Prosthetic Valves
A practical approach to imaging

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Disclosures

Advisory Board Member: Edwards Lifesciences, Philips, Bracco

Core Lab Contracts: Edwards Lifesciences, Medtronic, Abbott

Will not mention investigational devices

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Focus on aortic and mitral prostheses

More cases in case sessions

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JASE 2009 GUIDELINES AND STANDARDS

Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound

A Report From the American Society of Echocardiography's Guidelines and Standards Committee and the Task Force on Prosthetic Valves, Developed in Conjunction With the American College of Cardiology Cardiovascular Imaging Committee, Cardiac Imaging Committee of the American Heart Association, the European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography and the Canadian Society of Echocardiography, Endorsed by the American College of Cardiology Foundation, American Heart Association, European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography, and Canadian Society of Echocardiography

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Target Audience:

This activity is designed for all cardiovascular physicians and cardiac sonographers with a primary interest and knowledge base in the field of echocardiography. In addition, residents, researchers, clinicians, intensivists, and other medical professionals with specific interest in cardiac ultrasound will find this activity beneficial.

Objectives:

Upon completing this article, participants will be better able to:

1. Name the components of a complete imaging and Doppler evaluation for prosthetic valve function.
2. Identify the components of an integrative approach to assessing prosthetic aortic and mitral valve stenosis and regurgitation.
3. Identify the components of an integrative approach to assessing prosthetic pulmonary and tricuspid valve stenosis and regurgitation.
4. Describe the pitfalls and limitations of the evaluation of prosthetic valve function.
5. Recognize the special aspects of the pediatric population that add complexity to the evaluation of prosthetic valve function.

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REVIEW

Recommendations for the imaging assessment of prosthetic heart valves: a report from the European Association of Cardiovascular Imaging endorsed by the Chinese Society of Echocardiography, the Inter-American Society of Echocardiography, and the Brazilian Department of Cardiovascular Imaging†

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Things that can go wrong…..

- Stenosis
- Regurgitation
- Abnormal appearance
  - Degeneration
  - Endocarditis
  - Malpositioned
  - Thrombus/Pannus

Diagnostic Approach

Know what you're looking at

Try to get information on:

- Valve type
  - beyond mechanical vs. bioprosthesis
- Valve size
- Date of implant
- Details of surgery
  - anything else done?
    - especially for infective endocarditis

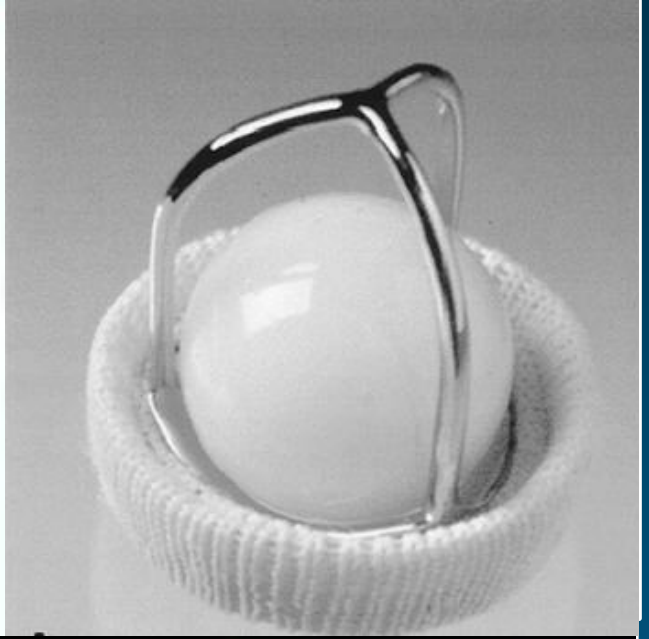
Overarching themes

- Have low threshold for TEE
  - Practice deep transgastrics
- Consider complementary imaging modalities
  - choice will vary depending on scenario

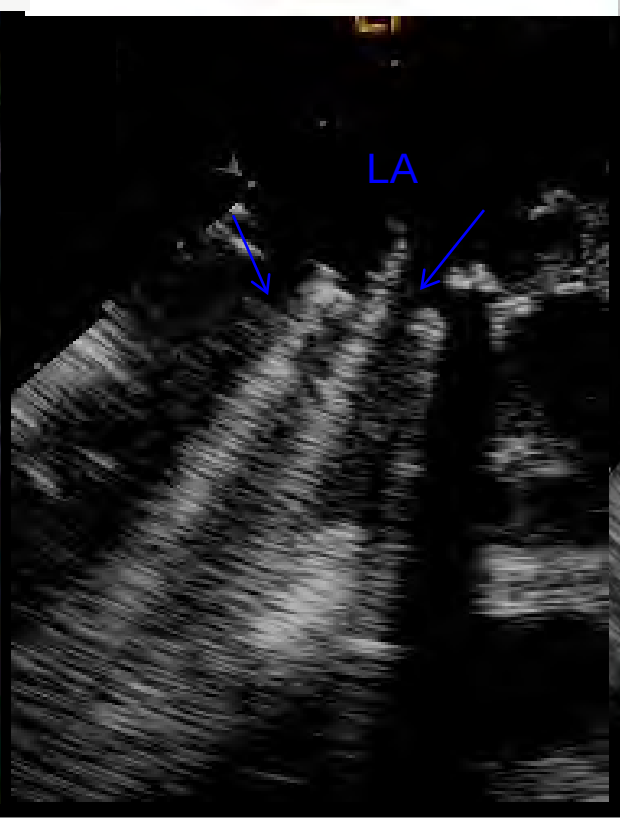
Valve Replacement is not curative!

- Even normal prosthetic valves are variably stenotic and regurgitant
- Understand normal range of “dysfunction”
  - Doppler
  - Imaging
    - TTE, TEE
  - Importance of baseline evaluation

Mechanical valves




Tape40
LA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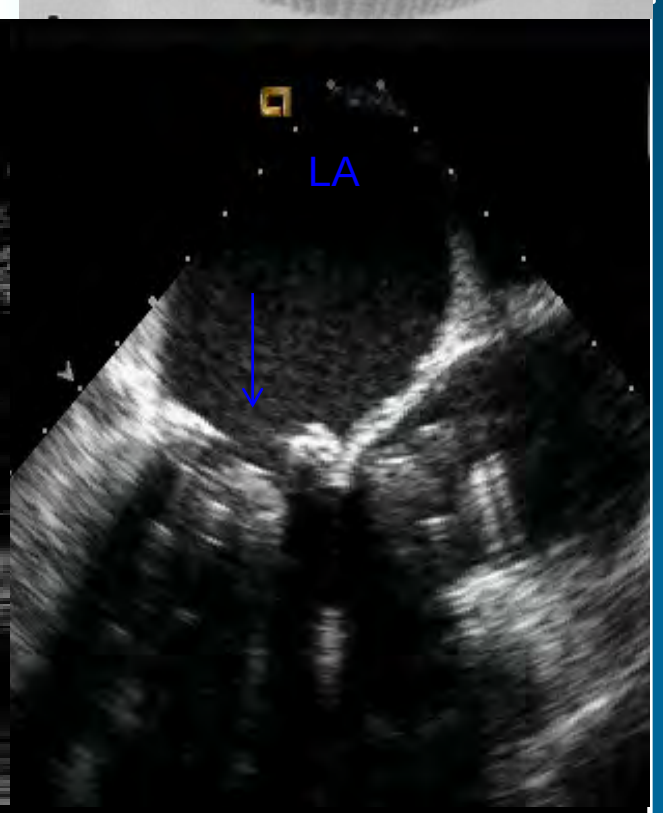
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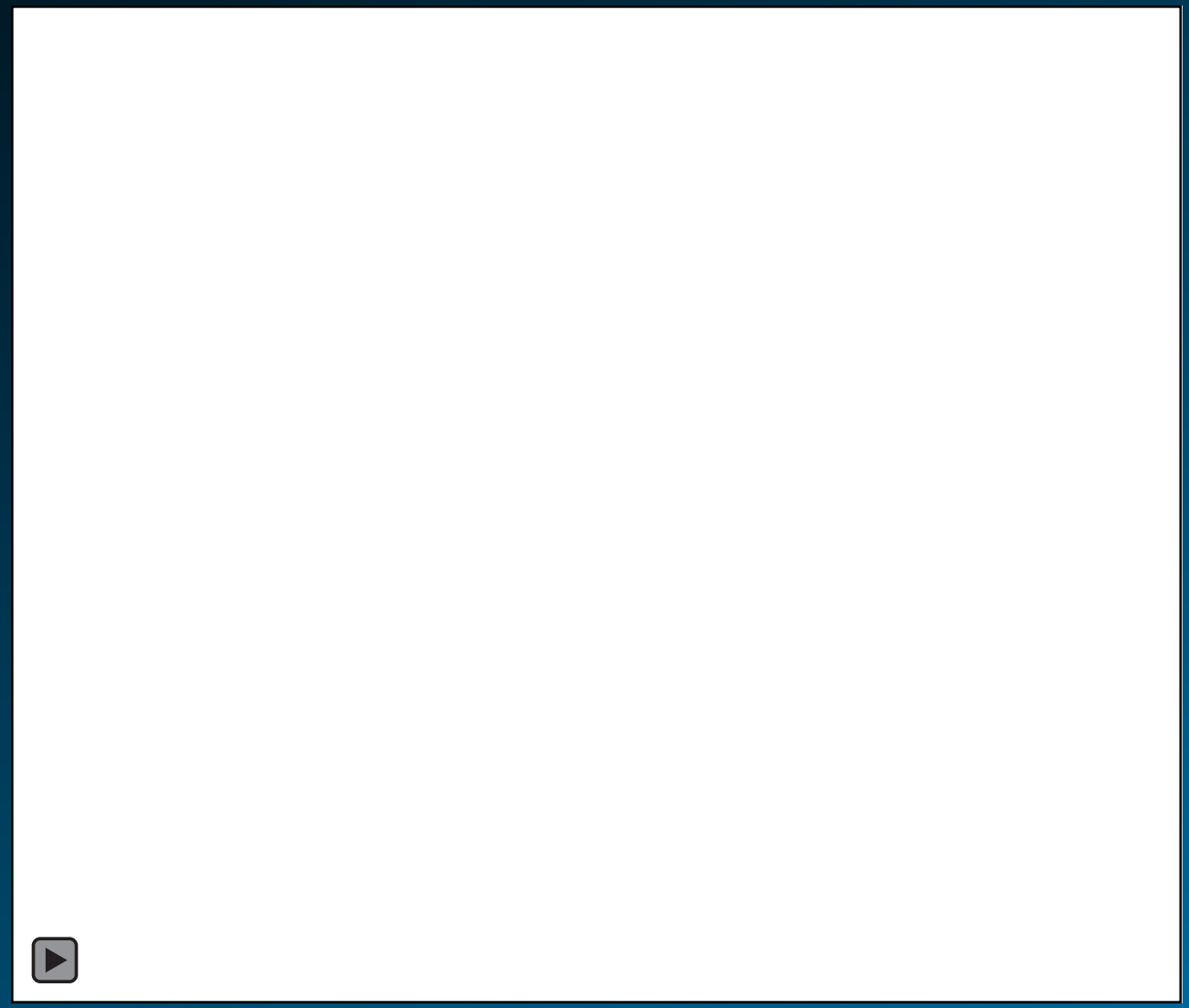
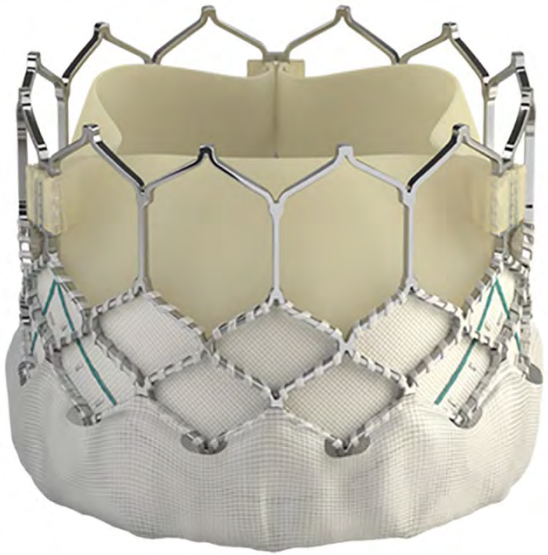
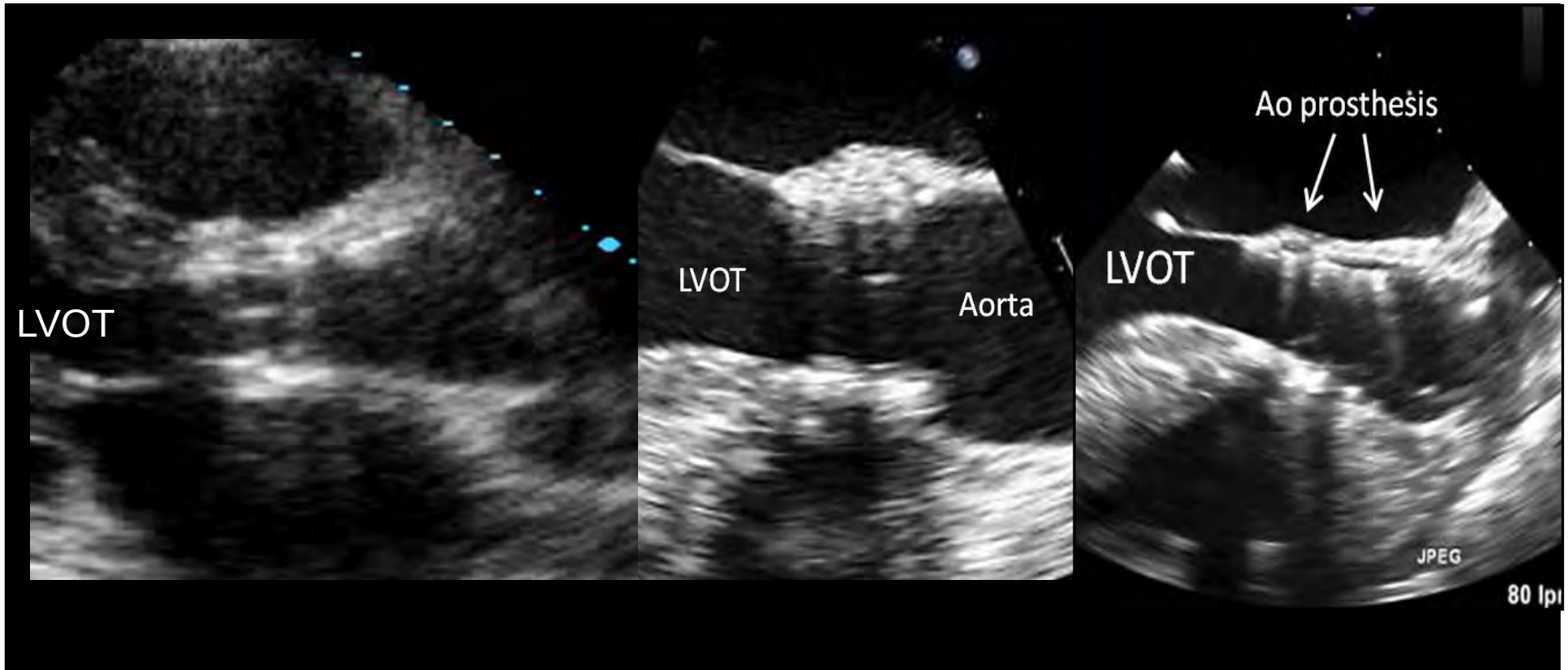
With thanks to Becky Hahn



Bioprostheses




LVOT
LVOT
Aorta
Ao prosthesis
LVOT
JPEG
80 Ip

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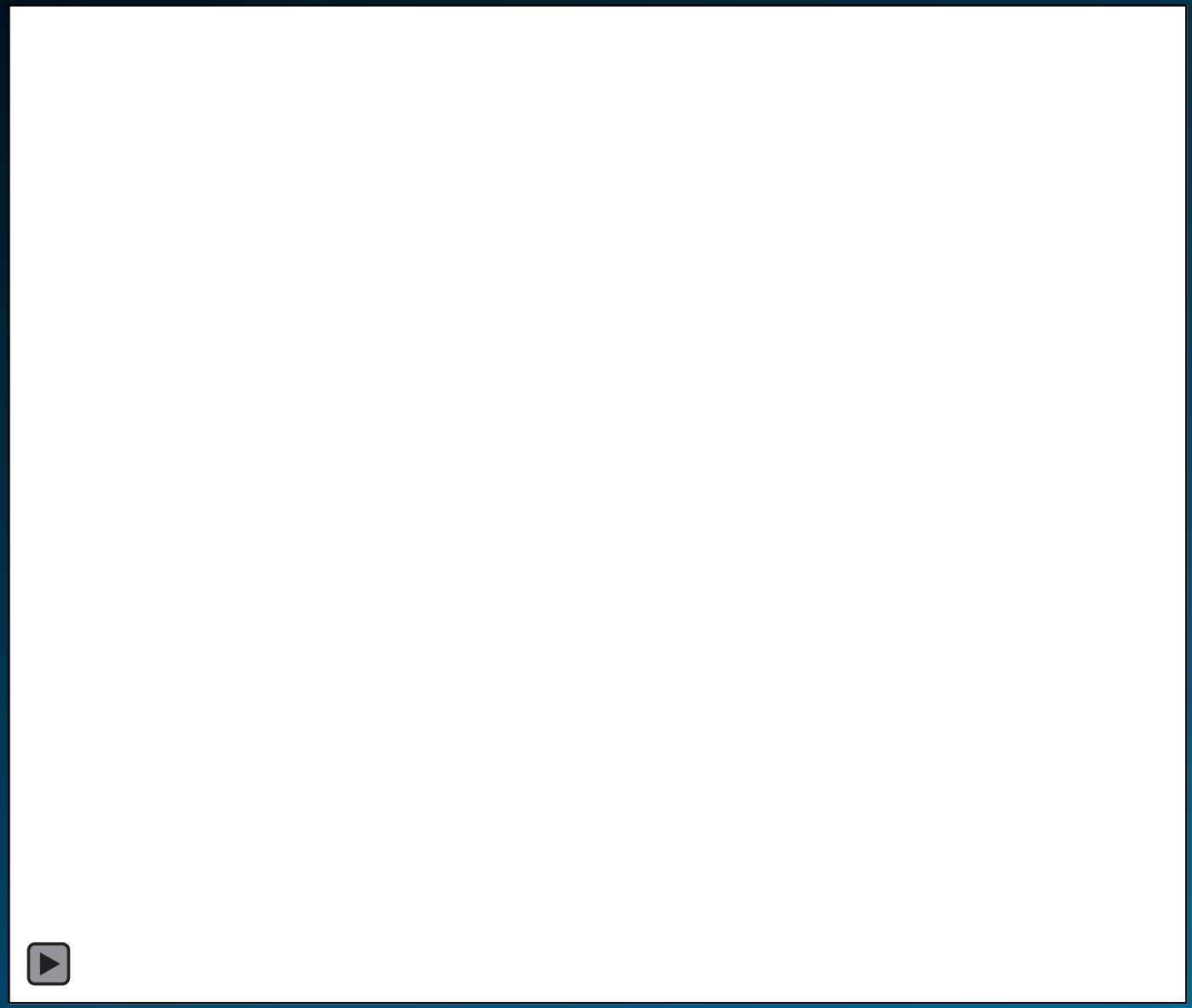

