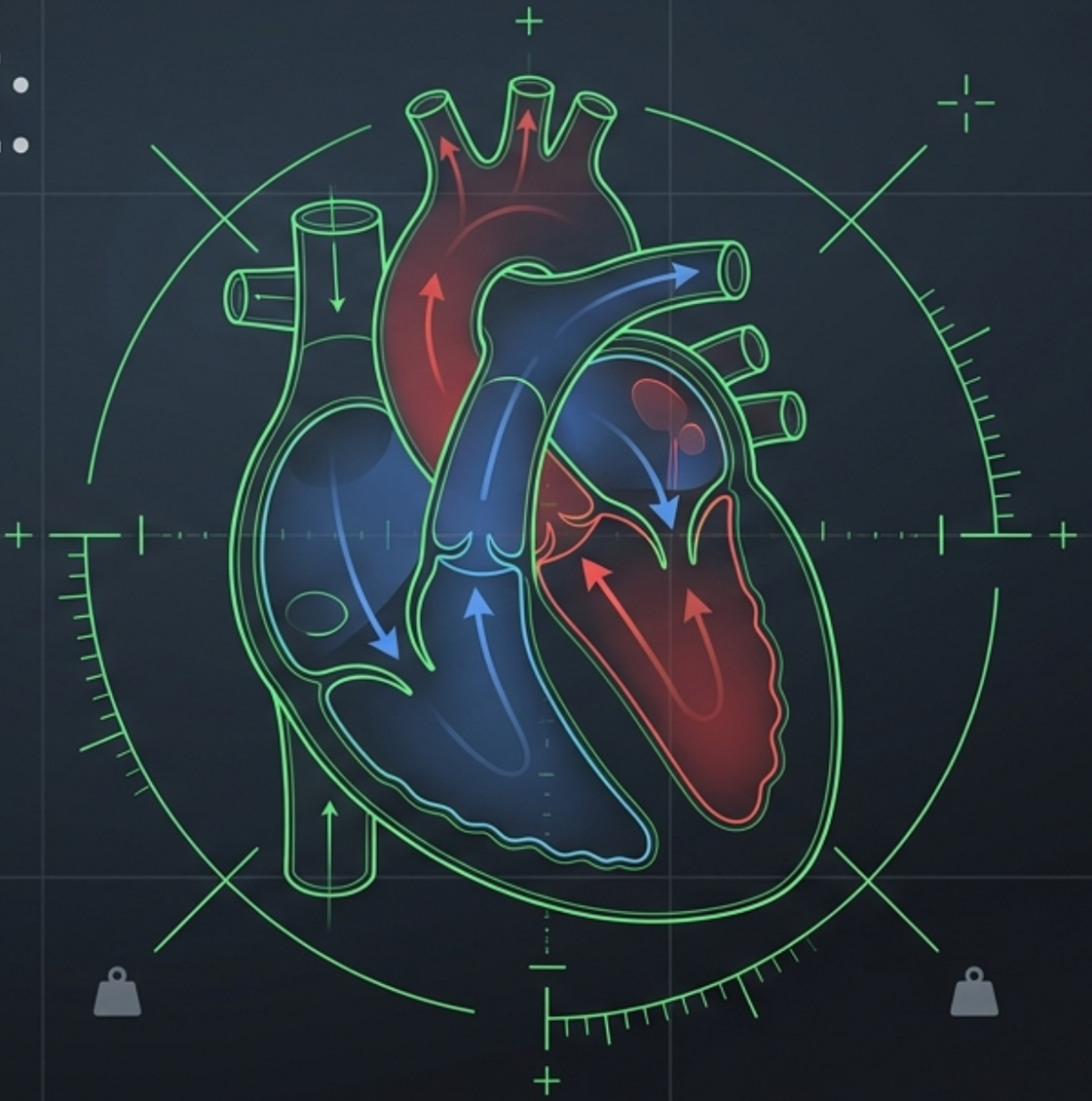
FPS: 19 | f: 5.0 MHz

TIS: 0.2 | MI: 0.4

Intraoperative TEE: The Surgical HUD

A High-Yield Visual Reference for Cardiac Surgery



DEPTH: 14 cm

TEMP: 37.0 C

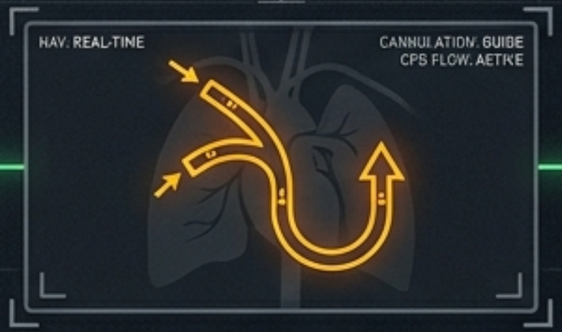
THE ACTIVE INTERVENTION PARADIGM

CONFIRM & REFINE

Verify preoperative diagnosis and measure baseline anatomy under anesthesia.

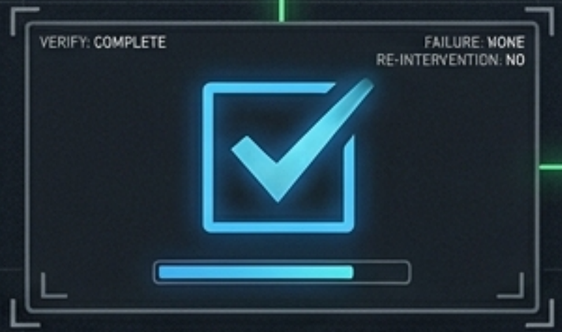
DETECT THE UNSEEN

Identify incidental findings that alter the surgical plan (e.g., PLSVC, PFO, aortic atheroma).



GUIDE THE INTERVENTION

Provide real-time navigation for CPB cannulation, cardioplegia, and de-airing.



ASSESS THE RESULT

Perform early post-CPB verification to rule out structural failure, iatrogenic injury, or re-intervention.

THE TEE MODALITY MATRIX: STRENGTHS & BLINDSPOTS

2D / M-Mode

STRENGTHS
Anatomical baselines and rapid temporal measurements.

PITFALLS
Off-axis foreshortening; extreme angle dependency.

3D Echocardiography

