Evaluation of Aortic Regurgitation

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Learning objectives

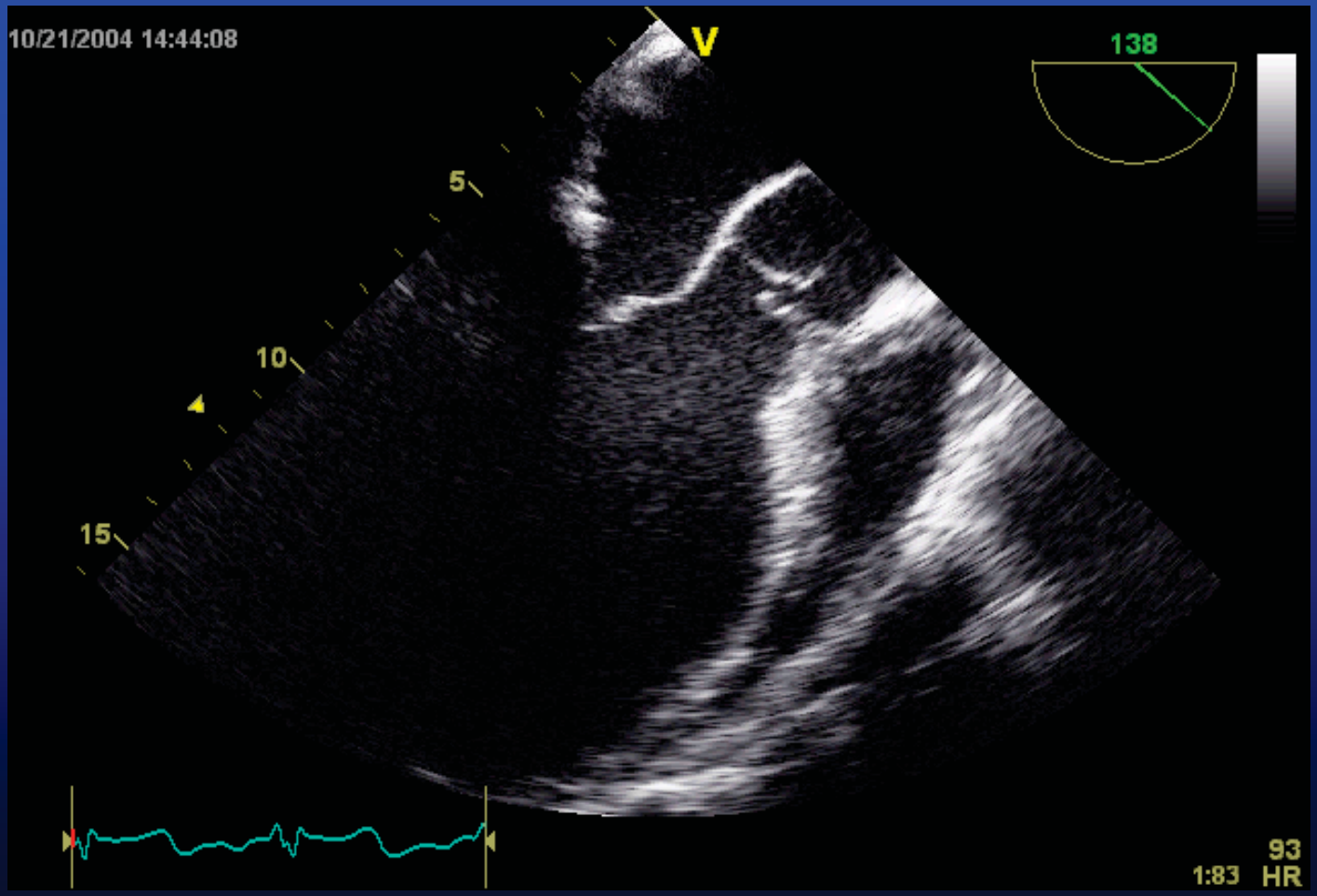
- What causes AR?
- When to replace?
- Assessment of severity with pitfalls
- What is the most accurate measurement?

Causes of AR in Patients Having Isolated AVR at Baylor University Medical Center (1993–2005)

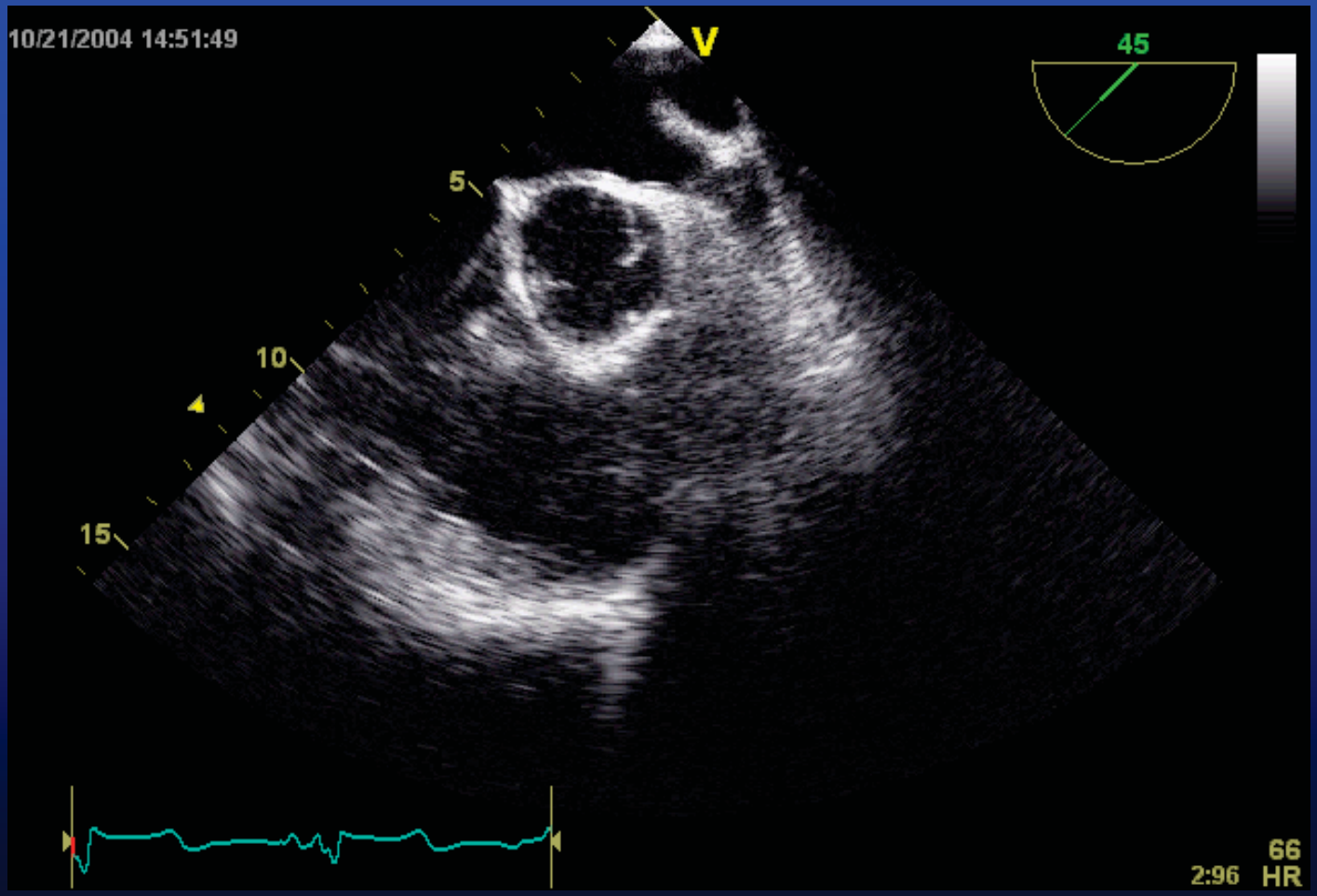
Cause of AR	Total	Ages at Operation, Range (Mean)	Acute	Chronic	HTN
Valve (122 (46%))					
Bicuspid	59 (22%)	22–77 (55)	0	59	39 (66%)
Quadricuspid	2 (1%)	53–79 (66)	0	2	0
Tricuspid	5 (2%)	33–48 (40)	0	5	2 (40%)
Infective endocarditis	46 (17%)	21–82 (45)	27	19	29 (63%)
Rheumatic (?)	8 (3%)	25–63 (47)	0	8	6 (75%)
Miscellaneous	2 (1%)	24–42 (33)	0	2	2 (100%)
Non-valve (146 (54%))					
Aortic dissection	28 (10%)	25–78 (58)	21	7	22 (79%)
Marfan	15 (6%)	21–71 (47)	0	15	10 (67%)
Aortitis	12 (4%)	35–82 (66)	0	12	10 (83%)
Cause unclear	91 (34%)	50–84 (66)	0	91	83 (91%)
Total	268 (100%)	21–84 (57)	48 (18%)	220 (82%)	203 (76%)

Roberts WC et al. Circulation. 2006 Aug 1;114(5):422-9.

