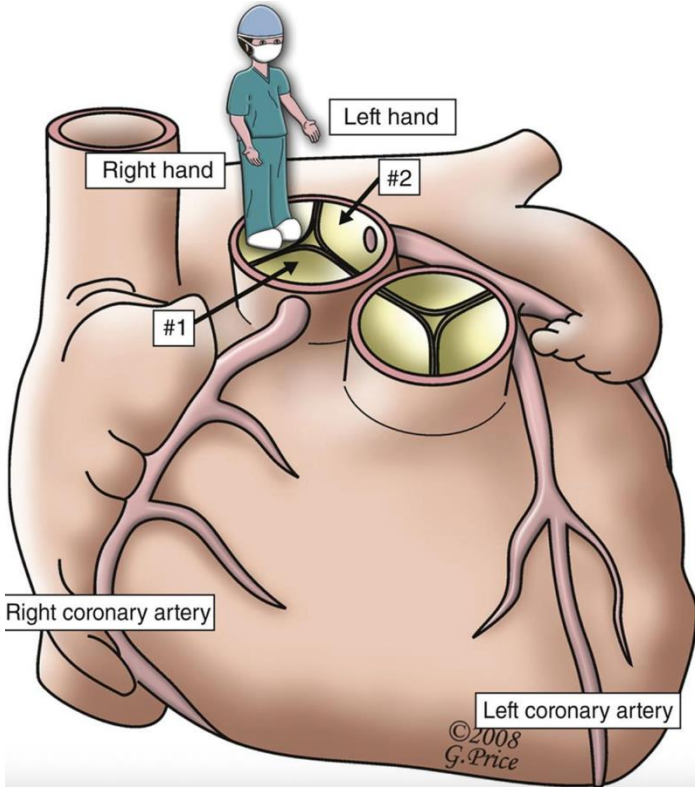
Jamal Anyalebechi, MD

Virginia Mason Franciscan Health
Center for Cardiovascular Health

Disclosures

- NO RELEVANT DISCLOSURES

What are we treating



Sellke, Frank, et al. *Sabiston and Spencer Surgery of the Chest*. Available from: Elsevier eBooks+, (10th Edition). Elsevier - OHCE, 2023.

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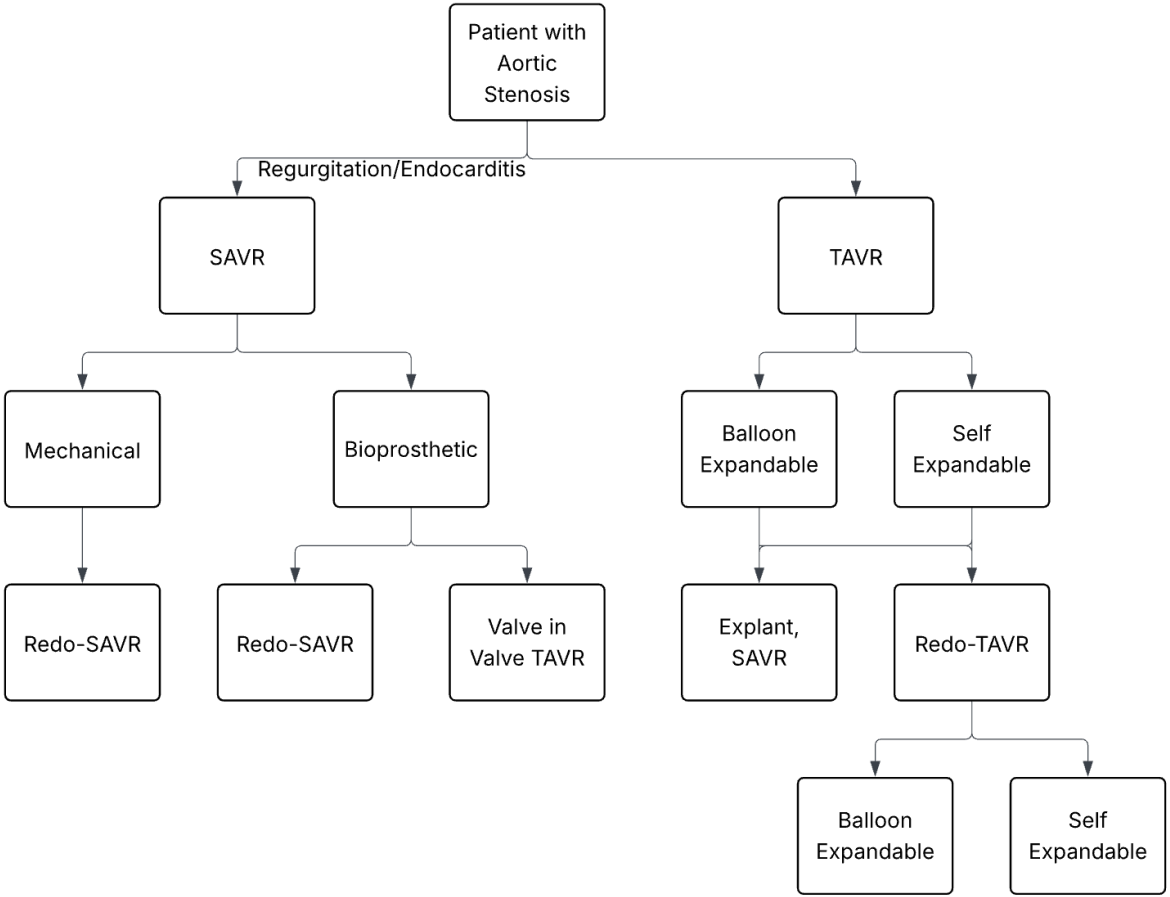
- What is the optimal 30-year plan?

30 Year Plan



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SAVR

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Sellke, Frank, et al. *Sabiston and Spencer Surgery of the Chest.* Available from: Elsevier eBooks+, (10th Edition). Elsevier - OHCE, 2023.

Recommendations for Choice of Mechanical Versus Bioprosthetic AVR

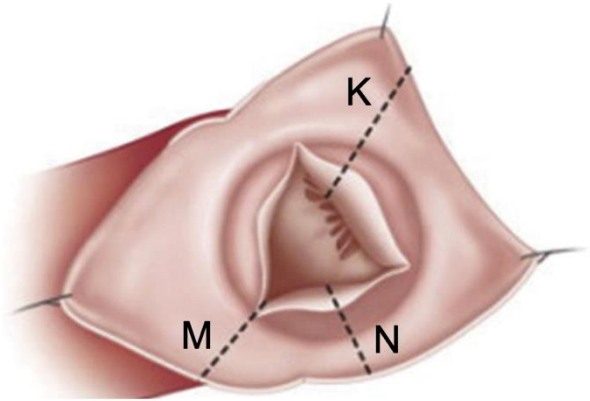
Referenced studies that support the recommendations are summarized in Online Data Supplements 11 and 12.

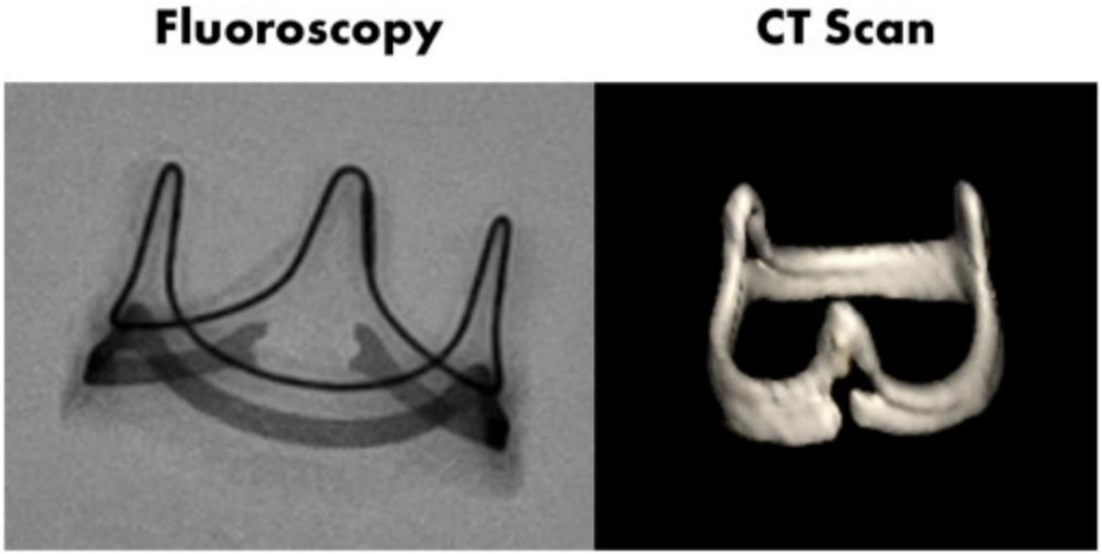
COR	LOE	RECOMMENDATIONS
1	C-EO	1. In patients with an indication for AVR, the choice of prosthetic valve should be based on a shared decision-making process that accounts for the patient's values and preferences and includes discussion of the indications for and risks of anticoagulant therapy and the potential need for and risks associated with valve reintervention.
1	C-EO	2. For patients of any age requiring AVR for whom VKA anticoagulant therapy is contraindicated, cannot be managed appropriately, or is not desired, a bioprosthetic AVR is recommended.

(Continued)

2a	B-R	3. For patients <50 years of age who do not have a contraindication to anticoagulation and require AVR, it is reasonable to choose a mechanical aortic prosthesis over a bioprosthetic valve. (1)
2a	B-NR	4. For patients 50 to 65 years of age who require AVR and who do not have a contraindication to anti-coagulation, it is reasonable to individualize the choice of either a mechanical or bioprosthetic AVR with consideration of individual patient factors and after informed shared decision-making. (1-10)
2a	B-R	5. In patients >65 years of age who require AVR, it is reasonable to choose a bioprosthesis over a mechanical valve. (1)
2b	B-NR	6. In patients <50 years of age who prefer a bioprosthetic AVR and have appropriate anatomy, replacement of the aortic valve by a pulmonic autograft (the Ross procedure) may be considered at a Comprehensive Valve Center (11-13).

SAVR





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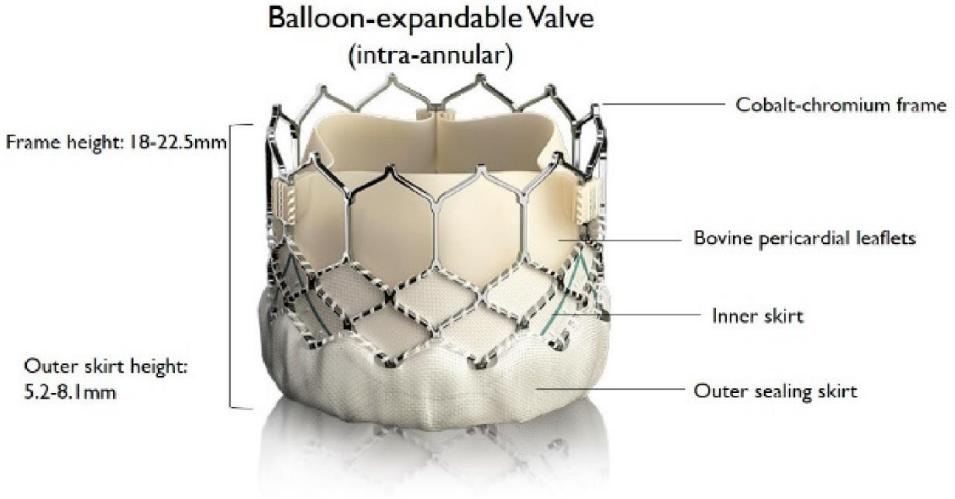
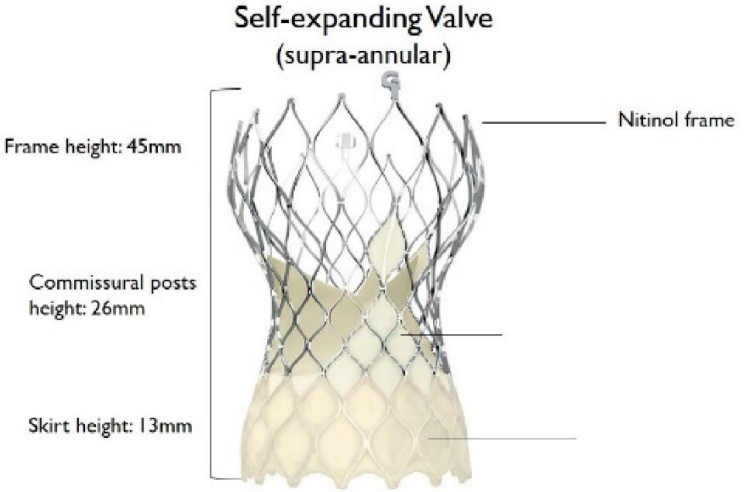
TAVR





Chiarito, Mauro, et al. "Types of Transcatheter Aortic Valve Replacement Devices." *Encyclopedia*, Alessandro Spirito, 3 Aug. 2022, encyclopedia.pub/entry/25772.

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Recommendations for Choice of SAVR Versus TAVI for Patients for Whom a Bioprosthetic AVR Is Appropriate
Referenced studies that support the recommendations are summarized in Online Data Supplement 11 to 13.

COR	LOE	RECOMMENDATIONS
1	A	1. For symptomatic and asymptomatic patients with severe AS and any indication for AVR who are <65 years of age or have a life expectancy >20 years, SAVR is recommended (1-3).
1	A	2. For symptomatic patients with severe AS who are 65 to 80 years of age and have no anatomic contra-indication to transfemoral TAVI, either SAVR or transfemoral TAVI is recommended after shared decision-making about the balance between expected patient longevity and valve durability (1,4-8).
1	A	3. For symptomatic patients with severe AS who are >80 years of age or for younger patients with a life expectancy <10 years and no anatomic contraindication to transfemoral TAVI, transfemoral TAVI is recommended in preference to SAVR (1,4-10).
1	B-NR	4. In asymptomatic patients with severe AS and an LVEF <50% who are ≤80 years of age and have no anatomic contraindication to transfemoral TAVI, the decision between TAVI and SAVR should follow the same recommendations as for symptomatic patients in Recommendations 1, 2, and 3 above (1,2,4-10).
1	B-NR	5. For asymptomatic patients with severe AS and an abnormal exercise test, very severe AS, rapid pro-gression, or an elevated BNP (COR 2a indications for AVR), SAVR is recommended in preference to TAVI (1-3,11).

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(Continued)

1	A	6. For patients with an indication for AVR for whom a bioprosthetic valve is preferred but valve or vascular anatomy or other factors are not suitable for transfemoral TAVI, SAVR is recommended (1-3,11).
1	A	7. For symptomatic patients of any age with severe AS and a high or prohibitive surgical risk, TAVI is recommended if predicted post-TAVI survival is >12 months with an acceptable quality of life (12,13,14,15).
1	C-EO	8. For symptomatic patients with severe AS for whom predicted post-TAVI or post-SAVR survival is <12 months or for whom minimal improvement in quality of life is expected, palliative care is recommended after shared decision-making, including discussion of patient preferences and values.
2b	C-EO	9. In critically ill patients with severe AS, percutaneous aortic balloon dilation may be considered as a bridge to SAVR or TAVI.

Writing Committee Members, et al. "2020 ACC/AHA guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines." *Journal of the American College of Cardiology* 77.4 (2021): e25-e197.

Durability

REVIEW ARTICLE | Originally Published 21 September 2020 |

Check for updates

Degeneration of Bioprosthetic Heart Valves: Update 2020

Alexander E. Kostyunin, PhD, Arseniy E. Yuzhalin, DPhil, Maria A. Rezvova, MSc, Evgeniy A. Ovcharenko, PhD, Tatiana V. Glushkova, PhD, and Anton G. Kutikhin, MD, PhD | AUTHOR INFO & AFFILIATIONS

Journal of the American Heart Association • Volume 9, Number 19 • https://doi.org/10.1161/JAHA.120.018506

JOURNAL ARTICLE

Transcatheter or surgical aortic valve implantation: 10-year outcomes of the NOTION trial

Hans Gustav Hørsted Thyregod, Troels Højsgaard Jørgensen, Nikolaj Ihlemann, Daniel Andreas Steinbrüchel, Henrik Nissen, Bo Juel Kjeldsen, Petur Petursson, Ole De Backer, Peter Skov Olsen, Lars Søndergaard Author Notes

European Heart Journal, Volume 45, Issue 13, 1 April 2024, Pages 1116–1124,
https://doi.org/10.1093/eurheartj/ehae043
Published: 07 February 2024 **Article history** ▾

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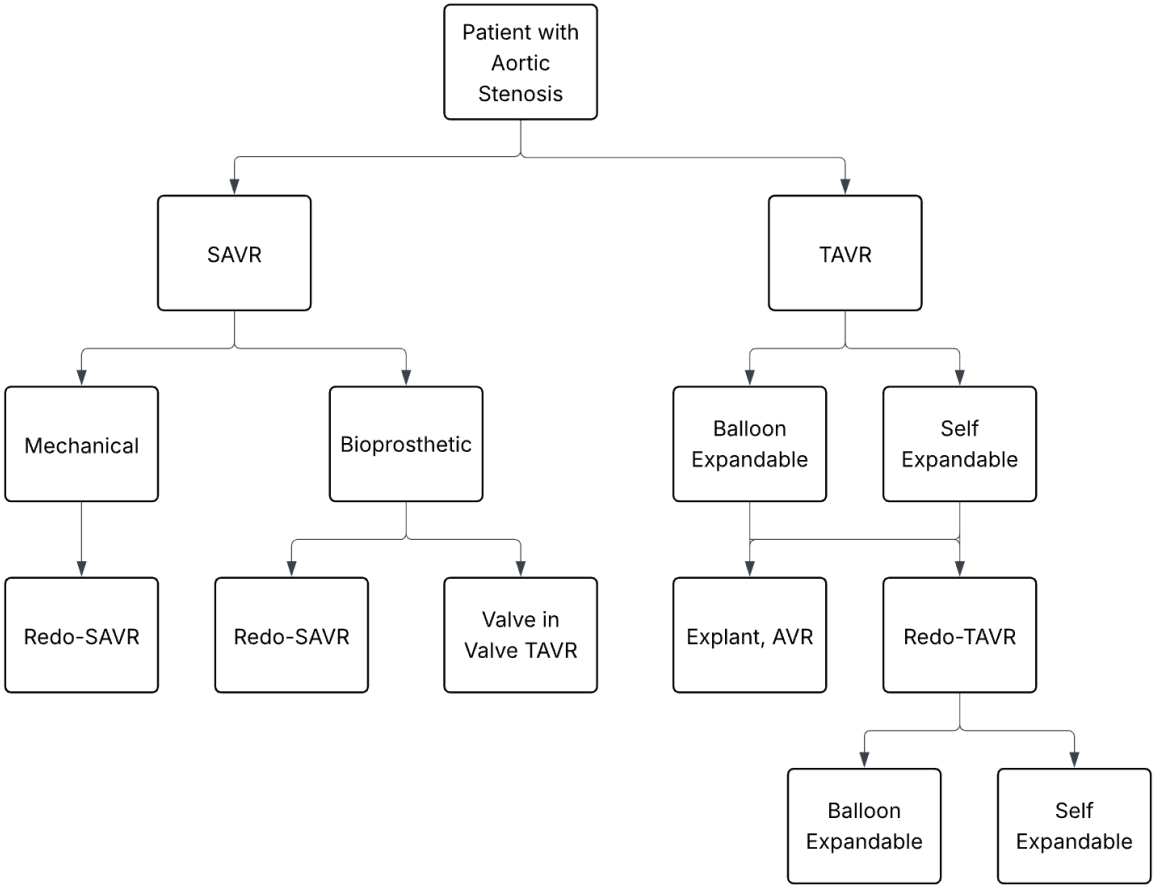
Valve Reintervention



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Redo SAVR

Bi-National Outcomes of Redo Surgical Aortic Valve Replacement in the Era of Valve-in-Valve Transcatheter Aortic Valve

Campbell D. Flynn, MBBS, MS [a,b], Lavinia Tran, BBiomedSci [c], Christopher M. Reid, PhD, MSc [c,d], Aubrey Almeida, FRACS [a], Silvana F. Marasco, PhD, FRACS [a,e,f,*]

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[b]School of Medicine, The University of Sydney, Sydney, NSW, Australia
[c]School of Public Health & Preventive Medicine, Monash University, Melbourne, Vic, Australia
[d]School of Population Health, Curtin University, Perth, WA, Australia
[e]Department of Surgery, Central Clinical School, Monash University, Melbourne, Vic, Australia
[f]Department of Cardiothoracic Surgery, The Alfred Hospital, Melbourne, Vic, Australia

- 1199 Patients; Australia + New Zealand over 20 Years; 40% Concomitant procedures
- 30 Day Mortality 6.4%; Survival 1 Year 90.5%, 5 Y 77%, 10 Y 57.2%; Median Survival 12.7 Y
- Age important risk factor; >70 Years increased mortality

Re-do SAVR

Redo-SAVR is still considered in peculiar conditions:

- patients at intermediate or low surgical risk;
- young individuals with longer life expectancy (because no data are available on long-term durability of ViV TAVR);
- patients with complex anatomical features for ViV TAVR, such as a high risk for coronary obstruction (without possibility of performing BASILICA) or with small anatomies.
- in cases of non-structural BHV dysfunction, such as patient-prosthesis mismatch (PPM) or severe PVL (percutaneous approach might be reasonable in cases of PPM when a balloon valve fracture might be performed within a stented surgical valve or in cases of PVL suitable for a percutaneous closure).

Di Muro, Francesca Maria et al. “Valve-in-Valve Transcatheter Aortic Valve Replacement: From Pre-Procedural Planning to Procedural Scenarios and Possible Complications.” *Journal of clinical medicine* vol. 13,2 341. 7 Jan. 2024, doi:10.3390/jcm13020341

Aspects ViV TAVR

Review Article

The Essential Aortic Valve-in-Valve Transcatheter Aortic Valve Replacement Update: Procedural Strategies and Current Clinical Results

Matheus Simonato, MD [a], José Honório Palma, MD [b], Zaid Alirhayim, MD [c], Raviteja Guddeti, MD [c], Tsuyoshi Kaneko, MD [d], Santiago Garcia, MD [c,*]

[a] *Yale School of Medicine, Yale University, New Haven, Connecticut*
[b] *Instituto do Coração da Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brazil*
[c] *The Carl and Edyth Lindner Center for Research and Education at The Christ Hospital, Cincinnati, Ohio*
[d] *Washington University, St. Louis, Missouri*

- True ID of Surgical Valve vs the Label size
- Stenosis, Size of Original Valve (True ID <21mm) => High Gradients + Worse Survival
- Consider SEV vs BEV (LYTEN Trial)
- Implantation Depth
- Coronary Obstruction

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Reintervention

Annibali *et al. Mini-invasive Surg* 2022;6:12
DOI: 10.20517/2574-1225.2021.101

Mini-invasive Surgery

Review

Open Access

Check for updates

Valve-in-valve transcatheter aortic valve replacement: the challenge of the next future

Gianmarco Annibali, Innocenzo Scrocca, Giuseppe Musumeci

J Clin Med. 2024 Jan 7;13(2):341. doi: 10.3390/jcm13020341

Valve-in-Valve Transcatheter Aortic Valve Replacement: From Pre-Procedural Planning to Procedural Scenarios and Possible Complications

Francesca Maria Di Muro [1], Chiara Cirillo [2], Luca Esposito [3,4], Angelo Silverio [3], Germano Junior Ferruzzi [3], Debora D'Elia [3], Ciro Formisano [3], Stefano Romei [3], Maria Giovanna Vassallo [3], Marco Di Maio [3], Tiziana Attisano [5], Francesco Meucci [1], Carmine Vecchione [3], Michele Bellino [3,*], Gennaro Galasso [3]

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Comparative Study > Ann Thorac Surg. 2025 Aug;120(2):335-344.
doi: 10.1016/j.athoracsur.2025.01.006. Epub 2025 Jan 24.

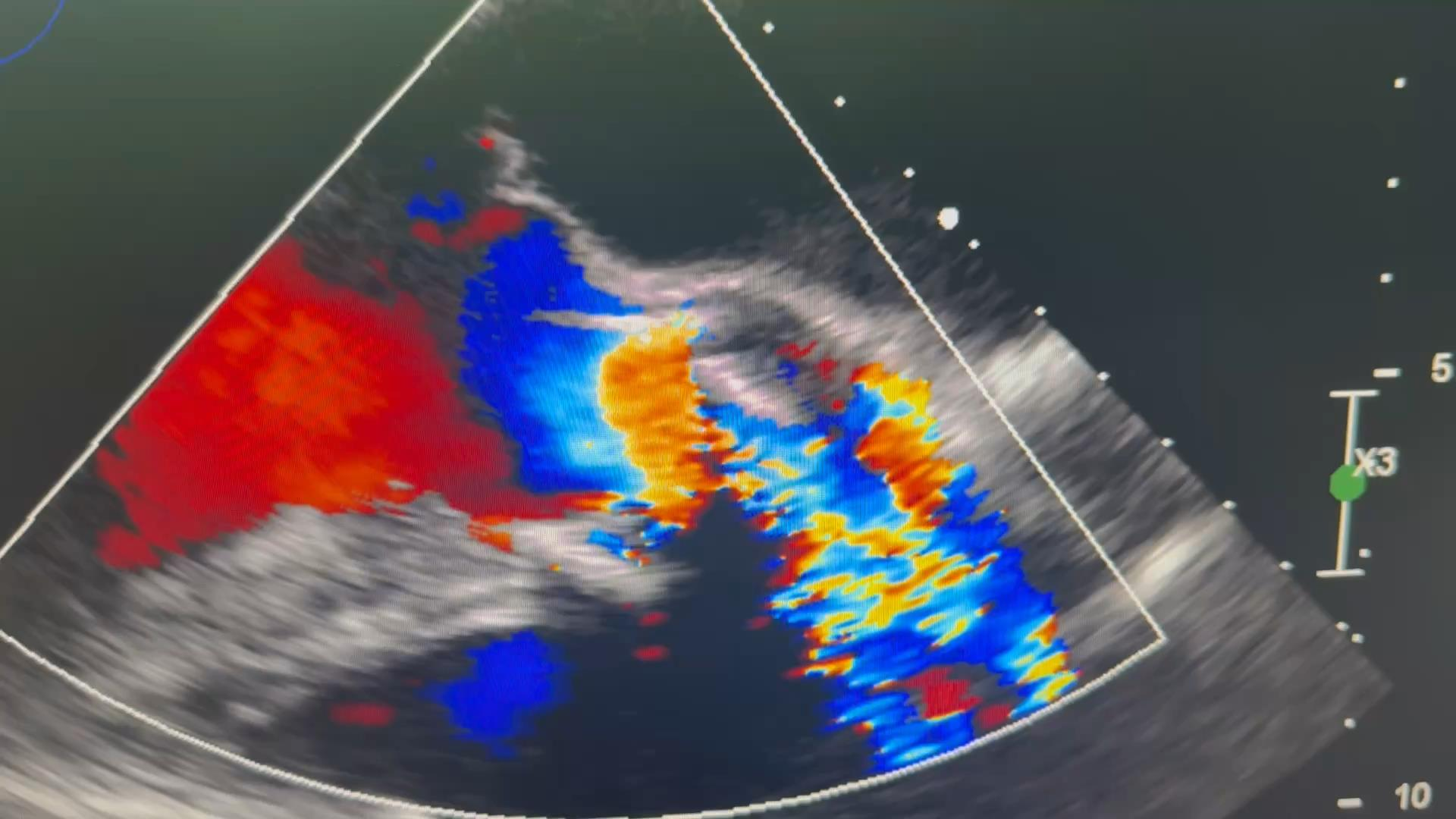
Redo Surgical Aortic Valve Replacement vs Valve-in-Valve Transcatheter Aortic Valve Replacement for Degenerated Bioprosthetic Valves

Jake Awtry [1], Thais Faggion Vinholo [2], Mansoo Cho [3], Philip Allen [4], Robert Semco [5], Sameer Hirji [4], Siobhan McGurk [4], Paige Newell [4], Tanujit Dey [3], Mark J Cunningham [6], Ashraf Sabe [4], Kim I de la Cruz [7]

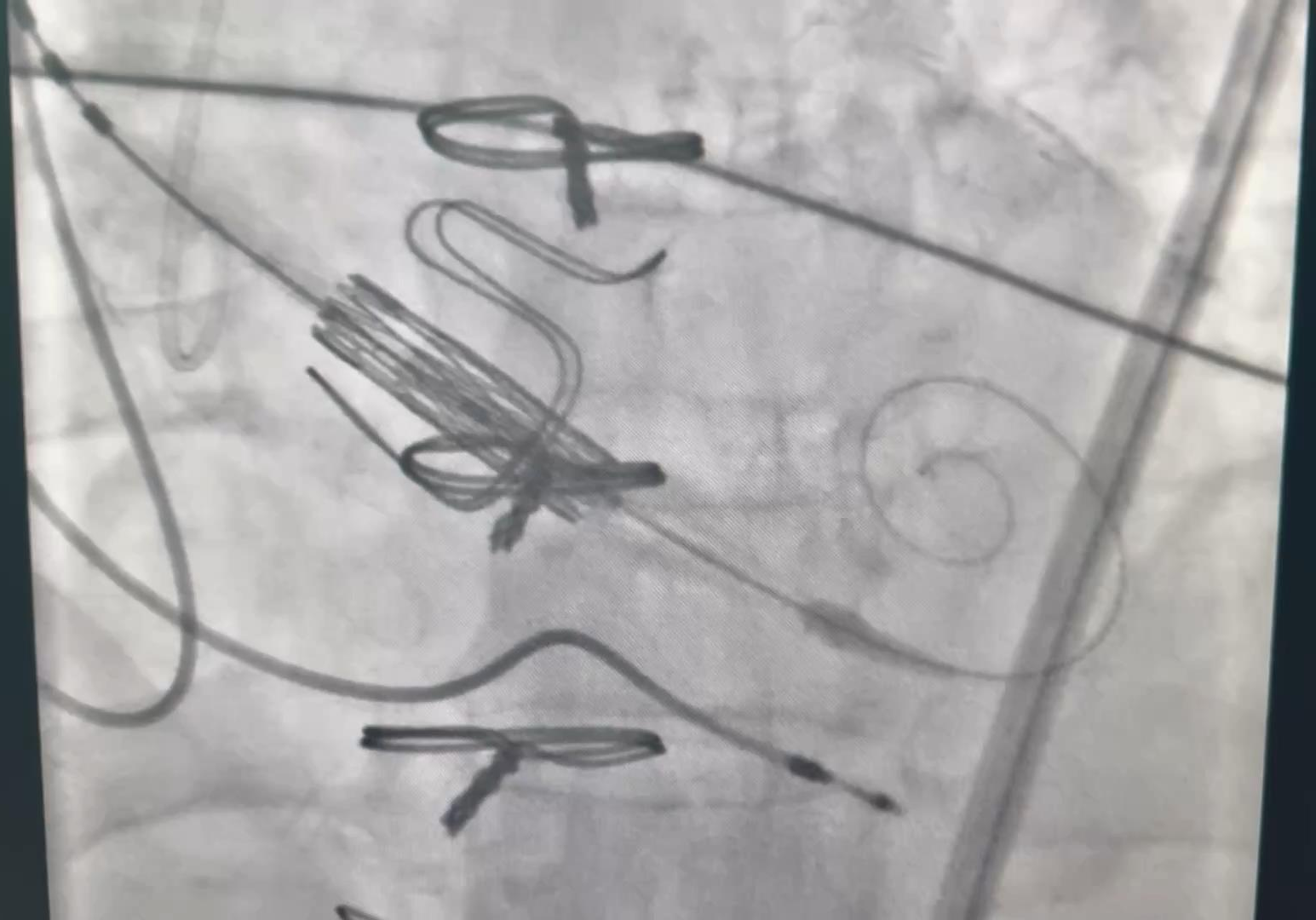
- 4699 Patients – 1775 Redo SAVR, 2924 ViV-TAVR over 10 year period
- ViV TAVR increased each year over the 10 year period
- 30 Day Mortality, PPM, Renal Failure, 30-Day Redmission – Worse in redo SAVR
- 5 Year Survival significantly better for Redo-SAVR (67.6% vs 54.9%)

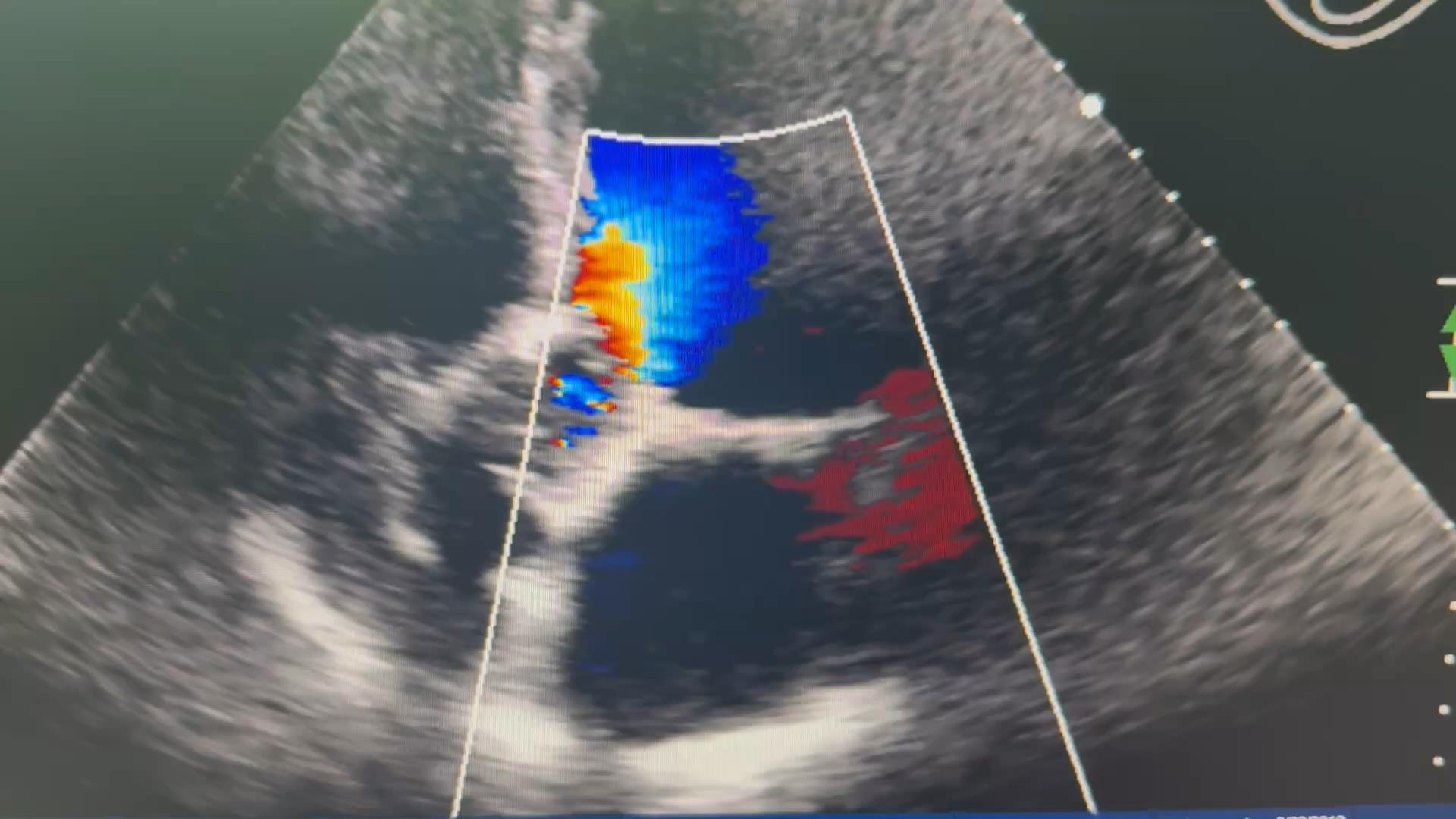
MK

- 81 yo M s/p AVR (Carpentier Edwards 31), CABGx4 - 2013
- Developed SOB, DOE in 2024
- TEE showed LVEF 55-60%, moderate central AI
- Cardiac MRI: Regurgitant Fraction 47% (Severe >50%)