STRENGTHS
Spatial context, en face Surgeon's Views, and volumetric analysis.

PITFALLS
Low temporal resolution; stitch artifacts in gated multi-beat acquisition.

Color Flow Doppler (CFD)

STRENGTHS
Rapid flow acceleration mapping and jet localization.

PITFALLS
Subject to Coanda effect (wall-hugging jets); low temporal resolution.

Spectral Doppler (CW/PW)

STRENGTHS
Velocity profiling and continuity equation derivations.

PITFALLS
Extreme sensitivity to beam misalignment and dynamic loading conditions.

Right vs. Left Ventricular Diagnostics

Left Ventricle (LV)

Method of Disks

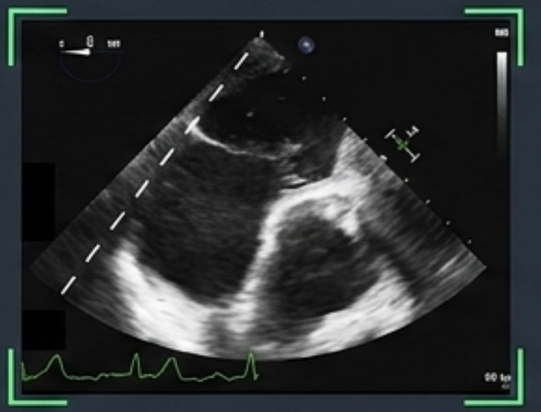
3D Volumetric Analysis

LVOT Stroke Volume

WARNING: LV parameters are highly sensitive to preload/afterload. Validate under simulated baseline physiology.

Right Ventricle (RV)

Challenge: Complex geometry requires specialized metrics.



TAPSE (<1.7cm abnormal): Neglects RVOT and regional wall motion; angle dependent.

