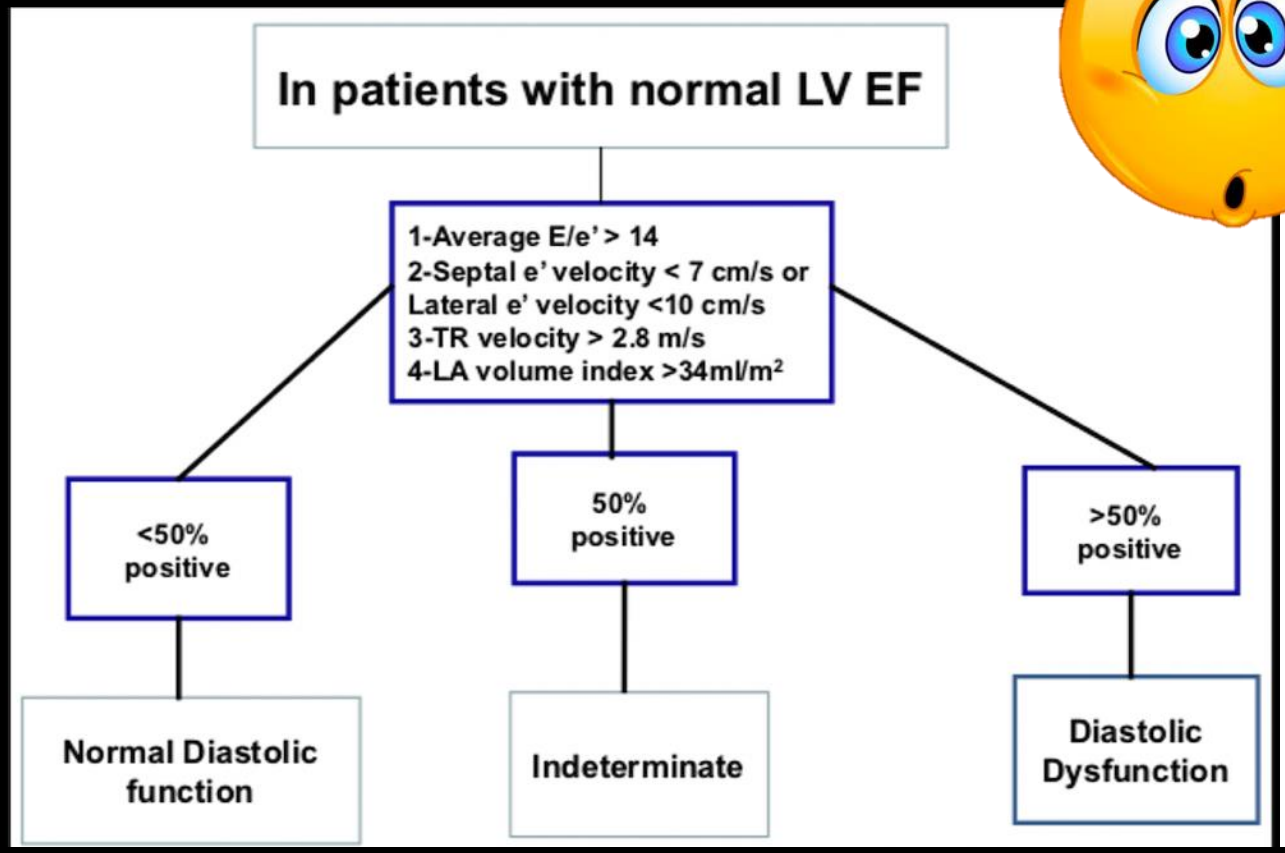
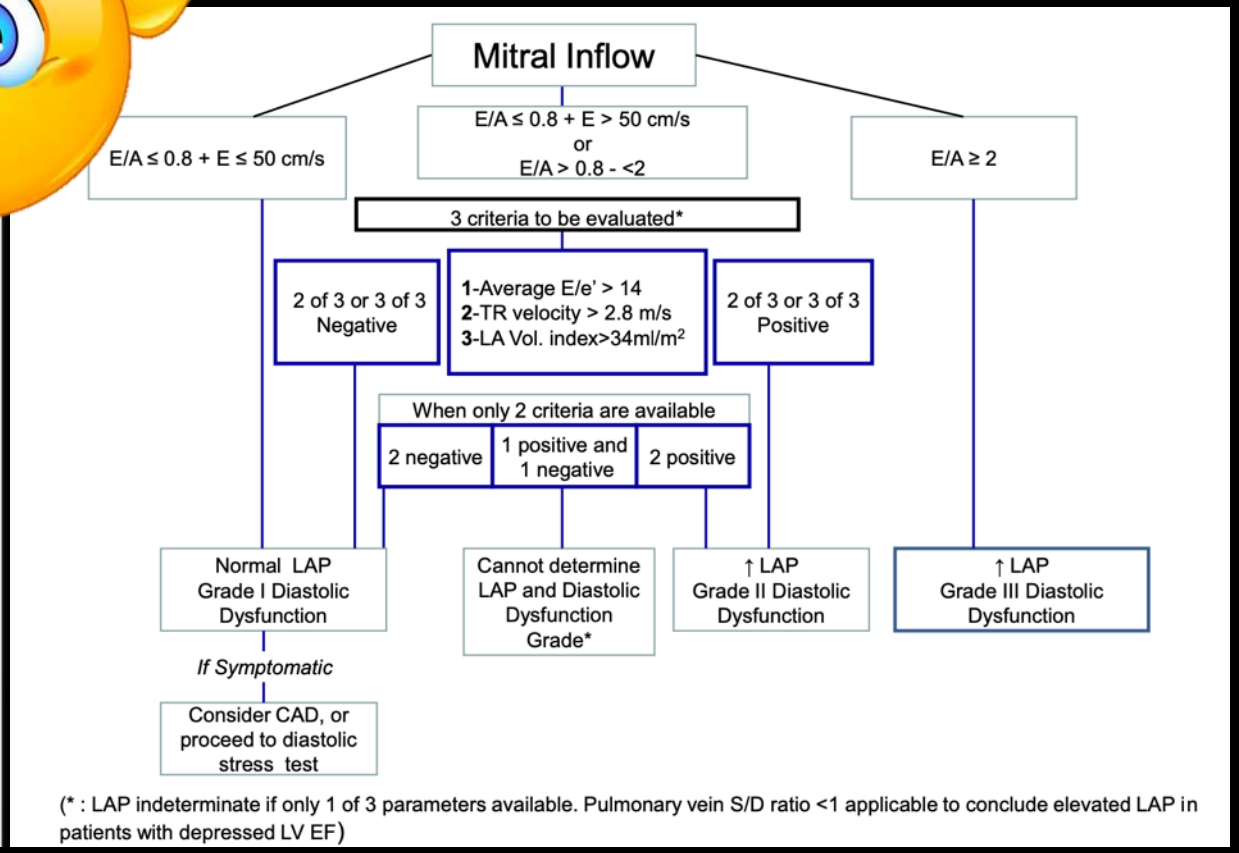
Sonographer's Role in Diastolic Assessment

Michigan Society of Echocardiography
February 11, 2026

Karen G Zimmerman BS, ACS, RDCS, RVT, FASE
Perioperative Echocardiography Project Manager
Michigan Medicine
University of Michigan

Diastolic algorithms are confusing and hard to remember.. Too many exceptions to the rules!





Nagueh, S F et al. J Am Soc Echocardiogr 2016;29:277-314

Good News…

There are new guidelines out!

Bad news! Still too many exceptions to everything …AGAIN!