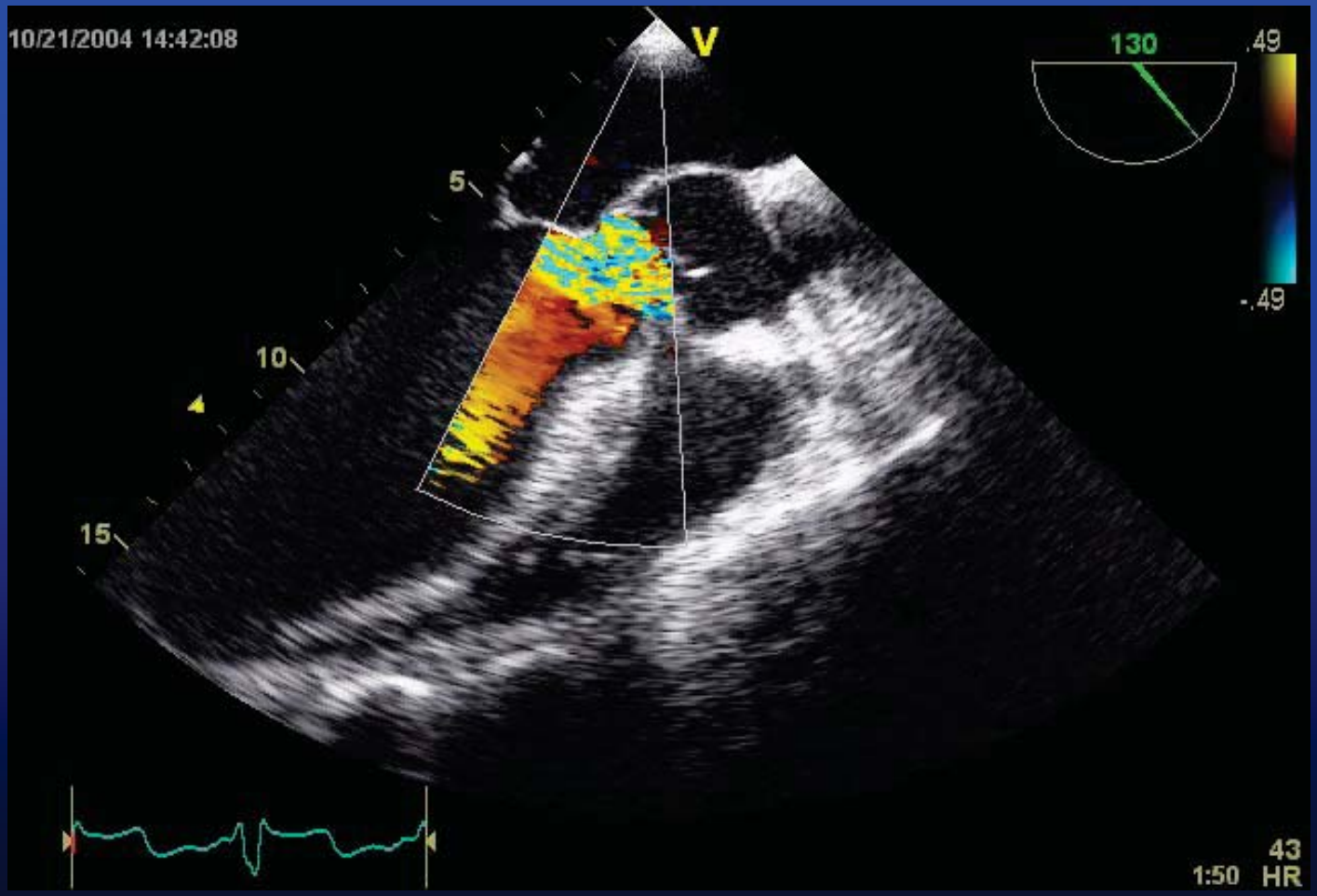
AR and Bicuspid AoV



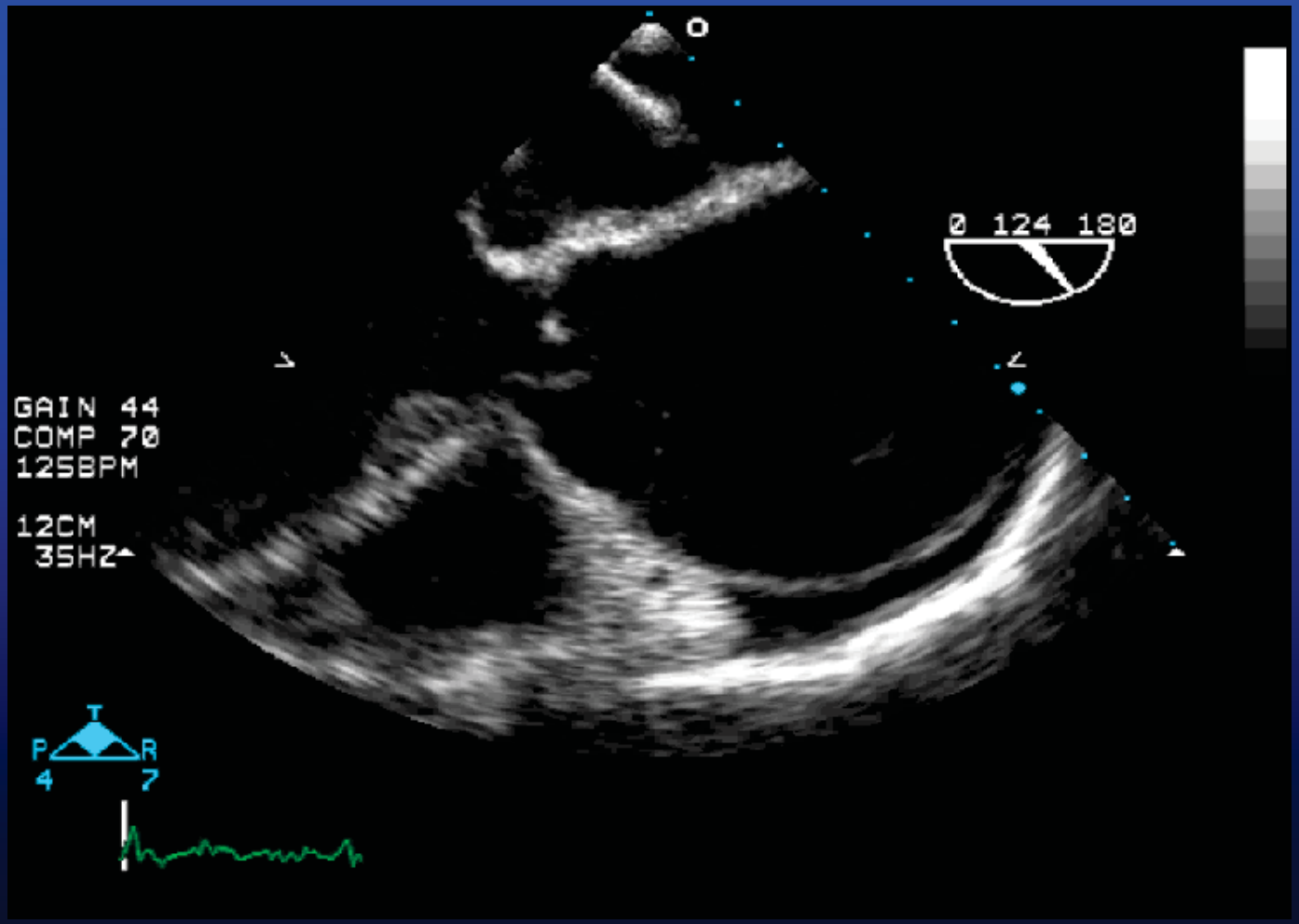
AR and Bicuspid AoV



AR and Bicuspid AoV



Aortic Root Disease



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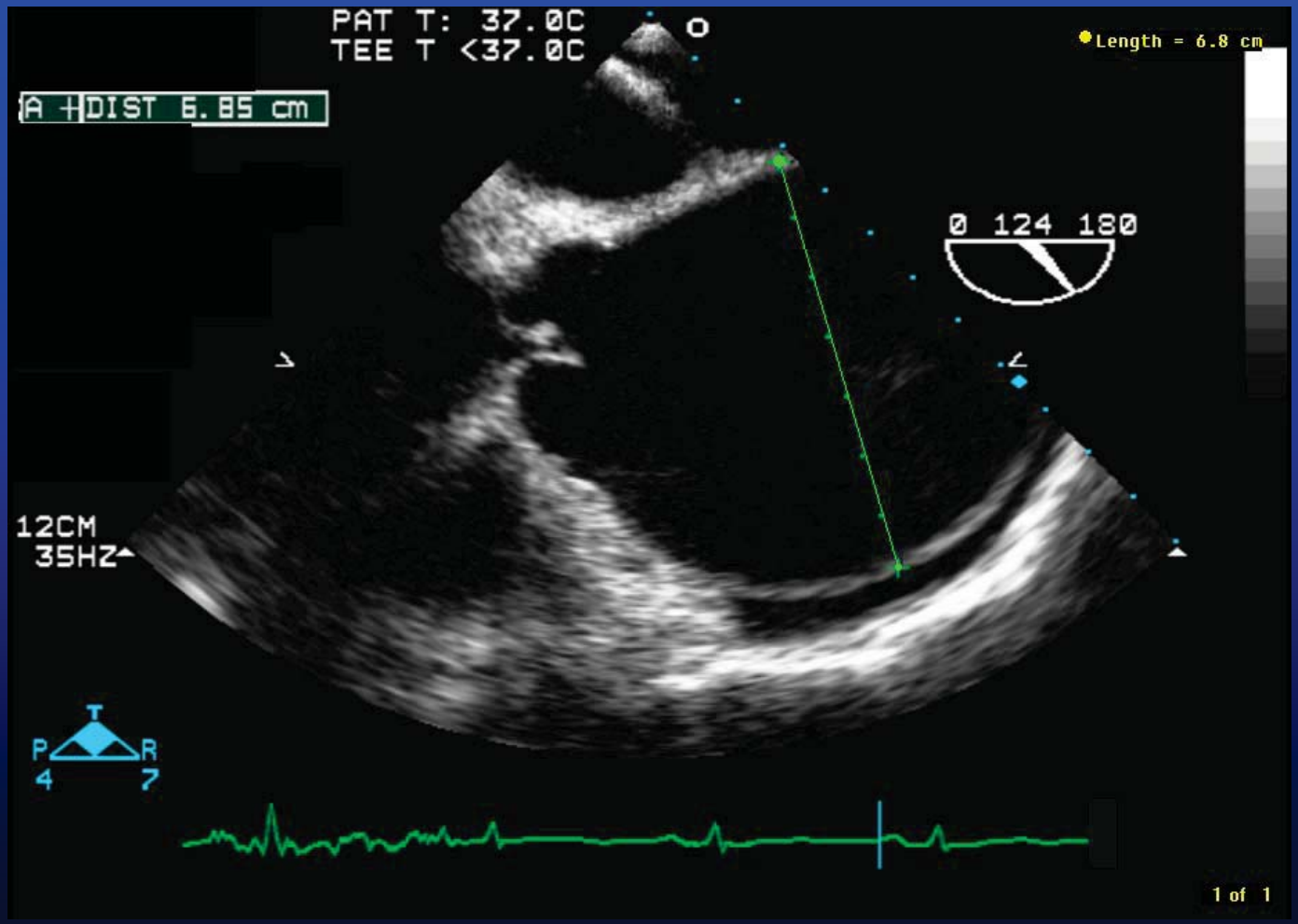