Tissue Doppler S' (<9.5 cm/s abnormal): Angle dependent; ignores RVOT.

FAC (<35% abnormal): Trabeculations introduce errors.

Mitral Valve Pre-Flight: Anatomic Mapping

The Orientation Check

Aortic Valve is always anchored at 12 o'clock, regardless of LA or LV perspective.

Targeted Measurements

Anatomic MVA traced in mid-diastole (TG basal SAX).

Stenosis Pitfalls

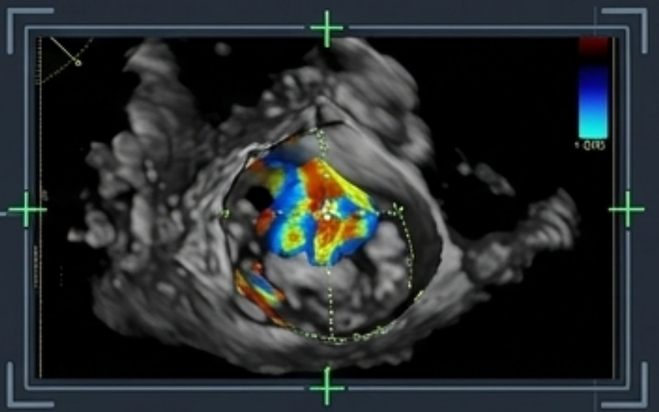
- Excessive 3D gain underestimates MVA (acoustic noise artificially thickens calcified leaflets).