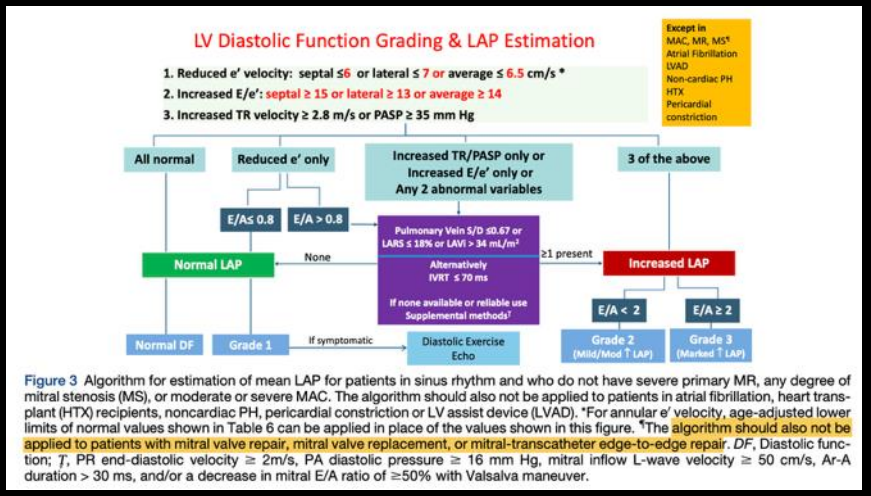


Figure 3 Algorithm for estimation of mean LAP for patients in sinus rhythm and who do not have severe primary MR, any degree of mitral stenosis (MS), or moderate or severe MAC. The algorithm should also not be applied to patients in atrial fibrillation, heart transplant (HTX) recipients, noncardiac PH, pericardial constriction or LV assist device (LVAD). *For annular e' velocity, age-adjusted lower limits of normal values shown in Table 6 can be applied in place of the values shown in this figure. †The algorithm should also not be applied to patients with mitral valve repair, mitral valve replacement, or mitral-transcatheter edge-to-edge repair. *DF*, Diastolic function; *T*, PR end-diastolic velocity ≥ 2m/s, PA diastolic pressure ≥ 16 mm Hg, mitral inflow L-wave velocity ≥ 50 cm/s, Ar-A duration > 30 ms, and/or a decrease in mitral E/A ratio of ≥50% with Valsalva maneuver.

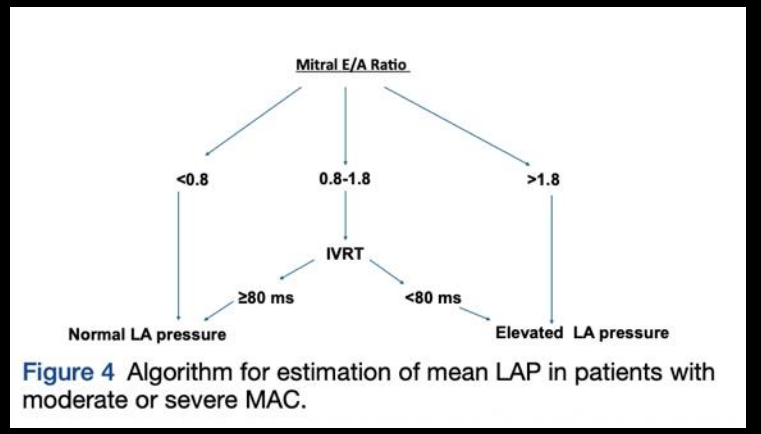


Figure 4 Algorithm for estimation of mean LAP in patients with moderate or severe MAC.

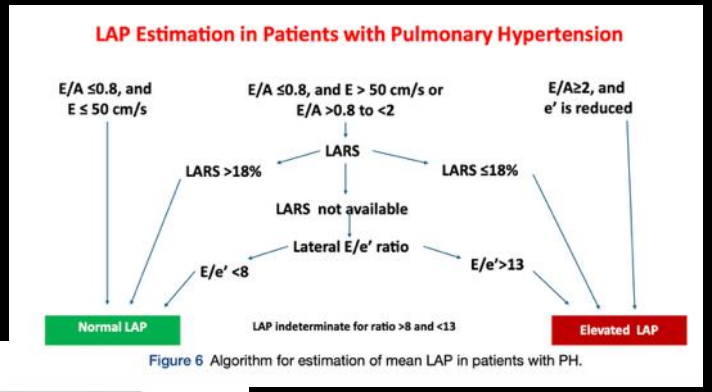
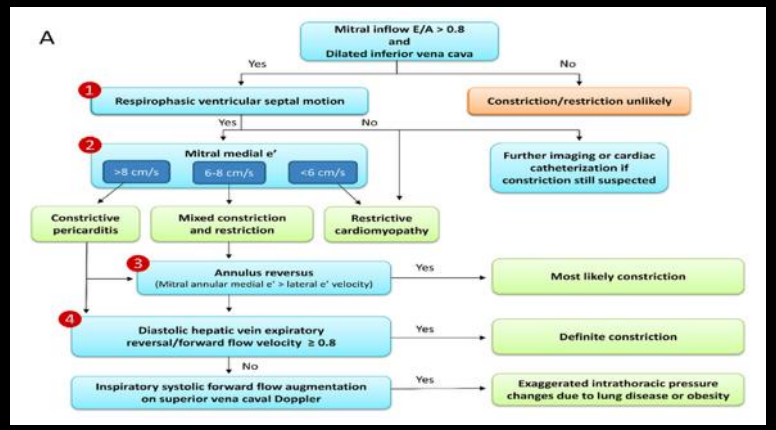


Figure 6 Algorithm for estimation of mean LAP in patients with PH.



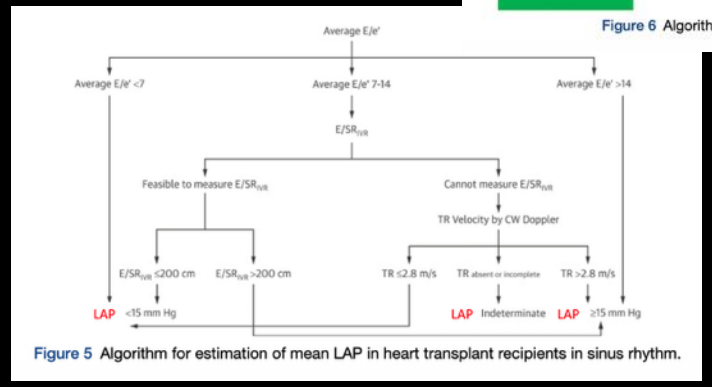


Figure 5 Algorithm for estimation of mean LAP in heart transplant recipients in sinus rhythm.

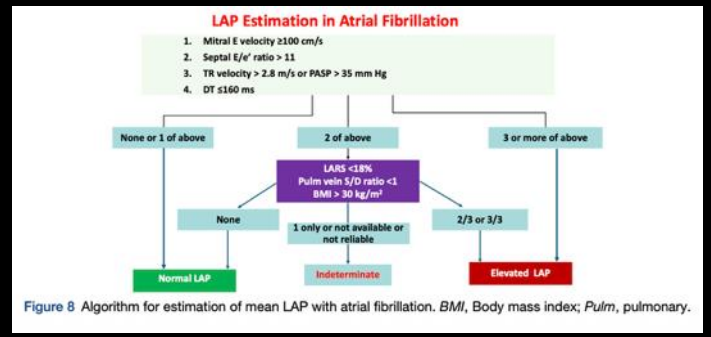


Figure 8 Algorithm for estimation of mean LAP with atrial fibrillation. *BMI*, Body mass index; *Pulm*, pulmonary.

Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Special problems require special recipes
CANNOT RELY ON A SINGLE VARIABLE

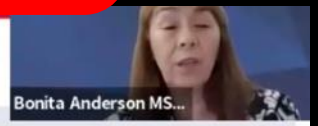


Table 7

- **Indicators of elevated LVFP in special populations**

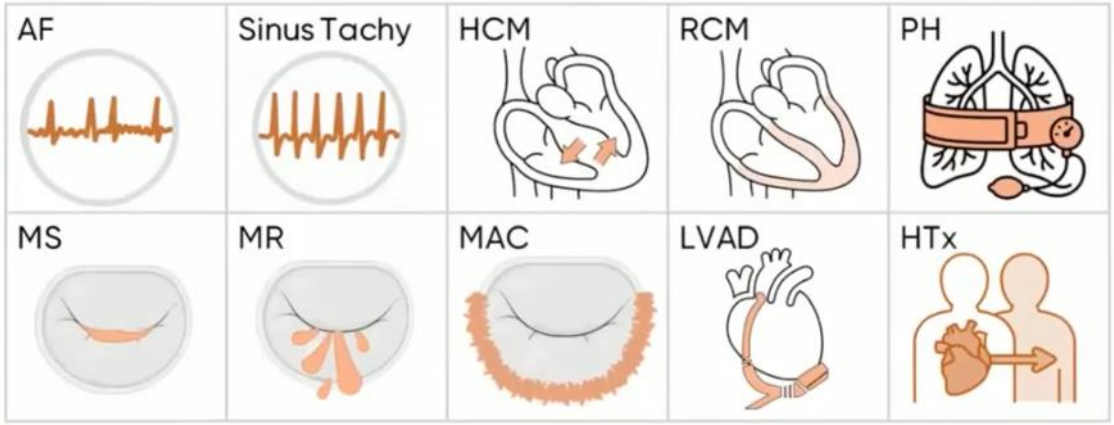


Table 7 Indicators of elevated LV filling pressures in special populations

Disease	Echocardiographic measurements indicative of elevated LV filling pressure
1. Atrial fibrillation[42]	1. DT < 160 ms in patients with depressed LVEF 2. Peak acceleration rate of mitral E velocity (≥1,900 cm/s²) 3. IVRT (≤65 ms) 4. DT of pulmonary venous diastolic velocity (≤220 ms) 5. E/Vp ratio (≥1.4) 6. Septal E/e' ratio (≥11) 7. Peak TR velocity > 2.8 m/s
2. Sinus tachycardia[43,44]	1. Predominant early LV filling pattern with depressed LVEF 2. IVRT ≤ 70 ms is specific (79%) 3. Pulmonary vein systolic filling fraction ≤40% is specific (86%) 4. Average E/e' ratio > 14 (high specificity but low sensitivity) 5. When E and A velocities are partially or completely fused, the presence of a compensatory period after premature beats often leads to separation of E and A velocities which can be used for assessment of diastolic function
3. HCM[45]	1. Average E/e' (>14) 2. Ar-A (≥30 ms) 3. Peak TR velocity (>2.8 m/s) 4. LA maximum volume index (>34 mL/m²)
4. Restrictive cardiomyopathy[46–49]	1. Average E/e' (>14) 2. DT < 140 ms* 3. E/A ratio > 2.5* 4. IVRT < 50 ms*
5. PH[50,51]	1. E/A ≥ 2 favors postcapillary PH 2. E/A ≤ 0.8 favors precapillary PH 3. When E/A ratio is >0.8 but <2, lateral E/e' ratio > 13, LA maximum volume index > 34 mL/m², and LARS < 18% favor the diagnosis of postcapillary PH.
6. Mitral stenosis[52]	1. IVRT < 60 ms* 2. Mitral A peak velocity > 1.5 m/s 3. IVRT/$T_{E-e'}$ ratio < 4.2
7. MR[52–54]	1. IVRT < 60 ms* 2. Ar-A (≥30 ms) 3. IVRT/$T_{E-e'}$ ratio < 5.6 4. Average E/e' ratio > 14 in patients with depressed EF
8. Moderate/severe MAC[55]	1. LV filling pressure normal when mitral E/A ratio is <0.8 2. LV filling pressure elevated when mitral E/A ratio is >1.8 3. E/A ratio >0.8 but <1.8, IVRT should be measured. LV filling pressure normal when IVRT is ≥80 ms, whereas it is elevated if IVRT <80 ms.
9. LV assist device[56,57]	1. E/A ratio > 2 2. RAP > 10 mm Hg 3. PASP > 40 mm Hg 4. Average E/e' ratio > 14 or septal E/e' ratio ≥ 15 5. LA maximum volume index > 33 mL/m² 6. Interatrial septum position†
10. Cardiac transplant recipients[58]	1. Average E/e' ratio < 7 denotes normal LV filling pressures 2. Average E/e' ratio > 14 denotes elevated LV filling pressures 3. For E/e' ratio > 7 and <14, SR_{VR}, from all three apical views, is measured, and the ratio of mitral E velocity to SR_{VR} is derived. A ratio ≤ 200 cm is consistent with normal LV filling pressure, but >200 cm denotes elevated LV filling pressure. 4. In patients in whom SR_{VR} cannot be measured, peak TR velocity is relied on. Peak TR velocity ≤ 2.8 m/s is consistent with normal LV filling pressures, but >2.8 m/s denotes elevated LV filling pressures.

*Specific but not sensitive indicators of elevated LV filling pressure.
†LAP = RAP if the interatrial septum position is neutral. If septum bulges to right, then LAP is 5 mm Hg higher than RAP. If septum bulges to left, then LAP is 5 mm Hg lower than RAP.

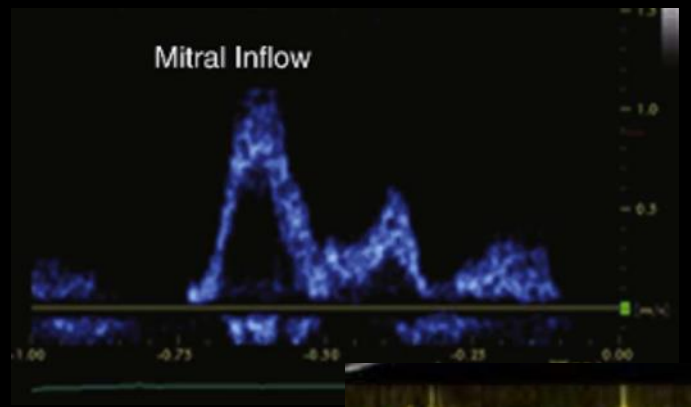
ASE
American Society of Echocardiography