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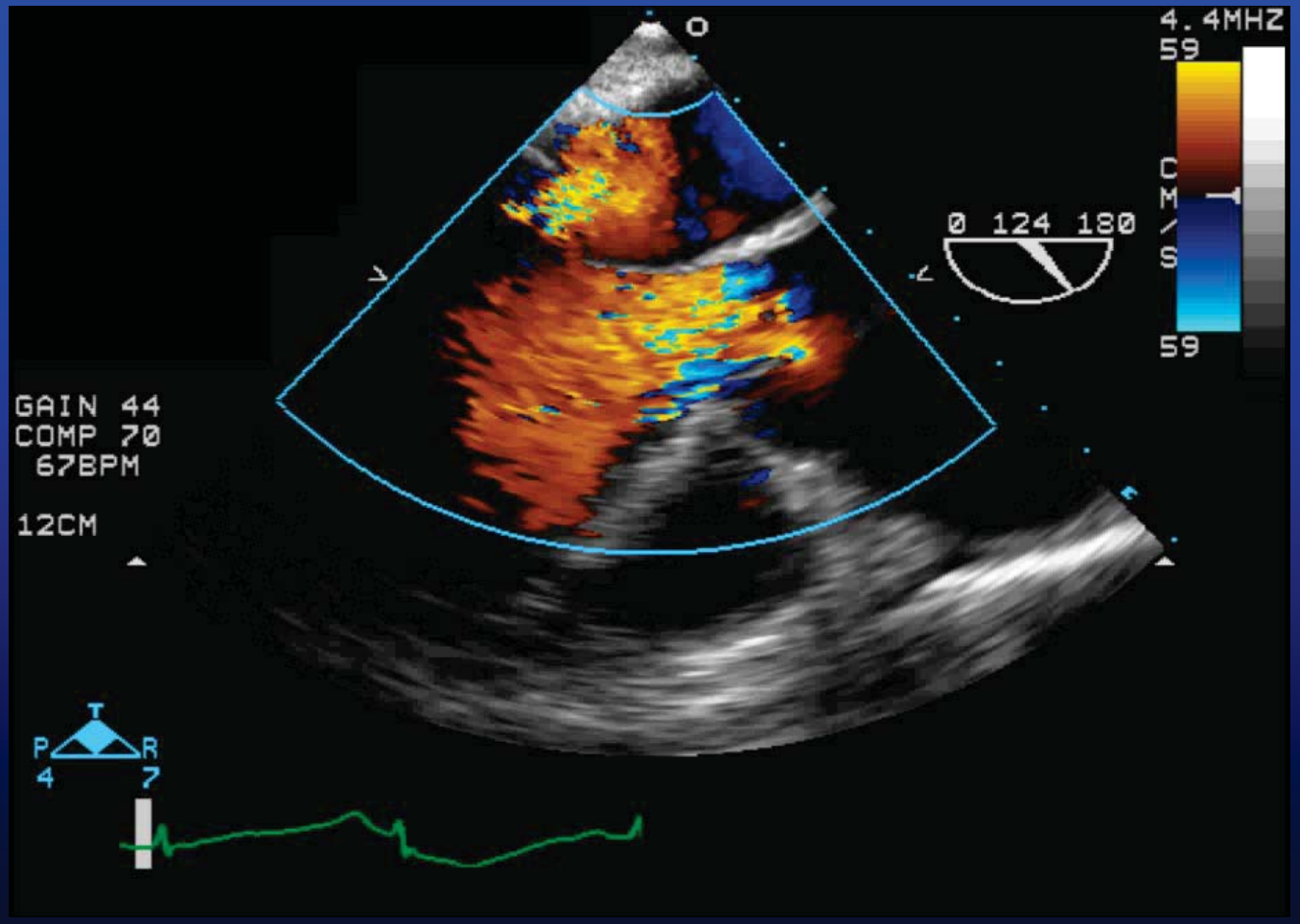

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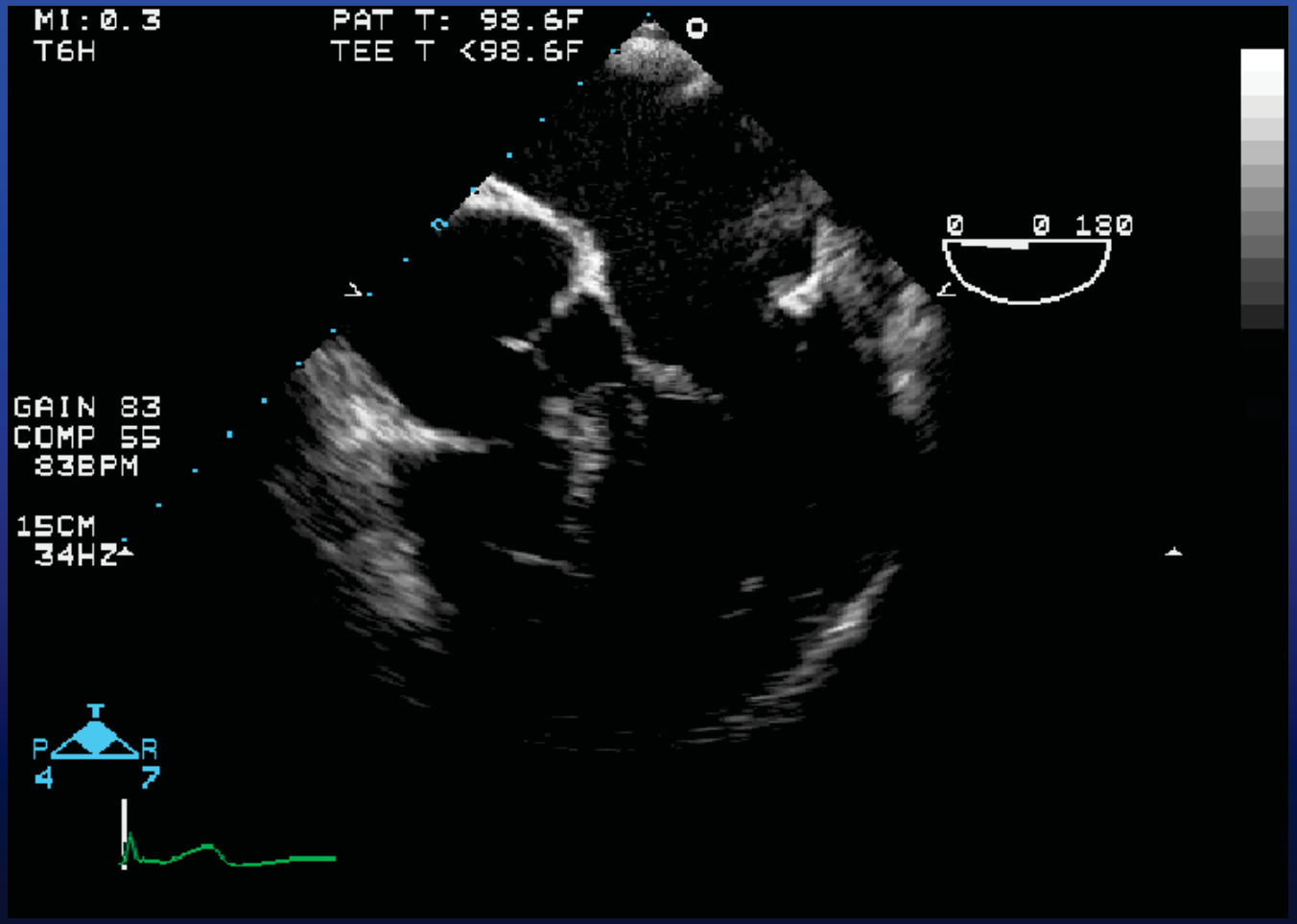