- Pressure gradients are highly heart-rate and flow dependent.

Mitral Regurgitation: The Jet Diagnostic Funnel

1. Mechanism (Origin & Direction)

Points AWAY from excessive motion (Primary/Prolapse)

Points TOWARD restricted motion (Secondary/Tethered)



2. Severity (Vena Contracta)

Non-circular, elliptical orifices cause vena contracta and PISA to underestimate severity.
DO NOT SUM MULTIPLE JETS.

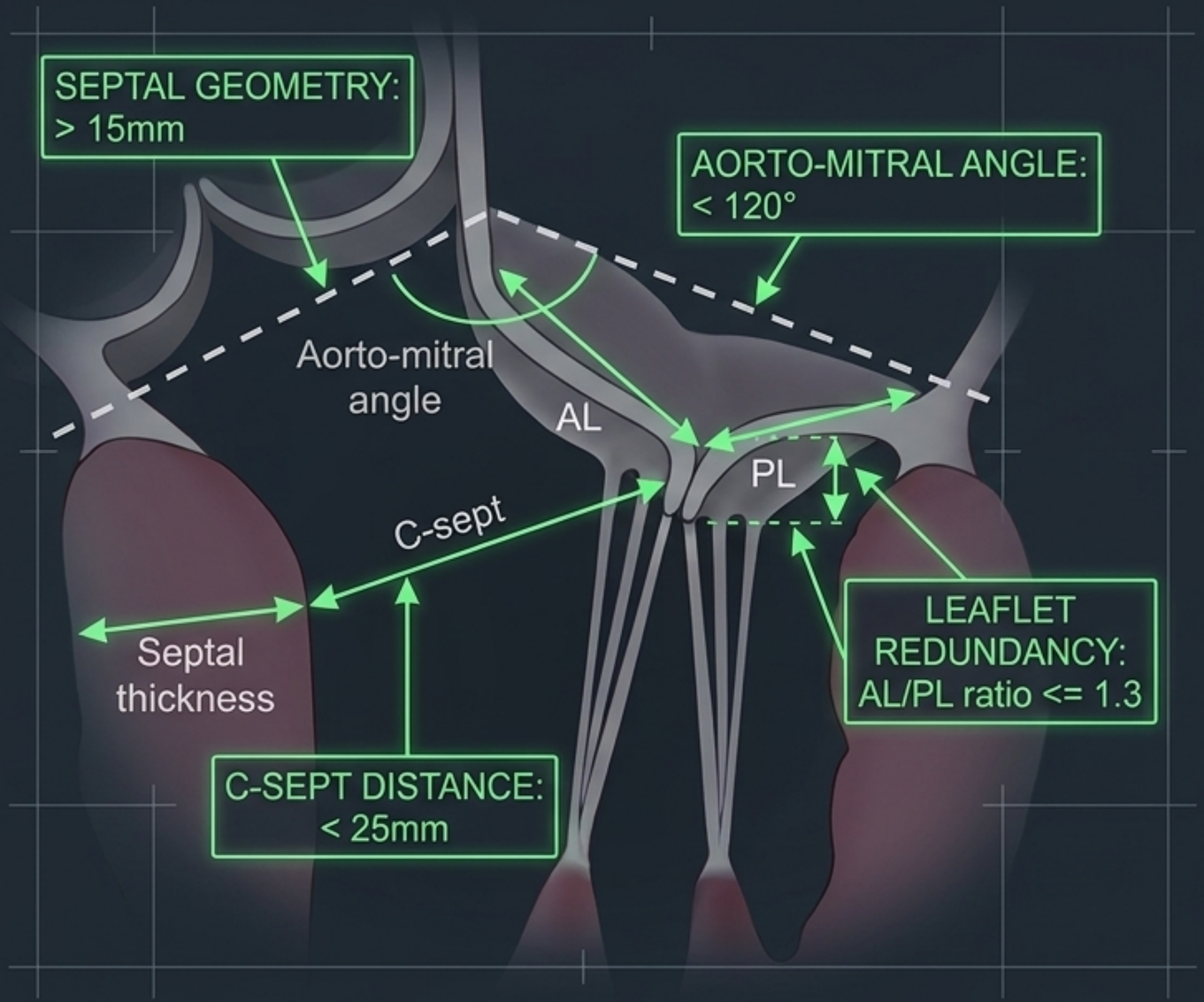
Non-circular, elliptical orifices cause vena contracta and PISA to underestimate severity.
DO NOT SUM MULTIPLE JETS.

