Anatomy of the Mitral Valve and Quantification of Mitral Regurgitation

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DISCLOSURE

Relevant Financial Relationship(s)

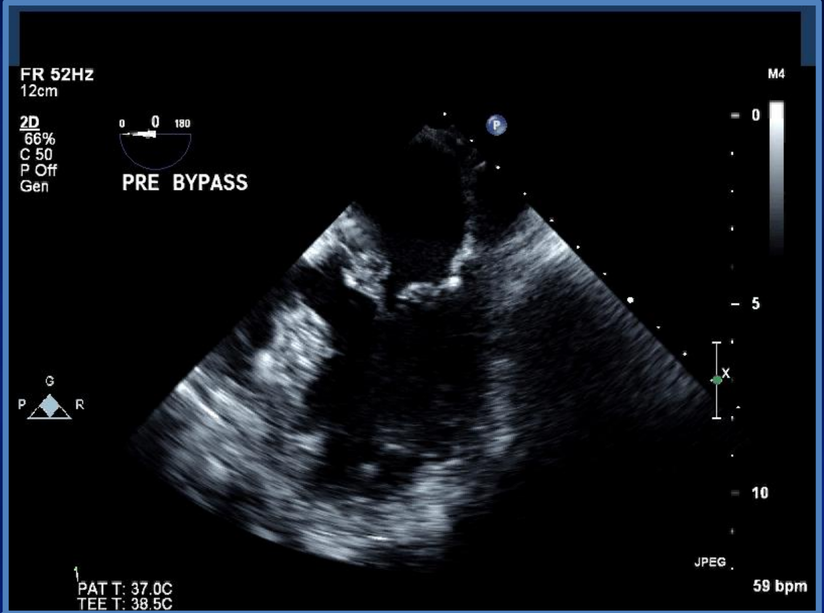
None

Off Label Usage

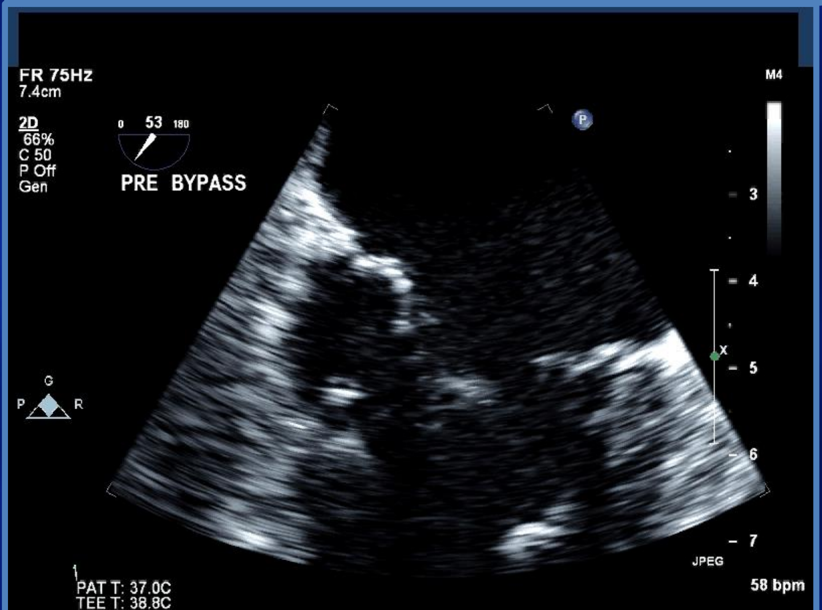
None

Pre-Test Questions

What is the specific abnormality of the mitral valve shown on this pre-operative TEE?

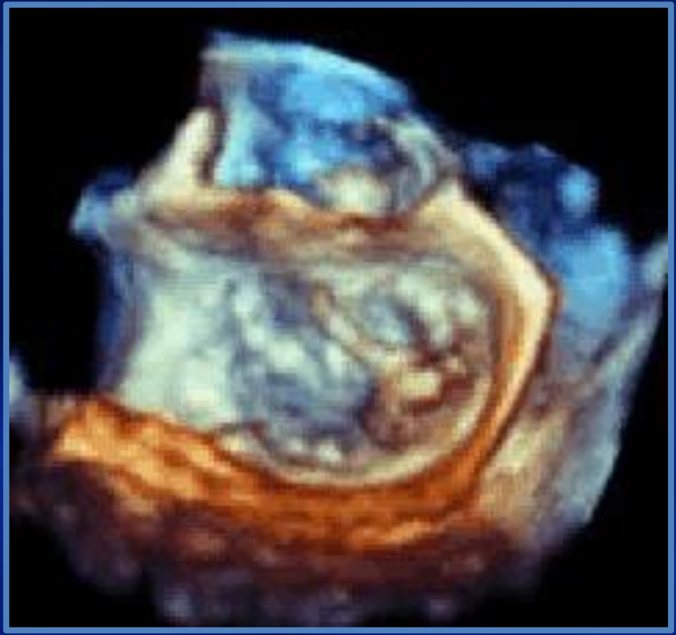


← 0° View



← 60° View

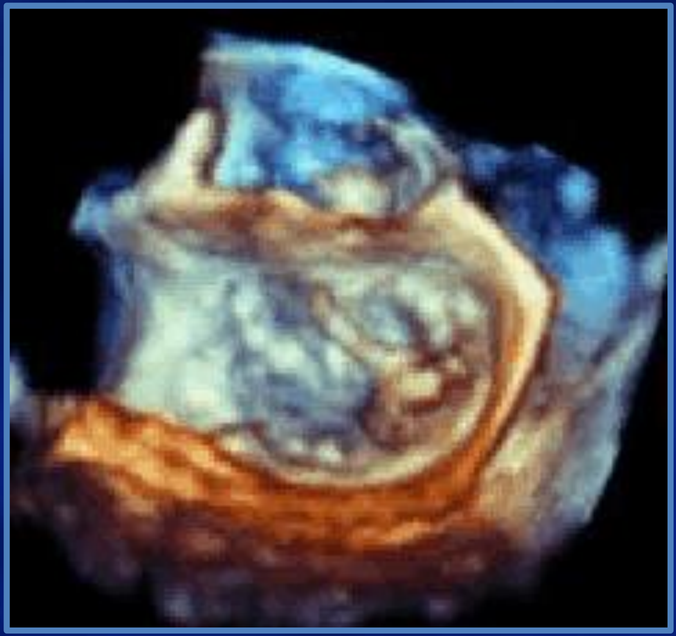
3D TEE



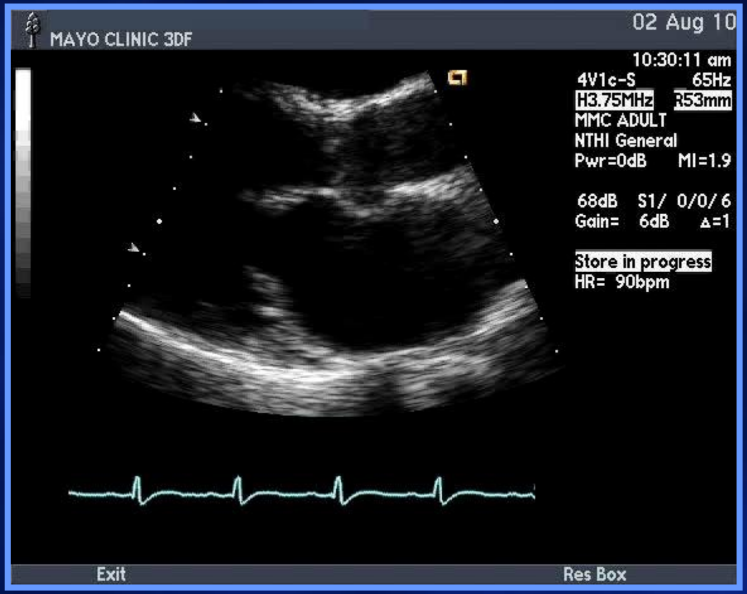
↑View from LA↑
"Surgeon's View"

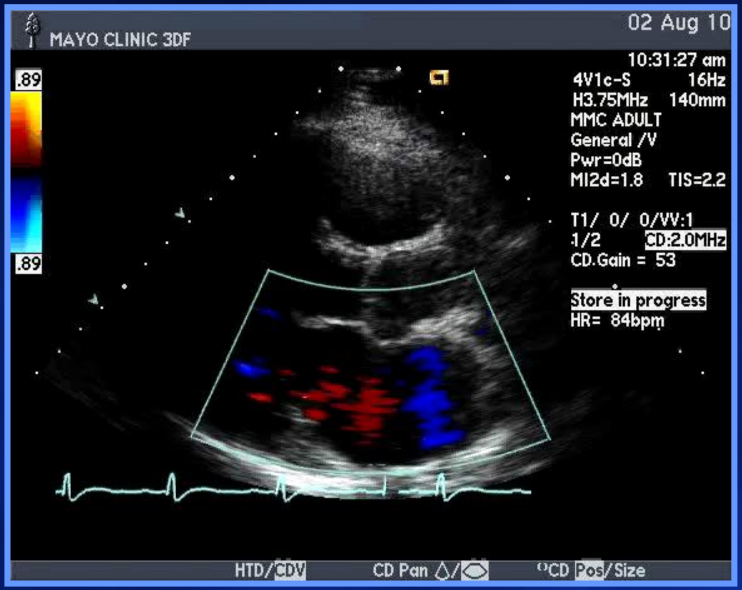
What is the specific mitral valve abnormality?

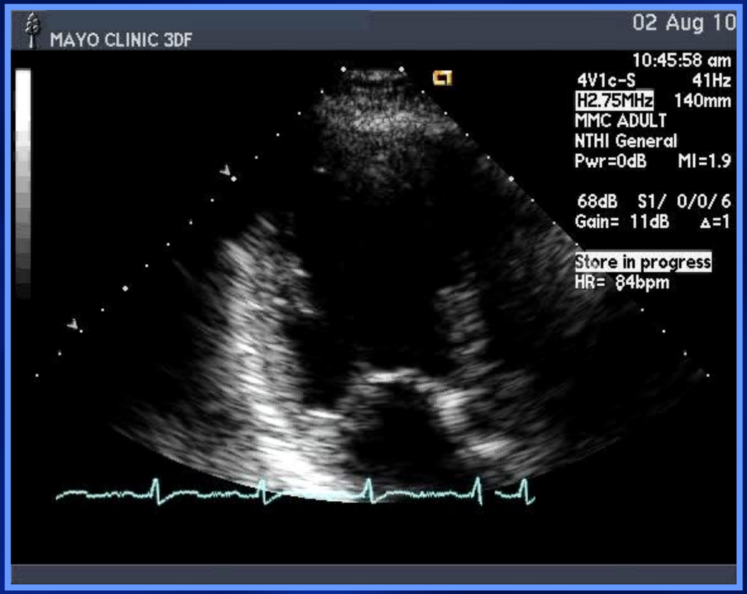
1. Flail P2
2. Flail P1
3. Flail P3
4. Barlow’s Disease
5. Flail A3

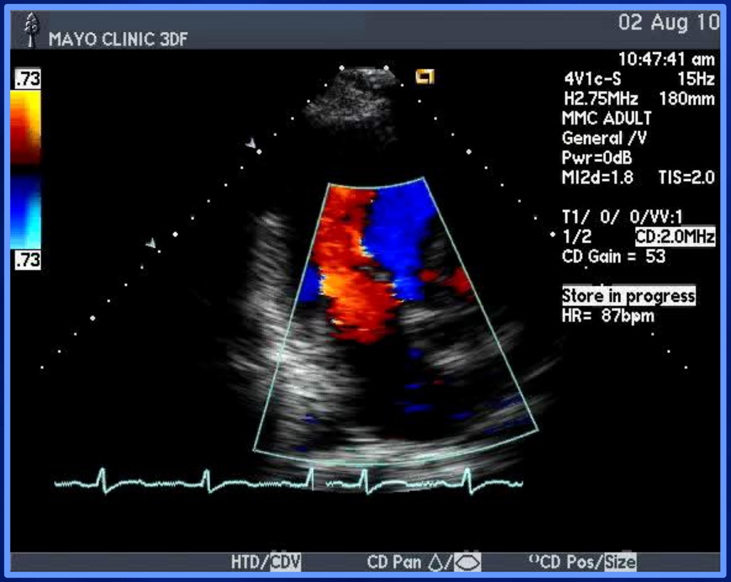


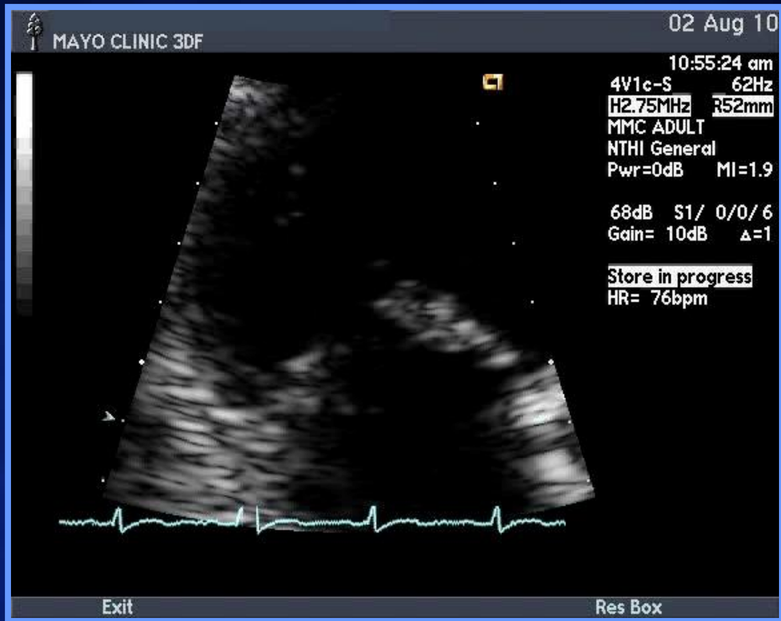
41 y/o woman: Dyspnea on exertion







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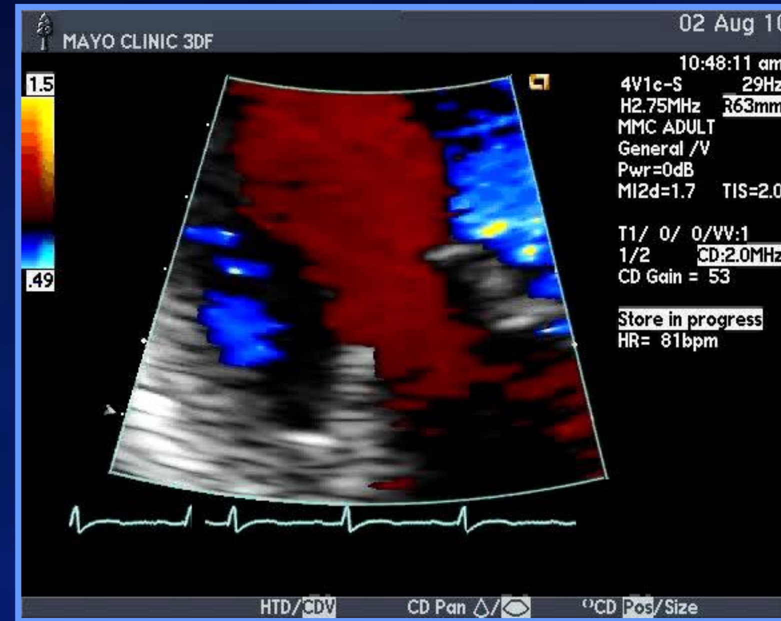
02 Aug 10
10:55:24 am
4V1c-S 62Hz
H2.75MHz R52mm
MMC ADULT
NTHI General
Pwr=0dB MI=1.9
68dB S1/ 0/0/ 6
Gain= 10dB Δ=1
Store in progress
HR= 76bpm
Exit
Res Box


MAYO CLINIC 3DF
02 Aug 10
10:48:11 am
4V1c-S 29Hz
H2.75MHz R63mm
MMC ADULT
General /V
Pwr=0dB
MI2d=1.7 TIS=2.0
T1/ 0/ 0/VV:1
1/2 CD:2.0MHz
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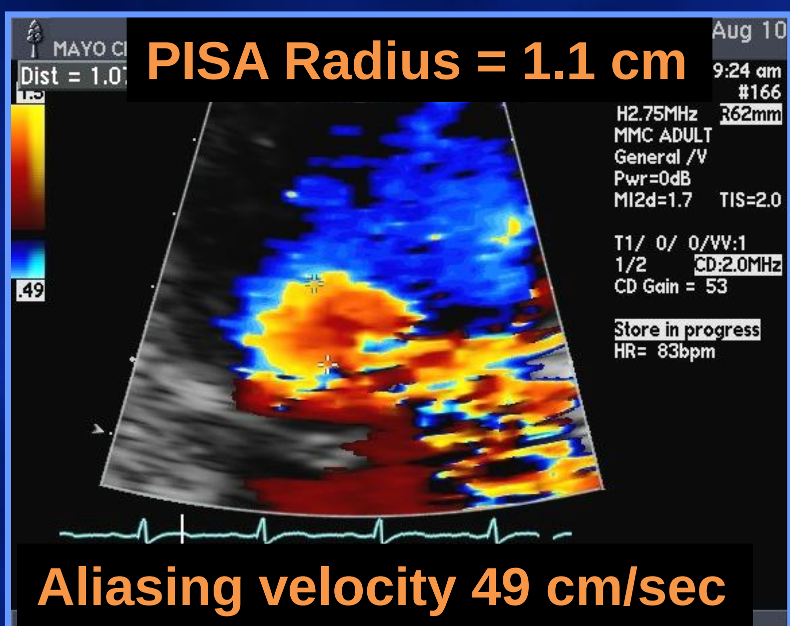
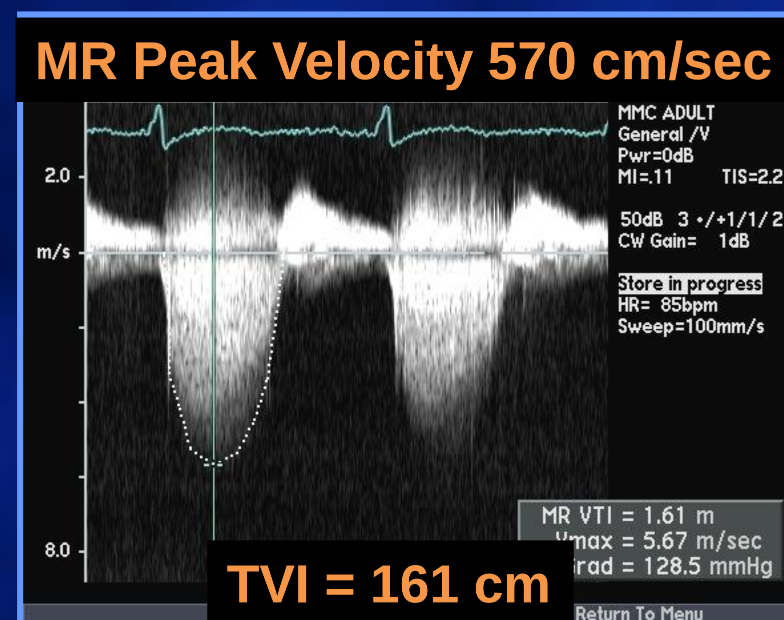
HR= 81bpm
1.5
.49
HTD/CDV
CD Pan
CD Pos/Size


PISA Radius = 1.1 cm
Aug 10
9:24 am
#166
H2.75MHz R62mm
MMC ADULT
General /V
Pwr=0dB
MI2d=1.7 TIS=2.0
T1/ 0/ 0/VV:1
1/2 CD:2.0MHz
CD Gain = 53
Store in progress
HR= 83bpm
.49
Aliasing velocity 49 cm/sec


MR Peak Velocity 570 cm/sec
MMC ADULT
General /V
Pwr=0dB
MI=.11 TIS=2.2
50dB 3 •/+1/1/ 2
CW Gain= 1dB
Store in progress
HR= 85bpm
Sweep=100mm/s
2.0
m/s
8.0
MR VTI = 1.61 m
Vmax = 5.67 m/sec
rad = 128.5 mmHg
TVI = 161 cm
Return To Menu

What is the calculated ERO?

1. 0.45 cm^2
2. 0.55 cm^2
3. 0.35 cm^2
4. 0.65 cm^2
5. 0.75 cm^2

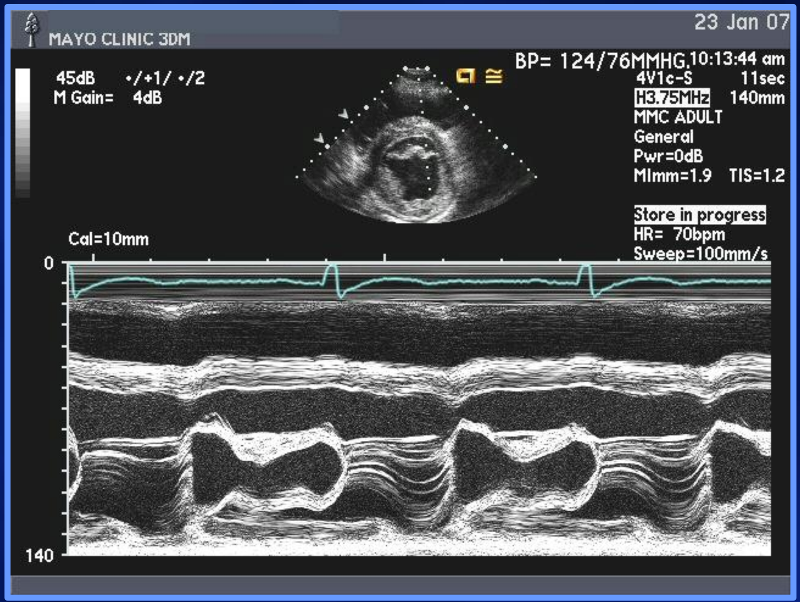
PISA Radius = 1.1 cm

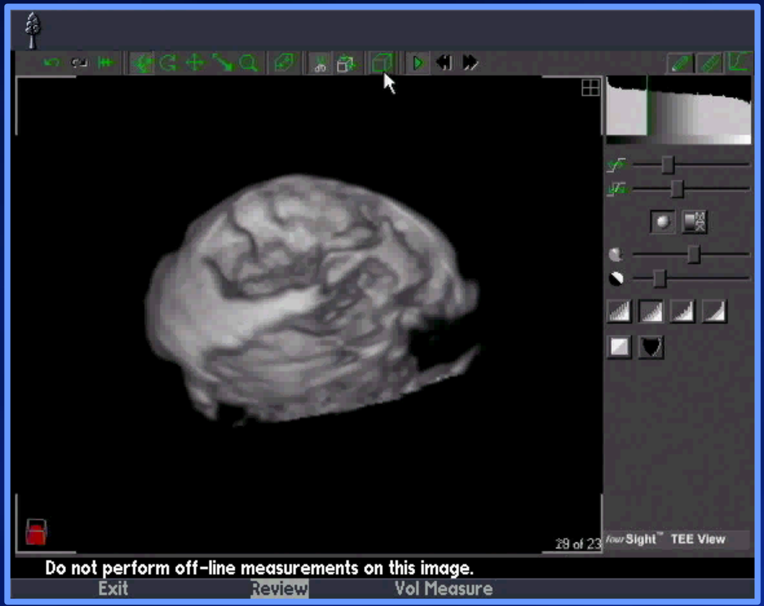
Aliasing velocity 49 cm/sec

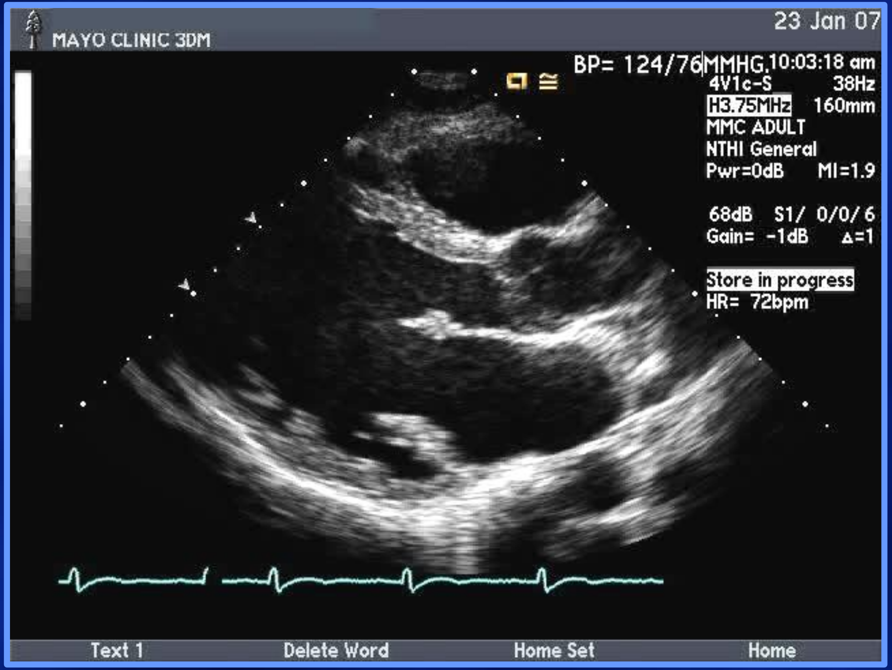
MR Peak Velocity 570 cm/sec

TVI = 161 cm

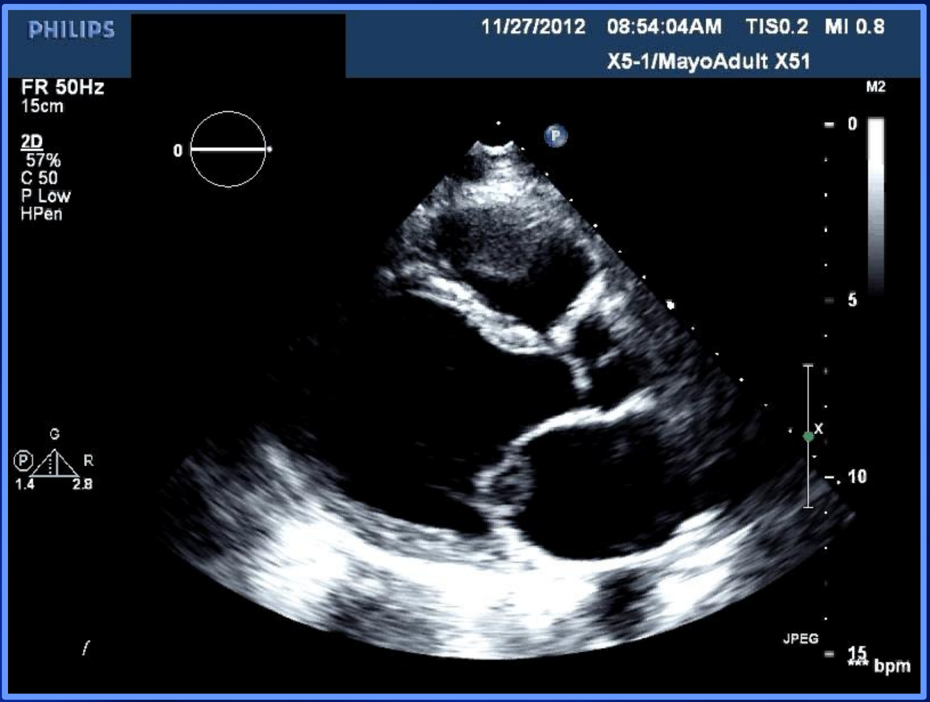
Mitral Valve Prolapse: Evolution of Echo