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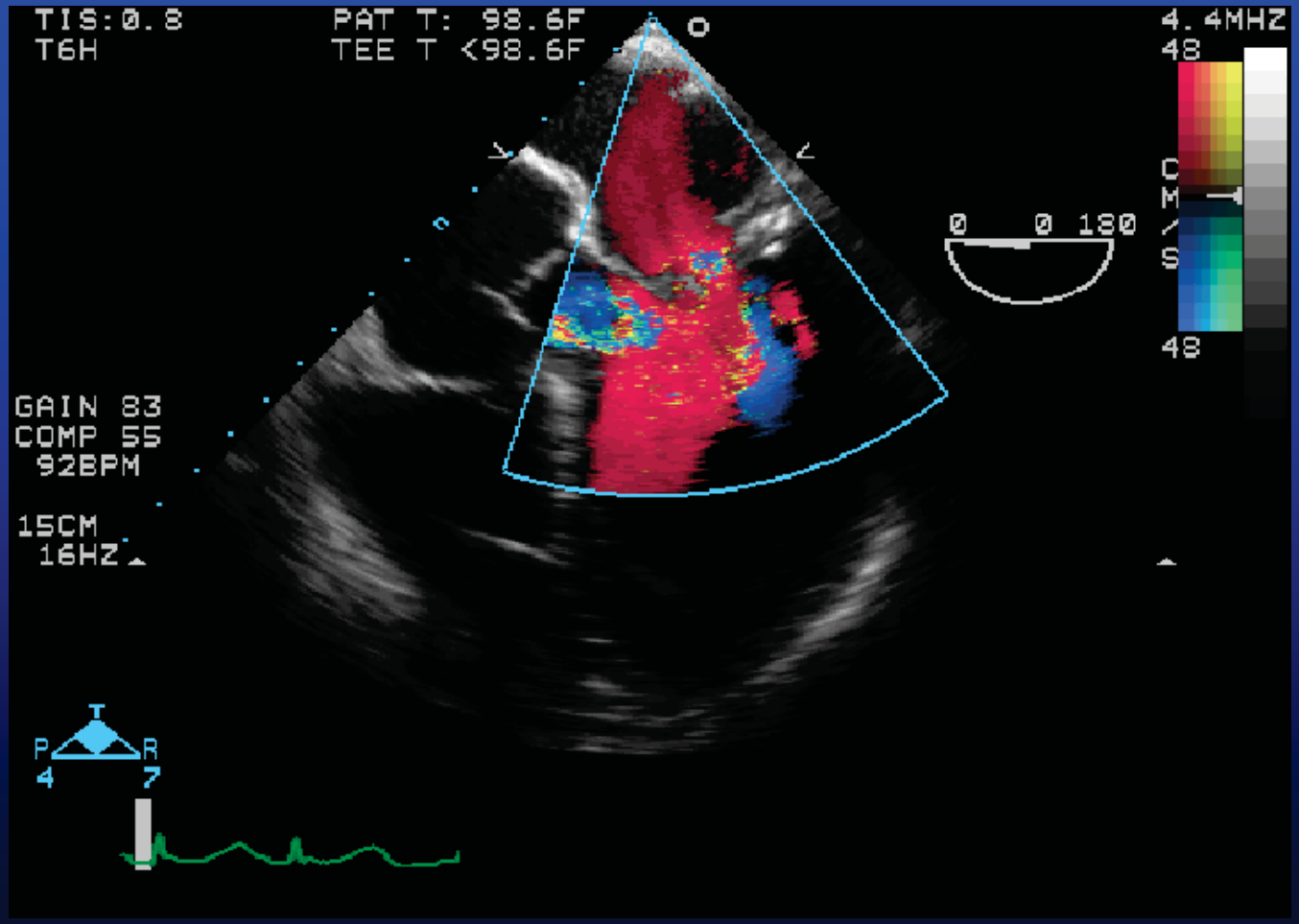
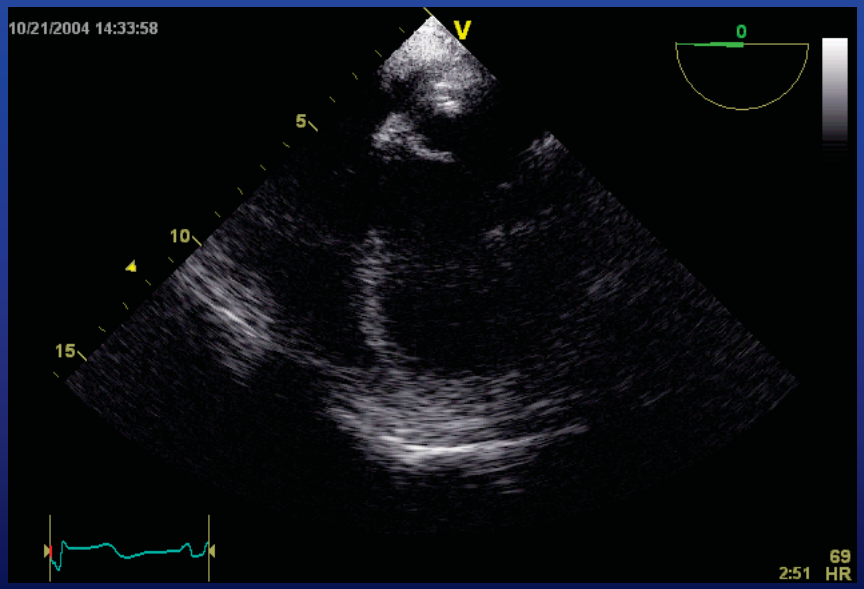
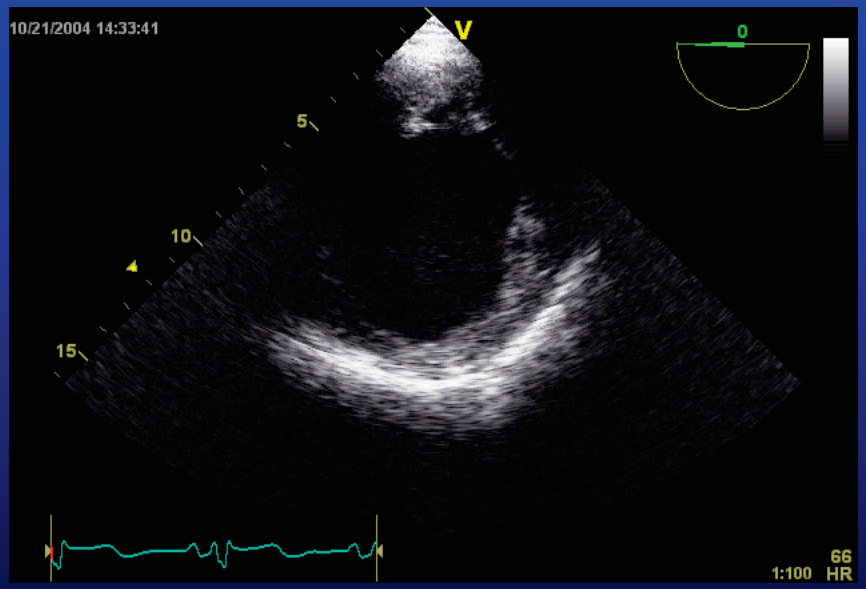
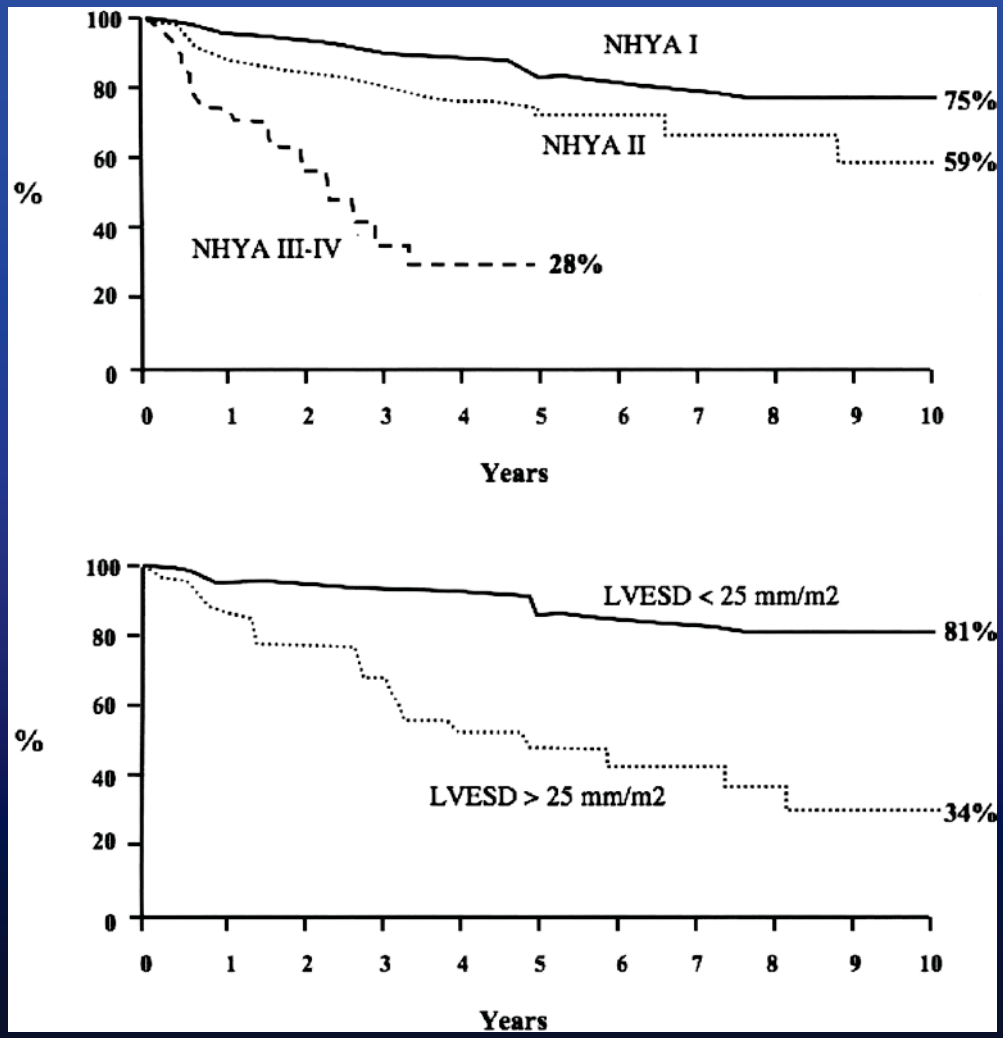


Dilated LV in AR



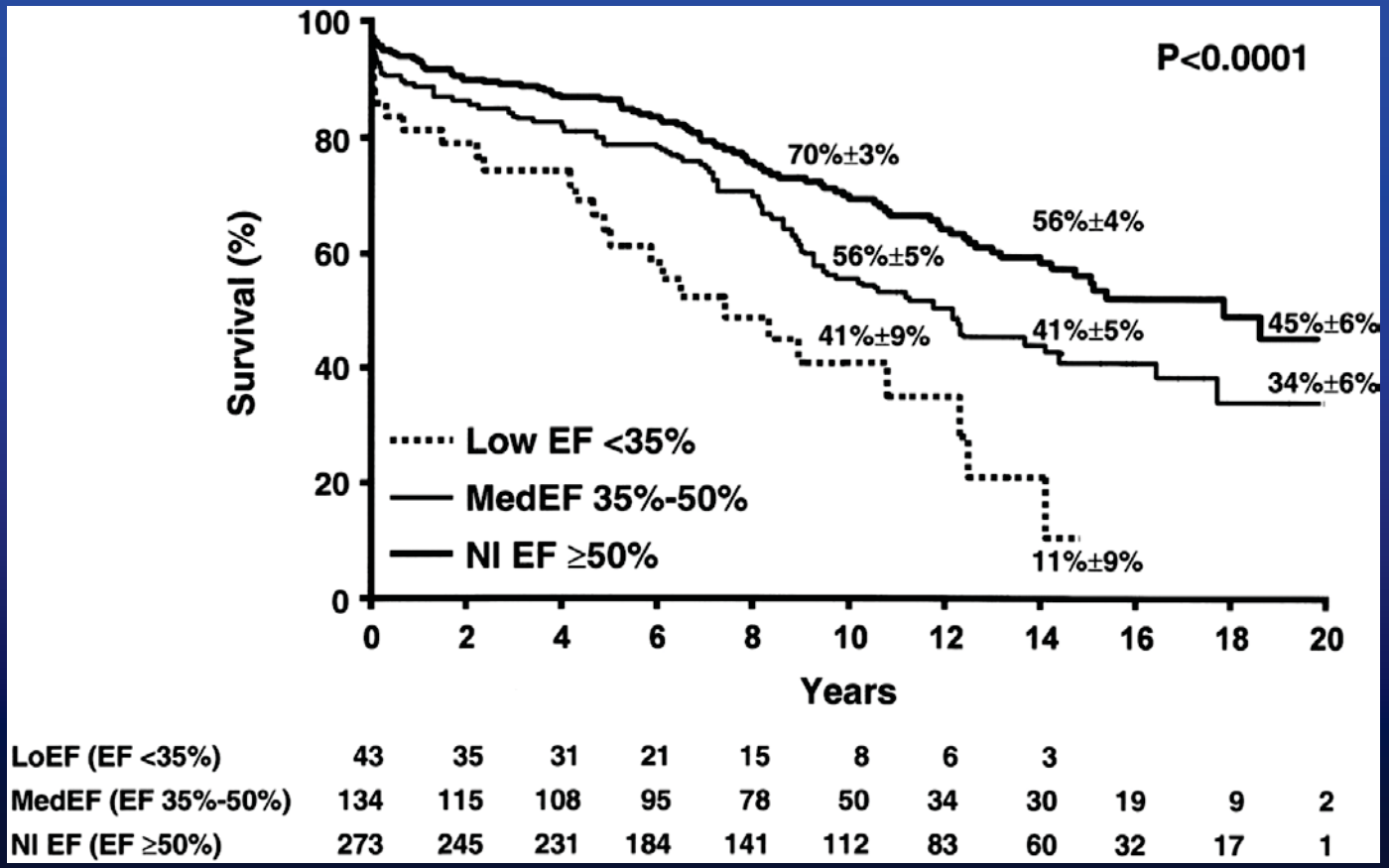


Survival of patients with chronic severe AR by symptoms (NYHA class) and LV diameter