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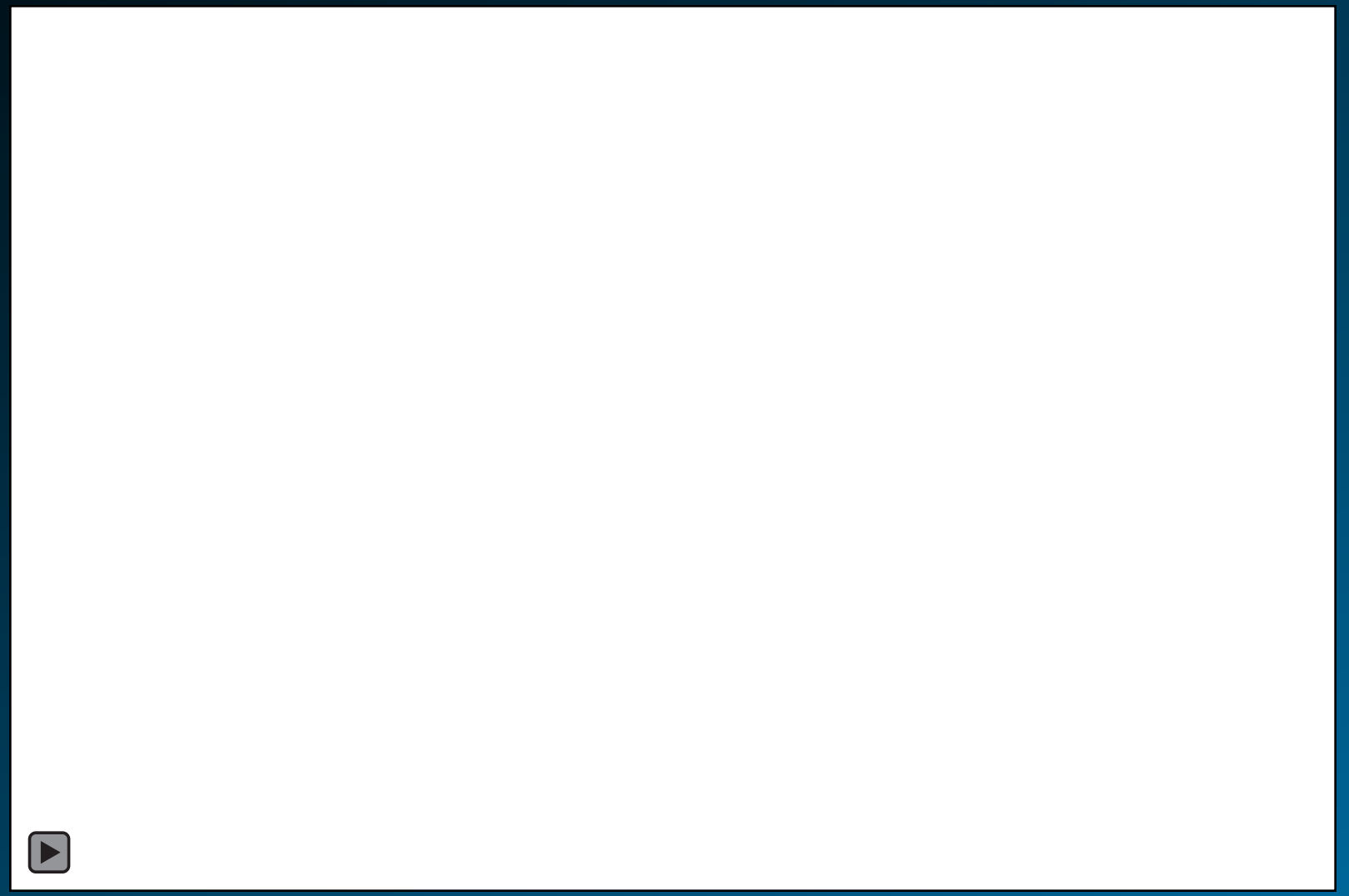

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Regurgitation not universal

Valve Stenosis

The Echo Toolbox

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Tools

- Gradients/velocities
- Valve area calculated by continuity equation = effective orifice area (EOA)
  - Pressure half time for monitoring only
- Doppler velocity index = dimensionless index
- Acceleration time

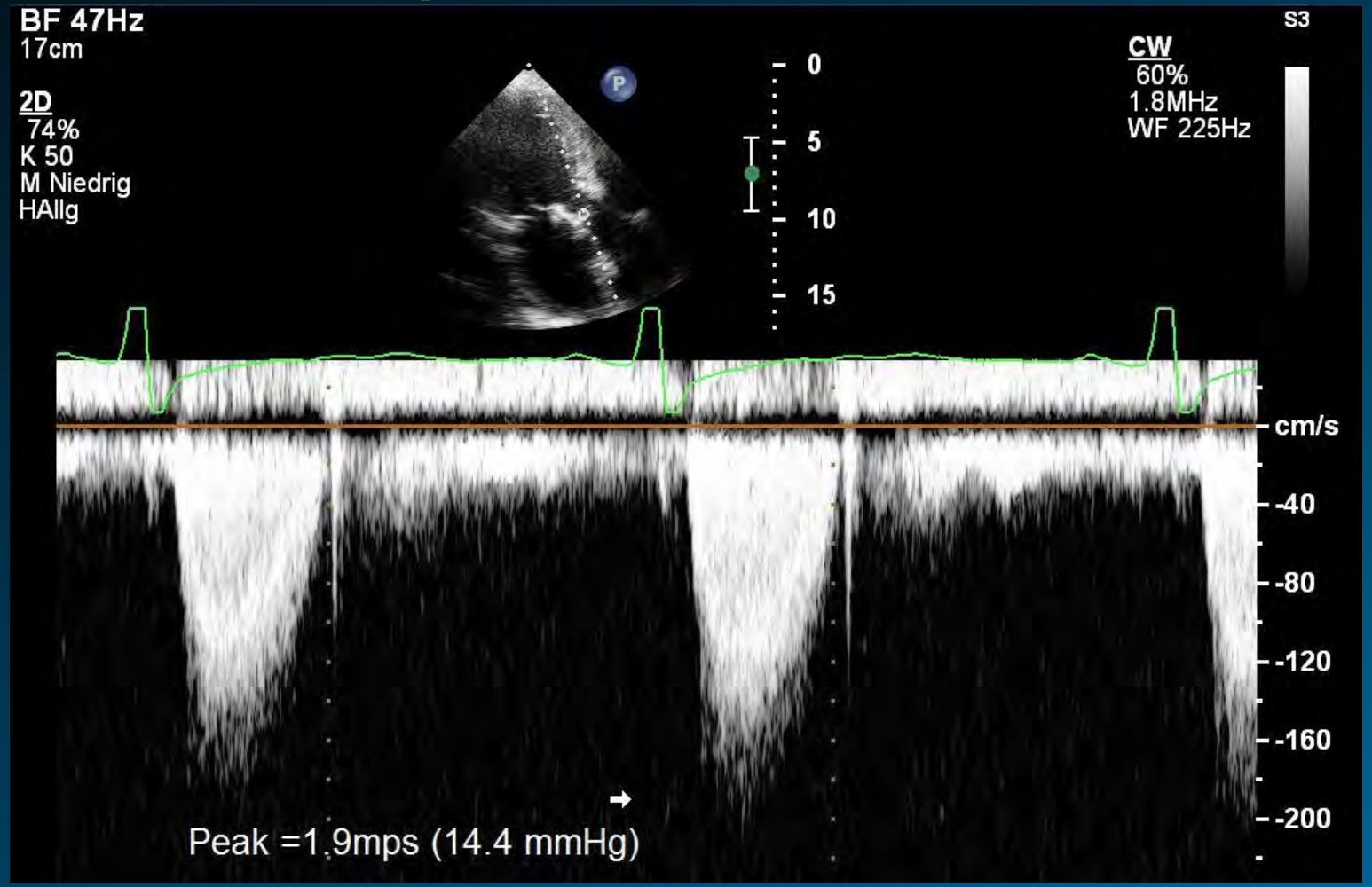
Gradients

Peak and Mean

Define normal gradients

- Reference tables
  - Size
  - Type
- Implantation values
  - Intraop
  - Pre discharge
- Understand impact of flow
  - Record HR, Hemodynamics (if available)
  - Valve area approaches for mitral valve not as robust for prosthetic valves

Apical Window



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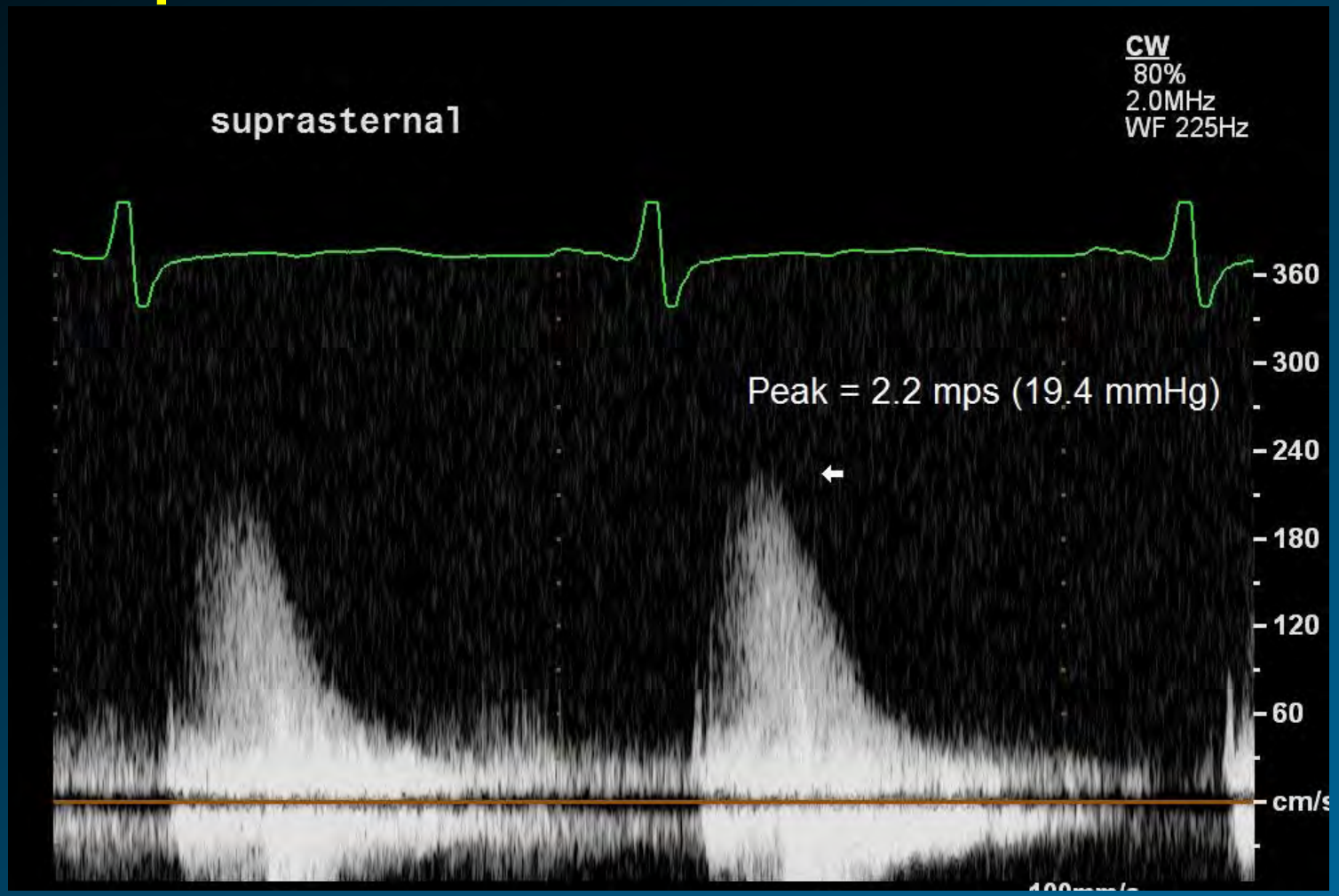
Suprasternal Notch Window



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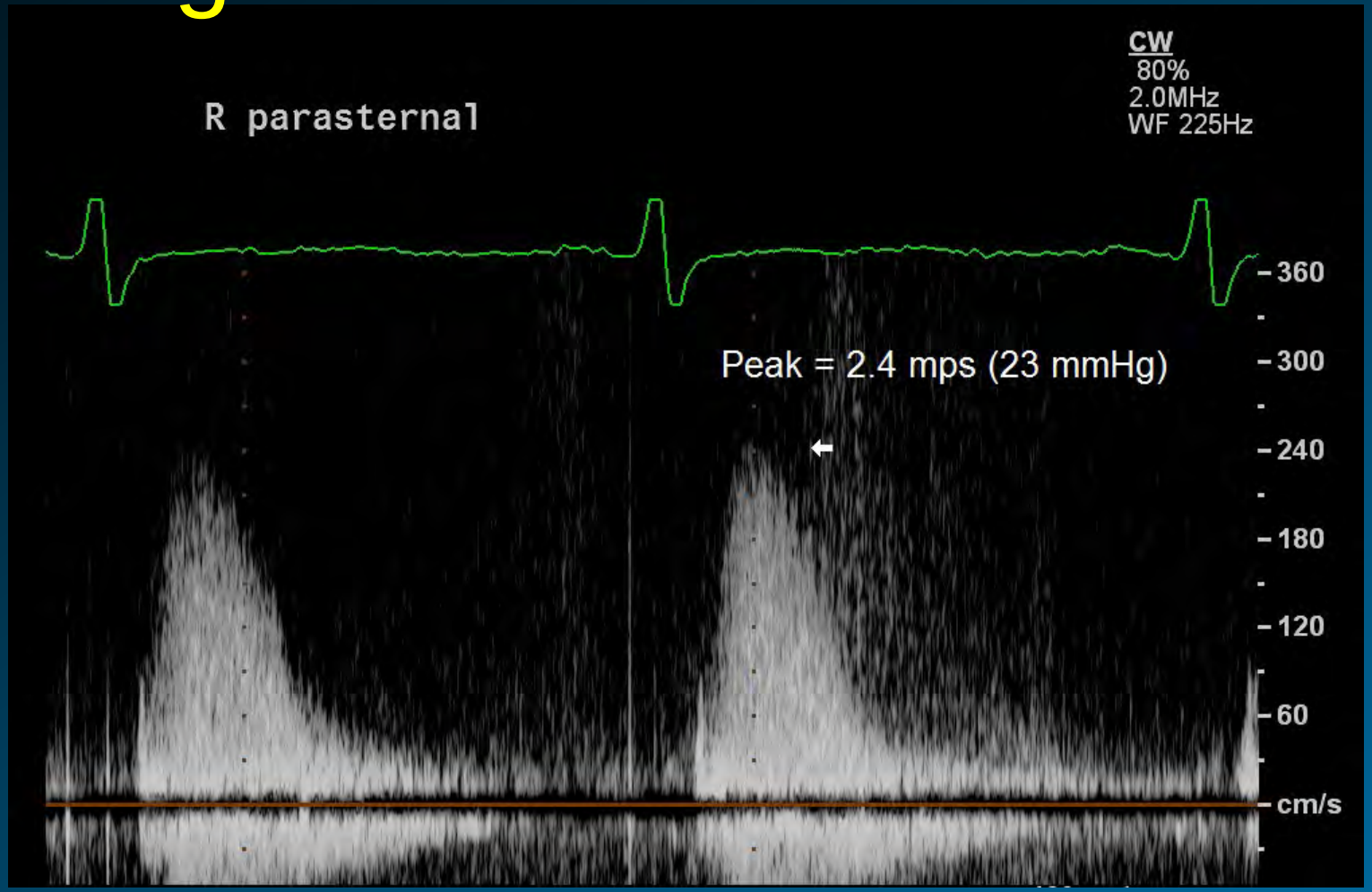
Right Parasternal Window



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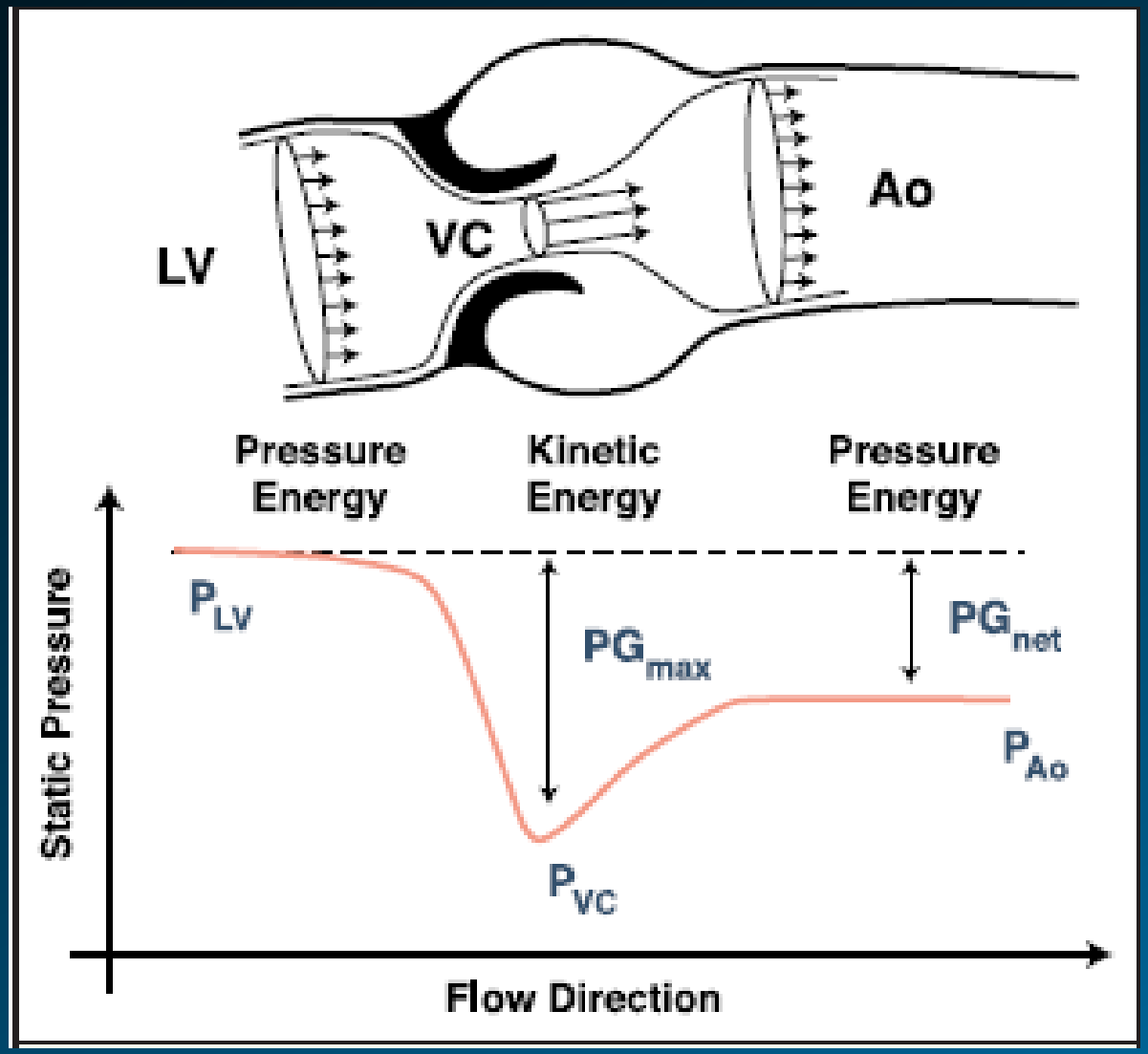
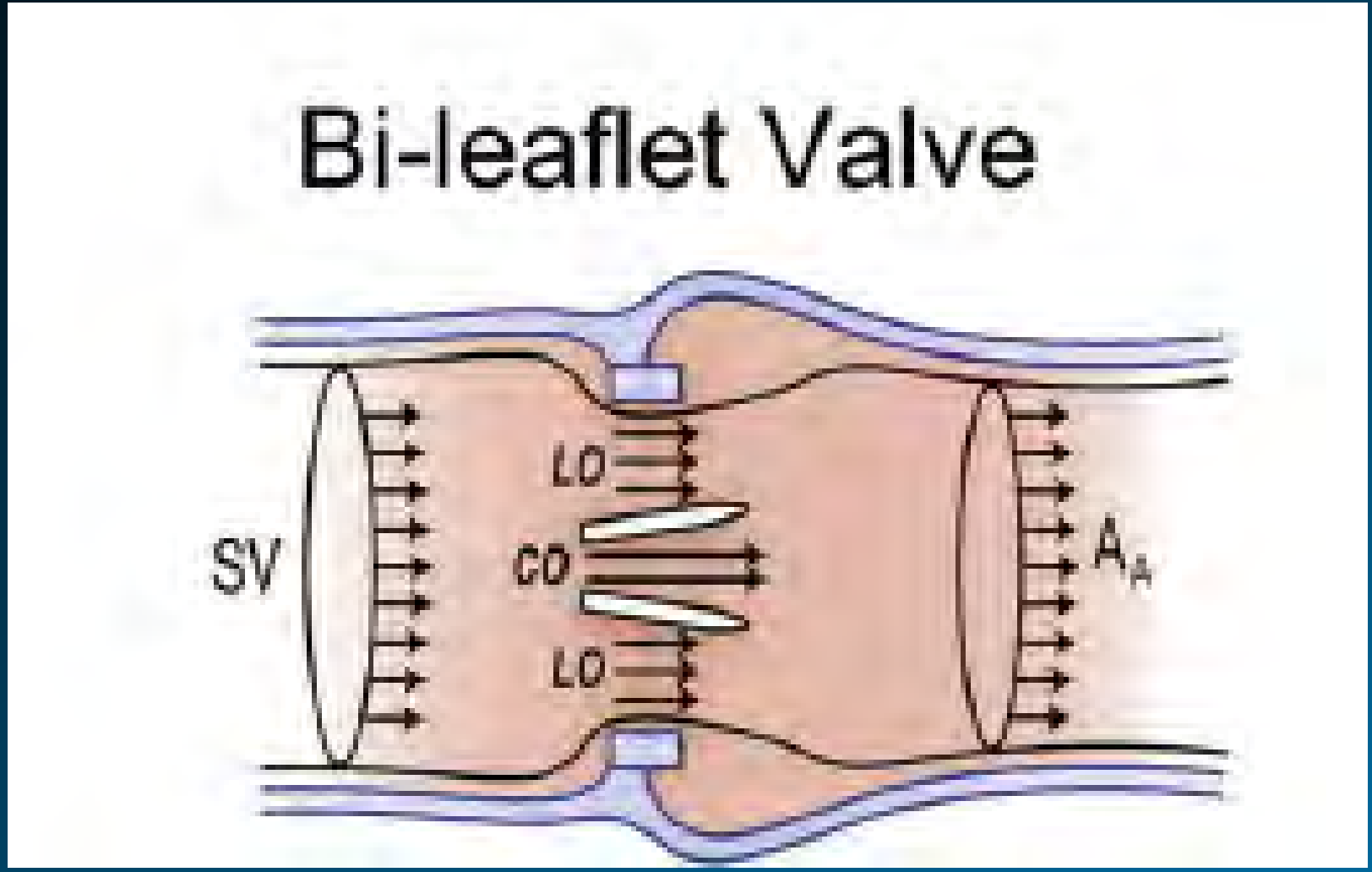
Pressure Recovery