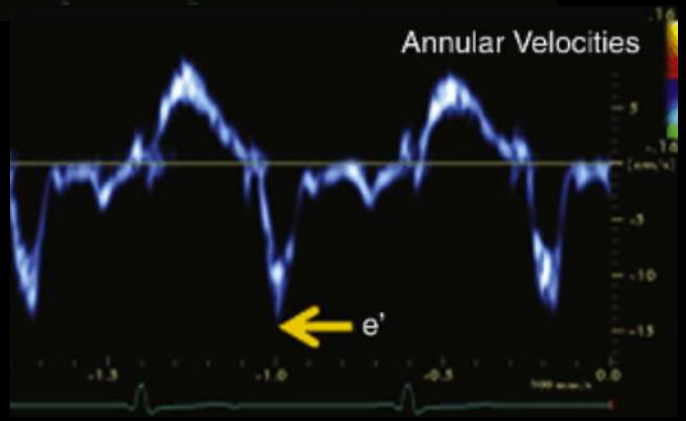
Special Problems → **Special recipes**

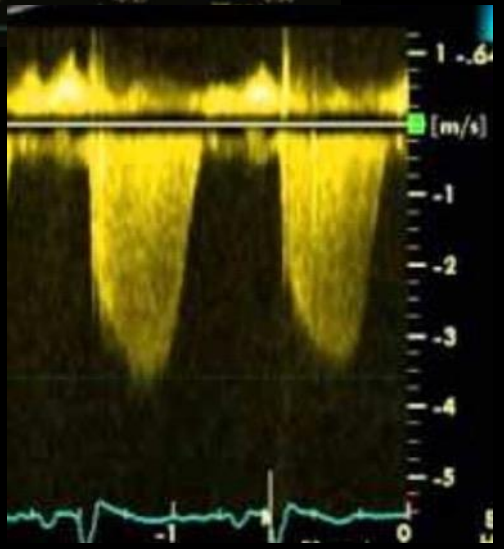
Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Don’t panic…
These essential parameters are the same ones we already do for every complete study!

- LA Volume
- LAS
- MV inflow
- TDI
- IVRT
- Pulm vein flow
- TR







Otto CM, ed. *The Practice of Clinical Echocardiography, 5th edition.* Elsevier Saunders, Philadelphia, Pennsylvania 2016

