Quantifying Valvular Regurgitation

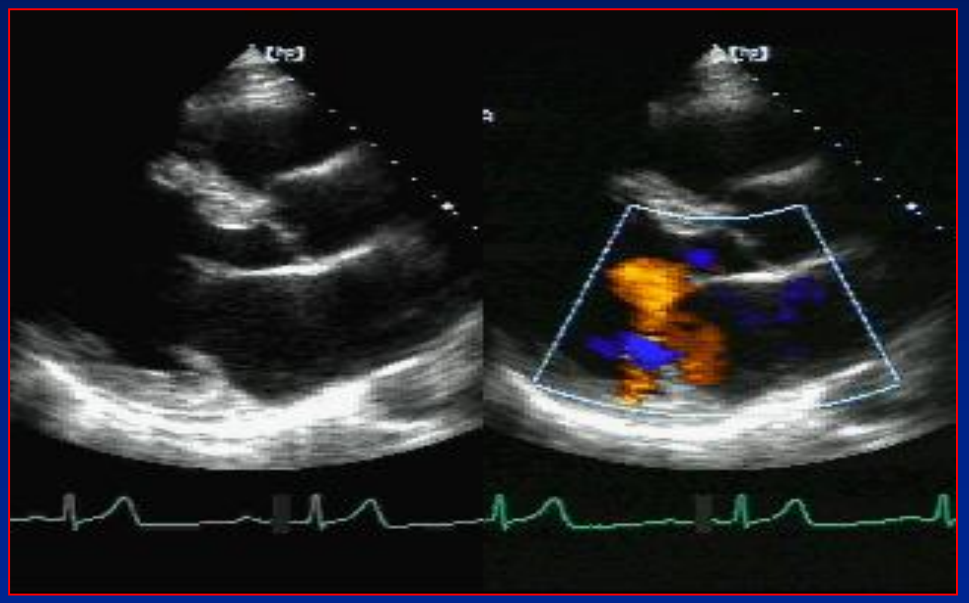
William A. Zoghbi MD, MACC
Elkins Family Distinguished Chair in Cardiac Health
Professor and Chairmen, Department of Cardiology
Houston Methodist DeBakey Heart & Vascular Center
Houston, Texas

Valvular Regurgitation
General Considerations

Importance of:

- Valvular structure/Mechanism
- Cardiac adaptation to the volume overload
- Hemodynamics: affect severity & regurgitation parameters—irrespective of the modality
- Acute vs. chronic regurgitation

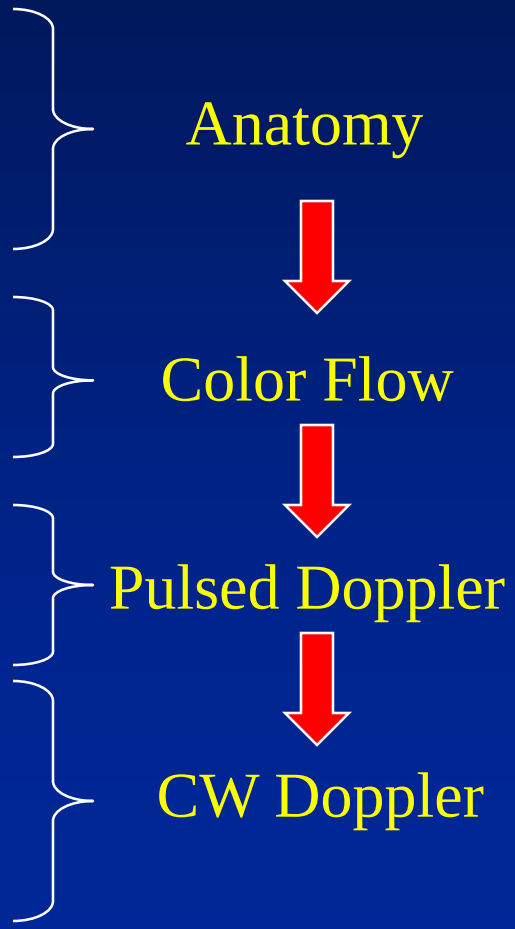
Mitral Regurgitation



Mitral Regurgitation

Indicators of Severity

- Mitral valve pathology
- LV/ LA size
- Color Doppler: Vena contracta
  Jet Area, Flow convergence
- Mitral E; Pulmonary vein pattern
- Regurgitant flow/fraction
- CW density and contour



Evaluating MR Severity

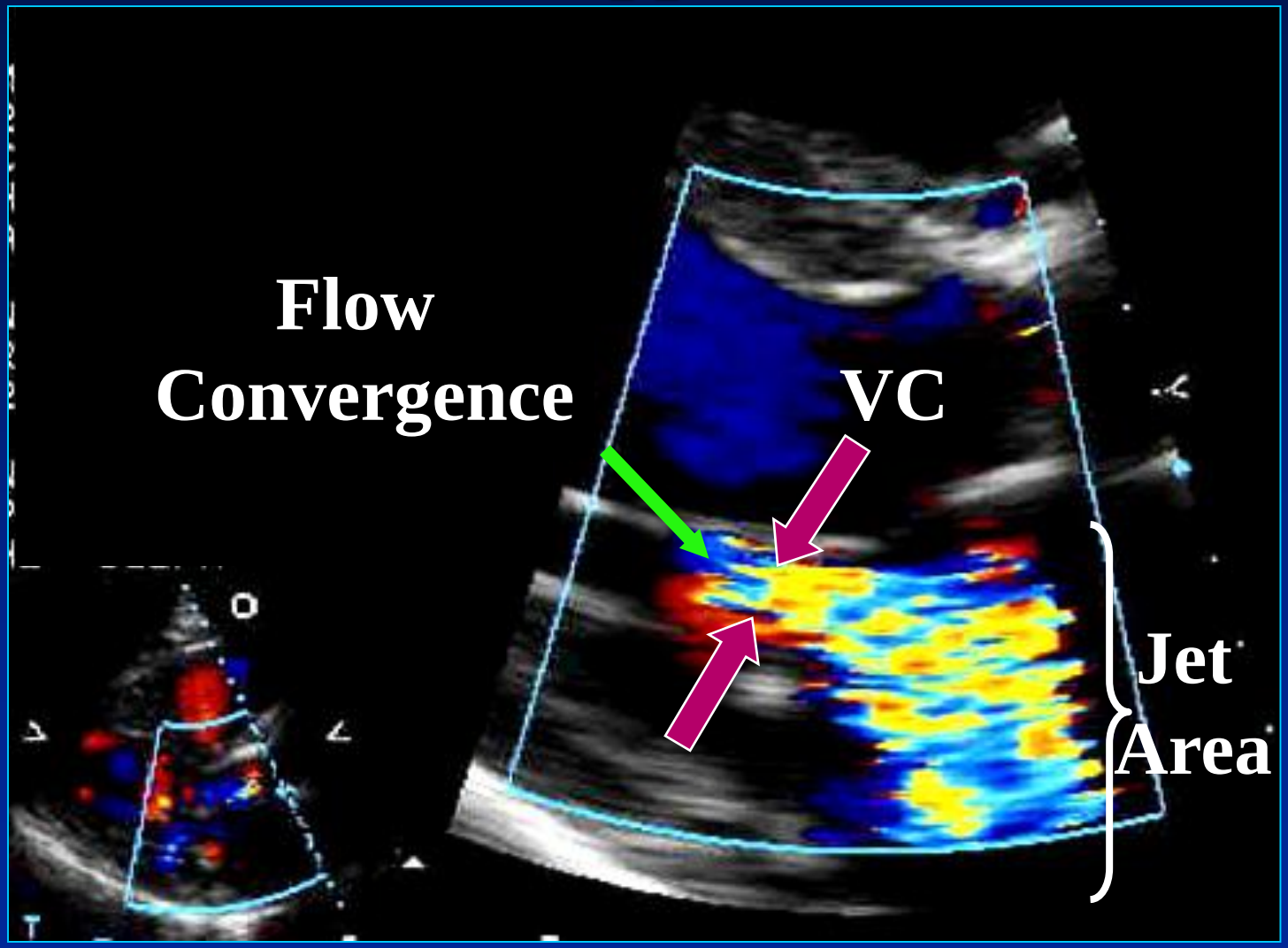
An Integrative Approach

	Mild	Moderate	Severe
Structural parameters			
LA size	Normal*	Normal or dilated	Usually dilated**
LV size	Normal*	Normal or dilated	Usually dilated**
Mitral leaflets or support apparatus	Normal or abnormal	Normal or abnormal	Abnormal/ Flail leaflet/ Ruptured papillary muscle
Doppler parameters			
Color flow jet area[§]	Small, central jet (usually < 4 cm^2 or $< 20\%$ of LA area)	Variable	Large central jet (usually > 10 cm^2 or $> 40\%$ of LA area) or variable size wall-impinging jet swirling in LA
Mitral inflow –PW	A wave dominant[ϕ]	Variable	E wave dominant[ϕ] (E usually 1.2 m/s)
Jet density –CW	Incomplete or faint	Dense	Dense
Jet contour –CW	Parabolic	Usually parabolic	Early peaking–triangular
Pulmonary vein flow	Systolic dominance[§]	Systolic blunting[§]	Systolic flow reversal†
Quantitative parameters[ψ]			
VC width (cm)	< 0.3	0.3-0.69	≥ 0.7
R Vol (ml/beat)	< 30	30-44 / 45-59	≥ 60
RF (%)	< 30	30-39 / 40-49	≥ 50
EROA (cm^2)	< 0.20	0.20-0.29 / 0.30-0.39	≥ 0.40