5
X3
10

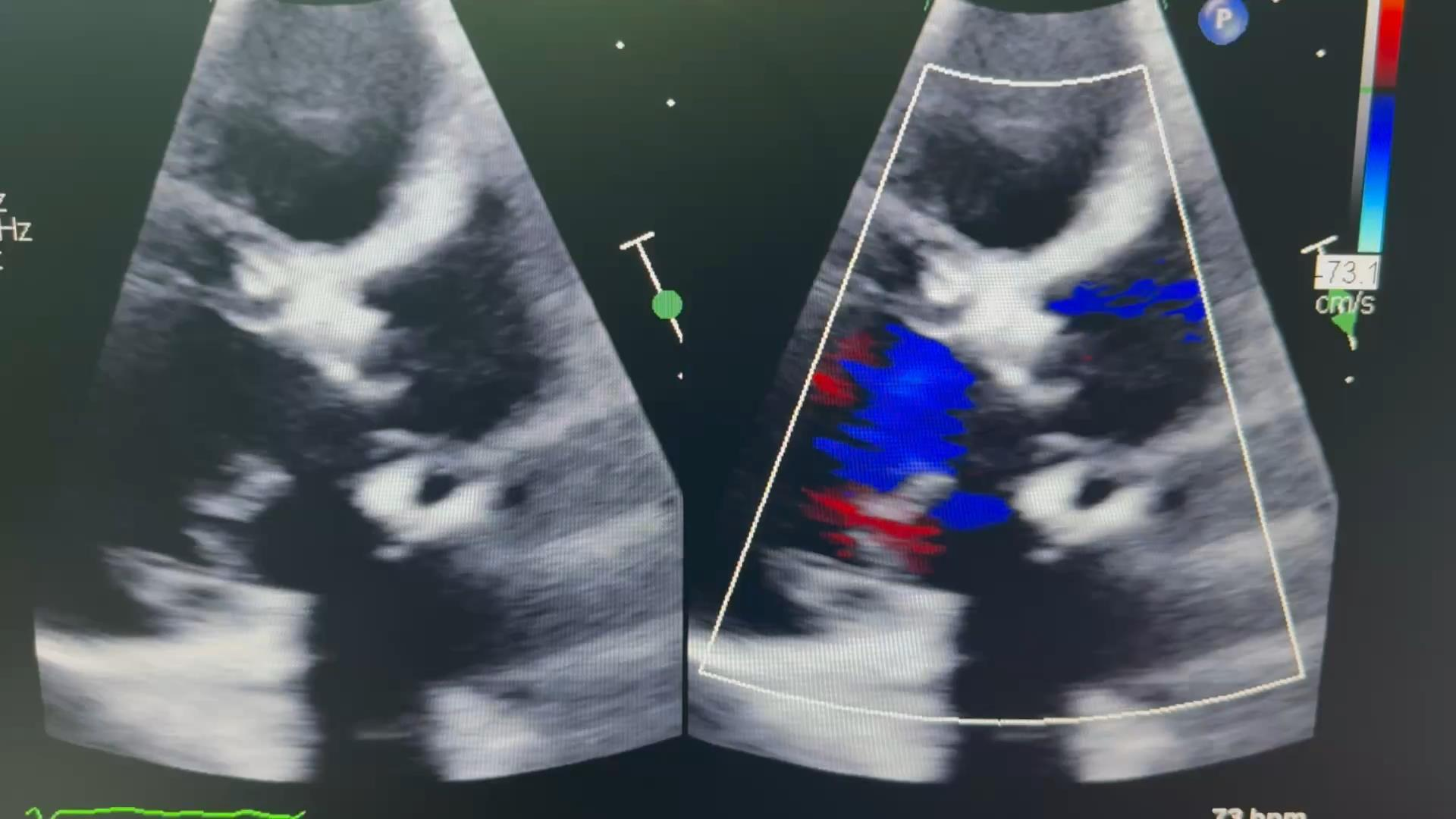
- Moderate to Severe symptomatic AI by Bioprosthetic Valve Failure
- Offered Valve in Valve TAVR
- TAVR CTA: 29mm Edwards Valve, 34mm Evolut FX+





PA

- 77 yo M s/p AVR (2007) – 27 mm Mosaic Valve
- Presented to clinic in 2024 – With in DOE, SOB
- AVA 0.7cm2, MG 37mmHg, Vmax 3.8m EF 65%
- Bioprosthetic Aortic Valve Failure secondary to stenosis
- Offered Explant vs Valve in Valve TAVR
- 26mm Medtronic Evolut FX+

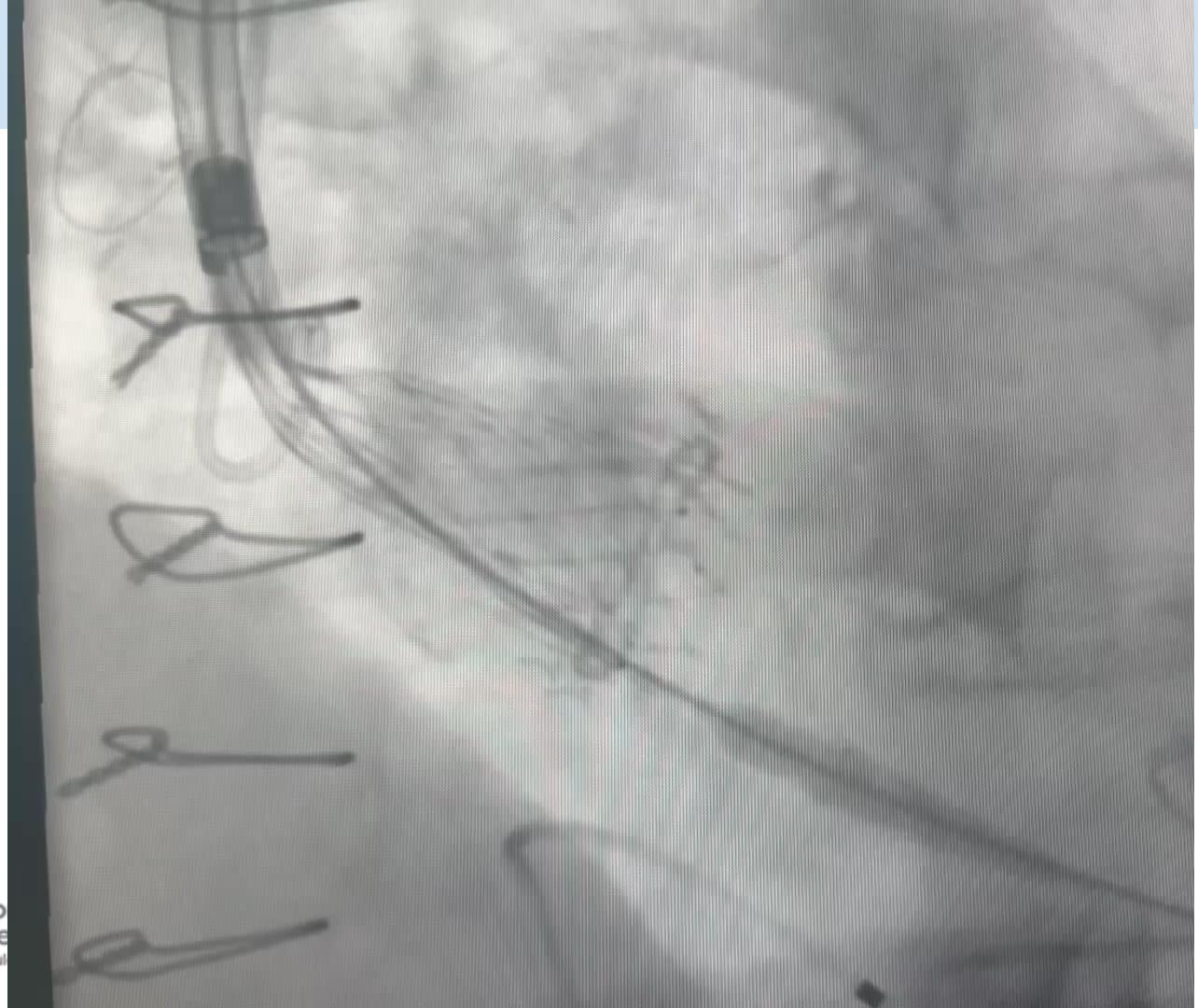

-73.1
cm/s


M1
G
R
2.6

RZ

- 81 yo M s/p AVR (21mm Trifecta) + CABG in 2018
- Multiple hospital admissions with SOB, newly reduced EF
- AVA 0.6, MG 40, Vmax 4.1, EF 35%, DI 0.16
- Recommended Valve in Valve TAVR


5
X2
10
15
R



RZ

- Improved lightheadedness, improved SOB
- Discharged shortly after procedure
- TTE Vmax 2.55, MG 16, DI 0.37

FINAL THOUGHTS

- The planning for Redo SAVR vs Valve In Valve begins with the Index Operation
- Redo-SAVR remains a good option for young and low risk patients
- VIV TAVR: CT Planning is crucial to avoid Coronary Obstruction and PPM
- The optimal repeat valve intervention can be patient dependent

WHAT IS NEXT

- Improved durability of BHV
- Alternatives to Sternotomy: Robotic AVR?
- Greater use of fracturable surgical valves?
- RCT VIV vs Re-do SAVR

Thank You

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Update: Aortic Valve Repair, Aneurysm Repair

Tim James MD
Franciscan Cardiothoracic Surgical Associates
St. Joseph Medical Center, Tacoma

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Disclosures

-Nonsalaried teaching role for national webinars on aortic ring use for CorCym company (honoraria).

-Nonsalaried consultant for Thoragenix (osteogenic bone matrix)

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Topics today:

Aortic valve disease: options for treatment

- AVR, TAVR
- Aortic Valve Repairs
  - Different historical techniques
  - Recent developments (Geometric ring, living tissue leaflet augmentation).

Aortic Aneurysm: Understanding risk

A couple technical developments: “Branch First” and approaches to arch in aneurysm and dissection.

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Aortic Valve Options

We all know aortic valve go bad, and when the valve goes bad, the heart eventually loses. About 20,000 surgical AVRs and 100,000 TAVRs are performed annually in the USA as a result:

Ann Cardiothorac Surg. 2025 Mar 12;14(2):151–153. doi: 10.21037/acs-2024-etavr-0136

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Aortic valve disease: the problem

We tend to practice as if aortic valve replacement is a great solution for a failing aortic valve.

But is it?

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Aortic Valve Replacement

All valve replacements have the effect of exchanging one disease for another(s)):

-STROKE

-INFECTION

-VALVE DEGENERATION (versus LIFE-LONG ANTICOAGULATION)

-WORSE OVERALL SURVIVAL

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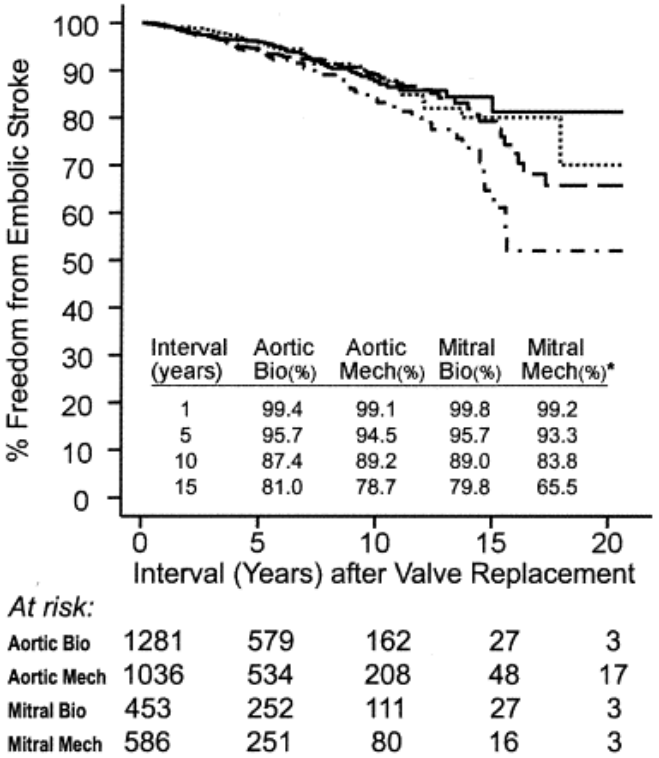
The Problem with AVR - Stroke

Ruel, M., et al. (2004). "Late incidence and determinants of stroke after aortic and mitral valve replacement". The Annals of Thoracic Surgery

10% Stroke rate by 10 years.



Interval (years)	Aortic Bio(%)	Aortic Mech(%)	Mitral Bio(%)	Mitral Mech(%)*
1	99.4	99.1	99.8	99.2
5	95.7	94.5	95.7	93.3
10	87.4	89.2	89.0	83.8
15	81.0	78.7	79.8	65.5

At risk:

Aortic Bio	1281	579	162	27	3
Aortic Mech	1036	534	208	48	17
Mitral Bio	453	252	111	27	3
Mitral Mech	586	251	80	16	3

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The Problem with AVR - Infection

At any given time, estimates of 20%+ of all endocarditis is in previously placed prosthetic valves.

The incidence of prosthetic valve endocarditis averages 1-4% in the first year after surgery, then around 1% per year thereafter.

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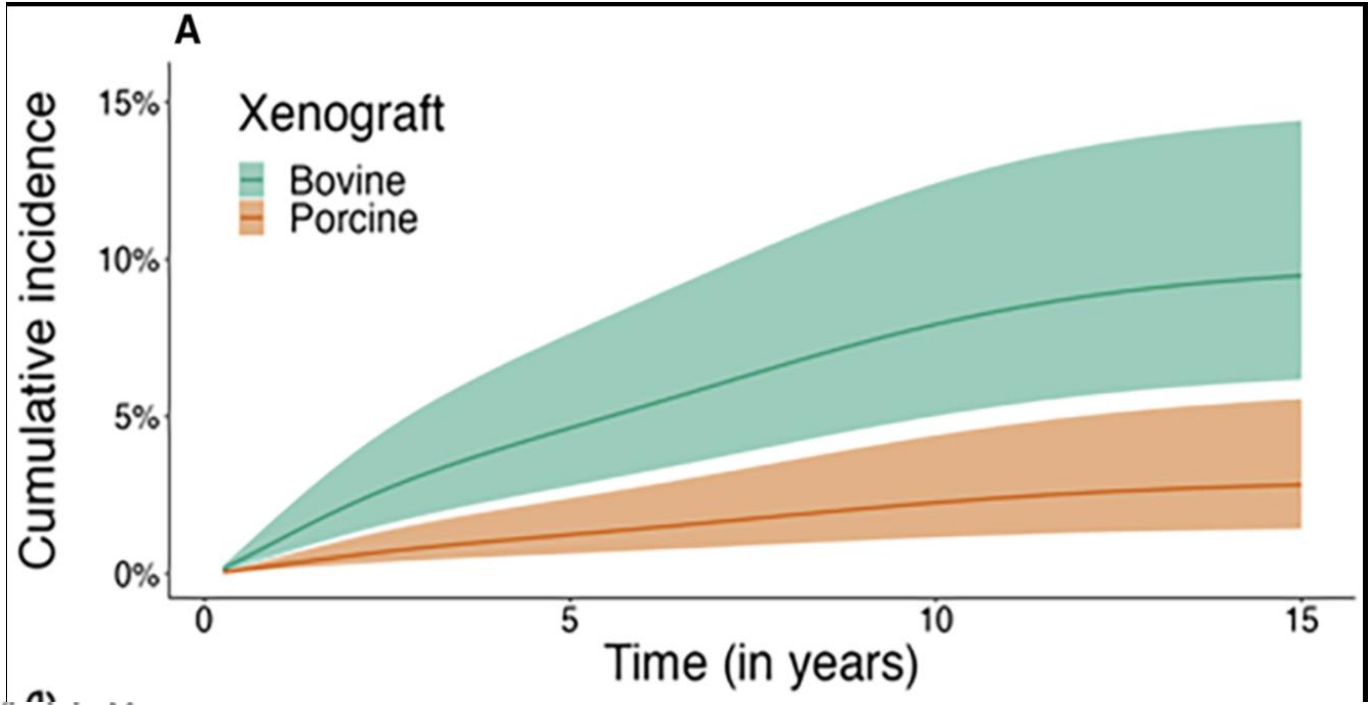
Infection Rates – Bioprosthetic Valves

J Am Heart Assoc. 2024;13:e031387. DOI: 10.1161/JAHA.123.031387



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The Problem with AVR: Structural Valve Deterioration

BMJ. 2016 Sep 29;354:i5065. doi: 10.1136/bmj.i5065

Prognosis after surgical replacement with a bioprosthetic aortic valve in patients with severe symptomatic aortic stenosis: systematic review of observational studies

Farid Foroutan [1,2,✉], Gordon H Guyatt [1], Kathleen O'Brien [2], Eva Bain [2], Madeleine Stein [2], Sai Bhagra [2], Daegan Sit [1], Rakhshan Kamran [1], Yaping Chang [1], Tahira Devji [1], Hassan Mir [1], Veena Manja [1,3,4], Toni Schofield [2], Reed A Siemieniuk [1,5], Thomas Agoritsas [1,6], Rodrigo Bagur [7], Catherine M Otto [8], Per O Vandvik [9,10]

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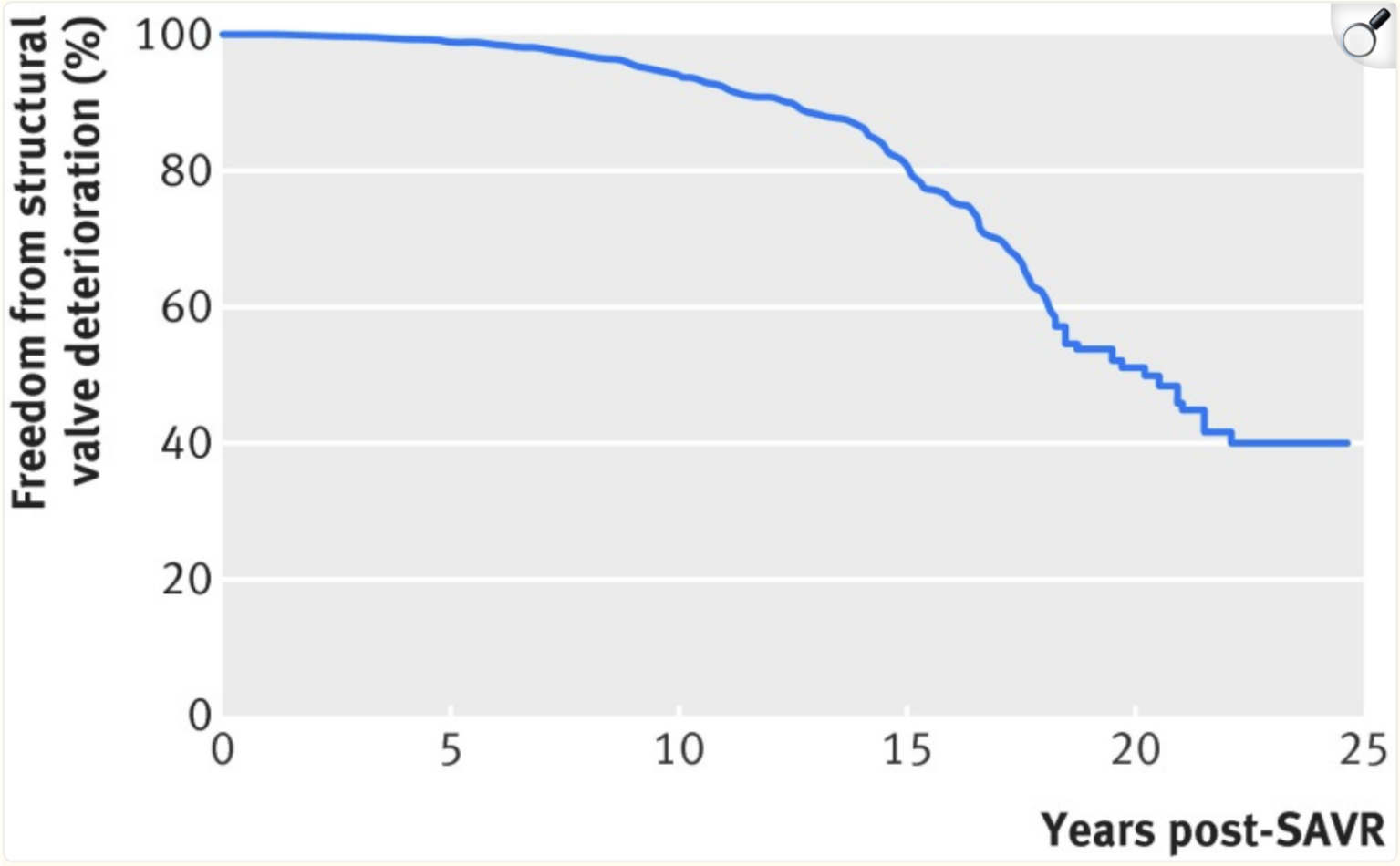
PMCID: PMC5040922 PMID: 27683072



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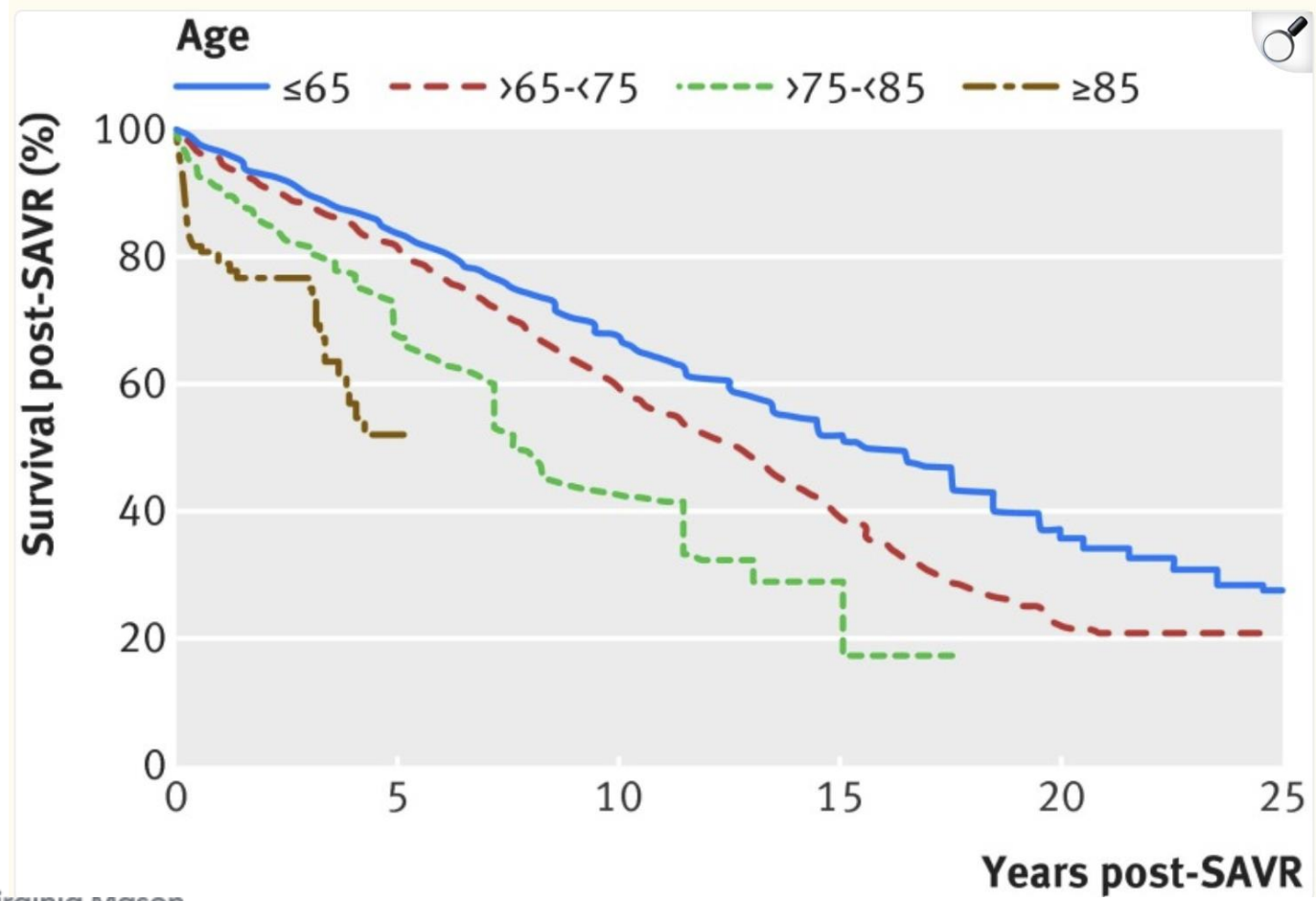
Survival after valve replacement

Surprisingly poor. These data for AVR (same BMJ review) parallel findings with mitral valve replacement.



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What about TAVR as primary herapy? Free Lunch??

Comparative Study > J Thorac Cardiovasc Surg. 2025 Mar;169(3):866-875.e6.
doi: 10.1016/j.jtcvs.2024.04.012. Epub 2024 Apr 28.

Surgical versus transcatheter aortic valve replacement in low-risk Medicare beneficiaries

J Hunter Mehaffey [1], Mohammad Kawsara [2], Vikrant Jagadeesan [2], J W Awori Hayanga [3], Dhaval Chauhan [3], Lawrence Wei [3], Christopher Mascio [3], J Scott Rankin [3], Ramesh Daggubati [2], Vinay Badhwar [3]

NEW long term TAVR data concerning (currently only AS, AR is coming)

Results: A total of 15,749 low-risk patients (8144 SAVR and 7605 TAVR) were identified. Comparison was performed with doubly robust risk adjustment accounting for all factors. TAVR was associated with lower perioperative stroke (odds ratio, 0.62; P < .001) and hospital mortality (odds ratio, 0.16; P < .001) compared with SAVR. However, risk-adjusted longitudinal analysis demonstrated TAVR was associated with higher late risk of stroke (hazard ratio, 1.65; P < .001), readmission for valve reintervention (hazard ratio, 1.88; P < .001), and all-cause mortality (hazard ratio, 1.54; P < .001) compared with SAVR.

Conclusions: Among low-risk Medicare beneficiaries younger than age 75 years undergoing isolated AVR, SAVR was associated with higher index morbidity and mortality but improved 3-year risk-adjusted stroke, valve reintervention, and survival compared with TAVR.

AFTER THREE YEARS, PRIMARY SAVR SURPASSES TAVR FOR AVOIDANCE OF DEATH, STROKE, AND VALVE REINTERVENTION. NO FREE LUNCH.

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Or TAVR following initial bio-AVR

What about the increasingly popular concept of

“tissue valve now, especially in young healthy patients, and TAVR later when the bio-SAVR fails”?

Is this a good option?

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NEW data, TAVR of Failing Bioprosthetic Valves is concerning

VALVE | RESEARCH · Volume 120, Issue 2, P335-344, August 2025

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Redo Surgical Aortic Valve Replacement vs Valve-in-Valve Transcatheter Aortic Valve Replacement for Degenerated Bioprosthetic Valves

Jake Awtry, MD, MA [1,2] · Thais Faggion Vinholo, MD, MSc [1,2] · Mansoo Cho, MS [2] · Philip Allen, MD [1]
Robert Semco, BSE [3] · Sameer Hirji, MD, MPH [1] · Siobhan McGurk, BS [1] · Paige Newell, MD [1] ·
Tanujit Dey, PhD [2] · Mark J. Cunningham, MD [4] · Ashraf Sabe, MD [1] · Kim I. de la Cruz, MD [5] Show less

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2 Department of Surgery, Center for Surgery and Public Health, Brigham and Women's Hospital, Boston, Massachusetts
3 Harvard Medical School, Boston, Massachusetts
4 Division of Cardiac Surgery, Rhode Island Hospital, Providence, Rhode Island
5 Division of Cardiothoracic Surgery, University of Virginia Health University Hospital, Charlottesville, Virginia

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What about VIV TAVR? Despite 10% surgical mortality, within 3 years redo-SAVR outperforms VIV TAVR, 62% vs 47% survival with better major valve event-free rates.

Results: Overall, 4699 patients, including 1775 redo-SAVR and 2924 ViV-TAVR patients, were identified. Redo-SAVR patients were younger (median [interquartile range], 72 [68-77] years vs 79 [73-84] years) with less congestive heart failure (39.6% vs 68.8%) and prior coronary artery bypass grafting (17.9% vs 32.0%; all P < .05). In the propensity score-matched cohorts of 1256 patients each, redo-SAVR had higher major adverse cardiovascular events (17.4% vs 13.1%; P = .003) but better major valve event-free (71 [62-79] months vs 43 [38-47] months; P < .001) and 5 year (62.3% vs 46.7%; P < .001) survival. After stratification by Charlson comorbidity index, the long-term survival benefit persisted in patients of lower (67.6% vs 54.9%; P = .001) and medium o higher risk (55.1% vs 36.7%; P < .001).

Conclusions: Redo-SAVR may have better long-term survival than ViV-TAVR despite greater perioperative morbidity. Clinical trial data are needed to fully inform clinical decision-making abou degenerated bioprosthetic valve reintervention, particularly for patients with reasonable life expectancy.

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What causes longer term liability in TAVR?

We are not sure. However, there is a similar experience in the vascular surgery literature where CAROTID STENTING (leaving a metal stent upstream of the brain) has LONG TERM deleterious effects – 2.5x higher risk of stroke and death after 10 years.

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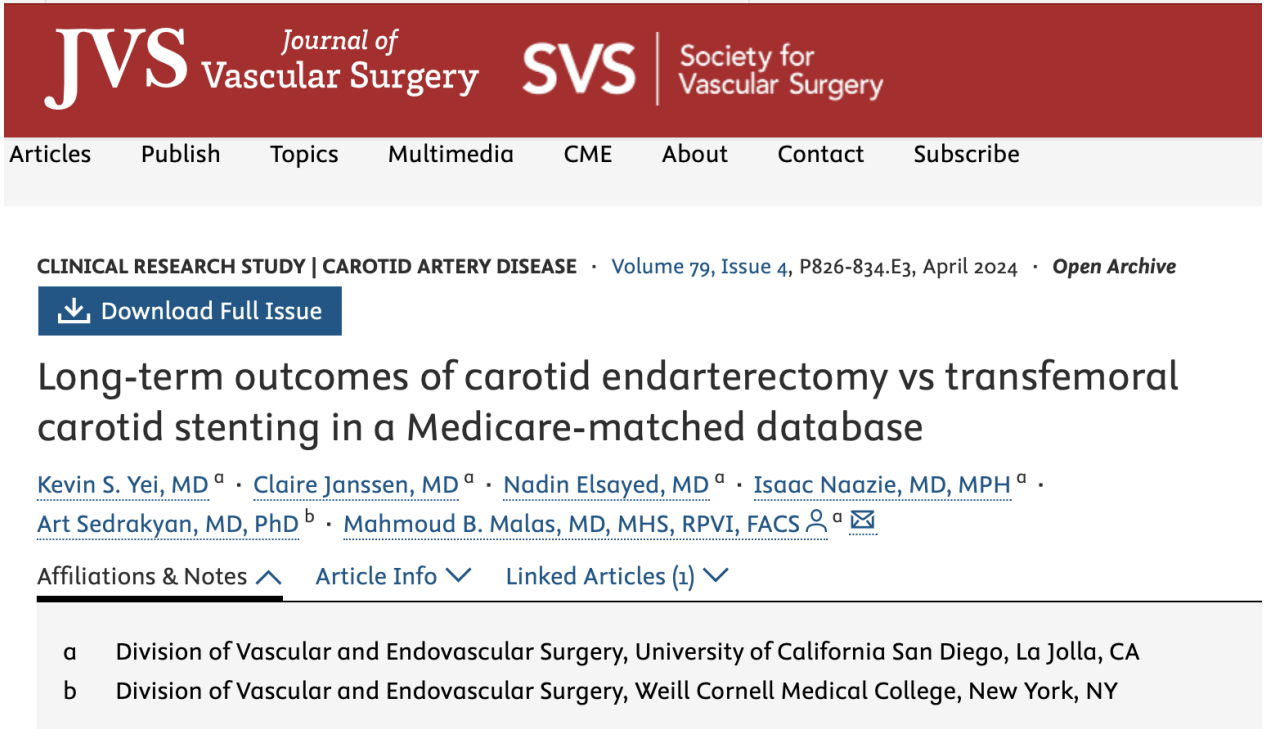
CEA versus Stenting Carotid Artery: 2.5x Higher Stroke/Death at 10 Years. Foreign Material upstream of the Brain Not Good.



JVS Journal of Vascular Surgery | SVS Society for Vascular Surgery

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CLINICAL RESEARCH STUDY | CAROTID ARTERY DISEASE · Volume 79, Issue 4, P826-834.E3, April 2024 · *Open Archive*

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Long-term outcomes of carotid endarterectomy vs transfemoral carotid stenting in a Medicare-matched database

Kevin S. Yei, MD [a] · Claire Janssen, MD [a] · Nadin Elsayed, MD [a] · Isaac Naazie, MD, MPH [a] · Art Sedrakyan, MD, PhD [b] · Mahmoud B. Malas, MD, MHS, RPVI, FACS [a]

Affiliations & Notes · Article Info · Linked Articles (1)

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Summary: A prosthetic valve, SAVR or TAVR, has substantial long term risks. CONCEPT: A bunch of artificial nonliving material upstream of the brain sending junk downstream is not ideal!

Thus, **in the first 10 years after bioprosthetic AVR, patients are exposed to a cumulative risk of stroke, infection, or valve degeneration of somewhere between 20-30%, and even in patients under 65, a cumulative mortality risk of over 30%**

Risks are similar for mechanical valve replacements overall.

Bioengineered materials are conceptually attractive, but the reality is highly complex, and nothing is on the horizon is anywhere close to being a reality.

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Summary – Aortic Valve Replacement

AVR is an improvement over the natural history of severe AR or AS, but analogous to MVR, has the effect of substituting one disease for another.

Despite an initial advantage for survival with TAVR, longer term results demonstrate ominous longer term results and benefit from SAVR.

Analogous to Carotid Stenting versus CEA results.

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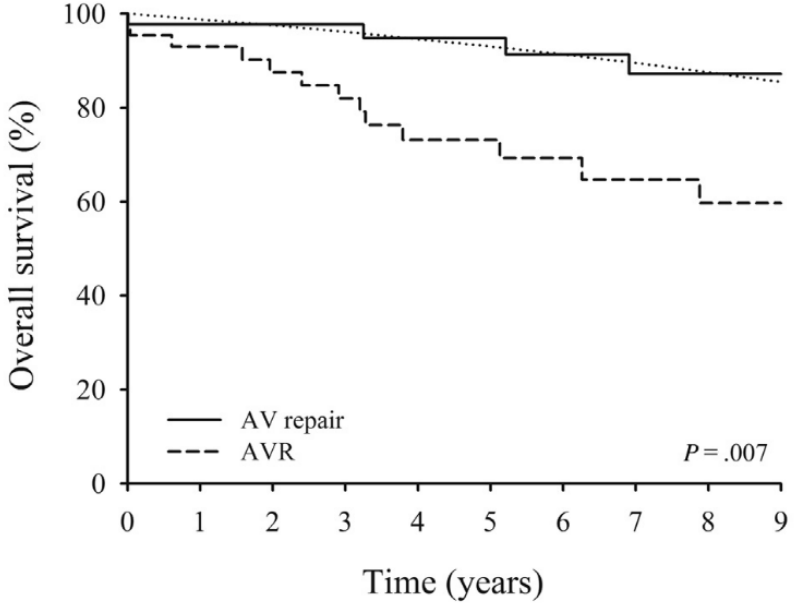
Outcomes are Better with Aortic Valve Repair

Valve repair improves the outcome of surgery for chronic severe aortic regurgitation: A propensity score analysis



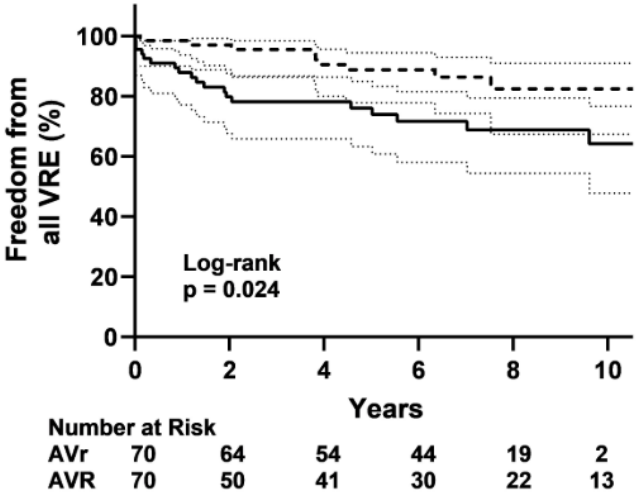
AV repair	44	41	39	35	31	28	26	22	17	13
AVR	44	38	33	30	24	20	17	15	13	11

ORIGINAL ARTICLE | ARTICLES IN PRESS
PDF [2 MB]

Aortic valve repair decreases risks of VRE in AI at 10 years: a propensity score-matched analysis

Habib Jabagi, MD MSc, FRCSC • Vincent Chan, MD MPH • Marc Ruel, MD MPH • Thierry G. Mesana, MD PhD • Munir Boodhwani, MD MSc

Kaplan-Meier curve: 10-year freedom from primary outcome



Outcomes better with repair

While stroke and infection may occur following aortic valve repair, overall risks appear to be reduced by 80-90%.