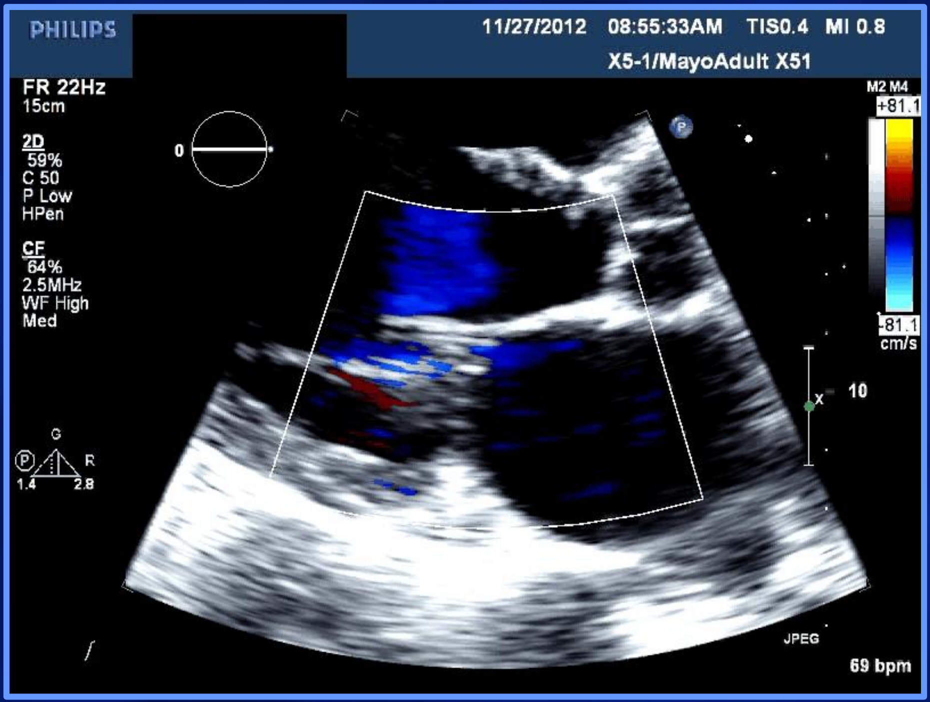




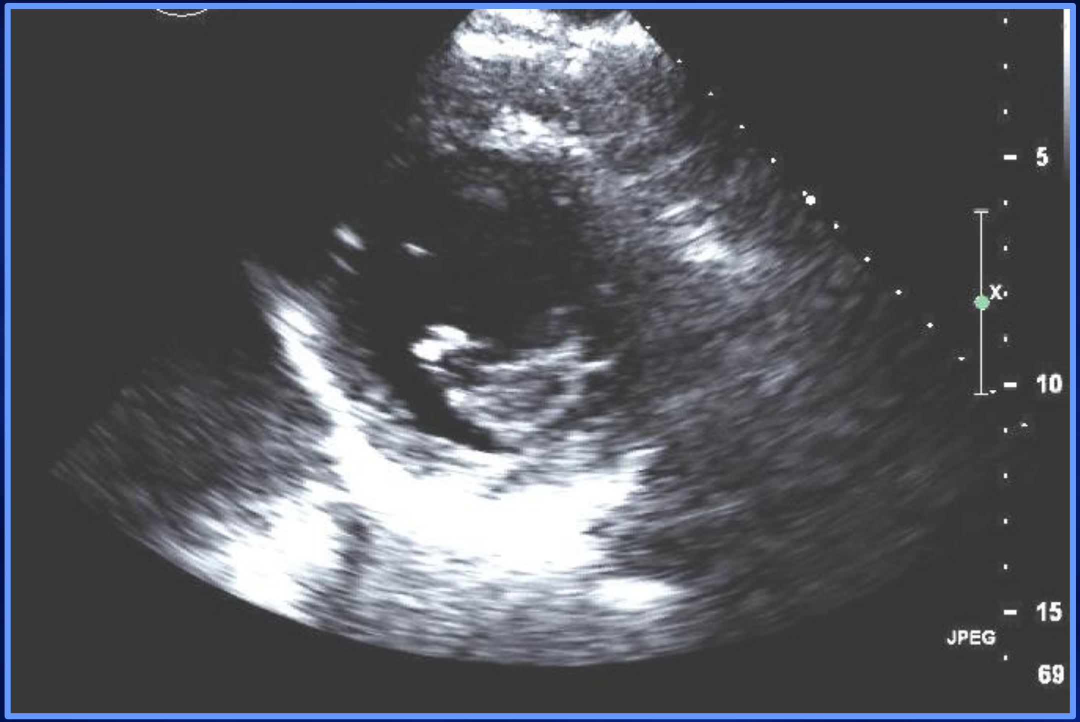


Mitral Valve Posterior Leaflet Prolapse





MAYO CLINIC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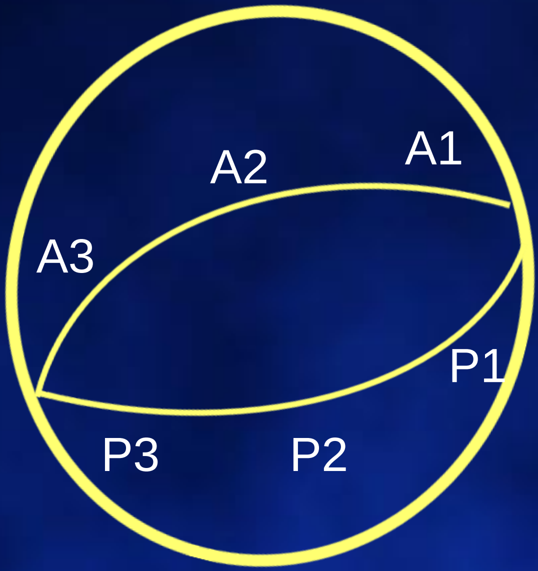
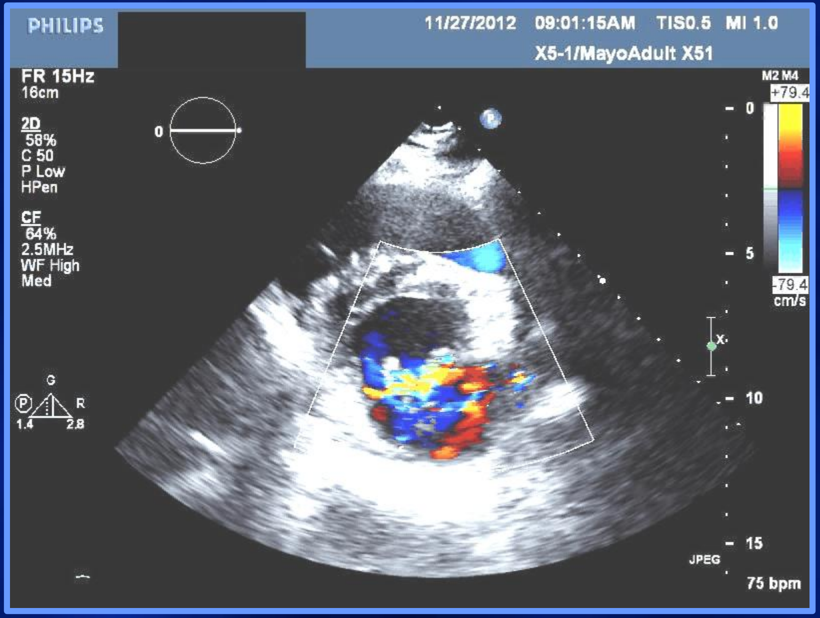
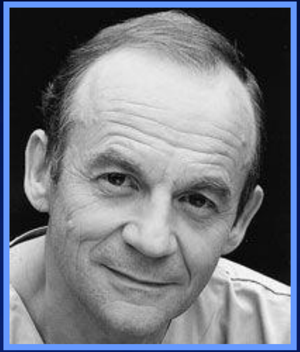
X
10
15
JPEG
69

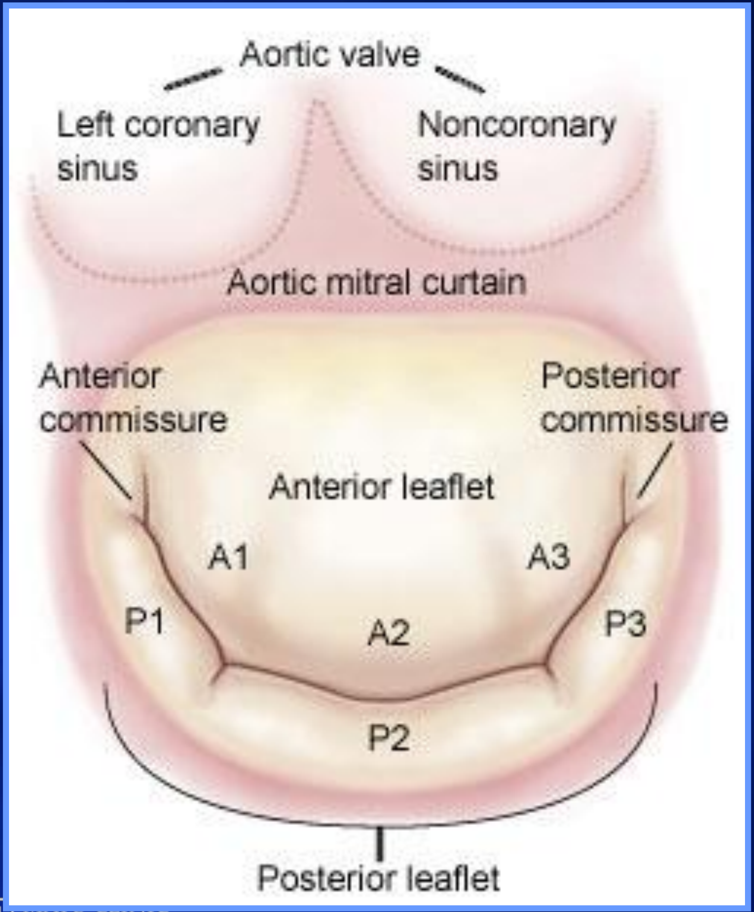

A1
A2
A3
P1
P2
P3

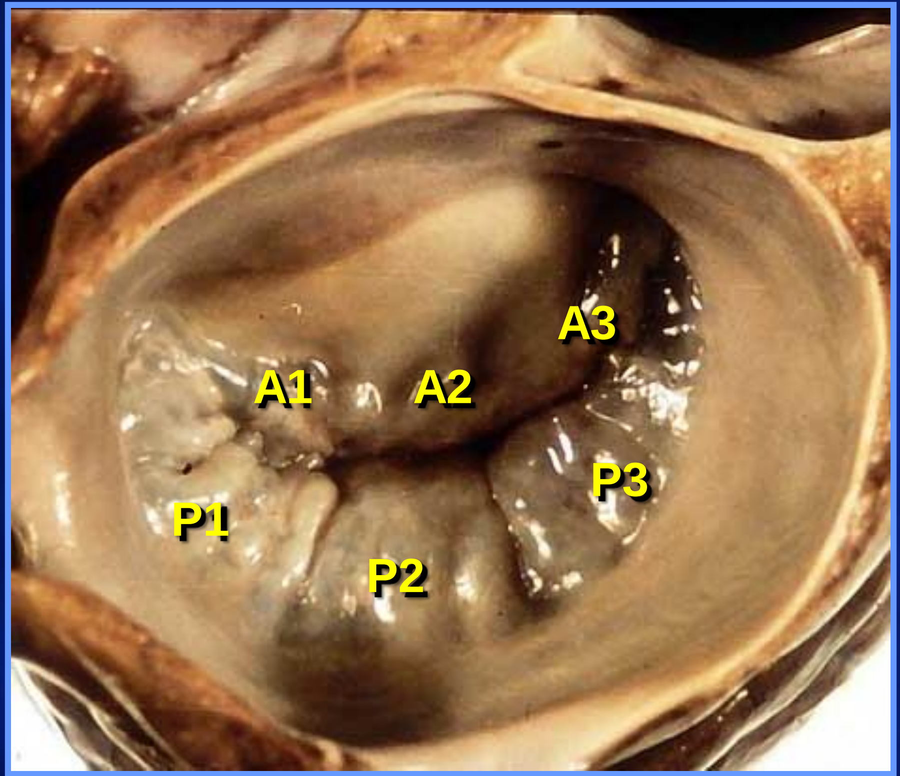

PHILIPS
11/27/2012 09:01:15AM TIS0.5 MI 1.0
X5-1/MayoAdult X51
FR 15Hz
16cm
2D
58%
C 50
P Low
HPen
CF
64%
2.5MHz
WF High
Med
M2 M4
+79.4
-79.4
cm/s
0
5
10
15
JPEG
75 bpm



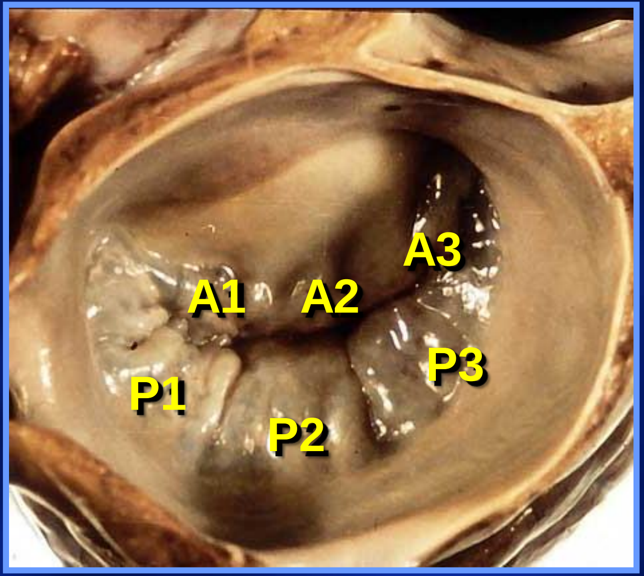
Mitral Valve Anatomy: View from the Left Atrium

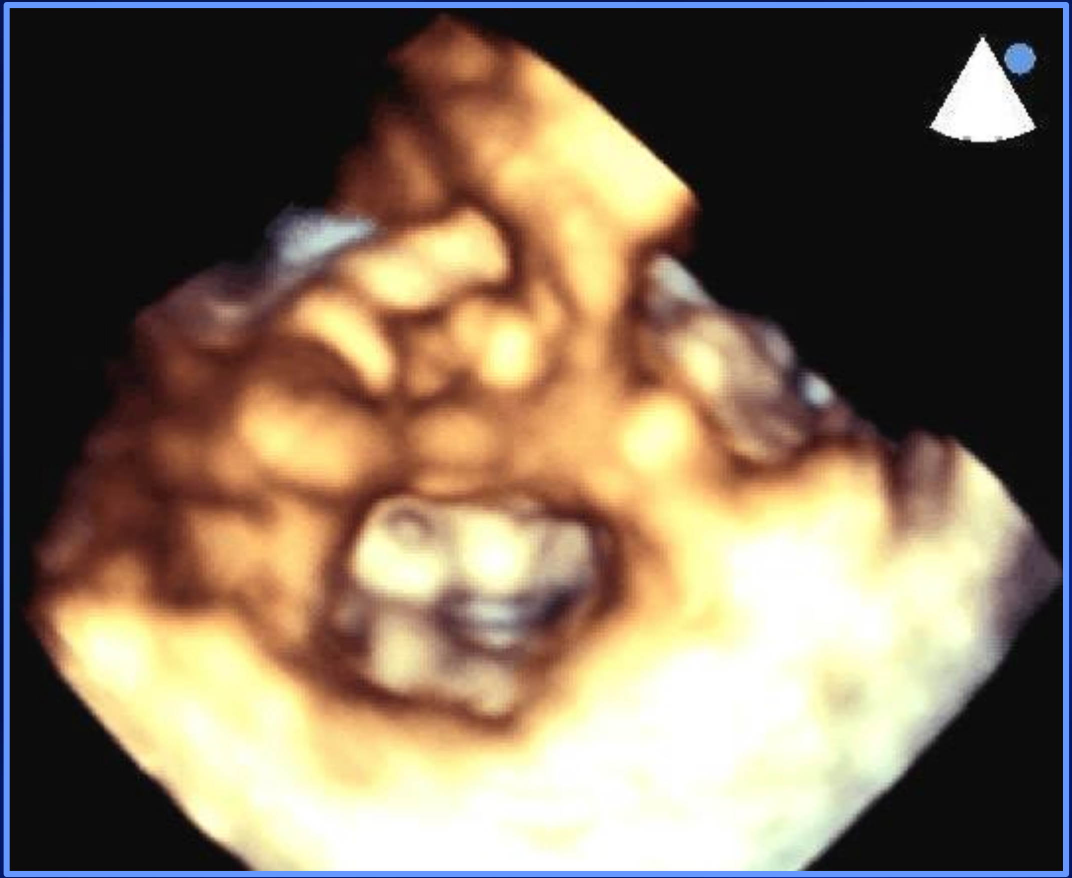
Carpentier Nomenclature



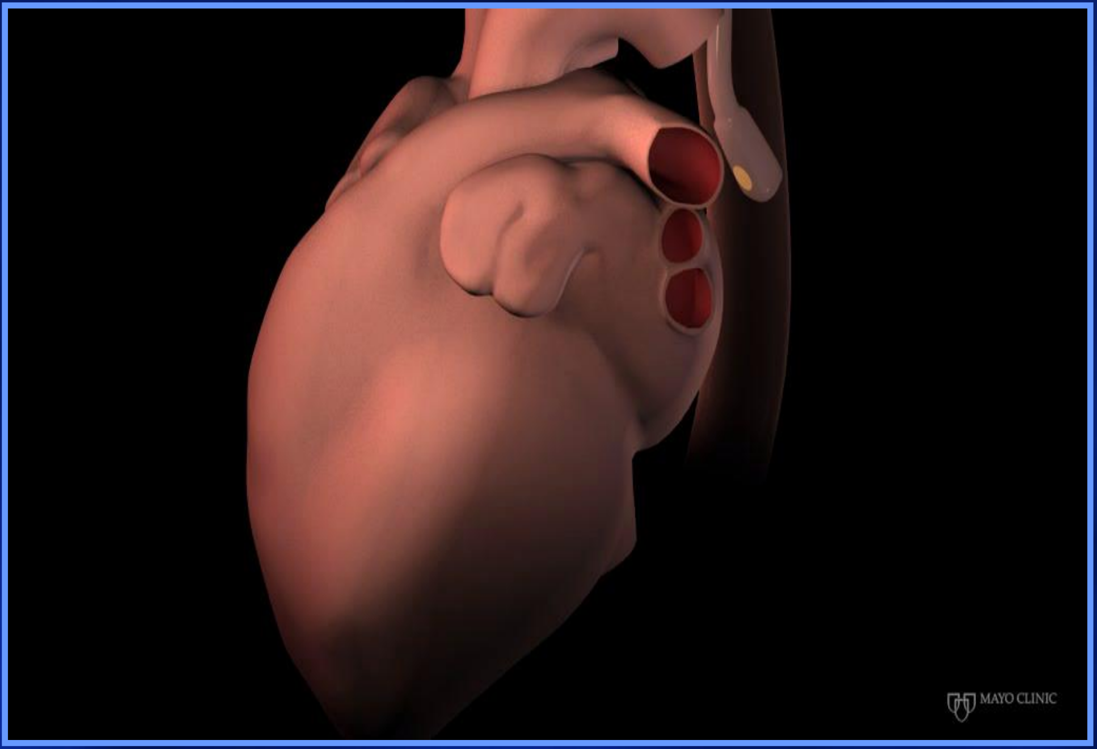


3D Transthoracic Echo: View from the Left Atrium





Transesophageal 3D Echocardiography

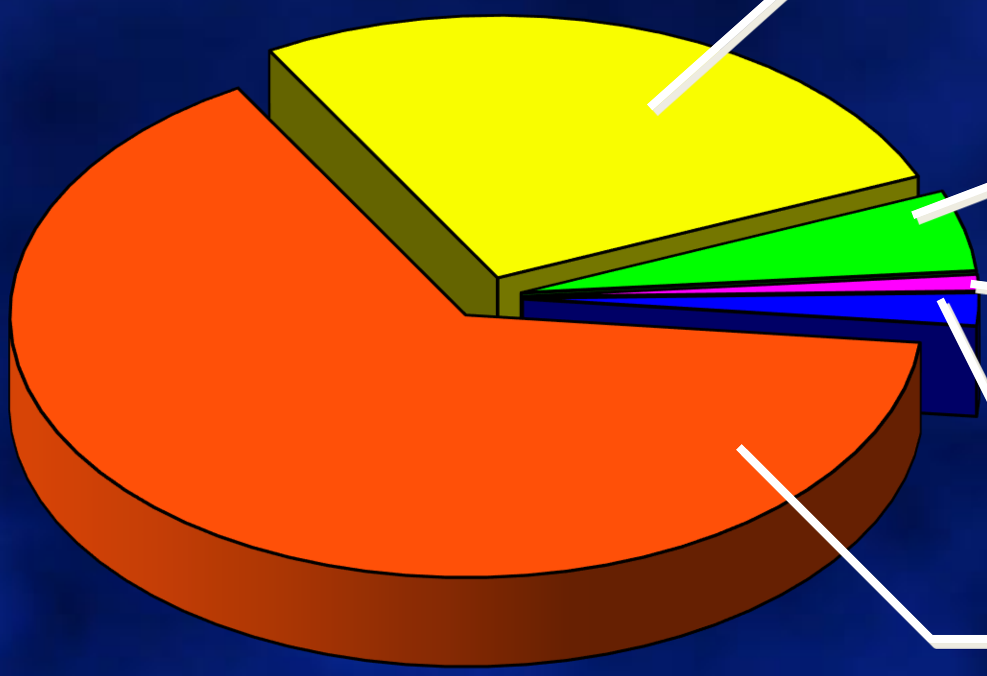


- Allows visualization of mitral valve leaflets, orifice, and submitral apparatus in a manner that is not possible using conventional 2D echo
- ***"En face"*** **views of the MV from atrial and ventricular perspective**
- **Fully sampled volume, not mechanically rotated**

Feasibility of Mitral Repair

1. **<u>Surgeon's skill and experience</u>**
2. Accurate identification the anatomic lesions of the mitral valve
    - Echocardiography is pivotal in defining the functional anatomy of the mitral valve
    - Surgeon and Echocardiographer
        - Speaking a common language
        - Mutual respect and honesty
    - Knowing when to send the patient to a "Surgical Centers of Excellence"

Etiology of Mitral Regurgitation



Waller BF et al: Clin Cardiol 17:395, 1994

Imaging Depth: 2D TEE

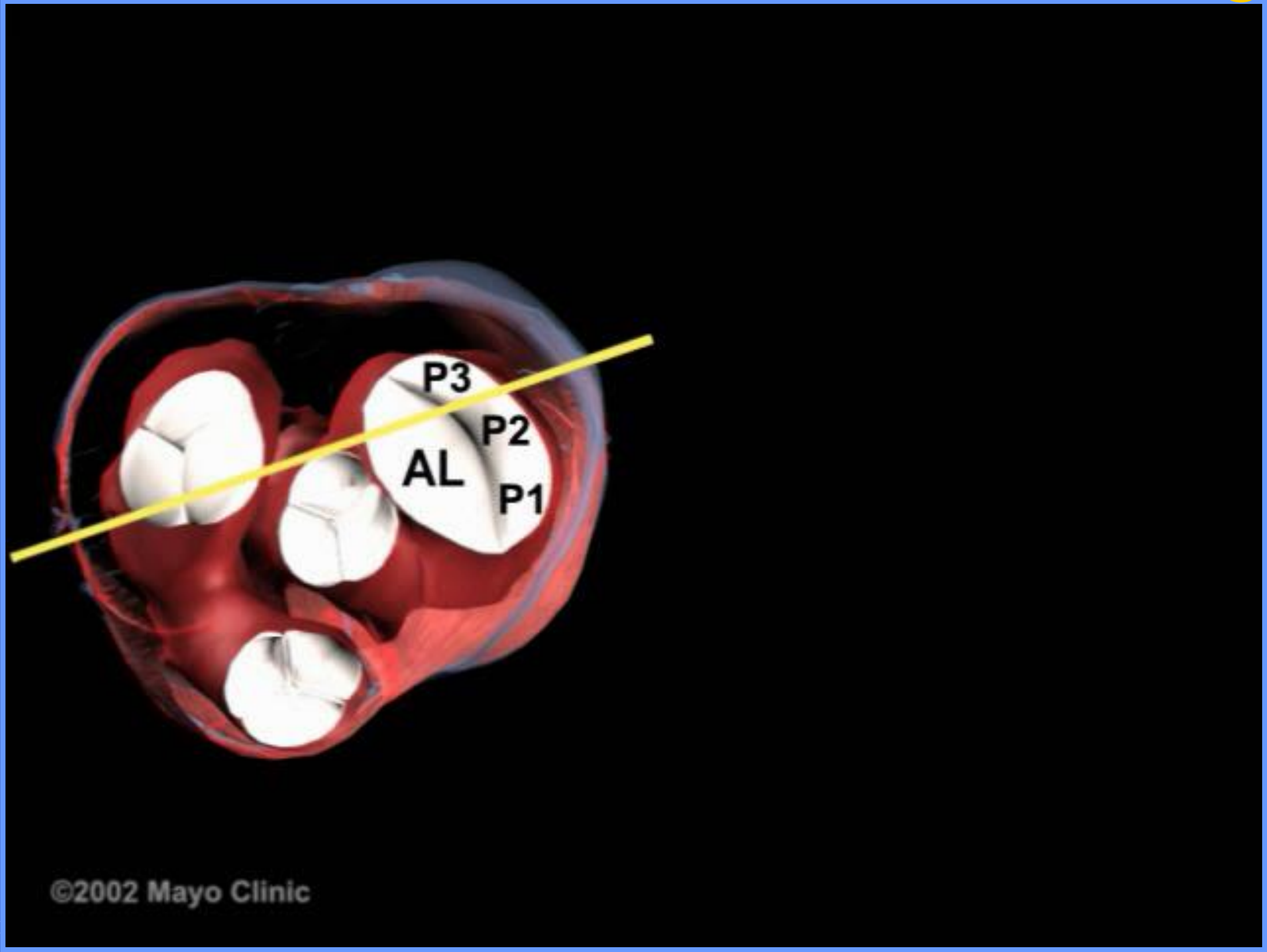
A2-P2

A1-P1

MAYO CLINIC

Mitral Valve Scallops

2-chamber: Commissural view at 60 degrees



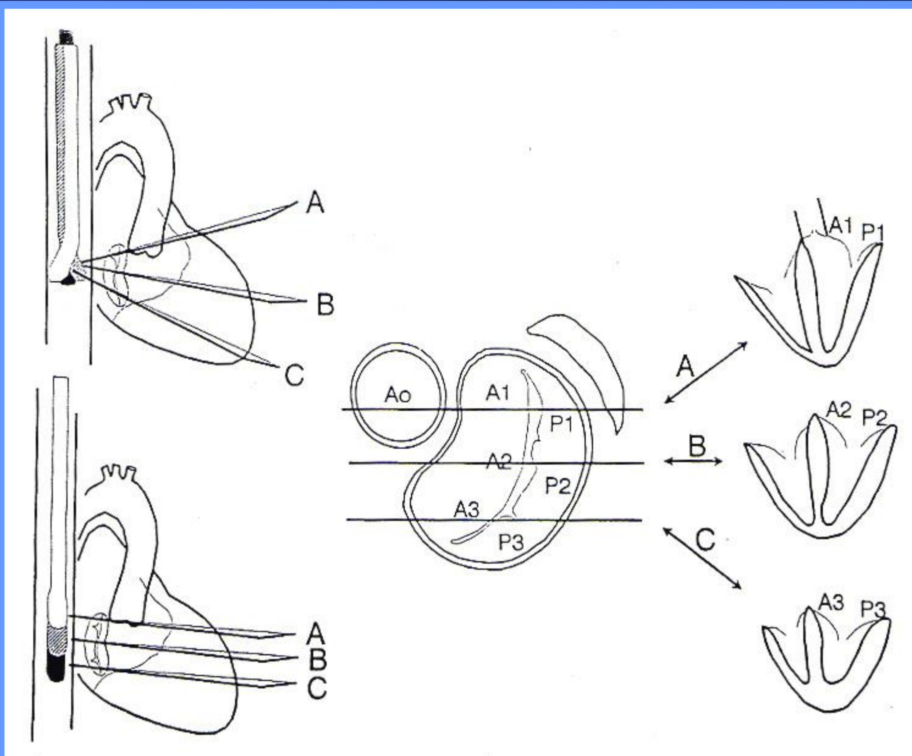
Mitral Valve Scallops

Commissural view at 60 degrees

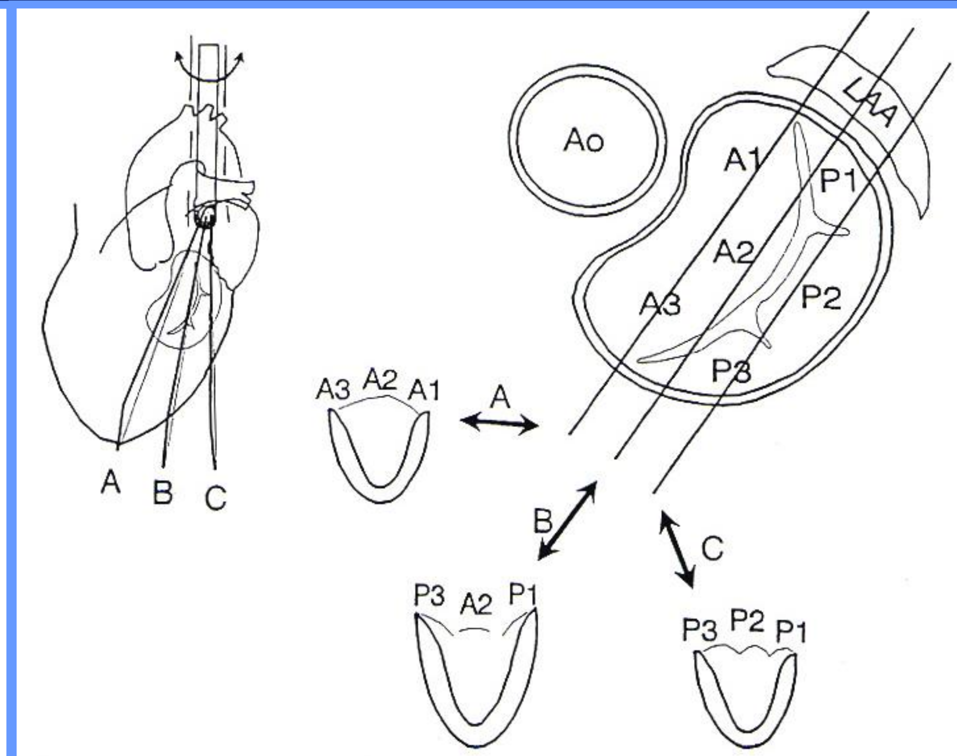
Flail MV Scallops

P1 P2 P3

Identification of Mitral Valve Scallops



Zero Degree View

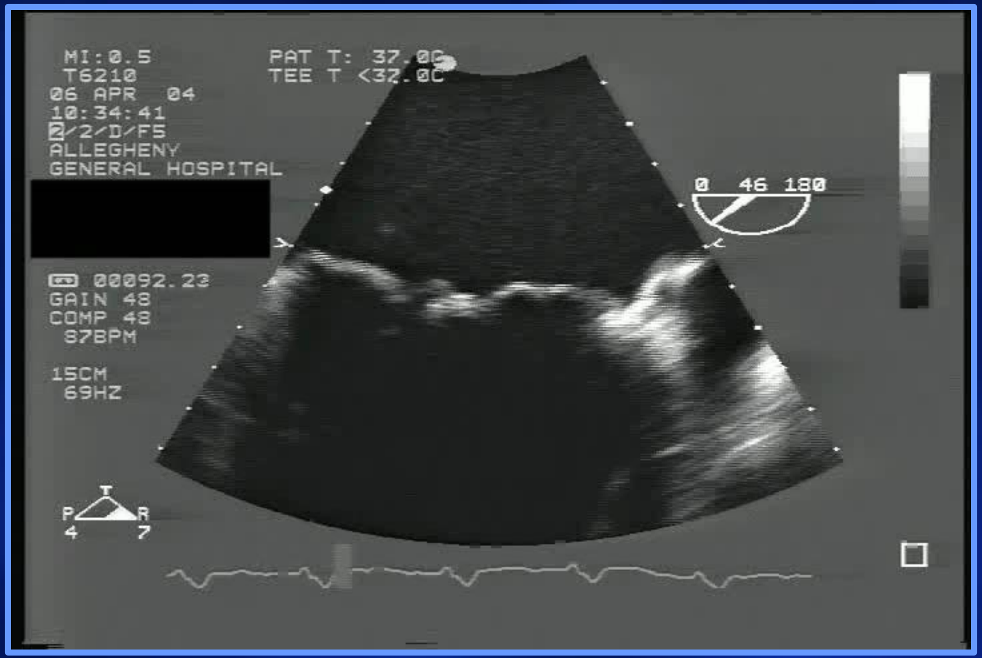


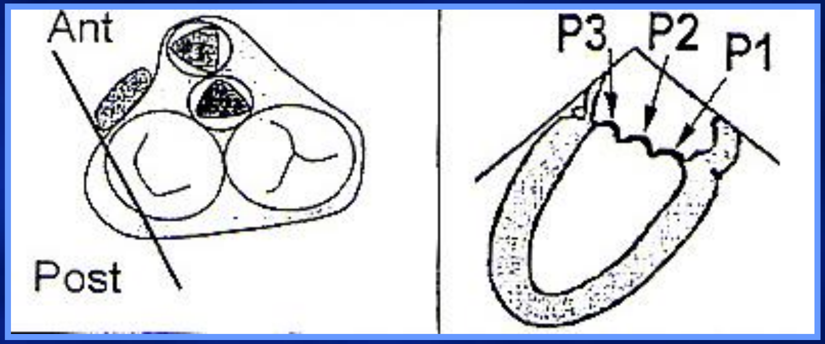
Commisural View

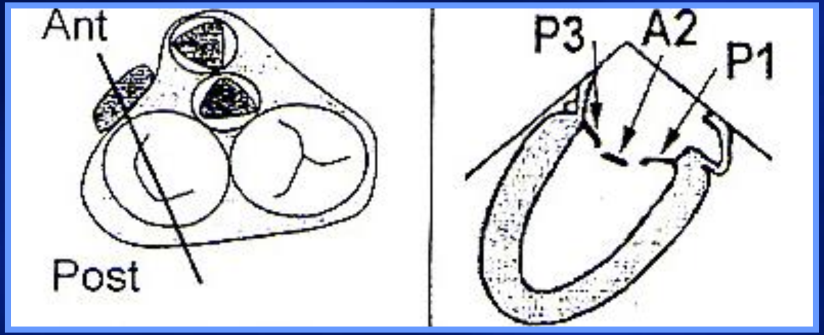
MAYO CLINIC

Foster GP et al. Thorac Surg 1998;65:1025-31.