Basic Goals of Diastolic Assessment

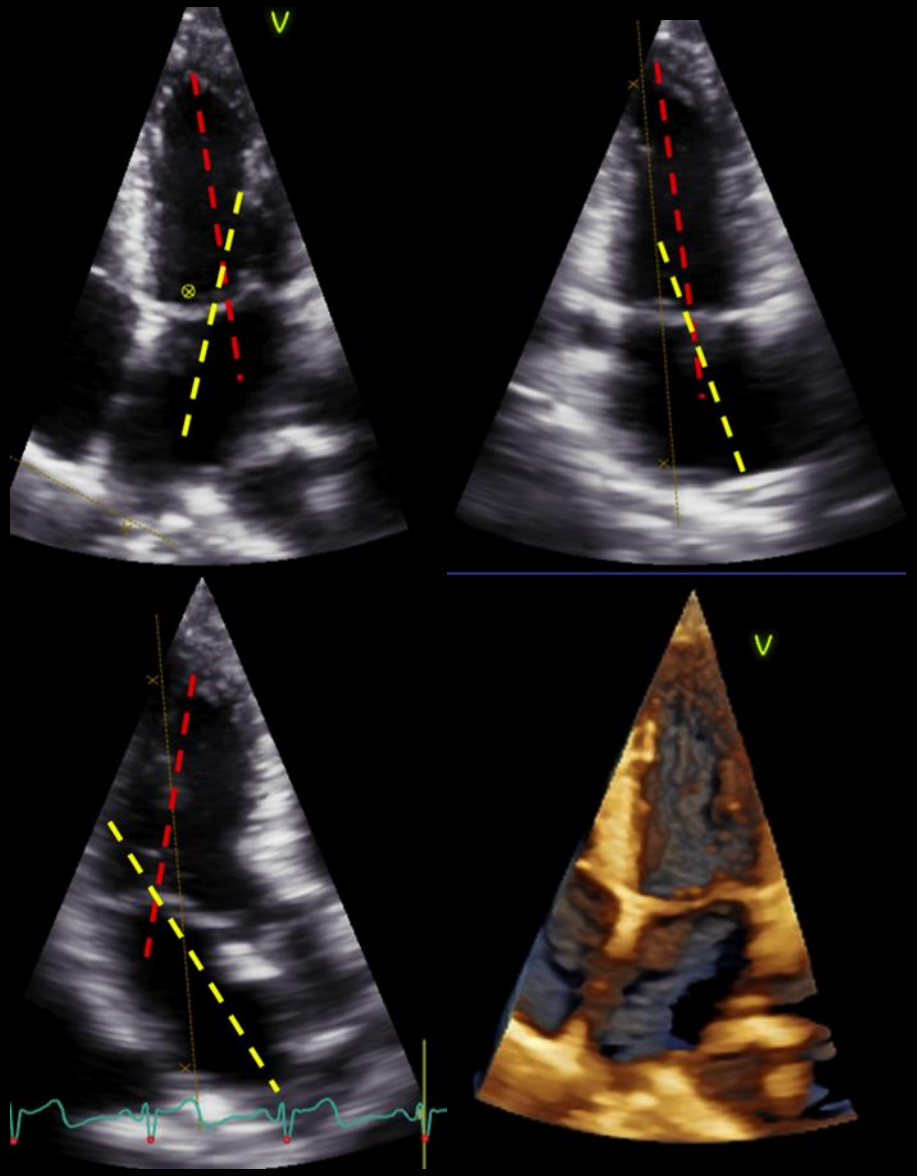
1) LA: Evaluate size and function

2) LV: Evaluate relaxation and compliance

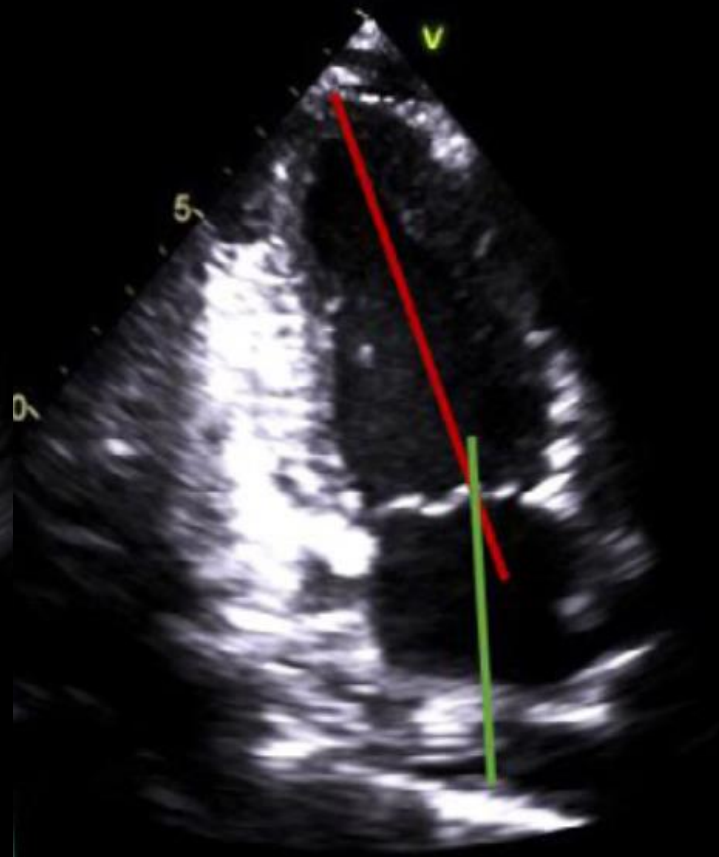
1) Assessing the LA

Evaluate LA size and function

LA and LV **do NOT** lie in the same plane

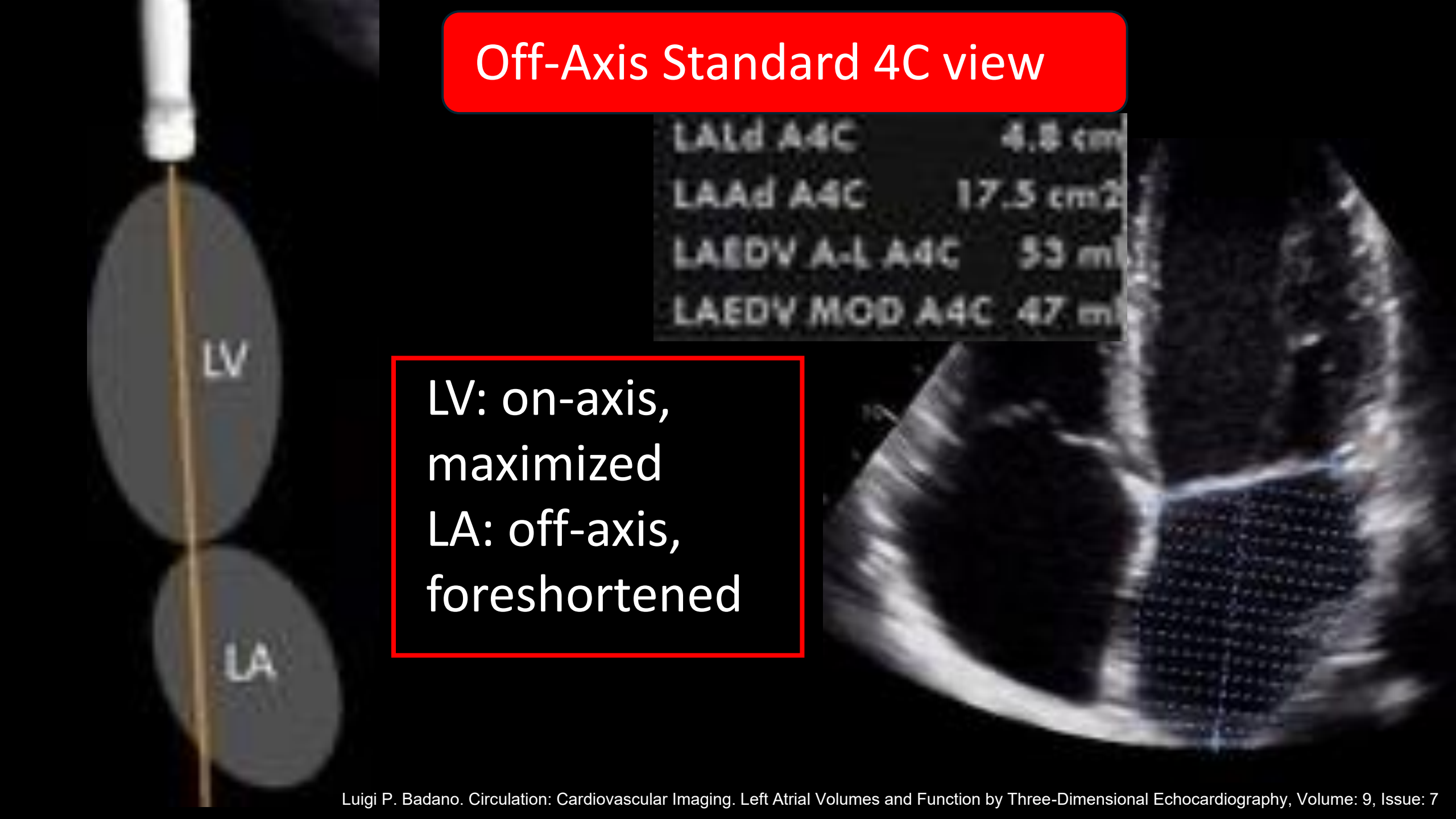


When LV is optimized, LA is not



Thomas et al J Am Soc Echocardiogr 2020,33:934-52

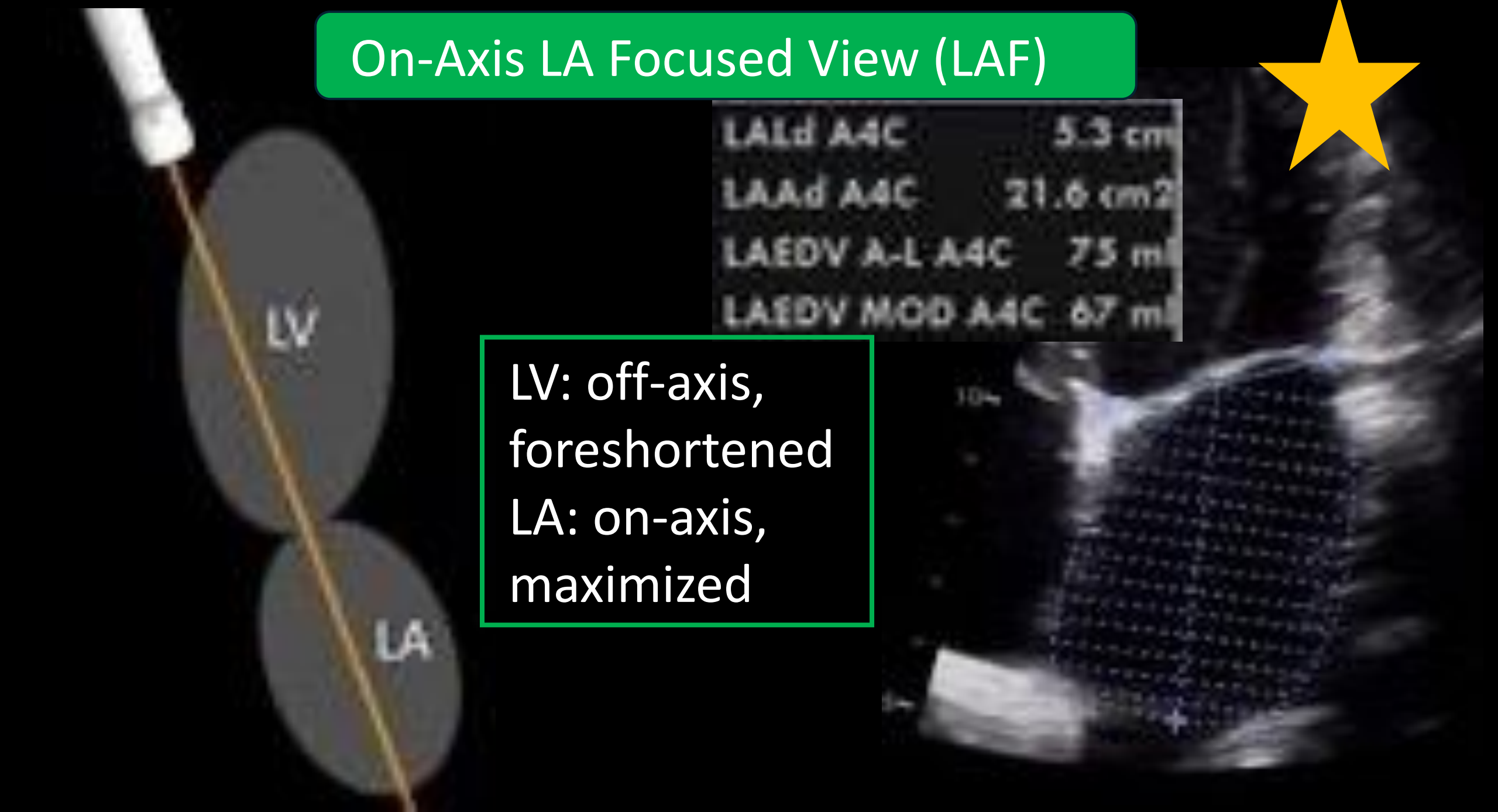
Off-Axis Standard 4C view



LV: on-axis, maximized
LA: off-axis, foreshortened

Luigi P. Badano. Circulation: Cardiovascular Imaging. Left Atrial Volumes and Function by Three-Dimensional Echocardiography, Volume: 9, Issue: 7