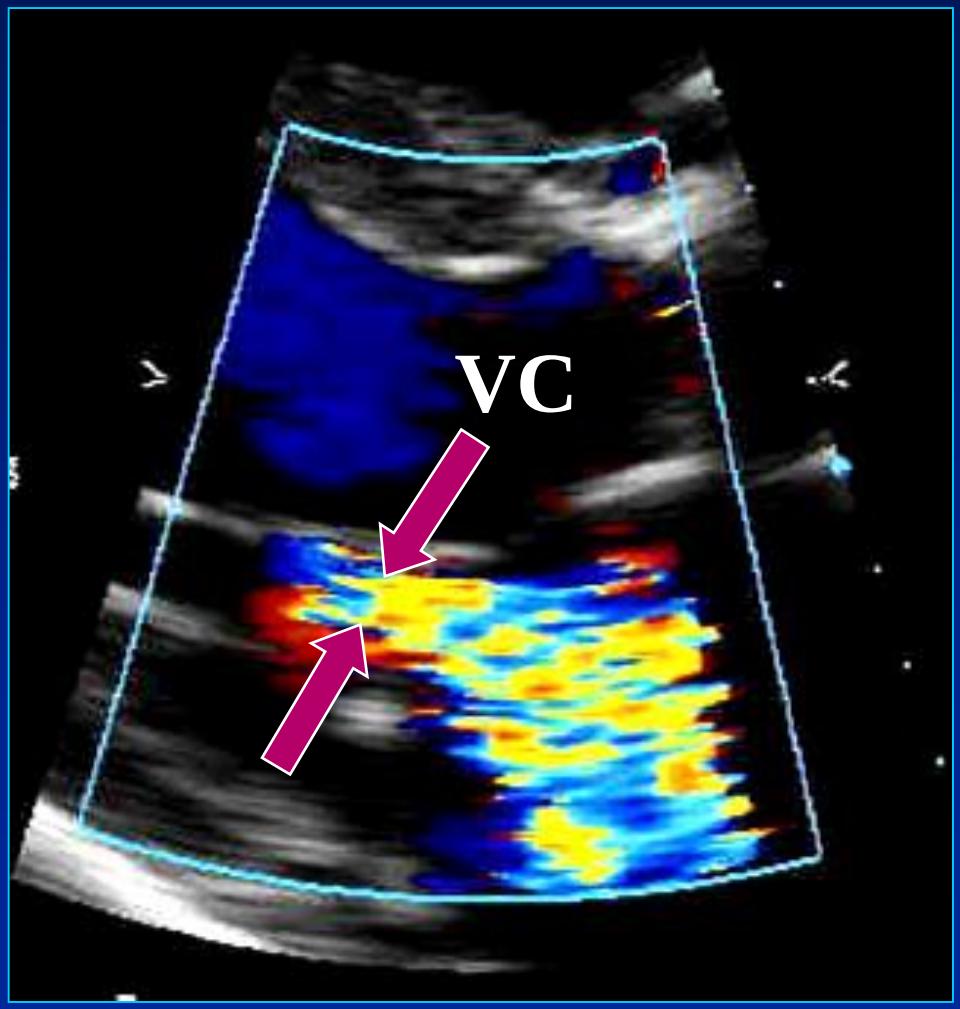
Zoghbi et al. J Am Soc Echocardiogr 2003;16:777-802

Mitral Regurgitation

Color Flow Doppler Evaluation



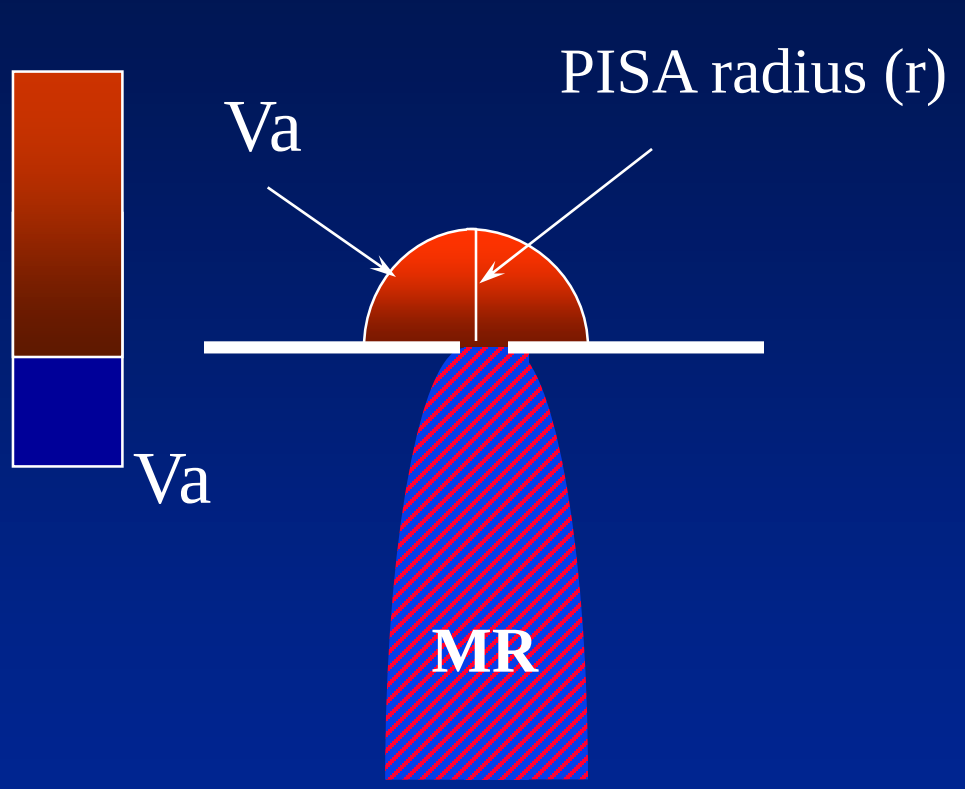
Vena Contracta
Proximal Jet Width

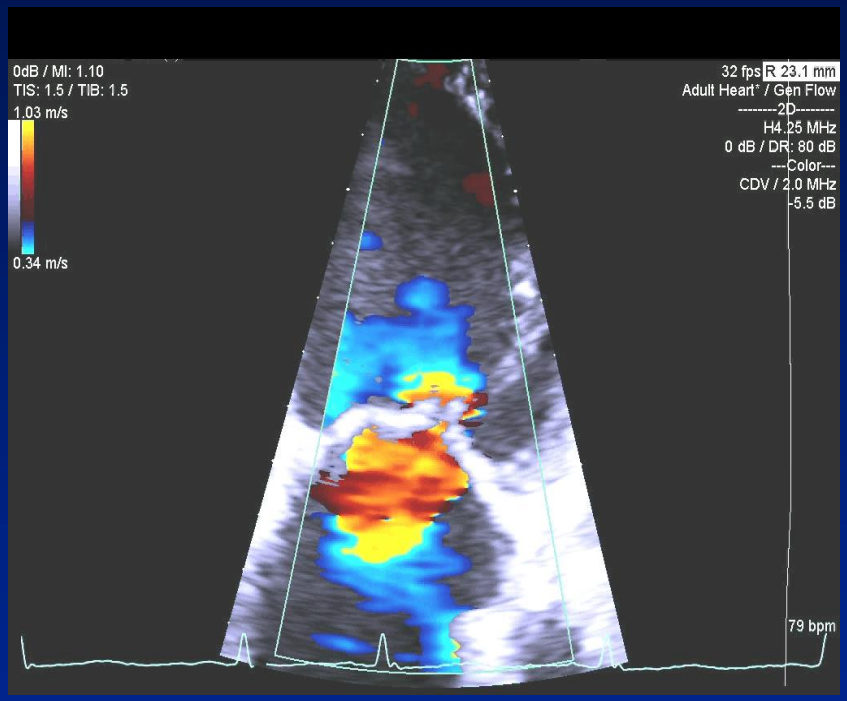


	VC width (cm)
Mild	< 0.3
Moderate	0.3-0.7
Severe	> 0.7

Flow Convergence Method

Proximal Isovelocity Surface Area (PISA)