Bekeredjian, R. et al. Circulation 2005;112:125-134

Survival in patients after aortic valve replacement as a function of preoperative LVEF



LoEF (EF <35%)	43	35	31	21	15	8	6	3			
MedEF (EF 35%-50%)	134	115	108	95	78	50	34	30	19	9	2
NI EF (EF ≥50%)	273	245	231	184	141	112	83	60	32	17	1

Chaliki HP et al. *Circulation.* 2002; 106: 2687–2693

Indications with pure, chronic AR for AVR

- Severe AR → AVR (irrespective of LV function)
- Mild AR – not candidates, if LV dysfunction, other causes have to be considered (CAD)
- Moderate AR – during CABG or surgery on Ascending Aorta → AVR

Additional Consideration for Surgery

- Symptomatic patient with LV dysfunction (EF 0.25 to 0.5) ⟹ AVR
- Asymptomatic patient with LV dysfunction (EF 0.25 to 0.5) ⟹ AVR
- Asymptomatic patient with normal LV function, but end diastolic dimension > 75 mm, or end-systolic dimension > 50 mm is an indication for AVR

TEE assessment of AR severity

- Color jet area
- Vena contracta
- AR pressure half-time (PHT)
- Aortic flow reversal
- Quantitative Doppler Flow measurements

Severity of Aortic Regurgitation (Qualitative)

	Mild	Moderate	Severe
Angiographic grade	1 +	2 +	3 – 4 +
Color Doppler width	Central jet, width < 25% of LVOT	Greater than mild but no sign of severe	Central jet, width > 65% of LVOT
Doppler vena contracta width (cm)	< 0.3	0.3 – 0.6	> 0.6

Severity of Aortic Regurgitation (Quantitative)

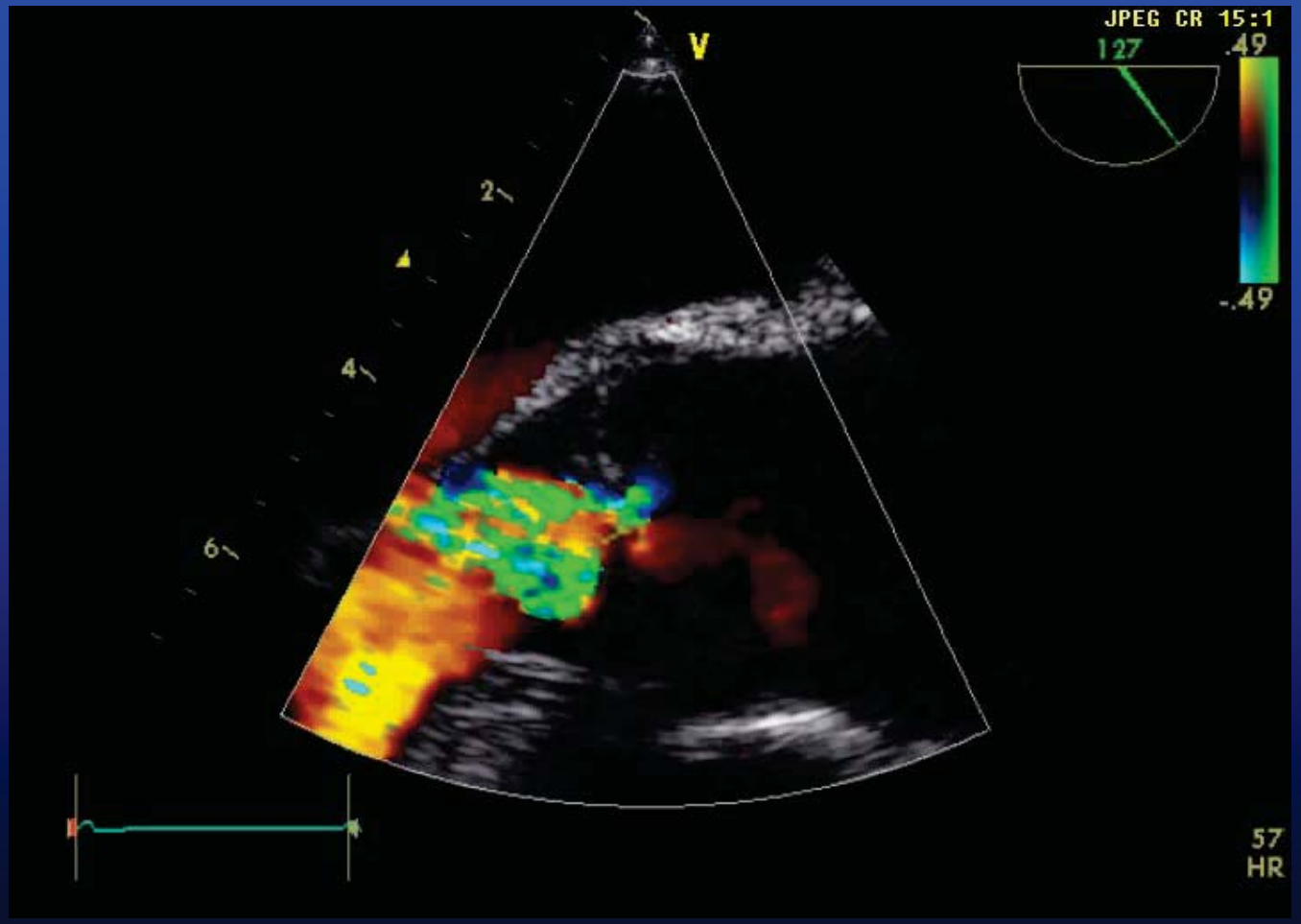
	Mild	Moderate	Severe
Regurgitant volume (ml/beat)	< 30	30 – 59	≥ 60
Regurgitant fraction (%)	< 30	30 – 49	≥ 50
Regurgitant orifice area ($cm^{2)}$	< 1.0	0.1 – 0.29	≥ 30
Additional criteria: LV size			Increased

Color jet area

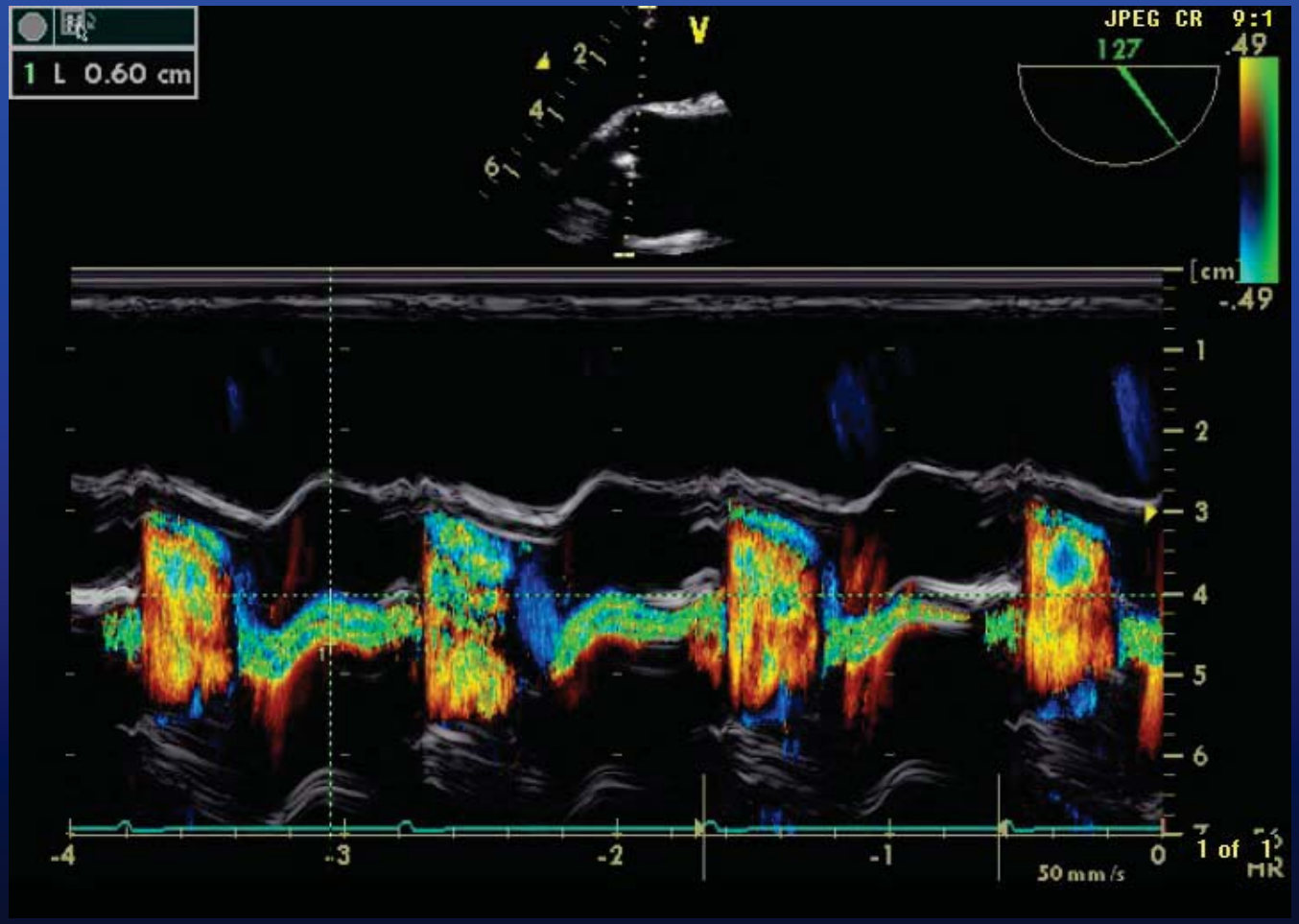
- Jet width/LVOT width
- Fast, easy, helps assessing mechanism
- Impacted by blood pressure (BP) – high-pressure jets appear larger than a low-pressure jet
- Eccentric (wall) jets only 50% the size of central jets (Coanda effect)
- Effect of instrumentation (next slide)