Bach et al: J A C C : C A R D I O V A S C U L A R I M A G I N G , V O L . 3 , N O . 3 , 2 0 1 0 M A R C H 2 0 1 0 : 2 9 6 – 3 0 4

Central vs Lateral Orifices



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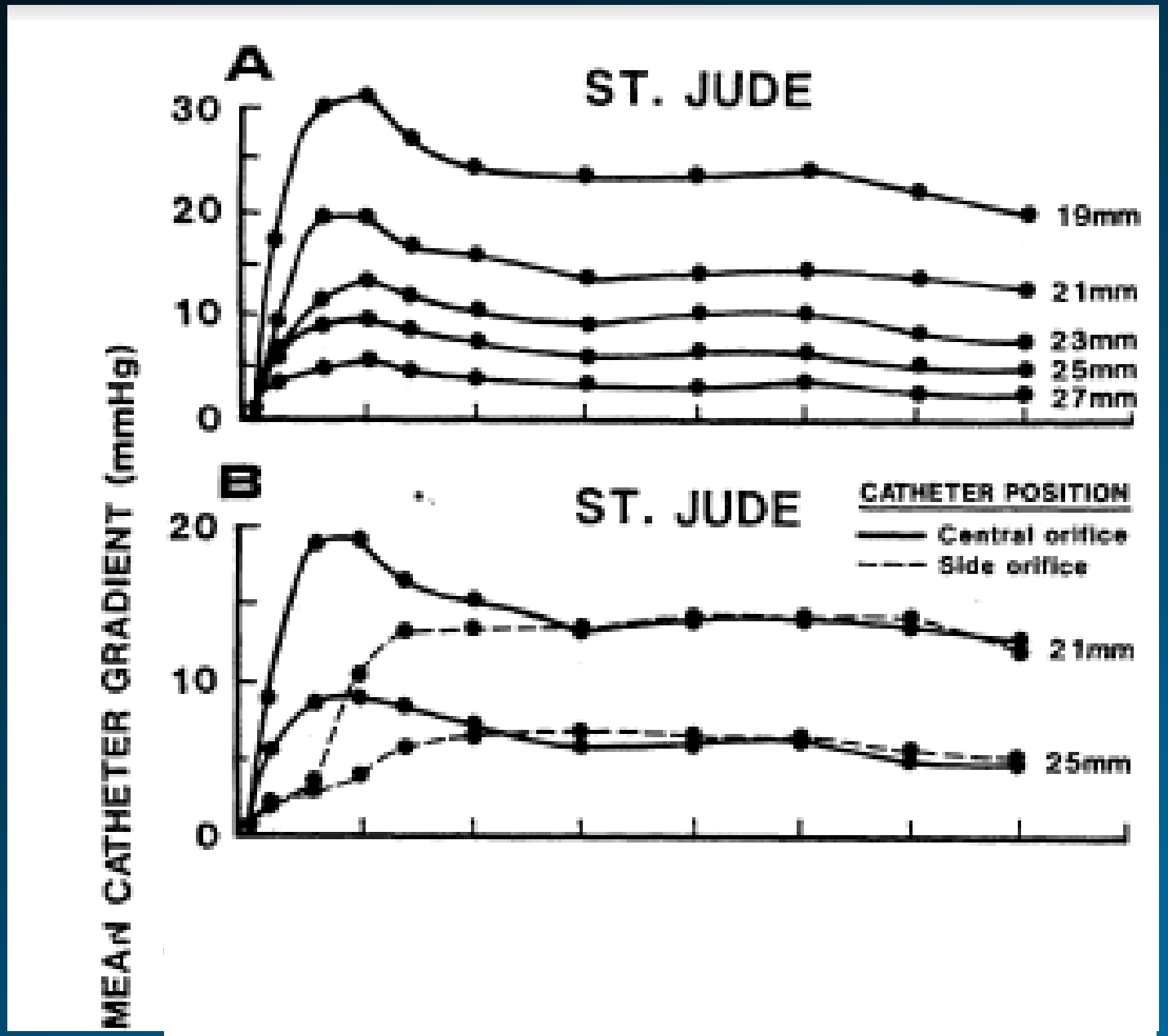
Baumgartner et al Circ 82:1467 1990



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Consideration in Small Bileaflet Aortic Valves (19 mm) with Small Aorta (3 cm-STJ)

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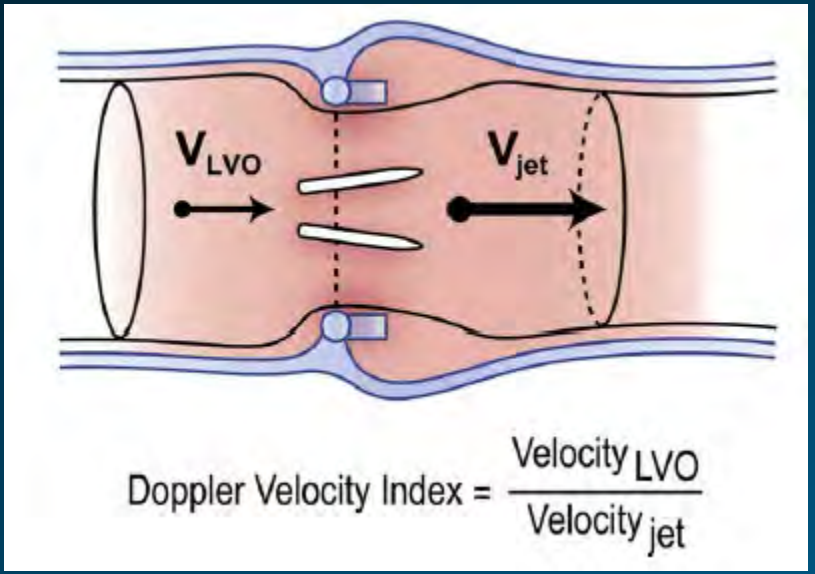
Effective Orifice Area

Continuity Equation

Reference Values

Doppler Velocity Index
Aortic Valve



A DVI < 0.25 is highly suggestive of significant aortic valve obstruction

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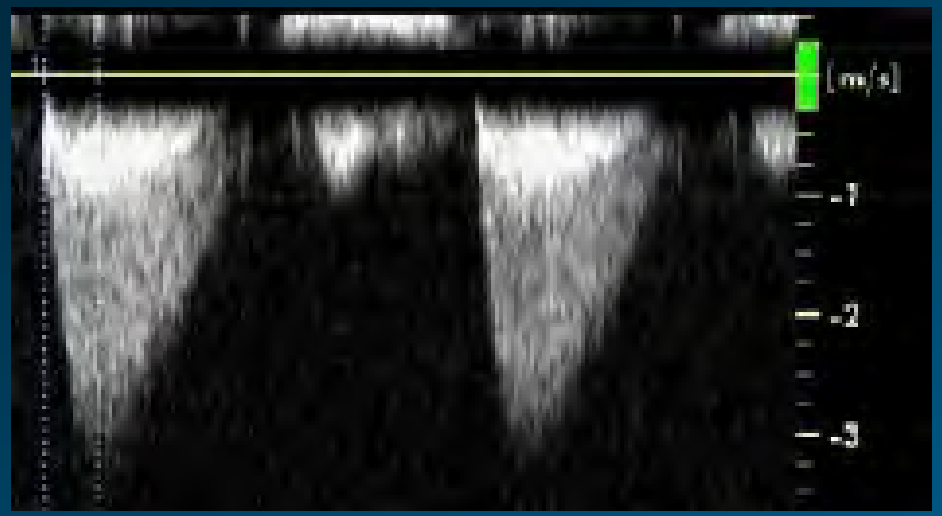
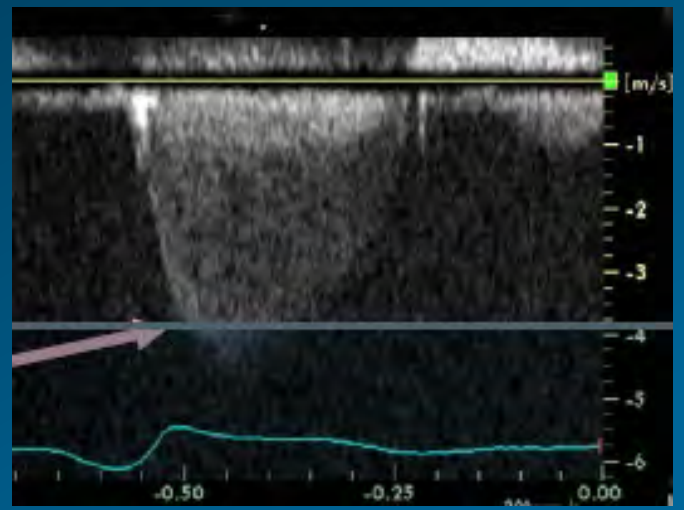
Accleration time (aortic prostheses)

Rounded jet envelope

AT>100 ms suggest intrinsic dysfunction



AT = 85 ms



AT = 142 ms

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Doppler Velocity Index
Mitral Valve

$$\frac{\text{VTI PrMv}}{\text{VTI LVO}}$$

A ratio >2.5 is highly suggestive of significant mitral valve obstruction

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The Gradients are High but the Valve is "Normal" (normal EOA and appearance)

Patient Prosthesis Mismatch

Pibarot et al: JACC 2000;36:1131

The ve is

- Pros
  - Th

Pibarot et al: JACC 2000;36:1131

Valve Prosthesis-Patient Mismatch (PPM)

- ***Definition***: **Prosthesis too small in relation to patient's body size**
- ***Consequence***: **Persistence of abnormally high postoperative gradients**

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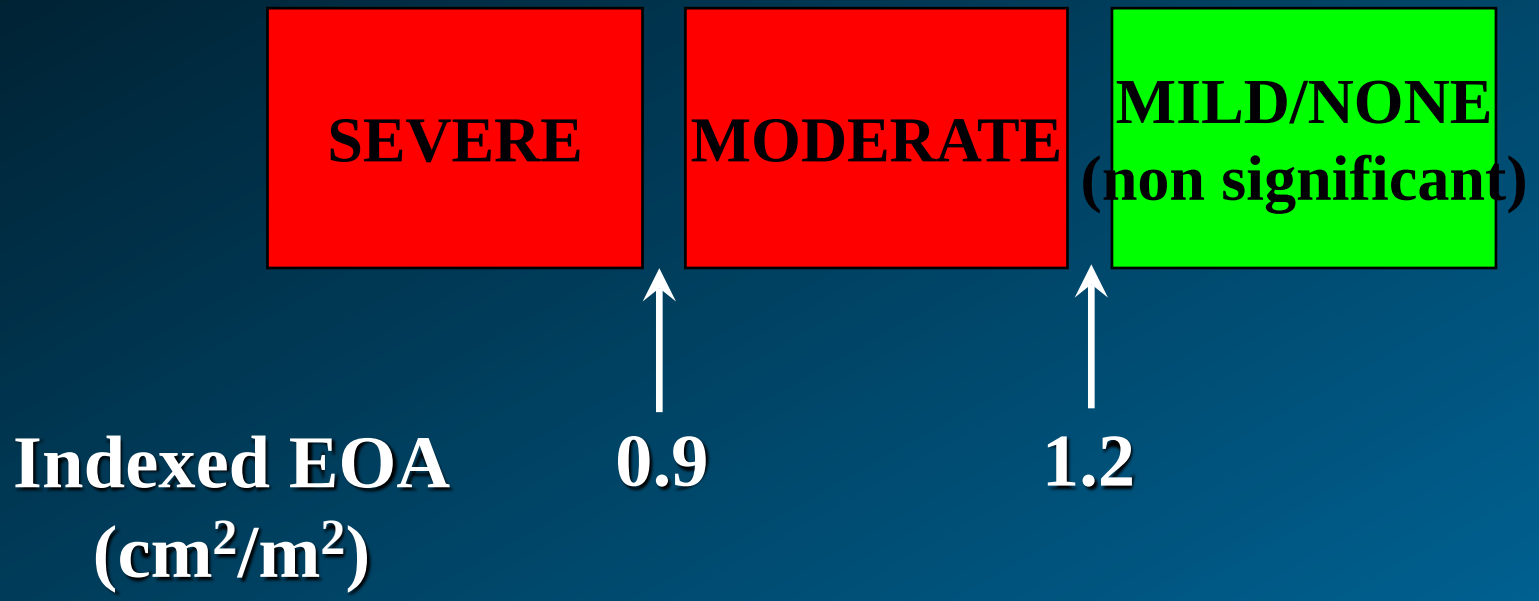
Prosthesis-Patient Mismatch

Indexed EOA (cm^2/m^2)	P-PM
>0.85	No P-PM
0.66-0.85	Moderate
≤0.65	Severe

Severity of PPM in the Mitral Position



Adverse Clinical Outcomes Associated with Aortic PPM

- Less improvement in functional class
- Increased incidence of late cardiac events
- Lesser regression of LVH
- Moderate impact on late mortality (>7years)
- Major impact on perioperative mortality, particularly if LV dysfunction is present

Dumesnil and Pibarot, J Thorac Cardiovasc Surg. 2006; 131(5):952-5
Pibarot and Dumesnil, Heart. 2006; 92(8):1022-9

Algorithm for Interpretation of High Gradients in Valve Prosthesis

- Calculate EOA and compare with reference value for same type and size of prosthesis
- Compare with previous echoes if available
- If EOA = ± reference value, suspect PPM and confirm by calculating indexed EOA (present if < 1.2 cm^2/m^2 for mitral <0.85 cm^2/m^2 for aortic, not validated for tricuspid)
- If EOA significantly < reference value, consider pressure recovery in bi-leaflet prosthesis and/or intrinsic dysfunction
- If dysfunction suspected, evaluate leaflet mobility and integrity using TEE and/or fluoroscopy

Case Study

- **70 y.o. male with aortic valve replacement for severe degenerative aortic stenosis**
- **Prosthesis implanted : 21 Mosaic bioprosthesis**

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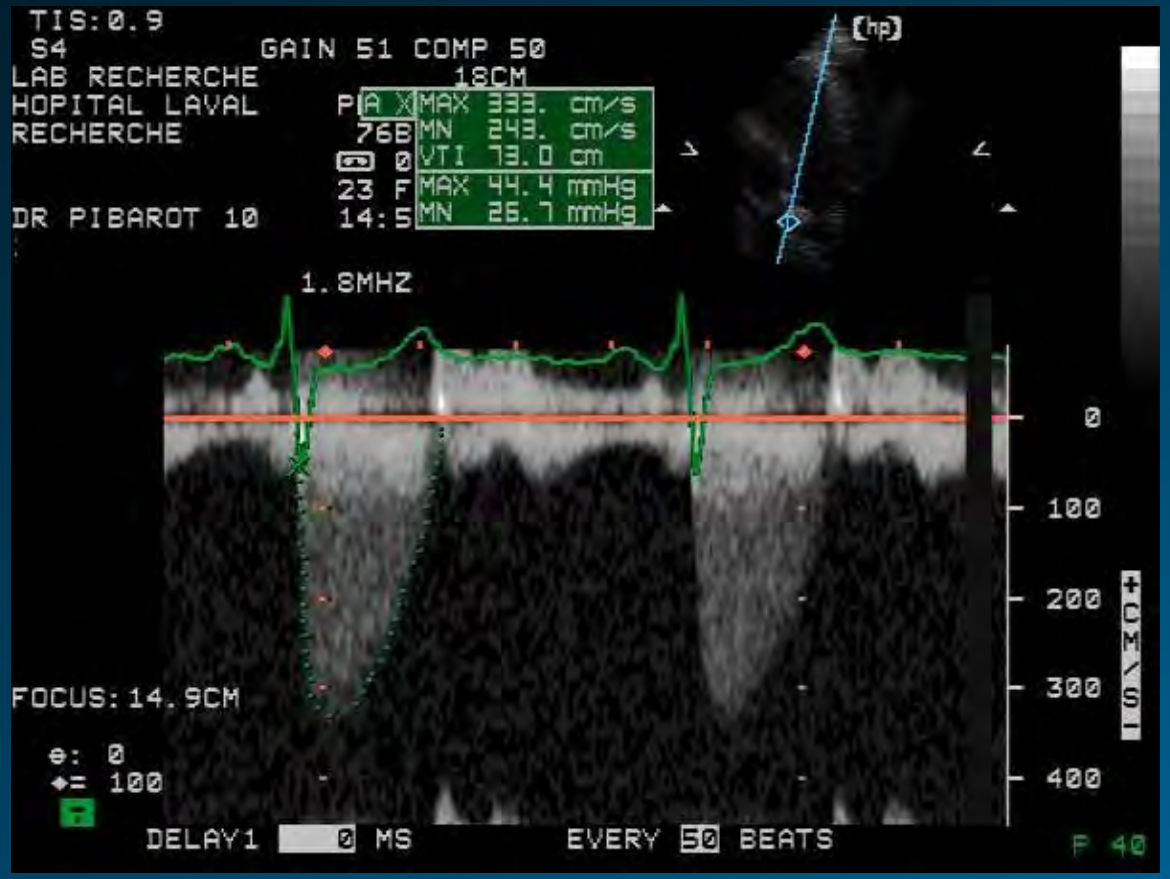
Postoperative Echocardiogram



Max Gradient = 44 mm Hg
Mean Gradient = 27 mmHg

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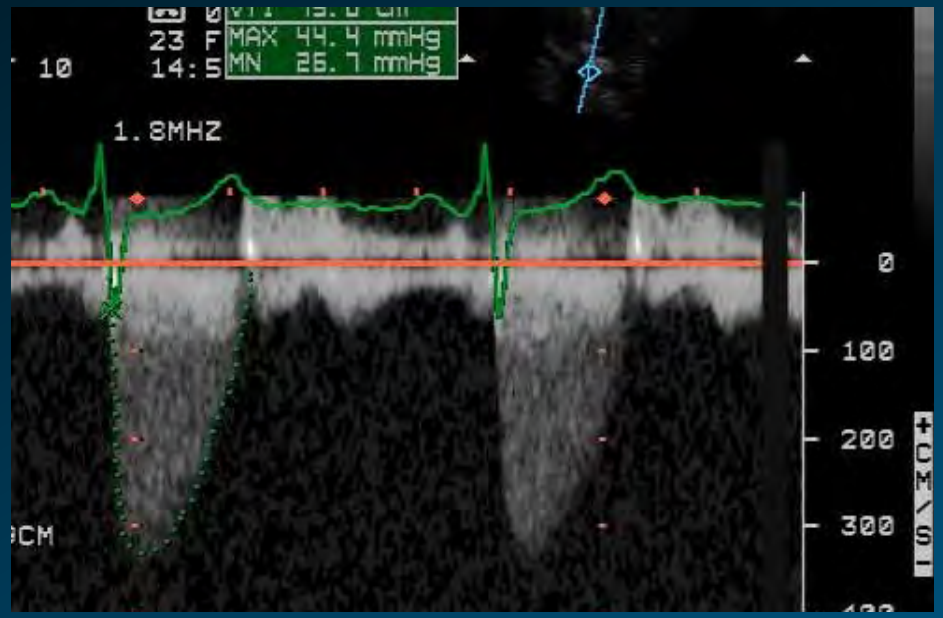
Algorithm to Interpret High Postoperative Gradient



EOA reference value forMosaic # 21 : 1.22±0.27 ⟷

EOA = 1.24 cm^2 (continuity equation)

↓ ⇠ **BSA = 1.90 m^2**

Indexed EOA = 0.65 cm^2/m^2

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IT IS PPM!