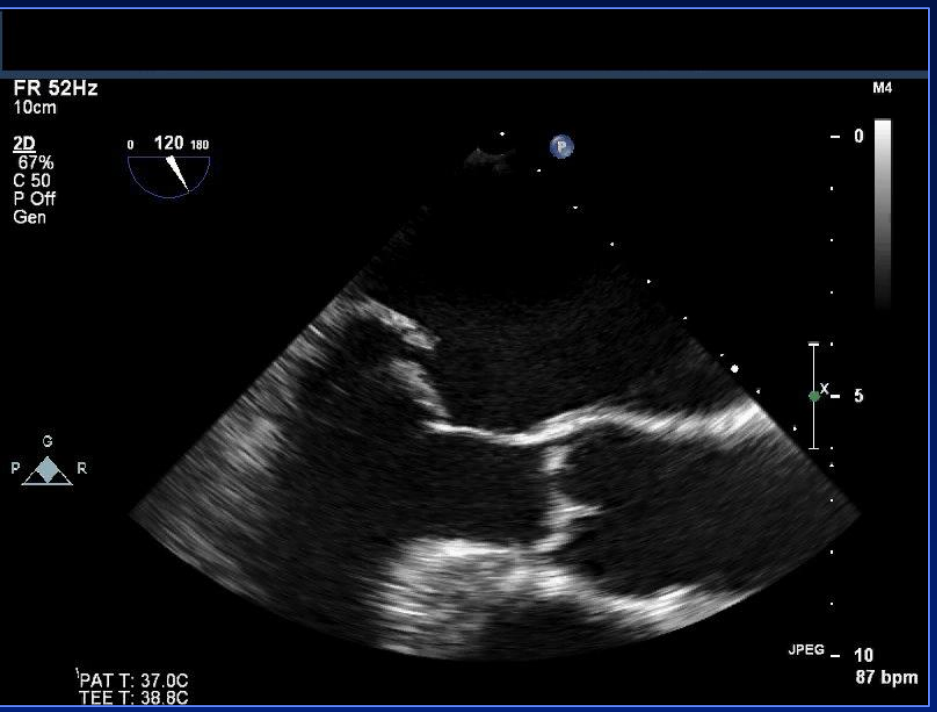


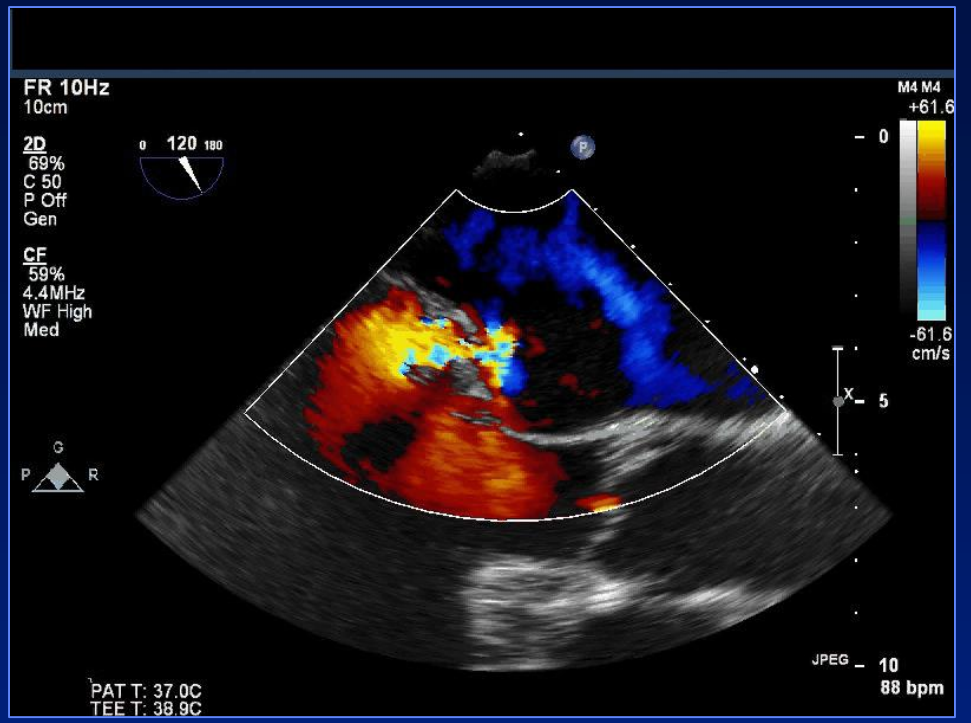
$$\text{Reg Flow} = 2\pi\, r^2 \times \text{Va}$$

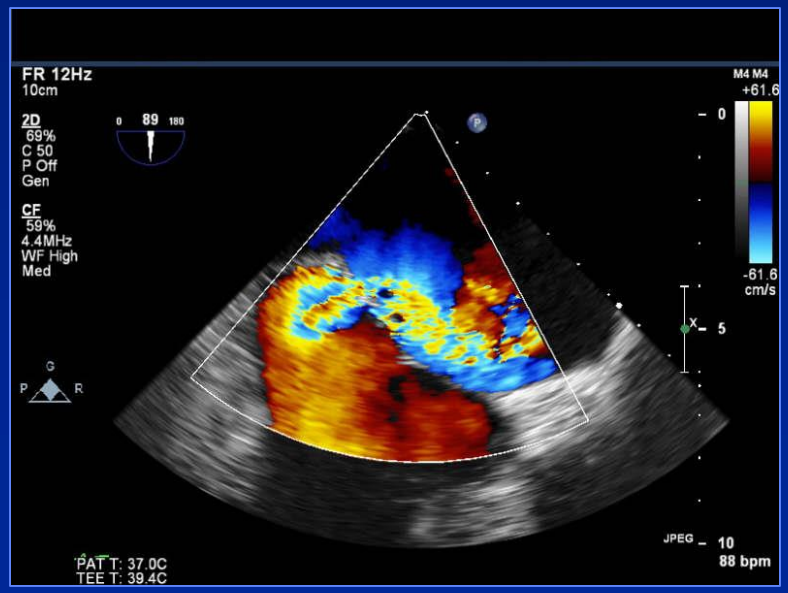
$$\text{EORA} = \text{Reg Flow} / \text{Vel}_{\text{MR}}$$

Effective Orifice Regurgitant Area & Regurgitant Volume

	Mild	Moderate		Severe
EROA (cm^2)	< 0.2	0.20-0.29	0.30-0.39	≥ 0.4
RVo1 (mL/beat)	< 30	30-44	45-59	≥ 60







Flow Convergence

- Can be used semiquantitatively
- Variability during the cardiac cycle
- Less accurate in eccentric jets
- Assumptions of hemispheric geometry, less accurate in functional MR

Mitral Regurgitation
Indicators of Severity

- Mitral valve pathology
- LV/ LA size
- Color Doppler: PISA-EROA, Vena Contracta, Jet Area…Beware of eccentric jets!
- Regurgitant flow/fraction (Pulsed Doppler)
- CW density and contour
- Mitral E; Pulmonary vein flow pattern

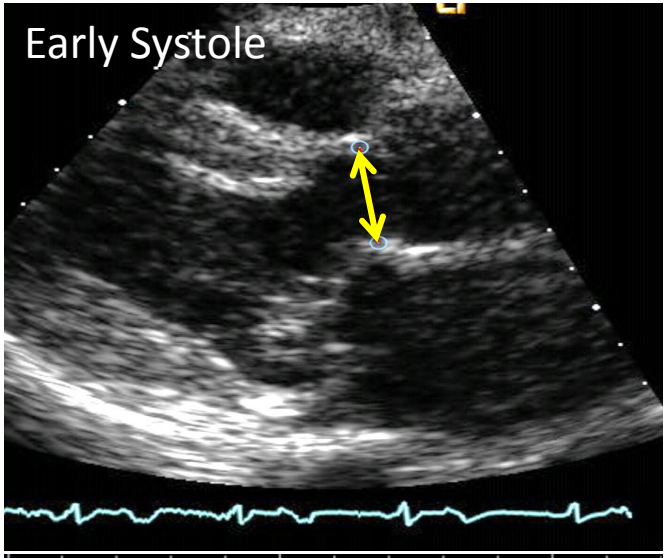
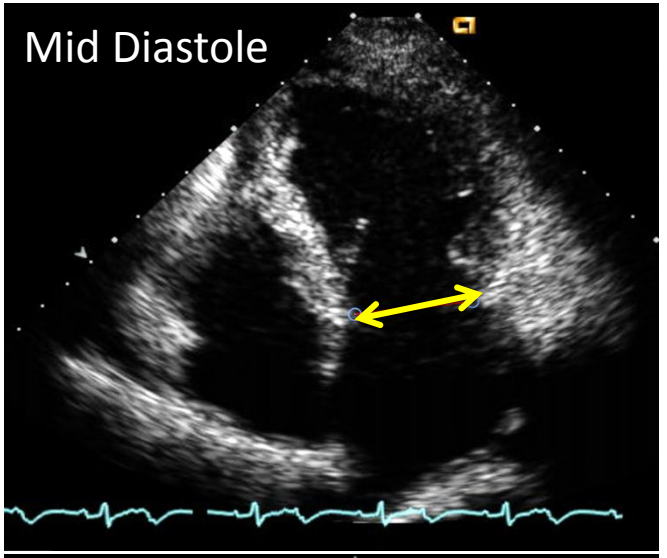
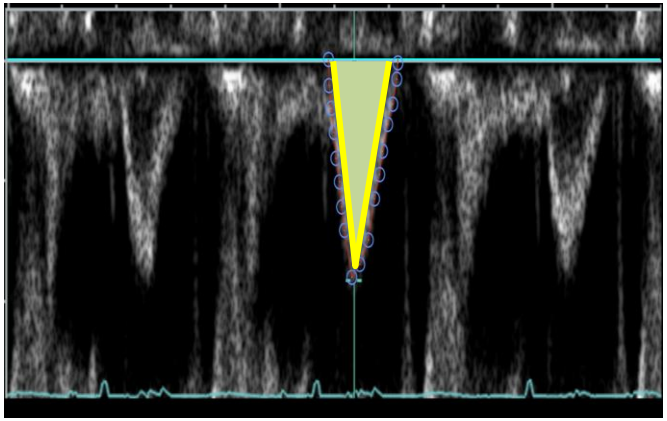
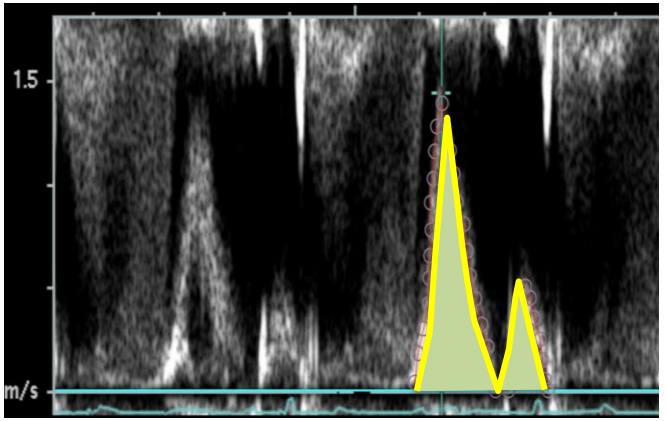
Regurgitant Fraction/Flow