3. The Hemodynamic Reality

Functional MR severity artificially IMPROVES under general anesthesia. Requires rigorous volume/afterload challenge to simulate baseline.

KEY INDICATOR: Systolic flow reversal in >1 pulmonary vein is specific, but insensitive, for severe MR.

The SAM Predictor Overlay



The Threat Map (SAM Risk Factors)

SEPTAL GEOMETRY:
Basal IVS > 15mm

C-SEPT DISTANCE:
Coaptation to septum < 25mm

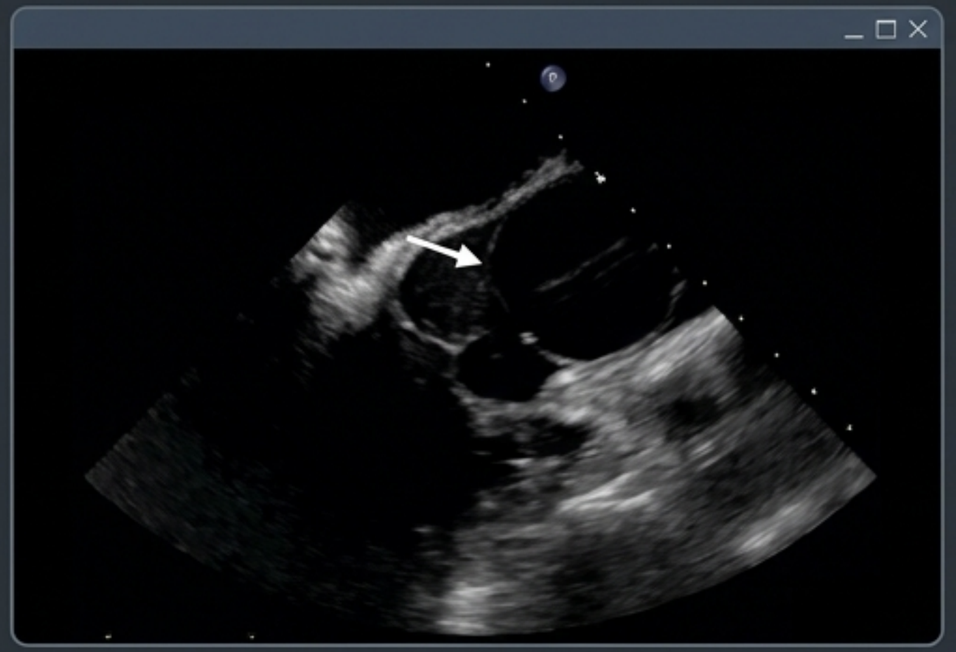
AORTO-MITRAL ANGLE:
< 120°

LEAFLET REDUNDANCY:
AL/PL height ratio <= 1.3
(measured annulus to coaptation)

CLINICAL CONTEXT:
Risk is highest in myxomatous MV with redundant anterior leaflets and hyperdynamic left ventricles.

TEE Guidance in Minimally Invasive MV Surgery

Step 1: Ascending Aorta Endoballoon

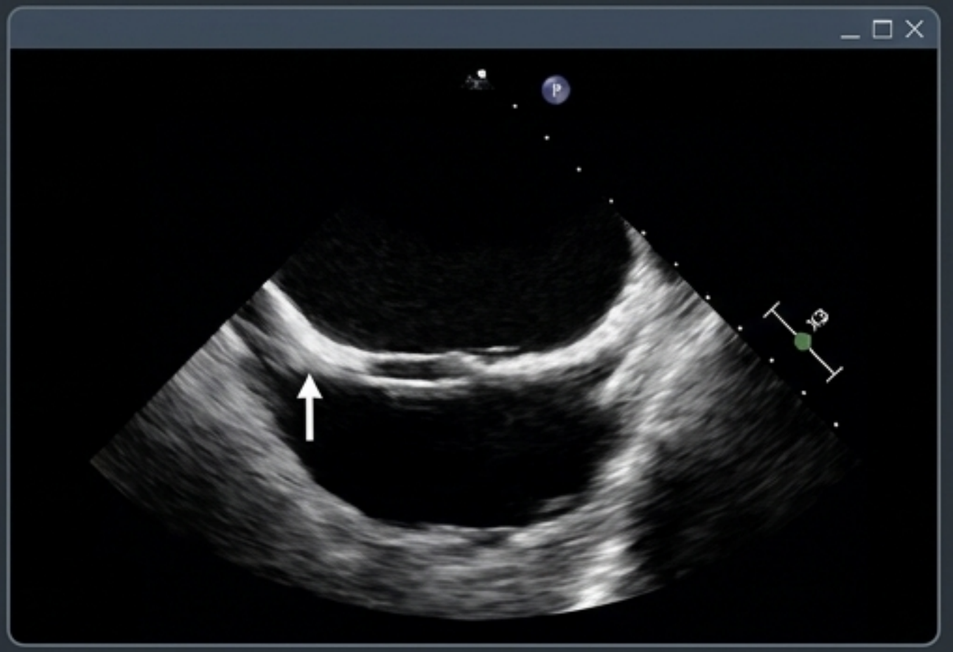


VIEW: ME AV LAX

ACTION: Balloon placed 2-4 cm above Sinuses of Valsalva.

VERIFICATION: CFD confirms complete aortic occlusion; strictly monitor for migration during CPB.

Step 2: Coronary Sinus (CS) Catheter



VIEW: ME modified bicaval -> deep ME 4Ch

ACTION: Advance via RA into CS.

PREREQUISITE: Must rigorously exclude Persistent Left Superior Vena Cava (PLSVC) prior to placement to ensure retrograde cardioplegia works.