Mortality following AV repair is reduced by 50% in the first year alone (German Aortic Valve Registry)

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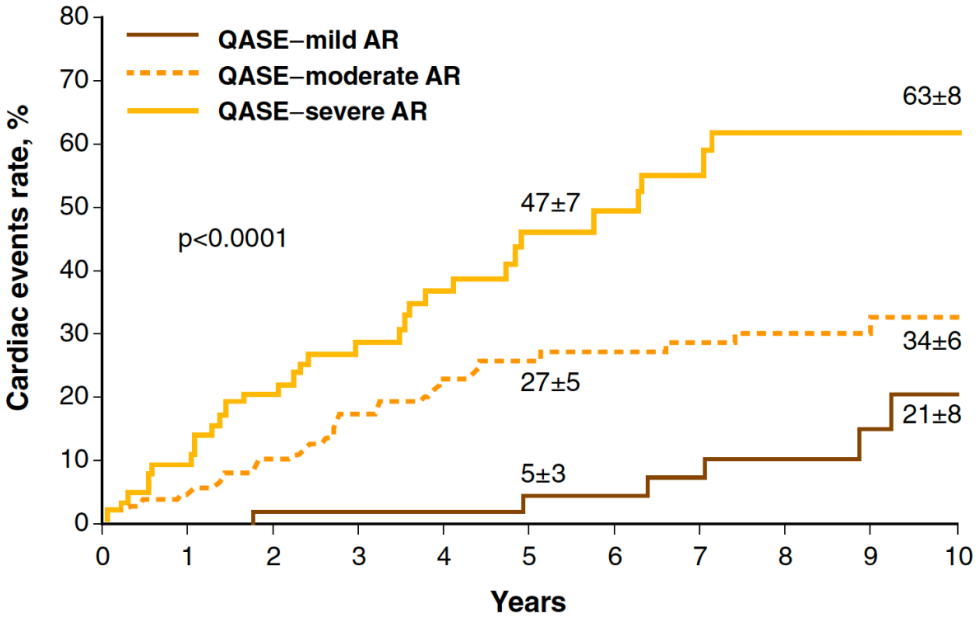
Should we consider earlier intervention due to poor long-term prognosis for asymptomatic severe and moderate AR?

Cardiac Events Rate

Under Conservative Management After Diagnosis of Asymptomatic AR



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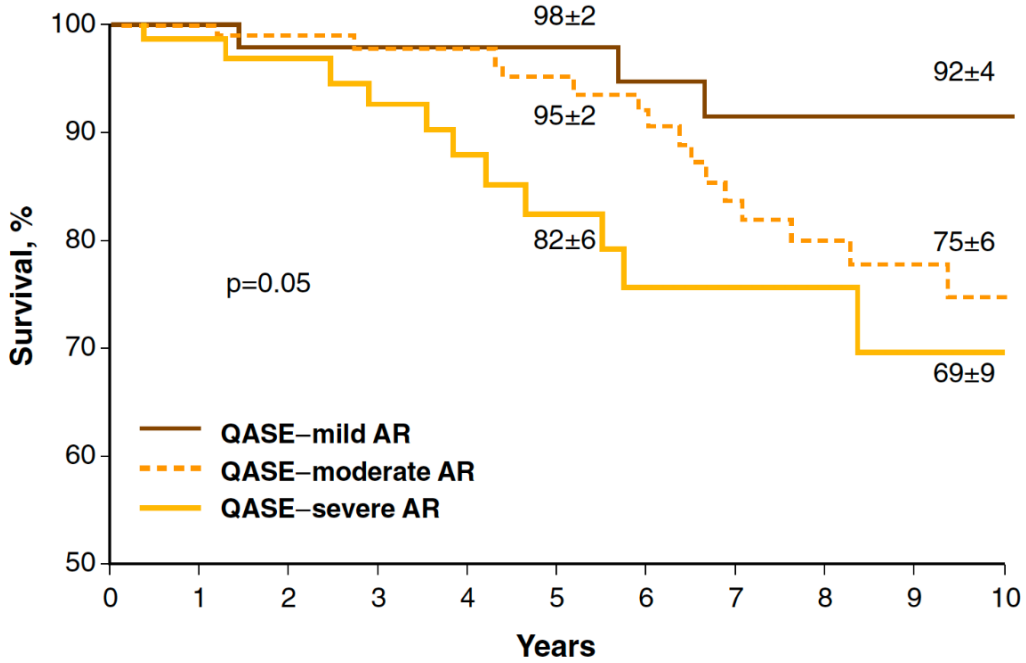
Detaint, D., et al. (2008). "Quantitative echocardiographic determinants of clinical outcome in asymptomatic patients with aortic regurgitation: a prospective study." JACC Cardiovasc Imaging **1**(1): 1-11.

Should we consider earlier intervention due to poor long-term prognosis for asymptomatic severe and moderate AR

Survival Rate

Under Conservative Management After Diagnosis of Asymptomatic AR



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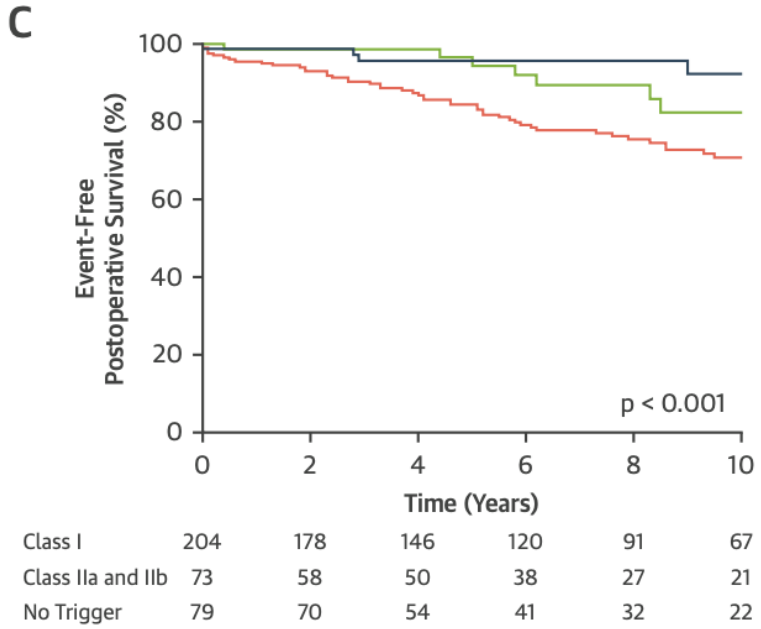
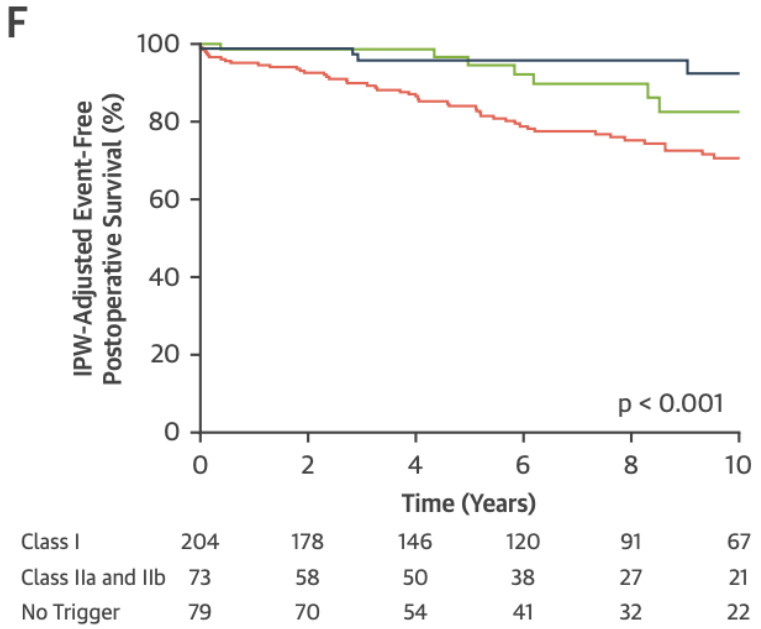
Detaint, D., et al. (2008). "Quantitative echocardiographic determinants of clinical outcome in asymptomatic patients with aortic regurgitation: a prospective study." JACC Cardiovasc Imaging **1**(1): 1-11.

Improved Long-term Outcomes associated with Early Intervention BEFORE guideline triggered interventions





Class I Class IIa and IIb No Trigger

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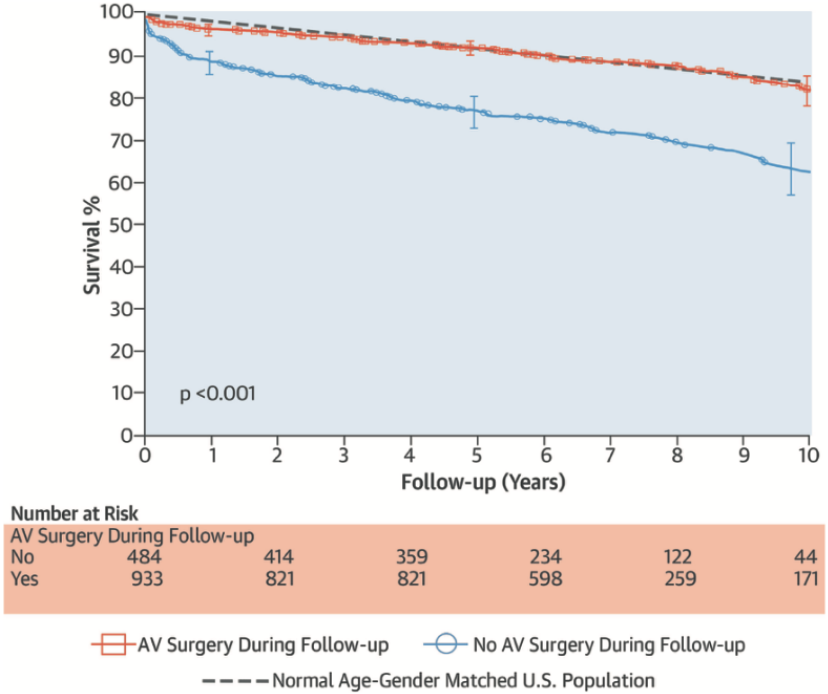
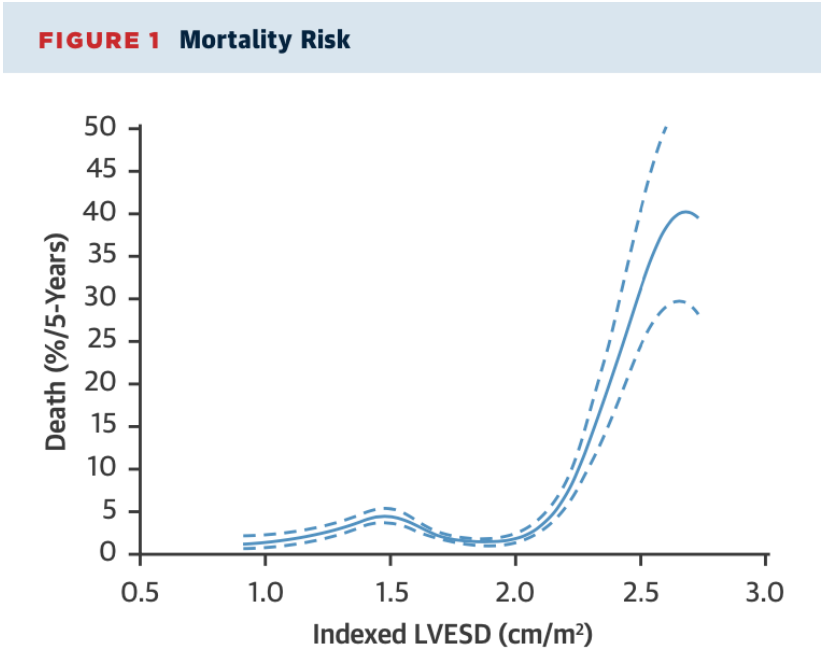
de Meester, C., et al. (2019). "Do Guideline-Based Indications Result in an Outcome Penalty for Patients With Severe Aortic Regurgitation?" JACC Cardiovasc Imaging.

Cleveland Clinic Experience – LVESDi vs Mortality Risk (Guidelines suggest an Indexed LVESDi 2.5cm/m2 trigger)

Survival: AV Surgery vs. No AV Surgery



LVESDi and Mortality Risk



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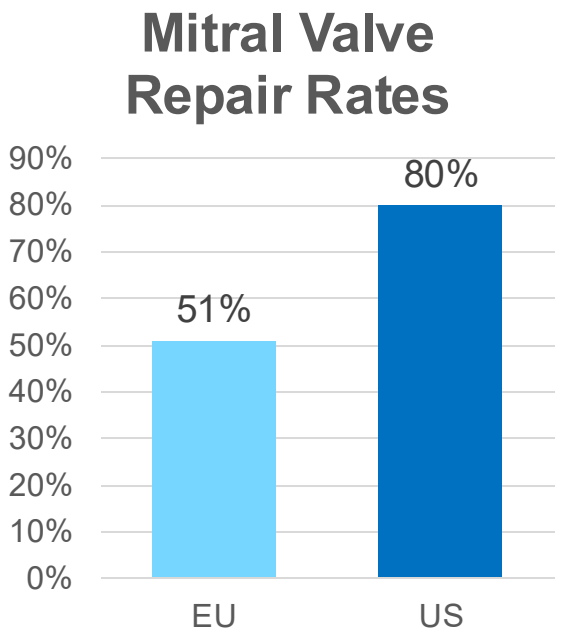
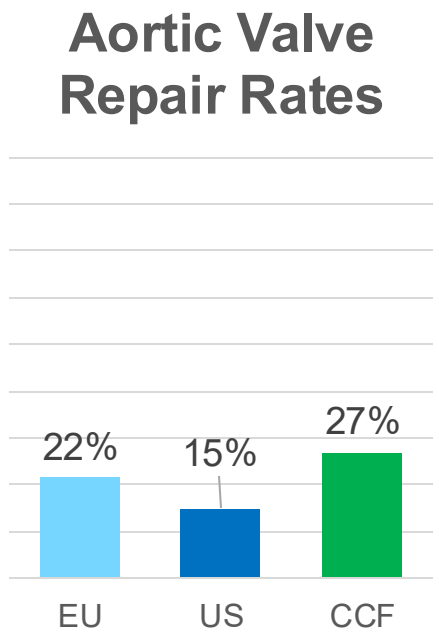
Mentias, A., et al. (2016). "Long-Term Outcomes in Patients With Aortic Regurgitation and Preserved Left Ventricular Ejection Fraction." J Am Coll Cardiol **68**(20): 2144-2153.

Current State: Underutilization of Aortic Valve Repair for AR





CCF Aortic Valve Surgery for Aortic Insufficiency 2003-2015

RESULTS

TOTAL STUDY SAMPLE. Baseline clinical and TTE data from the entire study sample (n = 865) are shown in Table 1. By study design, all patients had a preserved LVEF ≥50% and ≥3+ AR at baseline,

AV surgery was 38 days (IQR: 3 to 105 days). A total of 632 patients underwent AV replacement (492 had bioprosthetic replacements, 102 had mechanical =-replacements, and 38 had homografts), whereas 233 patients had AV repair. There were 309 patients who underwent minimally invasive isolated AV surgeries (101 had isolated AV repair, and 208 had AV replacement). Concomitantly, there were a total of 526 aortic surgeries (77 valve sparing aortic root replacements, 47 aortoplasties, 20 composite grafts, and 382 supracoronary grafts).

233/865 (27%) AI Patients had Aortic Valve Repair

1. Rankin JS, et al. The Impact of Mitral Disease Etiology on Operative Mortality After Mitral Valve Operations. Ann Thorac Surg. 2018;106(5):1406-1413.
2. Iung et al. Circulation. 2019 Sep 12. doi: 10.1161/CIRCULATIONAHA.119.041080
3. Bavaria J. Review of valve repair for aortic insufficiency worldwide. STS 56th Annual Meeting.
4. Alashi et al. JACC Cardiovasc Imaging. 2020 Jan;13(1 Pt 1):12-21.

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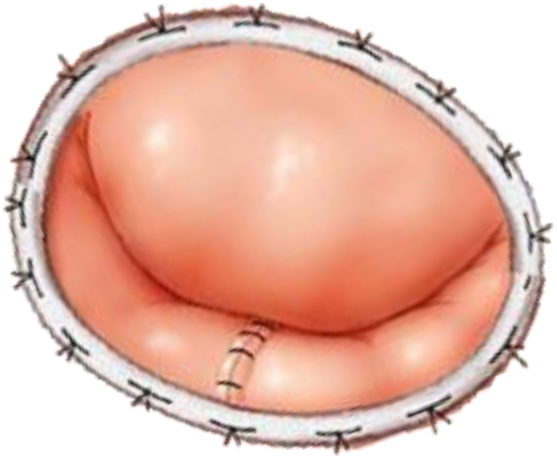
Mitral: Valve Repair Is Superior to Replacement

Mitral Valve Repair =
Ring Annuloplasty +
Leaflet Reconstruction



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Mitral: Valve Repair Is Superior to Replacement

- Repair is gold standard for mitral disease
  - Lower operative mortality
  - Improved long-term heart function & survival
  - No need for lifelong anticoagulation
  - Fewer reoperations
- Mitral valve repaired in 50-70% of cases

Aortic valve repair – What does the mitral valve teach us?

1. Steps to repair a mitral valve:
    1. Get the annulus right. Use a **RING** (Carpentier). Prior to the ring, every other option was tried and failed.
    2. Get the leaflets right – restore **coaptation LENGTH** where leaflets meet and seal.
    3. Get the chords right– restore **leaflet position** (artificial chordal replacement per Frater, Rankin, others).

    .

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Aortic valve repair: Lessons from the Mitral

As written by Alain Carpentier:

Prosthetic rings of a suitable shape and size are necessary to perform a measured annuloplasty which will [reproducibly] restore the normal [geometric] contour—and thereby both a normal orifice area and optimum function of the valve.

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My Version:

A valve repair without a ring is like a house without a foundation.

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Aortic valve repair – Current State

When do aortic valves get repaired?

Rarely. Perhaps 15% in US (but at most institutions, zero).

Are regurgitant or stenotic valves repaired, or both?

Aortic regurgitation only, never repair of aortic stenosis.

Why is this? We have previously lacked the tools to repair.

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Current approaches to aortic valve repair

Schafer's techniques include leaflet modification (cleft closure, leaflet plication), rare leaflet augmentation with fixed tissue, and suture annuloplasty.

David IV procedure: reimplants the valve in a dacron tube graft. An operation designed for root aneurysm. If root dilatation is the cause of AR, this may fix it, but there is no systematic approach to defective leaflets. Results for bicuspid valves, for example, are inferior. Requires deep root dissection.

Aortic valve repair – David for Bicuspid? No answer for leaflet issues.

David V reimplantation can be performed for bicuspid valves – but despite highly selective series, BAV doubles the risk for reintervention.

BAV have highly variable anatomy, variable annular height and area distribution of fused versus reference leaflets, and frequent calcification and leaflet abnormalities, all of which can disqualify a valve for repair.

Leaving the OR with Mild/moderate AR increases the hazard ratio for intervention to close to 6.

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TABLE 2. Fine and Gray subdistribution multivariable hazard model for AV reintervention for aortic insufficiency

	Multivariable			
AV reintervention for AI	Hazard ratio	95% CI	95% CI	*P*
Age, y	0.94	0.93	0.95	<.001
Bicuspid AV	2.18	0.88	5.41	.09
Postrepair AI degree (TEE)				
None/trace	Reference			
Mild/moderate	5.73	3.70	8.89	<.001

AV, Aortic valve; *AI*, aortic insufficiency; *CI*, confidence interval; *TEE*, transesophageal echocardiogram.

Reintervention after valve-sparing aortic root replacement: A comprehensive analysis of 781 David V procedures

Sameer K. Singh, MD,[a] Dov Levine, MD,[a] Parth Patel, MD,[b] Elizabeth Norton, MD,[b] Chunhui Wang, MD, MPH,[a] Paul Kurlansky, MD,[a] Patra Childress, MD,[a] Megan Chung, BA,[a] Oreoluwa Olakunle, BSc,[b] Isaac George, MD,[a] Bradley Leshnower, MD,[b] Edward P. Chen, MD,[c] Hiroo Takayama, MD, PhD[a]

Current approaches to aortic valve repair

Yacoub operation: “remodelling” procedure that replaces sinuses of Valsalva with graft tongues. Another root repair operation that has no systematic approach to leaflet disease, and no answer for the annulus.

Ross procedure: Auto-transplants the pulmonic valve into the LVOT and substitutes a homograft for the RVOT. Suffers from autograft enlargement and late AR, homograft failure. Working on external support for the autograft. No good answers for homograft failure. Use with caution in the presence of aneurysm disease/root enlargement.

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Approaches to aortic valve repair: Lansac

Masters of Cardiothoracic Surgery

Valve sparing root replacement: the remodeling technique with external ring annuloplasty

Emmanuel Lansac[1], Isabelle Di Centa[2], Jan Vojacek[3], Jan Nijs[4], Jaroslav Hlubocky[5], Gianclaudio Mecozzi[6], Mathieu Debauchez[7]

[1]Institut Mutualiste Montsouris, Paris, France;[2]Hôpital Foch, Suresnes, France;[3]University Hospital Hradec Kralove, Hradec Kralove, Czech Republic;[4]UZB, Brussels, Belgium;[5]General University Hospital, Prague, Czech Republic;[6]Thorax Centrum Twente, Enschede, The Netherlands;[7]Institut Mutualiste Montsouris, Paris, France

Corresponding to: Dr Emmanuel Lansac. Institut Mutualiste Montsouris, Paris, France. Email: emmanuel.lansac@imm.fr .

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doi: 10.3978/j.issn.2225-319X.2013.01.15

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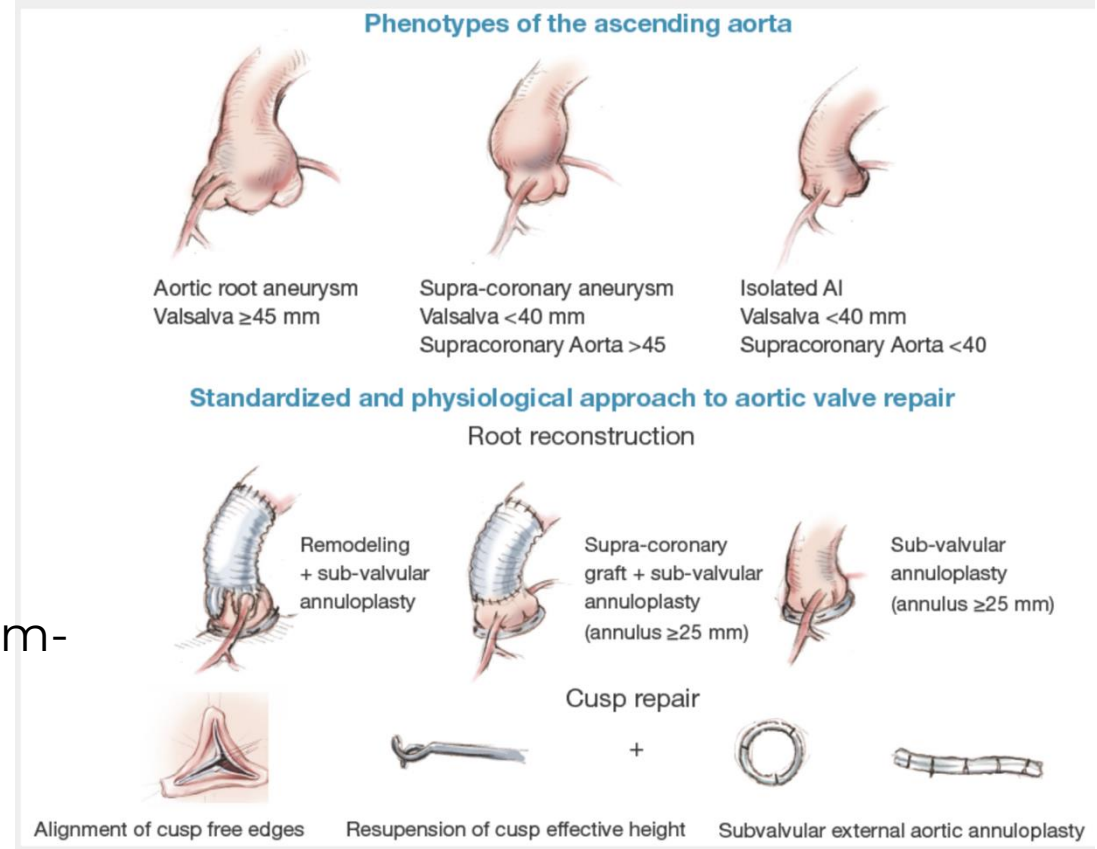
Current approaches to aortic valve repair

Opinion:

Dr. Lansac on the right track, but annuloplasty insufficient with soft ring in the upper LVOT. Coroneo ring available in Europe, not USA. No system-atic approach to leaflets.



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Aortic valve repair – what would be the aortic equivalent of a proper mitral repair?

1. **Get the annulus right** - Until recently, there was no prosthetic aortic ring, and the normal diastolic conformation of the aortic annulus was unrecognized, thus there was no way to establish normal annular anatomy.

2. **Get the leaflets right** - There is a paucity of tissue available in the aortic valve leaflets, resection is usually not an option, use of nonliving tissue associated with repair failure.

3. **Get the cords right** - The aortic equivalent of cords in the mitral is the shape of the aortic root and the structure of the leaflets which define how the leaflets coapt.

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Aortic valve repair

To properly repair any cardiac valve we have to start with an understanding of the ANNULUS.

What is the shape of the aortic annulus?

The answer was not discovered until 2013.

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This paper for the first time allowed an understanding of the diastolic conformation of the aortic valve.

A refined hemispheric model of normal human aortic valve and root geometry

J. Scott Rankin, MD,[a] M. Crockett Bone, BS,[a] Peter M. Fries, MD,[b] Diana Aicher, MD,[b] Hans-Joachim Schäfers, MD,[b] and Philip S. Crooke, PhD[a]

Conclusions: The normal human aortic valve is an elliptical structure, and ellipsoidal refinements improve representation of leaflet geometry. The left and noncoronary cusps commissure is located posteriorly; the right coronary cusp is located anteriorly. This model could be useful in quantifying pathologic geometry and in engineering devices for aortic valve reconstruction. (J Thorac Cardiovasc Surg 2013;146:103-8)

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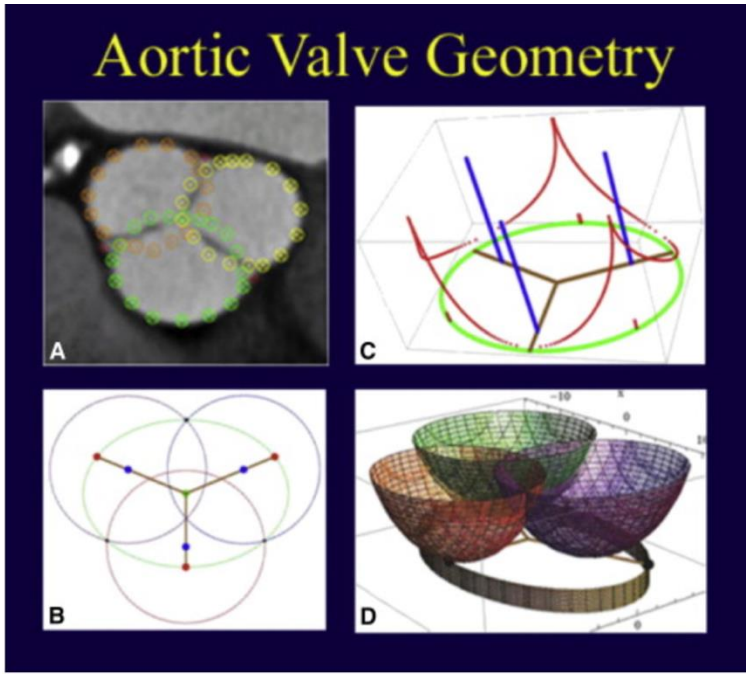
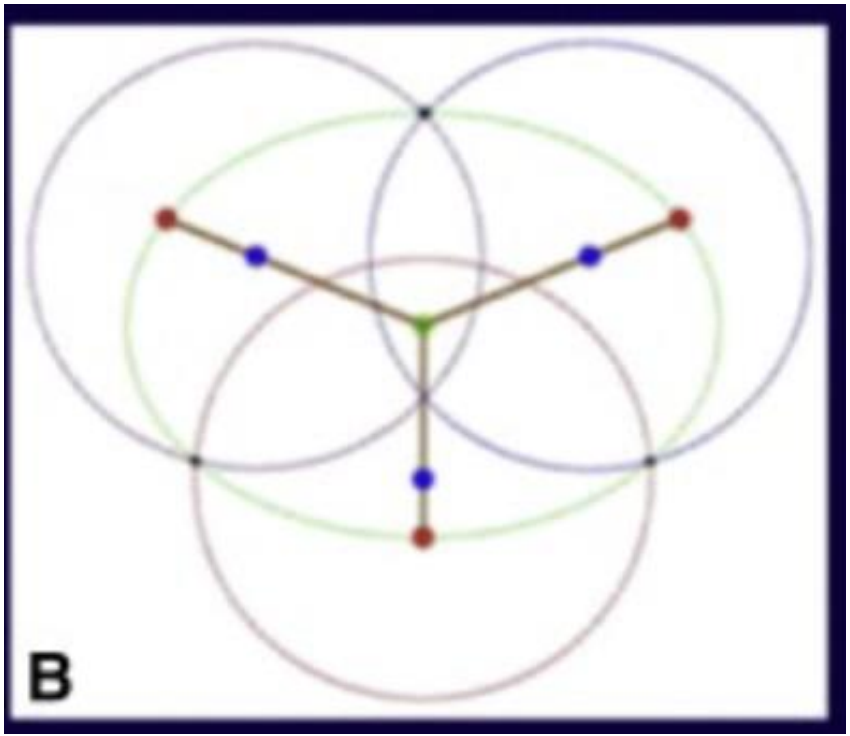
Aortic valve repair – the annulus is an ellipse with a 2:3 ratio in diastole.





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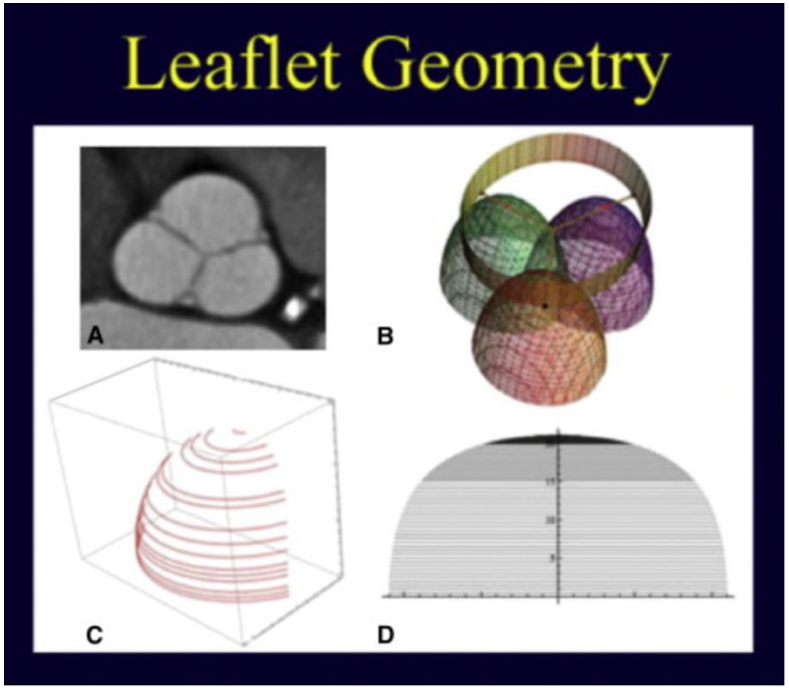
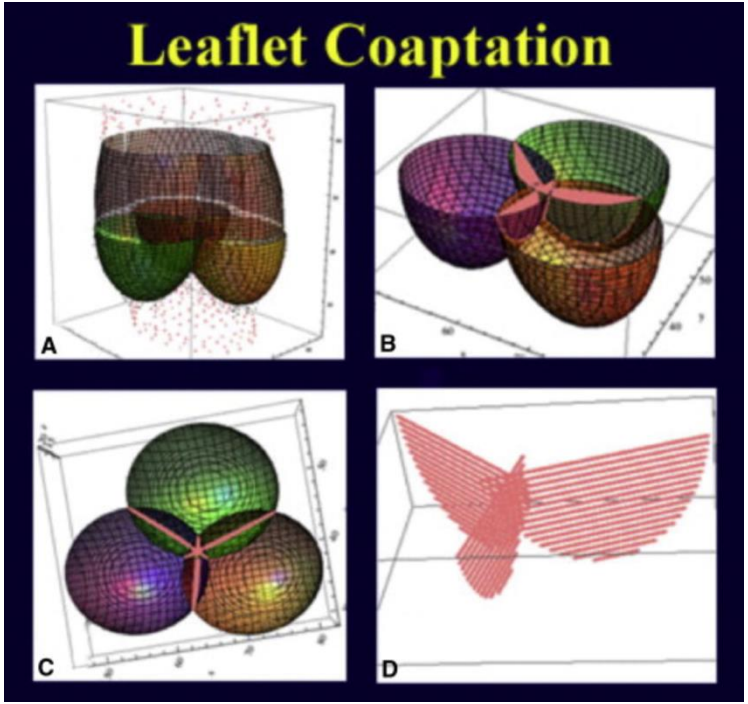
Aortic valve repair – leaflet shape mapped.

Leaflet free edge length = 1.5 x diameter of a circle with corresponding circumference of the annular ellipse.





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Aortic valve repair: NEW LAWS

For trileaflet valves the closed valve annulus is an ellipse

For bicuspid valves optimum annular shape is a circle.

In either case, the leaflet free-edge length has a relationship with the circumference of the ellipse or circle.

FEL= annular circumference/2

Alternatively, FEL=annular diameter x 1.5

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Aortic valve repair principles

Therefore, by measuring the normal leaflet free edge lengths, you can instantly back-calculate the proper corresponding size of the annulus that will provide the leaflets with the proper foundation for coaptation.

This was never before possible in cardiac surgery.

(In trileaflet valves we measure all three and tend to the smaller; in bicuspids, we measure the reference leaflet).

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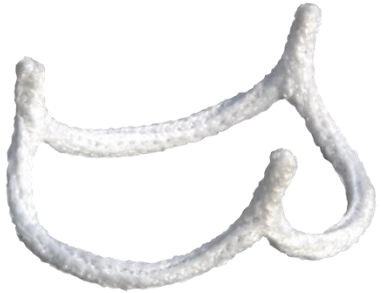
Rigid subannular geometric rings approved in Europe 2016, 2021. Both rings approved by the FDA in 2017.