TEE Commissural View



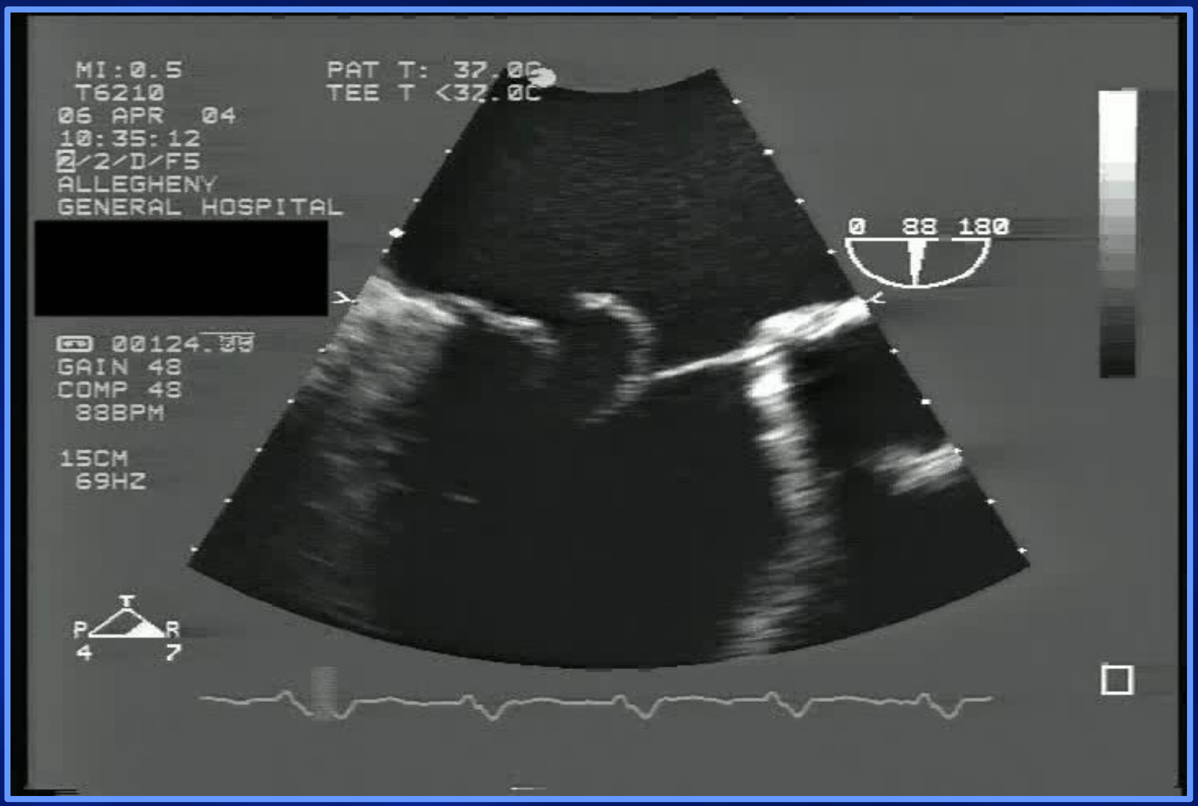


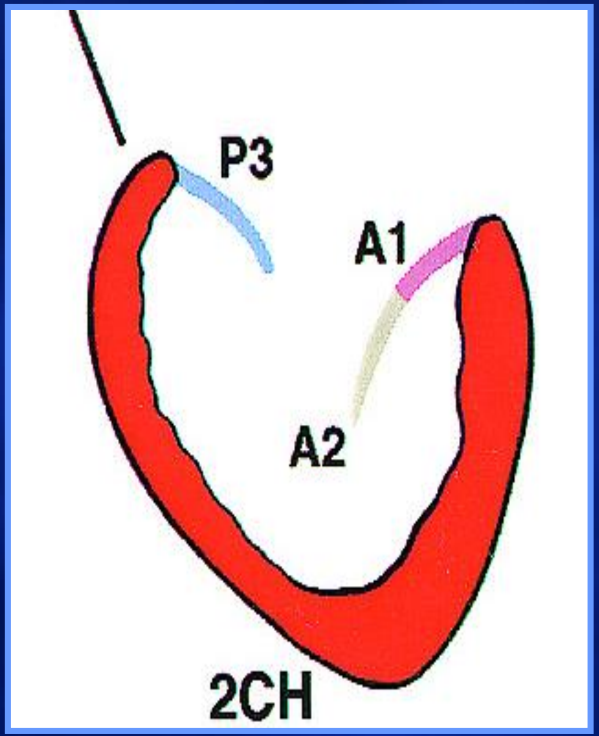


Lambert et al. *Anesth Analg* 1999;88:1205-12

TEE 90° View

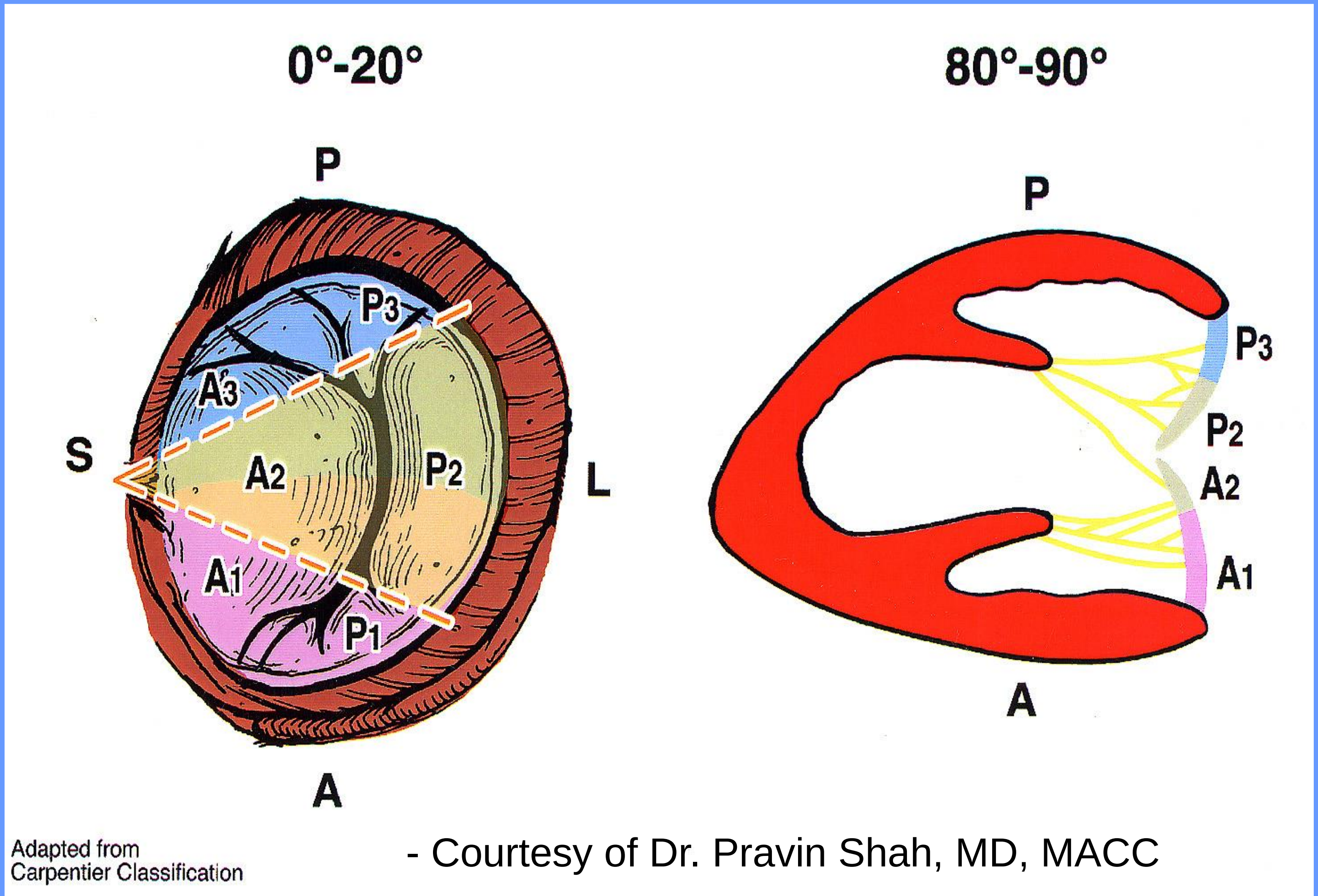
Flail A2





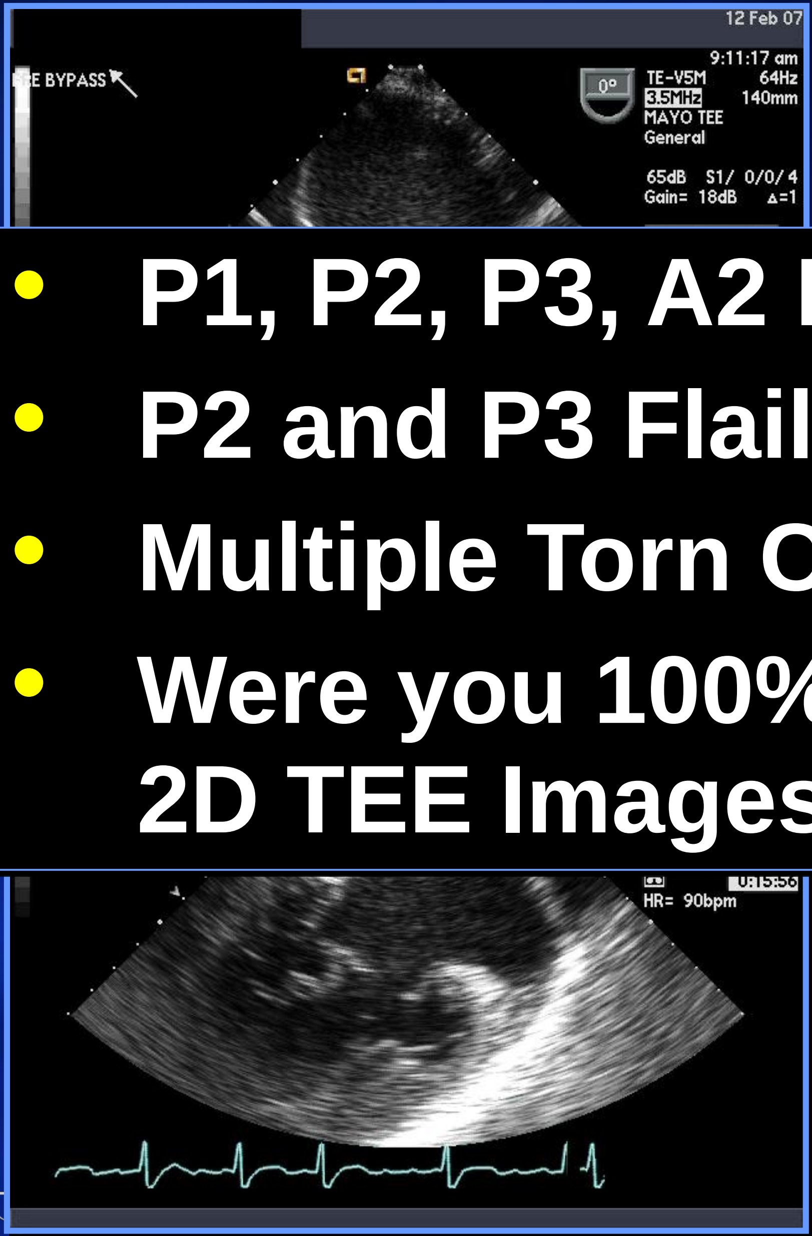
- Courtesy Pravin Shah MD

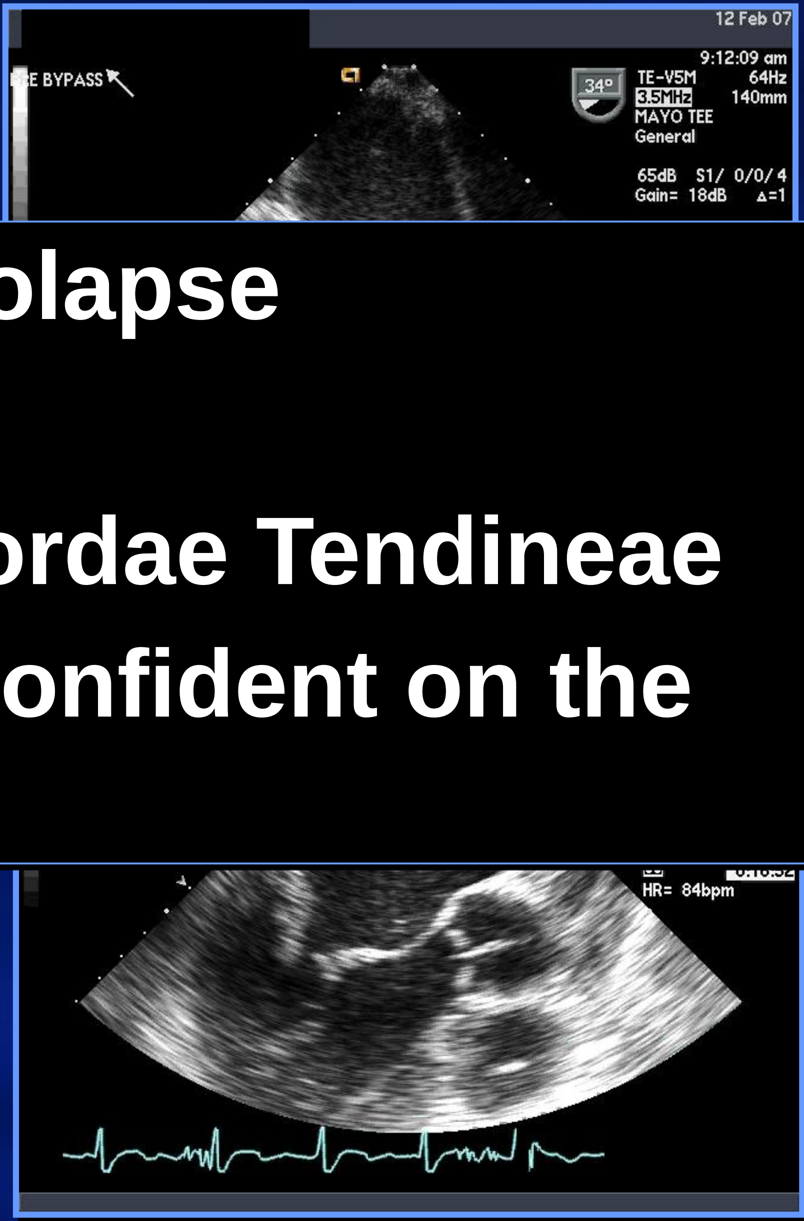
Transgastric Imaging



- Courtesy of Dr. Pravin Shah, MD, MACC

Limitation of 2D TEE

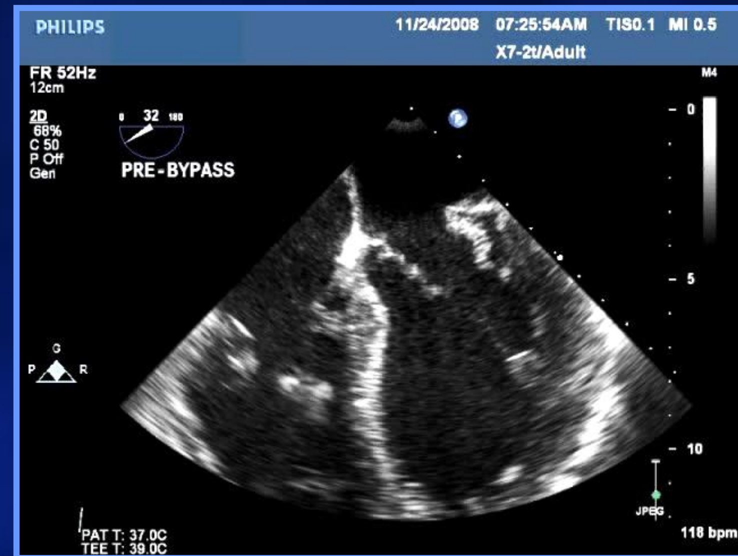




- P1, P2, P3, A2 Prolapse
- P2 and P3 Flail
- Multiple Torn Chordae Tendineae
- Were you 100% confident on the 2D TEE Images?

TEE

What's wrong with the mitral valve?

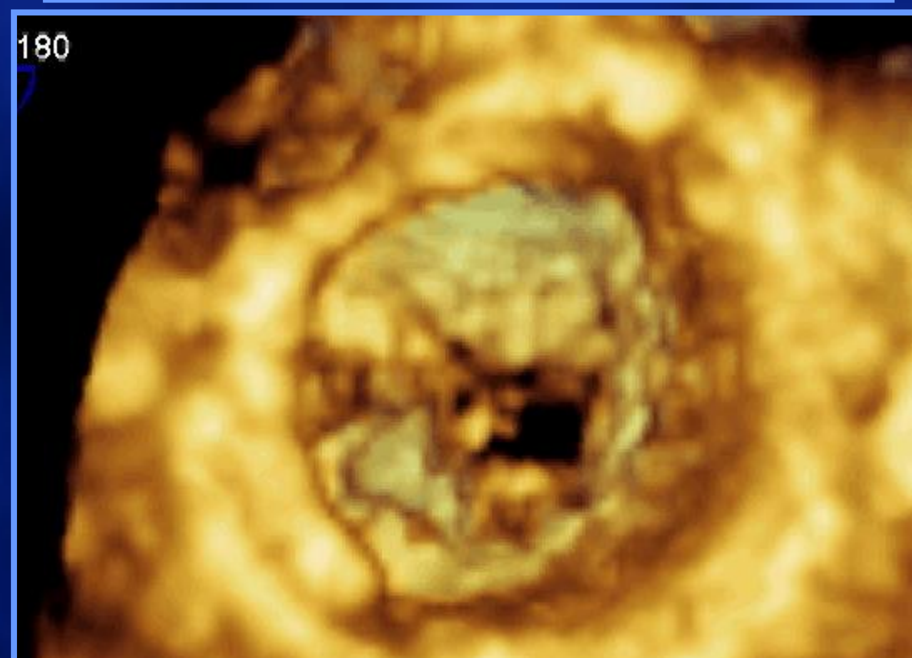


What’s wrong with the mitral valve?

1. Flail posterior lateral scallop (P1)
2. Flail posterior middle scallop (P2)
3. Flail posterior medial scallop (P3)
4. Flail anterior middle scallop (A2)
5. Mitral valve cleft

View from LA Perspective

View from LV Perspective



Surgical Note

Diagnosis: 1. Severe mitral valve regurgitation.

2. Flail middle scallop posterior leaflet.
3. Cleft between lateral and middle scallops of the posterior leaflet.

7. Medial scallop posterior leaflet prolapse.

Procedure: > 1. Robotic-assisted minimally invasive mitral valve repair.

1. Robotic-assisted minimally invasive mitral valve repair.
2. Triangular resection of the middle scallop of the posterior leaflet.
3. Closure of cleft between the lateral and middle scallops of the posterior leaflet.

What's wrong with the mitral valve?

1. Flail posterior lateral scallop (P1)
2. Flail posterior middle scallop (P2)
3. Flail posterior medial scallop (P3)
4. Flail anterior middle scallop (A2)
5. Mitral valve cleft

Objectives

CLINICAL INVESTIGATIONS
VALVULAR HEART DISEASE
J Am Soc Echocardiogr 2009;22:34-41

Real-Time Three-Dimensional Transesophageal Echocardiography in the Intraoperative Assessment of Mitral Valve Disease

Jasmine Grewal, MD, Sunil Mankad, MD, William K. Freeman, MD, Roger L. Click, MD, PhD, Rakesh M. Suri, MD, Martin D. Abel, MD, Jae K. Oh, MD, Patricia A. Pellikka, MD, Gillian C. Nesbitt, MD, Imran Syed, MD, Sharon L. Mulvagh, MD, and Fletcher A. Miller, MD, *Rochester, Minnesota*

pathologic anatomy of the MV leaflets and apparatus

Detection of Pathology with 2D and Live 3D TEE

n = 42 patients

	Sensitivity (%)		Specificity (%)		Accuracy (%)	
	2D	3D	2D	3D	2D	3D
P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Is	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

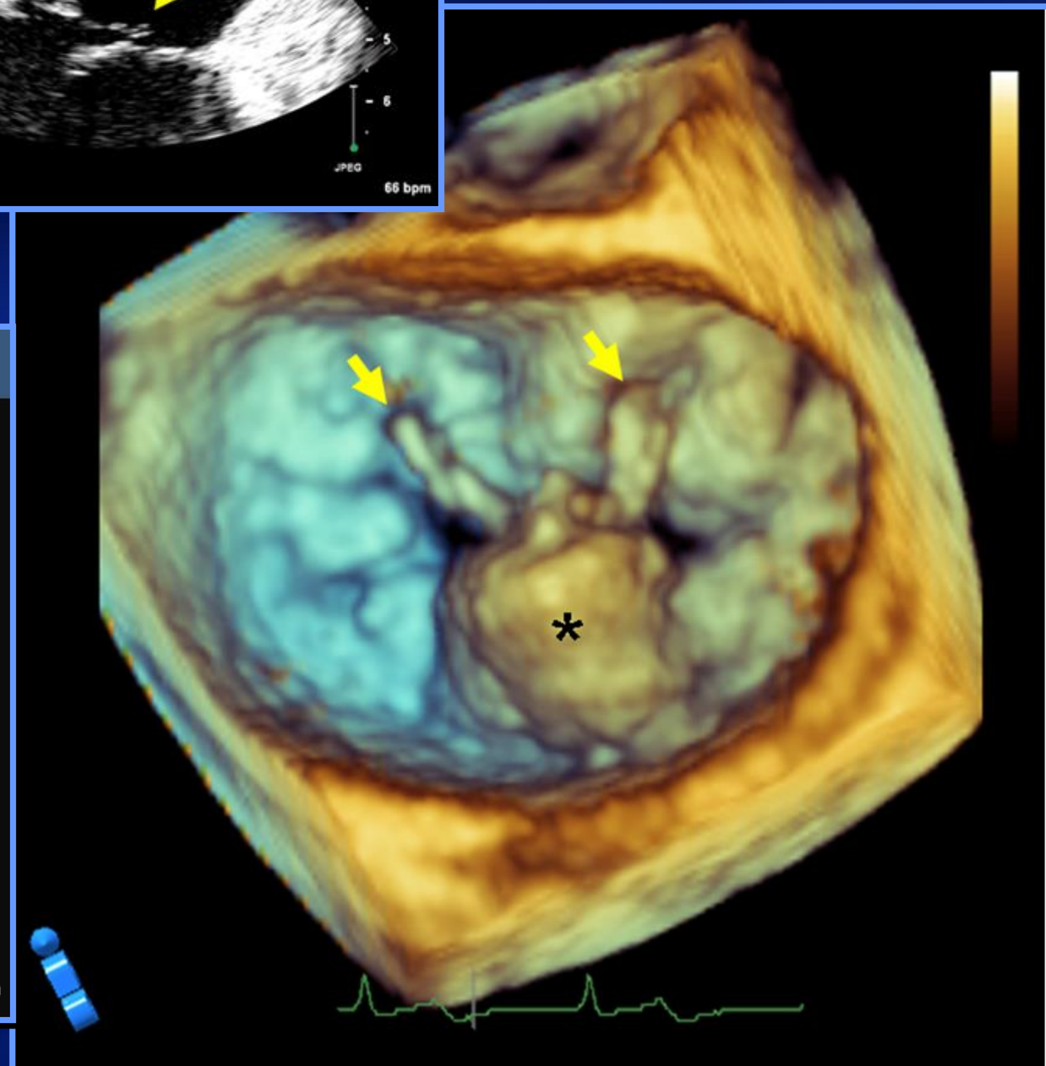
- The predominant MV pathology was correctly identified in 98% *vs.* 90% of patients for 3D TEE *vs.* 2D TEE ($p < 0.05$)

¶ $p < 0.05$ versus 2D TEE; BL= bileaflet involvement

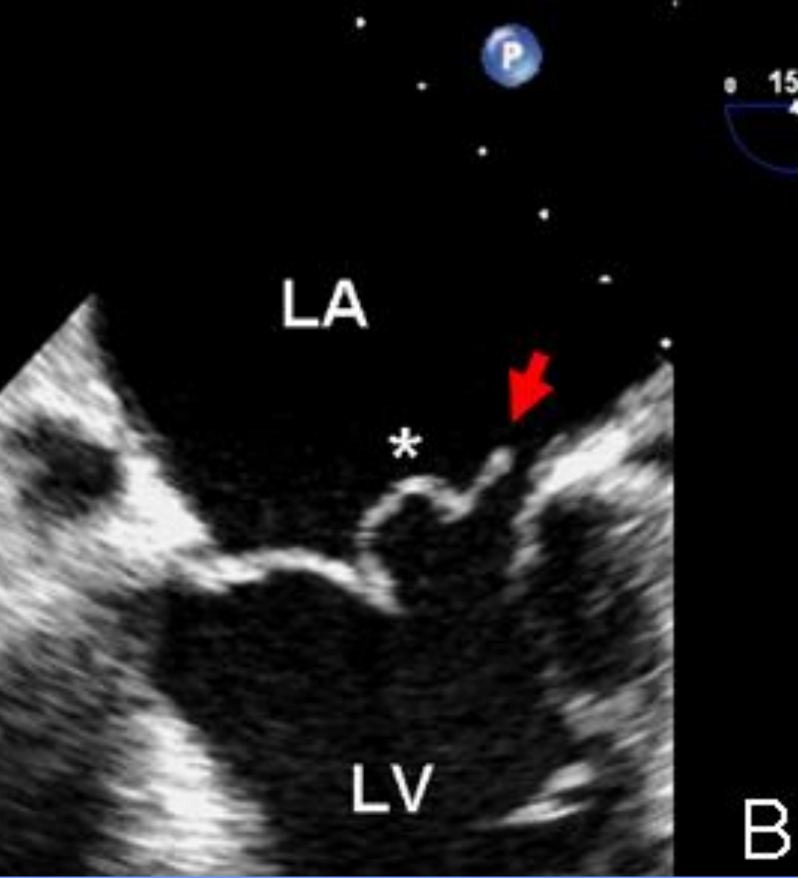
Flail Posterior Leaflet (P2)