Pulsed Doppler

$$RF = \frac{\text{Regurgitant Volume}}{\text{total LV stroke volume}}$$

$$RF = \frac{\text{Mitral SV - Systemic SV}}{\text{Mitral SV}}$$

In MR, Systemic SV = aortic SV or pulmonic SV

	LV Outflow	Mitral Annulus
Annular Diameter		
Velocity- PW		
	$SV_{LVOT} = CSA_{LVOT} * VTI_{LVOT}$ $= 0.785 * d^2_{LVOT} * VTI_{LVOT}$	$SV_{MV} = CSA_{MV} * VTI_{MV}$ $= 0.785 * d^2_{MV} * VTI_{MV}$

Assessment of MR Severity

Regurgitant Volume & Fraction

	Mild	Moderate		Severe
Reg Vo1ume	< 30 ml	30-44 ml	45-59 ml	≥ 60 ml
Reg Fraction	< 30%	30- 49%	45-59	≥ 50%

In low flow Functional, more emphasis on Reg Fraction

Regurgitant Volume & Fraction

Advantages

- Quantitative, valid in multiple jets and eccentric jets
- Provides both lesion severity and volume overload

Limitations

- Needs training; Cumbersome; wide (20%) confidence limits
- Measurement of flow at MV annulus is less reliable in calcific MV and/or annulus

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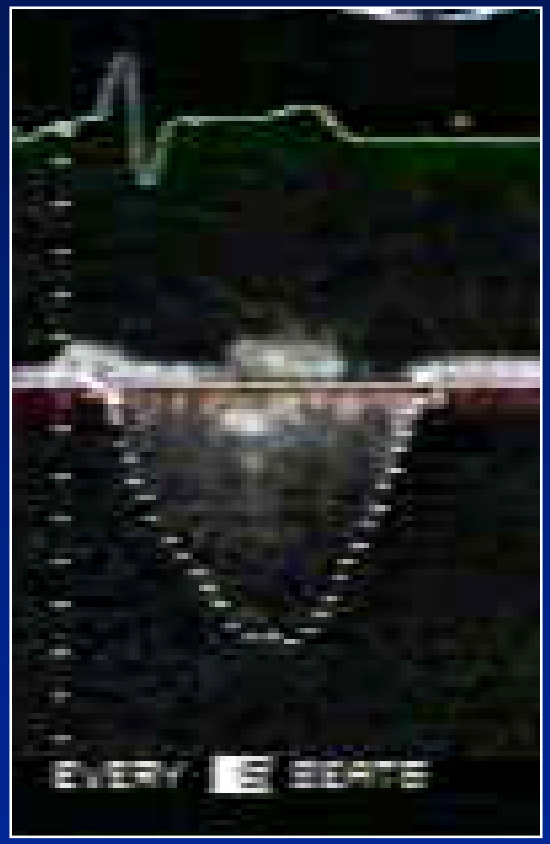
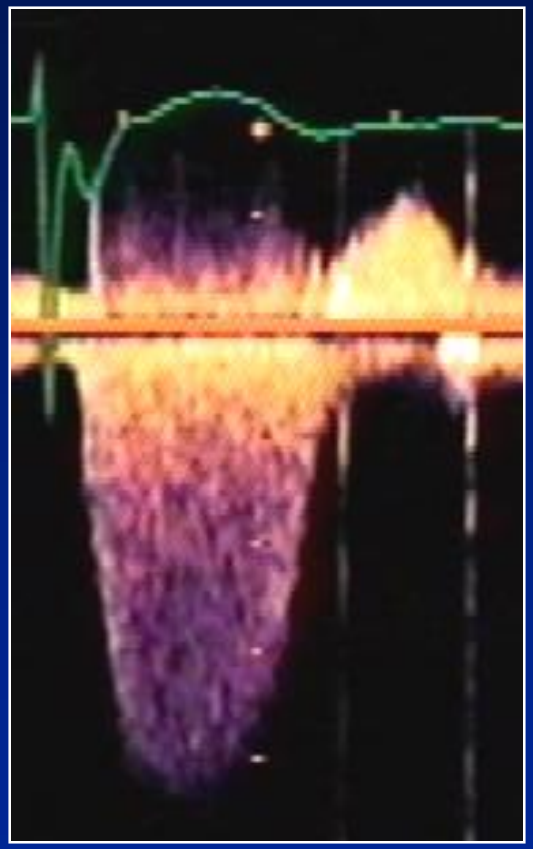
Assessment of MR Severity