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Sometimes when gradients are high, the problem is the valve…..

- Valve degeneration
- Leaflets or mechanical elements are impeded
  - Endocarditis
  - Thrombus
  - Pannus
- Look carefully!

Case

- 62 yo female s/p St Jude MVR
- Admitted with dyspnea
- TTE

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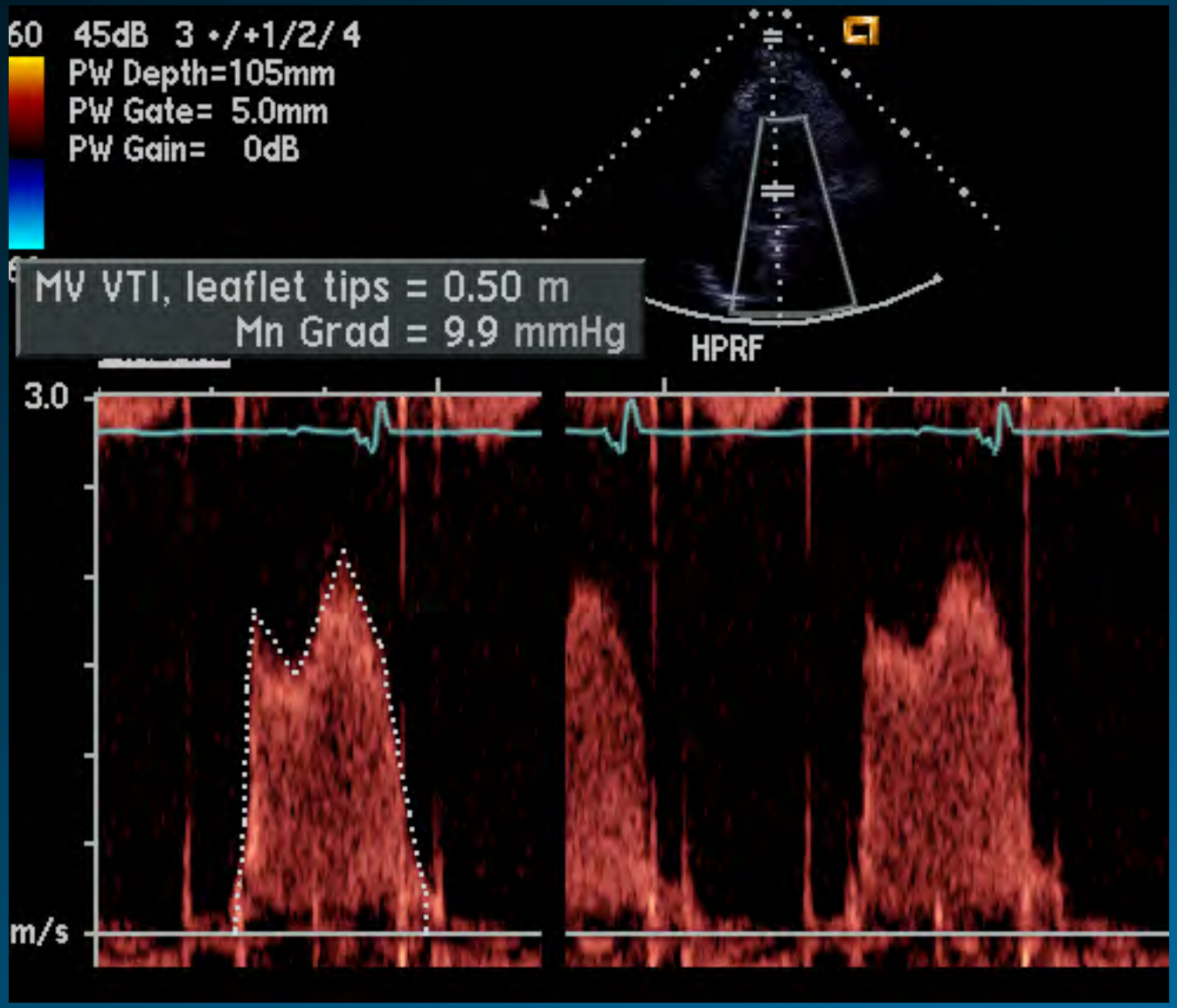
HR =72



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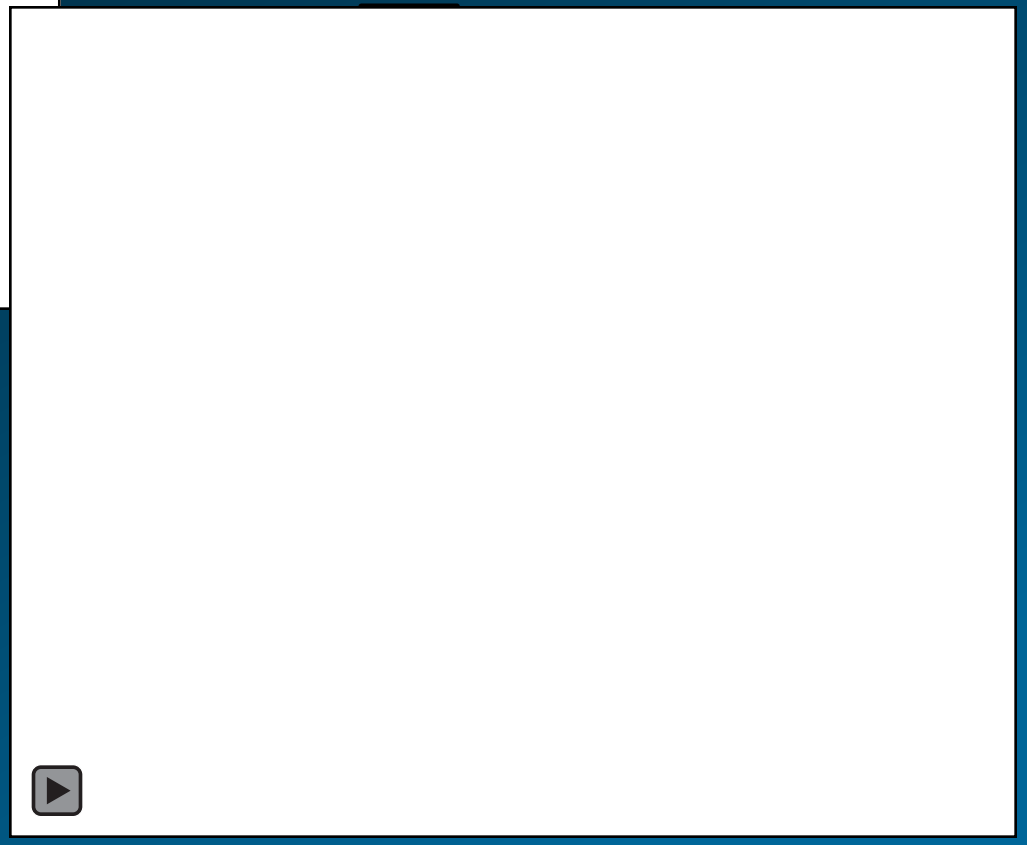
TEE



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Diagnosis

Acute valve thrombosis

Valve thrombosis

- Mechanical valves (less commonly recognized with bioprosthetic valves although historically likely underecognized)
- Inadequate anticoagulation

Case

- 58 yo female s/p bovine pericardial bovine valve replacement
- Presents with recurrent dyspnea
- Stress TTE- “high gradients”
  - Mean 25mmHG

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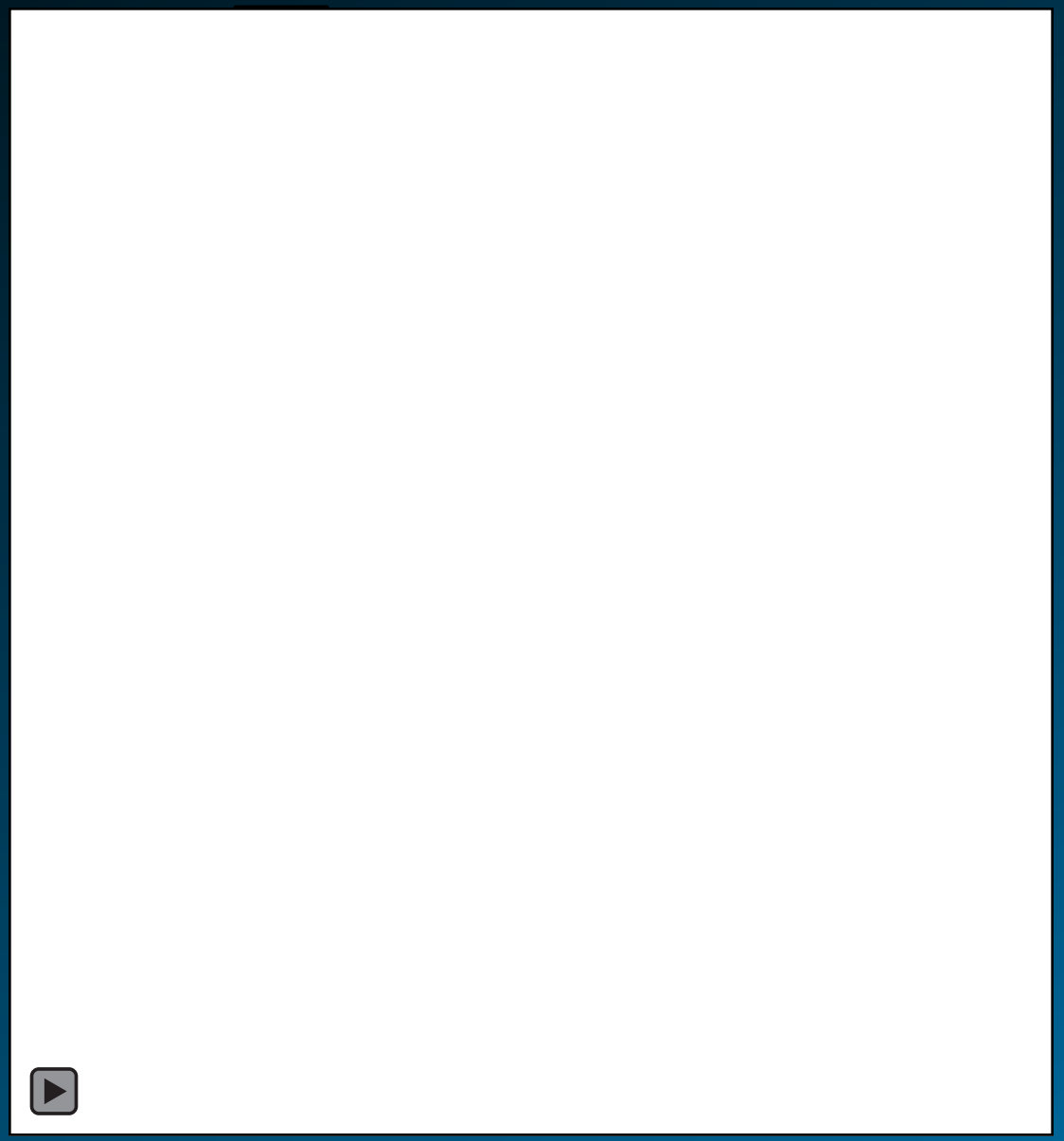

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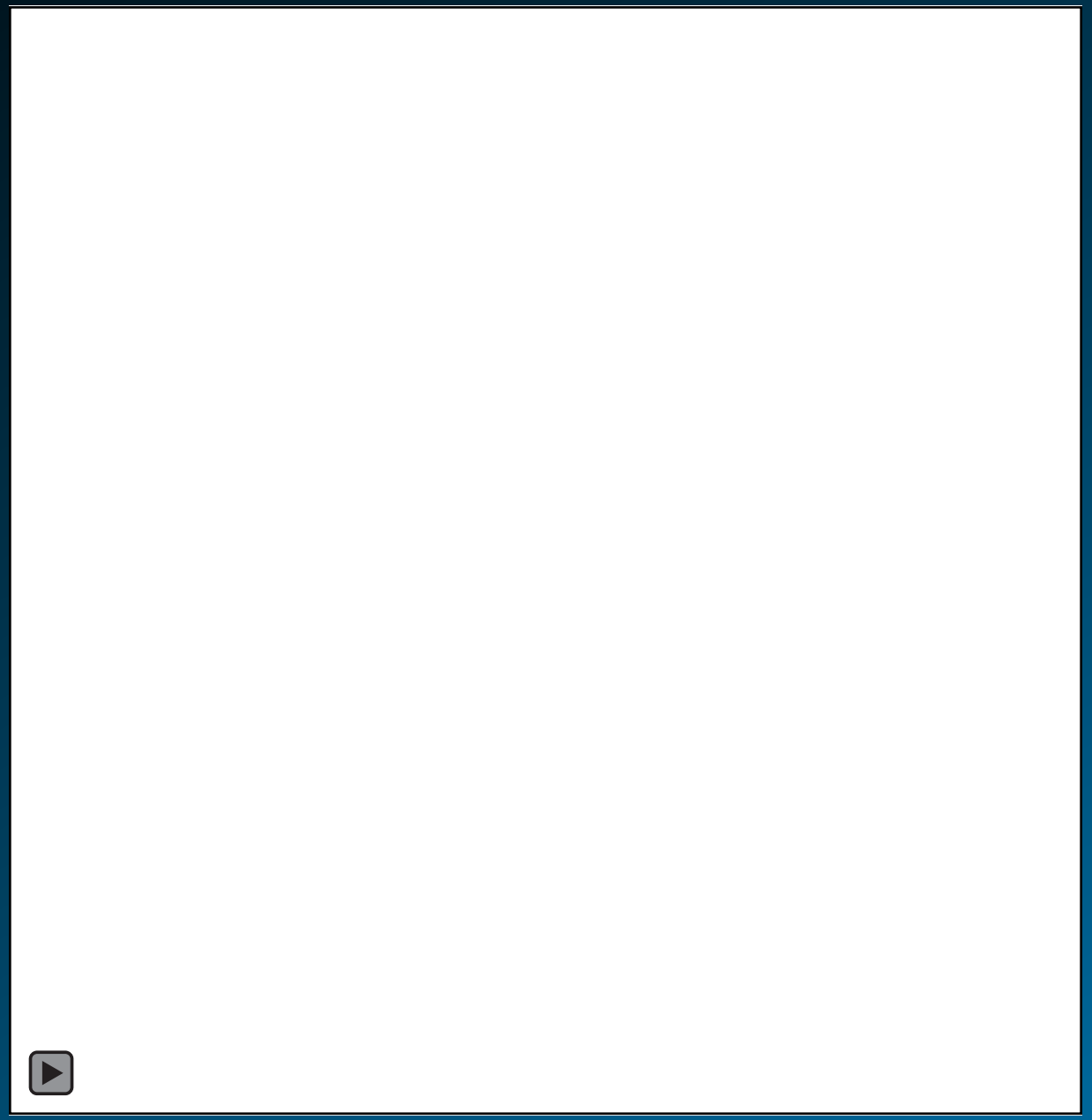

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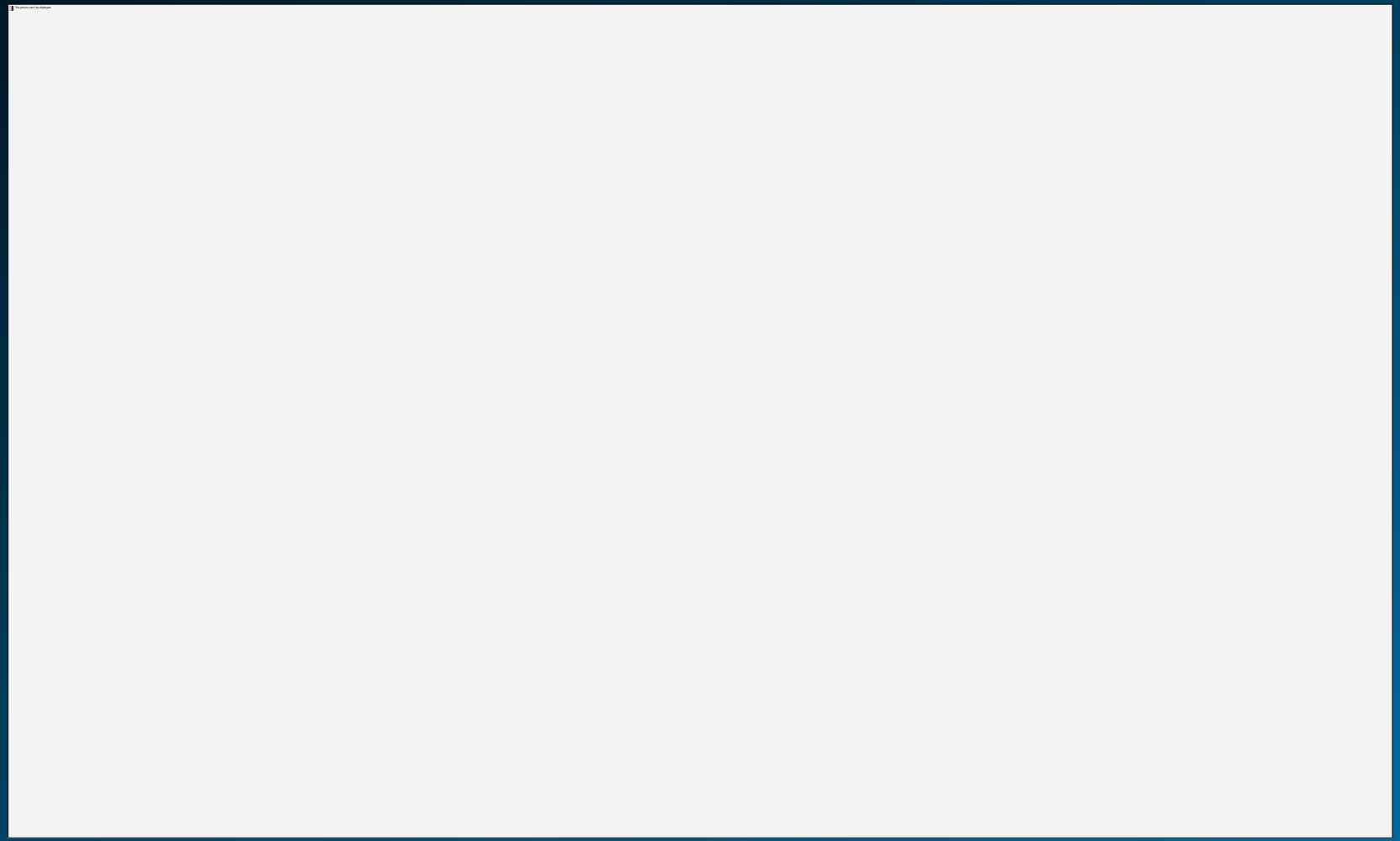
Mean Gradient = 10 mmHg (HR = 80)