Mitral Valve: Post-Flight Verification

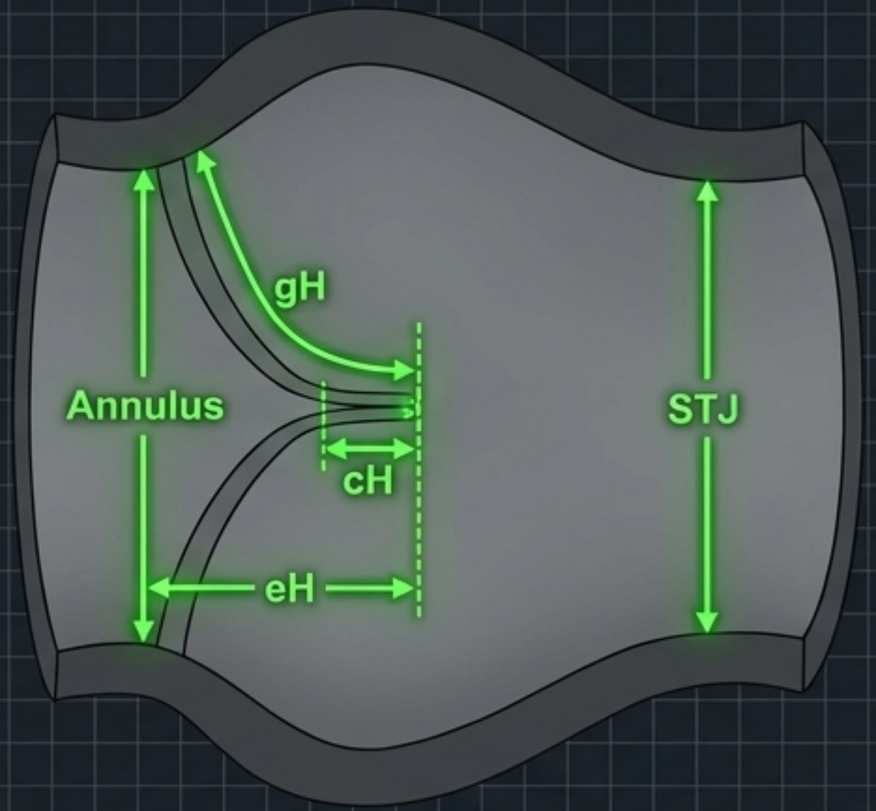
PASS	Residual MR	Expect <= mild. Must rigorously test under optimized preload and afterload conditions.
FAIL	Iatrogenic MS	Thresholds: Mean gradient > 6 mmHg OR Area < 1.8 cm2. Note: Transmitral gradients are highly dependent on HR/rhythm.
FAIL	Systolic Anterior Motion (SAM)	Look for LVOT flow acceleration and POSTERIORLY directed eccentric MR.
PASS	Circumflex Injury	Verify regional wall motion of the lateral/posterior LV, as the artery can be caught in the annuloplasty ring.

Aortic Root Architecture & Pre-Flight Sizing

BLUEPRINT DIMENSIONS (LEFT)

ANNULUS: Measured inner-edge to inner-edge in early/mid-systole.

STJ: Sinotubular Junction measurement.



BLUEPRINT DIMENSIONS (RIGHT)

eH (Effective Height) & cH (Coaptation Height): Normal coaptation is 1-2 mm, occurring strictly ABOVE the annular plane in the mid-sinus.

CRITICAL SIZING:
Sizing the LVOT diameter at the annulus vs. sub-annulus is critical; sub-annular measurement in a sigmoid septum may falsely underestimate Aortic Valve Area (AVA).

Aortic Valve: Hemodynamic Profiling

Aortic Stenosis (AS)

CHALLENGE: General anesthesia alters cardiac loading, often severely lowering pressure gradients compared to awake TTE.

SOLUTION:

- Use indexed AVA (<0.6 cm2/m2) for small patients.
- Rely on flow-independent metrics (AVA, velocity ratio) when flow is reduced.

Aortic Regurgitation (AR)

CHALLENGE: Quantitative volumes and EROA measurements are often impractical during fast-paced OR assessment.

SOLUTION:

- Use multi-plane, micro-adjustments (probe depth/rotation) to hunt for eccentric jet origins.
- Focus strictly on vena contracta width and holodiastolic flow reversal.