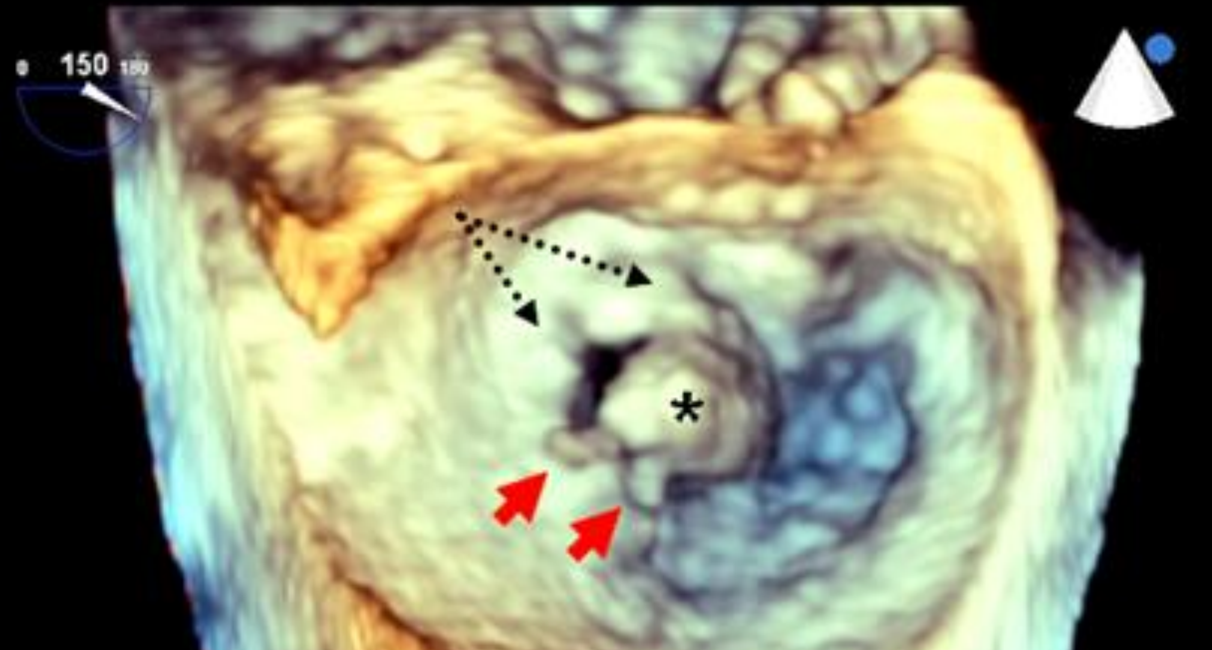
↓ 3D TEE ↓

↓ 2D TEE ↓



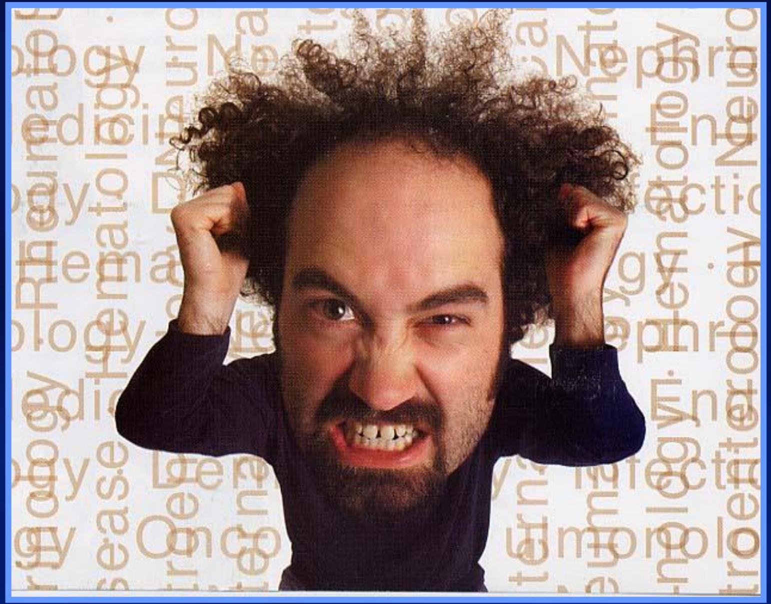
Flail Anterior Leaflet (A2)





Confusion: Unclear Terminology

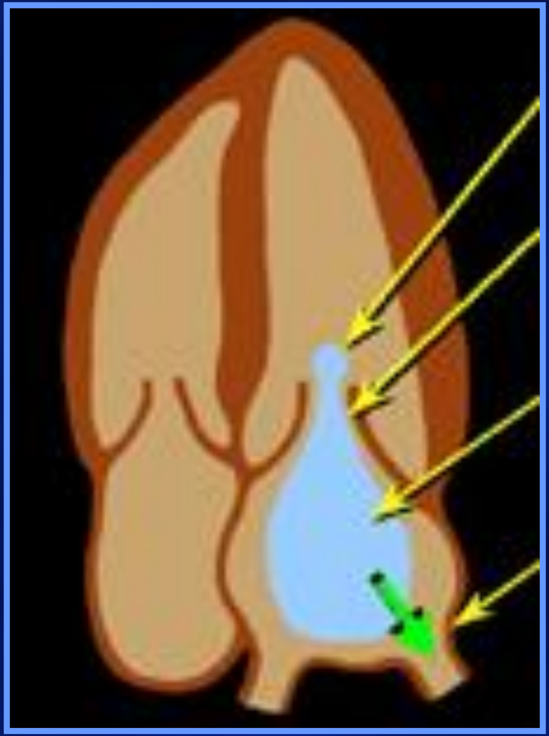
1) Trivial
2) Trace
3) Mild
4) Mild to moderate
5) Moderate
6) Moderate to severe
7) Moderately Severe
8) Severe
9) Industrial Strength
10) Torrential



Semi-Quantification

- 1+
- 1-2+
- 2+
- 2-3+
- 3+
- 3-4+
- 4+

Mitral Regurgitation Has Four Hallmarks



Flow Convergence

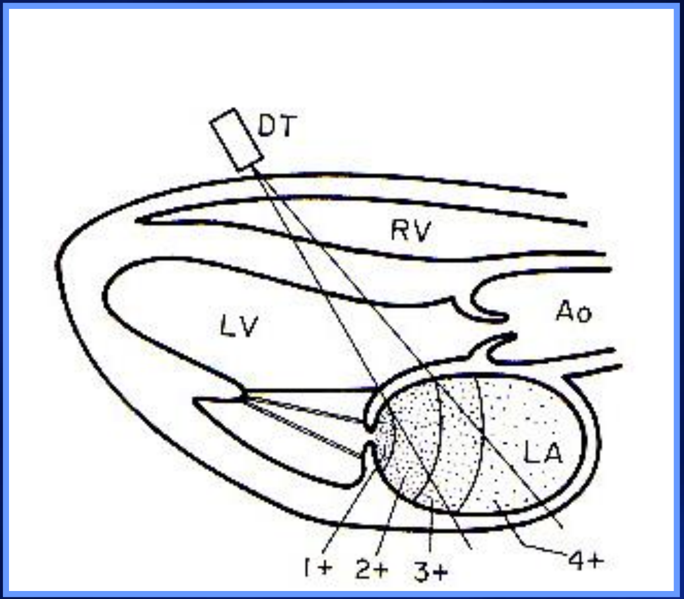
Flow Acceleration

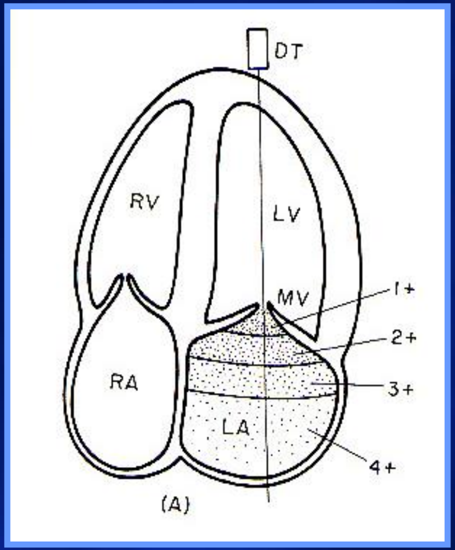
Turbulence → Jet Area

Downstream

Adapted from Echo in Context. Kisslo et al.

MR Jet Area Semi-Quantification





Adapted from Echo in Context – Kisslo et al.

Nanda N. Textbook of Color Doppler

Quantification of MR by Jet Area

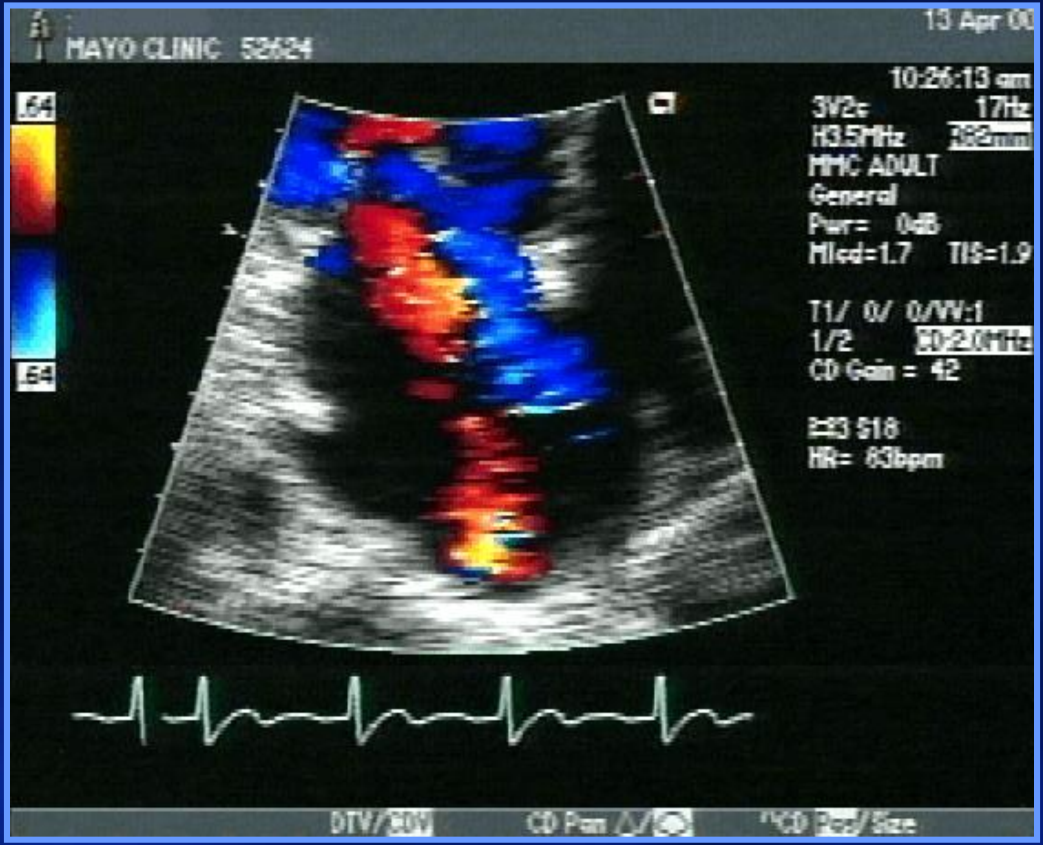
Mild	Moderate	Severe
Small Central Jet (usually < 4 cm^2) < 20% of LA Area	20-40% of LA Area	Large Central Jet (usually > 10 cm^2) > 40% of LA Area

Zoghbi WA et al. Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. *J Am Soc Echocardiogr* 2003;16:777-802.

Problems with Jet Area

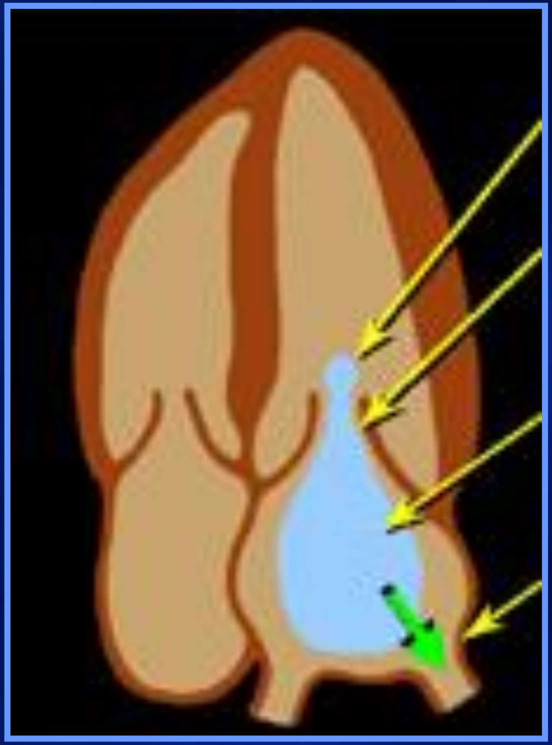
- Affected by instrumental factors
  - Pulse Repetition Frequency
    - Nyquist limit should be > 50-60 cm/sec
  - Color Gain
    - Gain set so that random color speckling does not occur in non-moving regions

How Much Mitral Regurgitation?: Eccentric Mitral Regurgitation Jet



Coanda Effect

Regurgitation Has Four Hallmarks



Flow Convergence

Flow Acceleration → Vena Contracta

Turbulence

Downstream

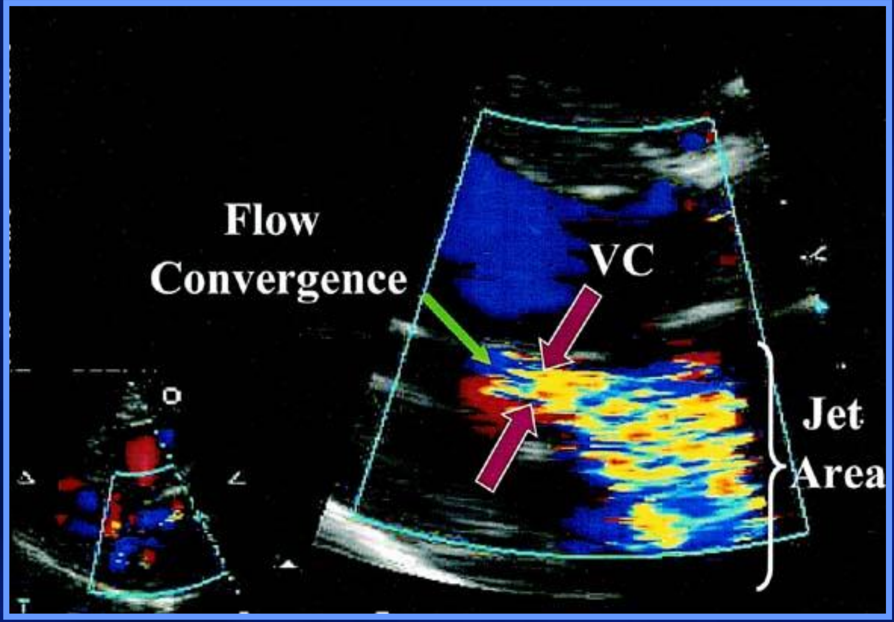
Adapted from Echo in Context. Kisslo et al.

MAYO CLINIC

Vena Contracta

- **Narrowest portion of a jet that occurs at or just downstream from the orifice**

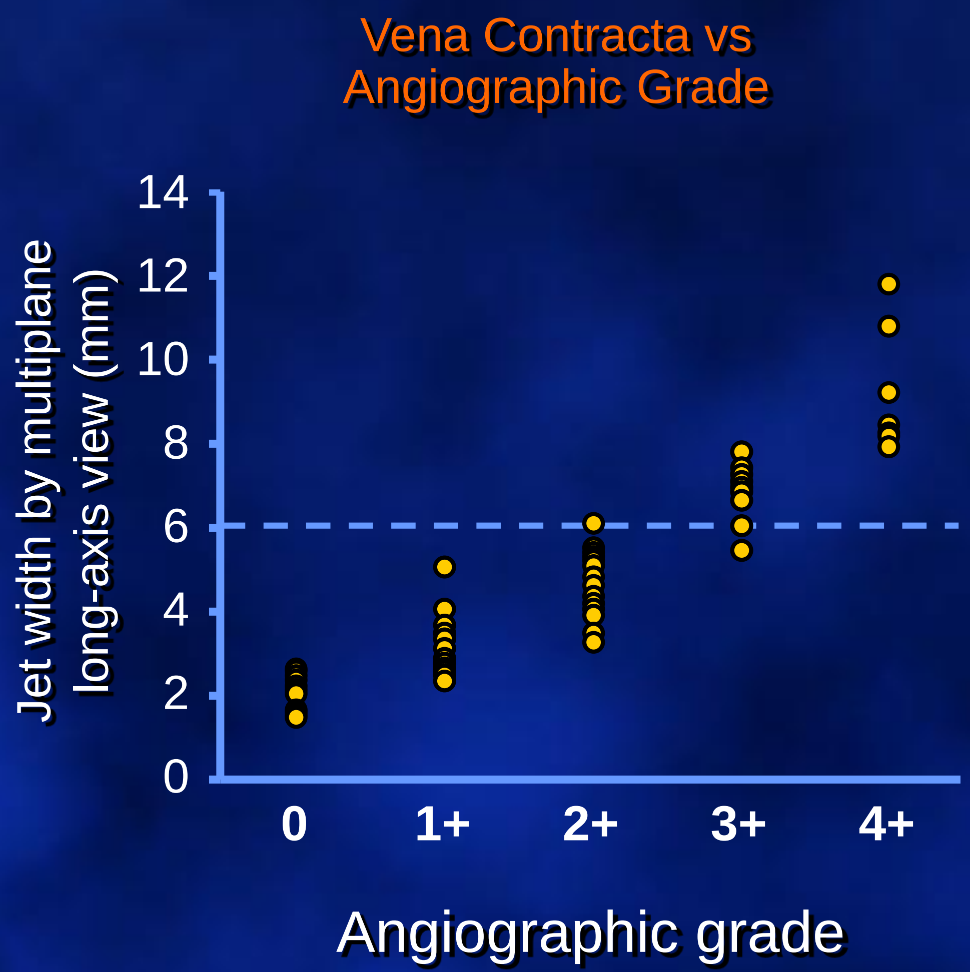
- **Vena Contracta Width**
  - **Mild < 0.3 cm**
  - **Moderate 0.3-0.69 cm**
  - **Severe > 0.7 cm**

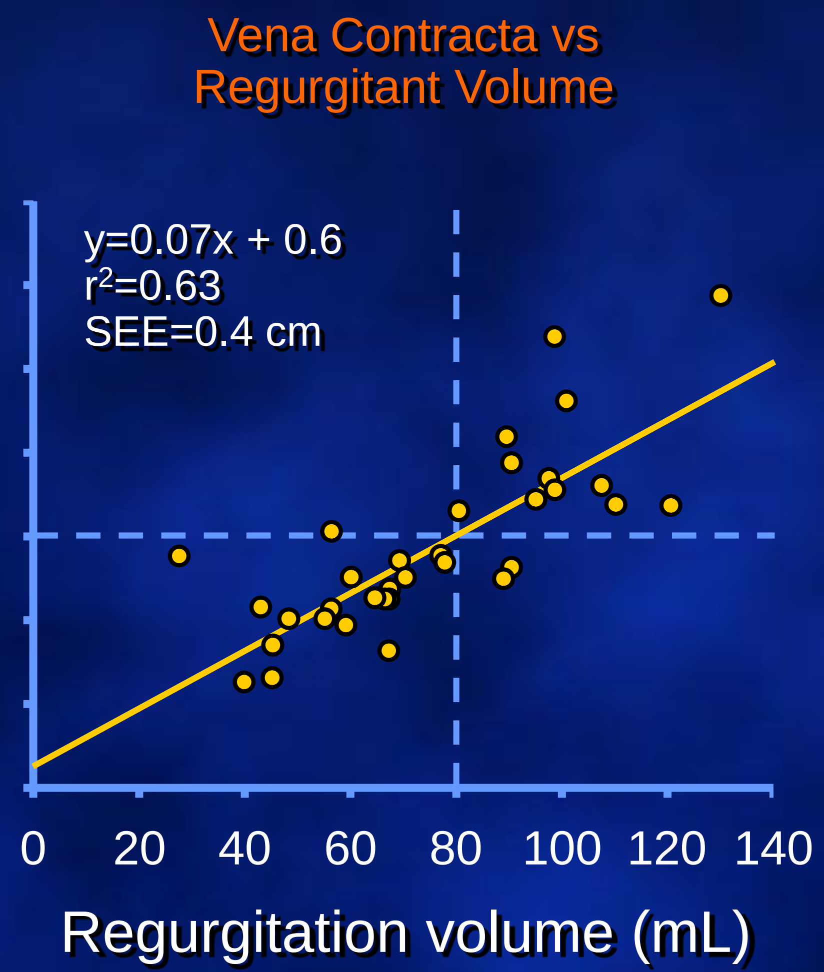


Zoghbi WA et al. Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. *J Am Soc Echocardiogr* 2003;16:777-802.

Mitral Regurgitation

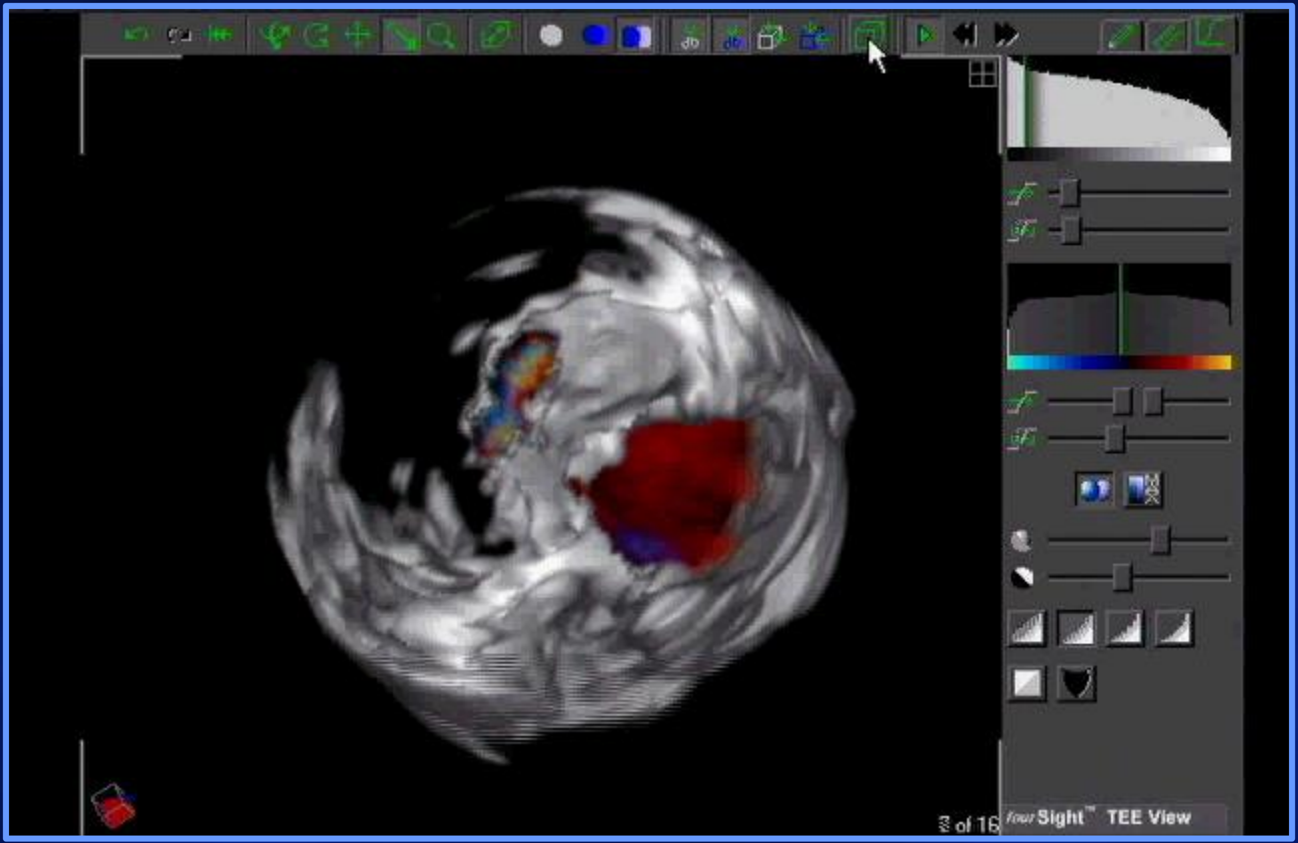
Transesophageal Echo Long Axis





Grayburn PA: AJC 74, 1994

MAYO CLINIC



Problems with Vena Contracta

Valvular Regurgitation

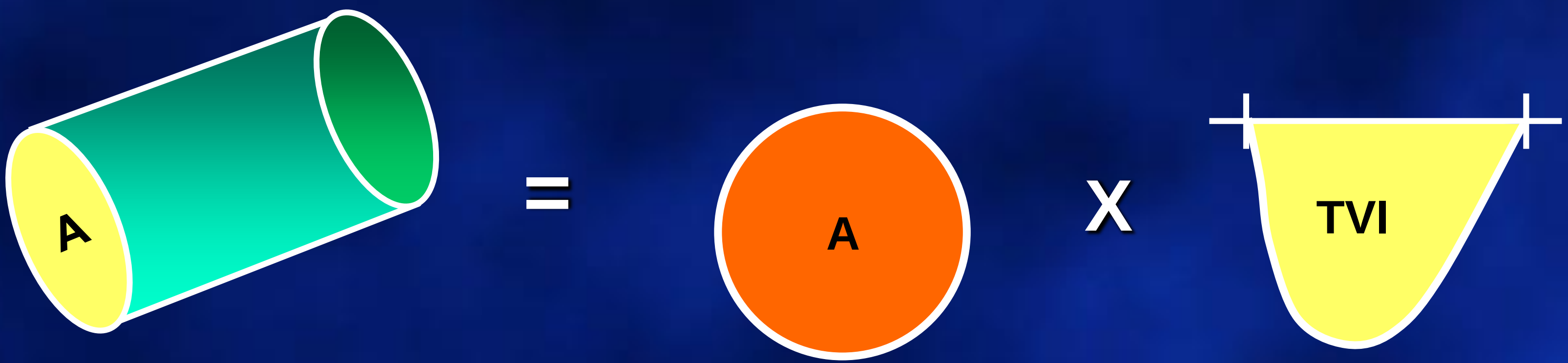
Quantitation

- Regurgitant volume (RV)
- Effective regurgitant orifice (ERO)
- Regurgitant fraction (RF)

Continuity Equation

Quantitative Hemodynamics

(Conservation of Mass Principle)