Aortic Annular Ring



- Trileaflet (ELLIPTICAL) & Bicuspid (CIRCULAR) Annuloplasty devices for aortic valve repair, SIZING BASED ON LEAFLET FREE EDGE LENGTH.
- Implants restore & maintain valve shape to allow proper valve closure
- Instruments and techniques facilitate sizing and simplify leaflet reconstruction
- Principles: measure leaflets and size annulus appropriately, place ring, then modify leaflets using standard techniques to fine tune function and eliminate insufficiency

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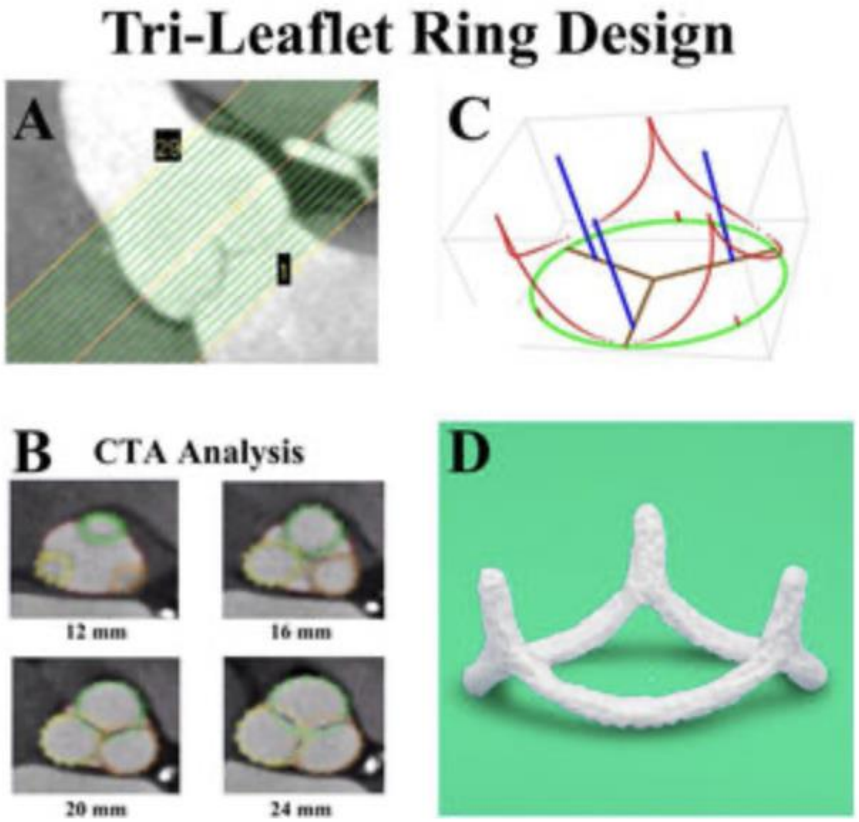
The trileaflet ring is elliptical, matching the native conformation of the aortic valve in diastole. Posts reflect actual angles of subcomissural triangles.

Going from a circle to a 2:3 ellipse keeping the same circumference causes a minimal change in surface area (6%).



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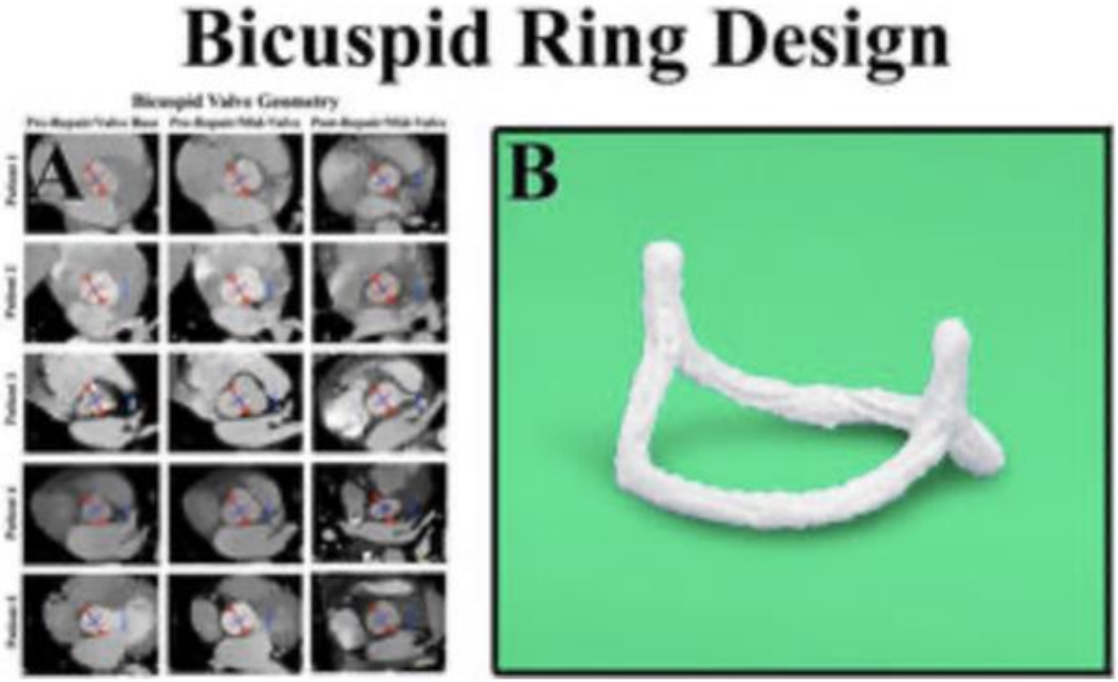
The bicuspid ring is circular and designed to correct bicuspid valve anatomy to a 180 degree orientation, long known to be the best for bicuspid geometry and long term function. This is the goal for essentially all bicuspid repairs.



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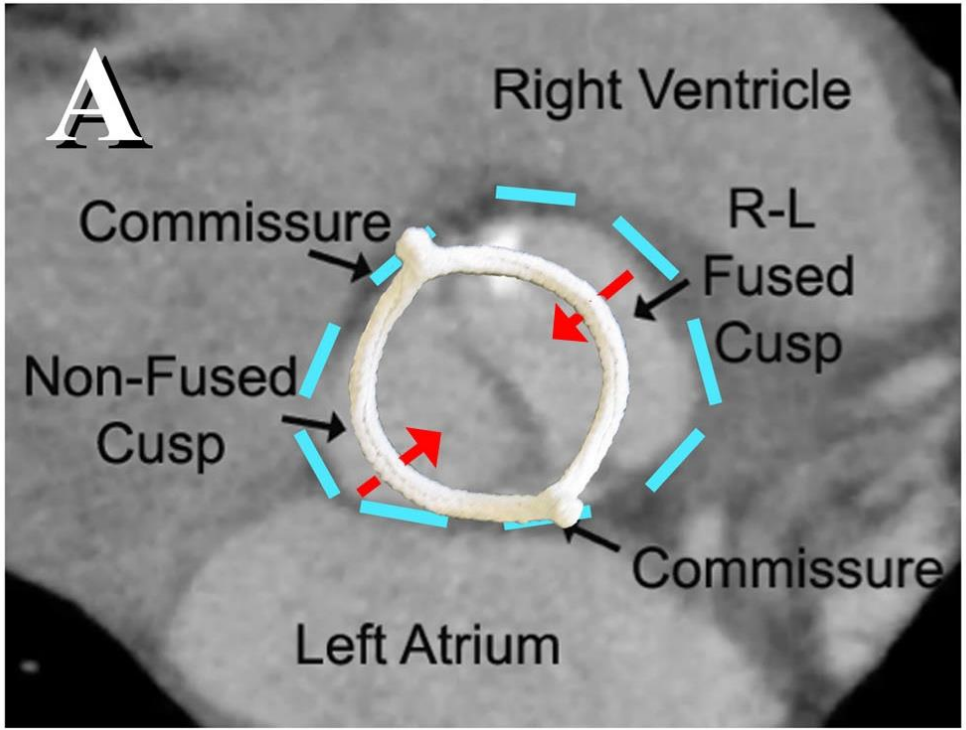
Symmetric reconstruction of bicuspid valves allows optimal leaflet geometry and coaptation.



Placement of 9 Transannular Sutures for BAV Ring Implantation

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Aortic Valve Repair – Do suture annuloplasty or LVOT (Coroneo) soft rings work? No, due to the nature of the annulus/subannulus being partly supported, and partly not.

Biomechanics of aortic valve annuloplasty: Same goal, different techniques

Evaldas Girdauskas, MD, PhD,[a] Theresa Holst, MD,[a] Sina Stock, MD,[a] Thomas Kröncke, MD, PhD,[b] Maria von Stumm, MD,[c,d] and Josua A. Decker, MD,[b] Augsburg and Munich, Germany

Address for reprints: Evaldas Girdauskas, MD, PhD, Department of Cardiothoracic Surgery, Augsburg University Hospital, Stenglinstr 2, Augsburg, 86156, Germany (E-mail: evaldas.girdauskas@uk-augsburg.de).

JTCVS Techniques 2024;25:43-7
2666-2507

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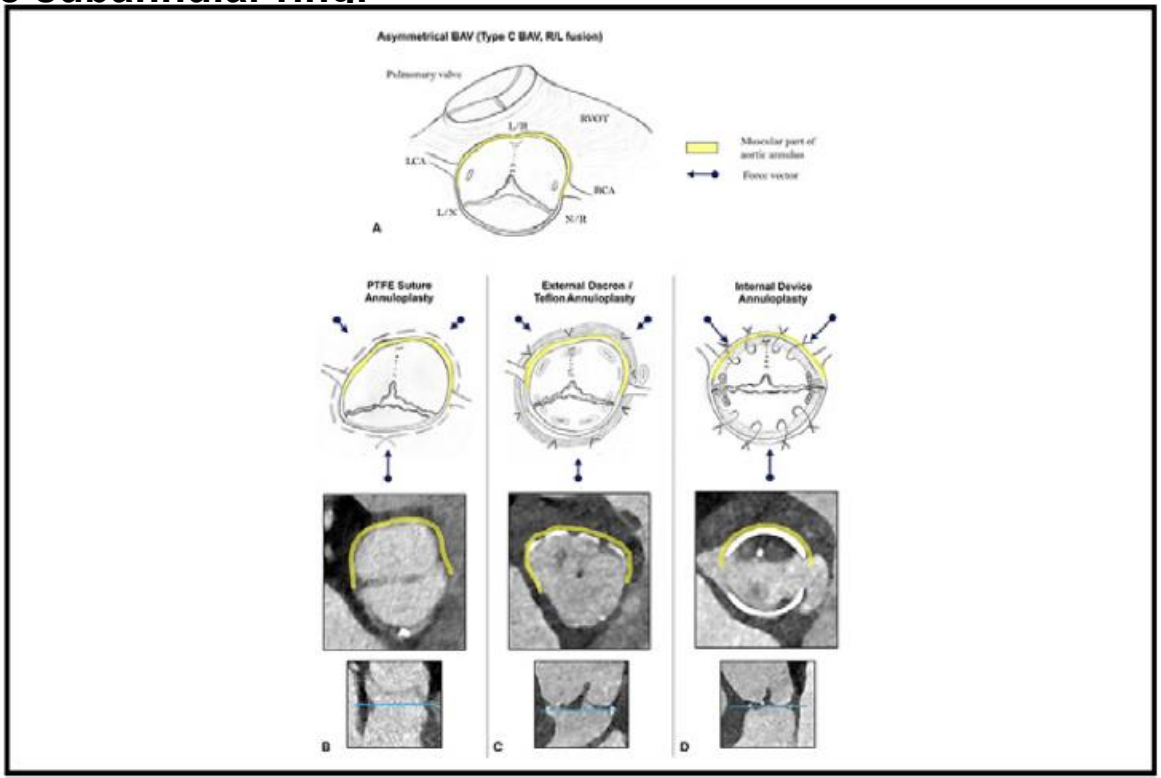
Aortic Valve Repair: Three Very Different Techniques for Annular Stabilization: ONLY ONE WORKS: a Geometric subannular ring.

Part of the aortic annulus is firmly supported by dense muscular tissue (septum), and the other half (RN commissure to left fibrous trigone) is not. Soft ring or suture annuloplasty compresses the unsupported annulus asymmetrically, and cannot properly influence the supported muscular portion. This paper looked at BAV repair annular architecture.



Biomechanical effects of 3 different aortic valve annuloplasty approaches.

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Aortic annular ring: practical considerations

Geometric rings were introduced over a decade ago in Europe and have undergone an extensive learning curve, similar to techniques that evolved for mitral repair.

I had the benefit of an extended mentorship from Scott Rankin MD, who invented the ring and operated in and ran the trials in Europe. Scott observed and trained me on every repair case with direct intraoperative video participation over a roughly 4 year period.

We repaired every kind of valve lesion, aneurysm, and dissection. I also spent a week in Paris with Dr Lansac to make sure I understood everything about that approach to repair.

Dr. Rankin and I discovered we worked well together and have now multiple publications together on use of the ring, and use of aortic wall for leaflet augmentation or leaflet replacement in aortic valve repair.

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Aortic valve repair: leaflet augmentation

Aortic valve repair has been severely hampered by lack of a living leaflet substitute. Fixed tissue used as a leaflet substitute uniformly fails.

Aortic wall was reported by Charles P. Bailey in 1959 as material for aortic valve reconstruction in a series of patients.

We have now reported and published multiple times on the use of living aortic wall as a “patch” to allow repair of a diseased aortic valve, or even as a leaflet replacement. IDEAL when patient has an ascending aneurysm.

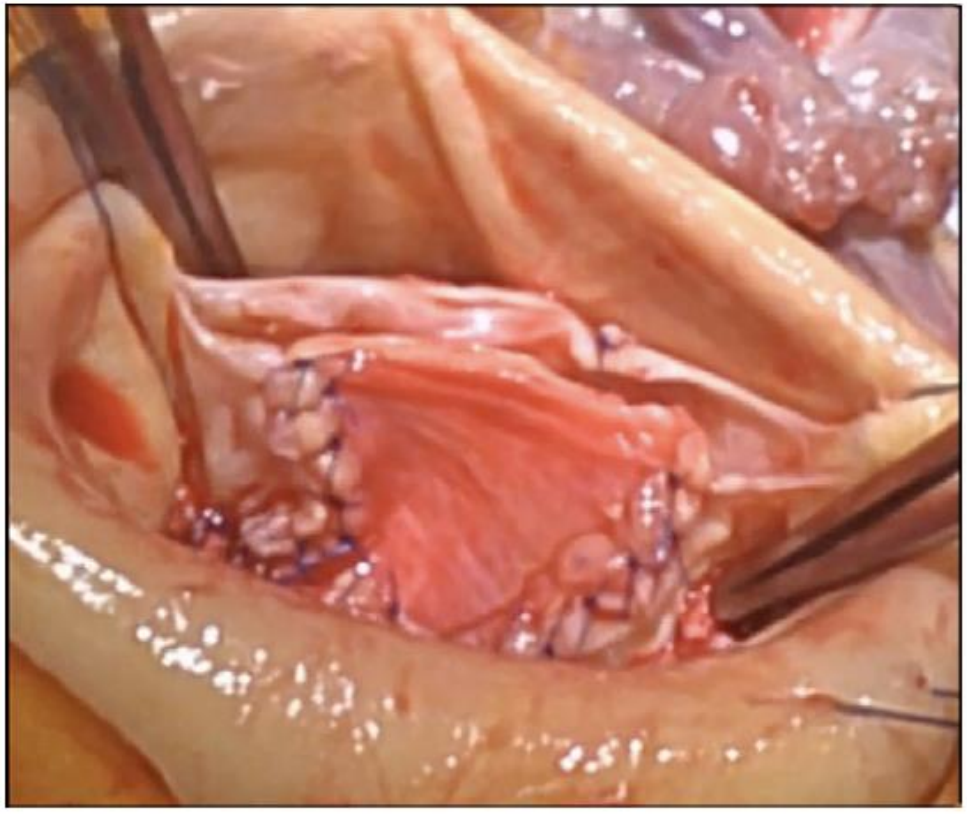
The concept is that aorta is fed substantially by diffusion, and should remain alive when suspended in the arterial stream. Thus far our reconstructions (up to 3 years) have no sign of calcification or degeneration.

JTCVS Tech. 2023 Apr 6;19:30–37. doi: 10.1016/j.xjtc.2023.02.017

Use of aortic wall patches as leaflet replacement material during aortic valve repair

John L Myers [a], J Brian Clark [a], Timothy W James [b], Emily Downs [c], Saad M Hasan [d], Robert S Binford [e], Jeffrey D McNeil [f], Victor M Rodriquez [g], Christopher E Mascio [h], Lawrence M Wei [h], Vinay Badhwar [h], J Scott Rankin [h,*]

Plicated reference leaflet in background, calcified raphe removed and replaced with an aortic wall patch in the foreground.



Aortic wall patching of a calcified raphe defect during bicuspid aortic valve repair.

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ADULT: AORTIC VALVE: CASE VIDEO · Volume 25, P48-51, June 2024 · ***Open Access***

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Repair of calcified bicuspid aortic valves using living autologous aortic wall leaflets

Timothy W. James, MD [a] · J. Hunter Mehaffey, MD [b] · Lawrence M. Wei, MD [b] · Rochus K. Voeller, MD [c] · Vinay Badhwar, MD [b] · J. Scott Rankin, MD [b]

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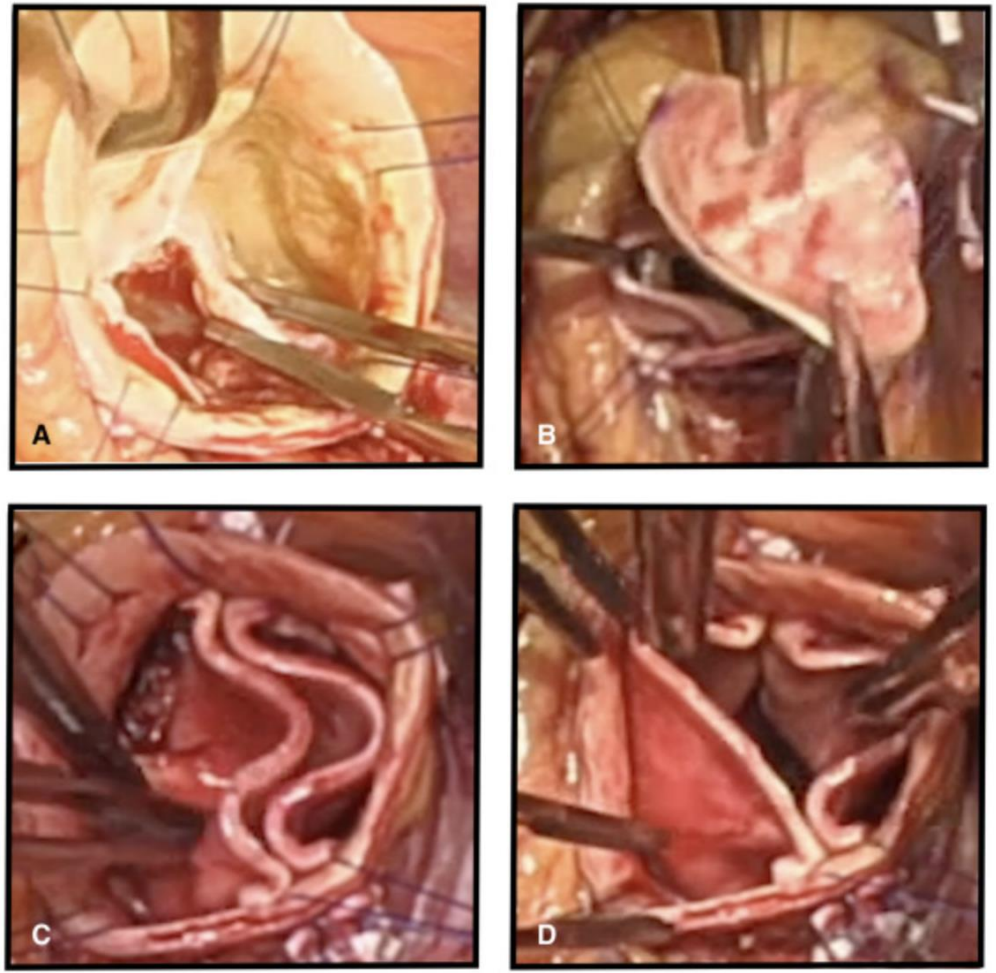
Autologous Tissue Valve



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Aortic valve repair

These are genuinely exciting times to be doing aortic valve repair.

We can deal with the annulus in a definitive logical way.

We can understand and tailor the leaflets in a logical way.

We have a living material that allows repair and reconstruction of valves that would ordinarily have been absolutely replaced.

We are now free to perform valve sparing root replacements with a supported/repaired annulus and leaflets that can be properly tailored/repaired (submitted for publication).

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Aortic valve repair: Case examples

27 year old man with bicuspid aortic valve (R-L fusion), severe AR, dilated cardiomyopathy with declining EF (45%). Holodiastolic flow reversal in descending aorta.

Operation: annulus measured 29 mm, fused right-left coronary cusp partly dehisced at commissures. Repaired with 25 mm geometric ring, RL leaflet resuspension with aortic wall buttresses, free edge length adjustment of both leaflets. Post-repair TEE: coaptation length 10 mm, mean gradient 10 mmHg, no AR.

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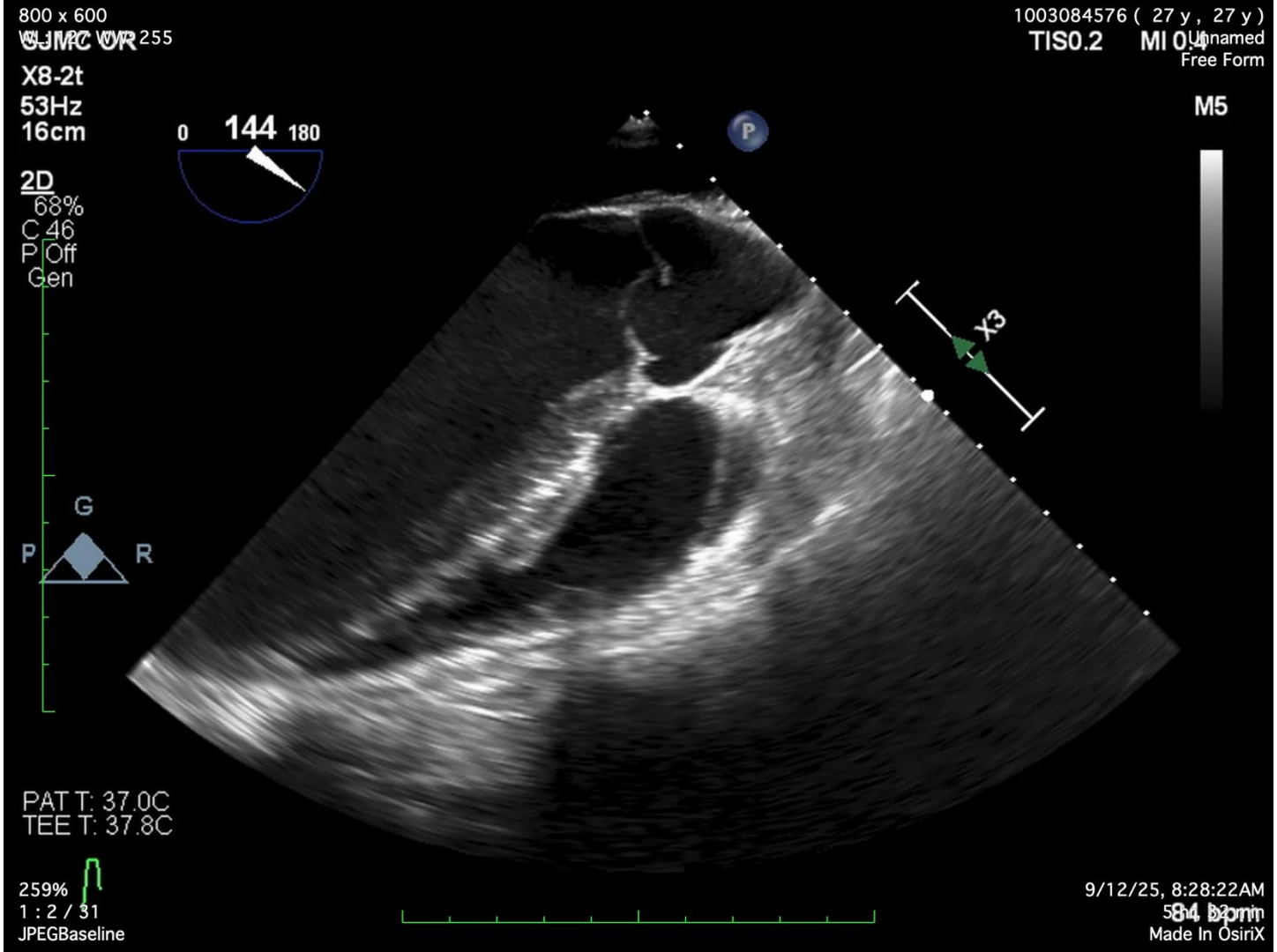
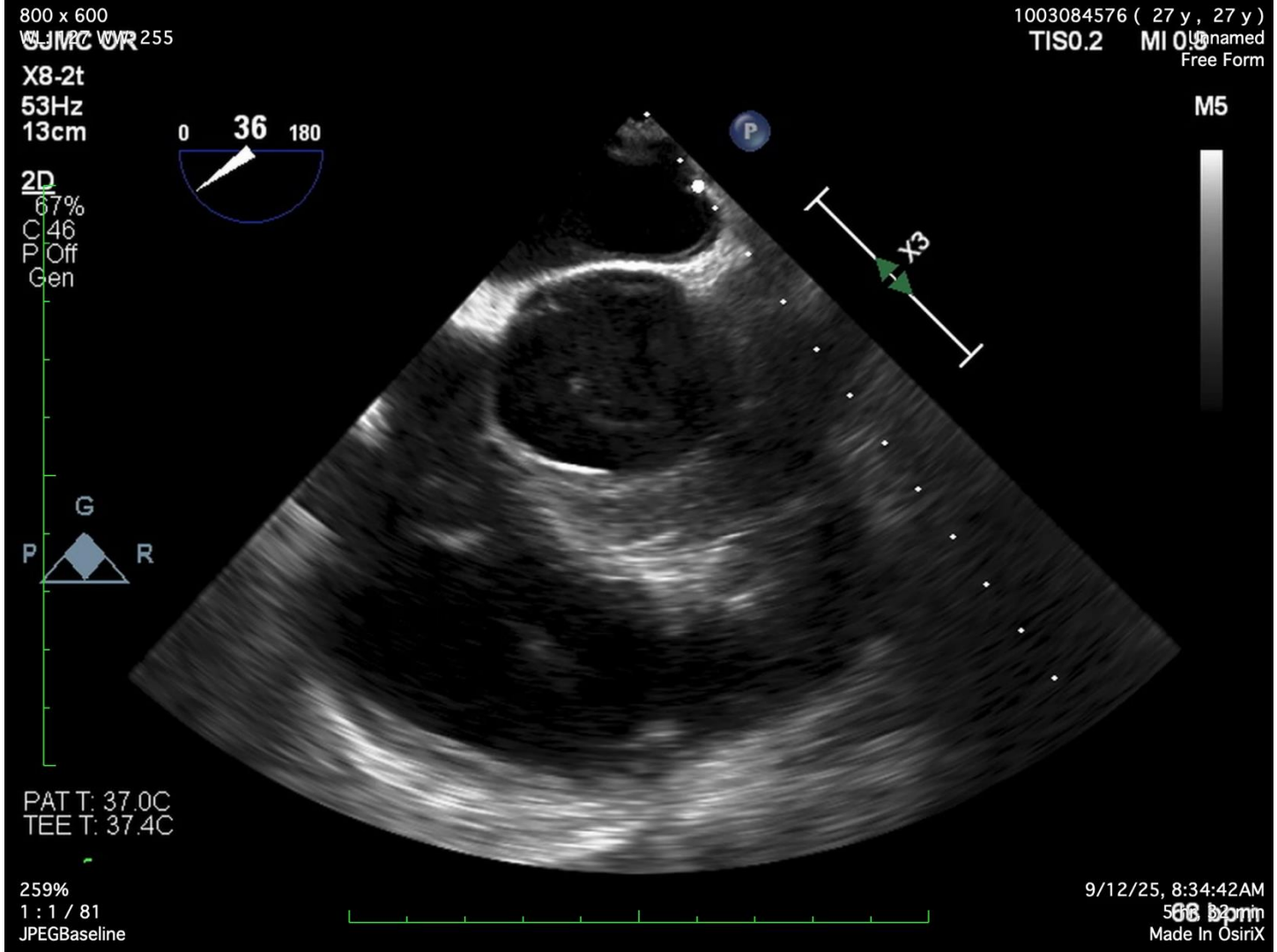


Virginia Mason Franciscan Health



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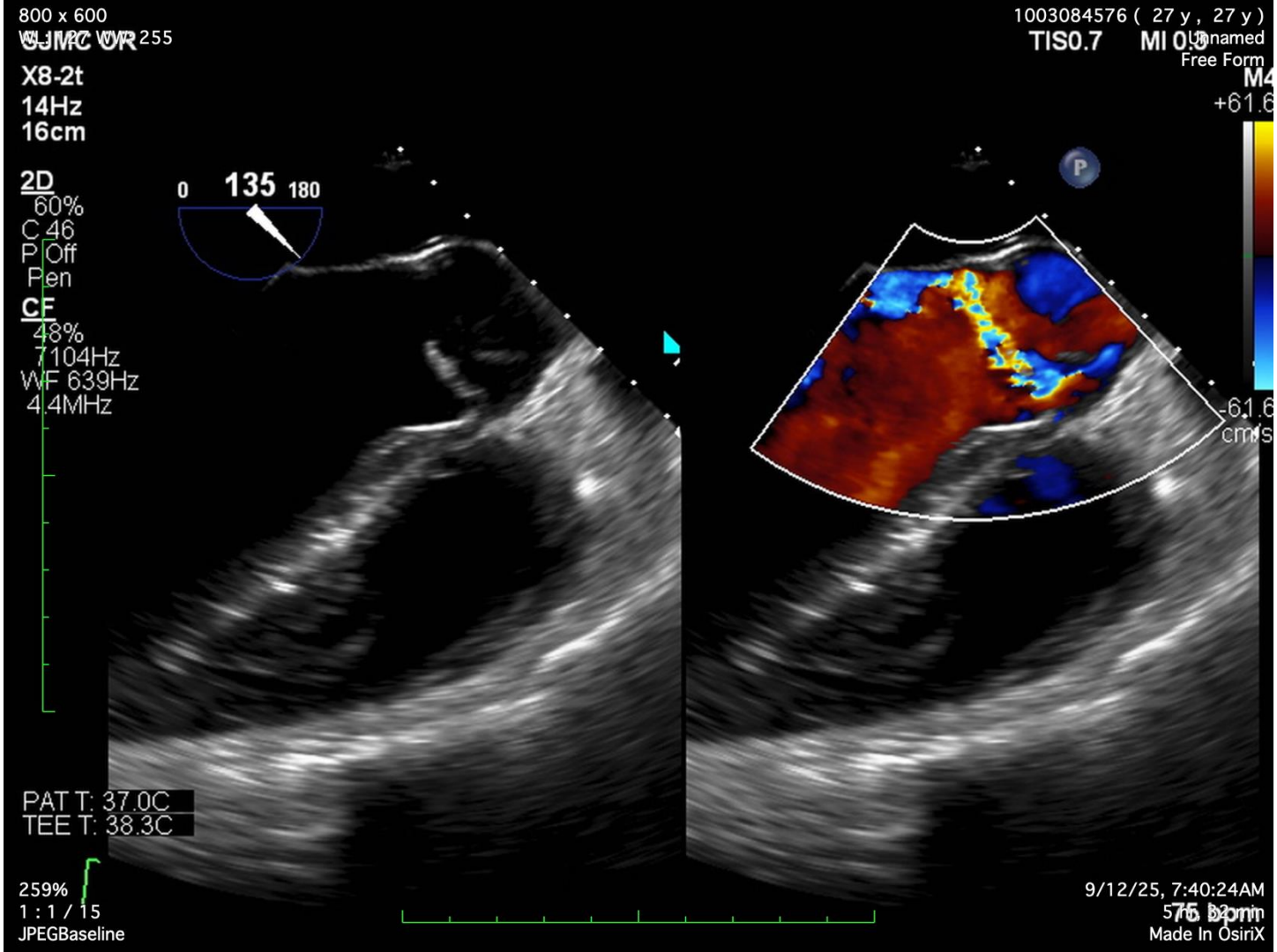

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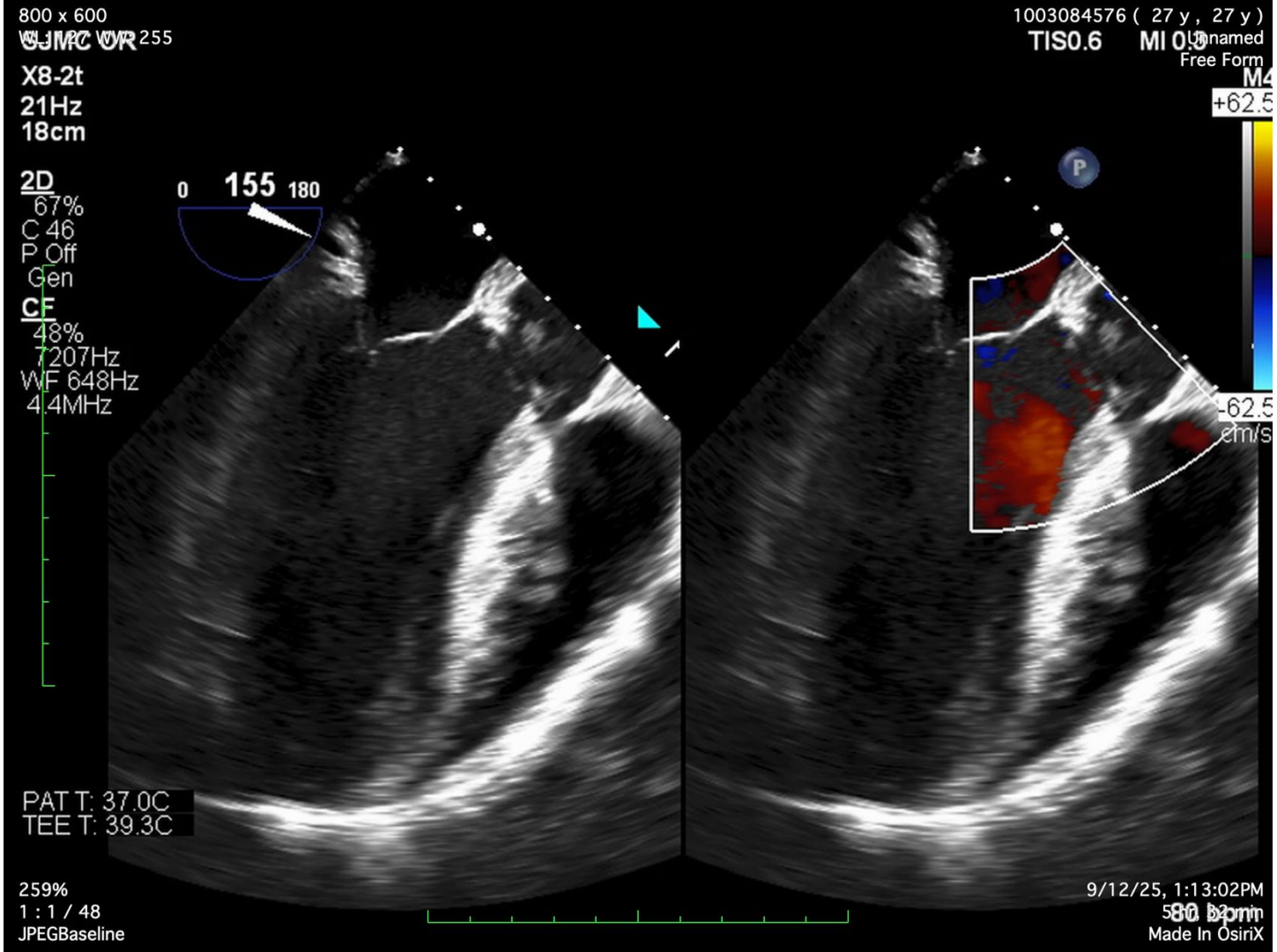