Aortic Valve: Post-Flight Verification

VERIFIED

Valve Competence

Confirm no/minimal residual AR. Ensure flawless motion of prosthetic disks/ leaflets.

VERIFIED

Paravalvular Leaks

Sweep the sewing ring from 0° to 180°. Distinguish true pathological leaks from normal normal mechanical washing jets.

Note: Moderate/Severe = Immediate Intervention

VERIFIED

Coronary Ostial Flow

Rule out ostial compromise (suture blockage/graft kinking) by confirming flow via CFD and monitoring for new global/regional wall motion abnormalities.

VERIFIED

LV De-airing

Use TEE to actively guide the removal of microscopic air from the left ventricle before formally formally discontinuing CPB.

Tricuspid Valve: The Right-Heart Dashboard

Structural Assessment (Pre-Flight)

- FOCUS: Functional TR is frequent and highly associated with left-heart disease.
- KEY MEASUREMENT: Tricuspid Annulus (TA) measured precisely in ME 4Ch.
- MODALITY NOTE: Use CW/PW Doppler and CFD for TR jet orientation. BEWARE of far-field position causing severe acoustic limitations.

Post-Flight Verification

- Assess residual TR severity.
- Rule out iatrogenic Tricuspid Stenosis (TS) using mean pressure gradients.

LIMITATION: Measurements are heavily distorted by loading conditions and inotropy immediately post-CPB.

Pulmonary Valve & Noninvasive Hemodynamics

PV Anatomy & Function

- Identify sub/supravalvular stenosis.
- Evaluate PR (Pressure Half-Time, Jet width to annulus ratio).

⚠ **PITFALL:** Anterior location and ultra-thin leaflets lead to extremely poor echogenicity. Severe acoustic shadowing from the aortic root is common.

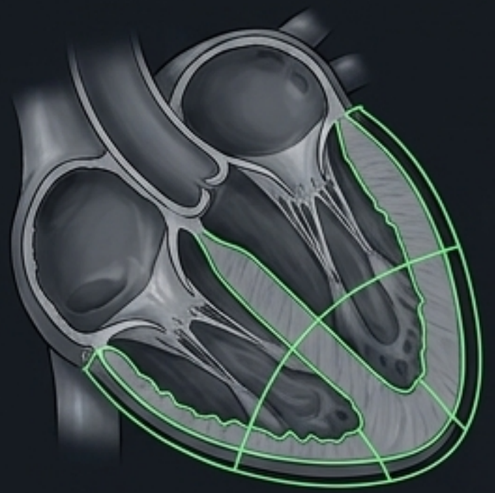
Hemodynamic Calculations

- Metrics: SPAP, Mean PAP, PA acceleration time, RVOT stroke volume.

DIAGNOSTIC MARKER:
Mid-systolic notching of the RVOT Doppler envelope is a highly specific indicator of critically elevated pulmonary resistance.

CABG: Ischemia and Aortic Scanning

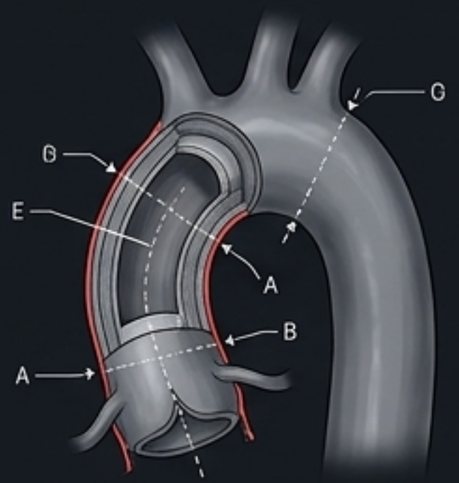
Left Ventricular Assessment



PRE/POST PROTOCOL: Rigorously compare global/regional shape, size, and absolute wall thickness.

- PITFALL: Myocardial stunning immediately post-CPB strongly mimics true ischemia.