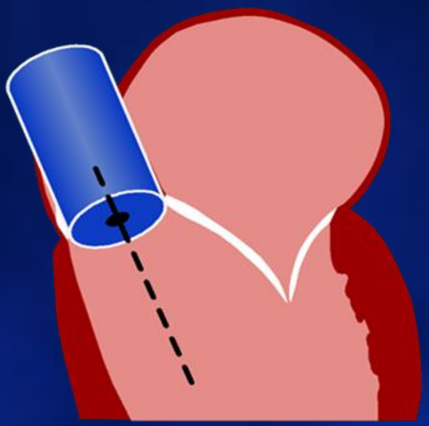


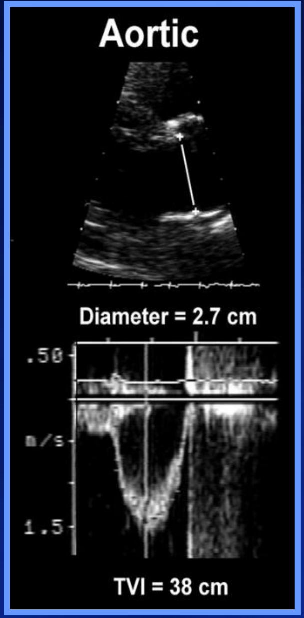
Stroke volume   Area   X   TVI

Four Measurements

- **LVOT Diameter**
- **LVOT TVI**

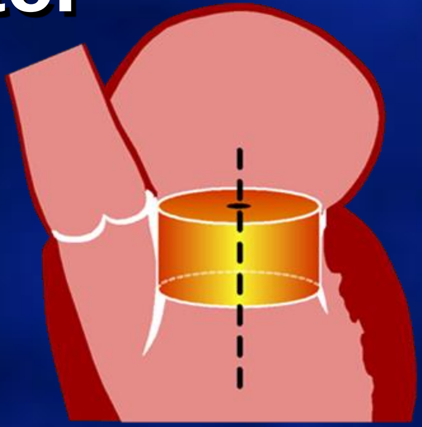
SV_{LVOT}

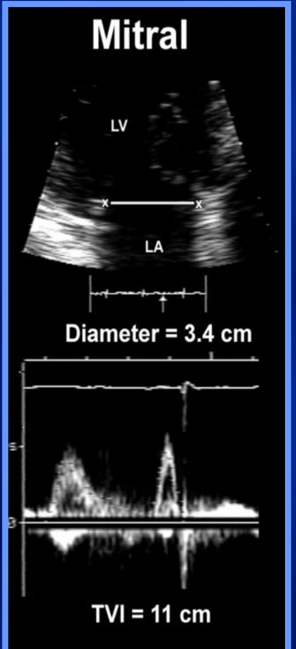


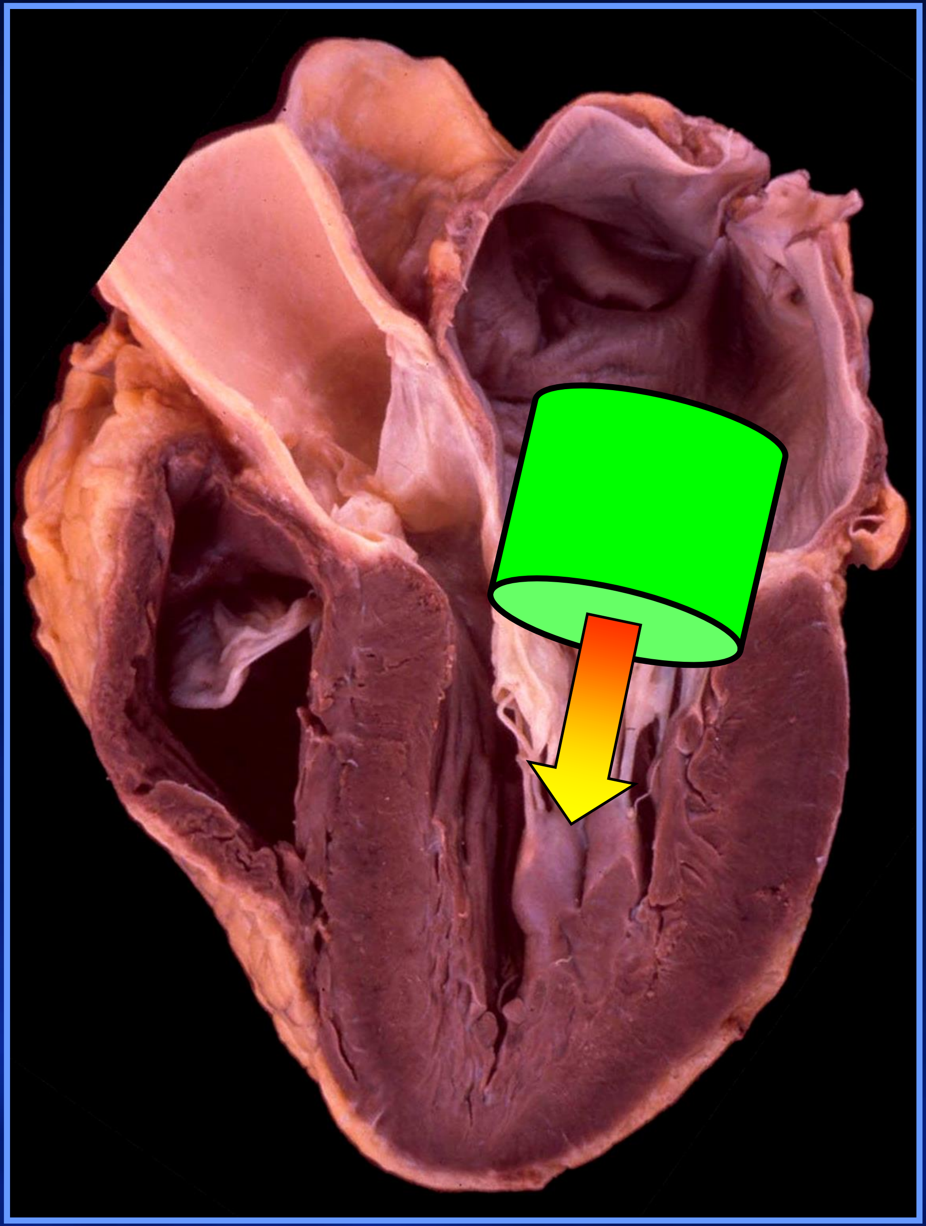


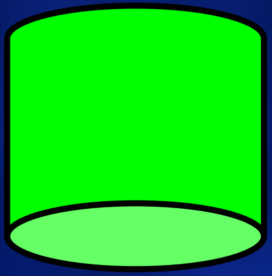
- **Mitral annulus diameter**
- **Mitral annulus TVI**

SV_{MV}



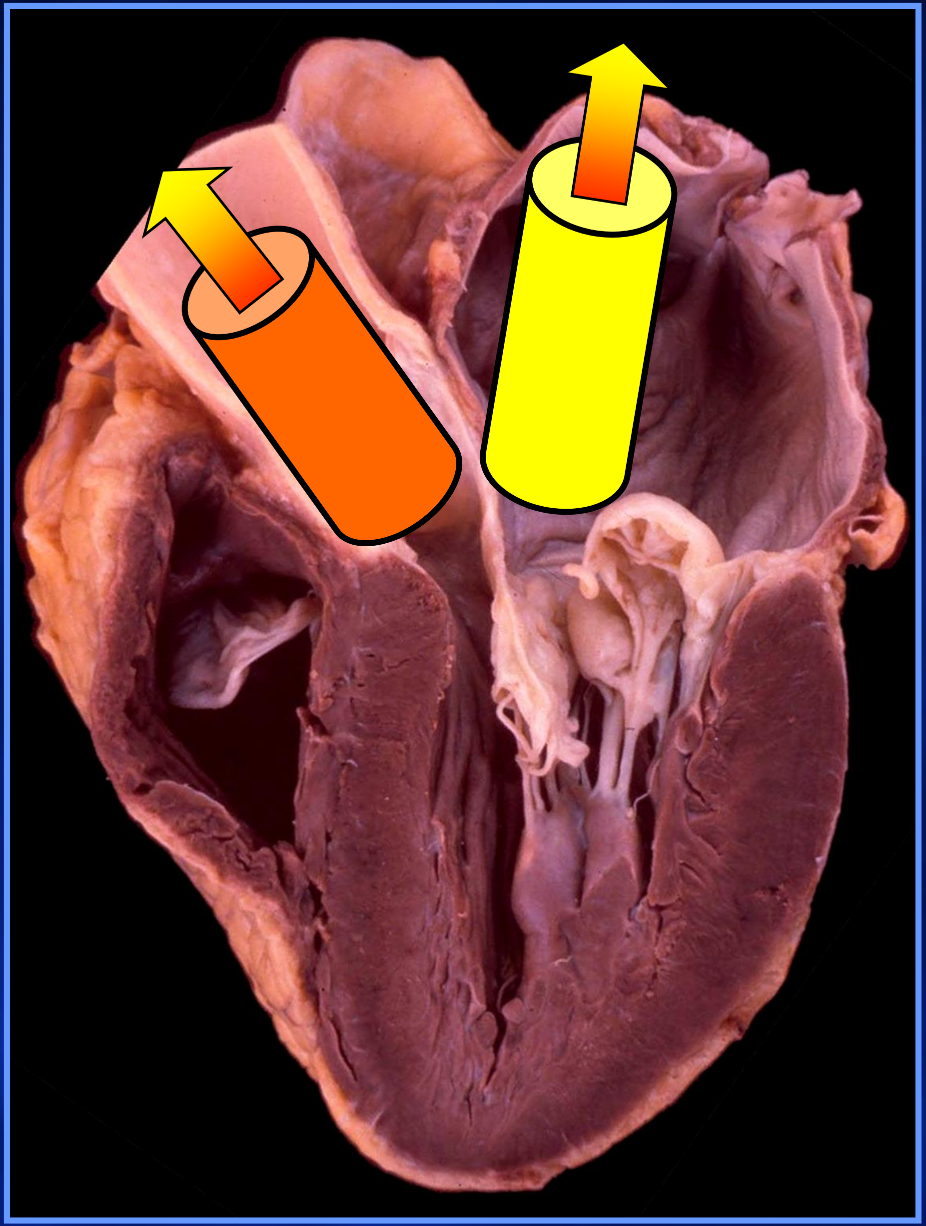




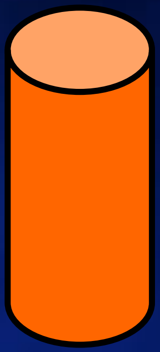


= MV Stroke Volume

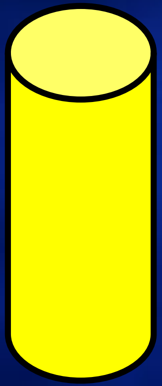
Diastole



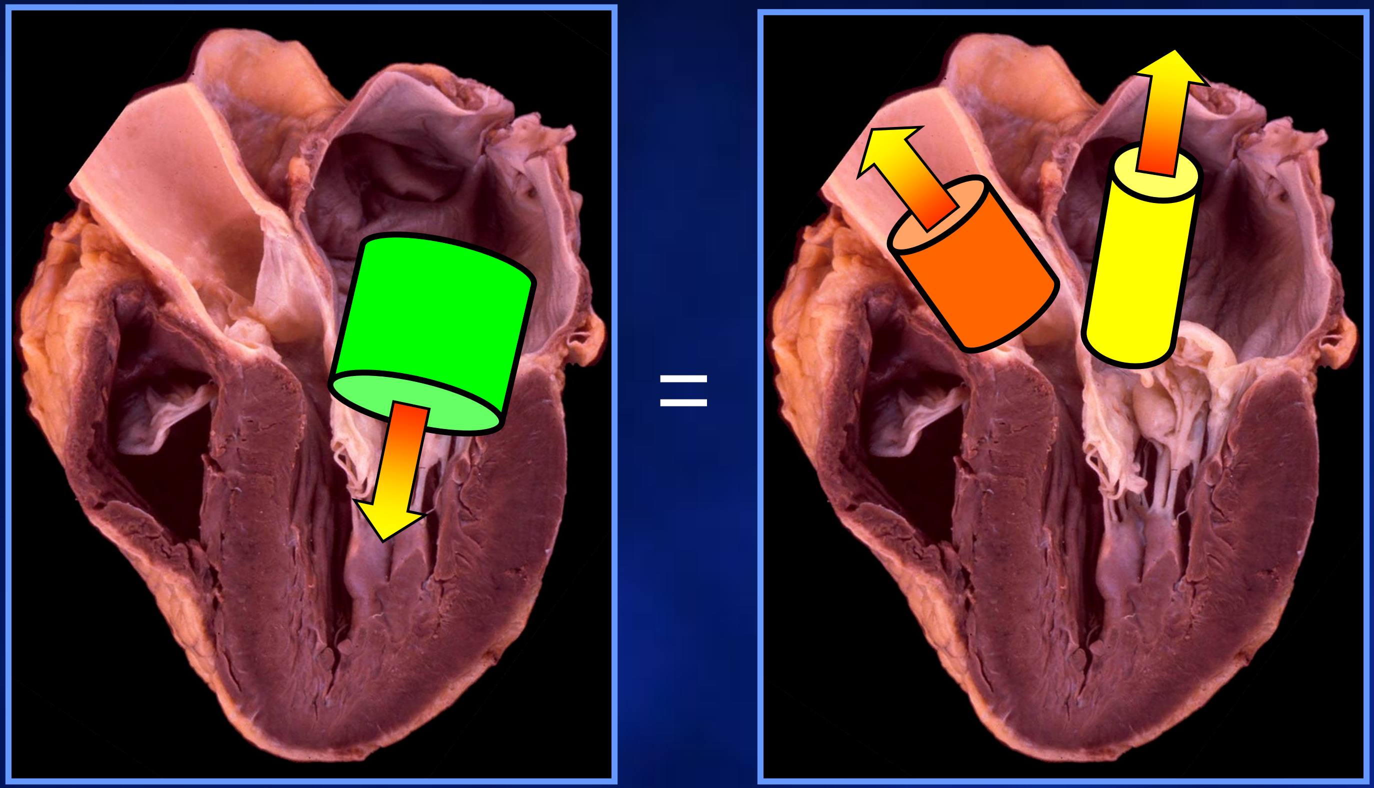
Systole

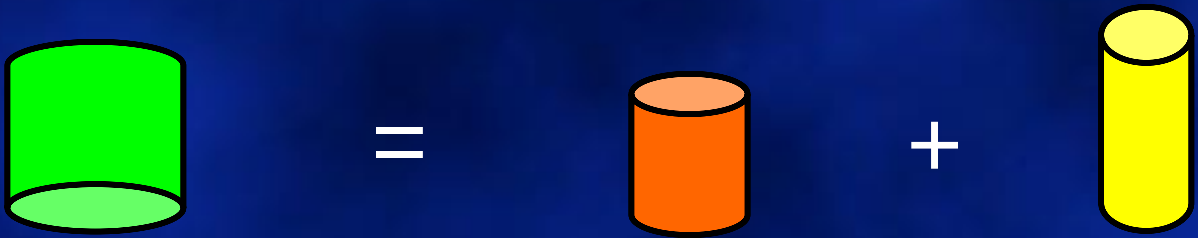


= LVOT Stroke Volume

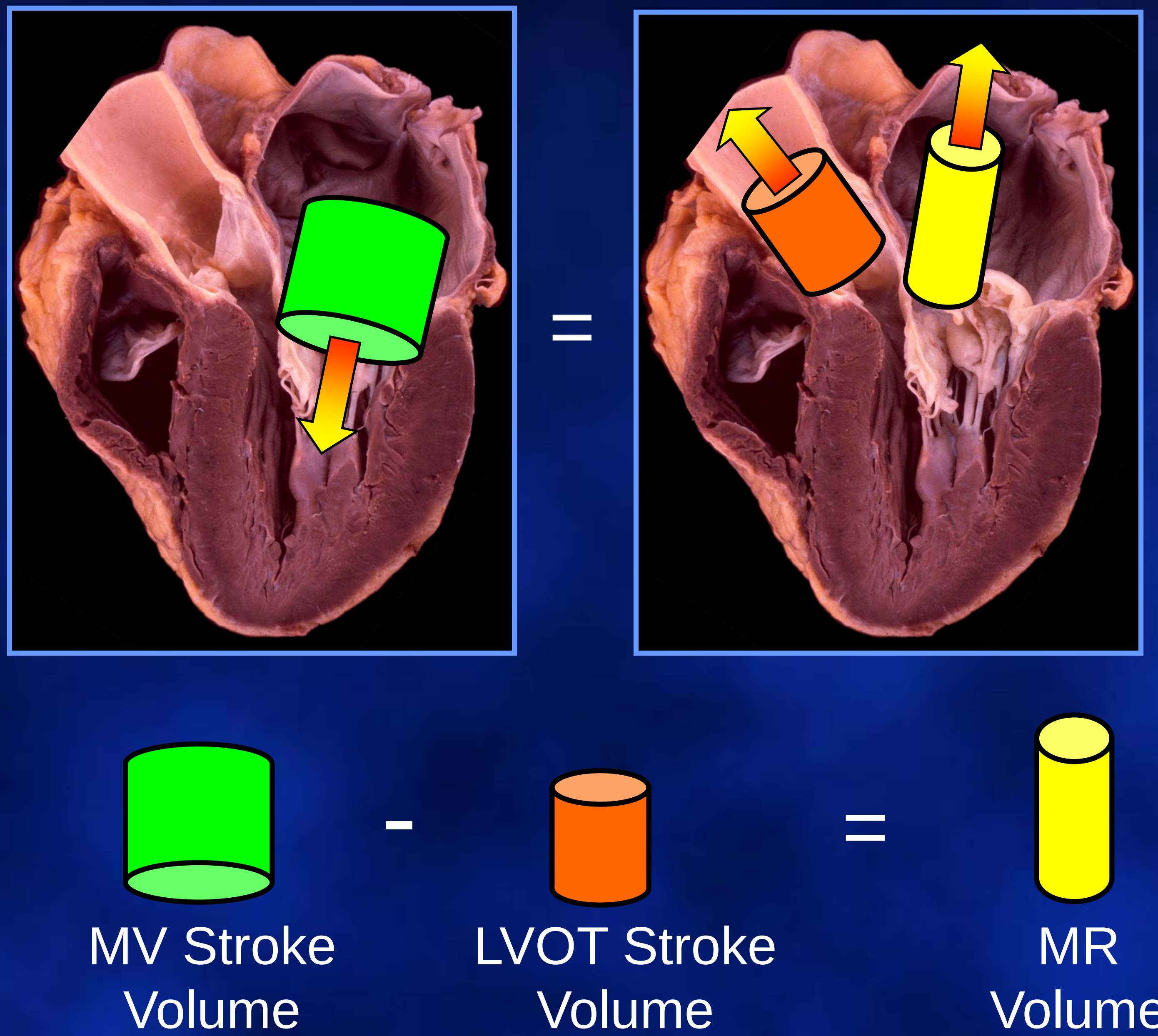


= MR Volume

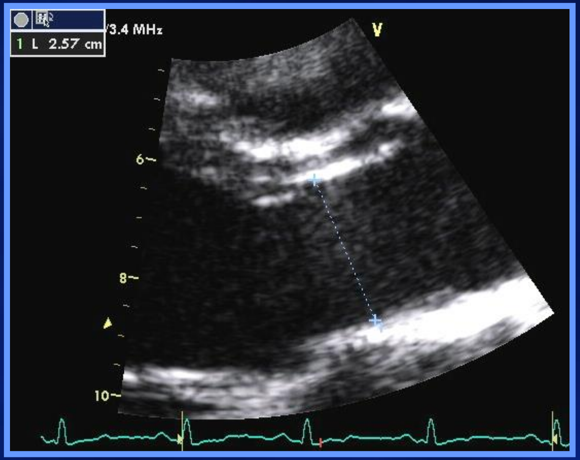




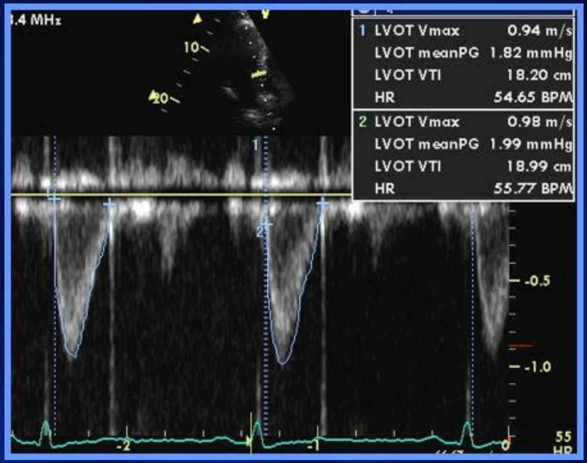
MV Stroke Volume = LVOT Stroke Volume + MR Volume


=
-
=
MV Stroke Volume
LVOT Stroke Volume
MR Volume

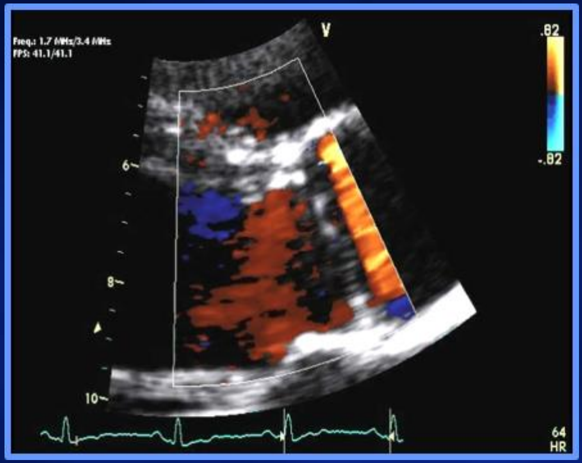
Step 1: Calculate LVOT Stroke Volume



LVOT diameter = 2.6 cm



LVOT TVI = 18 cm



No AR

LVOT Stroke Volume

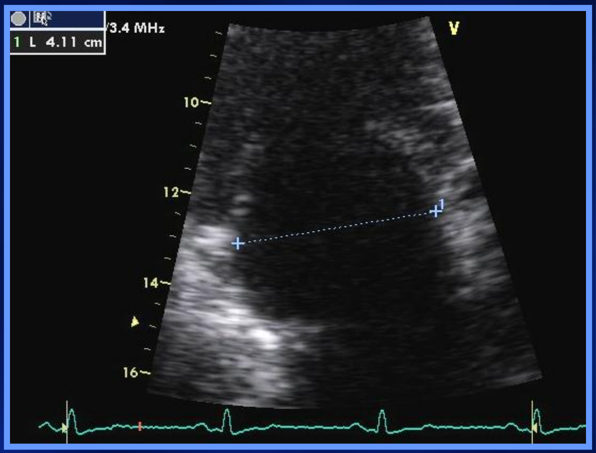
$$= \pi (D/2)^2 \quad X \quad 18\ cm$$

$$= 0.785\ (2.6\ cm)^2 \quad X \quad 18\ cm$$

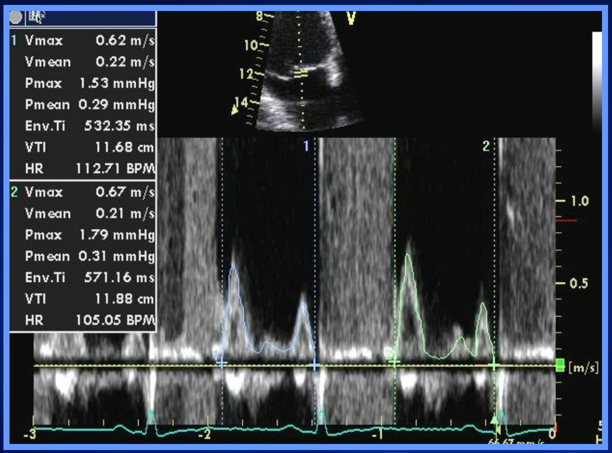
$$= 96\ cm^3$$

MAYO CLINIC

Step 2: Calculate MV Stroke Volume



MV diameter = 4.1 cm



MV Annular TVI = 12 cm

MV Stroke Volume $= 0.785\,(4.1\ \text{cm})^2 \quad \text{X} \quad 12\ \text{cm}$

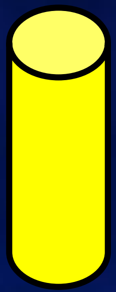
$= 158\ \text{cm}^3$

Step 3: Calculate MR Volume

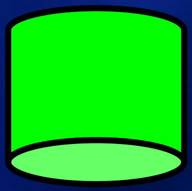
MV Stroke Volume - LVOT Stroke Volume = MR Volume

$158\ cm^3 - 96\ cm^3 = 62\ cm^3$

Step 4: Calculate Regurgitant Fraction (RF)



MR Volume

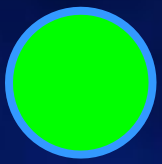


MV Stroke Volume

$$\text{Mitral RF} = \frac{\text{MR Volume}}{\text{MV Stroke Volume}} = \frac{62\ cm^3}{158\ cm^3} = 40\%$$

Step 5: Calculate MR ERO

E ffective
R egurgitant
O rifice



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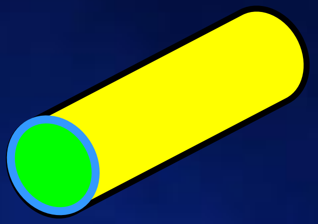
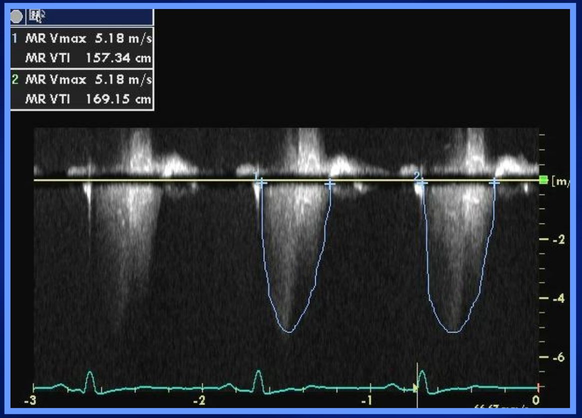


MR Volume 62 cm³



MR TVI (163 cm)

$$\text{ERO} = \frac{62\ \text{cm}^3}{163\ \text{cm}} = 0.38\ \text{cm}^2$$

Quantitation of Mitral Regurgitation

	Mild	Moderate		Severe
MR Volume (cm^3/beat)	<30	30 - 44	45 - 59	≥ 60
Regurgitant Fraction (%)	<30	30 - 39	40 - 49	≥ 50
ERO (cm^2)	<0.20	0.20-0.29	0.30-0.39	≥ 0.40

MAYO CLINIC

Zoghbi WA, et al. J Am Soc Echocardiogr 2003; 16: 777

Quantitation of Valvular Regurgitation Continuity Method: Potential Pitfalls

- Incorrect Doppler alignment to flow (θ > 20º)
- Incorrect sample volume placement:
  - Place at annulus, not leaflet tips
- Incorrect annular measurement: $(error)^2$
  - Mitral annular calcification (MAC)
- Failure to trace modal velocity (especially MV)
- Geometric assumptions of circular annulus
  - (LVOT – excellent, MV - good, TV - poor)
- Aortic regurgitation > mild (use RVOT instead)
- Arrhythmia; inadequate data averaged

Regurgitation Has Four Hallmarks

Flow Convergence → PISA

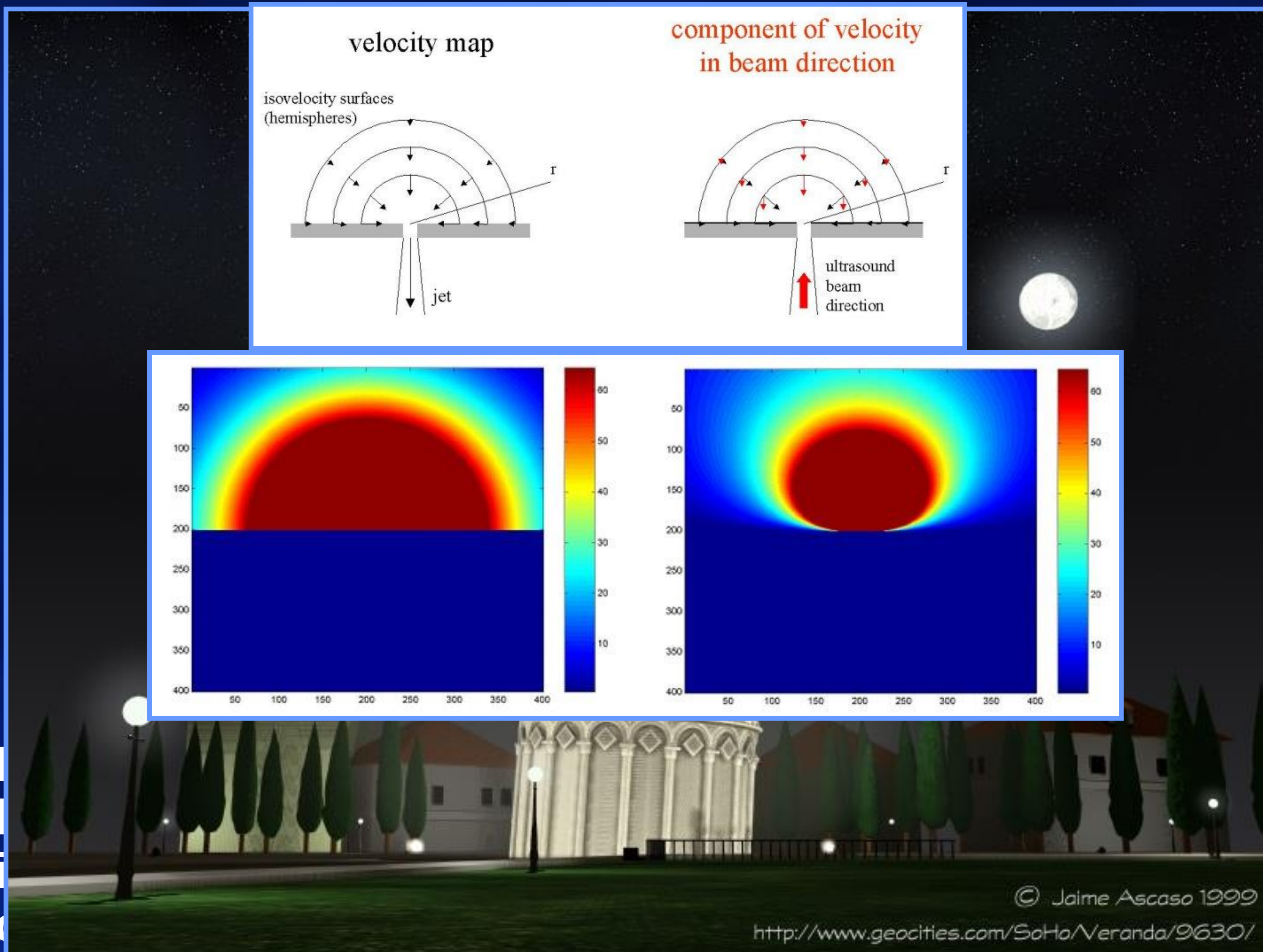
Flow Acceleration

Turbulence

Downstream

Adapted from Echo in Context. Kisslo et al.

What is PISA ?