LVOT width

Regurgitation



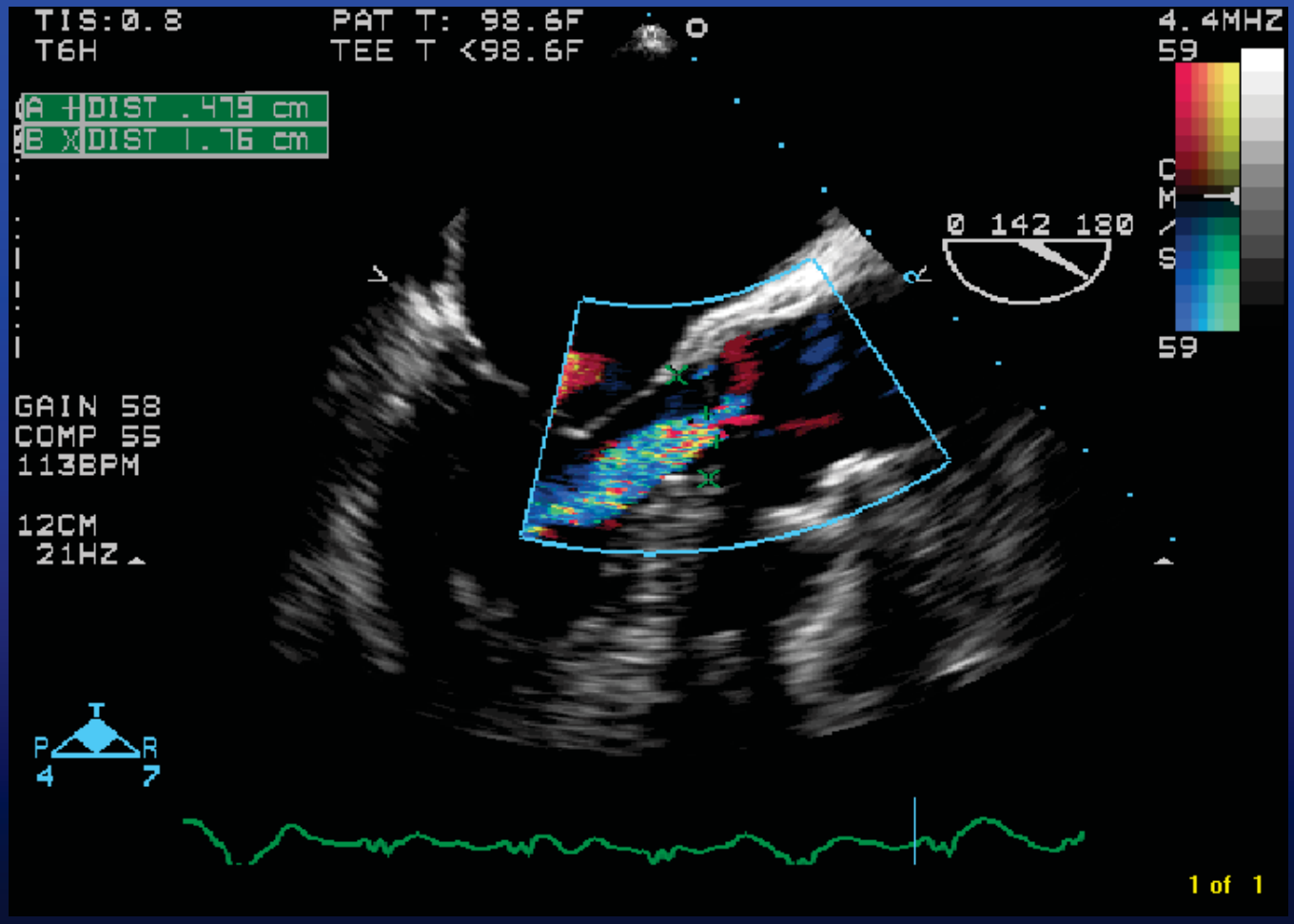
Color M-mode jet width



Effect of Color Doppler Instrumentation on Color Doppler Jet Size

- Increased Jet size:
  - ✓ ↑ Gain and output power
  - ✓ ↓ PRF (encoding lower velocities) – lowest velocity visible is 1/16 of the maximal velocity (determined by PRF)
  - ✓ ↑ Transducer frequency – Frequency effect (encoding lower velocities) – dominates TEE
  - ✓ ↓ Transducer frequency – Attenuation effect (higher frequency is attenuated more) – dominates TTE
  - ✓ ↓ Wall filter

Color Jet width

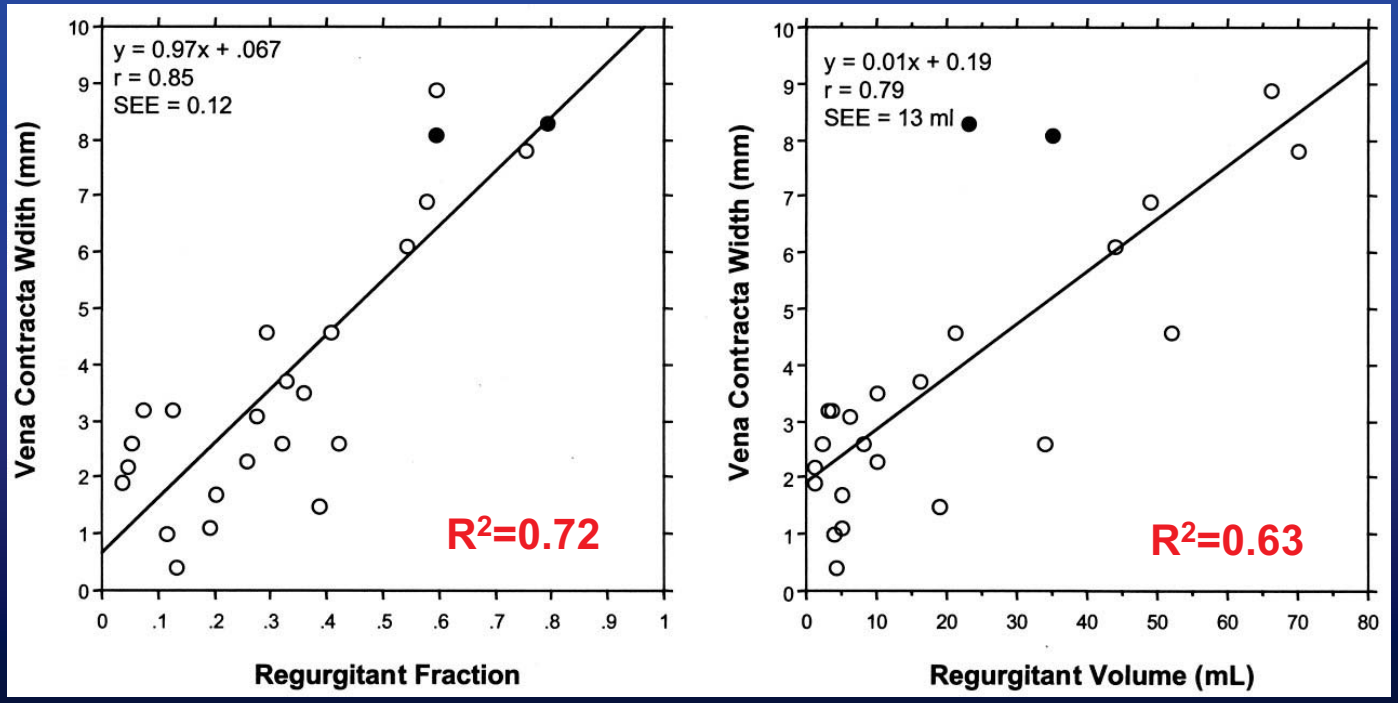


AR by Vena contracta

- Vena contracta is the narrowest portion of the jet located at or just distal to its orifice
- It is slightly smaller than the anatomic orifice due to contraction of the flow stream by viscous friction and boundary layer effects
- Afterload independent
- EROA = π x (VC width / 2)^2

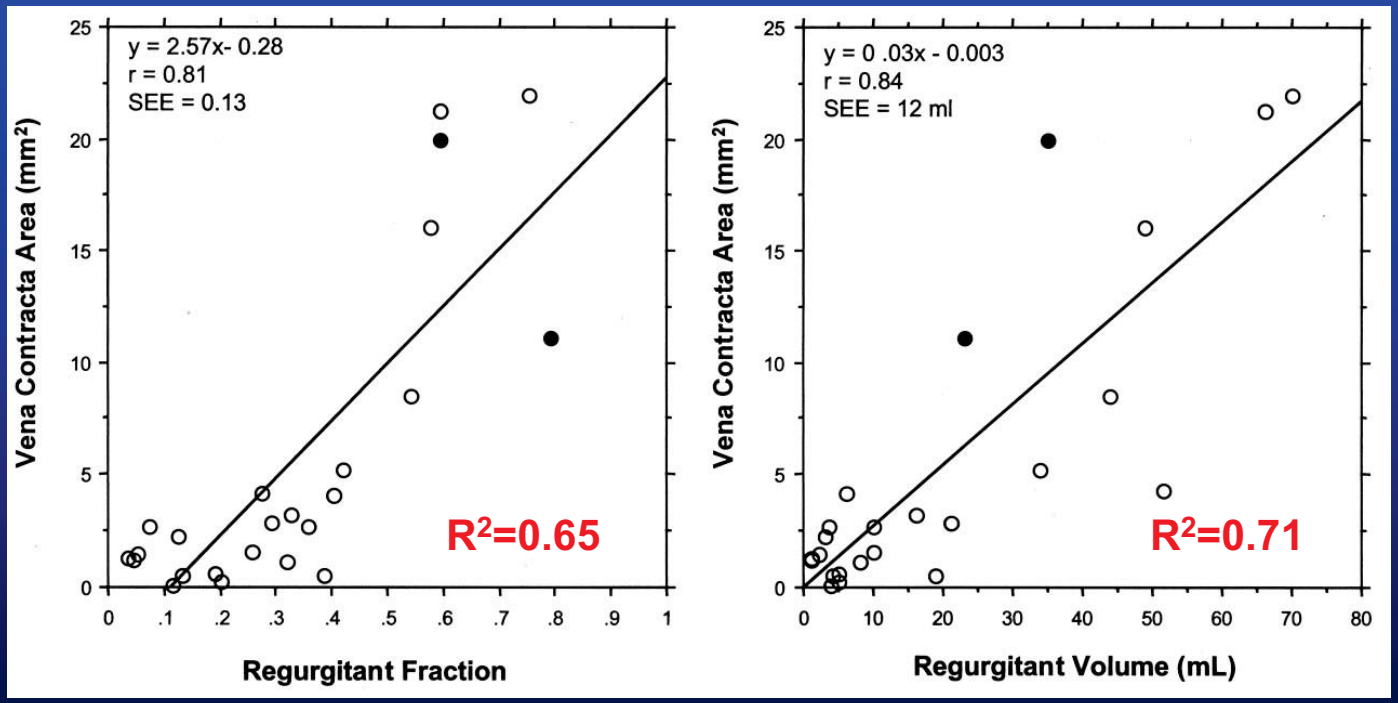
Ishii et al. Circulation. 1997;96:2009

Linear regression plots showing a comparison of vena contracta width in the long-axis view to regurgitant fraction (left) and regurgitant volume (right) assessed by intraoperative aortic flow probe