On-Axis LA Focused View (LAF)

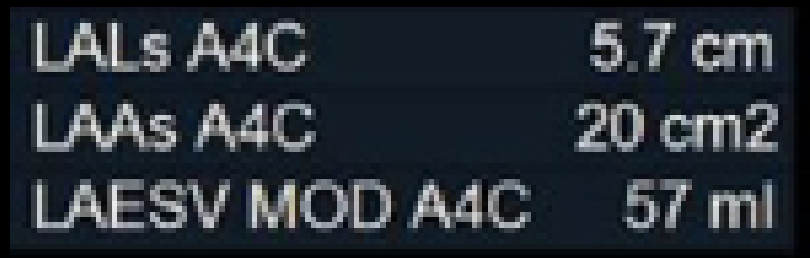


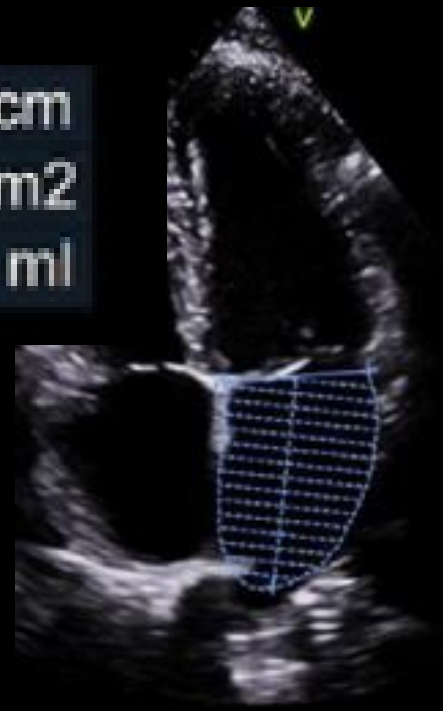
LV: off-axis, foreshortened
LA: on-axis, maximized

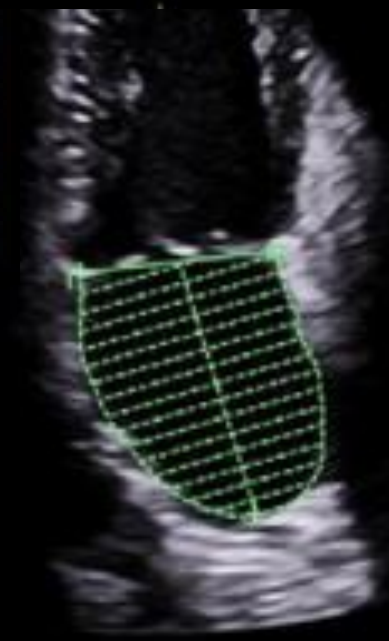
Luigi P. Badano. Circulation: Cardiovascular Imaging. Left Atrial Volumes and Function by Three-Dimensional Echocardiography, Volume: 9, Issue: 7

LA Size/Volume

- **Scroll to when the LA is biggest**, End-systolic frame (1 or 2 frames before MV opens)
- Trace blood-tissue interface
- **Linear dimension from middle MVA, <u>straight</u> back to LA wall**
- Linear dimension for both 4C / 2C within 5 mm of each other
- Good ≤ 34 mL/m^2