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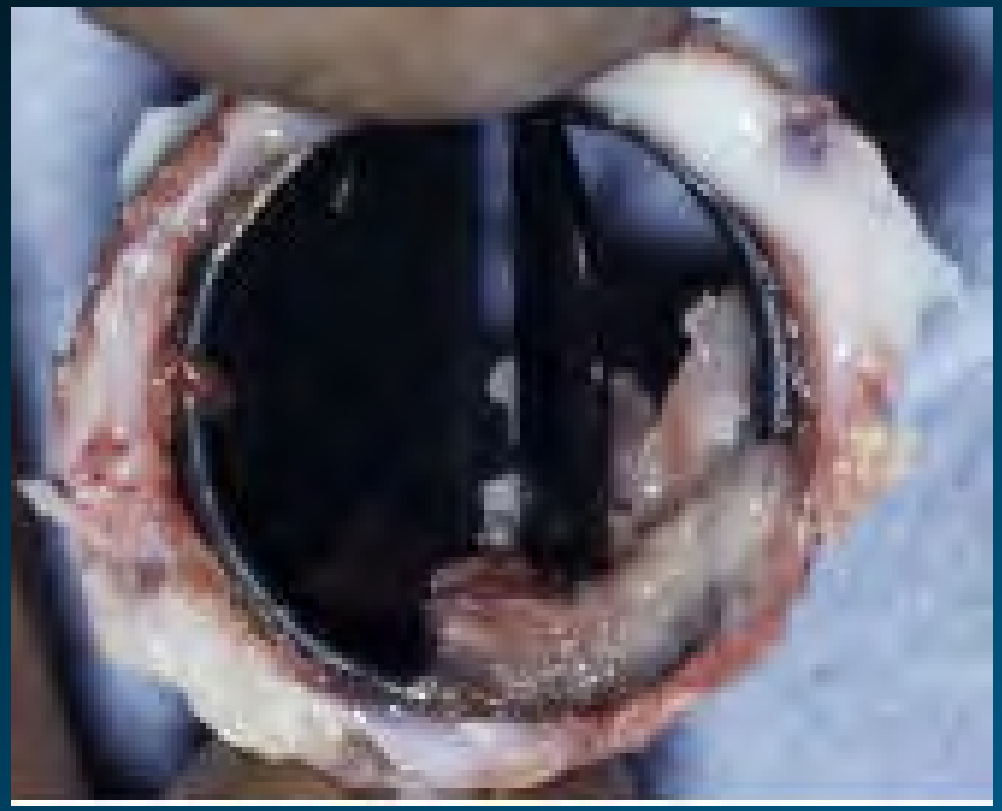
Diagnosis

Pannus vs. thrombus formation

Pannus = Fibrous Ingrowth

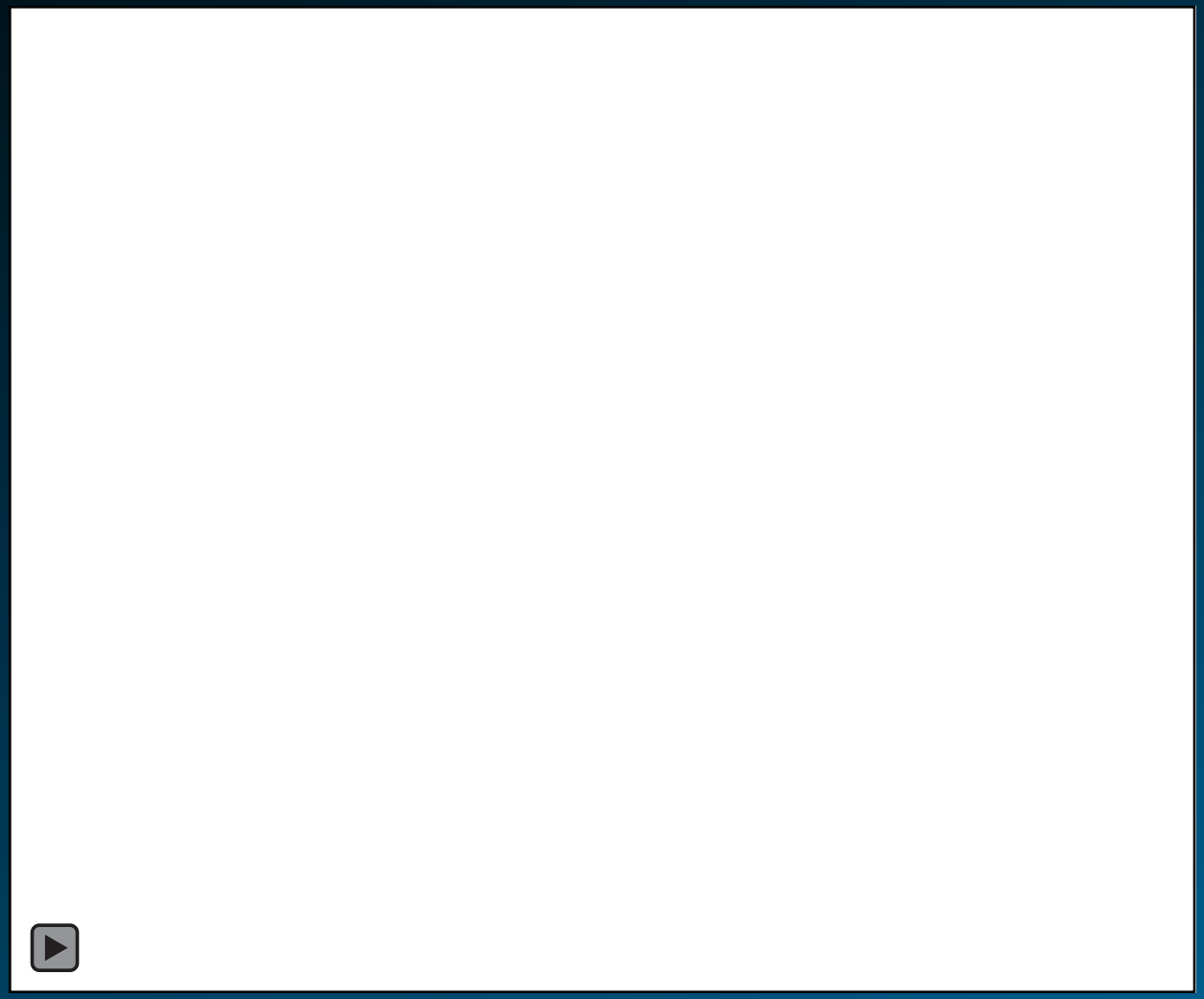
- Pannus vs. Thrombus
  - Clinical setting (acuity and anticoagulation status)
  - Echotexture (thrombus “softer”)
  - Size/Shape/Location (thrombus larger, more irregular and may extend beyond sewing ring)
- Low INR and soft appearance 87% PPV and 89% NPV for thrombus



ASE PV Guidelines

Case

Dyspnea 3 years post surgery



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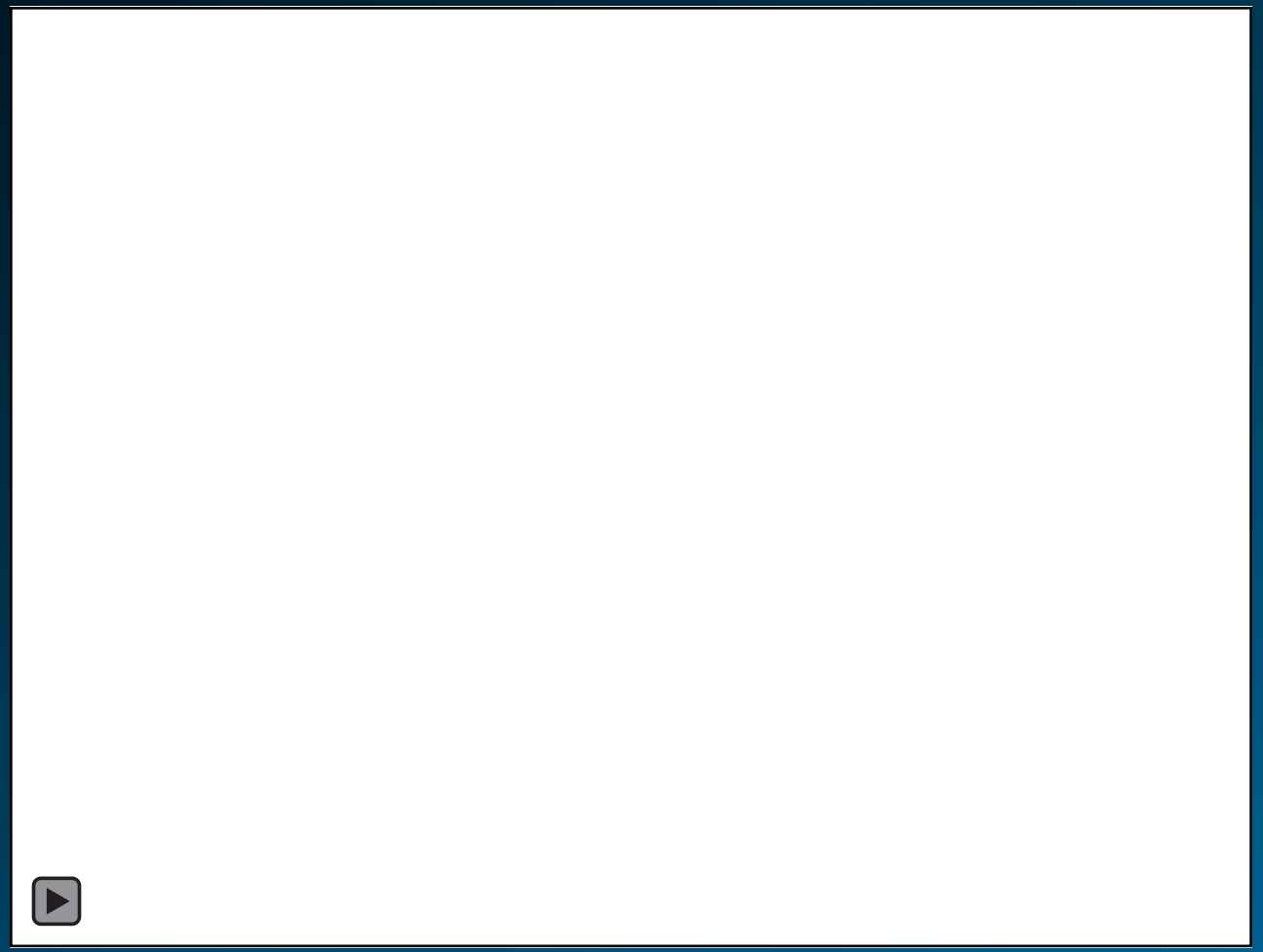

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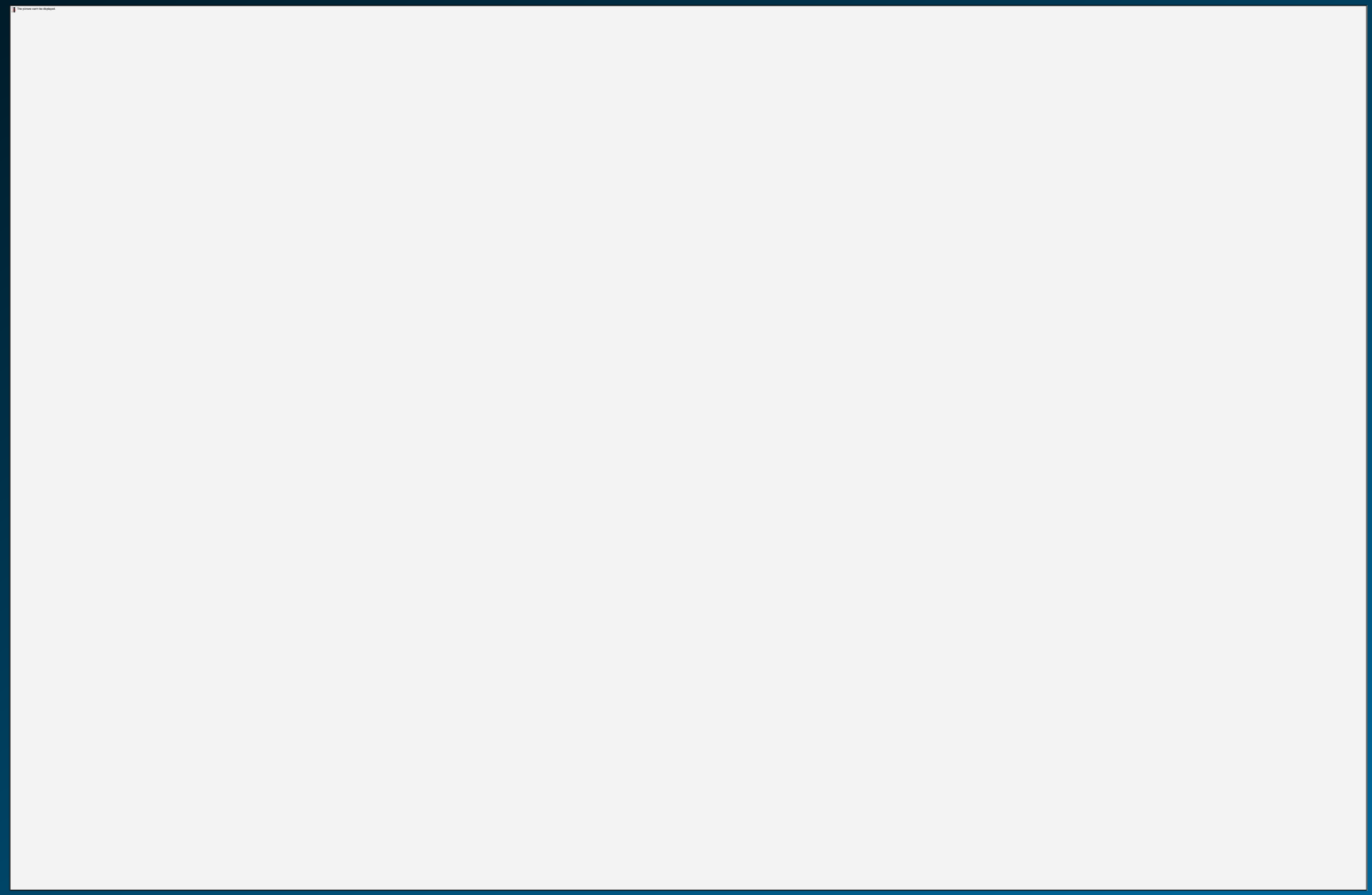
HR = 87



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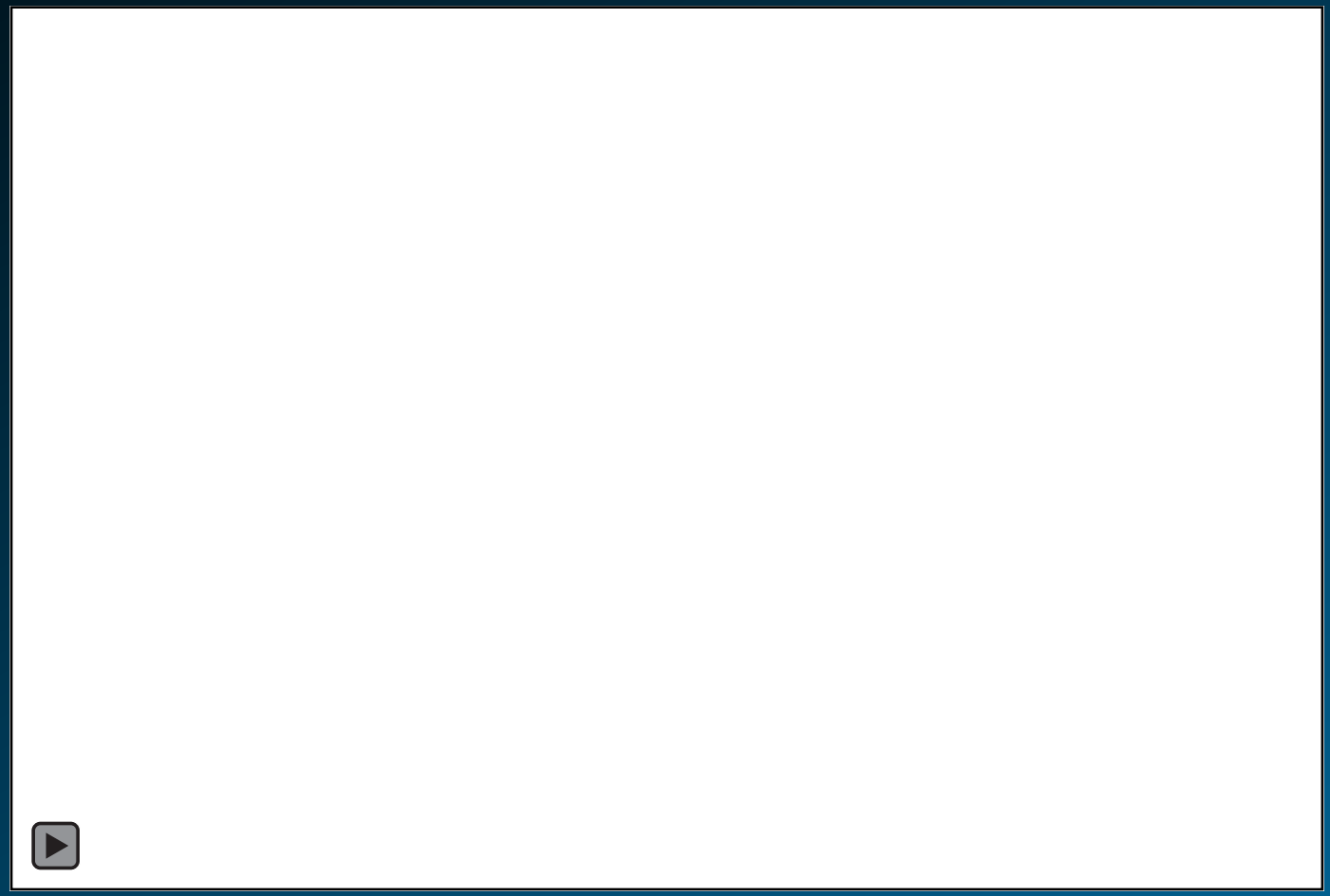