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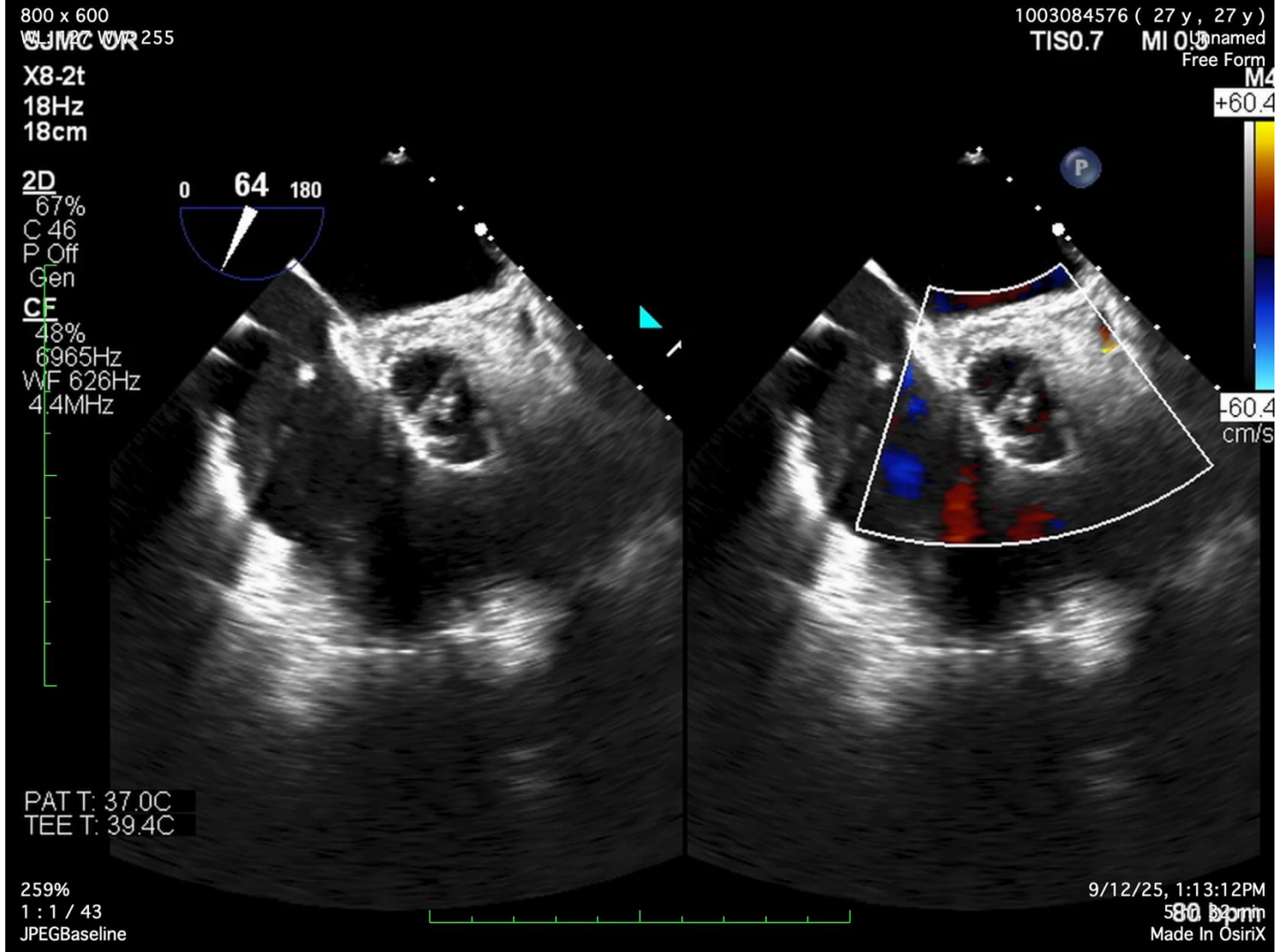

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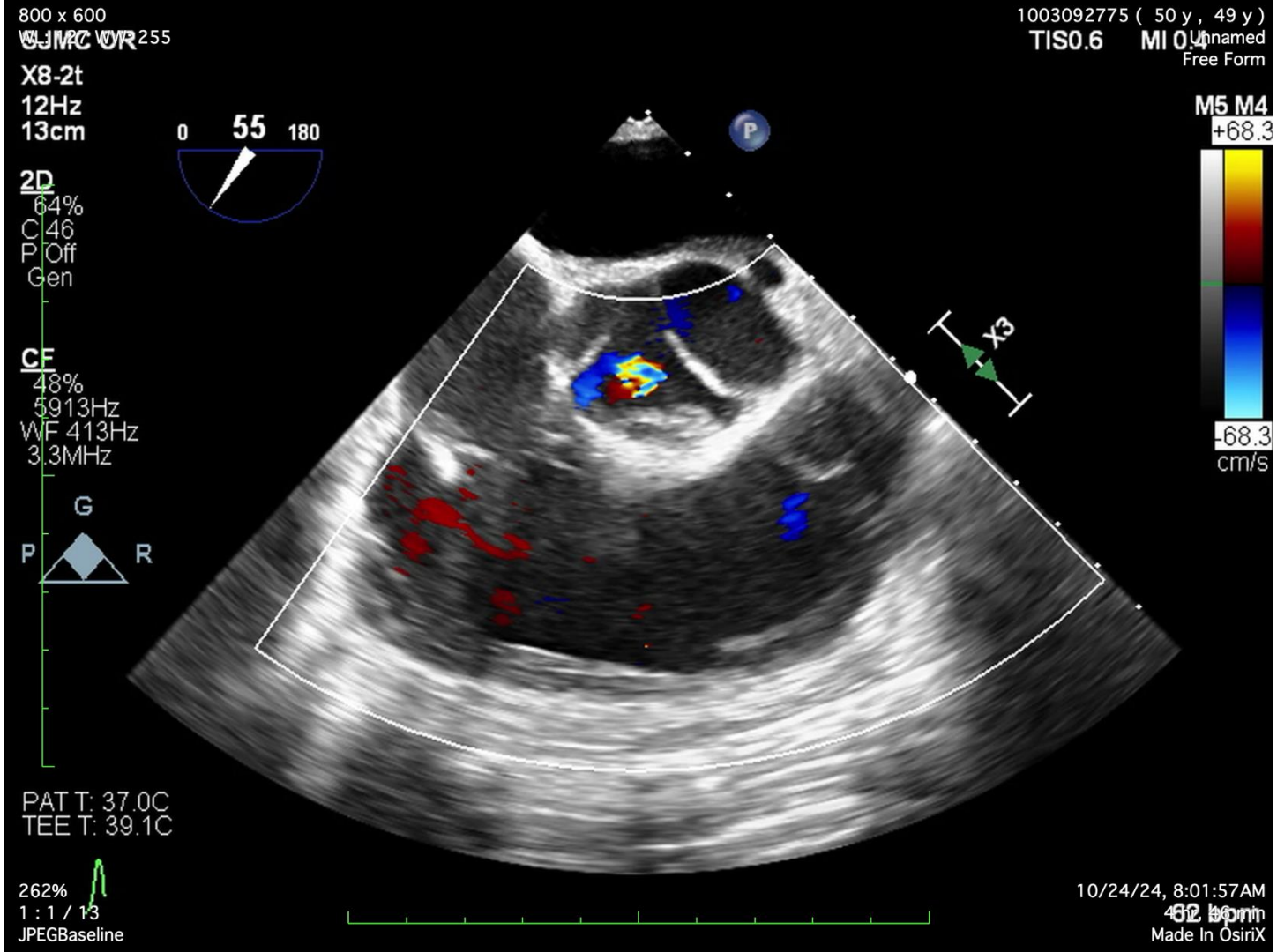
Aortic valve repair: Case example

50 year old man with large (7.3 cm) ascending aortic aneurysm extending into arch, trileaflet aortic valve with mod-severe AR (flow reversal in descending aorta in early diastole).

Operation: repair of aneurysm under circulatory arrest with ACP, aortic valve repair with elliptical geometric ring (21 mm), STJ reconstruction to 25 mm. Annulus sized to 26 mm (Hegar dilator), leaflets sized to 21 mm annulus. Post-repair TEE: trace AR, 7 mm mean gradient.



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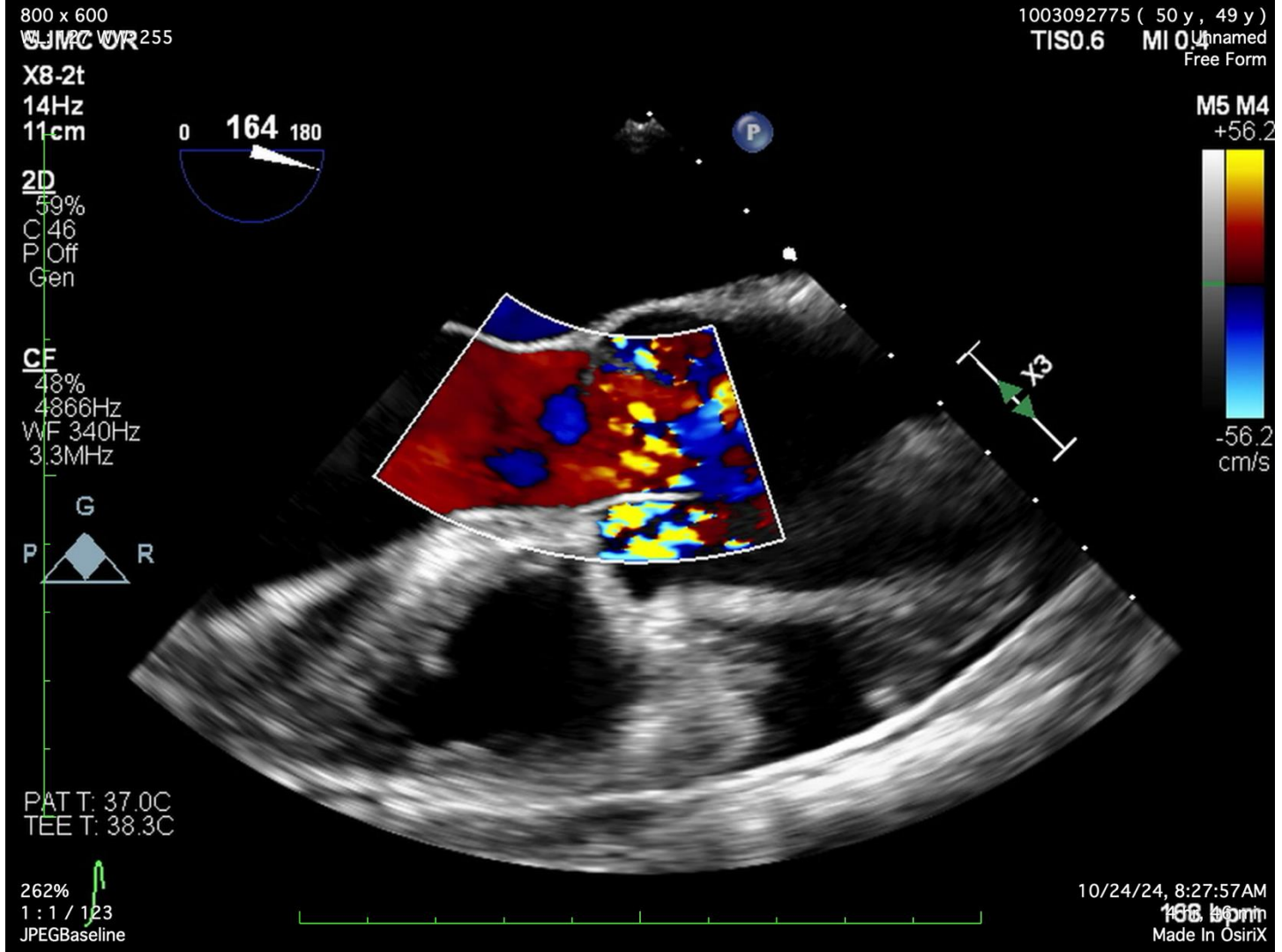

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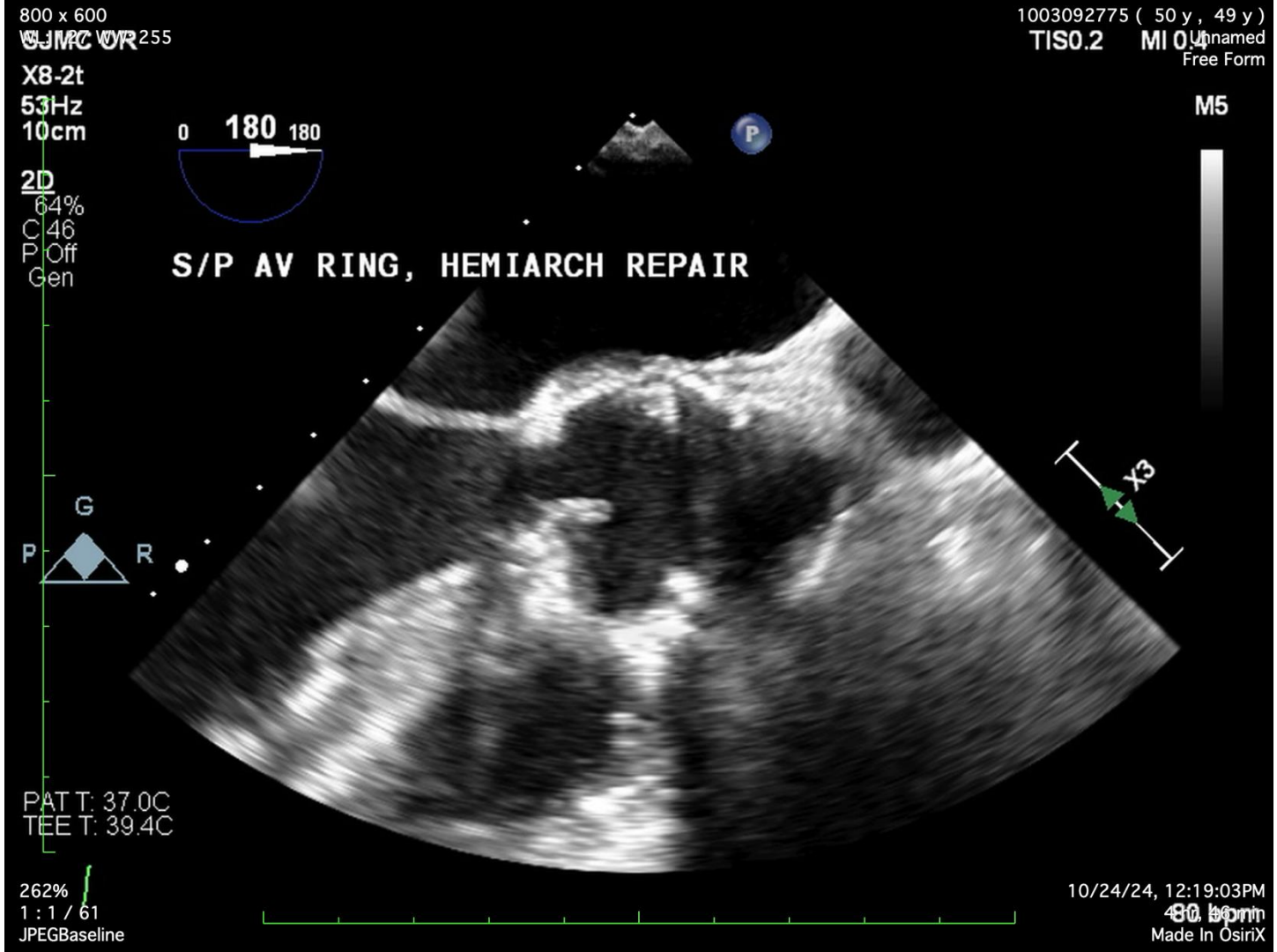

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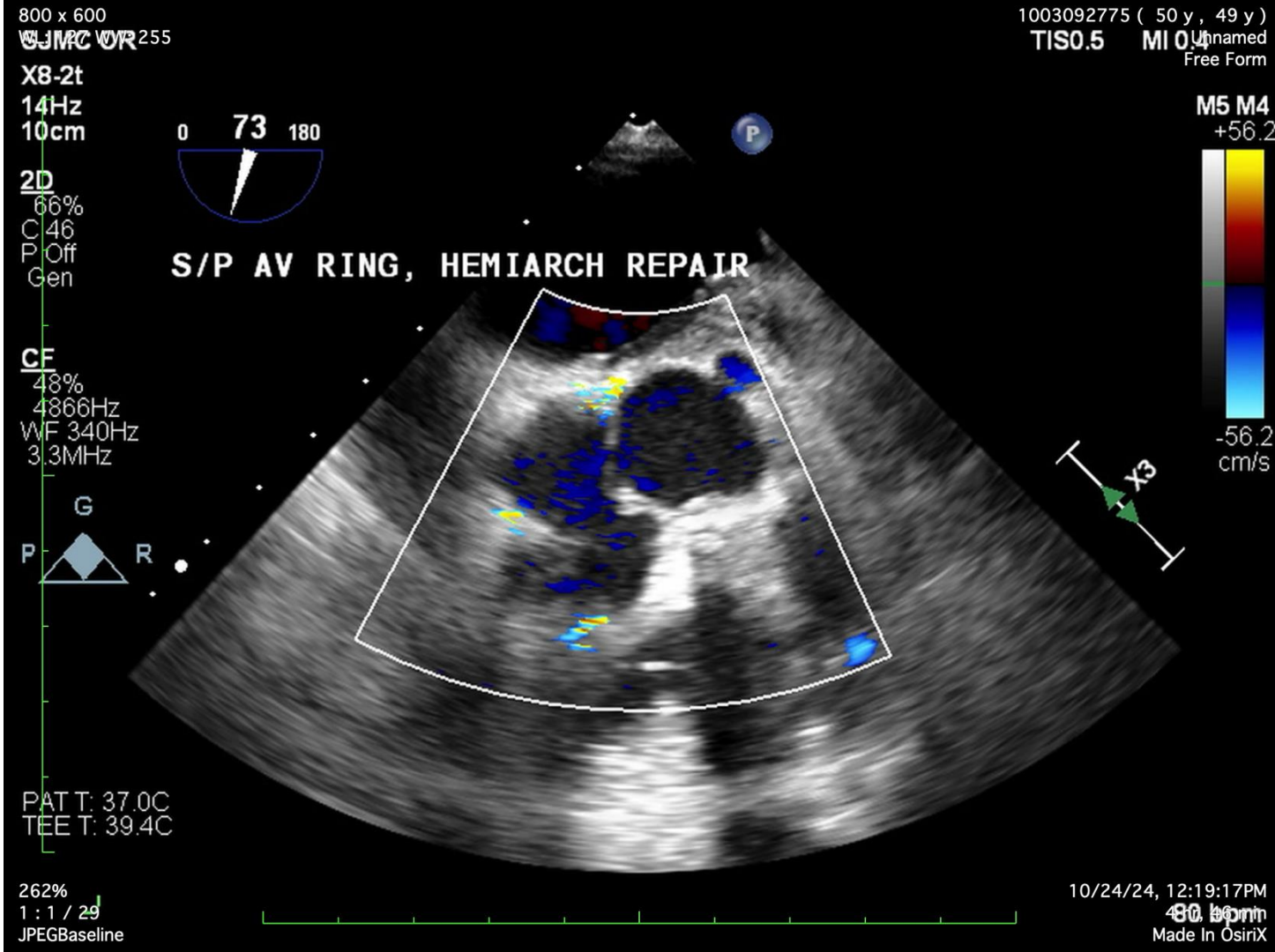

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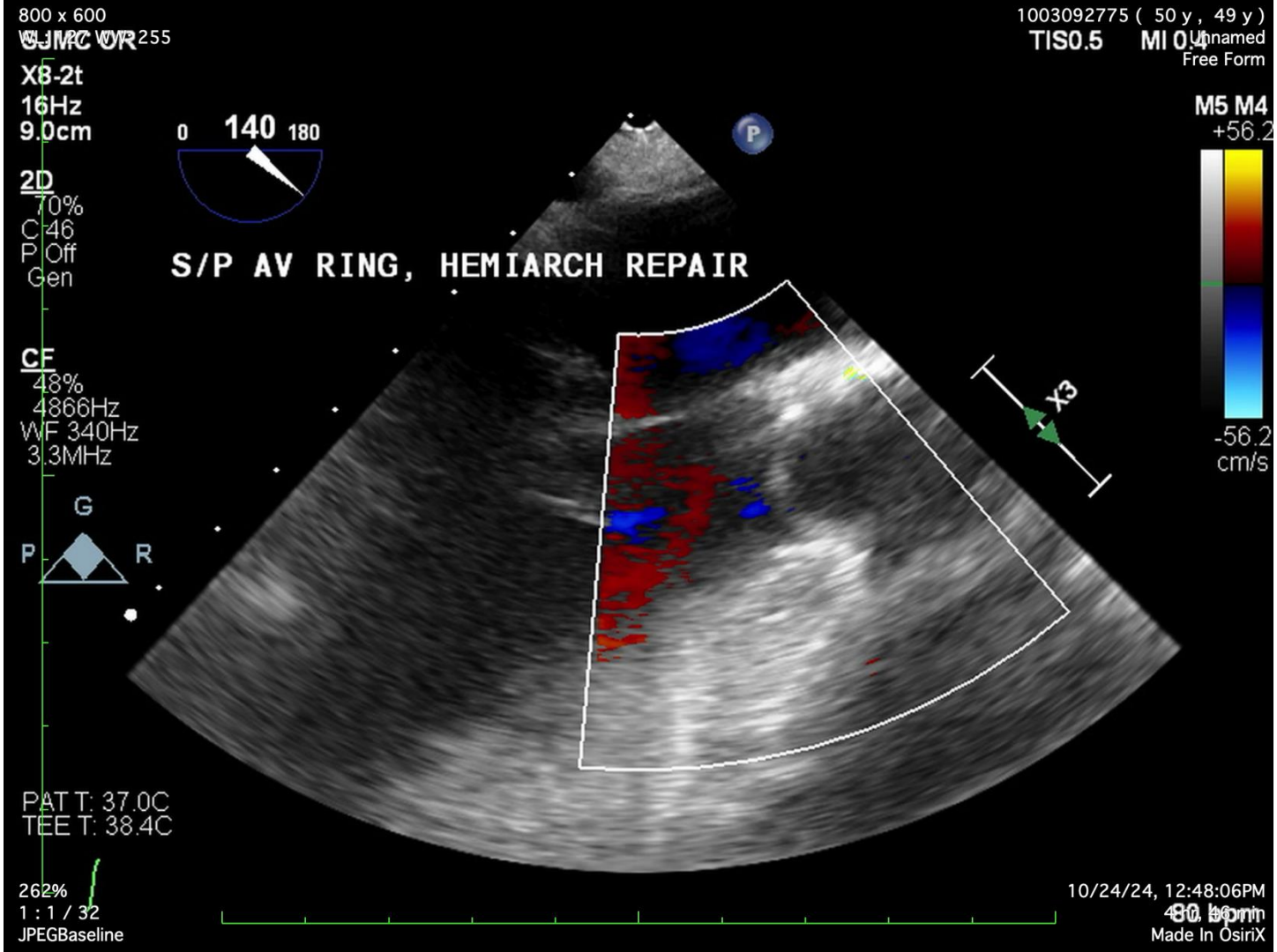

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Aortic valve repair: case example

64 year old man presented with acute TAAD; classic DeBakey I with hemopericardium and right leg ischemia, acute severe AR on TEE, shock with elevated lactate.

Operation: Hemiarch repair under circulatory arrest with ACP, reconstruction of noncoronary sinus of Valsalva with internal (Baker) patch and intramural felt, aortic valve repair with 21 mm geometric ring.

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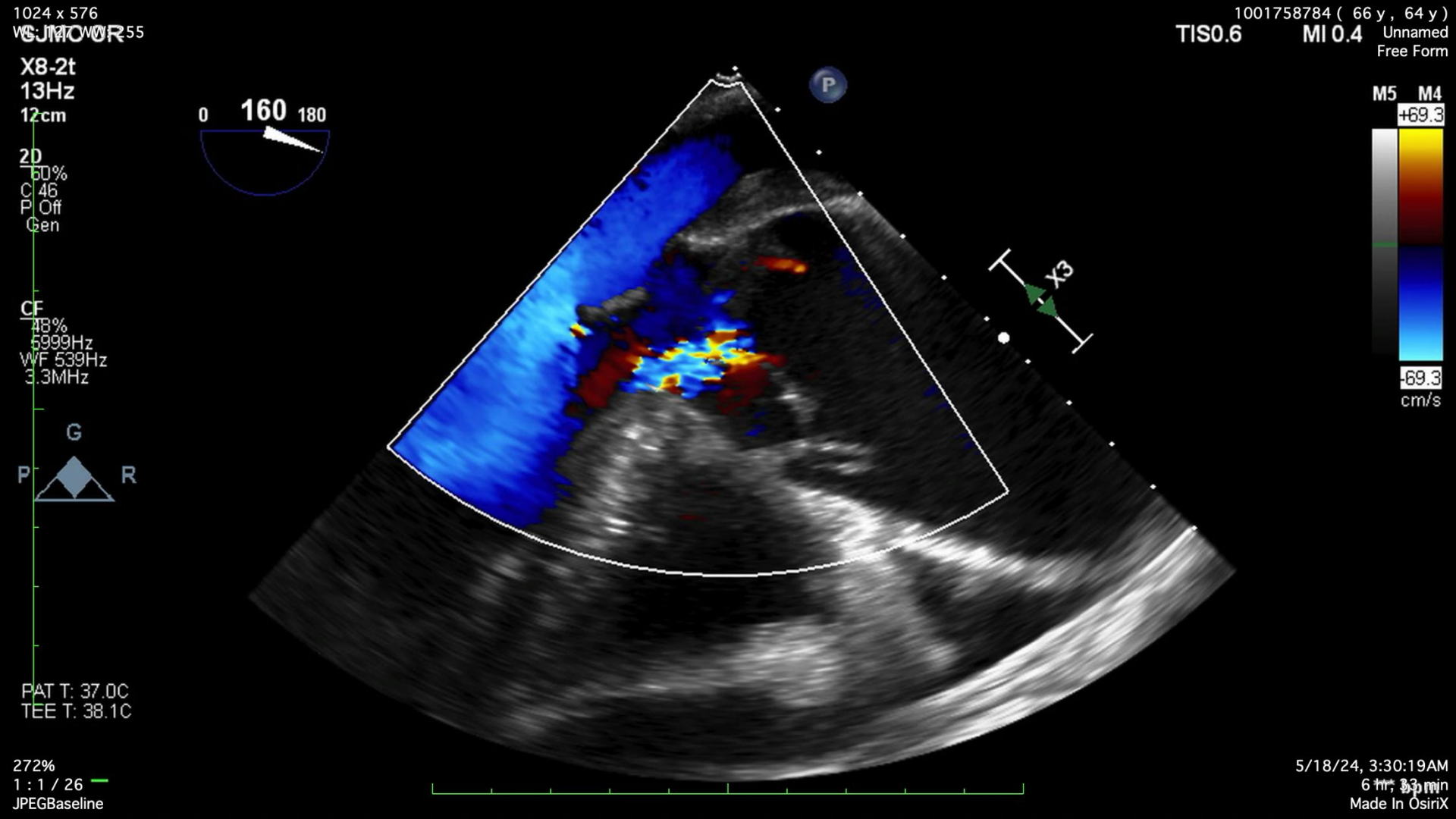
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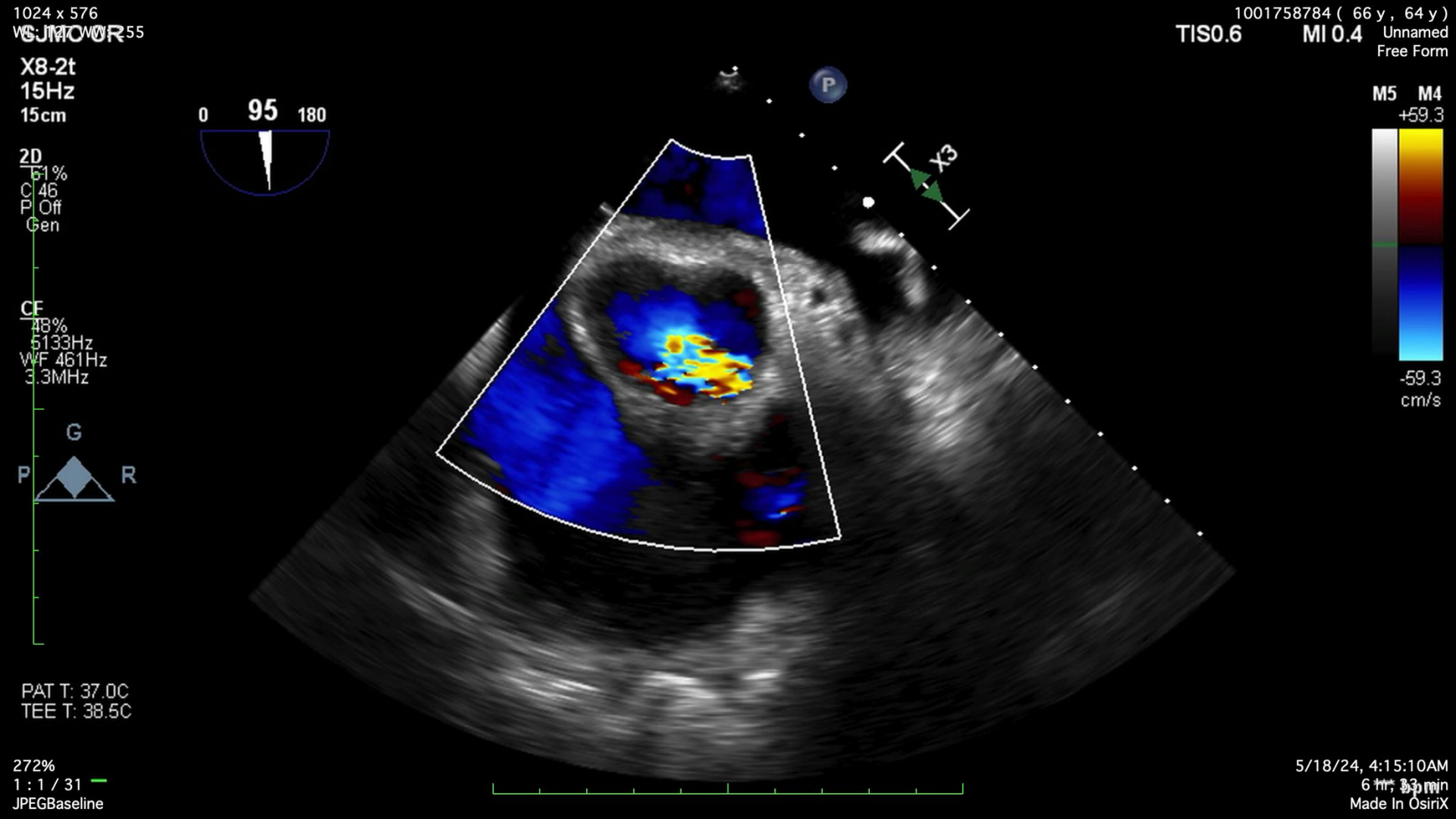
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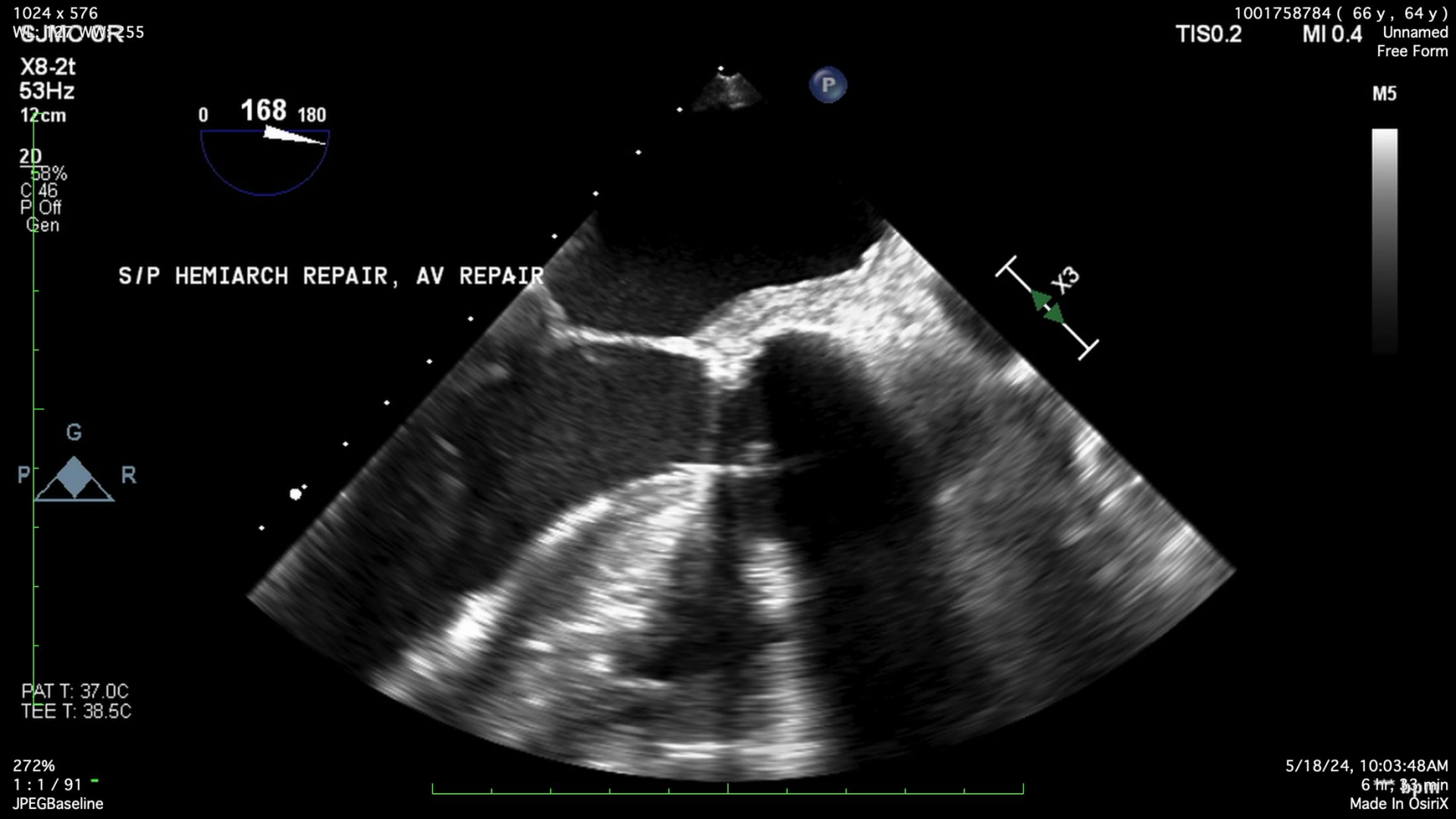
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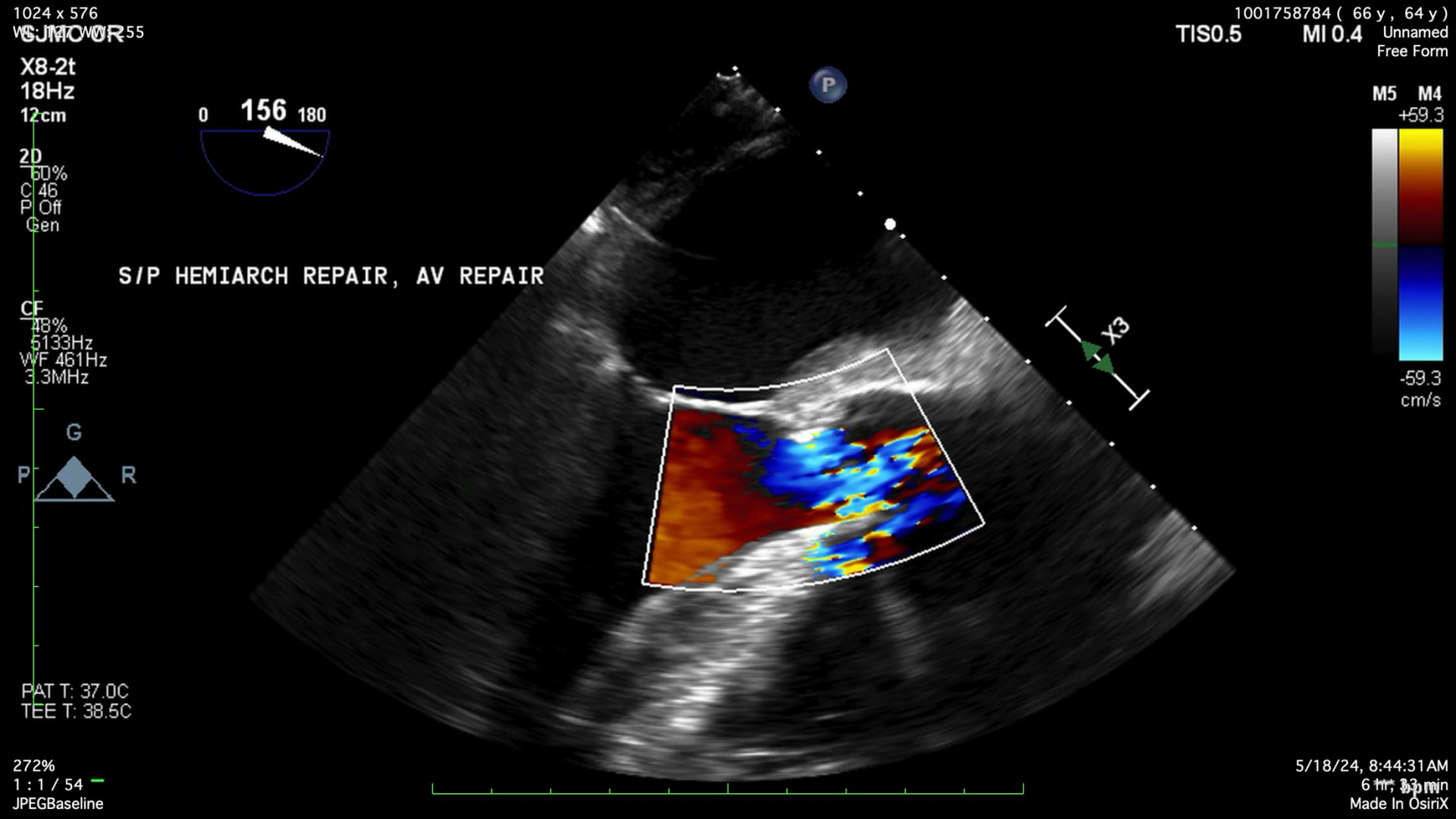
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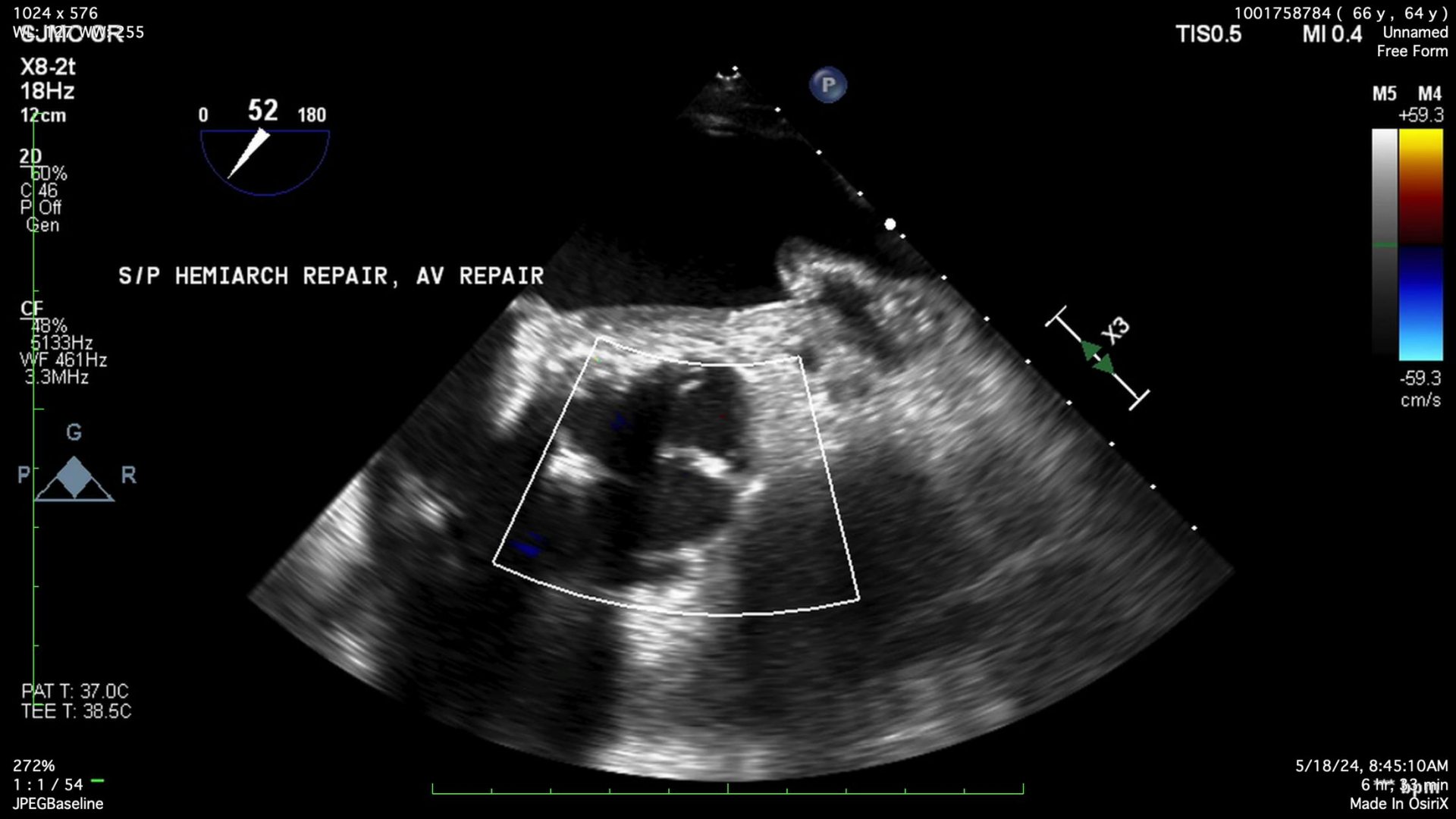
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Aortic valve repair: case example