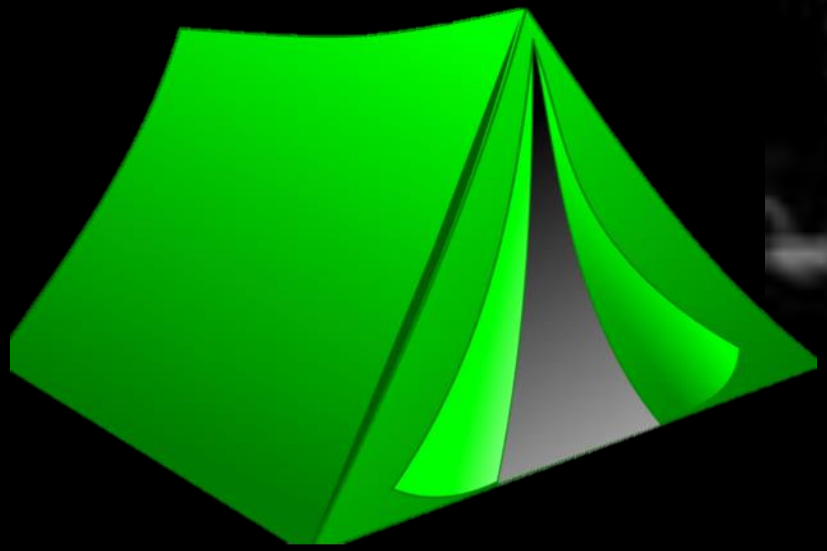


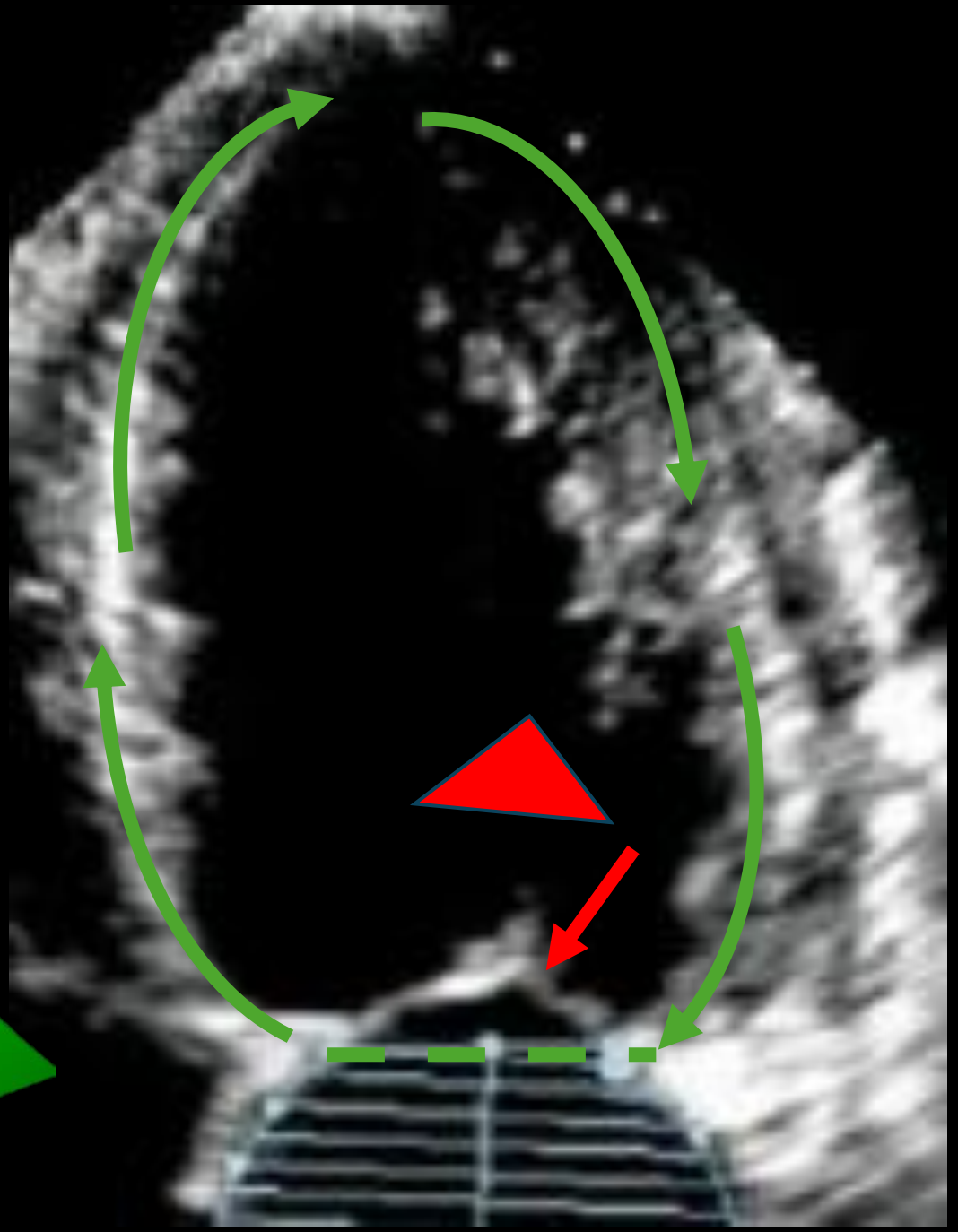


Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Common error:
Tent belongs to the LV

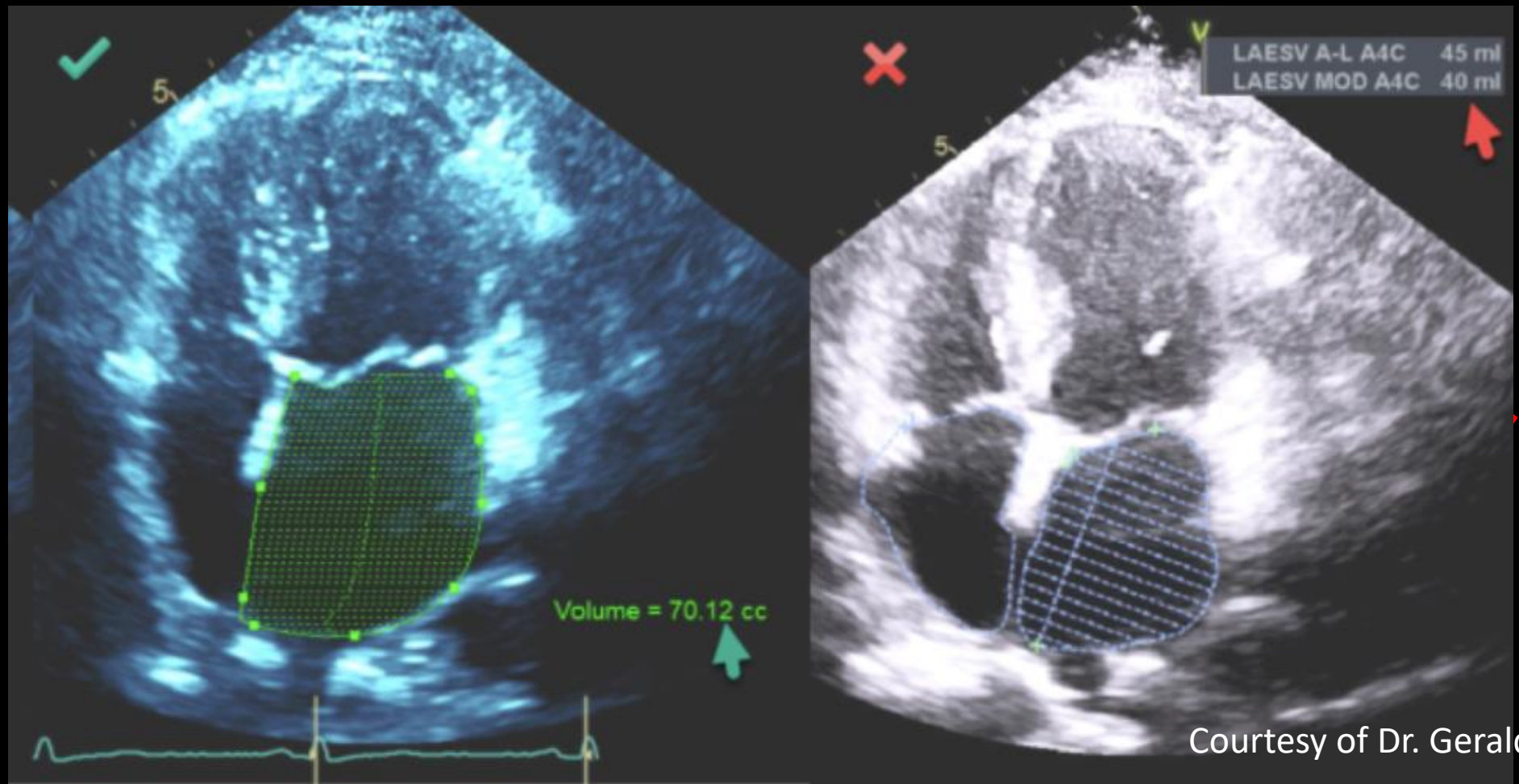
With an ischemic heart, mitral leaflets can be pulled into the LV.





Common error

Foreshortened and inaccurate linear dimensions will underestimate LA volume



Courtesy of Dr. Gerald Cohen

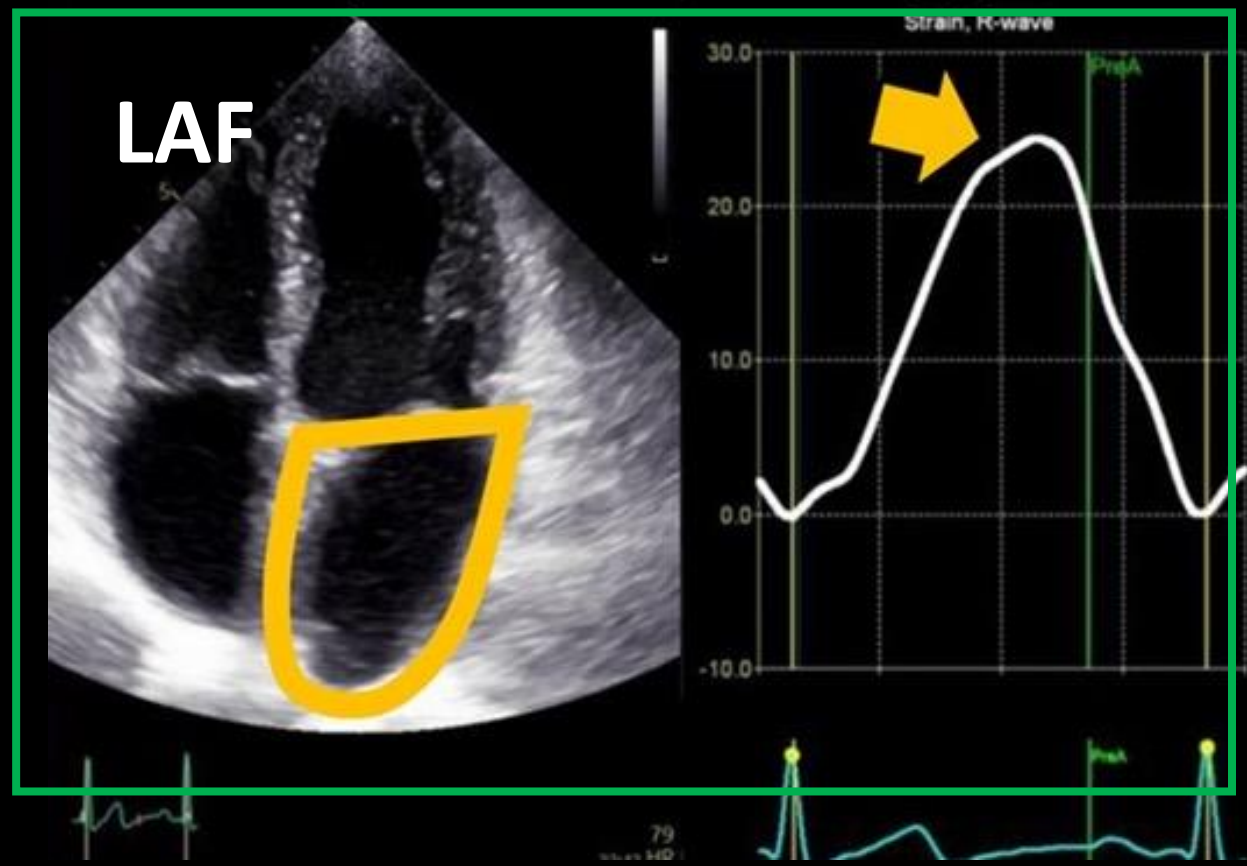
Now that we are talking about tracing the LA correctly, let's go to the next step…