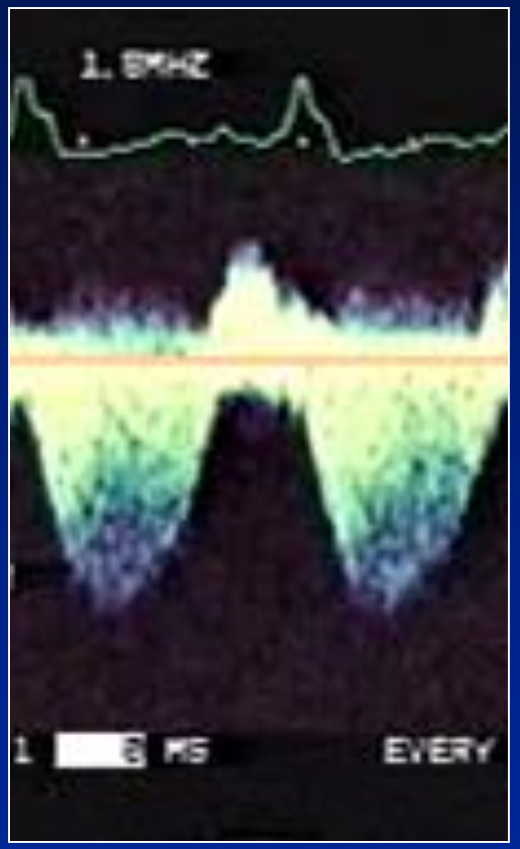
Density & Contour of MR jet by CW



Mild

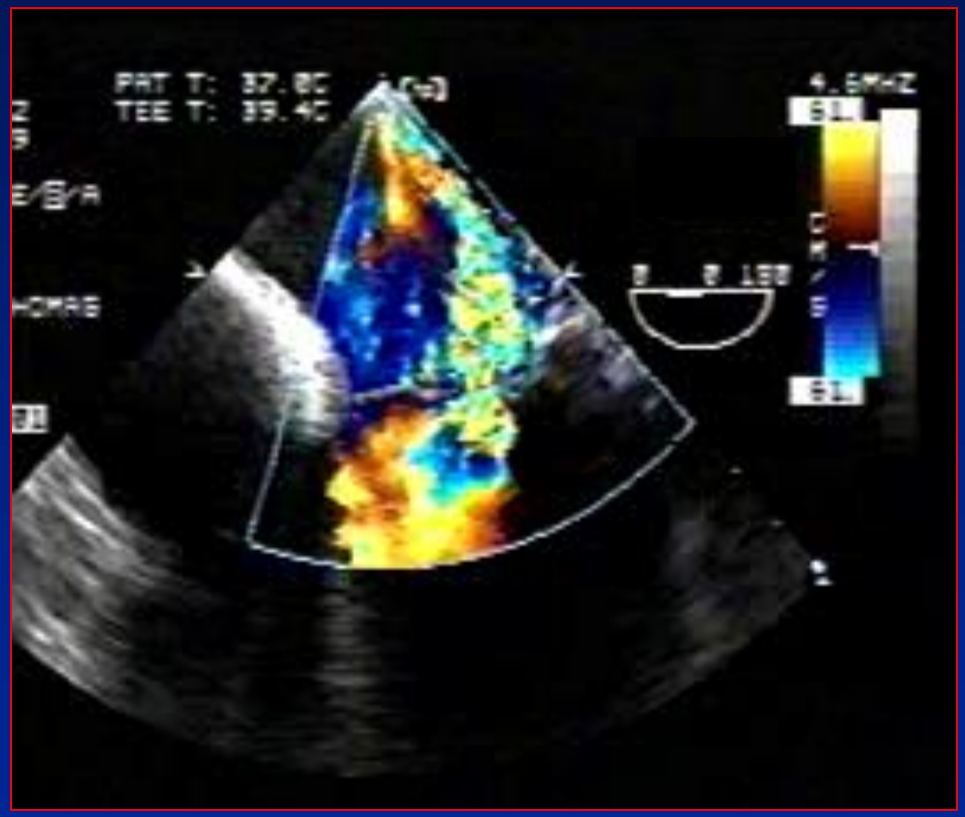


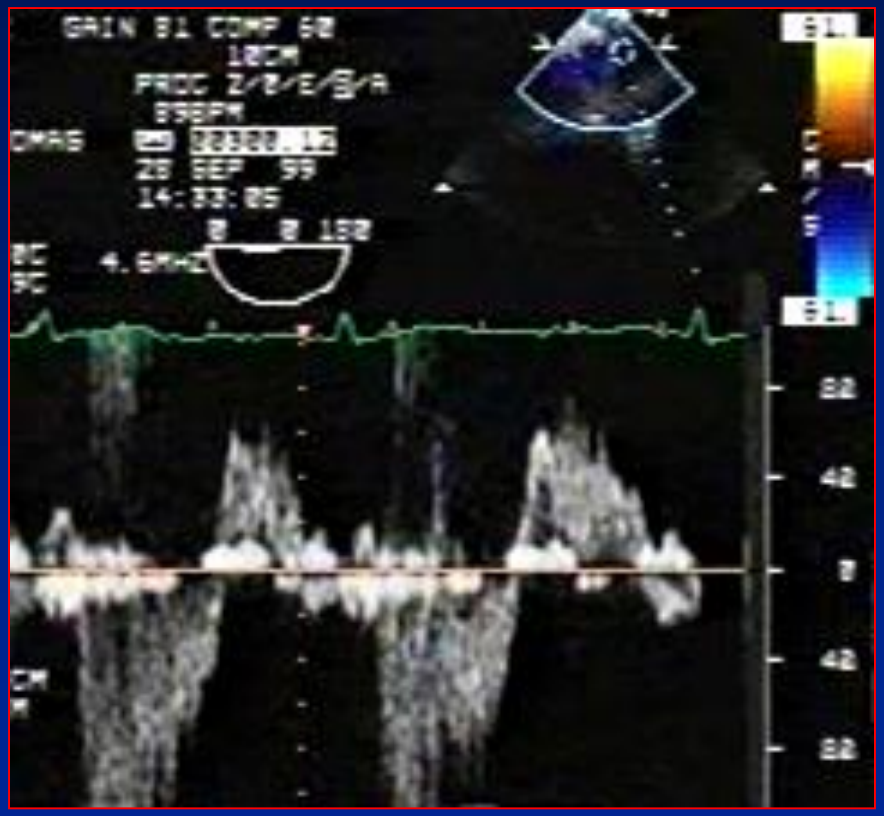
Moderate



Severe

Pulmonary Vein Flow in Severe MR





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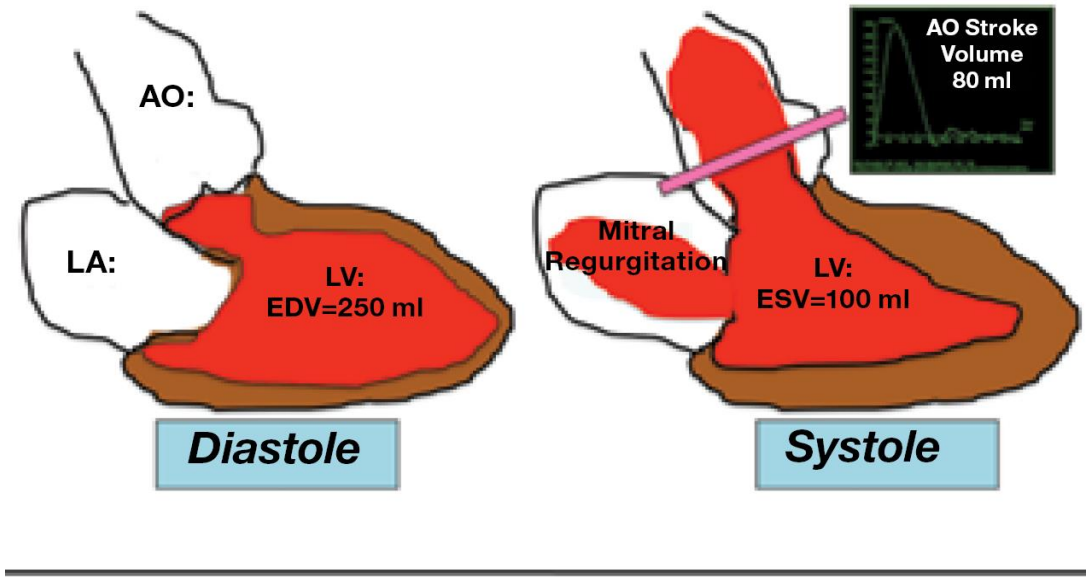
Zoghbi et al. J Am Soc Echocardiogr 2003;16:777-802

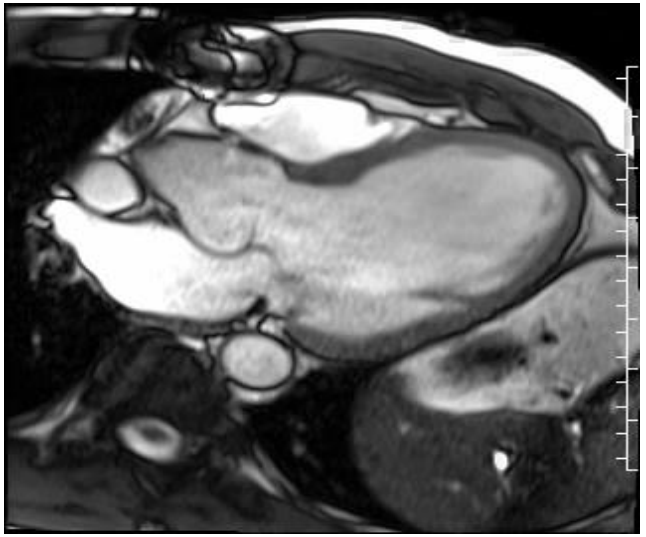
Mitral Valvular Regurgitation

Why an Integrative Approach

- Addresses difficulty and variability in quantitation
- Internal check & evaluation of hemodynamic impact *(heart remodeling, inflow dynamics, Pulmonary vein, and pressure).*
- Inherent cardiac remodeling with chronic significant MR