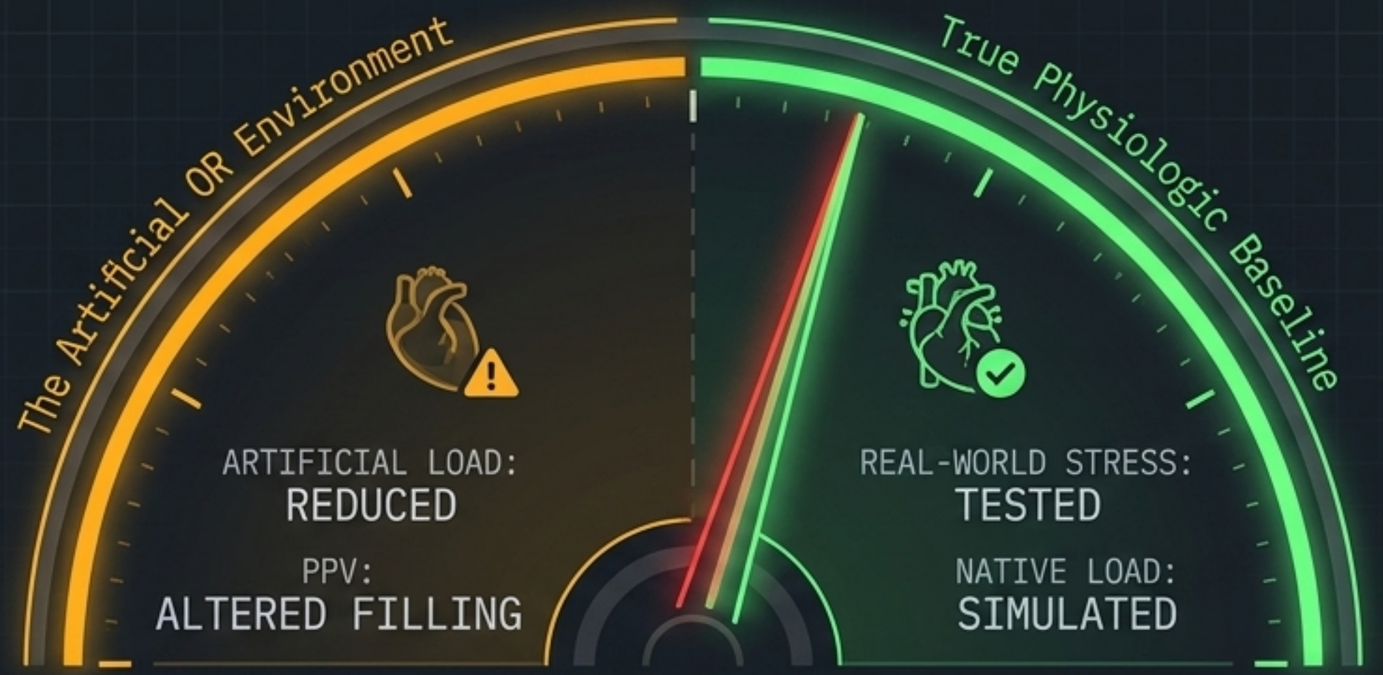
Aortic Atheromatous Disease



GOAL: Evaluate ascending aorta to guide cross-clamp and cannulation site selection. Post-op, strictly evaluate for iatrogenic dissection.

⚠ BLIND SPOT WARNING: TEE has a known acoustic blind spot at the distal ascending aorta and aortic arch due to the trachea. Epiaortic scanning is absolutely required for complete visualization.

The Synthesis: Simulating Hemodynamic Reality



The Anesthesia Illusion

General anesthesia, positive pressure ventilation (PPV), electrical pacing, and massive fluid shifts drastically alter cardiac loading.

⚠ **THE DANGER:** Functional lesions (like functional MR) will appear artificially improved or massively underestimated.

The Intraoperative Feedback Loop

To accurately assess native severity or post-repair durability, you must actively collaborate with anesthesia to perform VOLUME AND AFTERLOAD CHALLENGES.

✓ **CORE PHILOSOPHY:** TEE in the OR is not just taking pictures; it is simulating real-world physiologic stress to guarantee the surgical repair holds up in the real world.