- I … as
  I …
  i … ells
  c …

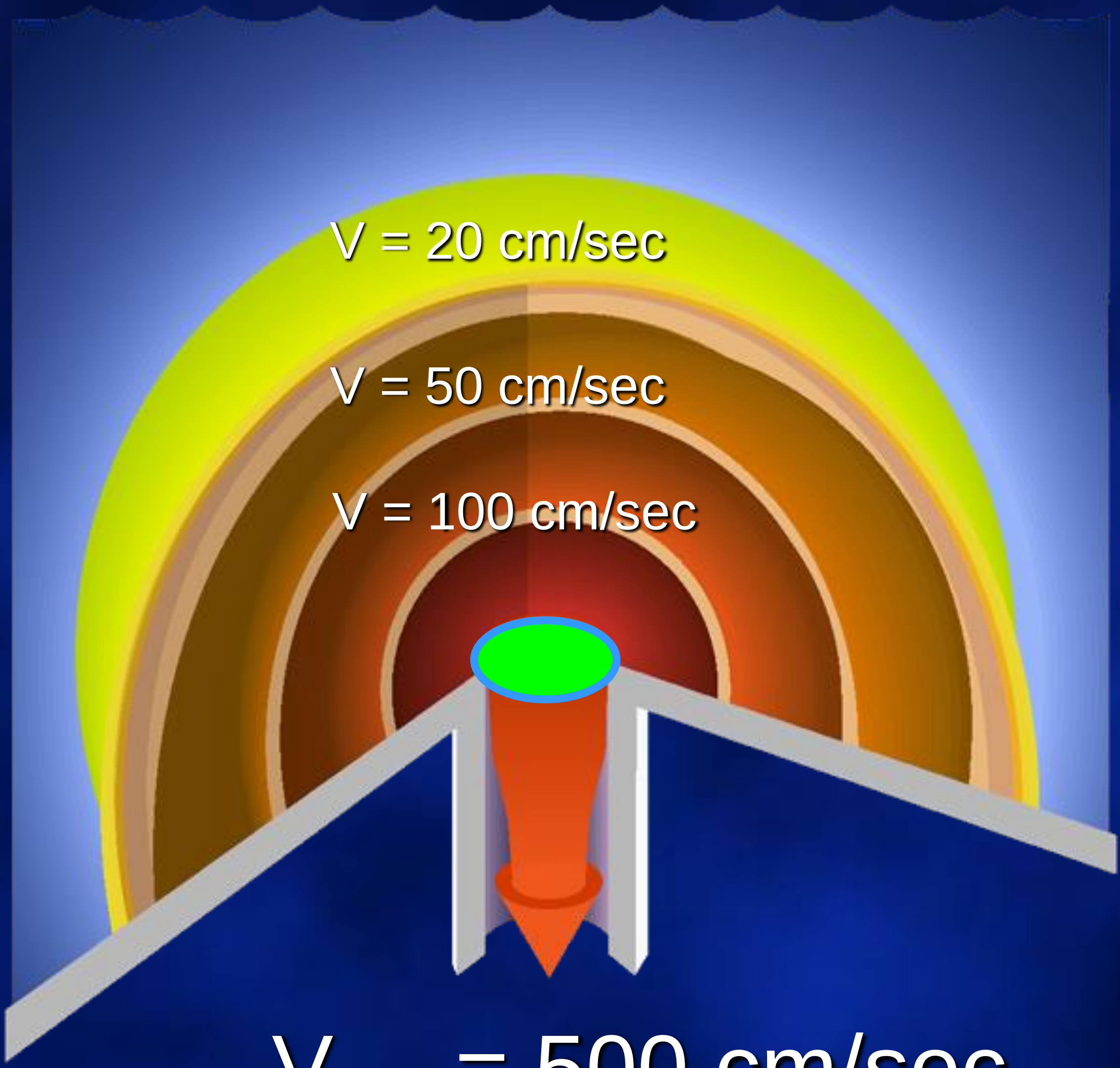
Flow Convergence

P roximal

I sovelocity

S urface

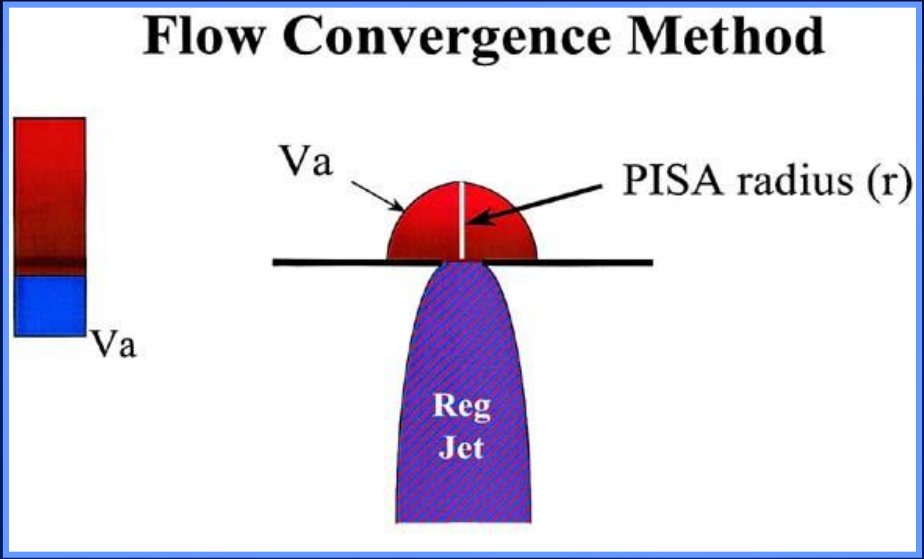
A rea



V_{MR} = 500 cm/sec

PISA Calculations

(Proximal Isovelocity Surface Area)



Zoghbi WA et al. *J Am Soc Echocardiogr* 2003;16:777-802.

- **Flow (cc/sec)**

  = 6.28 x [r (cm)]^2 x V_a (cm/sec)

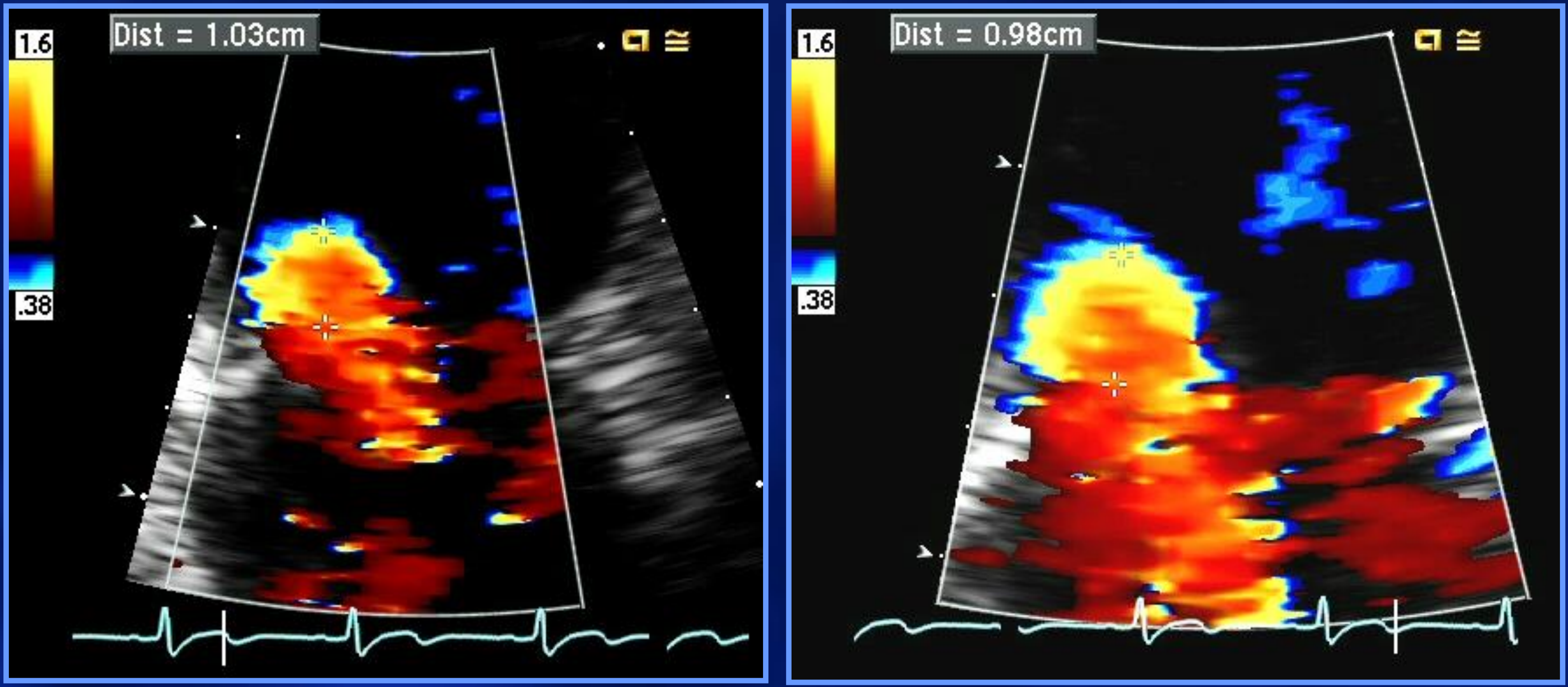
- **ERO (cm^2) = $\frac{\text{Flow (cc/sec)}}{\text{V (cm/sec)}}$**

- **RV (cc) = ERO (cm^2) x TVI (cm)**

Locating the Color Flow Convergence

- **Zoom region of interest**
  (Decreases error of radius measurement)
- **Shift color Doppler baseline in the direction of the regurgitant jet**
- **Baseline shift to obtain an optimal hemispheric flow convergence signal for PISA measurement**

Zoom In As Tight As You Can

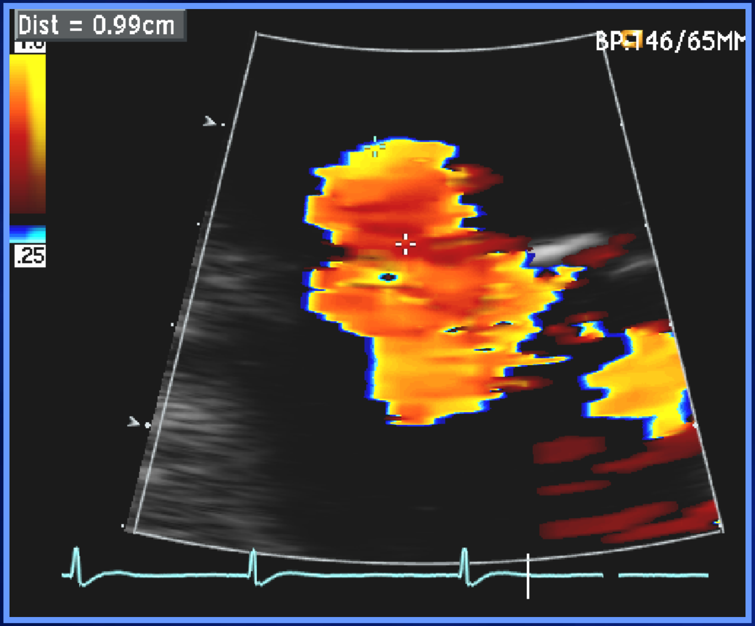


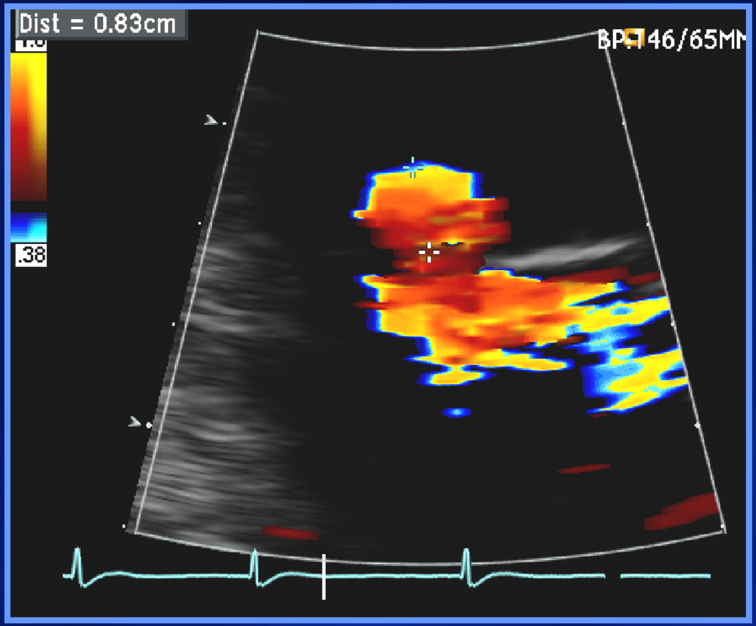
- **Larger zoom box**
- **Smaller zoom box**

- Courtesy of Leslie Elvert, B.S., R.D.C.S.

MAYO CLINIC

What is the best aliasing velocity?





- **Alias Vel. 25 cm/s**
- **Radius 0.99 cm**
- **ERO 0.32 cm2**
- **Reg Vol 44 cc**

- **Alias Vel. 38 cm/sec**
- **Radius 0.83 cm**
- **ERO 0.35 cm2**
- **Reg Vol 47 cc**

MAYO CLINIC

- Courtesy of Leslie Elvert, B.S., R.D.C.S.

Advantages of PISA Method

- Can be used in presence of other valvular regurgitation or shunts
- Can be used in presence of valve stenosis or prosthetic valves
- Uses fewer variables

Quantitation of Mitral Regurgitation

	Mild	Moderate		Severe
MR Volume (cm^3/beat)	<30	30 - 44	45 - 59	≥ 60
ERO (cm^2)	<0.20	0.20-0.29	0.30-0.39	≥ 0.40
Vena Contracta Width (cm)	< 0.3	0.3 - 0.69		≥ 0.7

Zoghbi WA, et al. J Am Soc Echocardiogr 2003; 16: 777

Simplified Approach to PISA (ERO)

- $ERO = 2\pi \cdot r^2 \cdot V/V_{max}$ of MR

  $= 6.28 \cdot r^2 \cdot V/V_{max}$ of MR

- If V/Vmax of MR can be adjusted to 1/12, then $ERO = 6.28/12 \times r^2$

  $= 0.5 \times r^2$

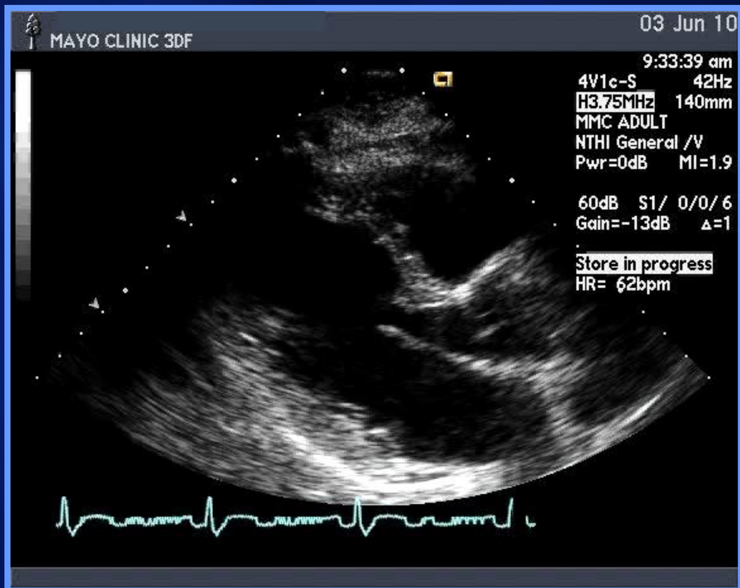
Aliasing velocity set at 40 cm/sec assuming MR maximum velocity ≅ 500 cm/sec

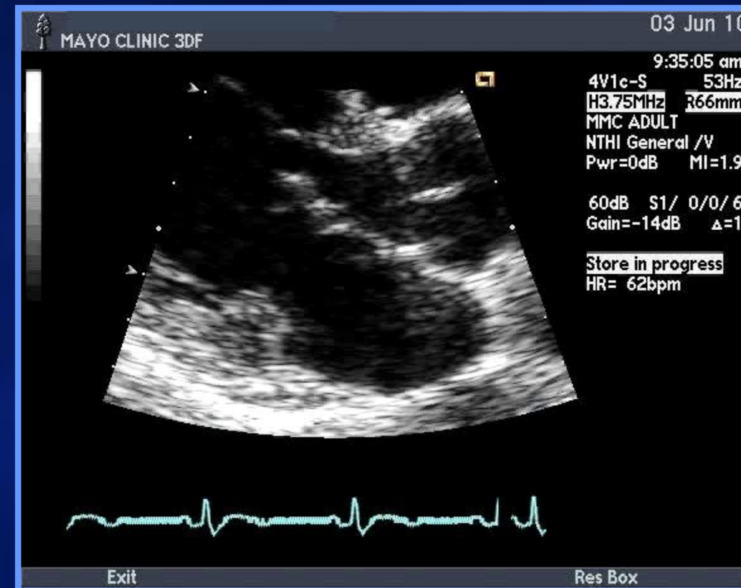
Pu M et al. *J Am Soc Echocardiog* 2001

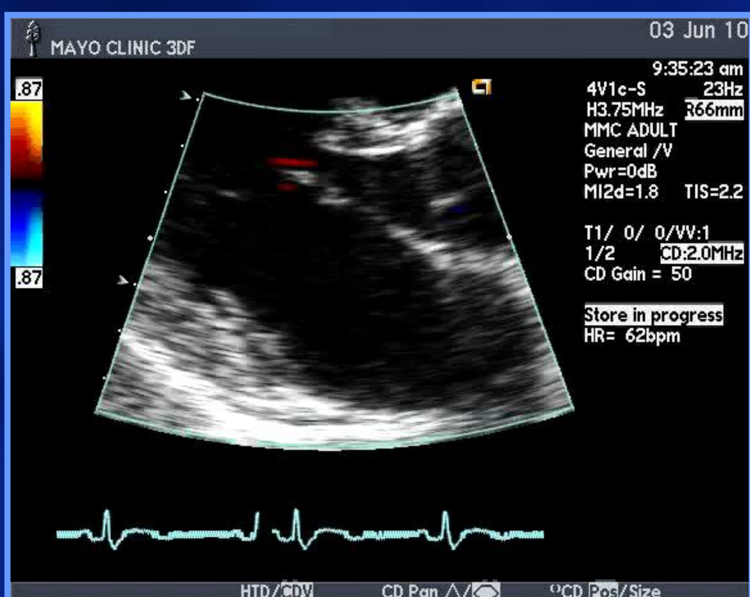
Simplified PISA (ERO)

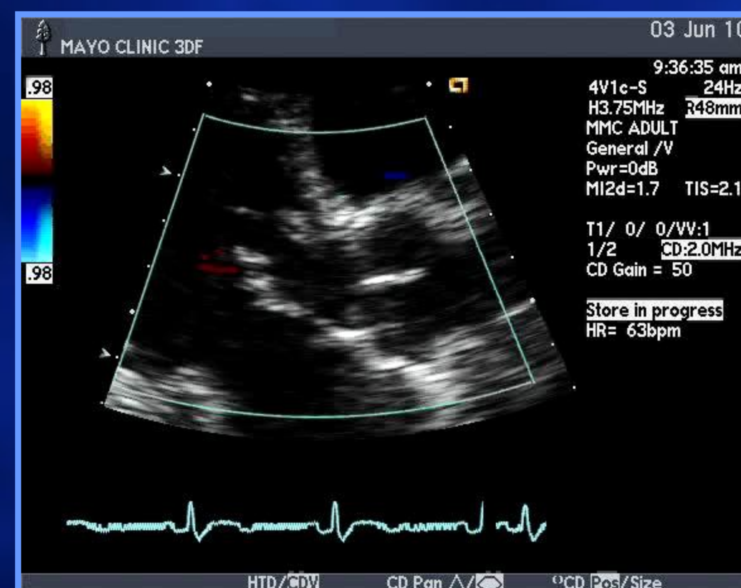
- Examples
  - r = 0.4 cm; r^2 = 0.16 cm^2; ERO = 0.08 cm^2
  - r = 0.6 cm; r^2 = 0.36 cm^2; ERO = 0.18 cm^2
  - r = 0.8 cm; r^2 = 0.64 cm^2; ERO = 0.32 cm^2
  - r = 0.9 cm; r^2 = 0.81 cm^2; ERO = 0.4 cm^2
  - r = 1.0 cm; r^2 = 1.0 cm^2; ERO = 0.5 cm^2

48 y/o Housewife: Heart murmur, dyspnea

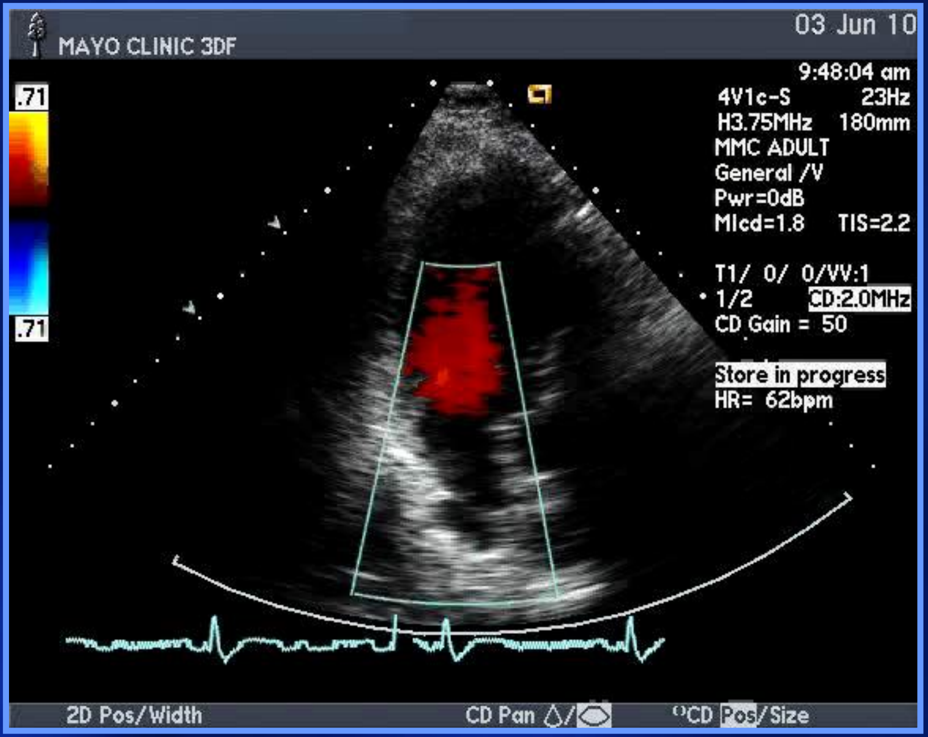


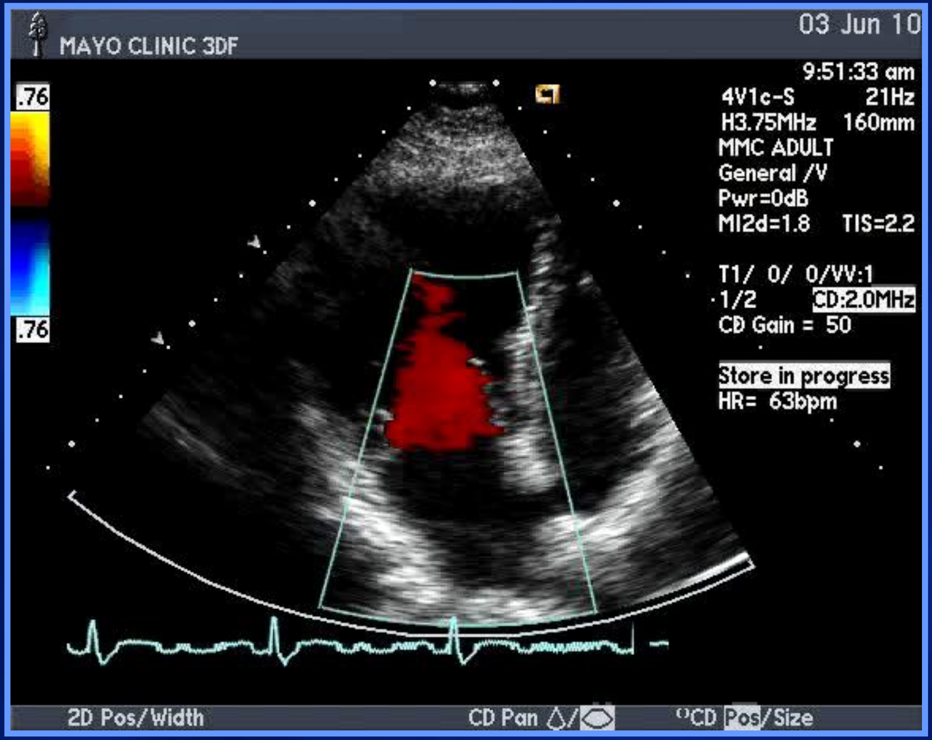




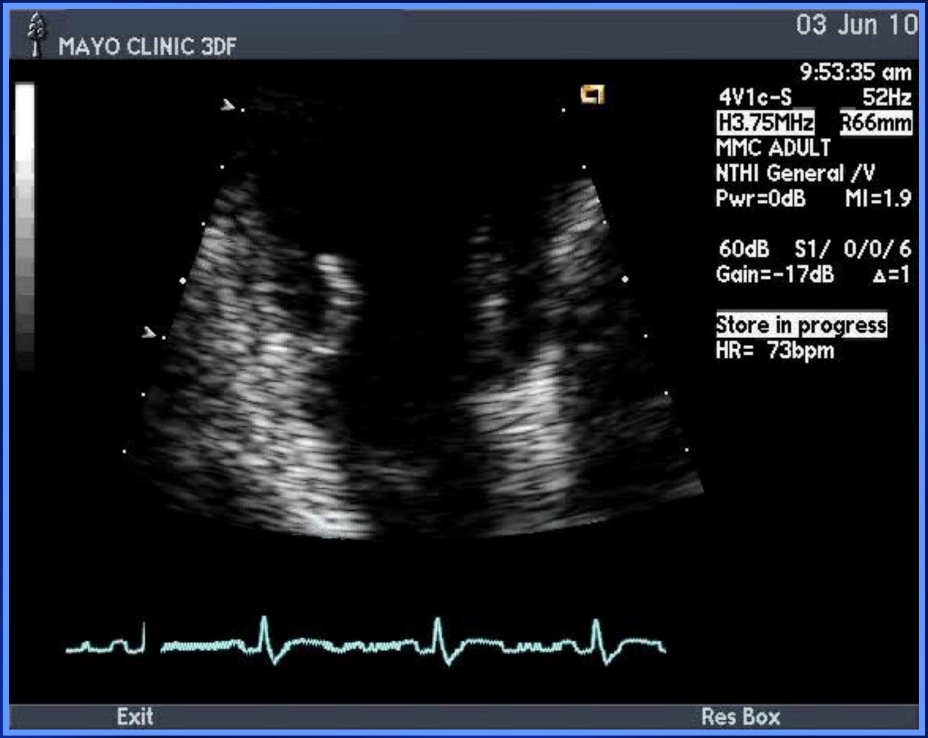


Apical Color Views: Mayo Clinic Format (ASE Type B Format)





Mayo Clinic Format
(ASE Type B Format)