CMR Quantification of MR Severity





Mitral Reg Vol = LV stroke volume – Aortic stroke volume

Assessment of MR Severity dependent on volume comparisons only

Mitral Regurgitation

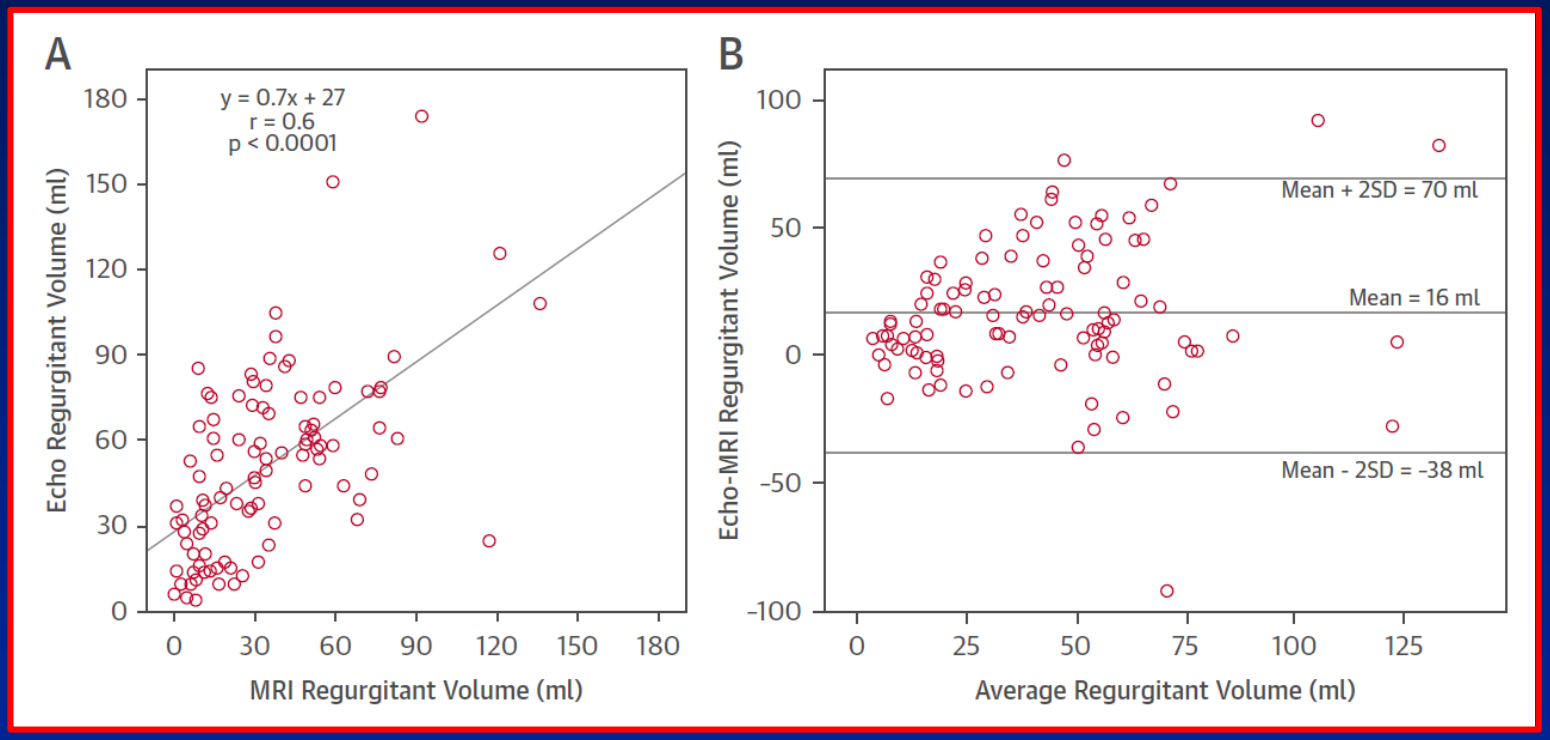
CMR vs Echo (mostly flow convergence)

	MRI			
	Mild	**Moderate**	**Severe**	**Total**
Echo				
Mild	14	0	0	14
Moderate	19	10	2	31
Severe	20	25	13	58
Total	53	35	15	103

Uretsky S et al JACC 65:1078, 2015

Regurgitant Volume

PISA vs. CMR



Uretsky S et al JACC 65:1078, 2015

? Why

- The only study to show an Overestimation of MR severity by Echo & PISA
- Time between Echo & CMR studies: Median 15 days
- Use of PISA alone, particularly that 57% had eccentric MR
- 47% were Degenerative MR (? some with late systolic MR, an Issue with PISA)

Mitral Regurgitation Severity Grades
Agreement between Echo & CMR

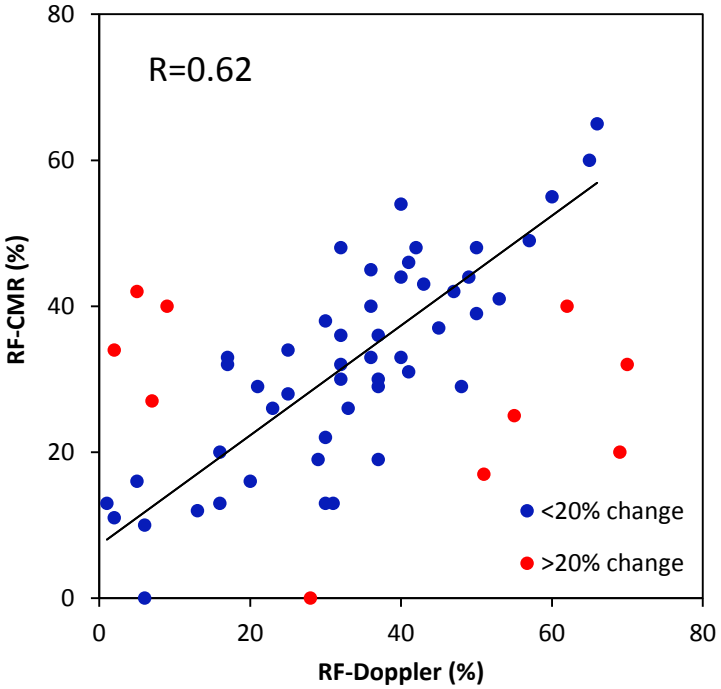
	Mild MR CMR	Moderate MR CMR	Moderately Severe MR CMR	Severe MR CMR
Mild MR Echo	20	7	3	0
Moderate MR Echo	7	7	3	0
Moderately Severe MR Echo	1	6	6	2
Severe MR Echo	1	1	4	2

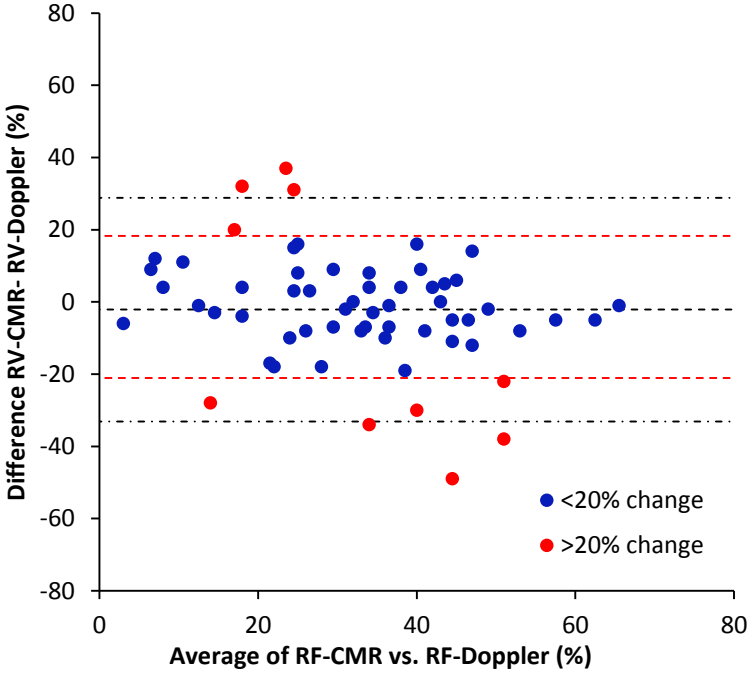
Exact agreement, Significant discrepancy

Agreement within 1 grade= 91%
Significant discrepancy= 9%

Lopez Mattei et al. AJC Dec 2015

Relation of Regurgitant Fraction by TTE & CMR





15% Significant Discrepancy by quantitation:

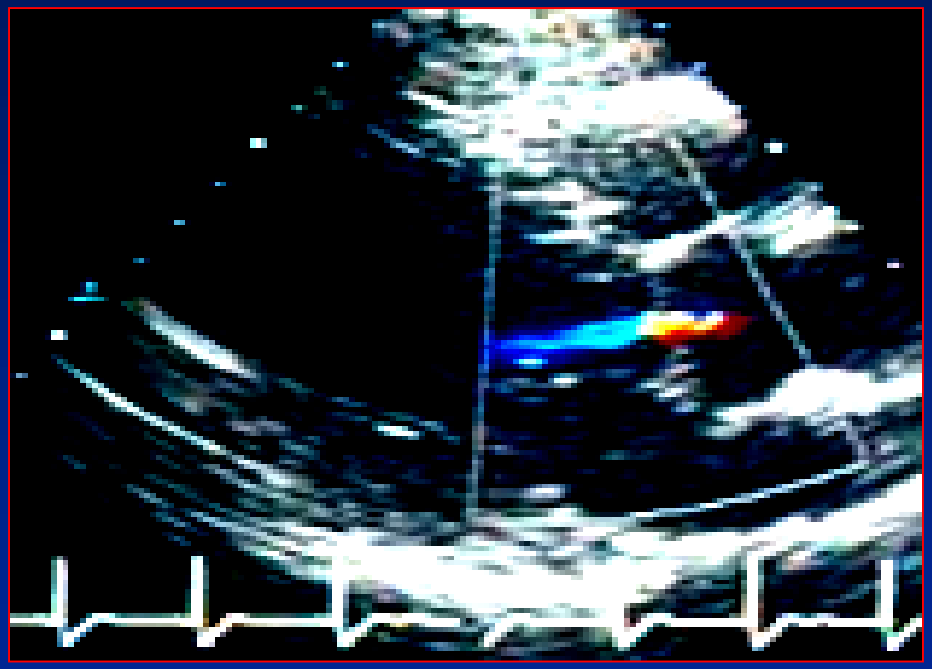
½ of outliers accounted for equally by Echo and CMR !