52 year old man with Chiari malformation, dizziness and frequent falls, vasovagal syndrome, severe AS, exercise intolerance, bicuspid aortic valve with heavy calcification, ascending aortic aneurysm 4.7 cm into arch, refused coumadin/tissue valve/Ross procedure. Requested repair, tissue valve as backup plan.

Operation: Hemiarch repair, placement 25 mm circular geometric ring, bileaflet aortic valve reconstruction using living aortic wall. Post repair TEE: trace AR, mean gradient 6 mmHg.

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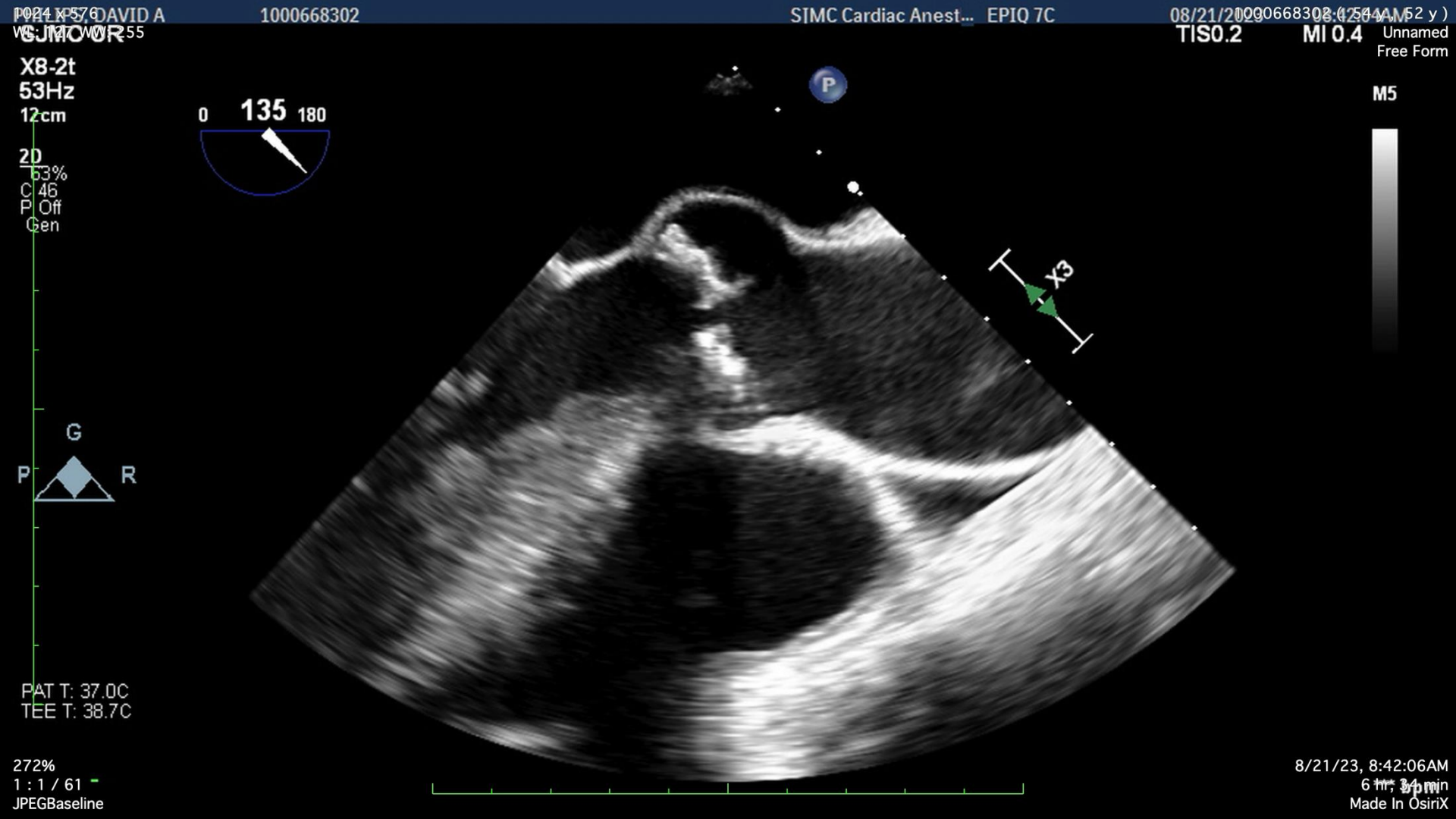
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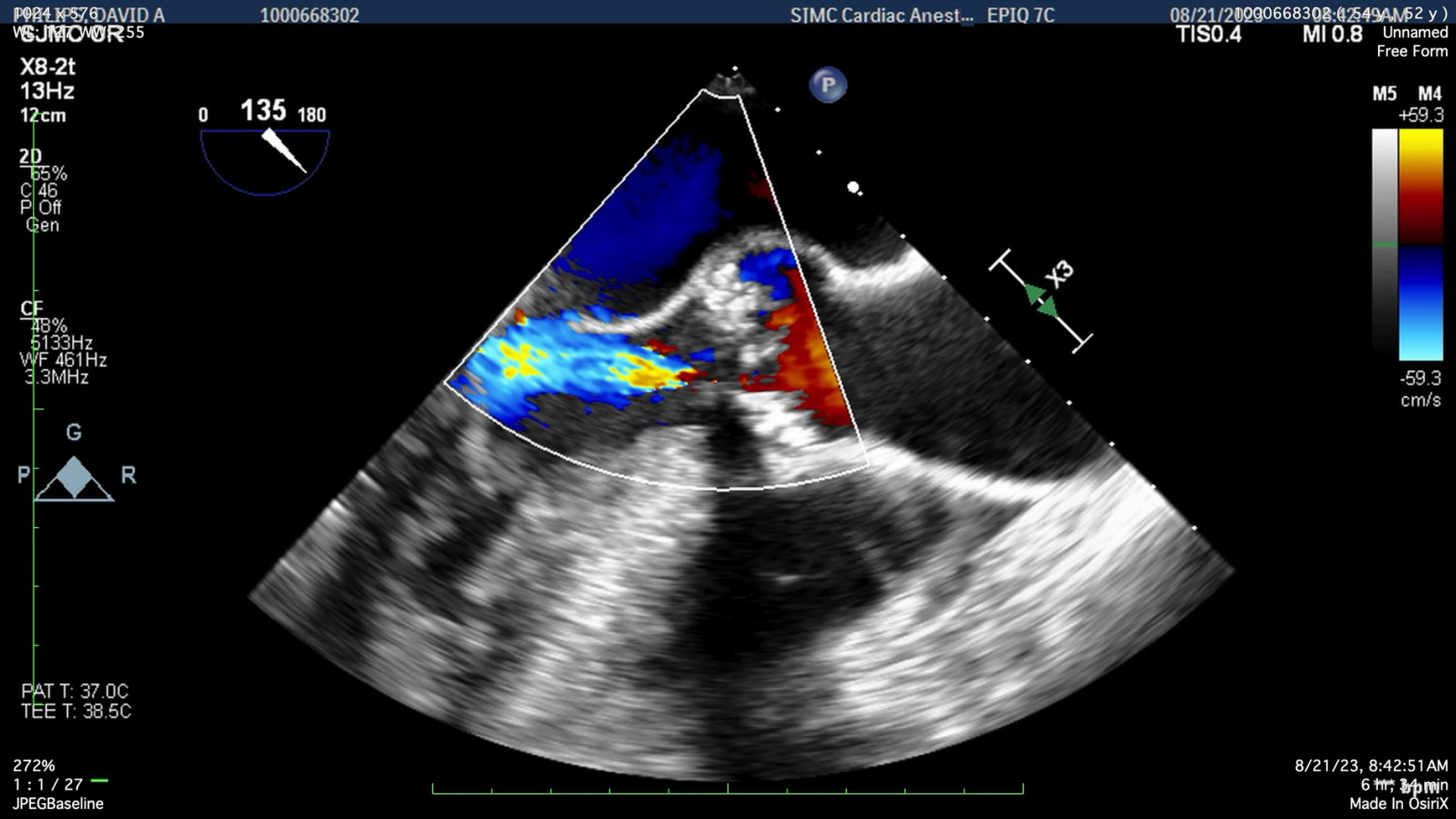
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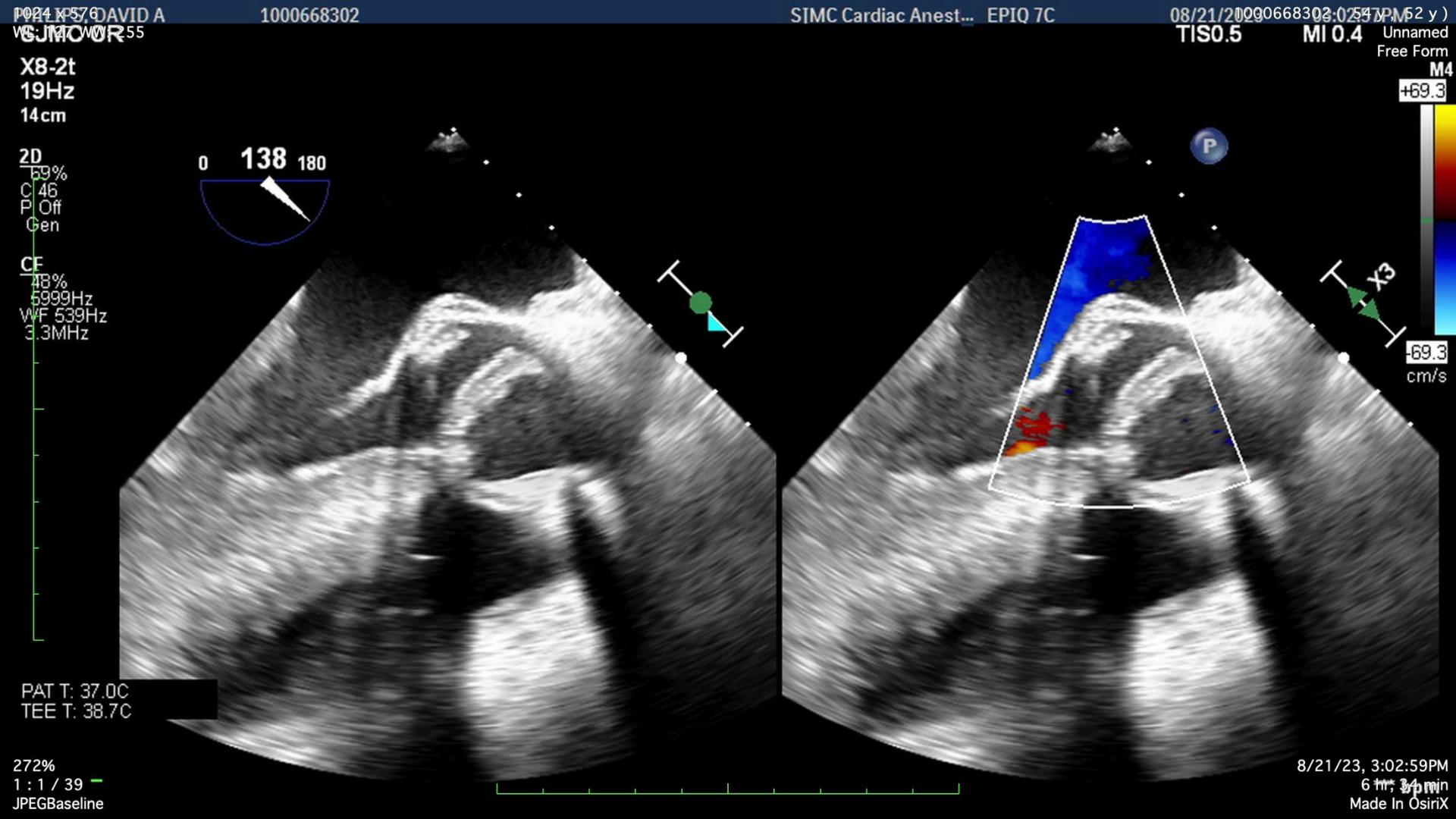
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Made In OsiriX


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Conclusions

1. Geometric ring annuloplasty is a simple and effective technique for aortic valve repair
2. One standardized aortic valve repair approach can be applied to both Trileaflet and Bicuspid aortic valve and the varying etiologies of AI
3. This internal annuloplasty approach is safe and early & mid-term outcomes are excellent.
4. The ring provides the foundation that is sized to the leaflets based on direct measurements.
5. Leaflet augmentation/replacement is a promising new therapy that may open another whole realm of valves for repair.

Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

Aneurysms frequently co-occur with aortic valve disease.

Class 1A Guideline Indication for Repair is 5.5 cm.

5.0 cm in experienced centers.

Is this helpful? Really?

I would argue NO.

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Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

Which aneurysm to repair?

Estimates:

- 8% of “cardiac sudden death” may be aortic deaths.
- Credible estimates that **60 – 90%** of ascending aortic aneurysms that rupture or dissect do so at a diameter **LESS THAN 5.5 cm**.
- And 40% of ruptures/dissections occur when the diameter is **LESS THAN 5 cm.**

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Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

Is a 5 cm aneurysm in a 4’10” female the same risk as a 5 cm aneurysm in a 6’5” male?

Shouldn’t the WALL TENSION be identical?

These aortas are the SAME DIAMETER!

What is the difference?

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Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

First thing to remember, if you double the size of a pipe for any given pressure, you just doubled the WALL TENSION in the pipe (for the same pressure).

When you take the curve out of a surface that is restraining a pressure, you increase the lateral force on that surface. That is what happens when the diameter of the pipe increases. Twice the diameter = twice the force.

What is different about these two patients with a 5 cm aorta?

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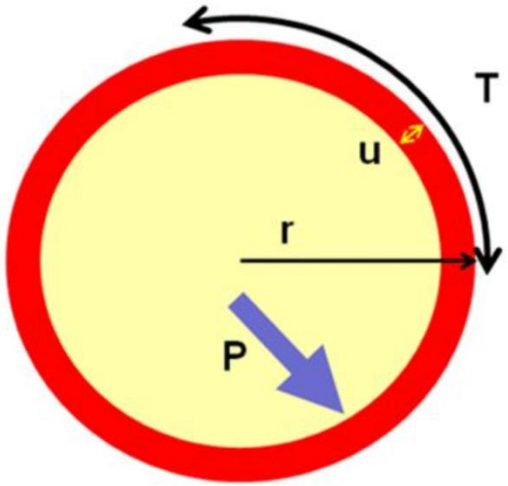
Shouldn't the wall tension be identical?

NO – WE ARE FORGETTING THE WALL THICKNESS TERM!

LaPlace's Law



$$\text{Wall Tension (T)} = \frac{\text{Transmural Pressure (P)} \times \text{Radius (r)}}{2 \times \text{Wall Thickness (u)}}$$

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Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

The larger person started with MORE AORTA.

So other things being equal, their aneurysm wall will be thicker, thus aortic wall tension will be lower. So clinically the smaller person is at higher risk.

We are not able to measure aortic aneurysm wall thickness reliably.

Prediction based on diameter and height alone has had some utility for extremes of body size but little else.

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Original Observation of Aortic length Predicting AAE

European Journal of Cardio-Thoracic Surgery 50 (2016) 241–247
doi:10.1093/ejcts/ezw025 Advance Access publication 16 March 2016

ORIGINAL ARTICLE

Cite this article as: Krüger T, Forkavets O, Veseli K, Lausberg H, Vöhringer L, Schneider W *et al*. Ascending aortic elongation and the risk of dissection Eur J Cardiothorac Surg 2016;50:241–7.

Ascending aortic elongation and the risk of dissection†

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Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict: Practical reference to guide patient selection. Wu et al (Elefteriades).

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY VOL. 74, NO. 15, 2019

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Ascending Aortic Length and Risk of Aortic Adverse Events

The Neglected Dimension

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Measuring Aortic Length

FIGURE 1 Ascending Aortic Length

Ascending aortic length is measured as distance **(blue)** from the aortic annulus **(red)** to the origin of innominate artery **(red)**.

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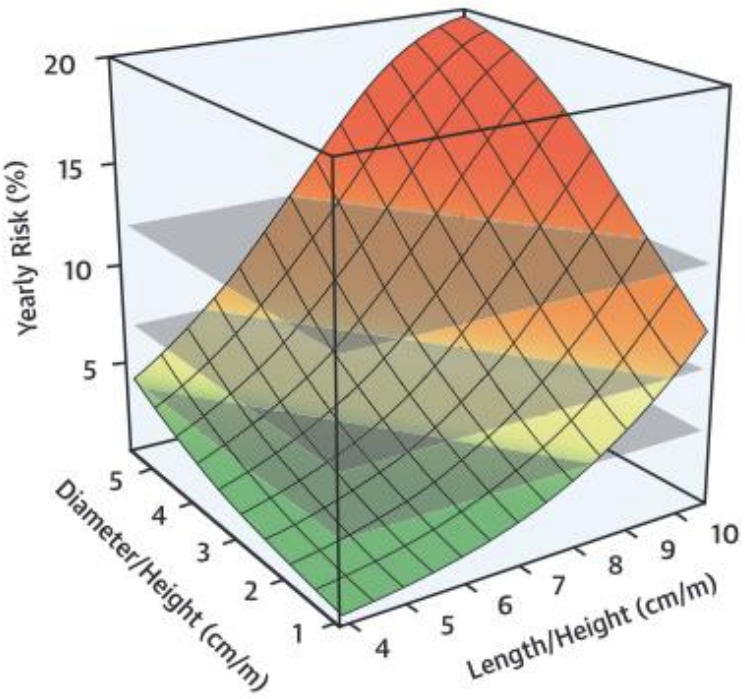
Aortic Length AND Diameter relative to Patient Height Predict AAE

FIGURE 8 3-Dimensional AAE Prediction Plot



Prediction plot as a function of DHI (x-axis) and LHI (y-axis), with the yearly risk of AAEs presented on the z-axis. AHI, aortic height index; other abbreviations as in Figure 3.

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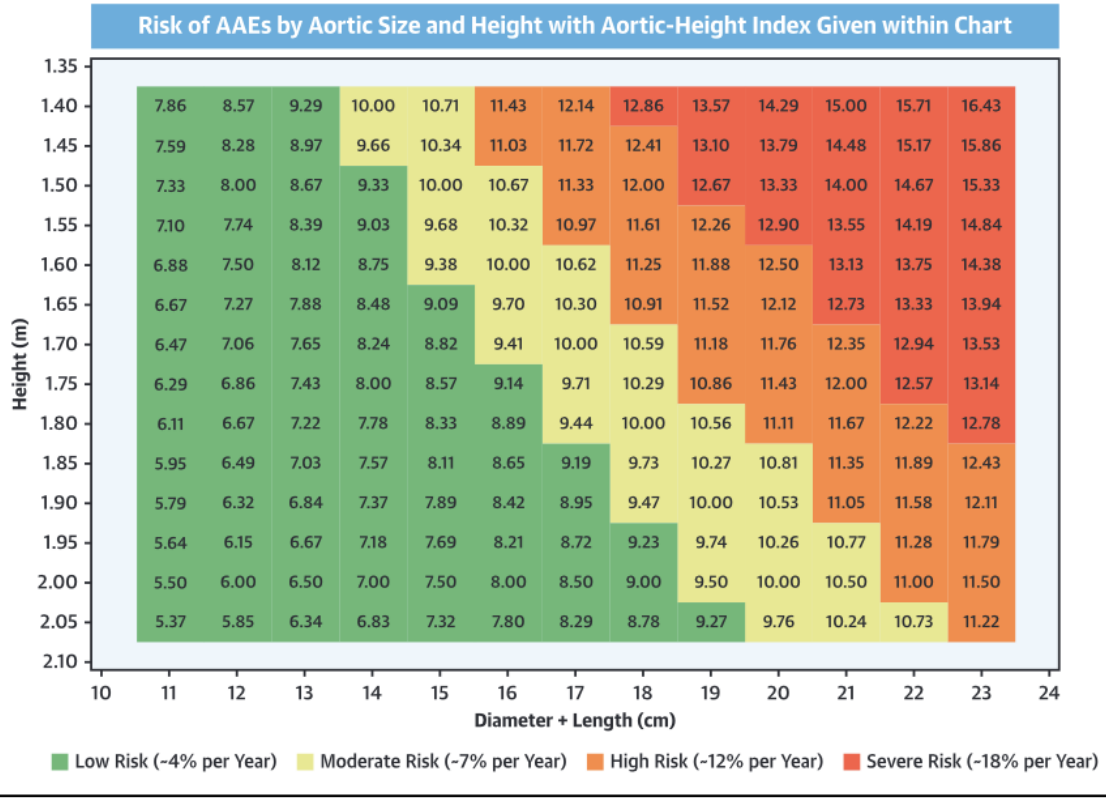
Assessing Annual Patient Risk of AAE Based on Height, and Aortic Length and Diameter:

FIGURE 7 AHI Nomogram



Aortic height index (AHI) nomogram as a function of aortic size (diameter + length) (x-axis) and height (y-axis), with the AHI given within cells. The table has a 4-tier, color-coded warning system, with **red** representing the most severe, followed by **orange**, **yellow**, and **green**. AAEs = aortic adverse events.

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Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

ELEFTERIADES: Currently the best way we have to predict risk of AAE incorporates diameter and length of aorta as well as size of patient.

Aorta is stronger circumferentially than longitudinally and usually tears horizontally.

Anything that makes the aorta longer or wider makes it thinner:

Still a very incomplete understanding as a clinical example will demonstrate.

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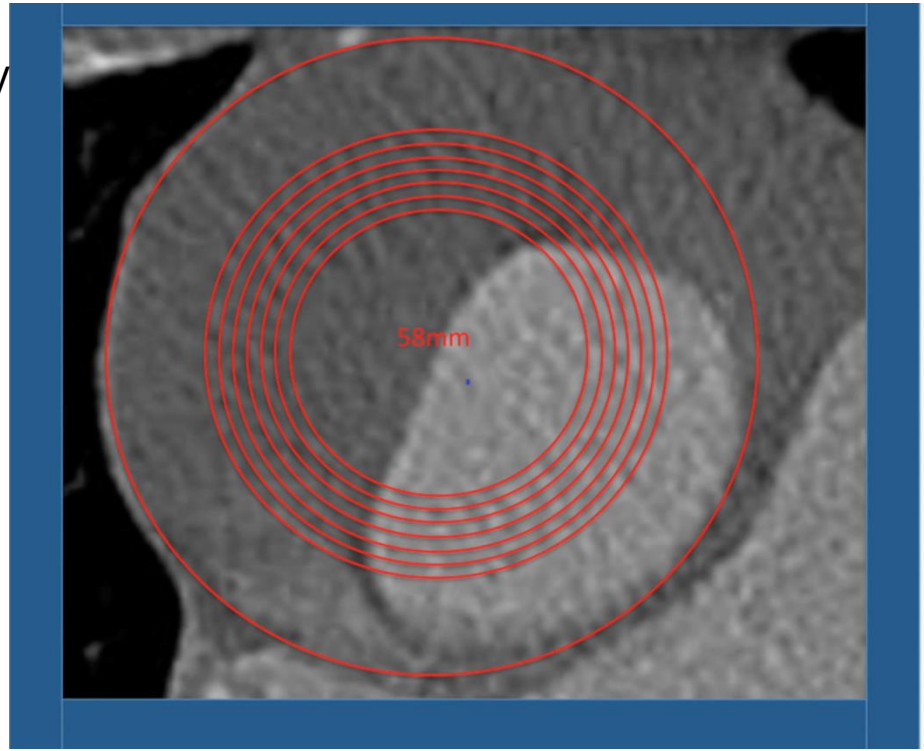
AATS AORTIC SYMPOSIUM: PROXIMAL AORTA · Volume 157, Issue 1, P37-42, January 2019 · *Open Archive*

Descending threshold for ascending aortic aneurysmectomy: Is it time for a "left-shift" in guidelines?

Bulat A. Ziganshin, MD, PhD · Mohammad A. Zafar, MBBS · John A. Elefteriades, MD, PhD (hon)

This diagram beautifully illustrates the problem with using existing diameter thresholds as surgical triggers for scending aortic aneurysm repair. This dovetails perfectly with my practice experience.



Patient 220

-8years: 45mm
↓
-7years: 46mm
↓
-6years: 47mm
↓
-5years: 48mm
↓
-4years: 48mm
↓
-3years: 49mm
↓
-2years: 50mm
↓
-1years: 51mm
↓
@dissection: 58mm

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Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

In my experience (following hundreds of patients with ascending aortic aneurysms), I have had two dissect. Both were under 5 cm.

One was offered surgery (length over 13 cm) and declined.

The other was under surveillance.

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CLINICAL EXAMPLE
58 year old woman, 5'8" tall, 1.73 m

Sinuses of Valsalva: 4 x 3.9 x 3.9 cm
Sinotubular junction: 3.6 x 3.6 cm
Mid ascending aorta: 4.5 x 4.3 cm
Mid aortic arch, proximal to left subclavian artery takeoff: 3.8 x 3.8 cm
Distal descending aorta: 2.7 x 2.6 cm

The ascending aortic length (aortic annulus to the innominate origin) measures 9.7 cm.

Aortic Aneurysm and Adverse Aortic Events: A Better Way to Predict

What would be a normal aortic size for this woman?

Normal length 1.73 m female about **8 cm – now 9.7 cm**

Normal diam **2.7 cm – now 4.5 cm**

W + L = 14.2 and height 1.73

Risk not minimal but still less than 4%.

Aortic length increased by 21%, diameter increased by 67%

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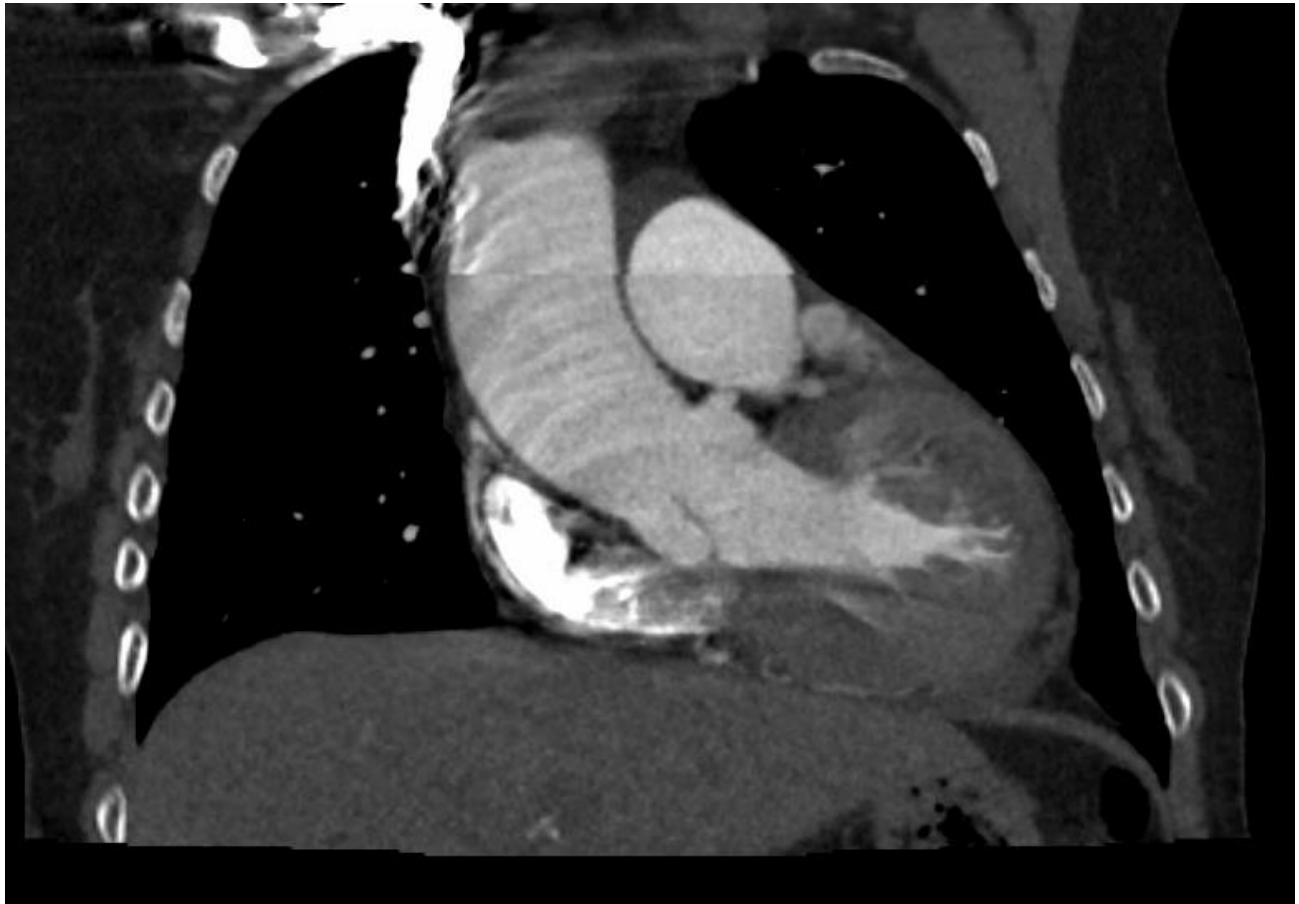
CTA PRE-DISSECTION Note absence of STJ, tubular nature, AoV points left.