Willett, D. L. et al. J Am Coll Cardiol 2001;37:1450-1455

Linear regression plots showing a comparison of vena contracta area in the short-axis view to regurgitant fraction (left) and regurgitant volume (right)



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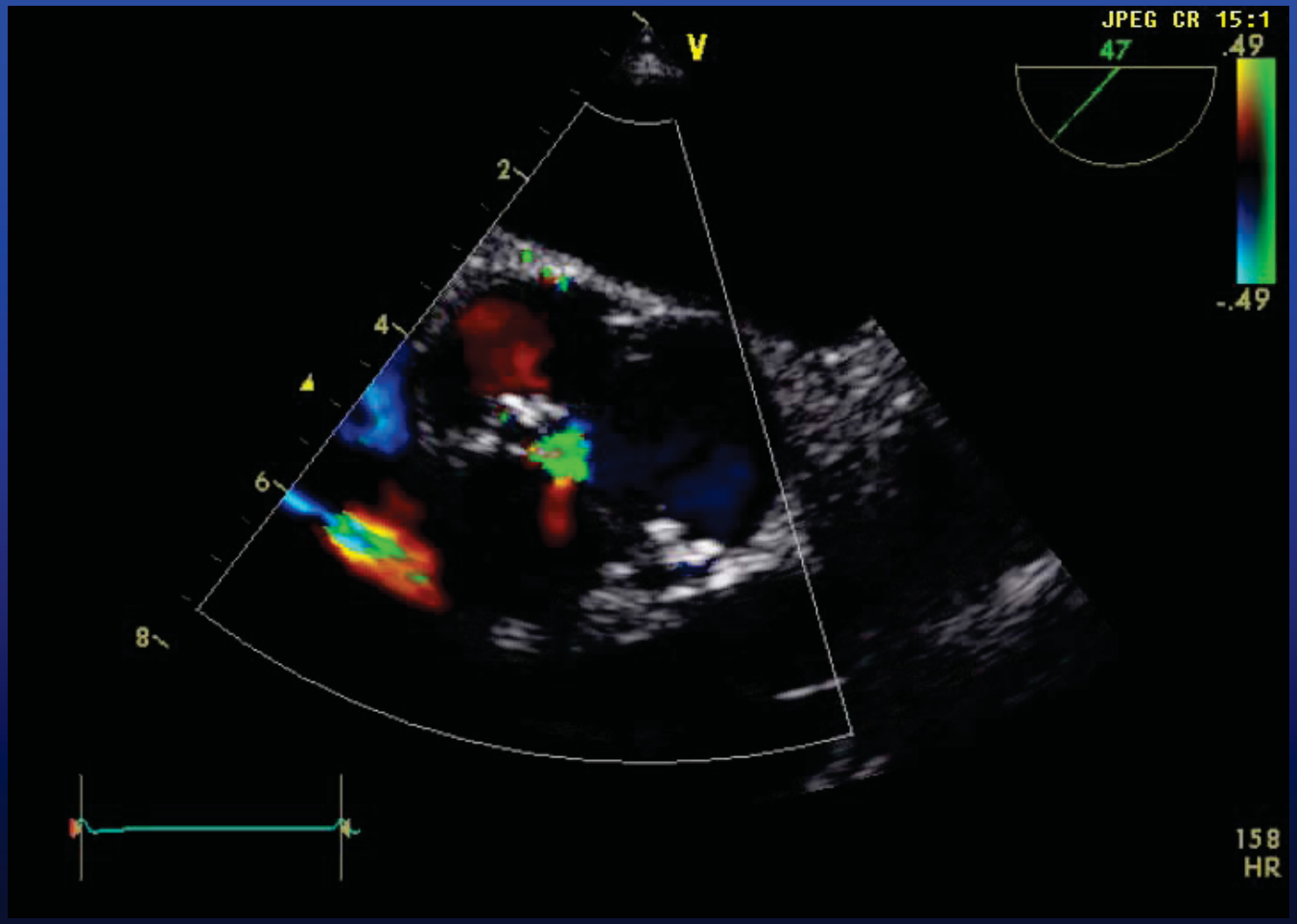
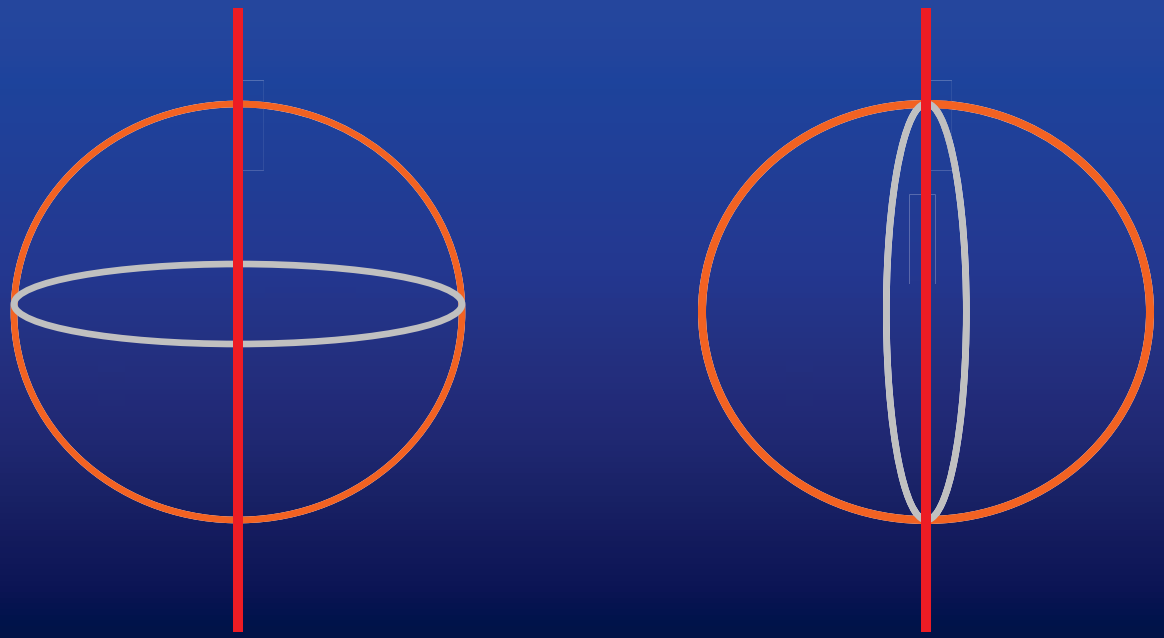
Short Axis VC



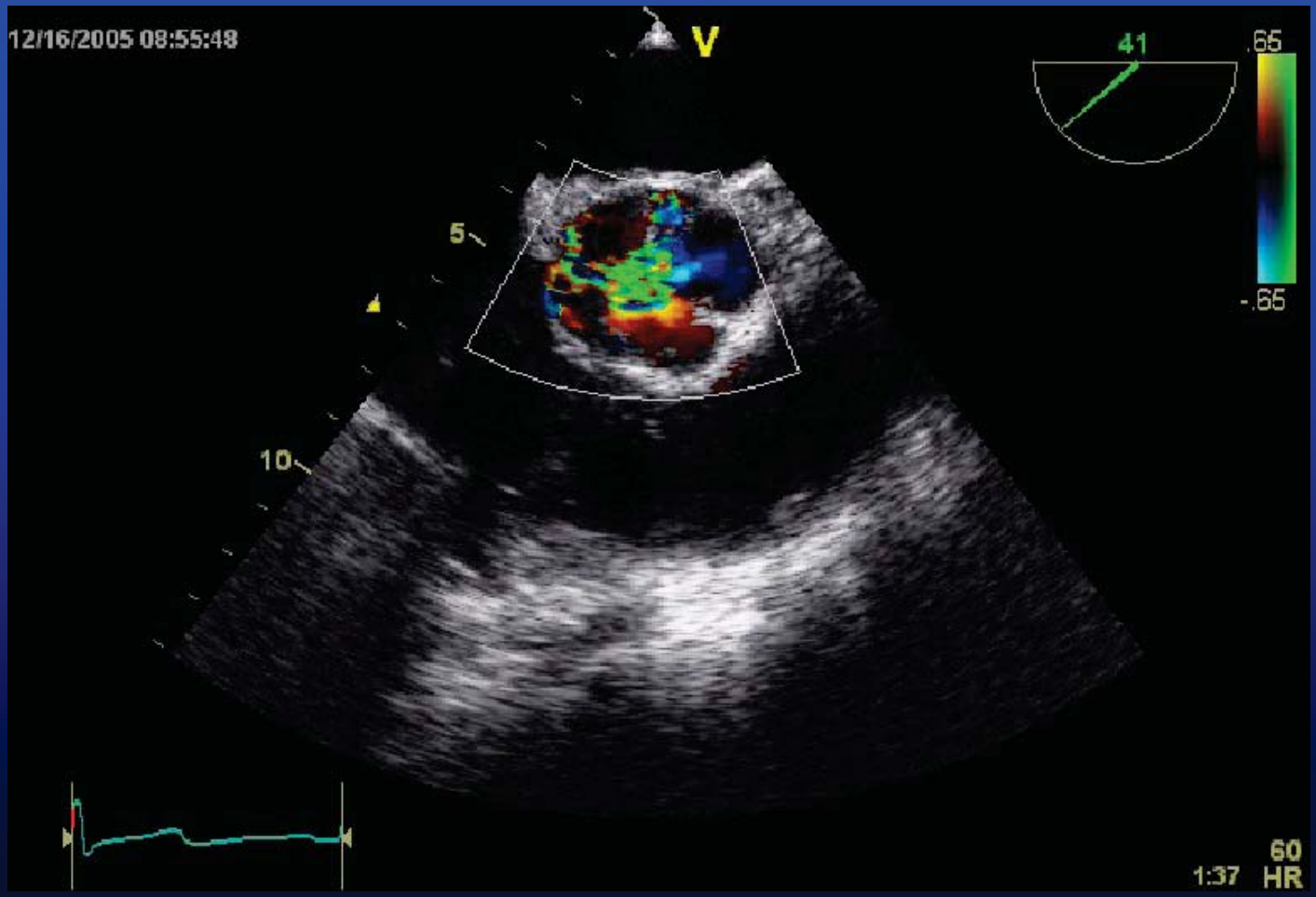
VC Limitations

- Jet width depends on valve morphology



Underestimates Overestimates

VC limitations



VC Limitations

- Color Doppler instrumentation changes may affect jet size
  - Increased Jet size:
    - ✓↑ Gain and power
    - ✓↑ Transducer frequency
    - ✓↓ PRF
    - ✓↓ Transducer frequency
    - ✓↓ Wall filter