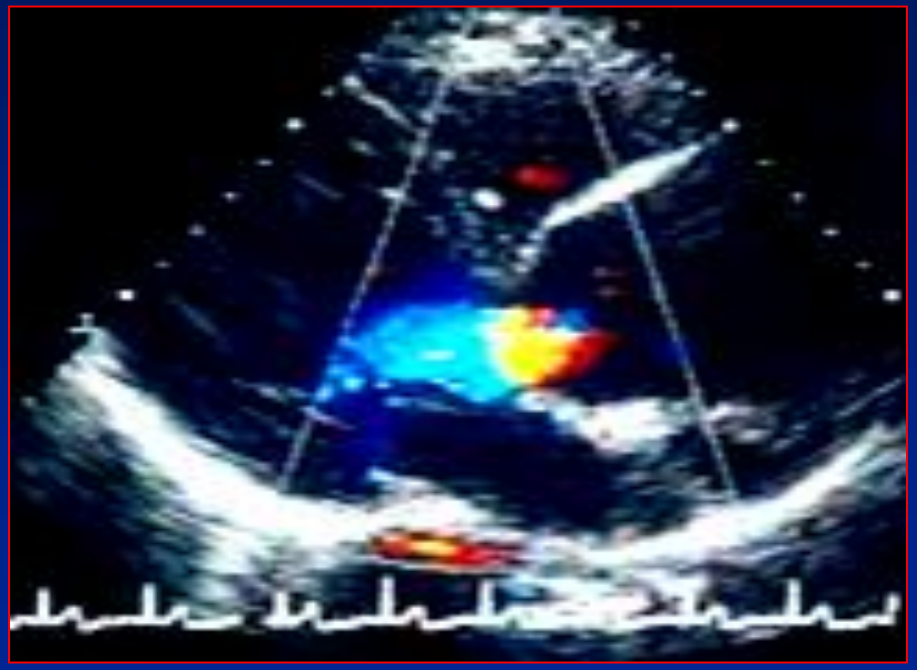
All in secondary MR

Yes, Variability in Quantitating Regurgitation is less for CMR, *but…It is not Nil!*

- In Pts without Regurgitation:
  - "pseudo regurgitation" for CMR is: 10 ± 9 % (Gelfand, 2006), 3 ± 12 % (Lopez- Mattei, 2013)
  - " Pseudo regurgitation" for Echo is 5 ± 14 % (Lopez-Mattei, 2013)

Aortic Regurgitation





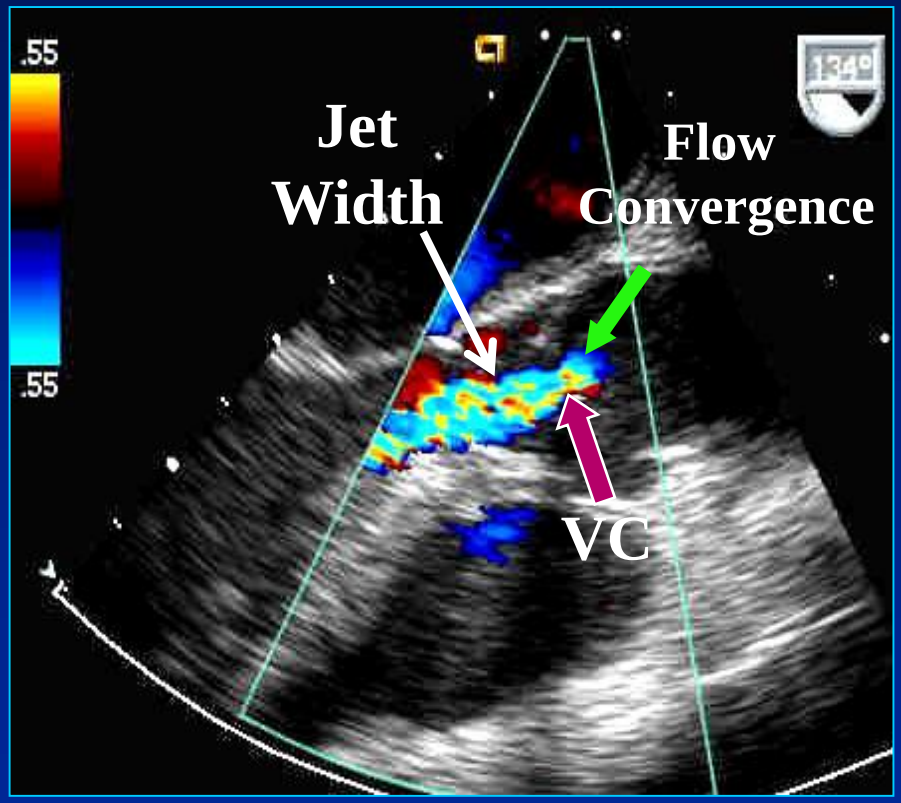
Assessment of AR Severity

Echo/Doppler Indicators of Severity

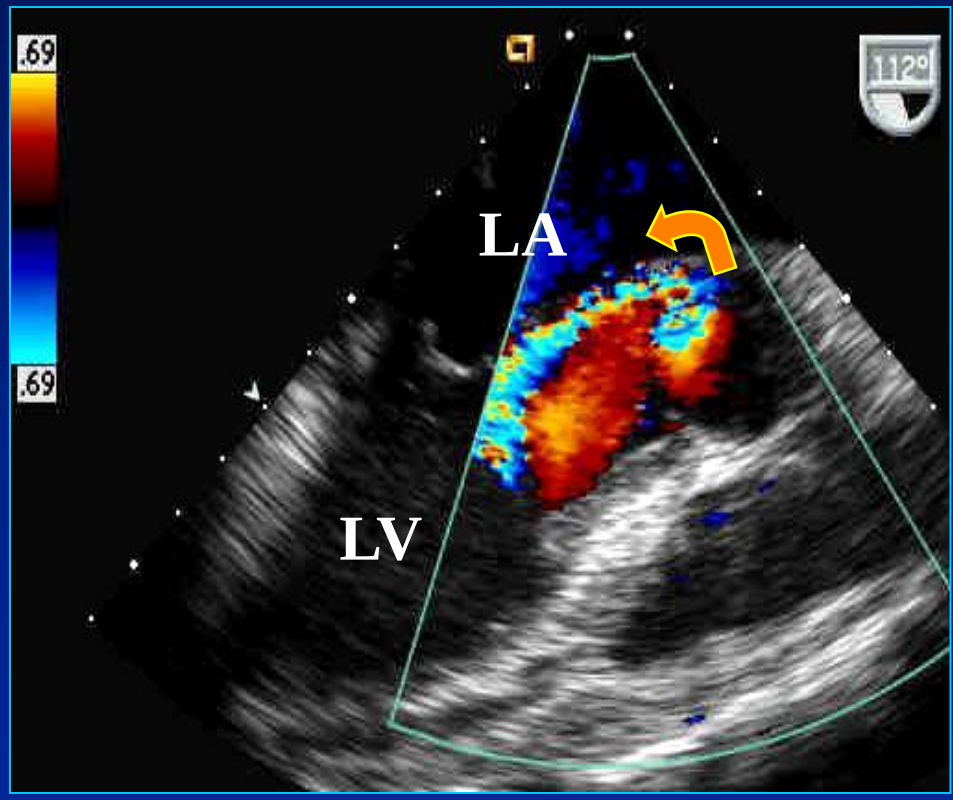
- Aortic Valve/ Root/Mechanism
- LV enlargement
- Color Doppler: jet width; vena Contracta
- Pressure half-time
- Regurgitant Volume/Fraction
- Diastolic retrograde flow in aorta