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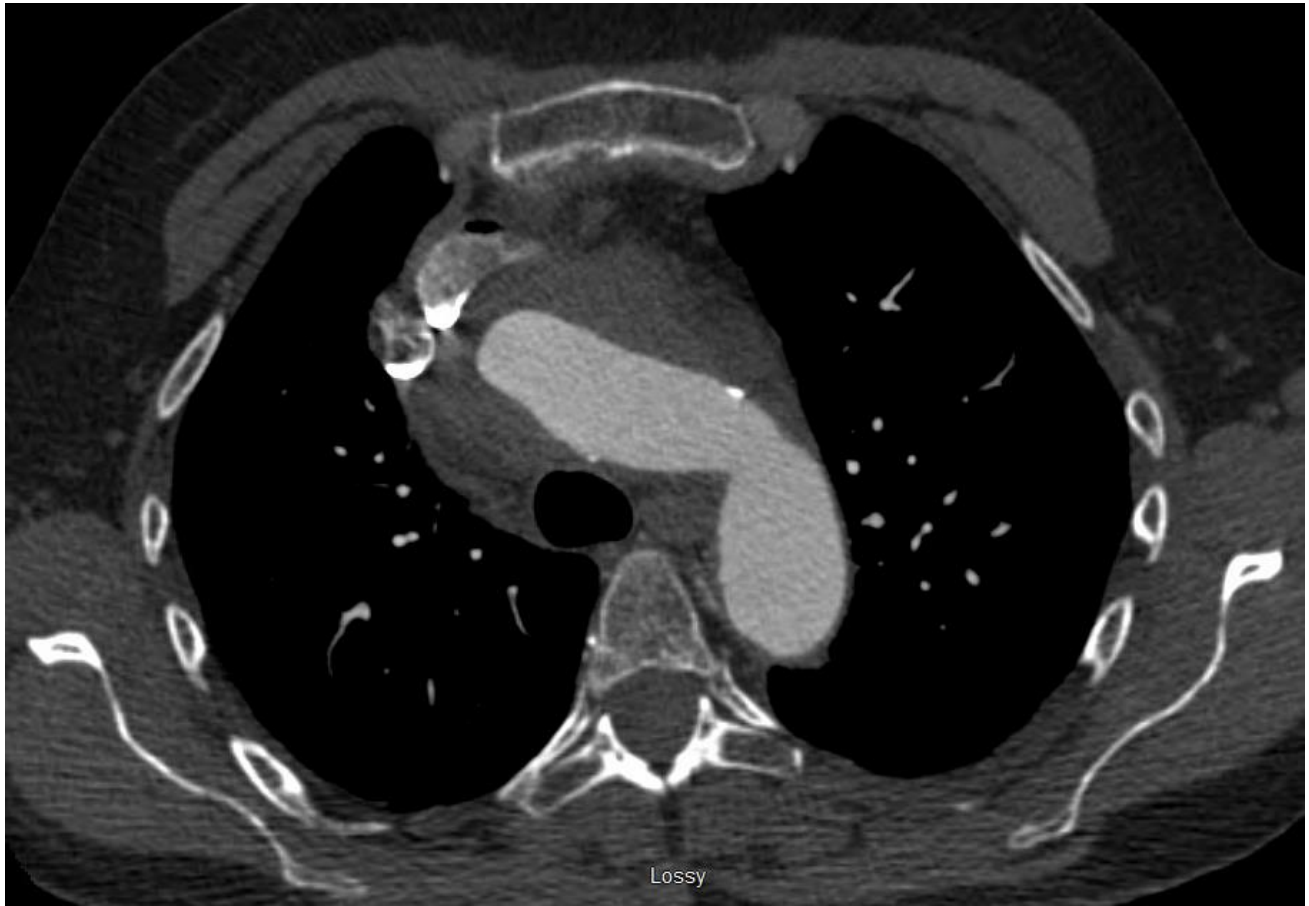
CTA POST – DISSECTION, False lumen thrombosed.



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CTA POST - DISSECTION

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We can now better assess individualized risk for surgery versus risk of AAE

STS Debuts Risk Calculator for Ascending Aorta and Aortic Root Surgery

Developed using data from more than 67,000 patients, the new calculator provides individualized operative risk estimates for four key procedural groups.

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Aneurysm Patient Selection

These tools, (AAE risk based on three factors, and STS surgical risk calculator), allow us to calculate a risk:benefit ratio for any patient with ascending aortic aneurysm for repair versus surveillance.

And at the time of aneurysm repair, what do we do with the valve?

Annular enlargement in aneurysms. Normal heart leaflet FELs match annular size, but virtually all aneurysms show annular enlargement. Jasinski et al Innovations 2021, 16(3):267-272

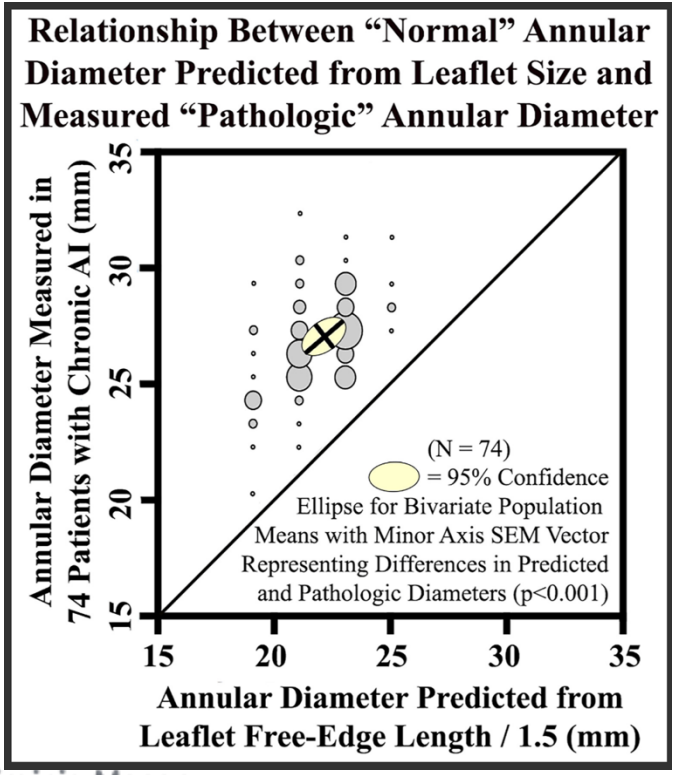

Figure 1. Comparison of "normal" annular diameter predicted from leaflet free-edge length and pathologic annular diameter assessed with Hegar dilators in 74 patients with chronic aortic insufficiency (AI). Measured annular diameter was enlarged to some extent in every patient. The 95% covariate confidence ellipse of mean values did not intersect the line of identity, indicating significant annular dilatation (minor axis standard error of the mean [SEM] vector) in most patients with chronic AI. Average pathologic dilatation (y-axis of ellipse center vs line of identity) was 4.9 ± 2.1 mm. Modified from Jasinski and associates.[1]

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Aortic valve treatment during aneurysm repair (annulus always abnormal)

Repair (ring) for any AR.

Consider repair (ring) for enlarged annulus despite minor or no AR to prevent later progressive dilatation and AR.

For root aneurysms, perform a Yacoub-variant valve sparing root replacement with a ring in place and sew dacron tongues of neo-sinuses to the pledgeted looping sutures that secure the ring (technique submitted for publication) which whould prevent future annular enlargement.

The arch may need reconstruction!

Zone 2 reconstruction of TAAD involving grafts to both dissected carotid arteries in the neck.

Arch reconstruction using modified antegrade cerebral perfusion under hypothermic circulatory arrest now routine and associated with minimal morbidity.

In the case of dissection this protects the cerebral vasculature from further dissection and embolization, and allows treatment of the chronic enlarged descending aorta without a need for repeat sternotomy and debranching.

This patient also had aortic valve repair with geometric ring.

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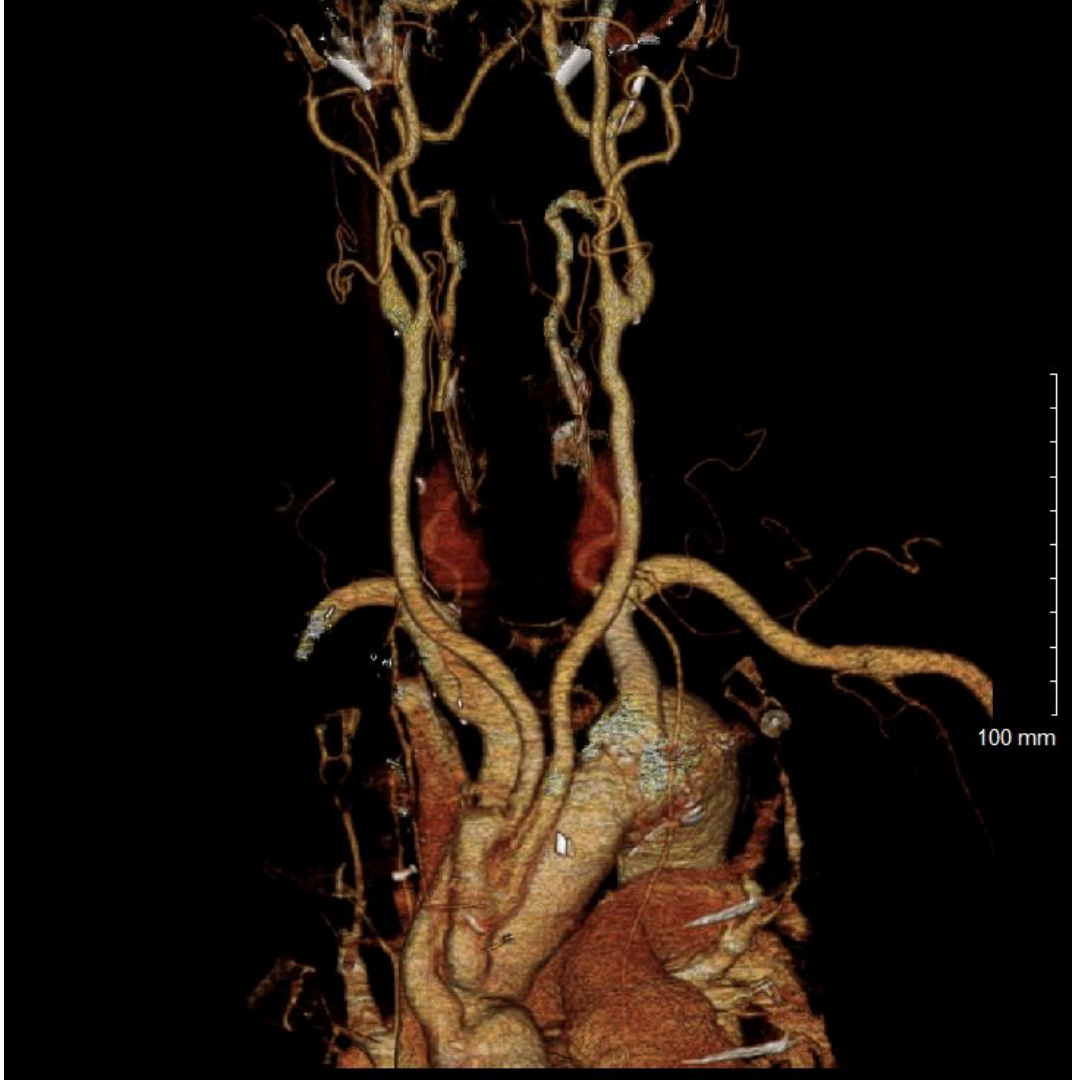
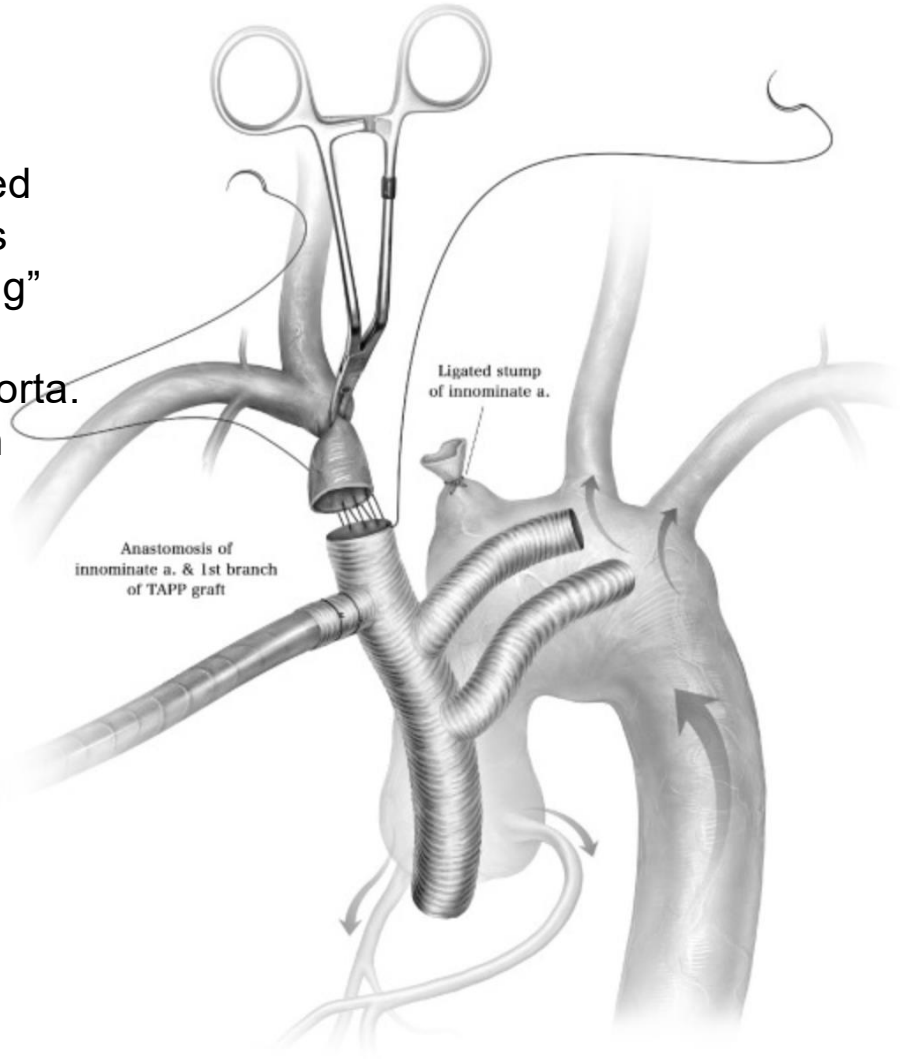


The branch-first technique places the patient on bypass but does not require circulatory arrest or antegrade cerebral perfusion to revascularize the head vessels. This is performed with a trifurcated graft with a side-port that allows perfusion of the head vessels as the “debranching” proceeds. Then typically a much shorter period of circulatory arrest to revascularize the aorta. This allows for a more expeditious operation with less physiologic stress for the patient.



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Thank You

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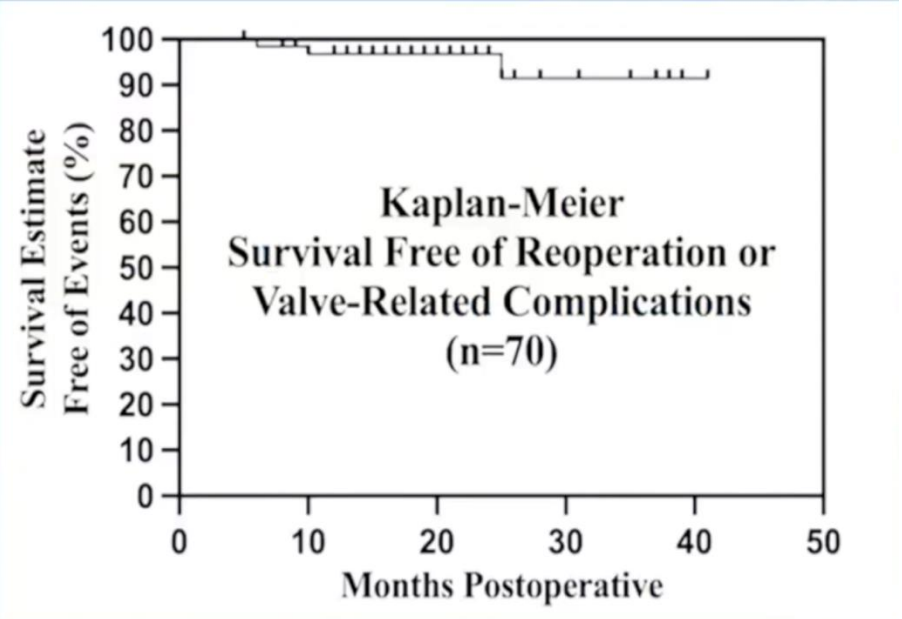
AATS 2021 - BAV Series - Results

All repairs successful

- Ring size: 21.6±2.2mm
- Aortic clamp time: 145±13min
- AI Grade Post-op: 0.2±0.8
- Mean Gradient: 12.3±5.8 mmHg

Max Follow-up 42 months (mean 20±9mths)
No early or late mortalities
3 valve related comp. (commissural rupture / suture fracture)
AI Grade FU: 0.2±0.6
Mean Gradient FU: 11.7±7.3 mmHg



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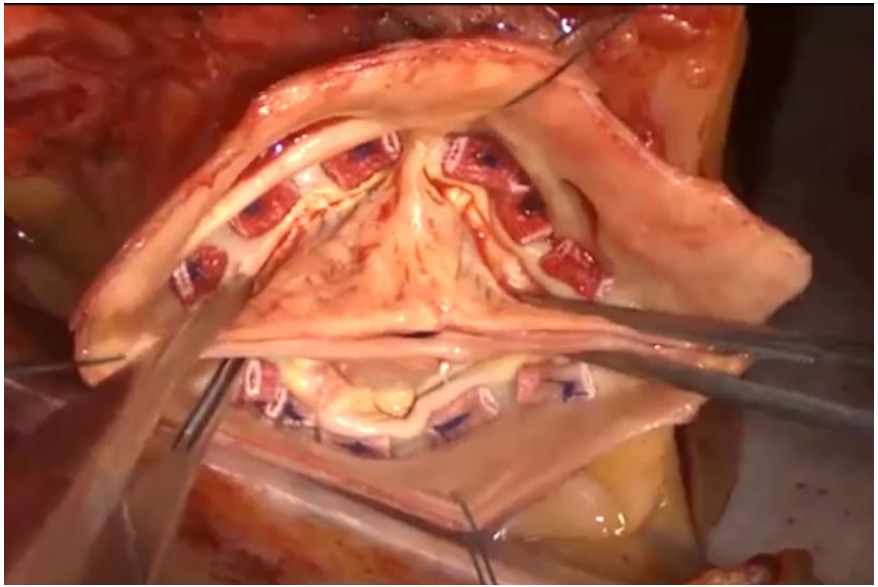
BAV Repair Simplified



HAART 200
Aortic Annuloplasty Device

- Circular shape delivers leaflets to midline
  - Straight line of coaptation between leaflets
  - Equalizing lengths & heights of parallel leaflets
  - Enables identification & closure of fused leaflet cleft
- 180° posts simplify leaflet reconstruction
- Create central transvalvular flow
- Sizing standardized from non-fused leaflet

  (Diameter = Leaflet free-edge length/1.5).

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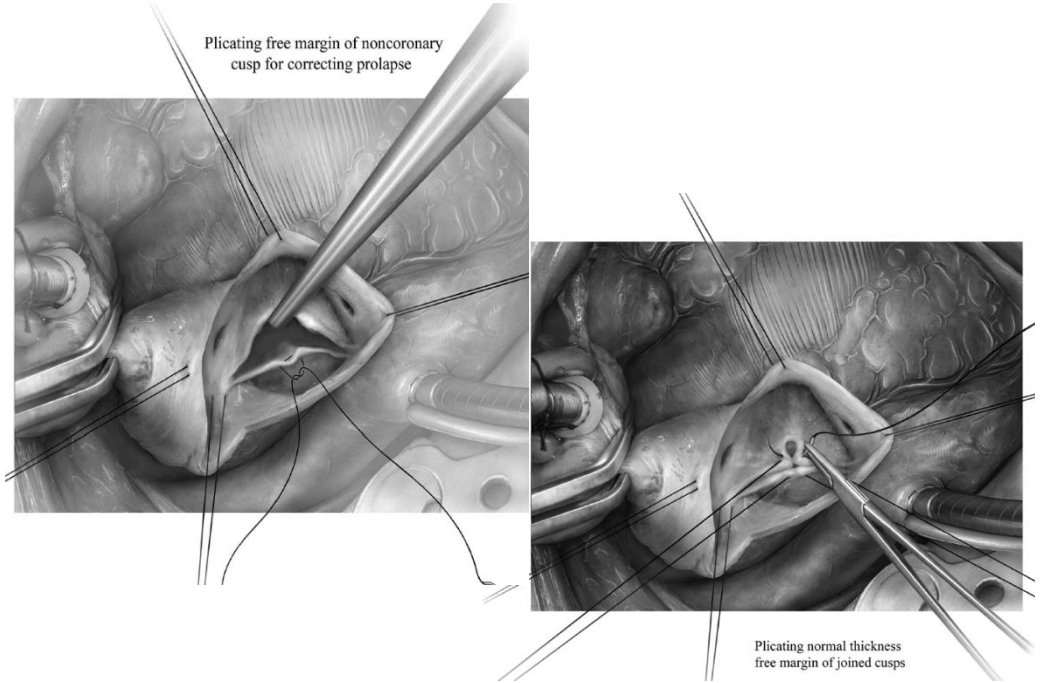
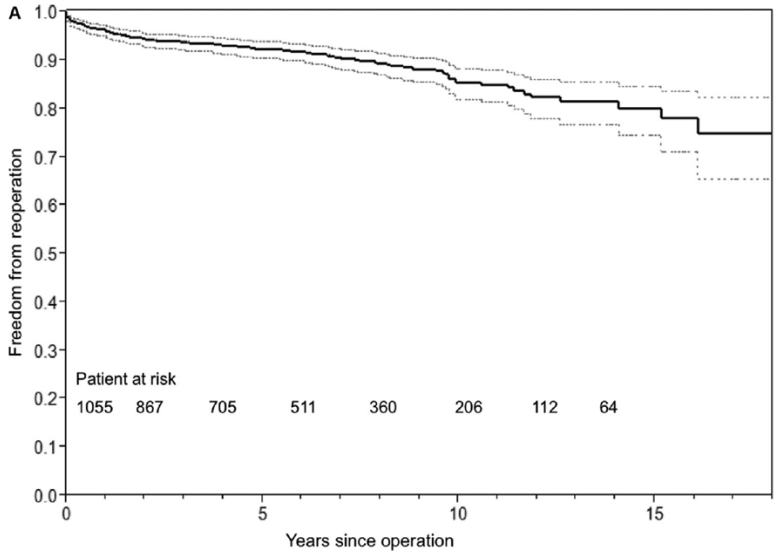
Aortic Valve Leaflet Repair - Schaefers Techniques for matching free edge length and optimizing coaptation





H-J Schaefers, 2007, 2020

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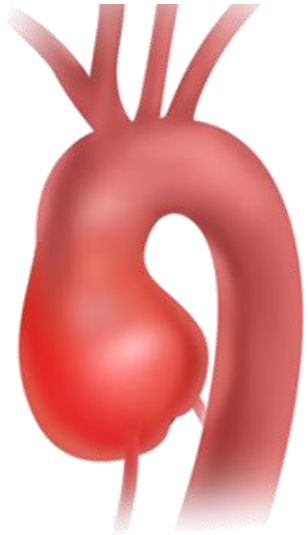
Applying Aortic Root Aneurysm Repair Experience to many types of AI



Experienced Application

- **Arch / Ascending Aneurysms**
- Dissections w/ AI
- **Syndromic Aneurysms**
- Complex Leaflet Pathologies
- **Bicuspid Aortic Valve Defects**
- Multiple Valve Repair
- **Isolated Aortic Insufficiency**
- Complex Congenital Applications

New & Emerging Applications

- Revision of Failed VSRR
- Dilated Ross Root
- Unicuspid (Type 2 BAV)
- Destination VAD w/ AI

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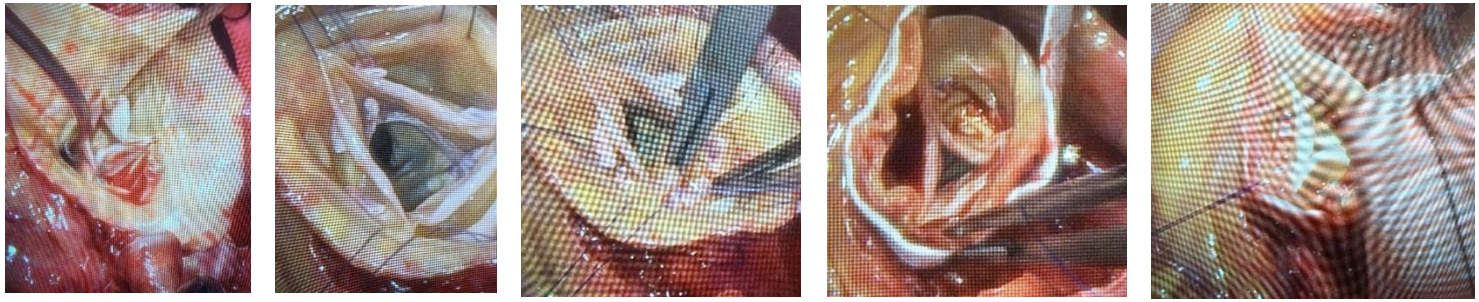
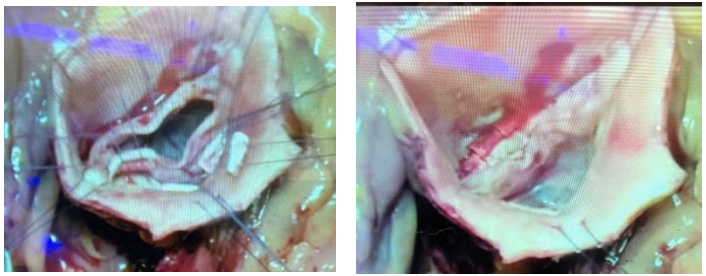
Aortic Valve Repair

Selected Case Examples

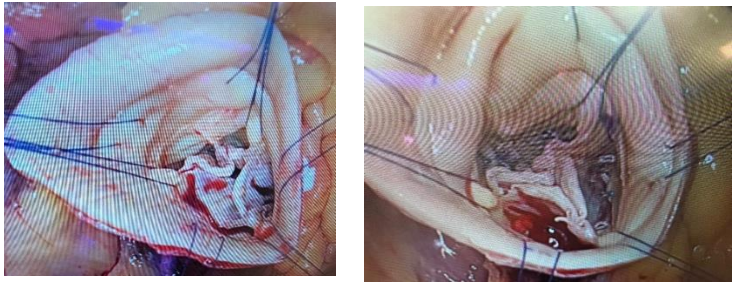
8cm Ascending Aortic Aneurysm



Symmetric Bicuspid Aortic Valve



Quadricuspid Aortic Valve



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Clinical issues:

- Aortic valve repair has been limited to a handful of centers due to large variation in causes of AR combined with lack of standardization and complexity of corrective procedures.
- Guideline indications for treatment of aortic insufficiency may be too conservative and are due for an update.

Recently Published Outcomes

ORIGINAL ARTICLE

Geometric Ring Annuloplasty for Aortic Valve Repair During Aortic Aneurysm Surgery

Two-Year Clinical Trial Results

J. Scott Rankin, MD, Domenico Mazzitelli, MD,† Theodor Fischlein, MD,‡ Yeong-Hoon Choi, MD, PhD,§ Jan Pirk, MD,|| Steffen Pfeiffer, MD,‡ Lawrence M. Wei, MD,* and Vinay Badhwar, MD**

Prospective, regulated EU clinical trial
47 pts with root / ascending aneurysm + AI
40 (85%) trileaflet & 7 (15%) bicuspid
96% survival - 2 late non-valve related deaths
98% freedom from reoperation – 1 recurrent AI
98% freedom from AI>2+ - 1 pt reoperated for AI

>25 peer-reviewed preclinical & clinical publications

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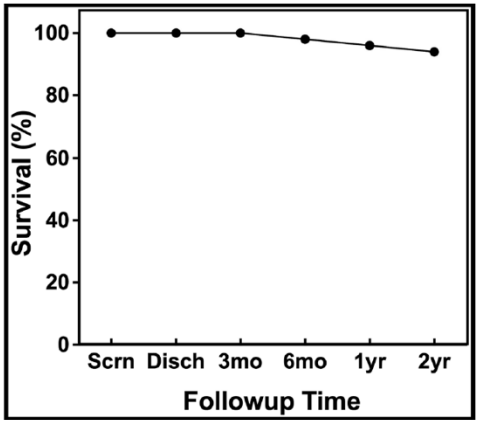
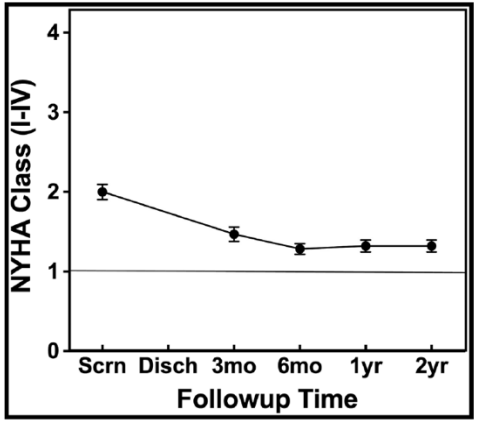
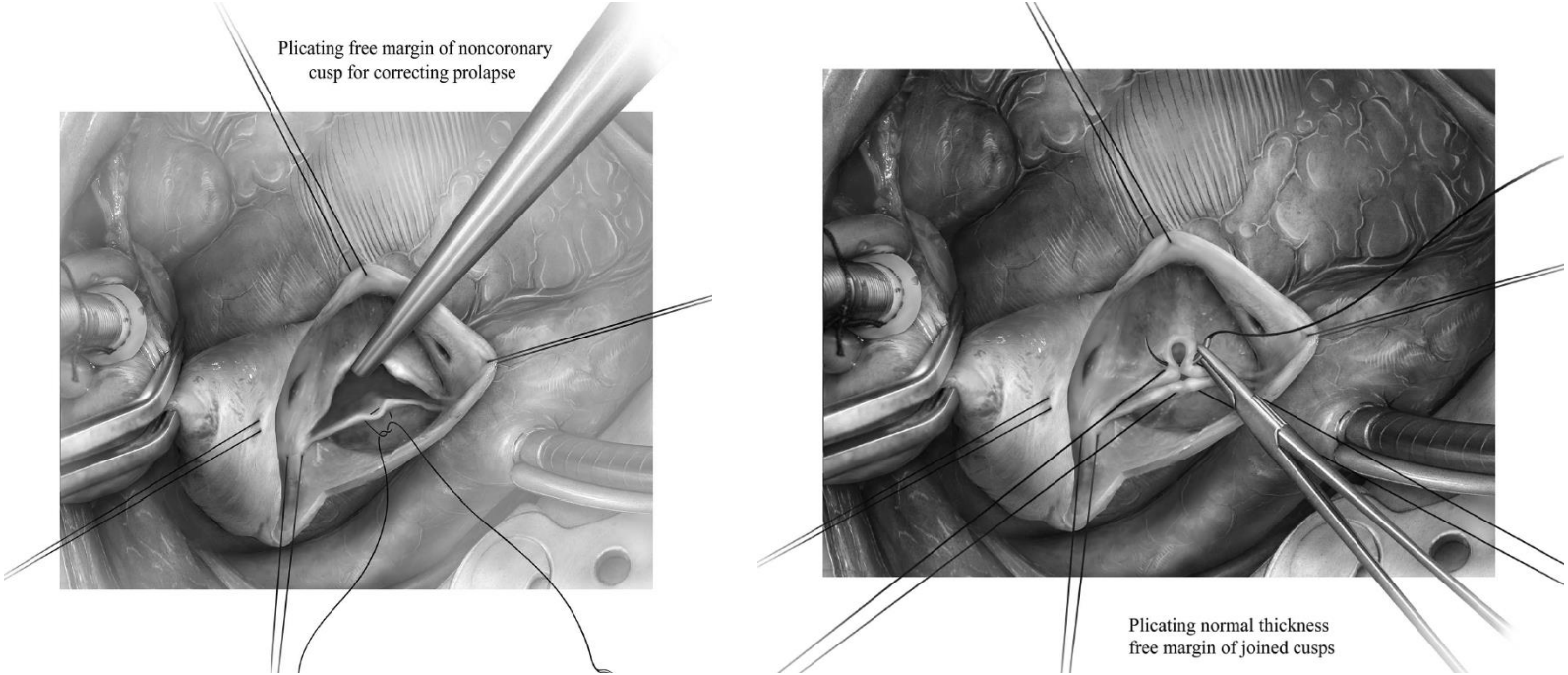




Bicuspid Valve Leaflet Repair - Schaefers



H-J Schaefers, 2007, 2020

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Divider Slide
Keep/edit as appropriate

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Current Status and Future Outlook of TAVR

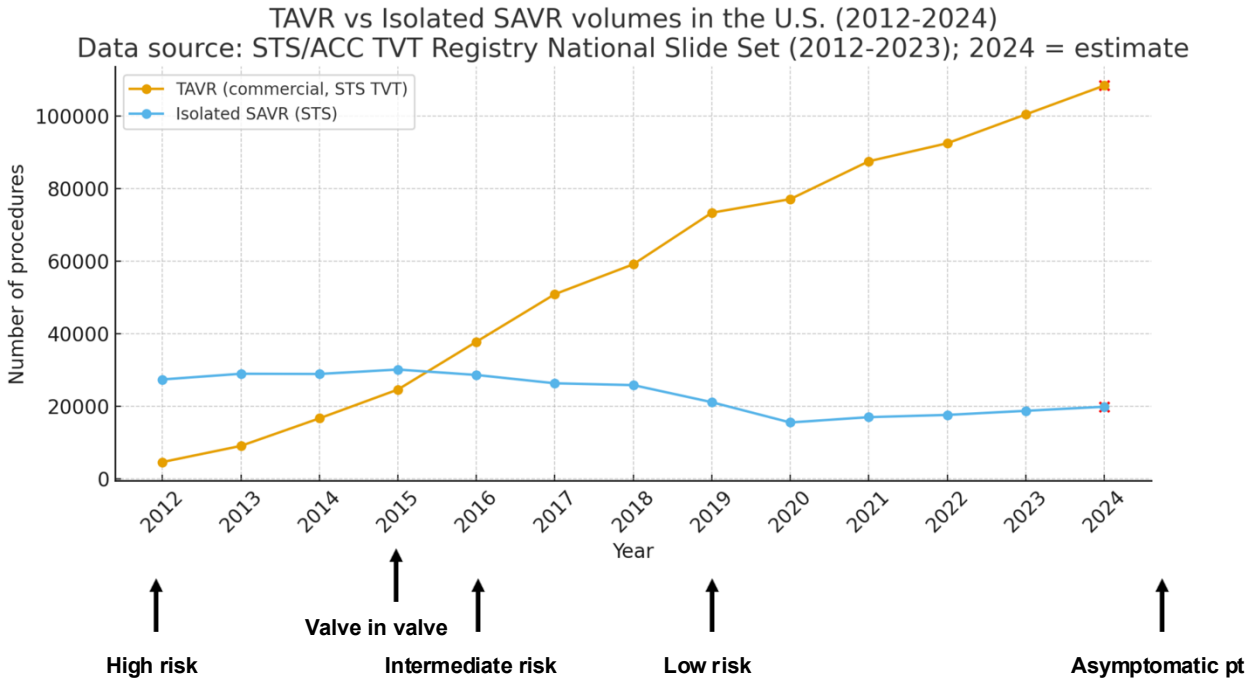
Ronald Reiter, MD

Virginia Mason Franciscan Health
Center for Cardiovascular Health

Disclosures

- NO RELEVANT DISCLOSURES

TAVR and SAVR Volumes in the US



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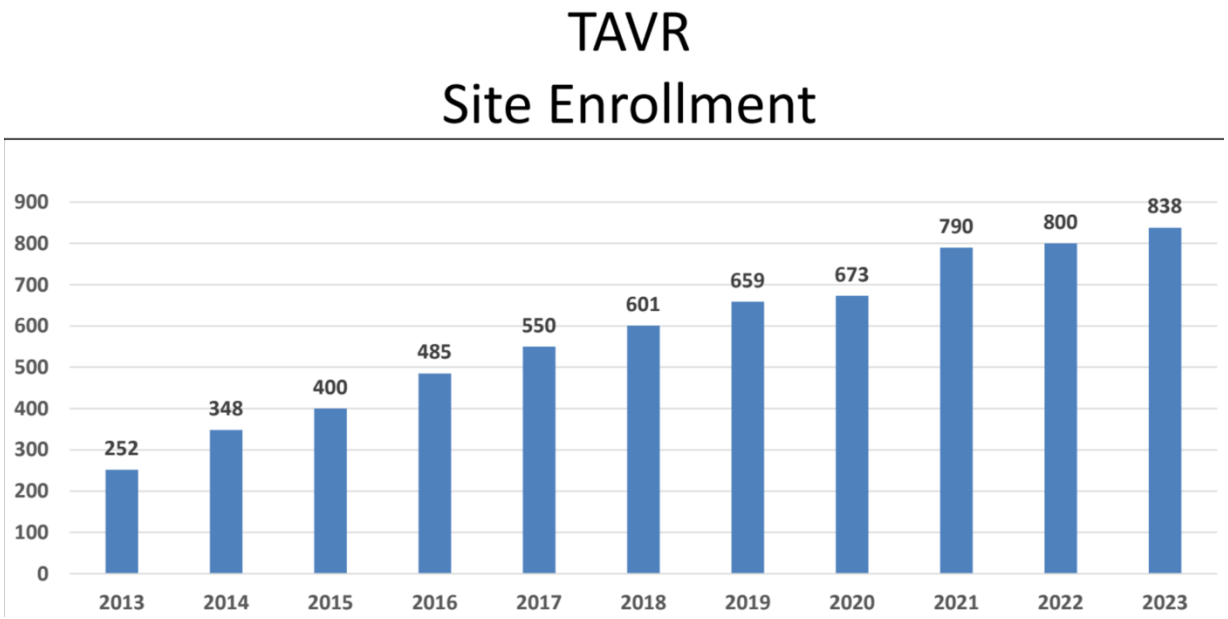
STS/ACC TVT Registry