PISA R = 0.5 cm; Aliasing velocity 61 cm/sec

Step 1: Calculate proximal MR flow

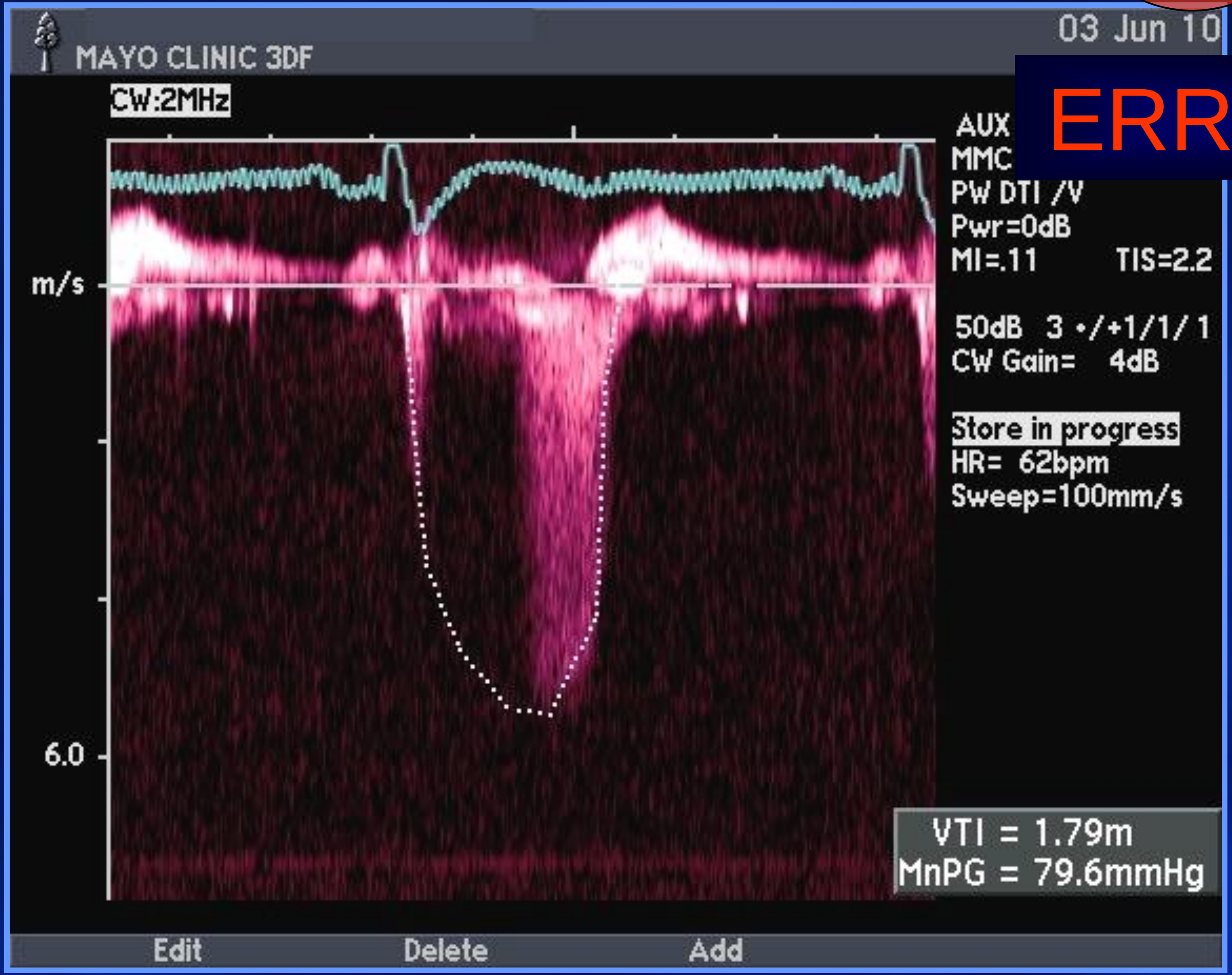
$$\text{Flow}_{MR} = \text{Area}_{PISA} \times \text{Velocity}_{Alias}$$

$$= 2\pi \times R^2 \times V_{Alias}$$

$$= 6.28 \times (0.5\text{cm})^2 \times 61 \text{ cm/sec}$$

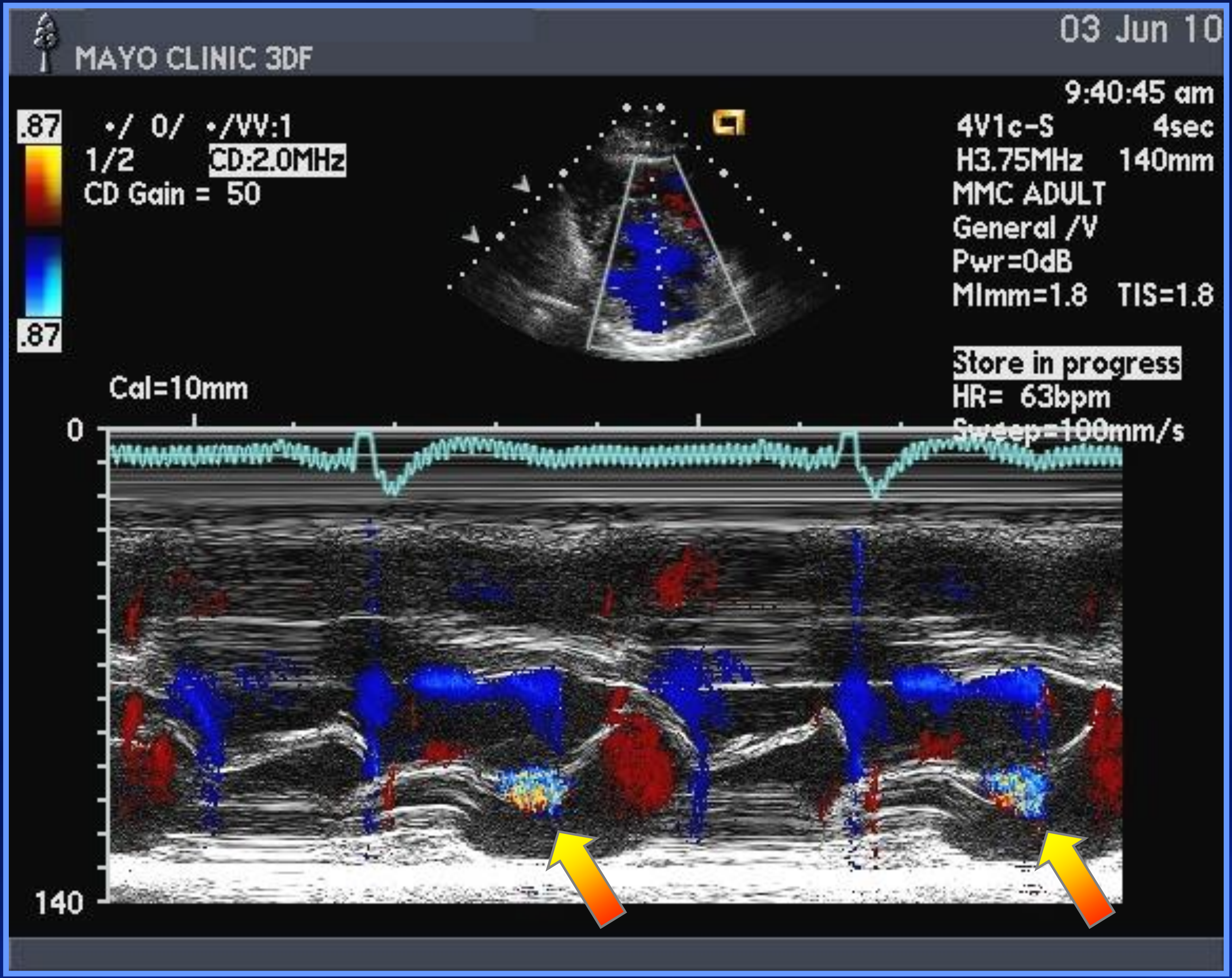
$$\text{Flow}_{MR} = 96 \text{ cm}^3/\text{sec}$$

MR Peak Velocity 570 cm/sec; TVI = 179 cm

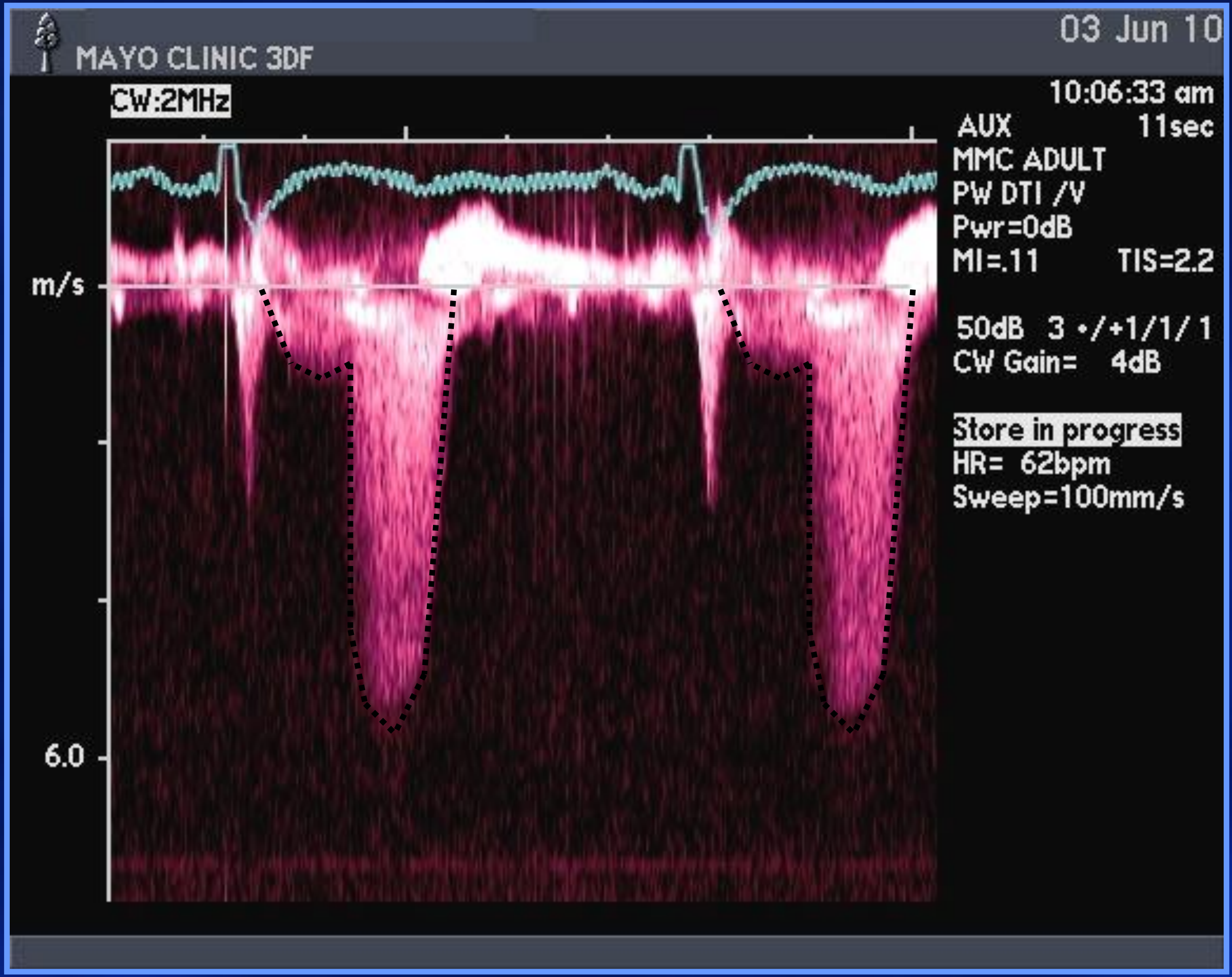


ERROR

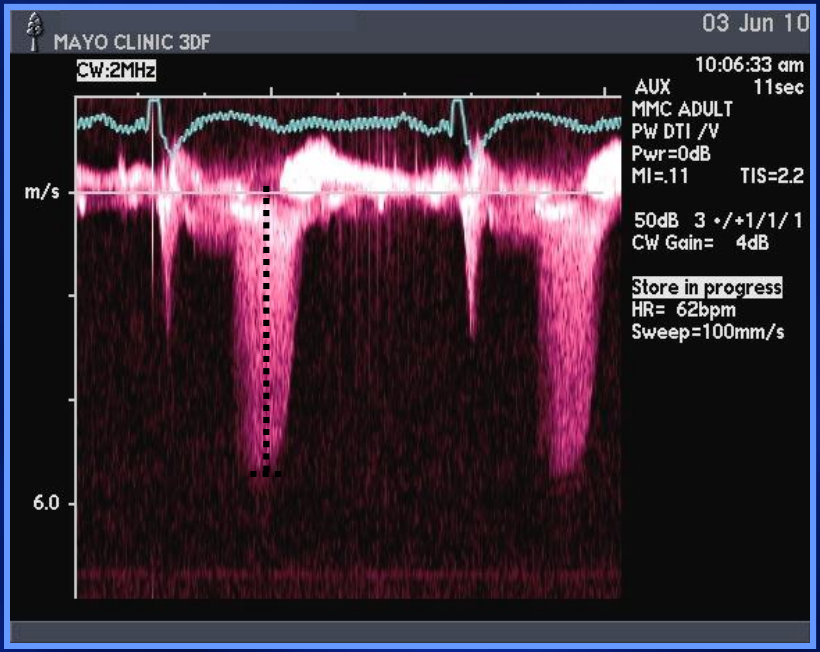
Color M-Mode: MVP and MR



MR Peak Velocity 570 cm/sec; TVI = 127 cm



Step 2: Calculate the mitral ERO



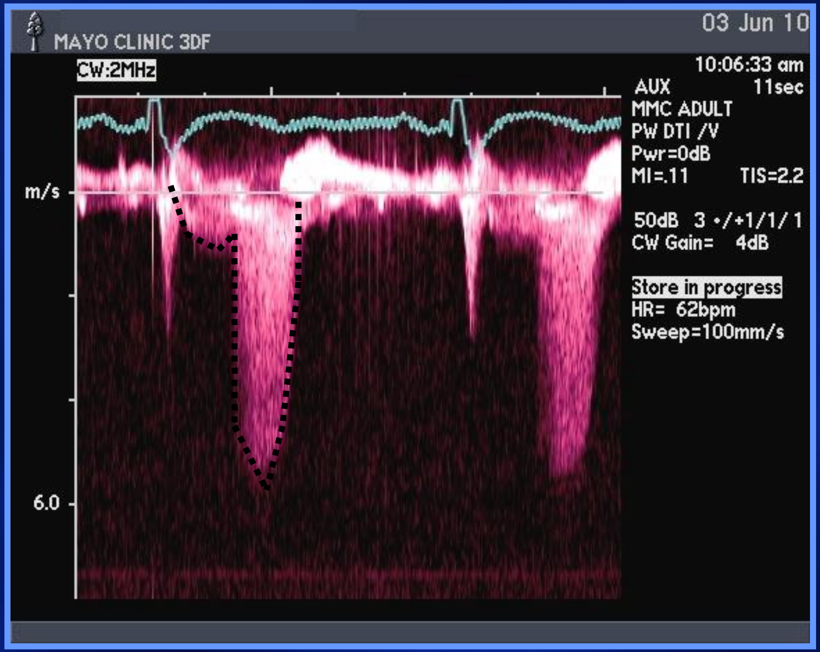
$Velocity_{MR}$ = 570 cm/sec

$$ERO = \frac{Flow_{MR}}{Velocity_{MR}}$$

$$= \frac{96\ cm^3/sec}{570\ cm/sec}$$

$$= 0.17\ cm^2$$

Step 3: Calculate MR volume



TVI_{MR} = 127 cm

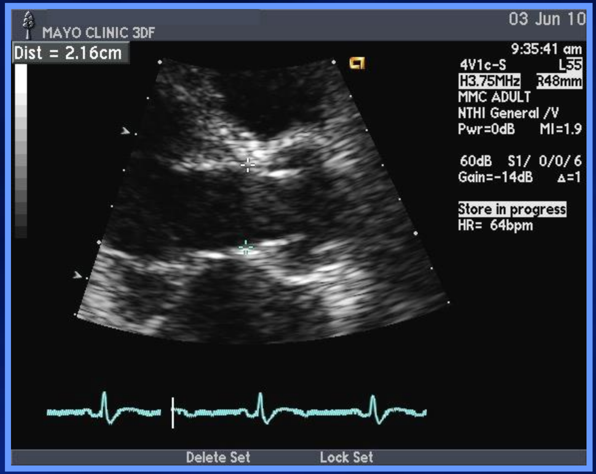
$Volume_{MR}$

= ERO x TVI_{MR}

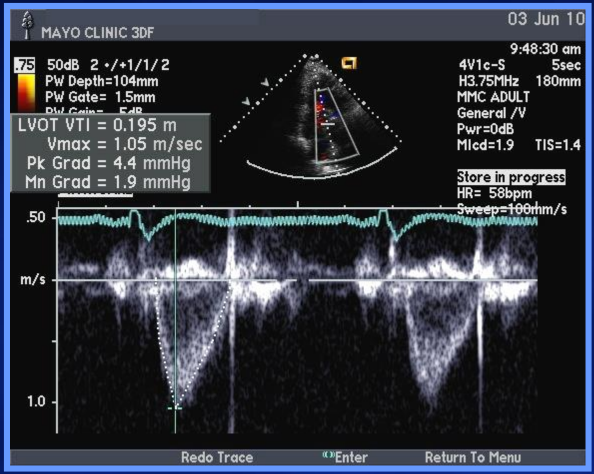
= 0.17 cm^2 x 127 cm

= 22 cm^3

Step 1: Calculate LVOT Stroke Volume



LVOT Diameter = 2.2 cm

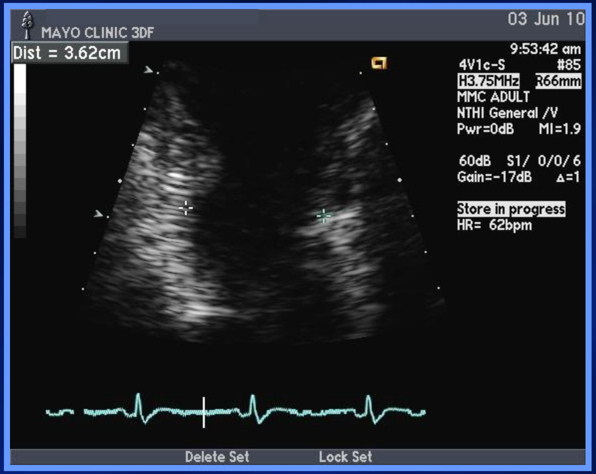


LVOT TVI = 20 cm

LVOT Stroke Volume $= 0.785\,(2.2\text{ cm})^2 \times 20\text{ cm}$

$= 76\text{ cm}^3$

Step 2: Calculate MV Stroke Volume



MV Annulus = 3.6 cm

MV Annulus TVI = 10 cm

MV Stroke Volume $= 0.785\ (3.6\ \text{cm})^2 \times 10\ \text{cm}$

$= 102\ \text{cm}^3$

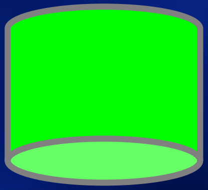
Step 3: Calculate MR Volume

MV Stroke Volume − LVOT Stroke Volume = MR Volume

$$102\ cm^3 - 76\ cm^3 = 26\ cm^3$$

Step 4: Calculate Regurgitant Fraction (RF)

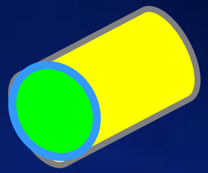
$$\text{Mitral RF} = \frac{\text{MR Volume}}{\text{MV Stroke Volume}} = \frac{26 \text{ cm}^3}{102 \text{ cm}^3} = 25\%$$



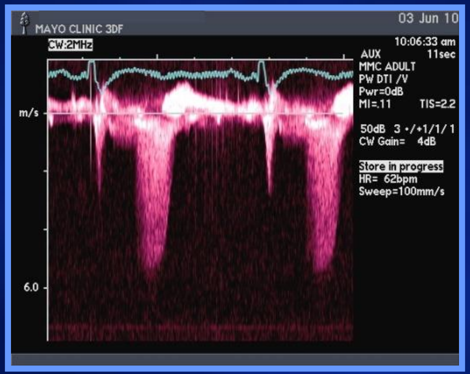
Step 5: Calculate MR ERO

E ffective **R** egurgitant **O** rifice

=



MR Volume ($26\ cm^3$)



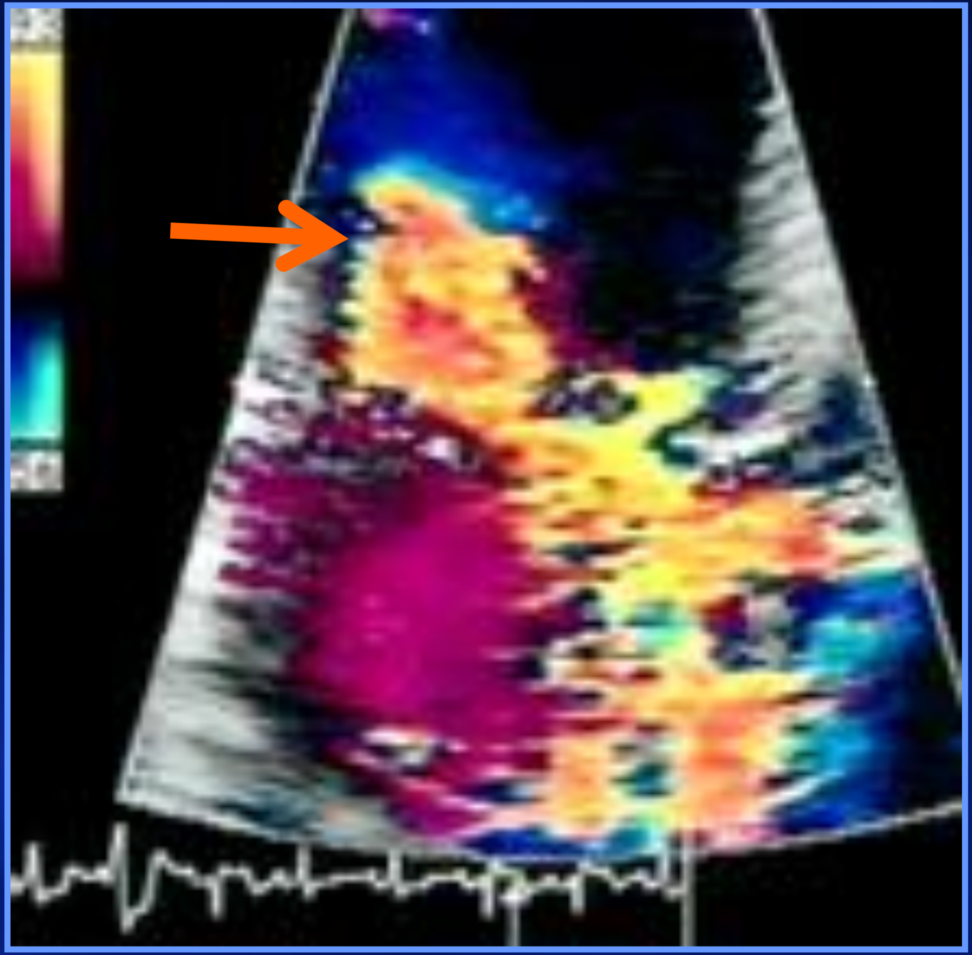
MR TVI (127 cm)

$$\text{ERO} = \frac{26\ cm^3}{127\ cm} = 0.20\ cm^2$$

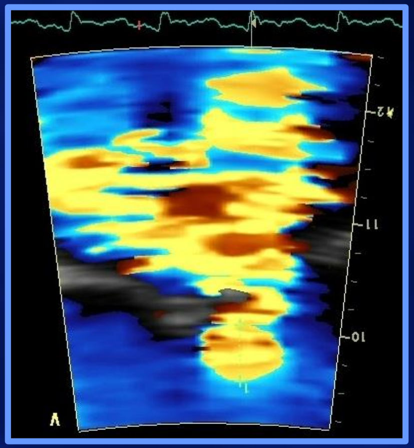
Problems with PISA

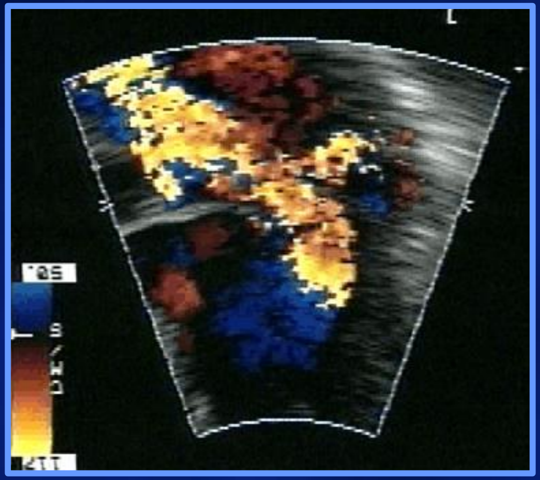
- **Sub-optimal flow convergence**
  - **Non-hemispheric flow**
  - **Not useful in large orifices**
- **Multiple MR jets**
- **Some eccentric jets may impinge on hemisphere**
- **LVOT obstruction may distort the isovelocity convergence zone**
- **PISA is dynamic during systole, timing is crucial**
- **PISA is too complicated for routine clincal use**
  - **Simplified PISA**
- **PISA just doesn’t work**

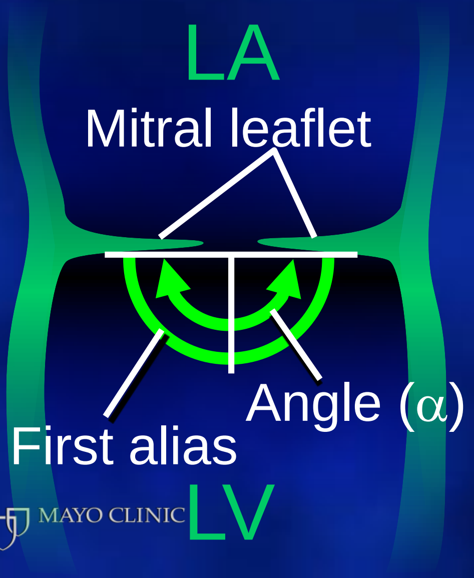
Sub-optimal Flow Convergence

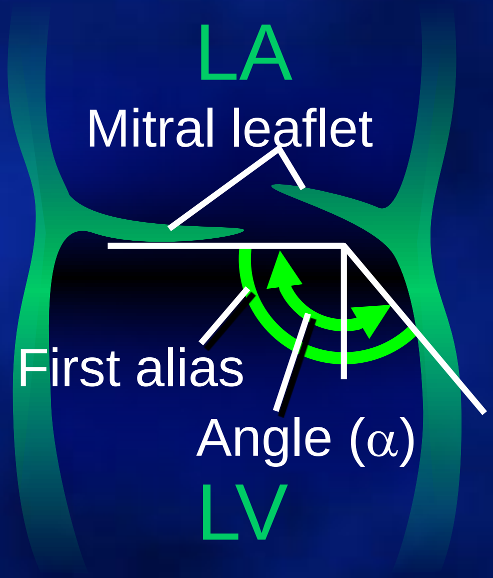


Non - Hemispheric Flow Convergence: Wall Impingement







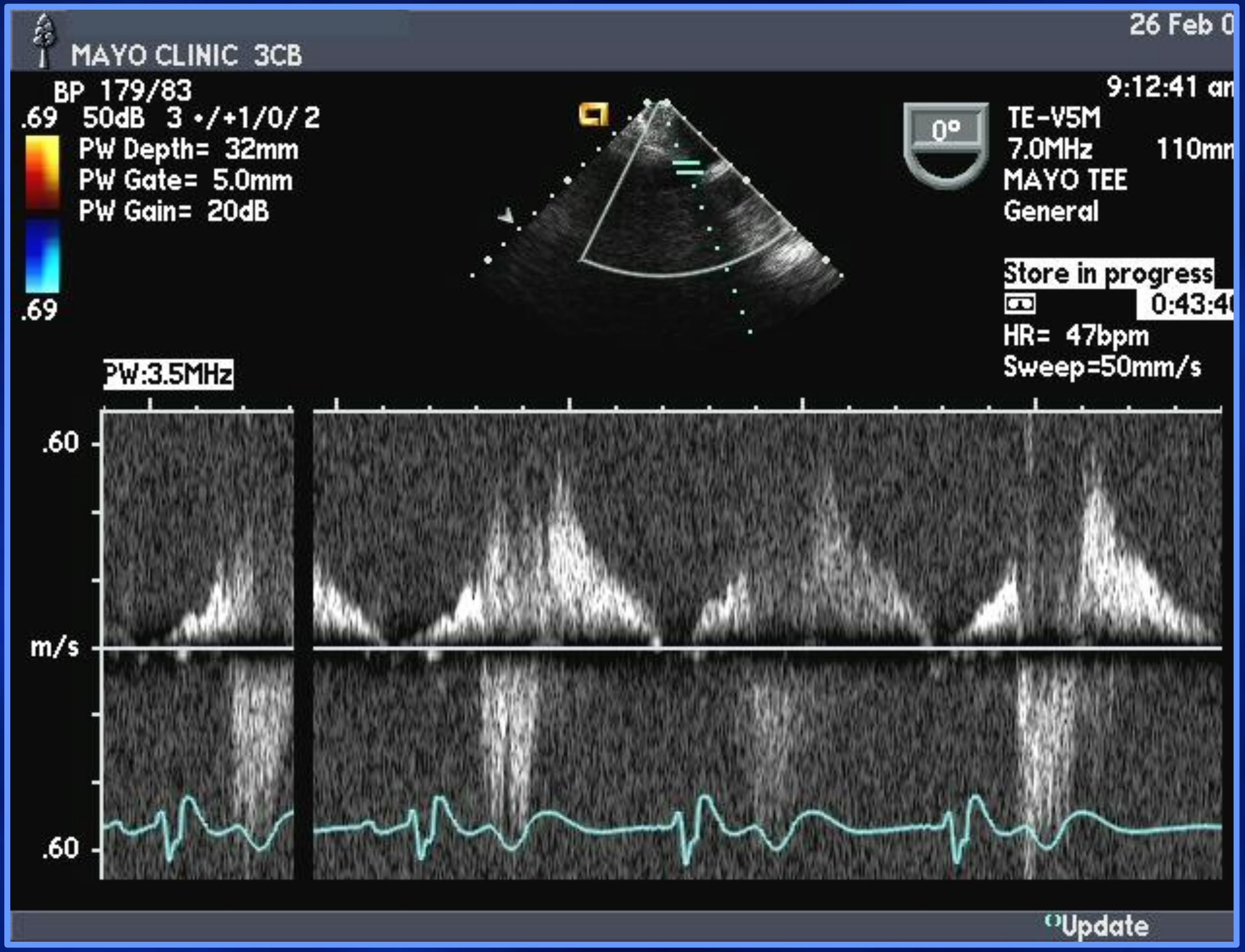


$$ERO = \frac{\pi \times r^2 \times Av}{MR\ Vmax} \times \frac{\alpha}{180}$$

MAYO CLINIC

Severe Mitral Regurgitation
- Supportive Signs

Pulmonary Vein Systolic Reversal of Flow



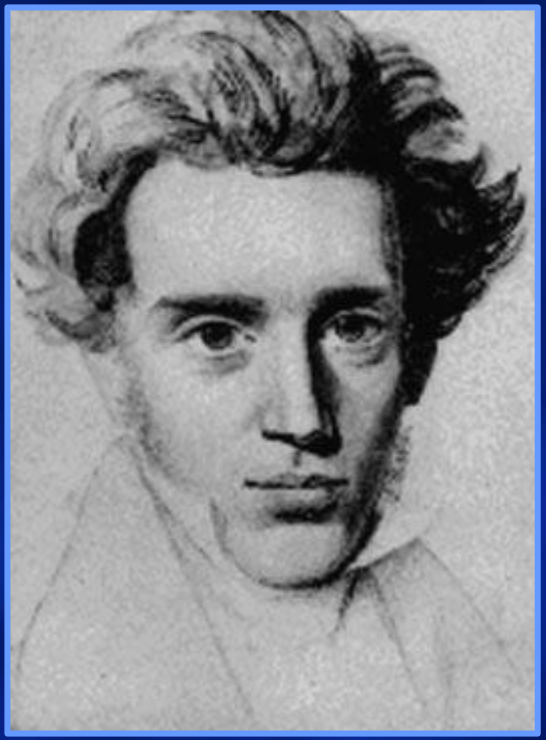
- Enlarged LA
- Enlarged LV

Final Points

- **Mild, well visualized, central jet = MILD**
- **If suspect more that mild, analyze**
- **Use all available info, no method is perfect**
- **Learn to quantify**
- **Responsibility to patients and colleagues to produce a report closest to the truth**

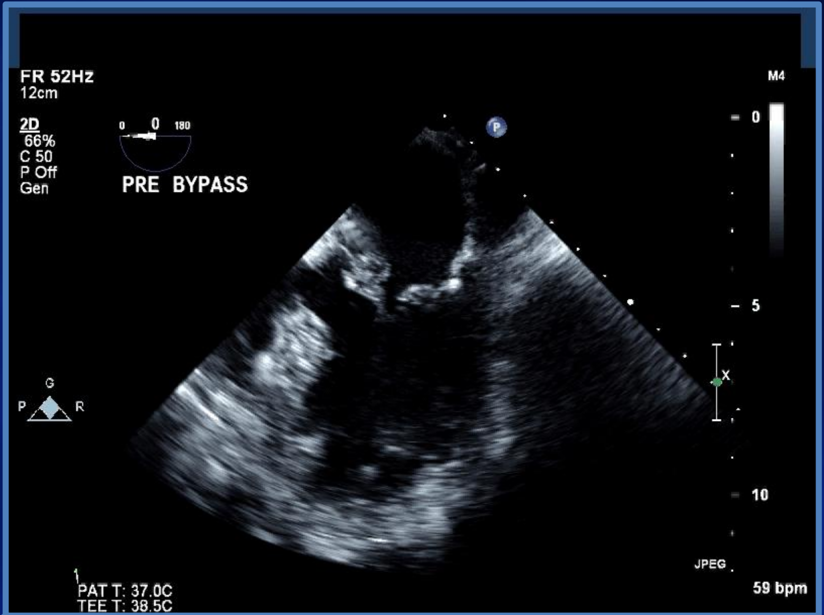
To dare is to lose one's footing momentarily, not to dare is to lose oneself

- Soren Kierkegaard

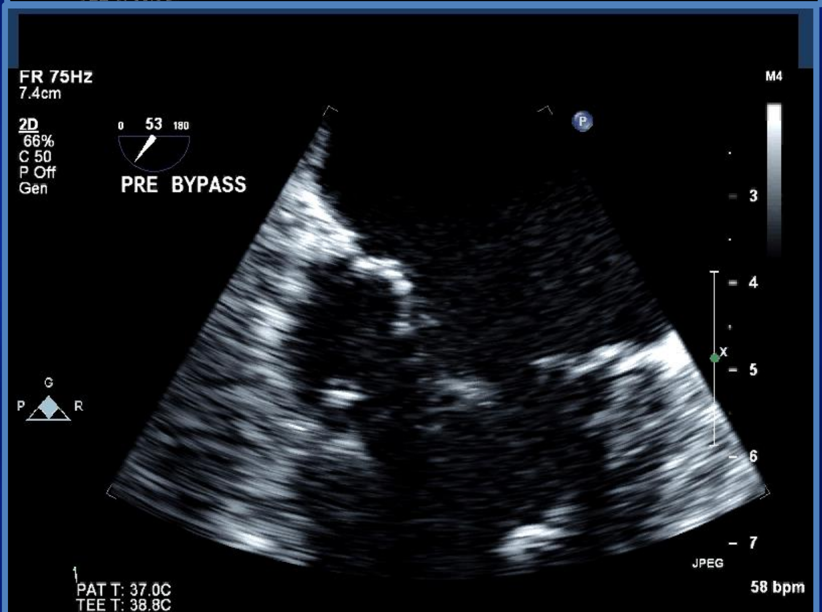


Post-Test Questions

What is the specific abnormality of the mitral valve shown on this pre-operative TEE?