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

Central AR Jet



Eccentric AR Jet



Vena Contracta

- Different from Jet height/LVOT
- Valid in eccentric jets

Mild < 0.3 cm

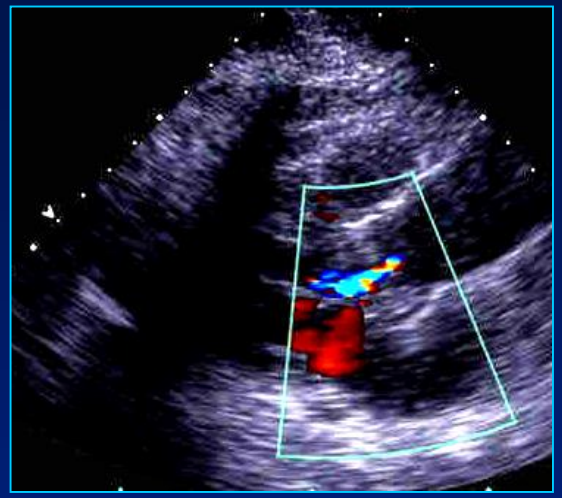
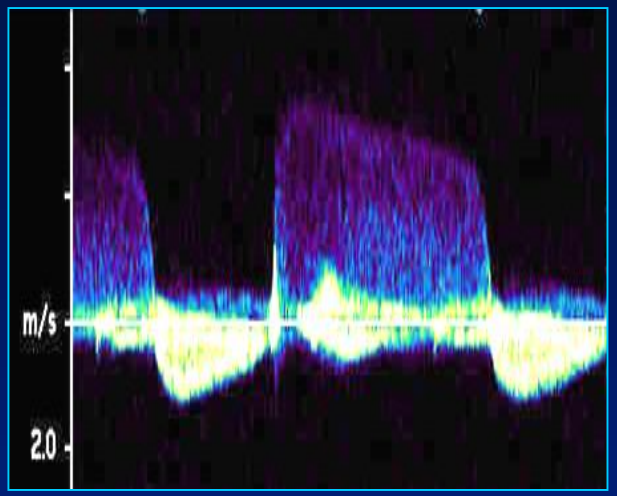
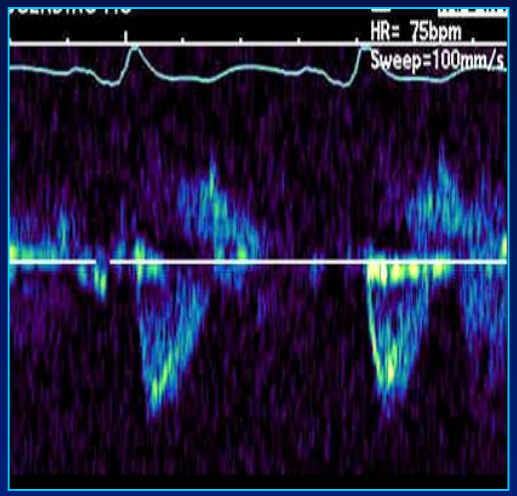
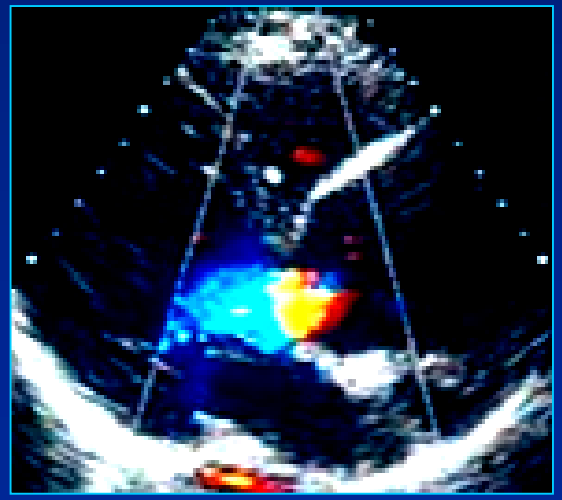
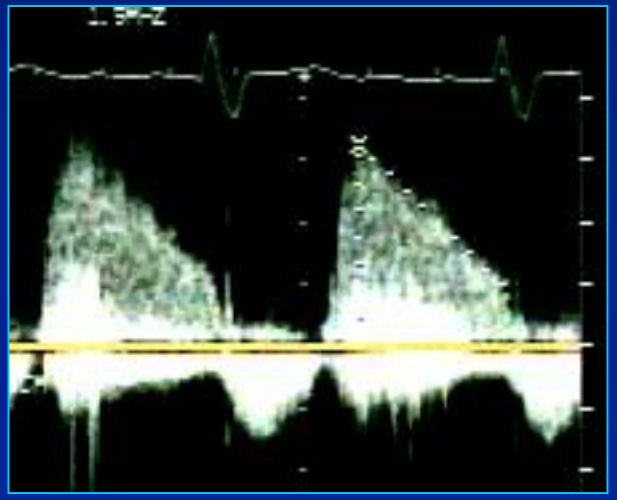
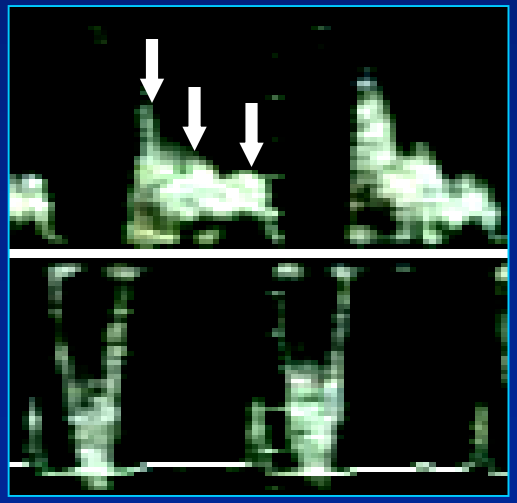
Moderate 0.3-0.6 cm

Severe >0.6 cm

Assessment of AR Severity

Indicators of Severity

- Aortic Valve/ LV enlargement
- Color Doppler: Proximal jet width/CSA;
  Vena Contracta > PISA
- Intensity of jet by CW
- Pressure half-time
- Diastolic retrograde flow in aorta
- Regurgitant Volume/Fraction

	Color Doppler	CW Doppler	Desc Aorta - PW
Mild AR			
Severe AR			

Regurgitant Fraction

$$RF = \frac{\text{Aortic SV} - \text{Systemic SV}}{\text{Aortic SV}}$$

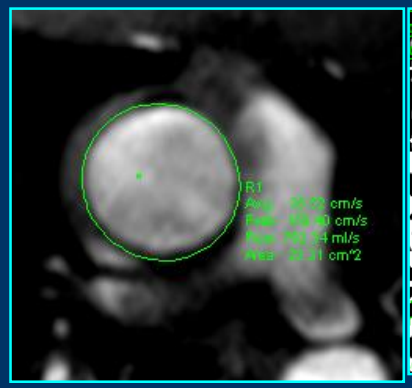
Systemic SV = mitral, pulmonic or average

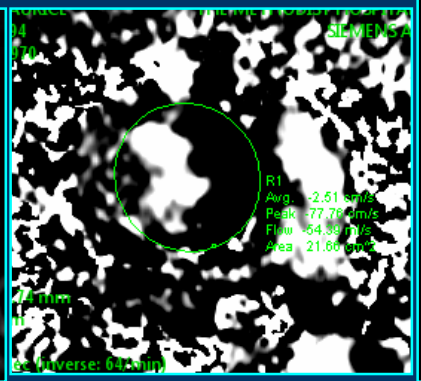
Grading of AR Severity
Quantitative Parameters

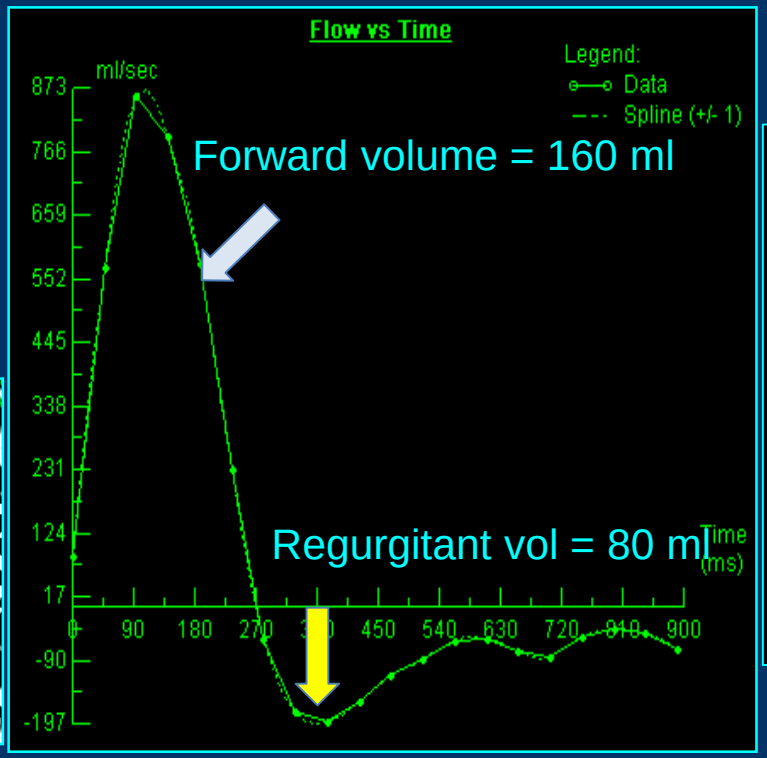
	Mild	Moderate		Severe
RVo1 (mL/beat)	<30	30-44	45-59	≥ 60
RF (%)	<30	30-39	40-49	≥ 50
EROA ($cm^{2)}$	<0.10	0.10-0.19	0.20-0.29	≥ 0.30

CMR in Aortic Regurgitation

HOUSTON Methodist
DEBAKEY HEART & VASCULAR CENTER







Valvular Regurgitation

Towards a More Accurate Assessment of Severity…

- Have a methodical approach….
- Know advantages and limitations of various Echo/Doppler methods and which ones are reliable in a particular patient
- Learn quantitation
- Look for internal consistency of flow findings (LV size/function/Doppler)
- The more you quantitate, the more accurate you are at estimation of regurgitation severity and integration of findings
- CMR quantitation of regurgitant volume/fraction is easier and more reproducible, but lacks hemodynamic assessment