Number of TAVR Sites in US



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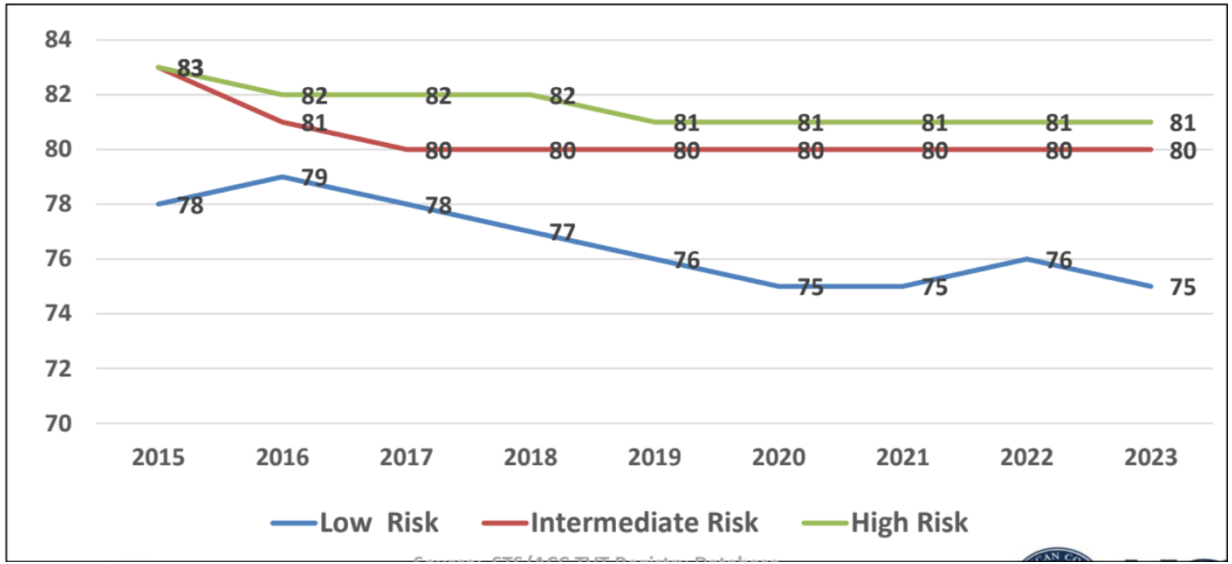
STS/ACC TVT Registry

Median Age of TAVR



STS/ACC TVT Registry

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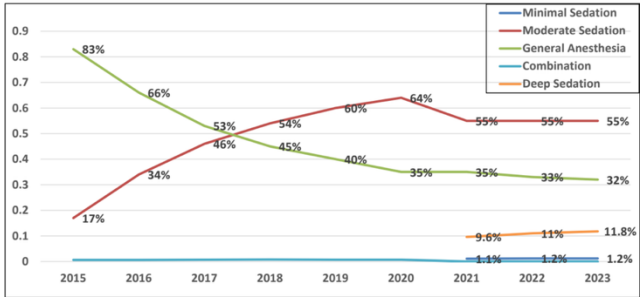
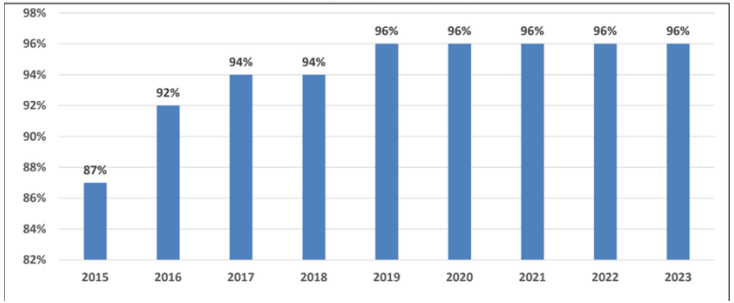
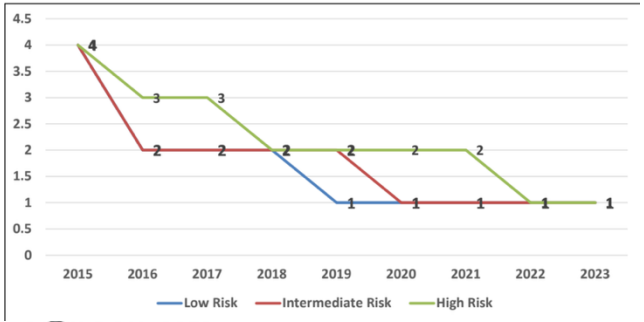
TAVR
Anesthesia Type



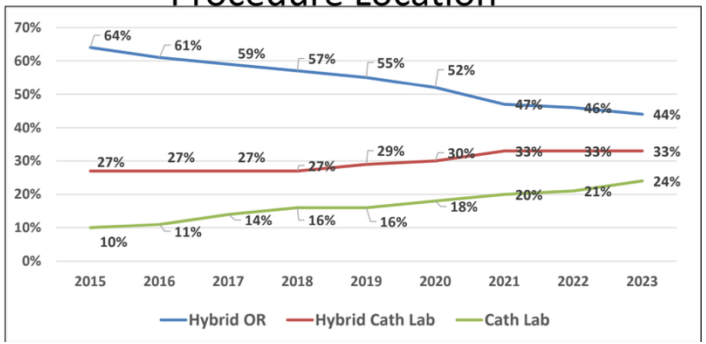
TAVR
Femoral Access



TAVR
Median LOS in Days



TAVR
Procedure Location



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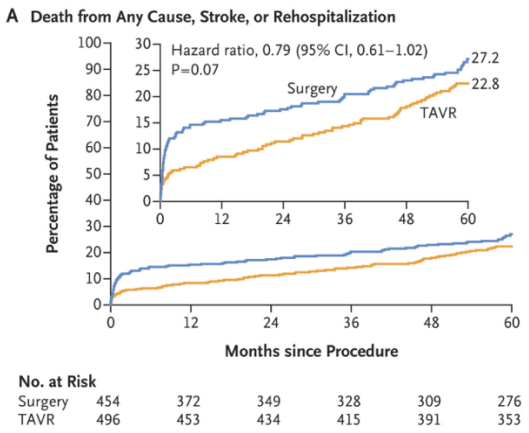
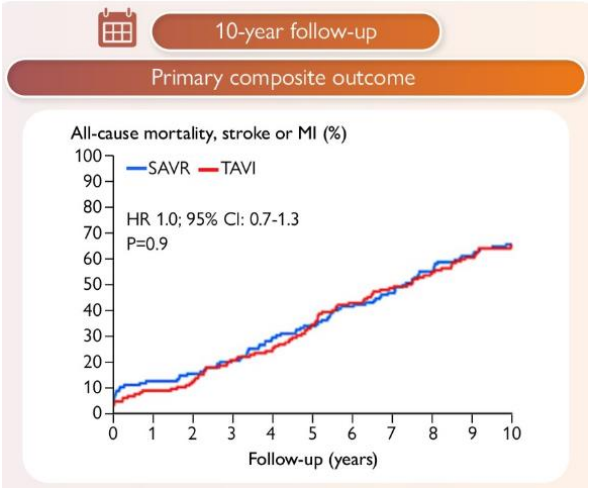
STS/ACC TVT Registry

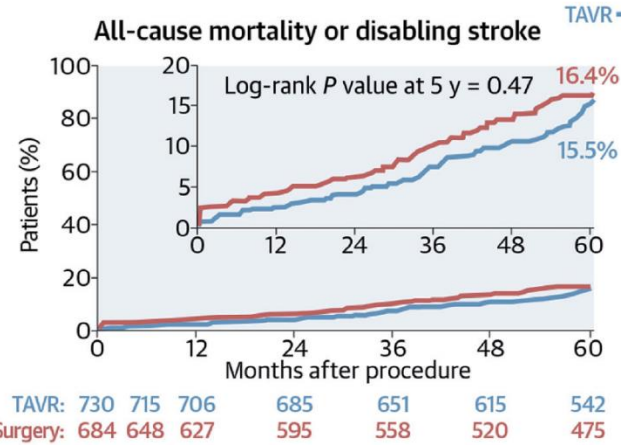
Expanding Indications and Patient Population

- Low Risk and Younger Patients
- Bicuspid Aortic Valve Disease
- Asymptomatic severe AS
- Moderate AS
- Use beyond AS

Low Risk Patients







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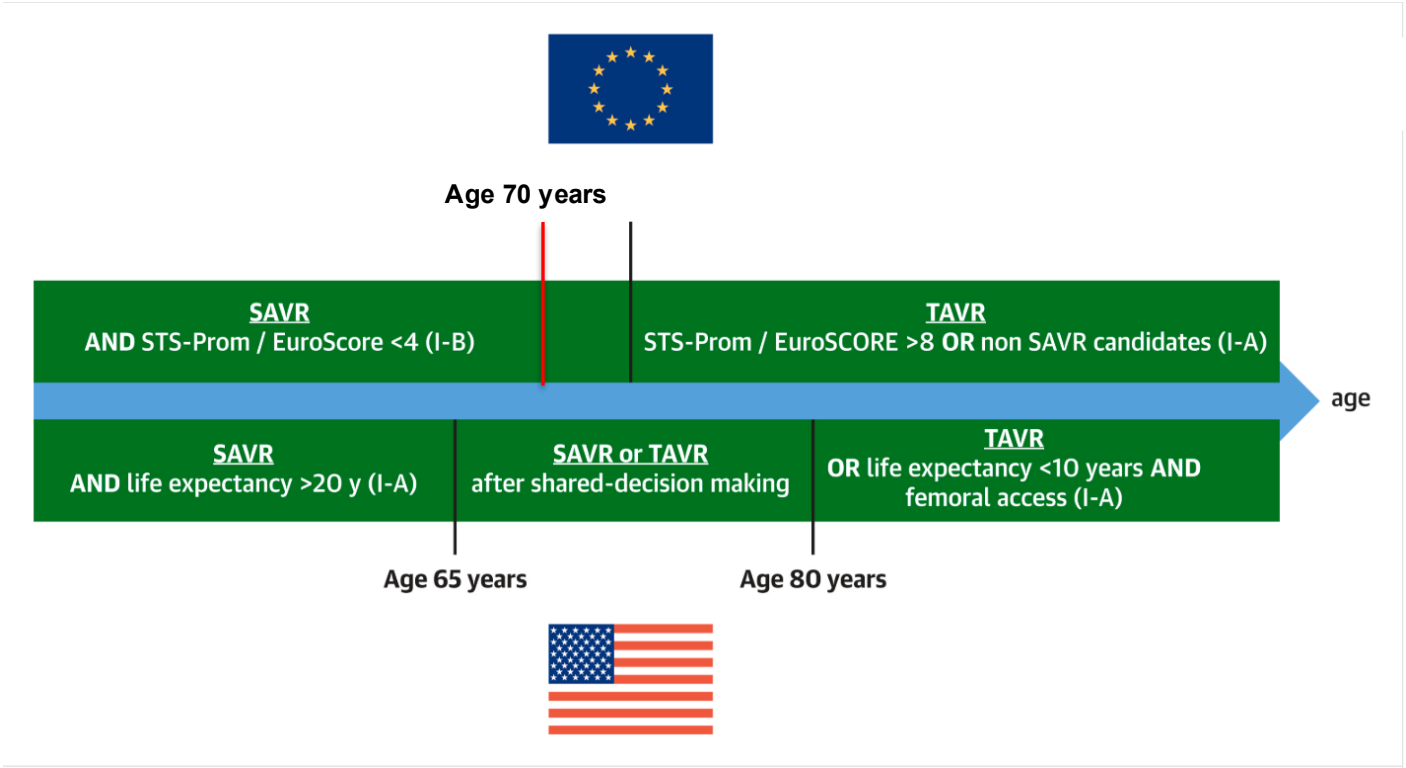
Partner, Evolute Low Risk and NOTION Trials

American and European Guidelines for AVR



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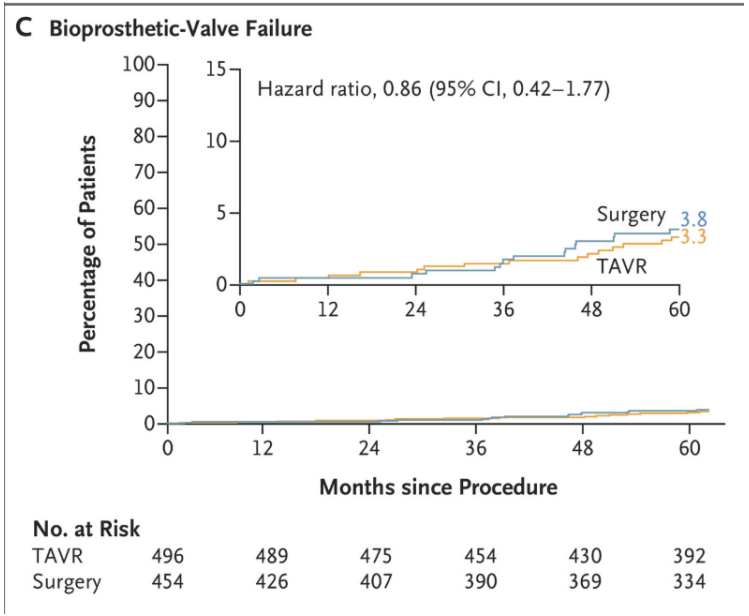
Theory
Practice

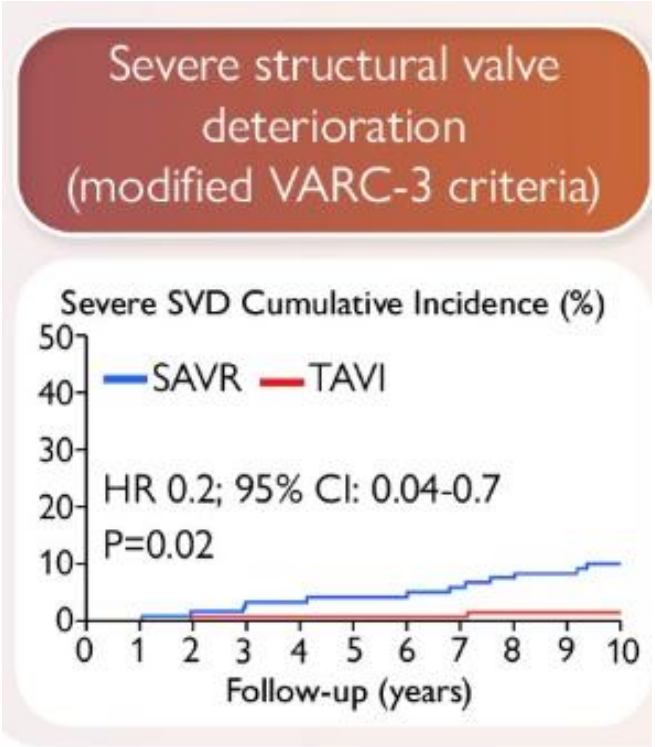
- **No one wants a mechanical valve**
- **No one wants SAVR if they can have TAVR**

Key Considerations in Younger Patients

- **Durable outcomes are essential**
- **The first intervention paves the way for lifetime management**

Longevity of Bioprosthetic Aortic Valve

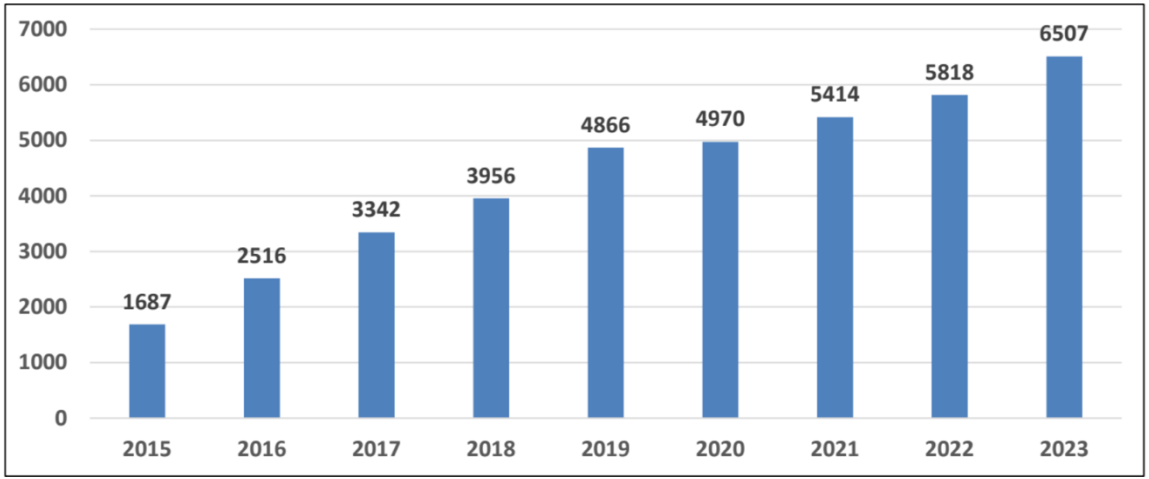




Partner and NOTION Trials

TAVR
Valve in Valve

(Includes TAVR in Prior Surgical AVR and TAVR in prior TAVR)



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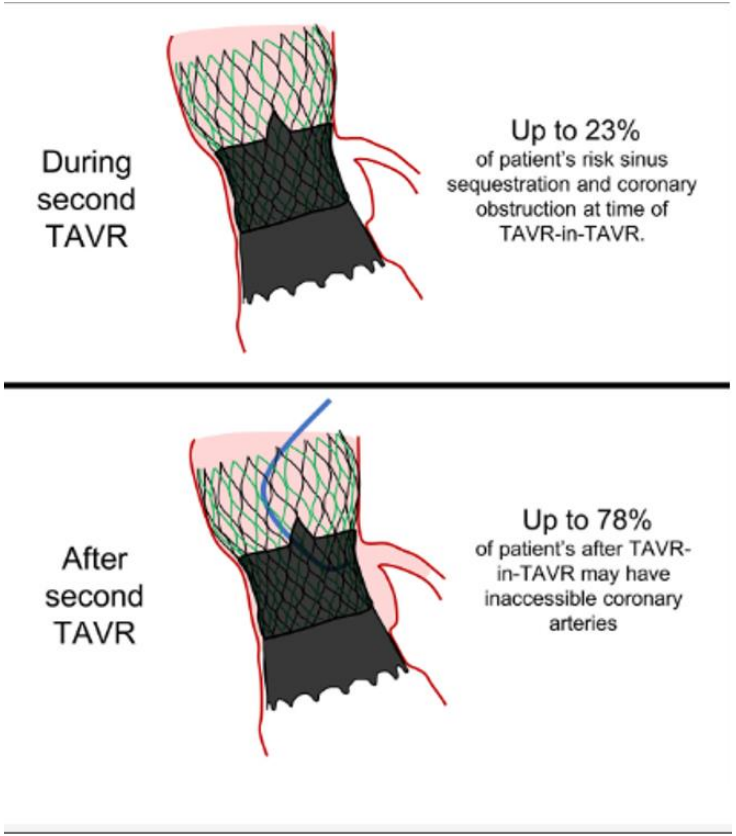
STS/ACC TVT Registry

Valve in Valve TAVR



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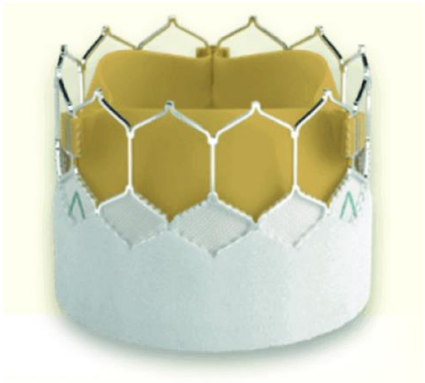
TAVR Valves Commercially Available in US



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Bicuspid Aortic Valve Disease

What we know

- Feasible and safe
- One-year mortality similar to surgery and TAVR
- Better results with newest generation of THV
- Better understanding of anatomical features and sizing

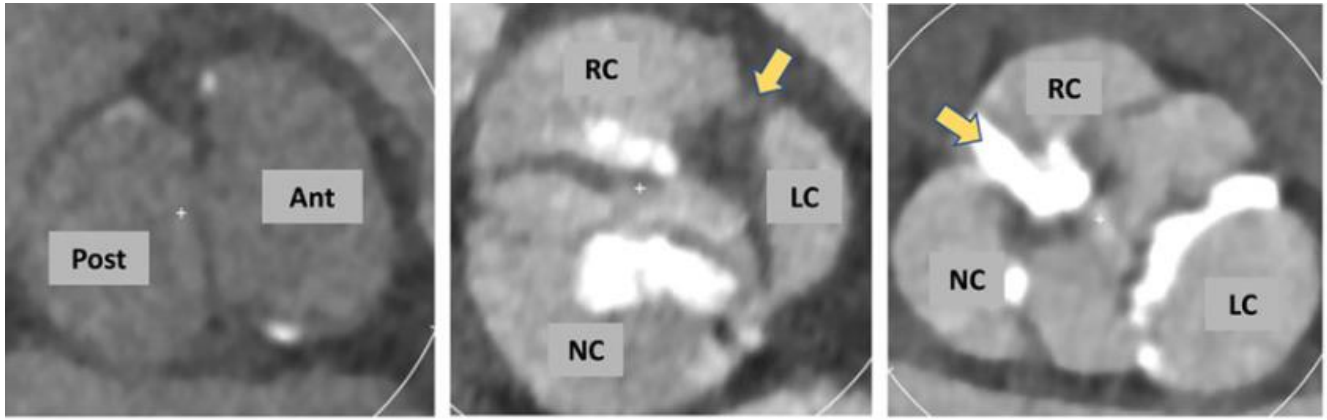
Concerns

- Higher risk of stroke
- Higher risk of pacemaker implantation
- Higher risk of annular rupture
- Higher risk of >=mild PVR

Remaining questions

- Type of valve based on anatomy
- Prosthetic valve durability
- Prosthetic valve thrombosis
- Evolution of aortopathy after TAVR

Anatomies of Bicuspid Valve



Circ, March 2021

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Trials in Asymptomatic AS

Trial	Population	# of patients & followup	Intervention	Result
RECOVERY	>4.5m/s	145 pts, 6.2yrs f/u	SAVR vs conservative	All cause mortality 7% vs 21% favoring SAVR
AVATAR	>4m/s, neg exercise test	157 pts, 2.7 yrs f/u	SAVR vs conservative	Composite endpoint 15% vs 35% favoring SAVR, mortality 10% vs 20% favoring SAVR, NS
EARLY-TAVR	>4m/s, neg exercise test	901 pts, 3.8 yrs f/u	TAVR vs conservative	Composite endpoint 27% vs 45% favoring TAVR, no difference in mortality
EVOLVED	>4m/s, fibrosis on CMR	224 pts, 3.5 yrs f/u	SAVR or TAVR vs conservative	Composite endpoint not significant

2025 ESC Guidelines

Indications for intervention in symptomatic and asymptomatic severe aortic stenosis, and recommended mode of intervention—*Section 8.5*		
Intervention should be considered in asymptomatic patients (confirmed by a normal exercise test, if feasible) with severe, high-gradient AS and LVEF ≥50%, as an alternative to close active surveillance, if the procedural risk is low.	**IIa**	**A**

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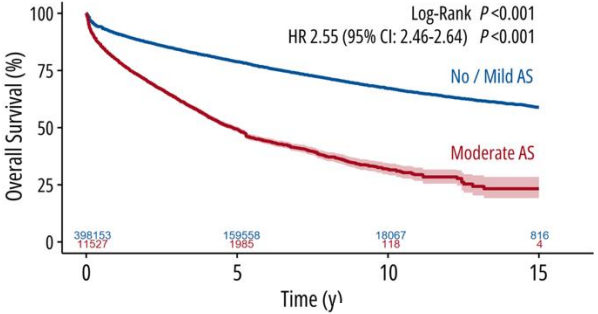
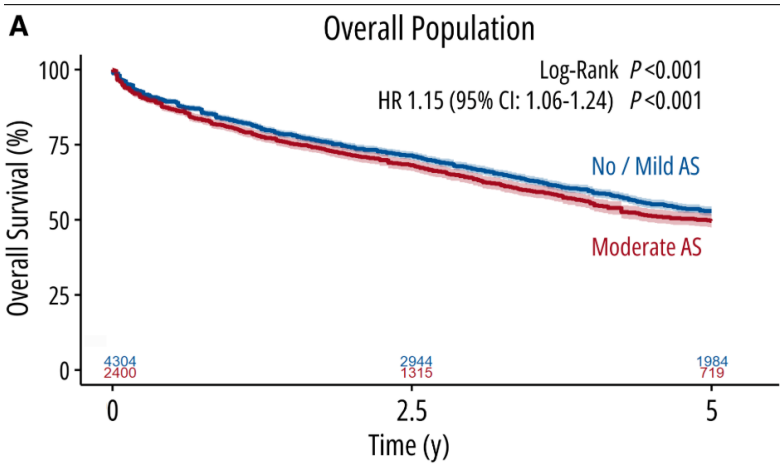
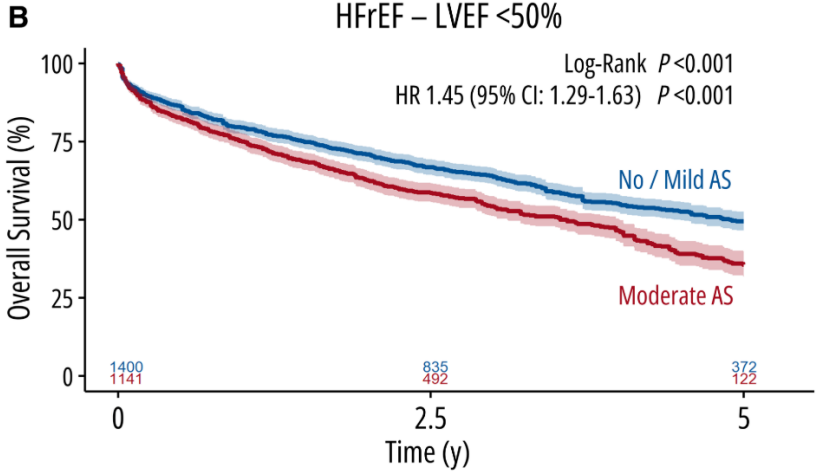
Survival in Moderate AS







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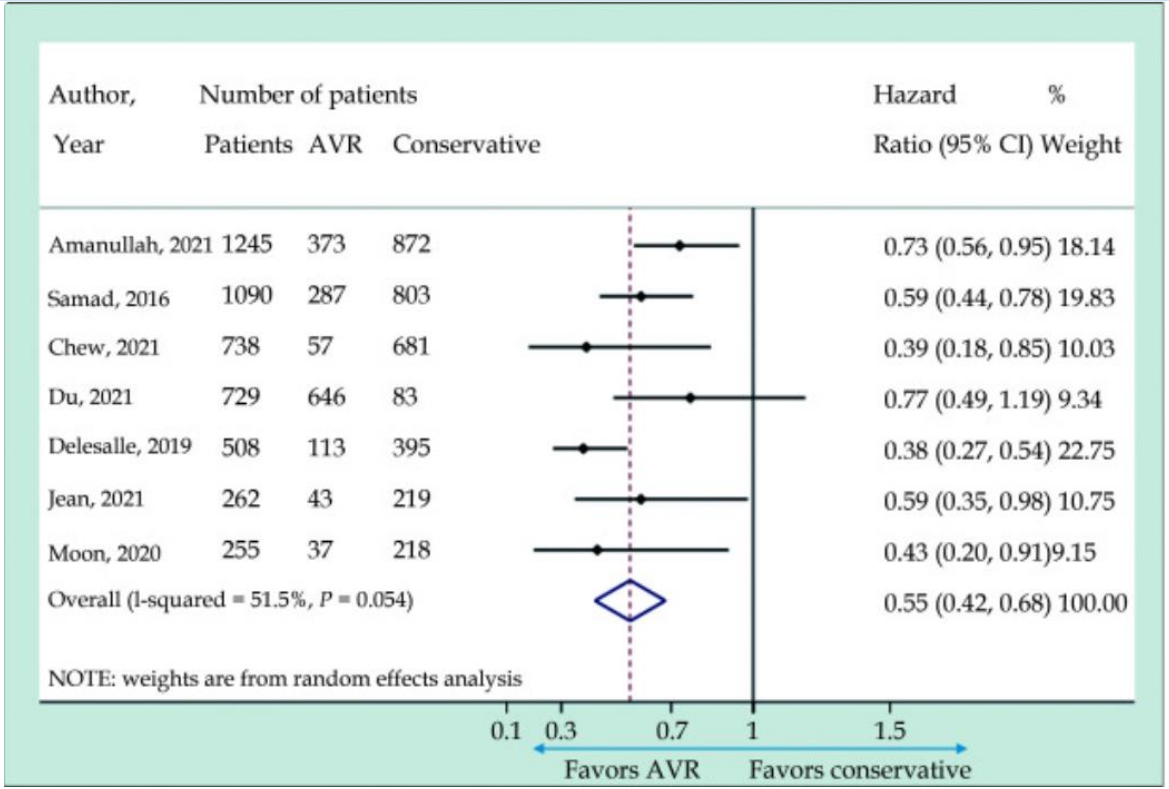
Jacquemyn et al, JAHA 2024

Mortality in Patients with Moderate AS according to Treatment



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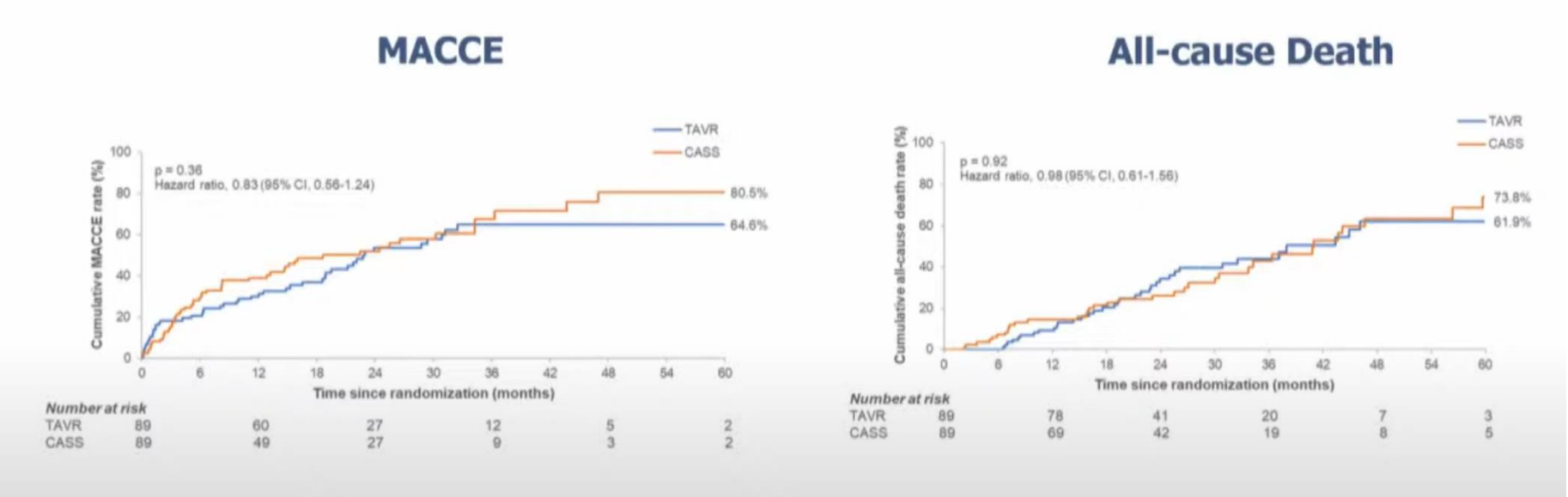
Franke, J Geriatr Cardiol 2023

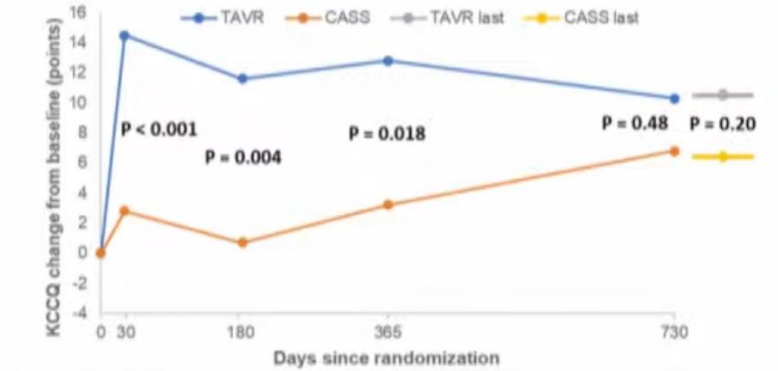
TAVR in Moderate AS

TAVR-UNLOAD

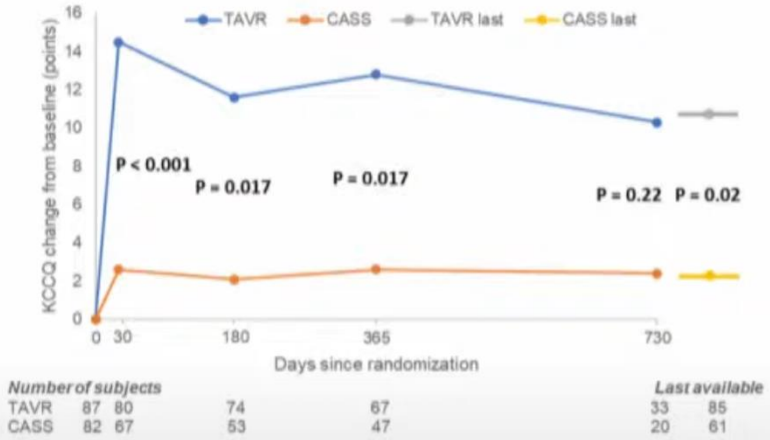


Van Mieghem, J Am Coll Cardiol 2024

Quality of Life by KCCQ



All available KCCQ-OS measurements



KCCQ measurements with CASS patients censored at the time of TAVR

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Van Mieghem, J Am Coll Cardiol 2024

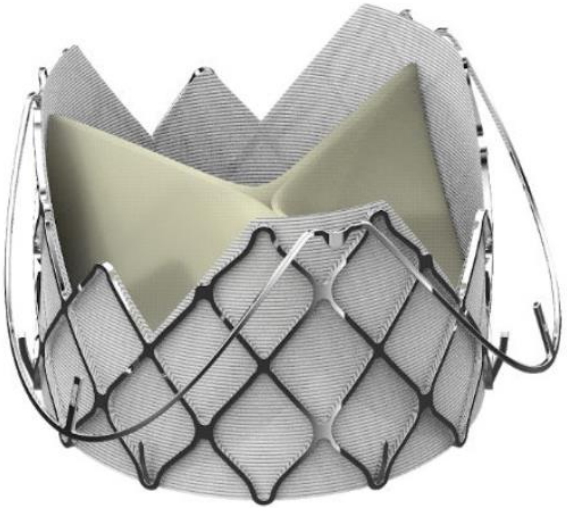
Ongoing Trials in Moderate AS

PROGRESS Trial – Moderate AS with symptoms or cardiac damage/dysfunction

EXPAND TAVR II – Moderate AS with additional risk features (low EF, Pro BNP, strain, E/e')

TAVR in Aortic Insufficiency

ALIGN-AR study (<1% mod or greater AR)



JOURNEY study

Thank You

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