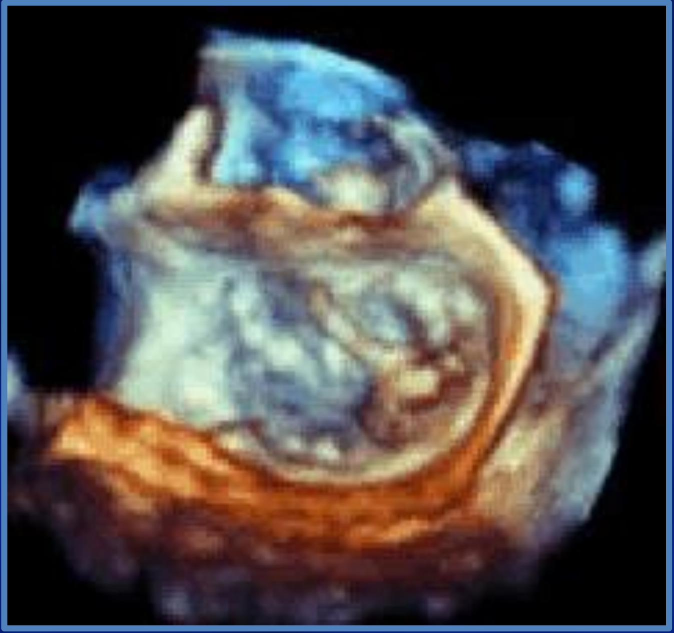


← 0° View



← 60° View

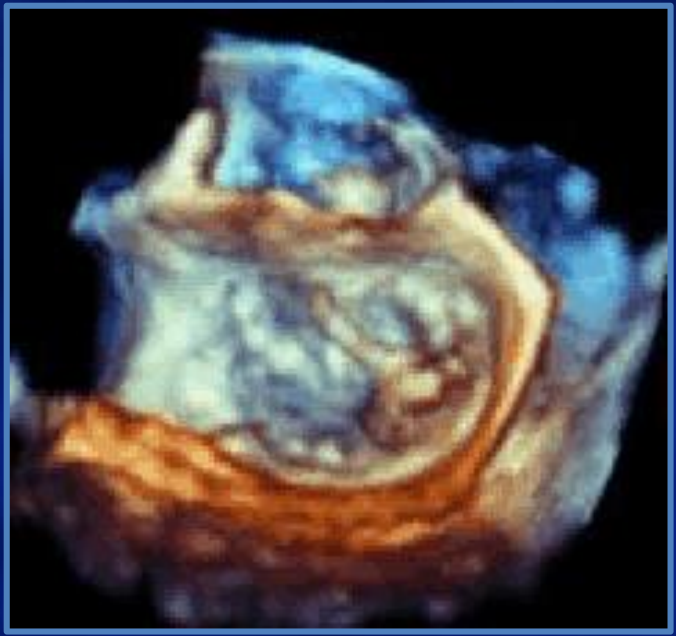
3D TEE

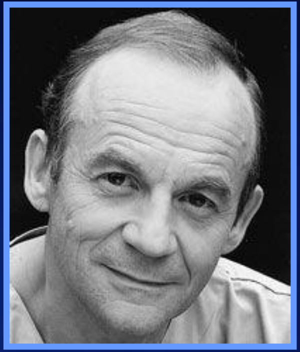


↑View from LA↑
“Surgeon’s View”

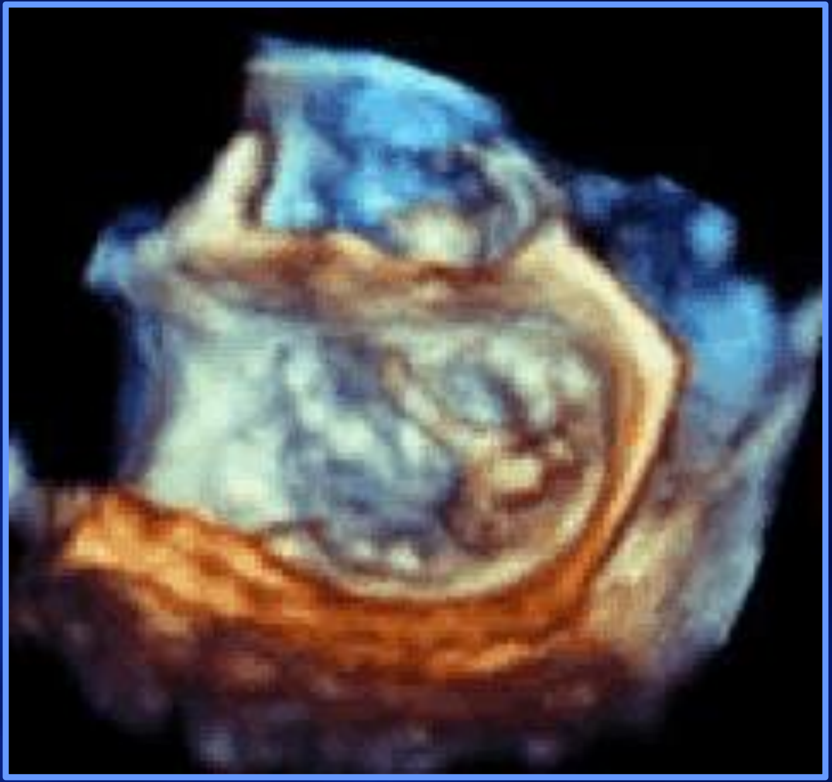
What is the specific mitral valve abnormality?

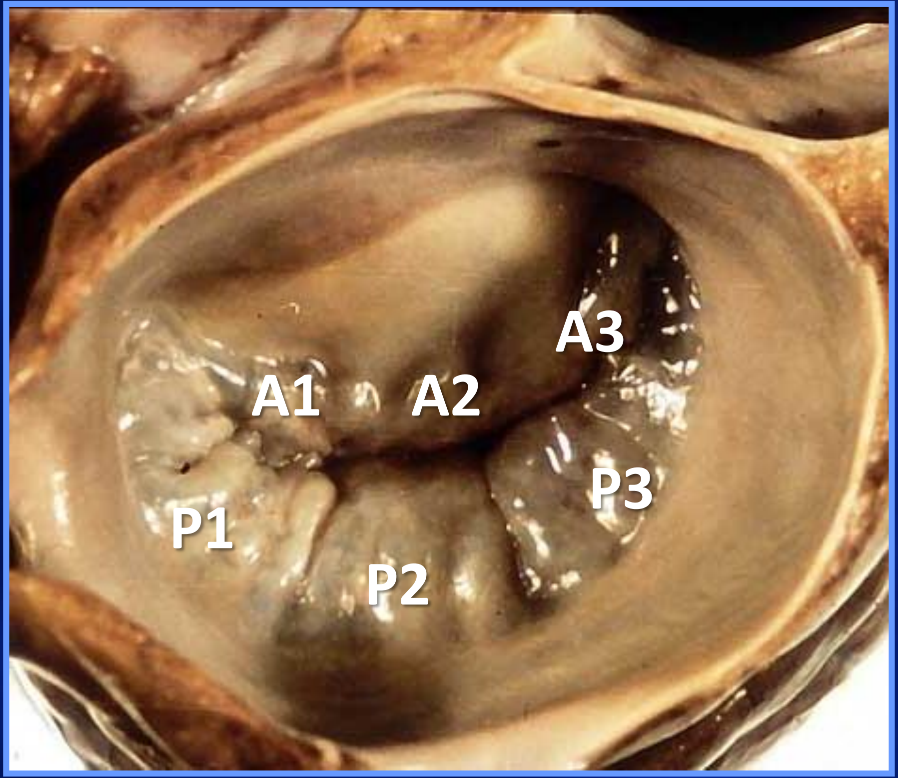
1. Flail P2
2. Flail P1
3. Flail P3
4. Barlow’s Disease
5. Flail A3



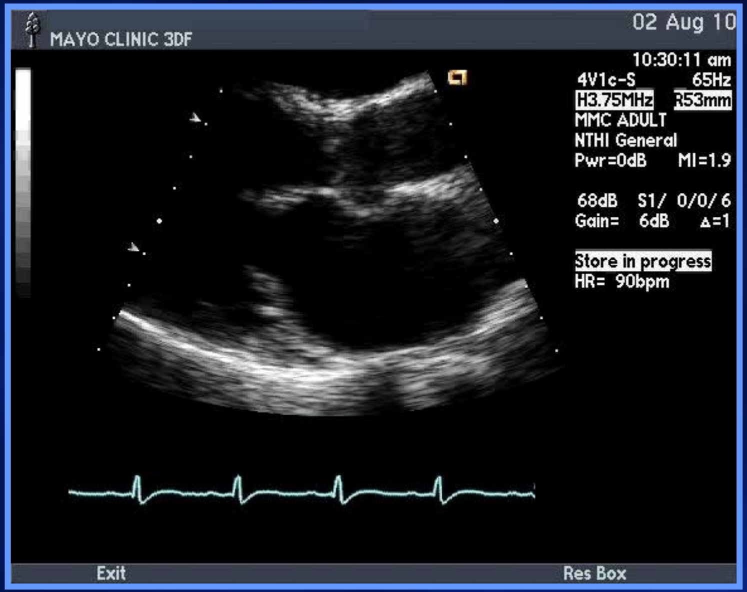


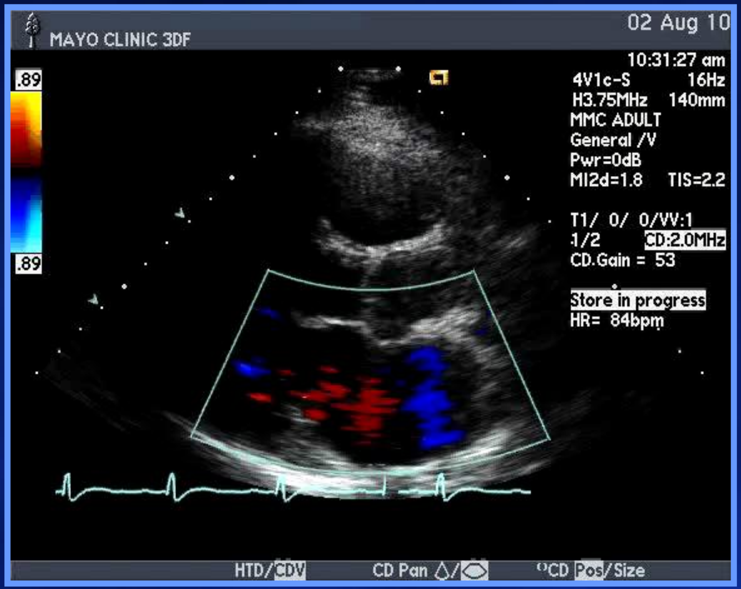
Mitral Valve Anatomy: View from the Left Atrium

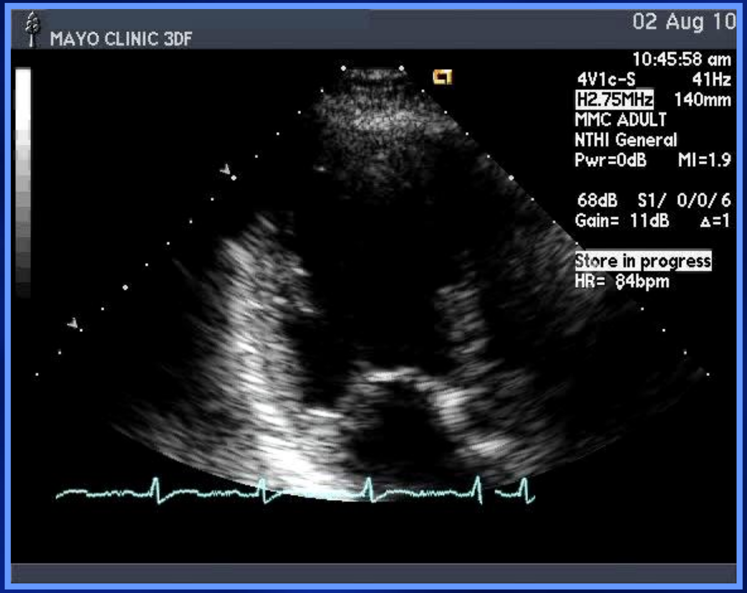


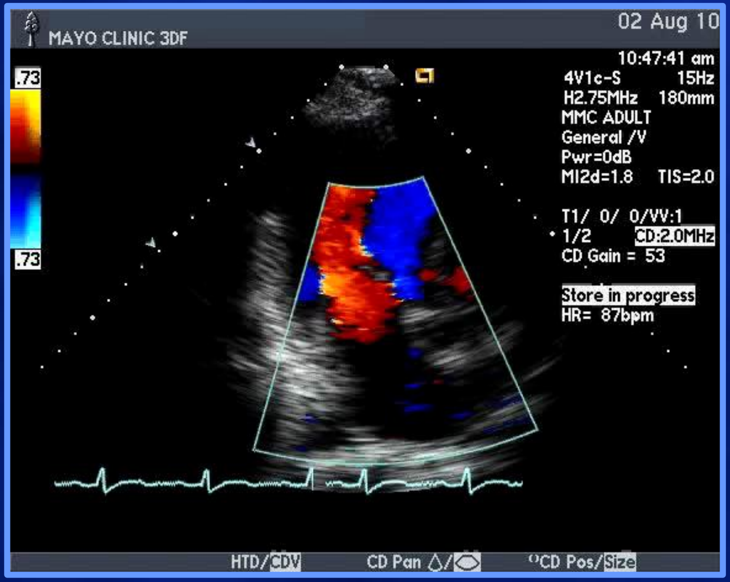


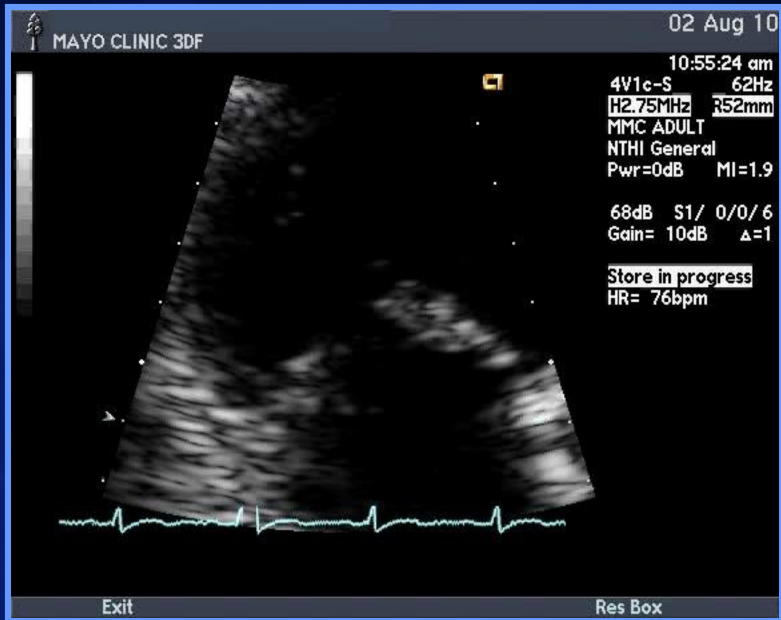
41 y/o woman: Dyspnea on exertion

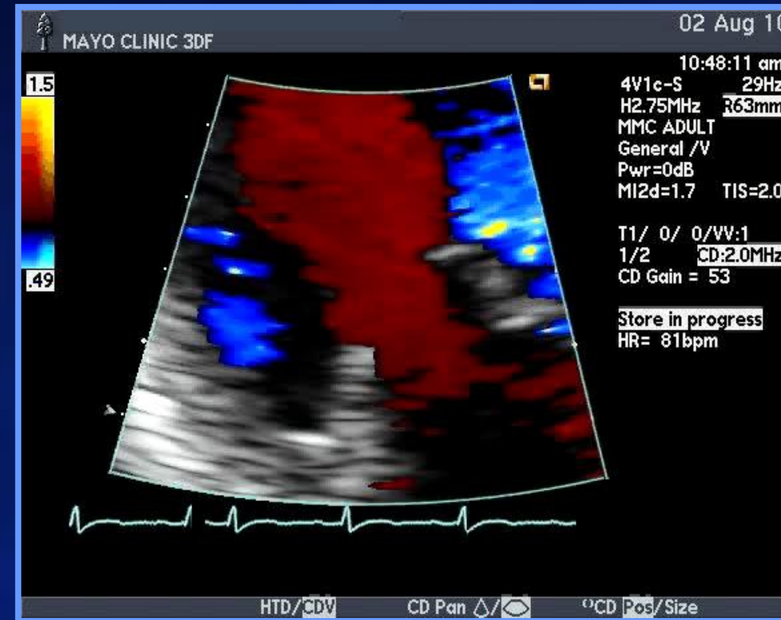


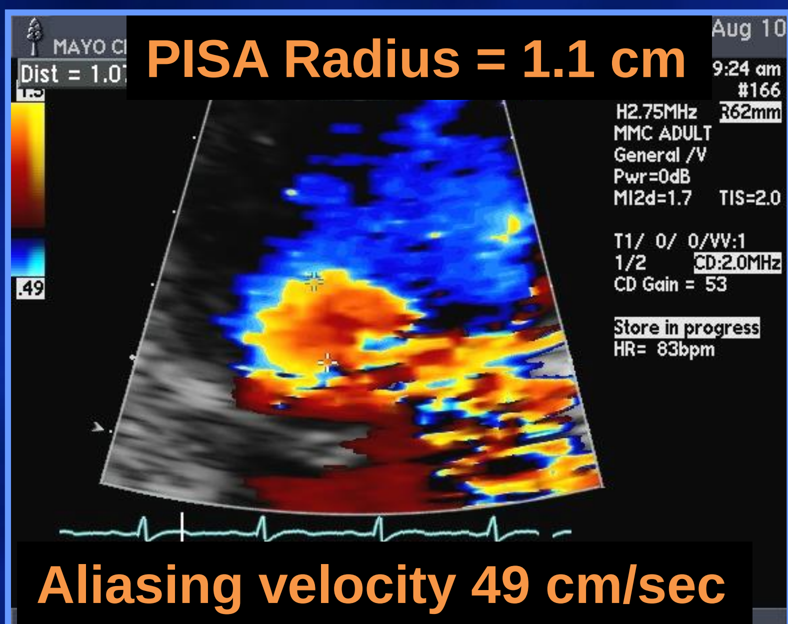


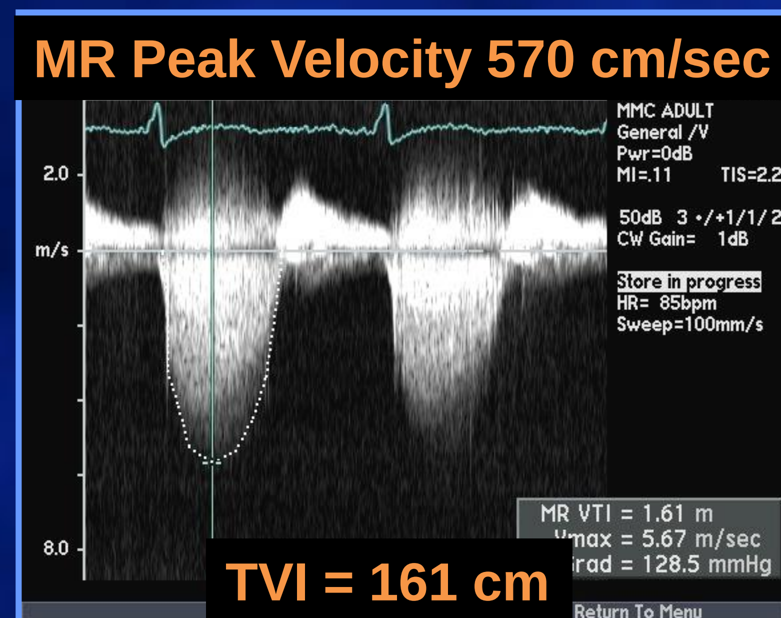





MAYO CLINIC 3DF
02 Aug 10
10:55:24 am
4V1c-S 62Hz
H2.75MHz R52mm
MMC ADULT
NTHI General
Pwr=0dB MI=1.9
68dB S1/ 0/0/6
Gain= 10dB ∆=1
Store in progress
HR= 76bpm
Exit
Res Box


MAYO CLINIC 3DF
02 Aug 10
10:48:11 am
4V1c-S 29Hz
H2.75MHz R63mm
MMC ADULT
General /V
Pwr=0dB
MI2d=1.7 TIS=2.0
T1/ 0/ 0/VV:1
1/2 CD:2.0MHz
CD Gain = 53
Store in progress
HR= 81bpm
1.5
.49
HTD/CDV
CD Pan
CD Pos/Size


PISA Radius = 1.1 cm
Aug 10
9:24 am
#166
H2.75MHz R62mm
MMC ADULT
General /V
Pwr=0dB
MI2d=1.7 TIS=2.0
T1/ 0/ 0/VV:1
1/2 CD:2.0MHz
CD Gain = 53
Store in progress
HR= 83bpm
.49
Aliasing velocity 49 cm/sec


MR Peak Velocity 570 cm/sec
MMC ADULT
General /V
Pwr=0dB
MI=.11 TIS=2.2
50dB 3 •/+1/1/2
CW Gain= 1dB
Store in progress
HR= 85bpm
Sweep=100mm/s
2.0
m/s
8.0
MR VTI = 1.61 m
128.5 mmHg
TVI = 161 cm
Return To Menu

What is the calculated ERO?

1. 0.45 cm^2
2. 0.55 cm^2
3. 0.35 cm^2
4. 0.65 cm^2
5. 0.75 cm^2

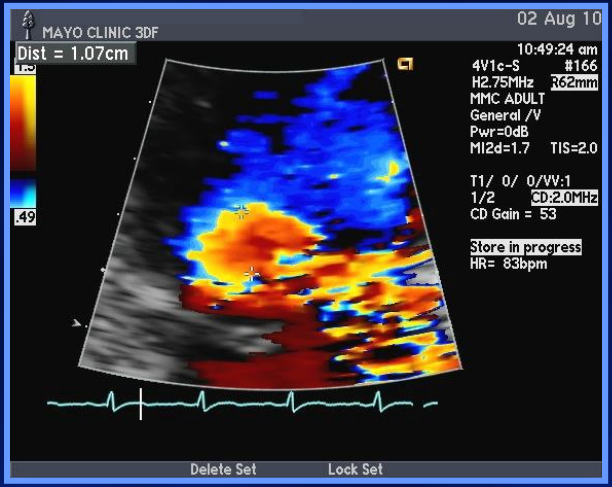
PISA Radius = 1.1 cm

Aliasing velocity 49 cm/sec

MR Peak Velocity 570 cm/sec

TVI = 161 cm

Step 1: Calculate proximal MR flow



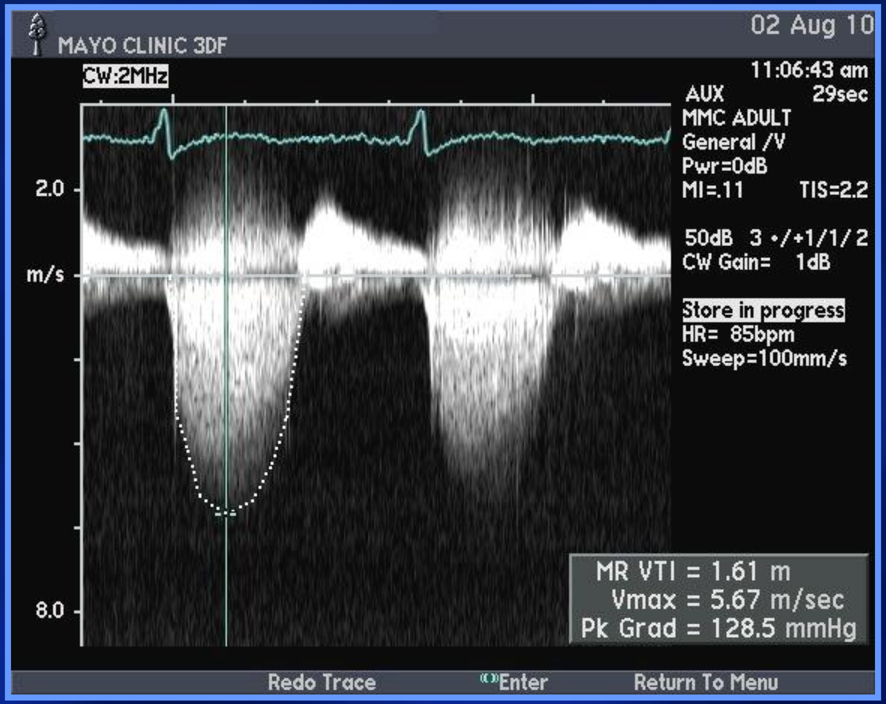
$$Flow_{MR} = Area_{PISA} \times Velocity_{Alias}$$

$$= 2\pi \times R^2 \times V_{Alias}$$

$$= 6.28 \times (1.1cm)^2 \times 49 \text{ cm/sec}$$

$$Flow_{MR} = 372 \text{ cm}^3\text{/sec}$$

Step 2: Calculate the mitral ERO



$$ERO = \frac{Flow_{MR}}{Velocity_{MR}}$$

$$= \frac{372\ cm^3/sec}{570\ cm/sec}$$

$$= 0.65\ cm^2$$

$Velocity_{MR}$ = 570 cm/sec

Thank You!

mankad.sunil@mayo.edu