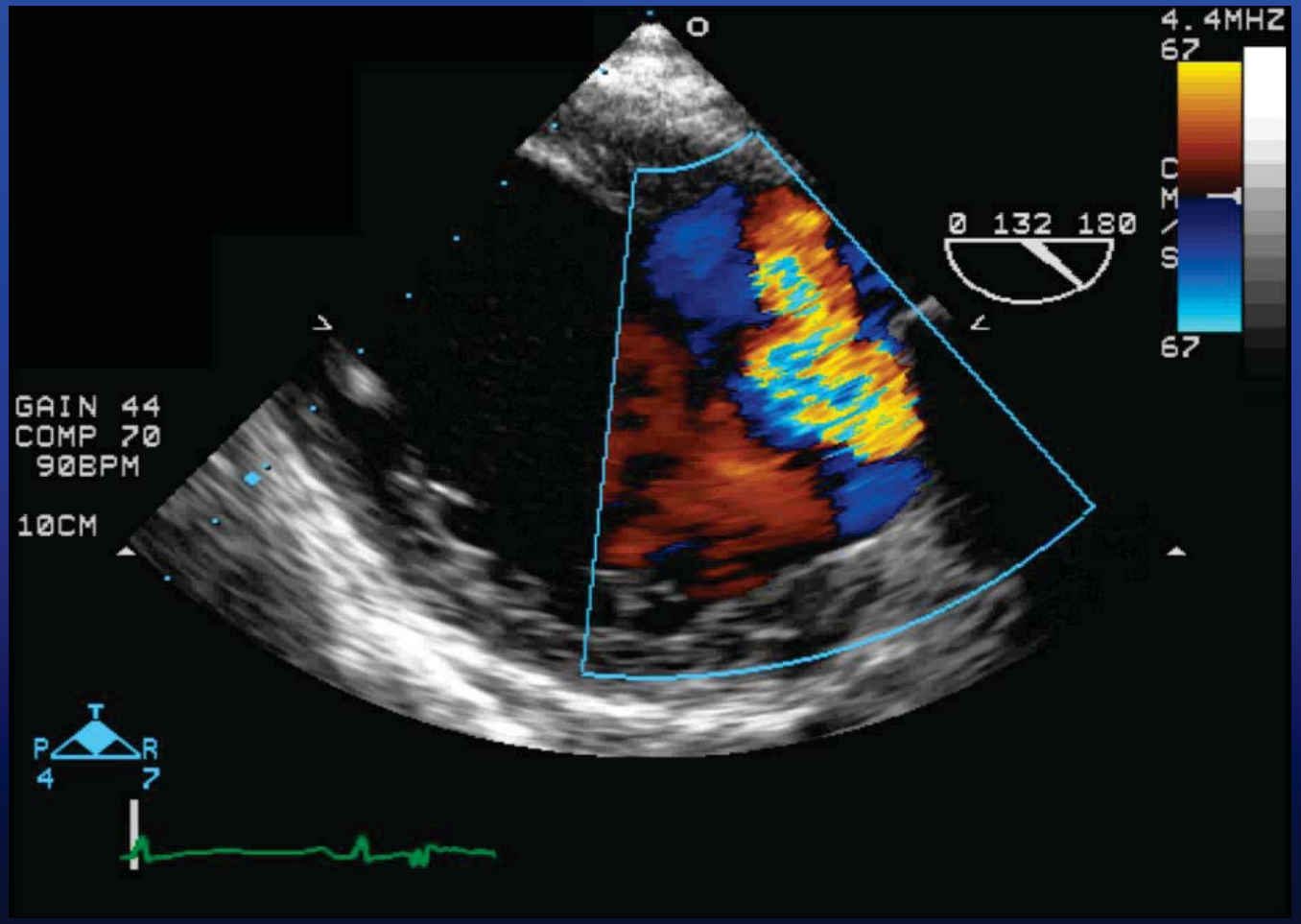
Pressure half time (PHT)

- Quantitative parameter of the pressure equilibration between aorta and left ventricle
- With increasing severity of AR the aortic regurgitant velocity slope gets steeper, and PHT shortens

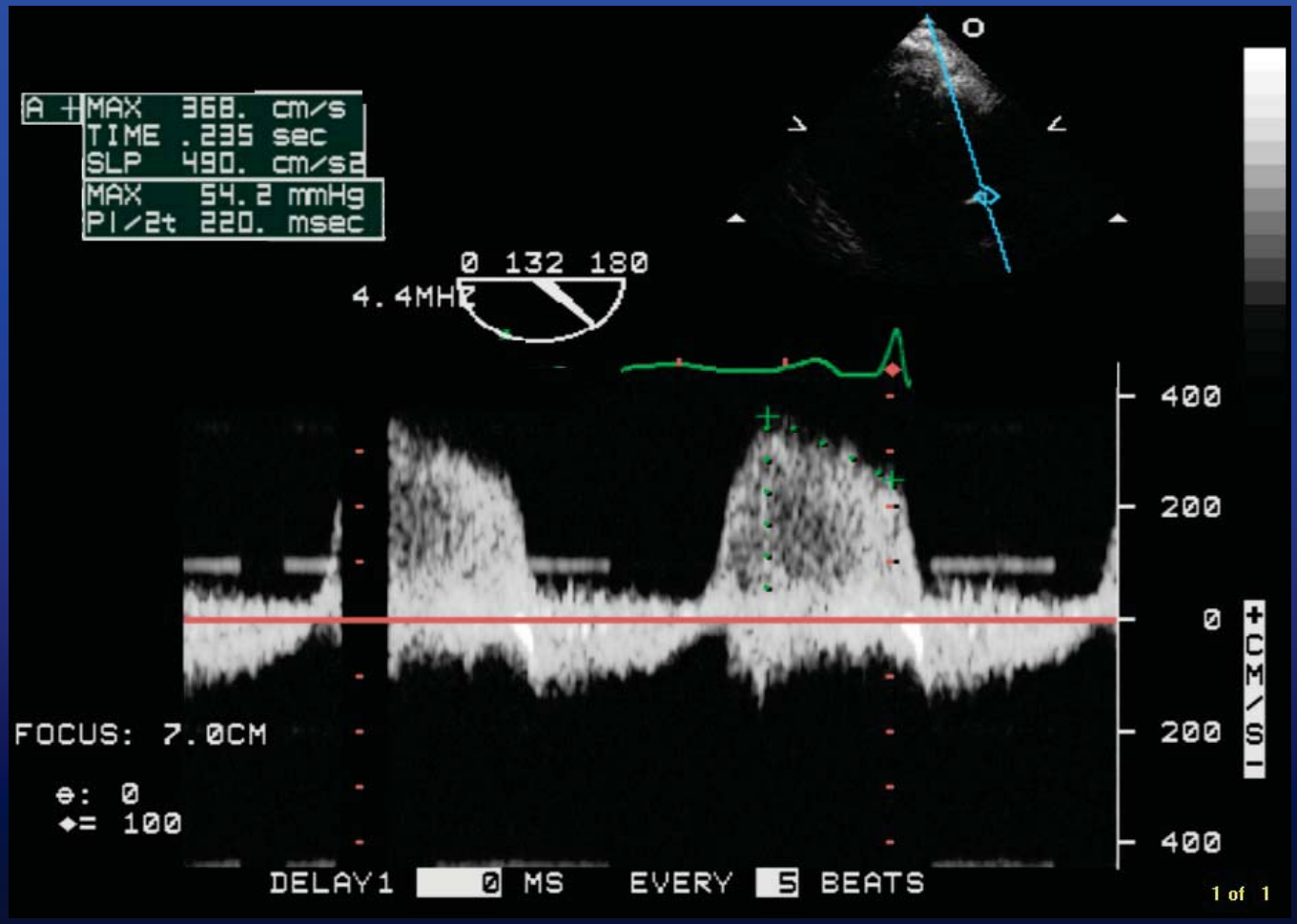
Pressure half time (PHT)

- Mild AR: Slow > 500 ms, incomplete/faint spectral density
- Moderate AR: Medium 500 – 200 ms, dense
- Severe AR: Steep < 200ms, dense

Color Jet Area



Pressure Half Time



Limitation of PHT

- Pressure equilibration is not only influenced by regurgitant orifice area BUT
- ✓ By the systemic vascular resistance: Increasing SVR increases regurgitation and increases PHT (contradiction!)
- ✓ By left ventricle compliance:

  Decreased compliance increases PHT

Limitation of PHT

- In the presence of impaired left ventricular relaxation the pressure or velocity decay of aortic regurgitation is not related to its severity
- PHT assessment of aortic regurgitation should only be used in patients with pure AR, normal EF and normal LV mass

Marchi et al. Heart. 1999;82:607

Griffin et al. Am Heart J. 1991;122:1049

Aortic Flow Reversal

- PWD sample obtained in the descending aorta just beyond the aortic arch at a multiplane angle around 90

Aortic Flow Reversal

- Diastolic flow reversal in descending aorta with Pulsed Wave Doppler (PWD)

✓ Mild: brief, early

✓ Moderate: Intermediate

✓ Severe: Holodiastolic reversal

➢ Most Reliable!

Regurgitant Volume (RV) in AR

1. ERO (effective orifice area) x AR flow (VTI)
2. Difference between total SV and forward SV (no intracardiac shunt)
    1. RV = Total SV – Forward SV
        - Total SV = (CSA_{LVOT} x VTI_{LVOT})
        - Forward SV = (CSA_{PA} x VTI_{PA}

Regurgitant Volume (RV) in AR

- Mild: < 30 ml/beat
- Mild to Moderate: 30 – 44 ml/beat
- Moderate to Severe: 45 – 59 ml/beat
- Severe: ≥ 60 ml/beat

How Do We Measure AR?

•Mild

•Moderate

•Severe

Evaluation of Aortic Regurgitation

Thank you!