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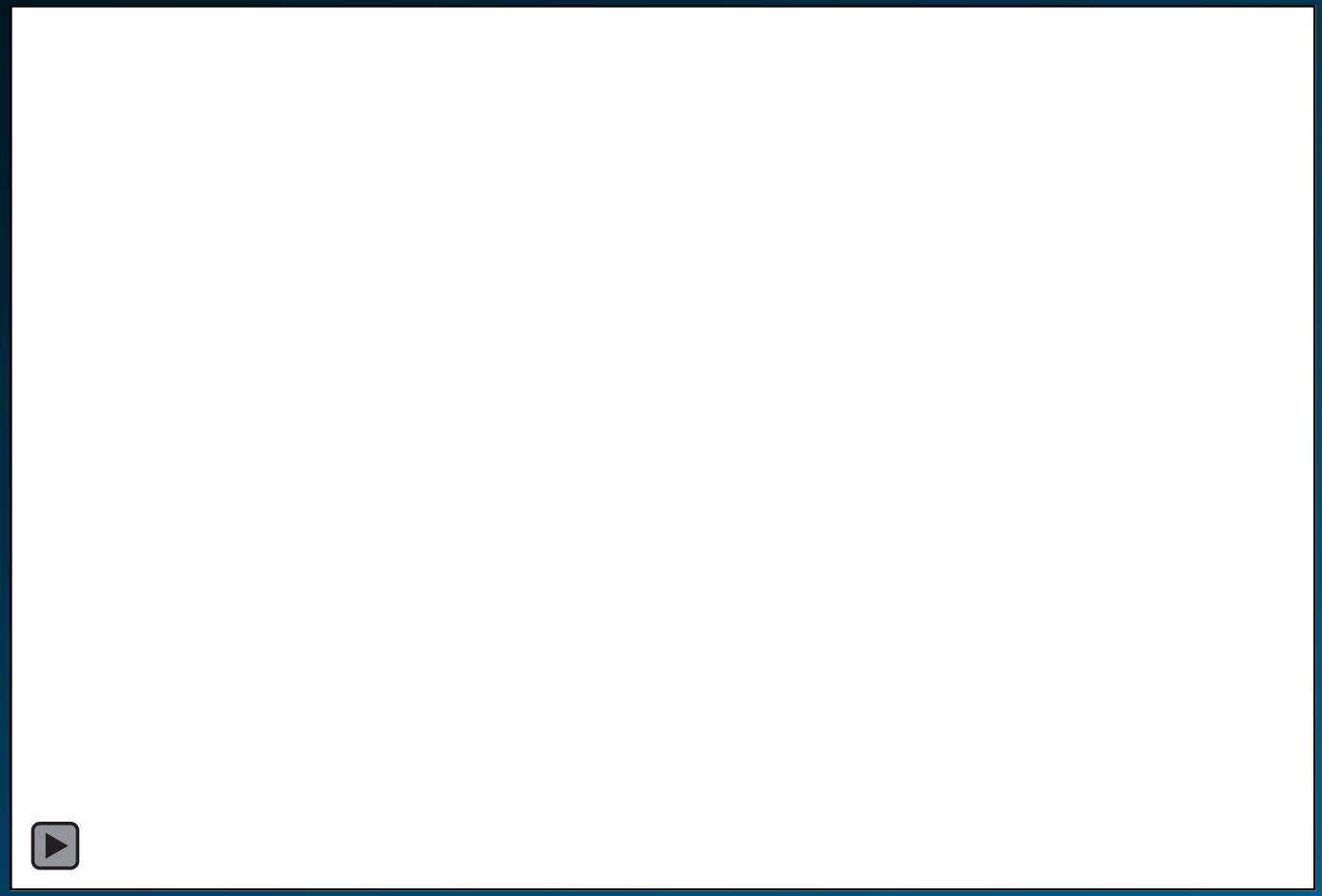

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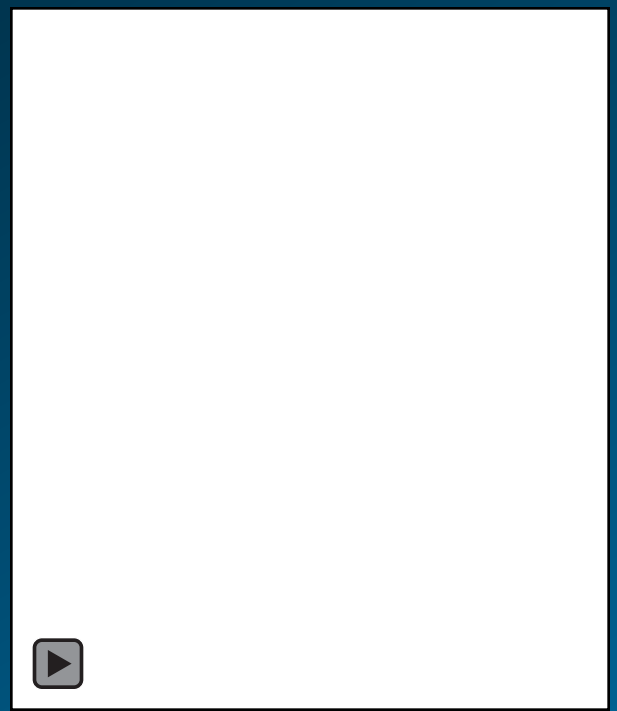
Premature Degeneration

Valve Regurgitation

“Normal” Valve Regurgitation

- Normal closure jets
- Trivial paravalvular regurgitation



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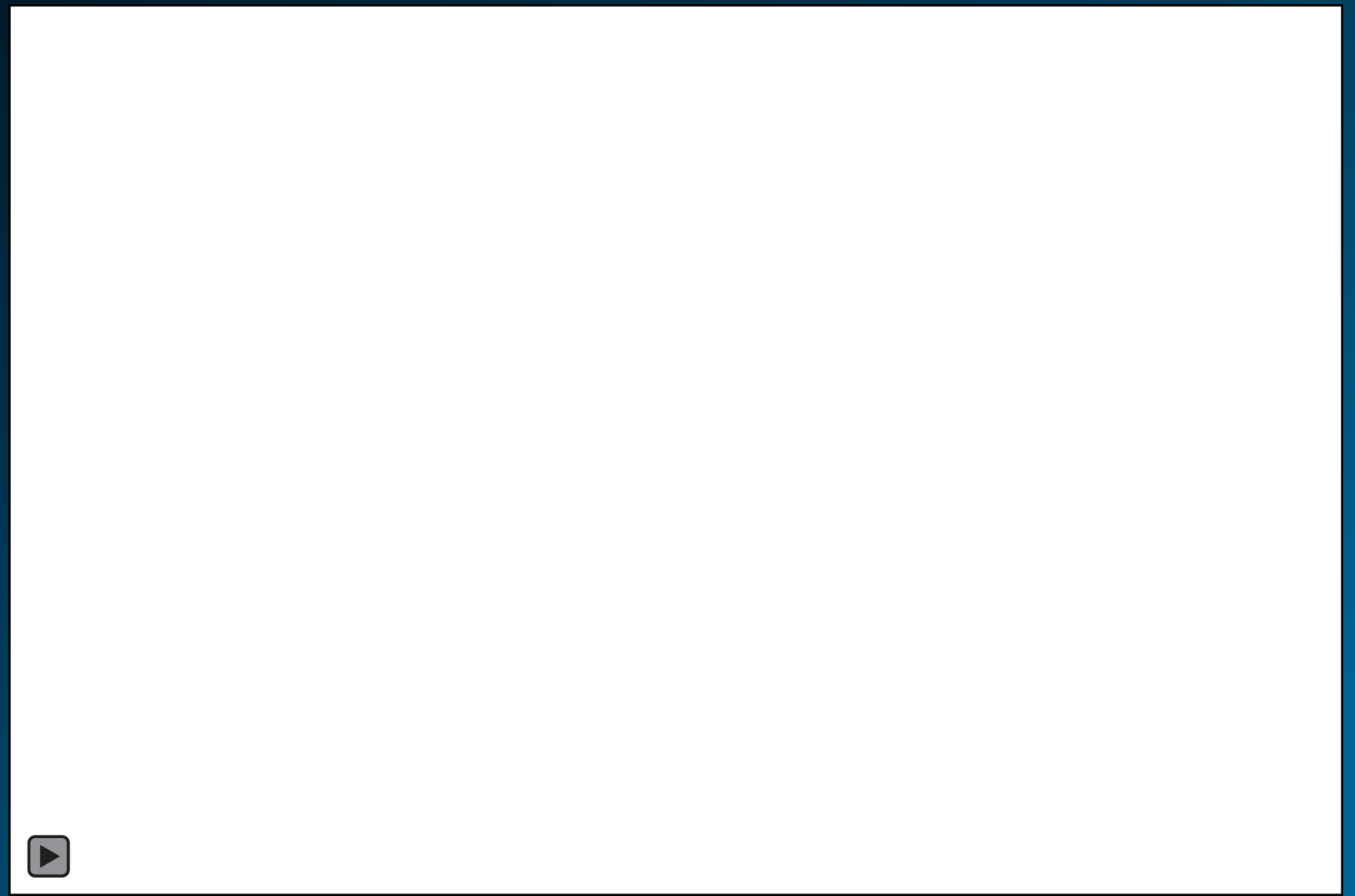
Pathologic Regurgitation

- Valve degeneration
- Valve dehiscence
- Vegetation
- Interference with valve closure
  - Stenosis and regurgitation may coexist
- Miscellaneous
  - Look carefully!

Valve dehiscence



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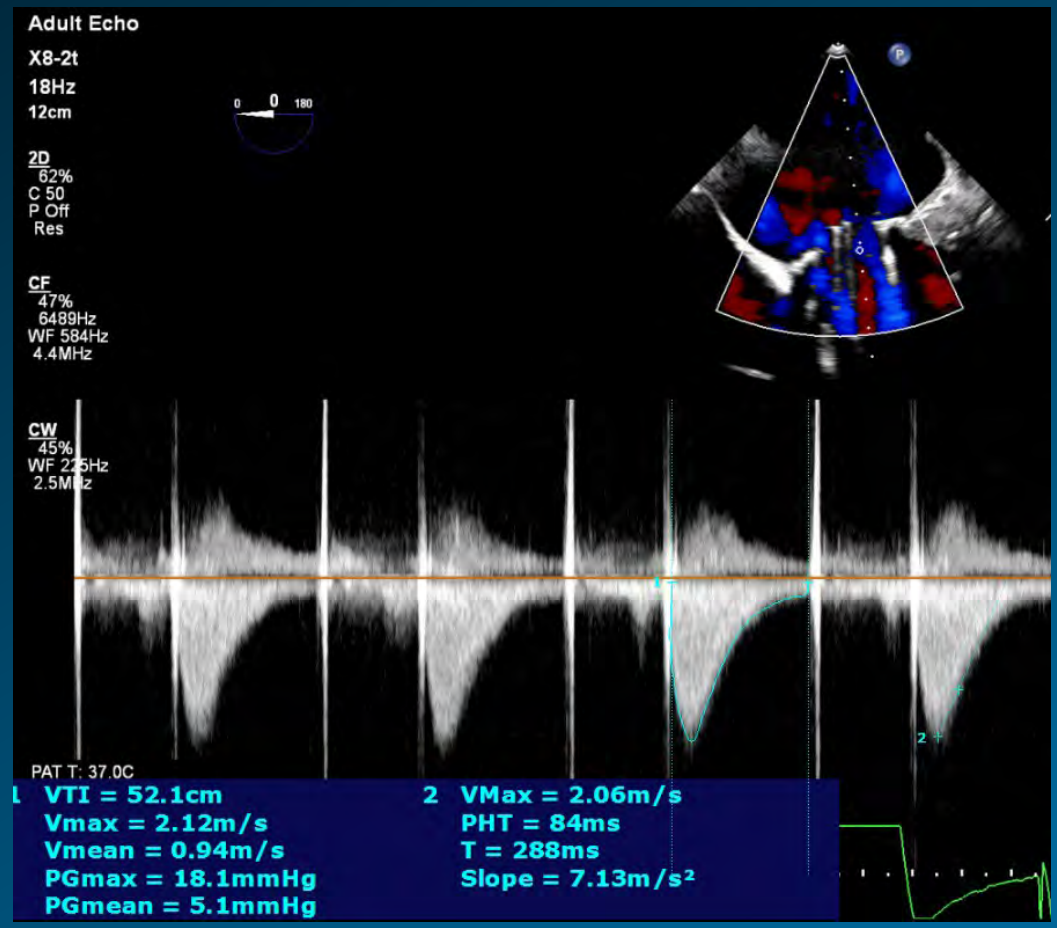
Paravalvular regurgitation



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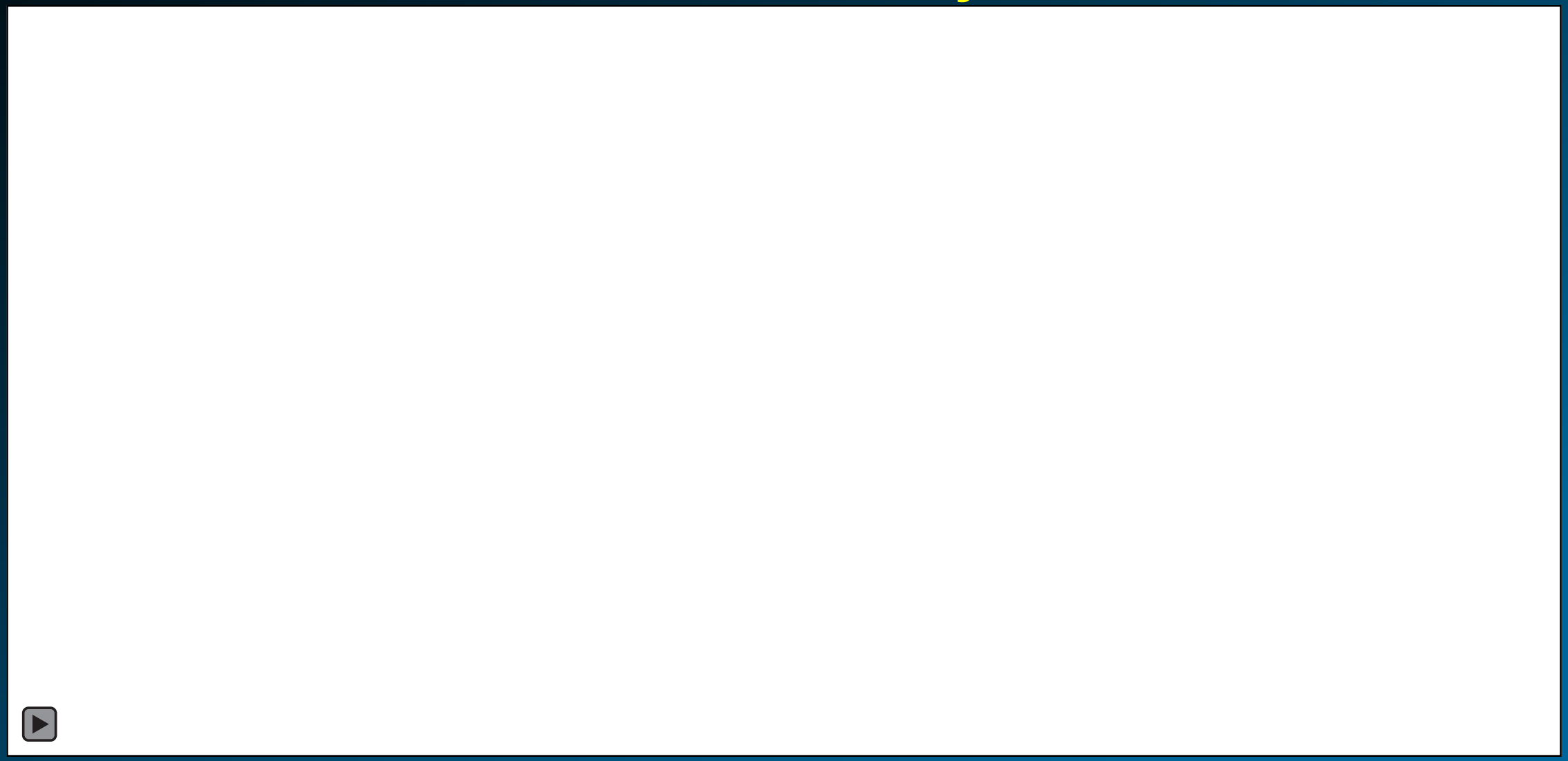
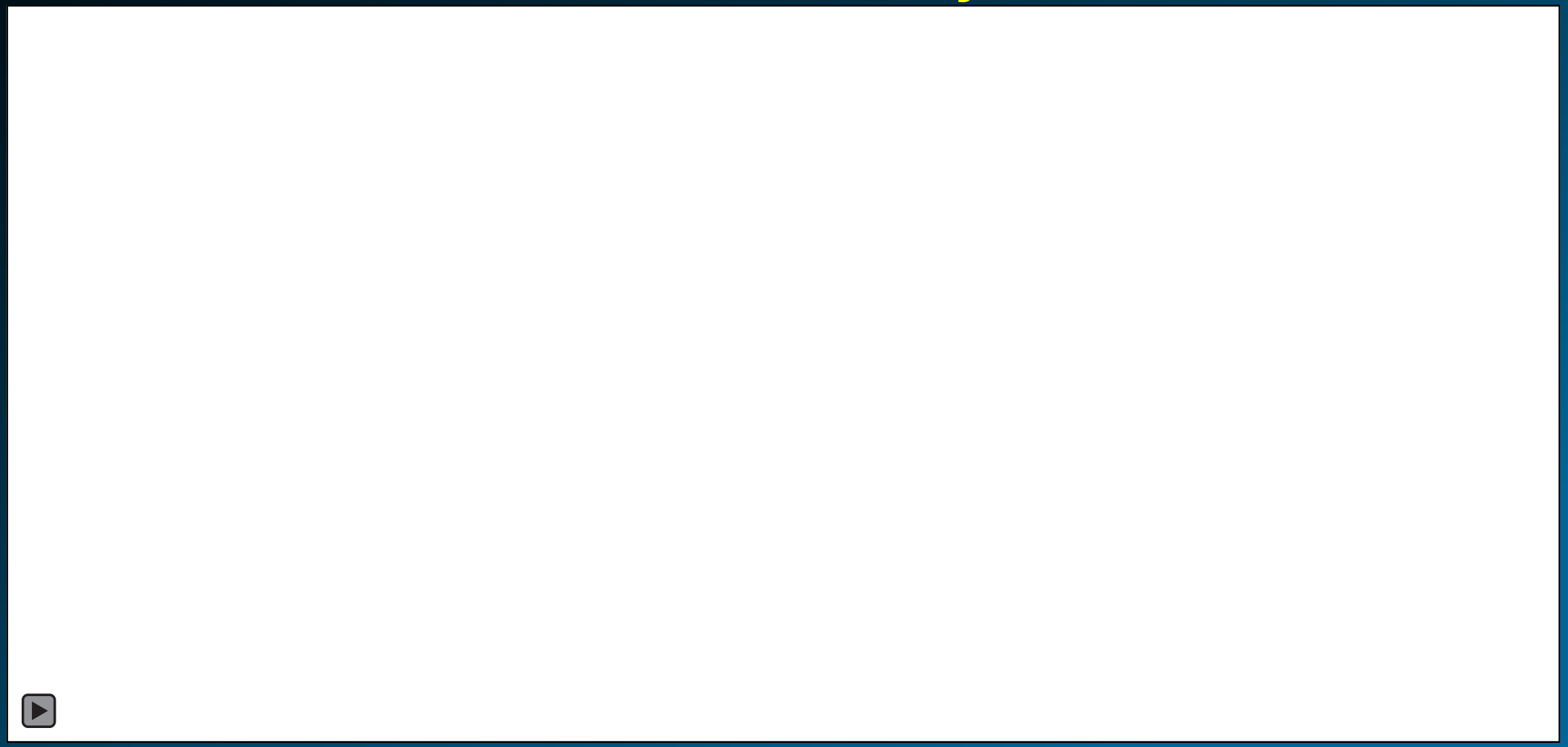
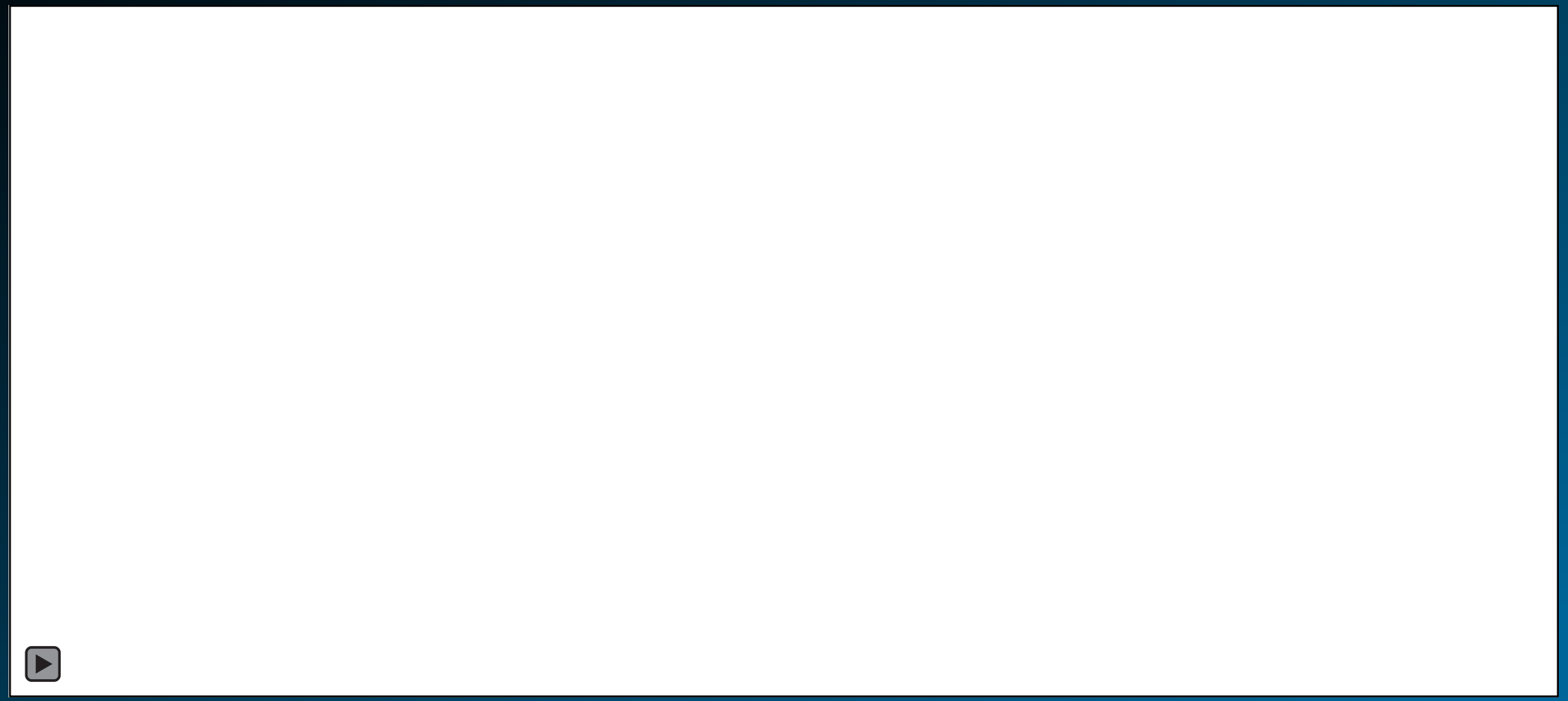
Medial PVL jet



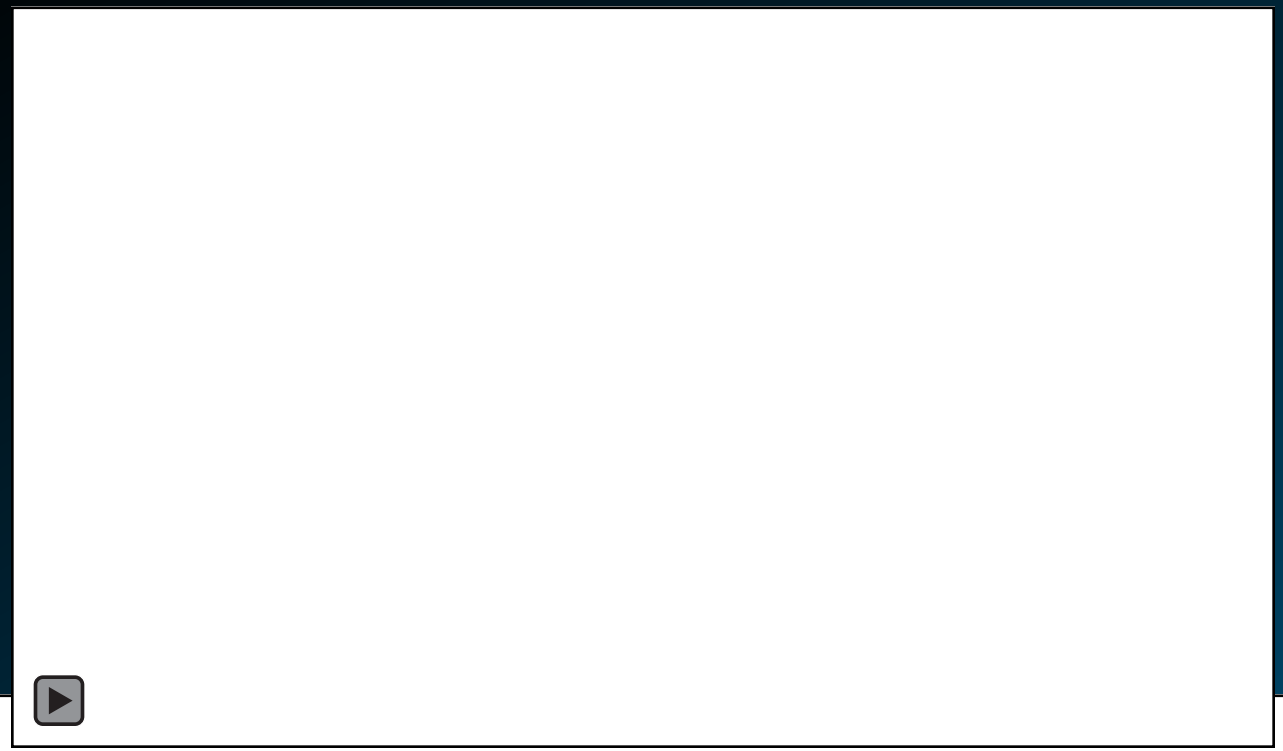
Lateral PVL jet



Both PVL jets



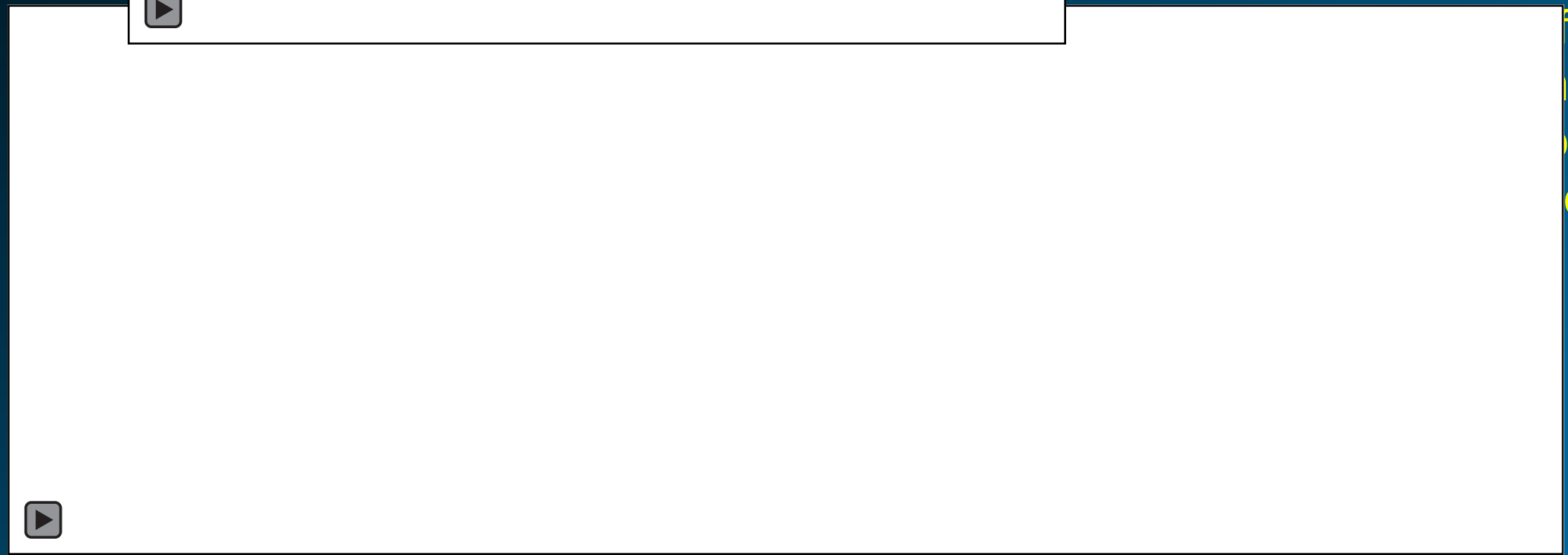
Good 3d imaging to bring it all together…

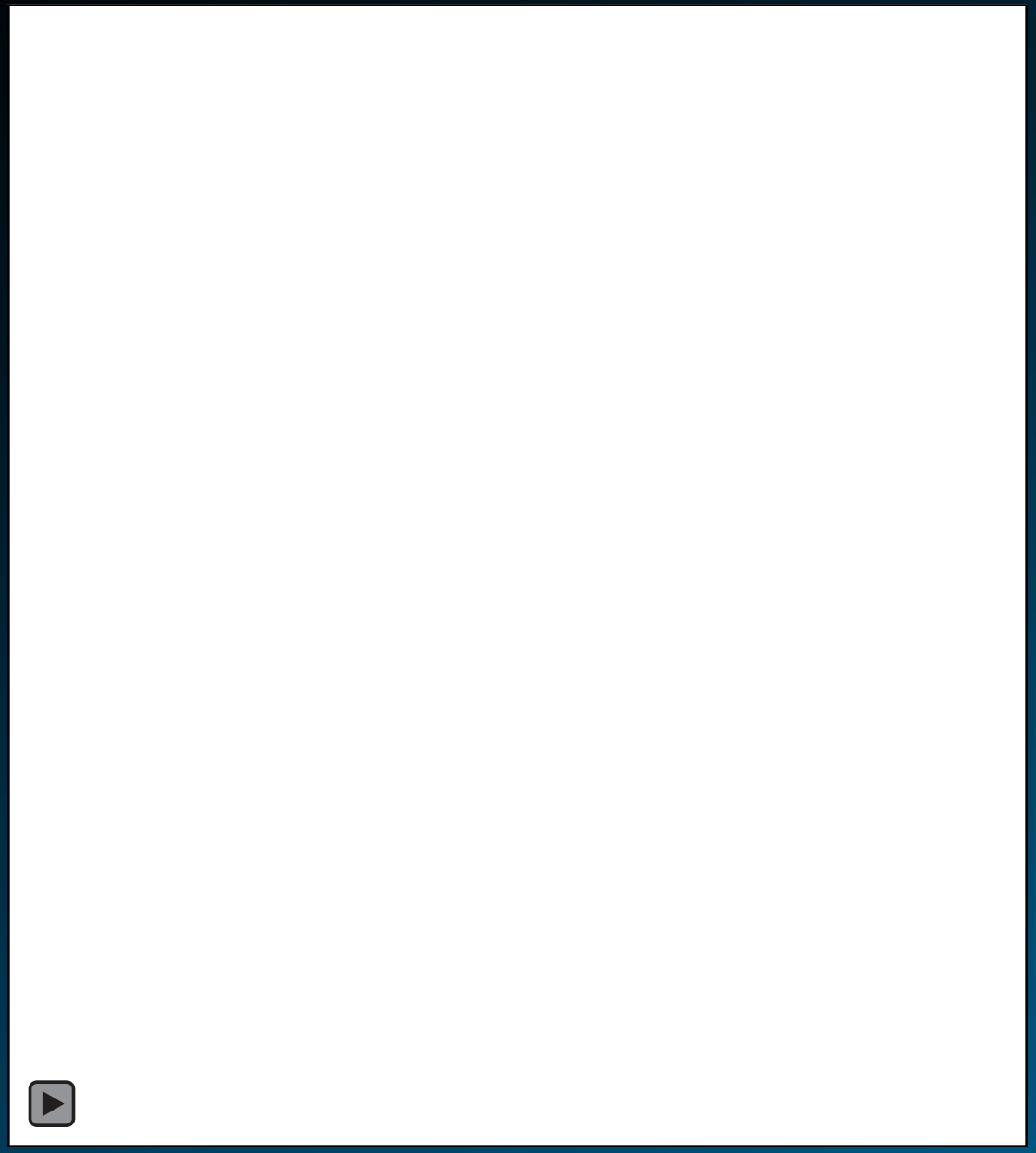


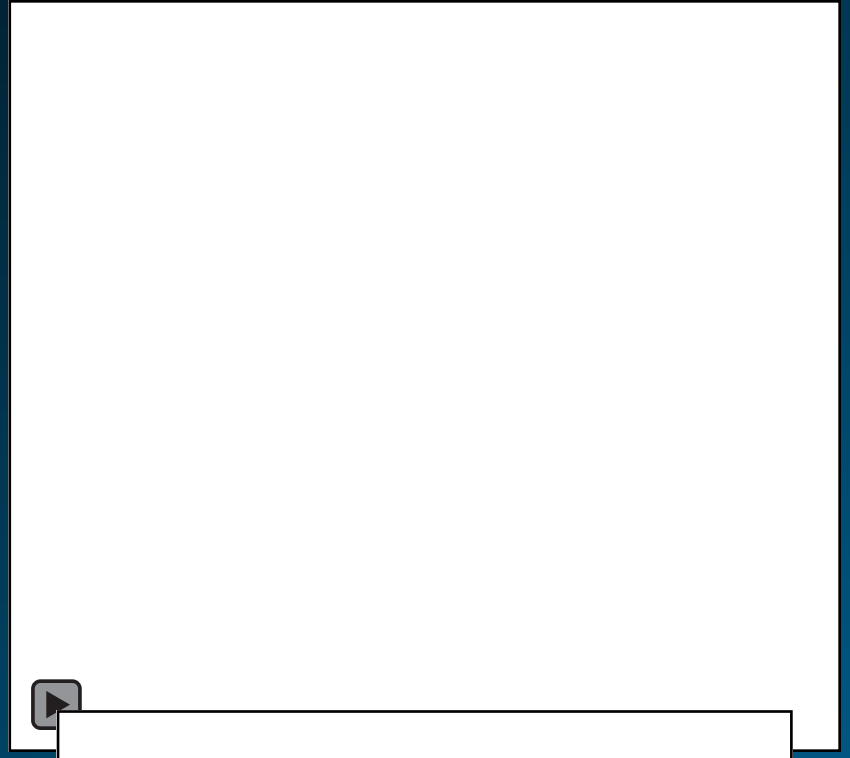
3D echo tip:

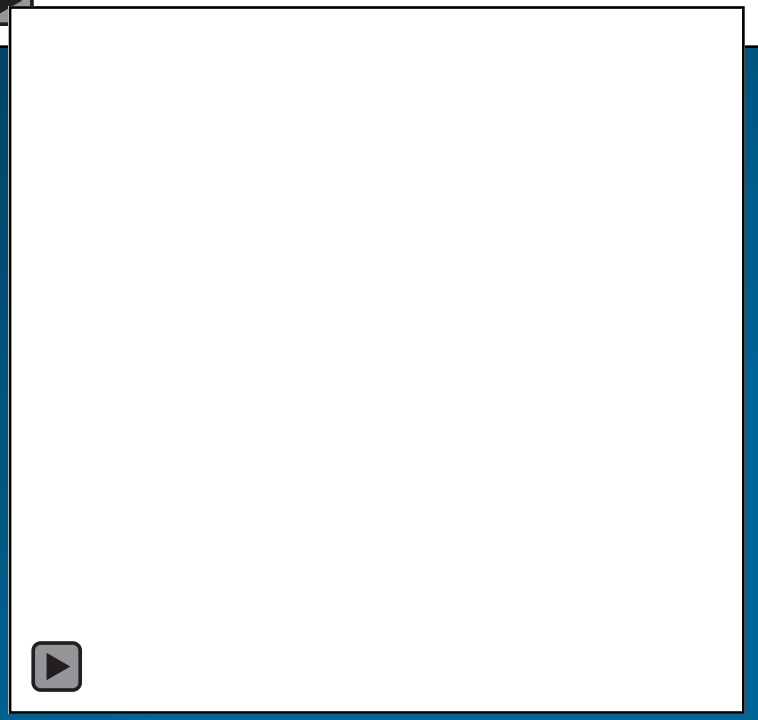
Trade-off between spatial and temporal resolution

3D color Doppler: goal FR > 10 Hz (minimum)



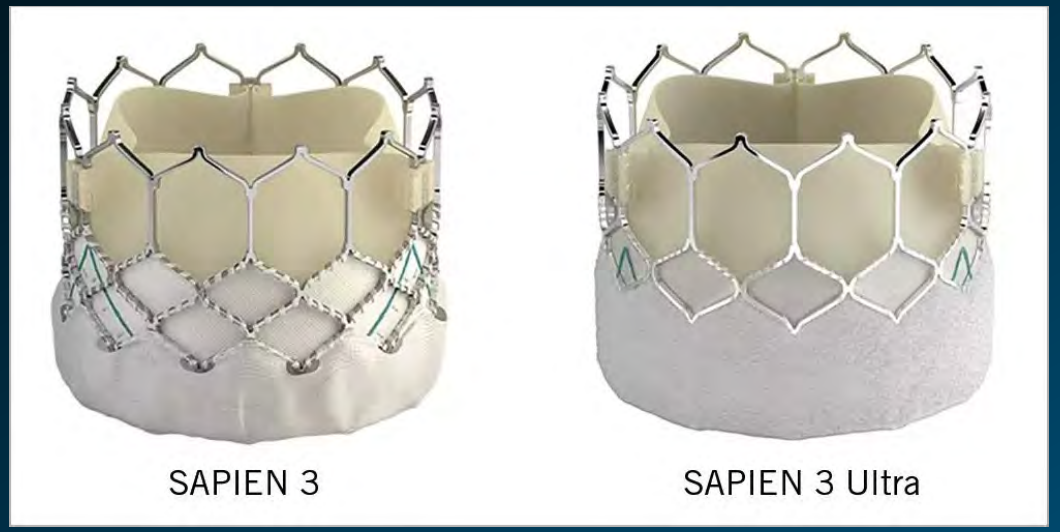




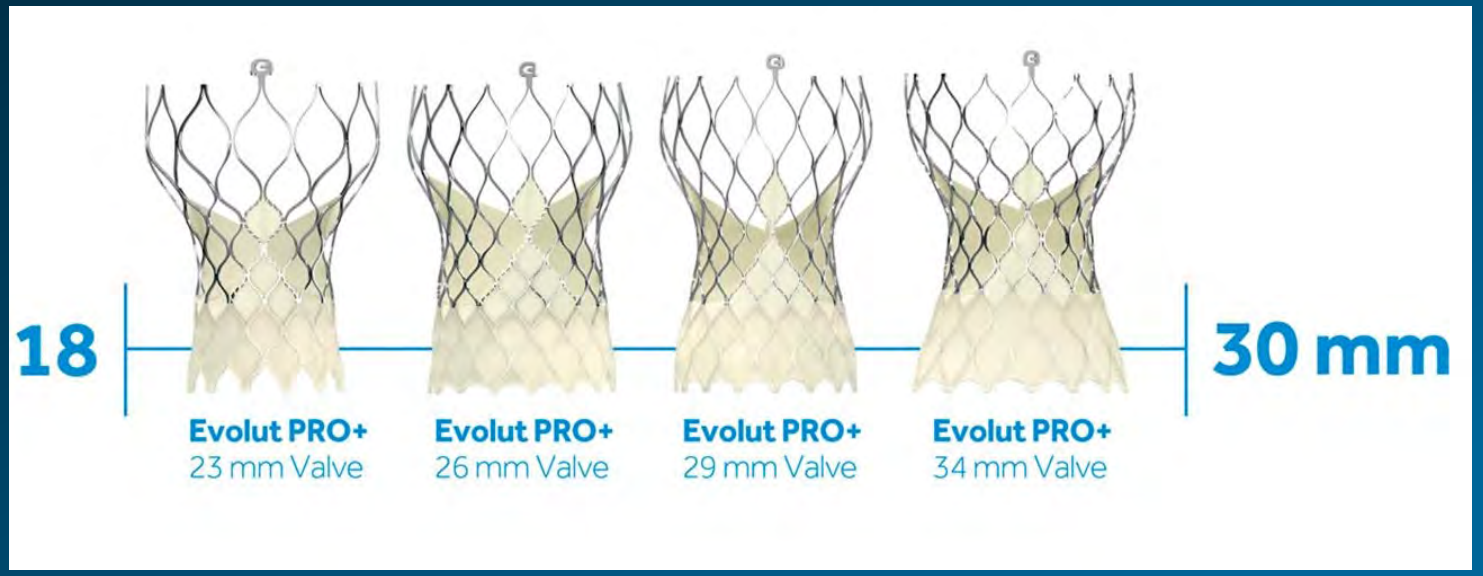


A word about TAVRs

TAVR: balloon and self expandable valves



(20mm,
23mm,
26mm,
29mm)



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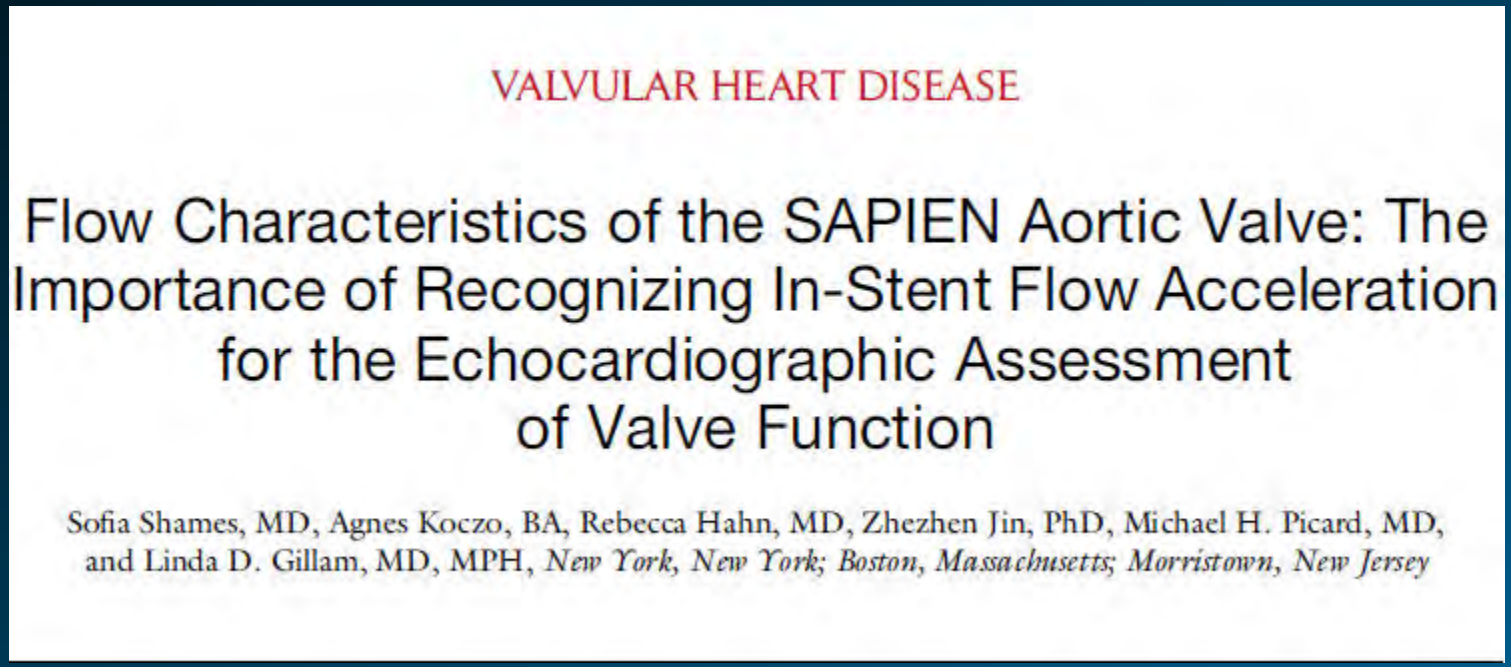
Core Principle

Both the frame and the cusps contribute to the total obstruction caused by the valve



J Am Soc Echocardiogr 2012;25:603-9.)

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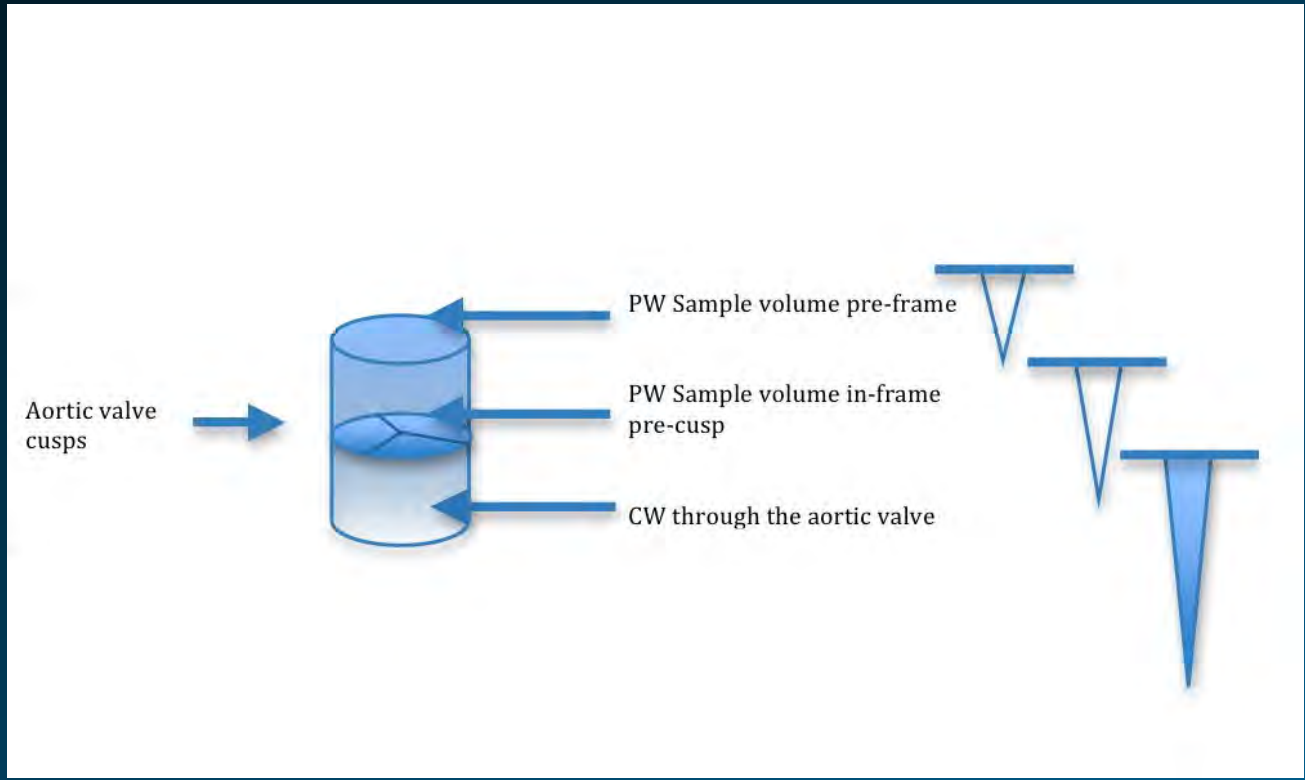
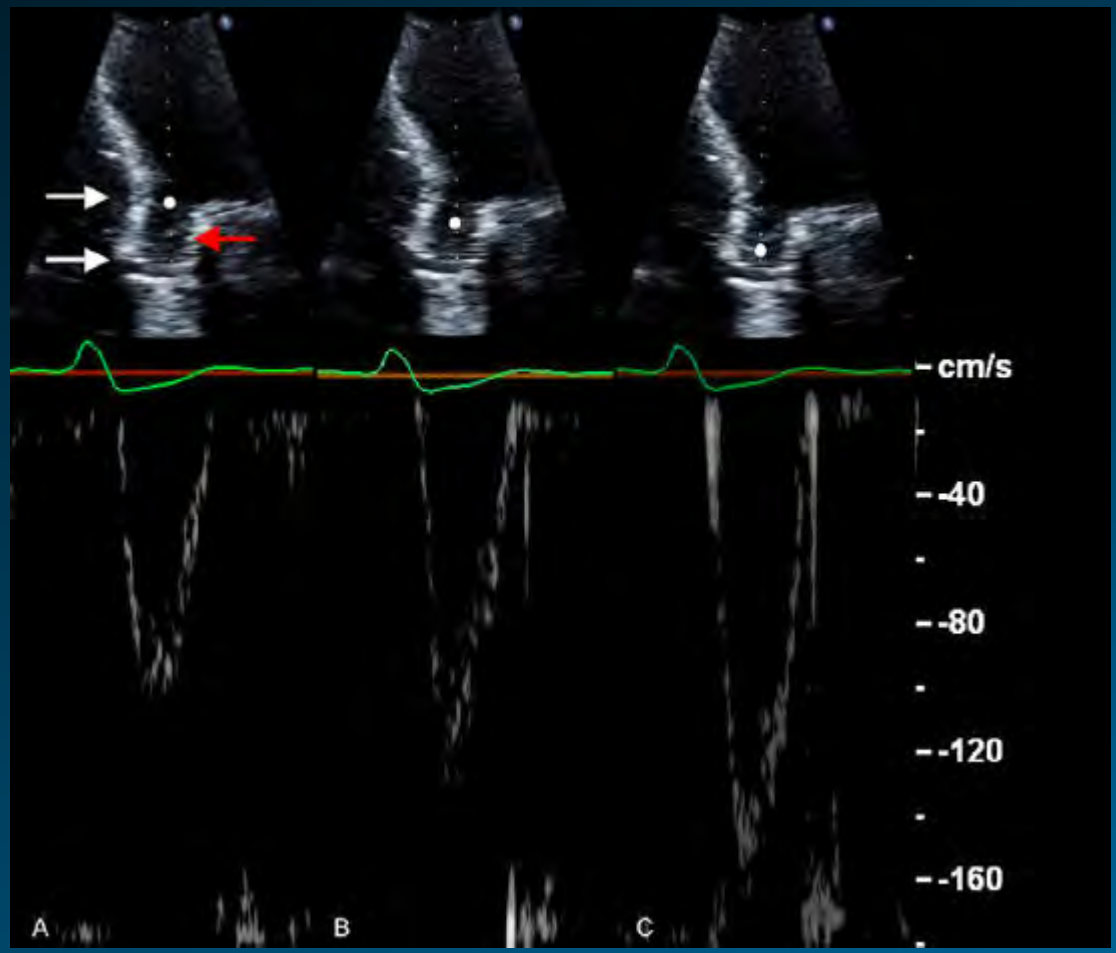
Flow acceleration at 2 levels





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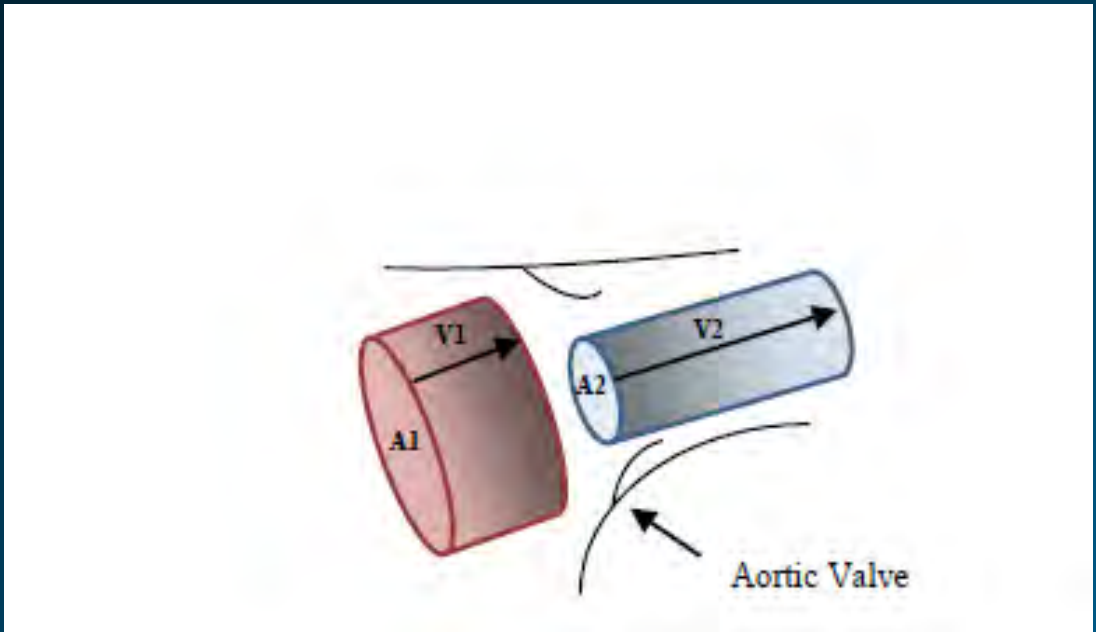
Doppler evaluation: calculating effective orifice area



$$A_2 = \frac{A_1 \times VTI_1}{VTI_2} \quad \text{OR} \quad \frac{A_1 \times V_1}{V_2}$$

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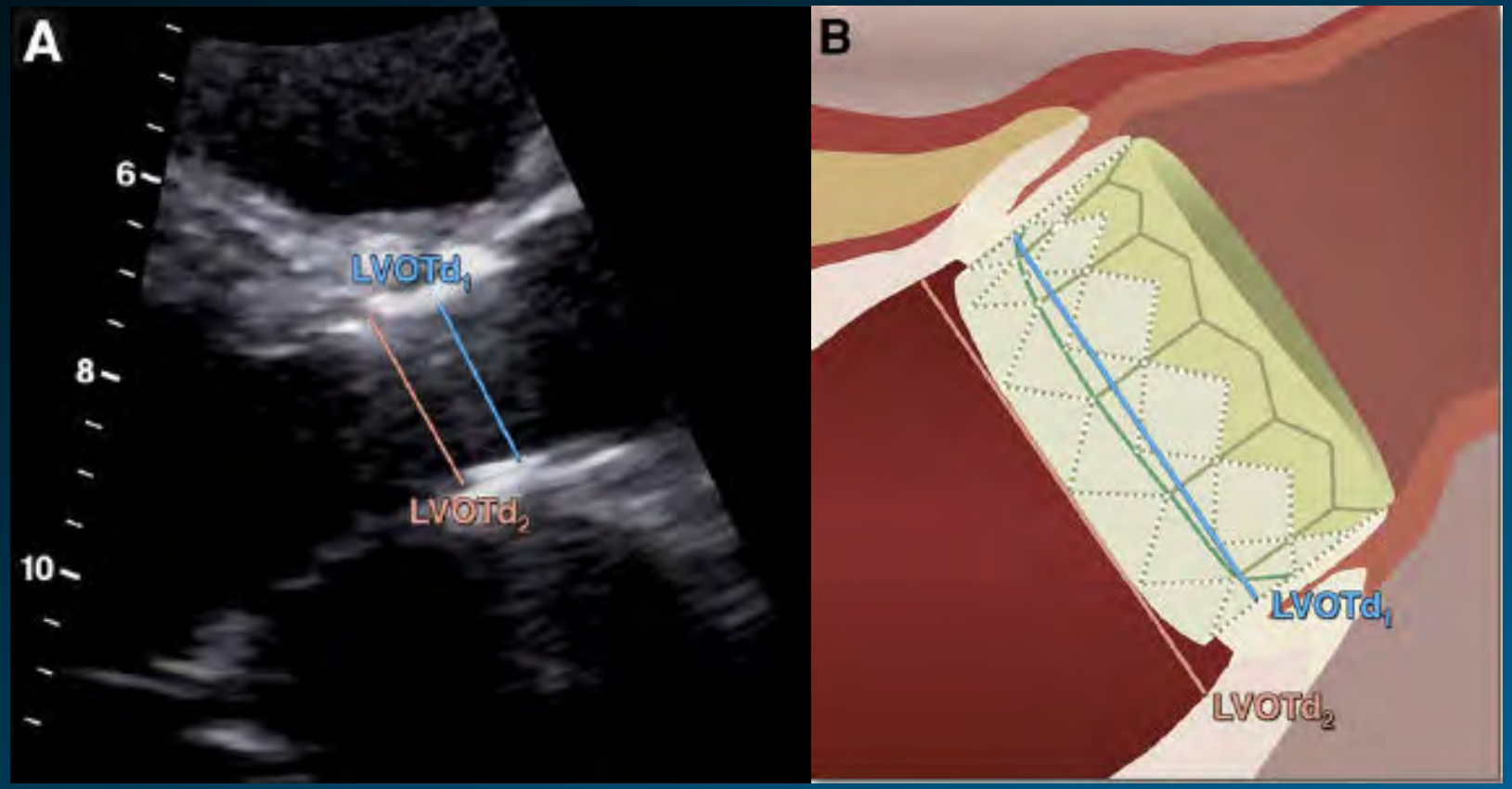
Measuring the LVOT Diameter



CLAVEL ET AL: JACC: CV MAGING, VOL. 4, NO. 10, 2011
OCTOBER 2011: 1053–62

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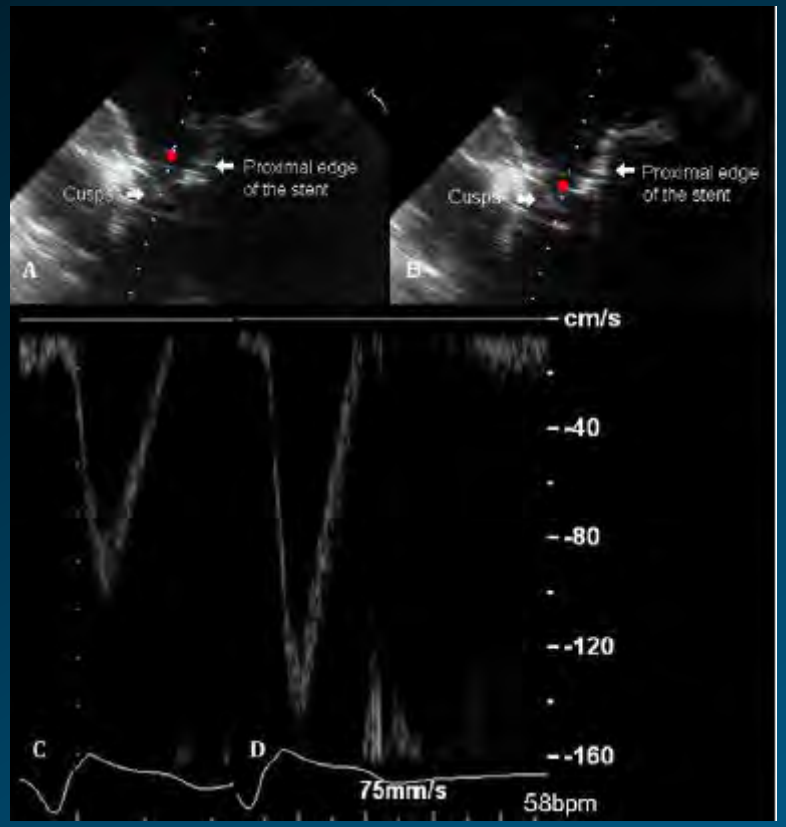

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Take Home Messages

- The flow characteristics of transcatheter valves differ from those of conventional surgical bioprostheses
- These differences translate to important considerations in the assessment of valve function
- Assessing these parameters correctly is essential in the ongoing evaluation of these valves

Summary
For prosthetic valves

- Understand range of normal function
- Have a low threshold for TEE
- Use post-pump intraoperative TEE if available or post implantation TTE to the fullest
- Remember the valve does not live in isolation (remember the atria, ventricles and PA pressures)

Thank you