- LA Function using LA Strain

LA focused (LAF) vs 4C (foreshortened)

On-Axis is KEY!

Foreshortened LAS will also affect strain values!



Eur Heart J Cardiovasc Imaging, Volume 21, Issue 7, July 2020, Pages 715–717

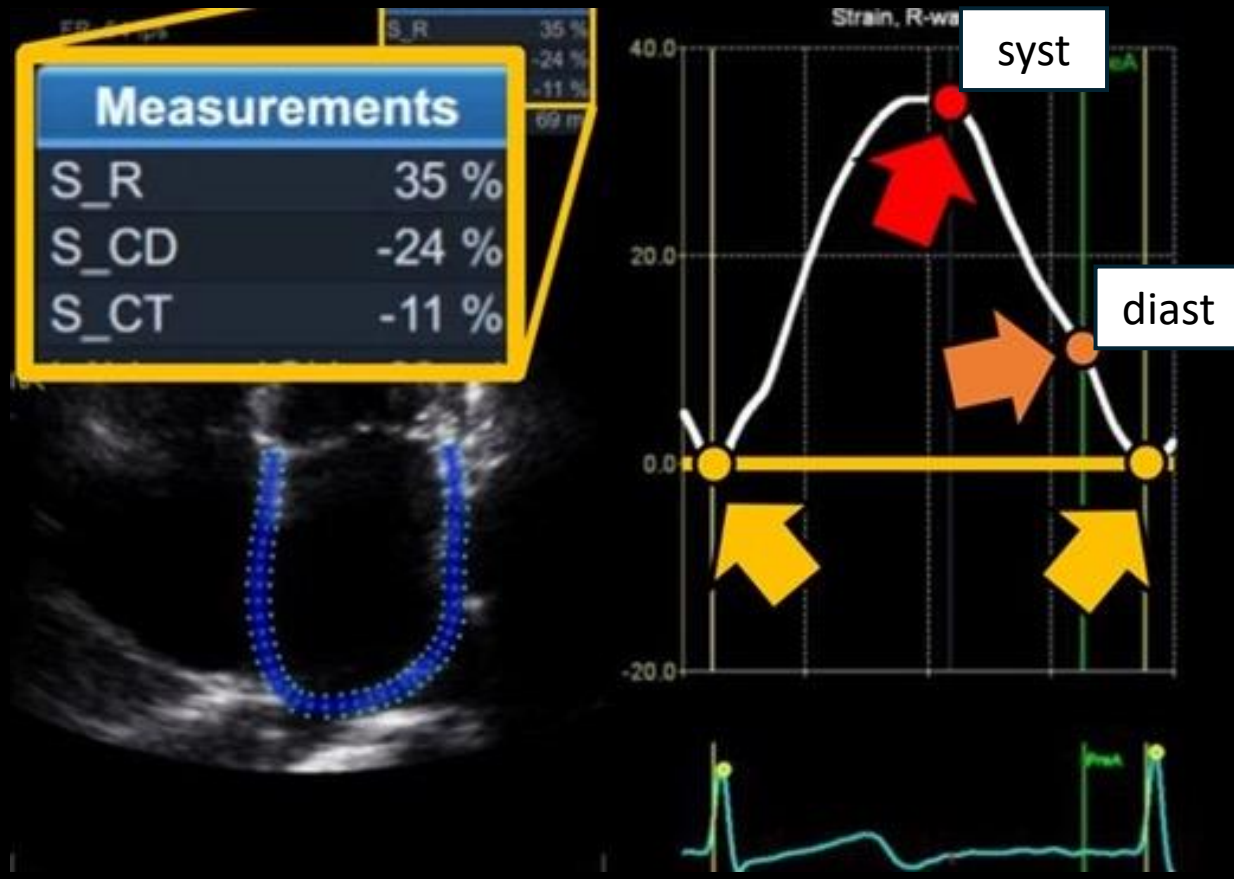
3 Phases of Deformation and Measurements

Systole: Ventricular contraction:

- Reservoir (LASr): + value

Diastole: Atrial contraction:

- Conduit (LAScd): Mid-Diastole, - value
- Contraction (LASc): End-Diastole, - value



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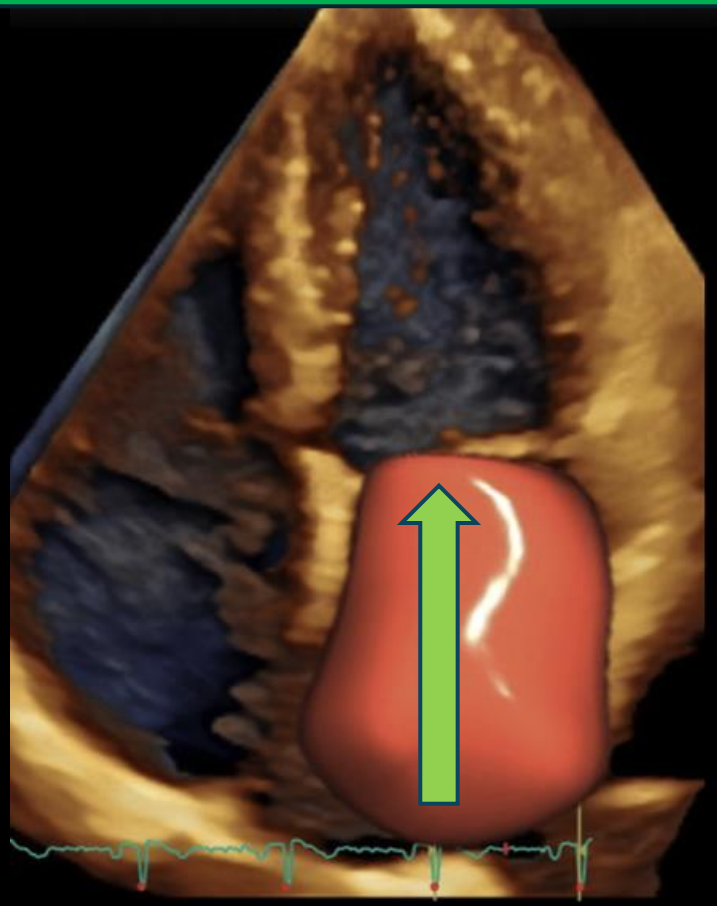
LARS reporting is recommended

LARS (reservoir) LA lengthening

LARS < 18 is indicator of diastolic dysfunction



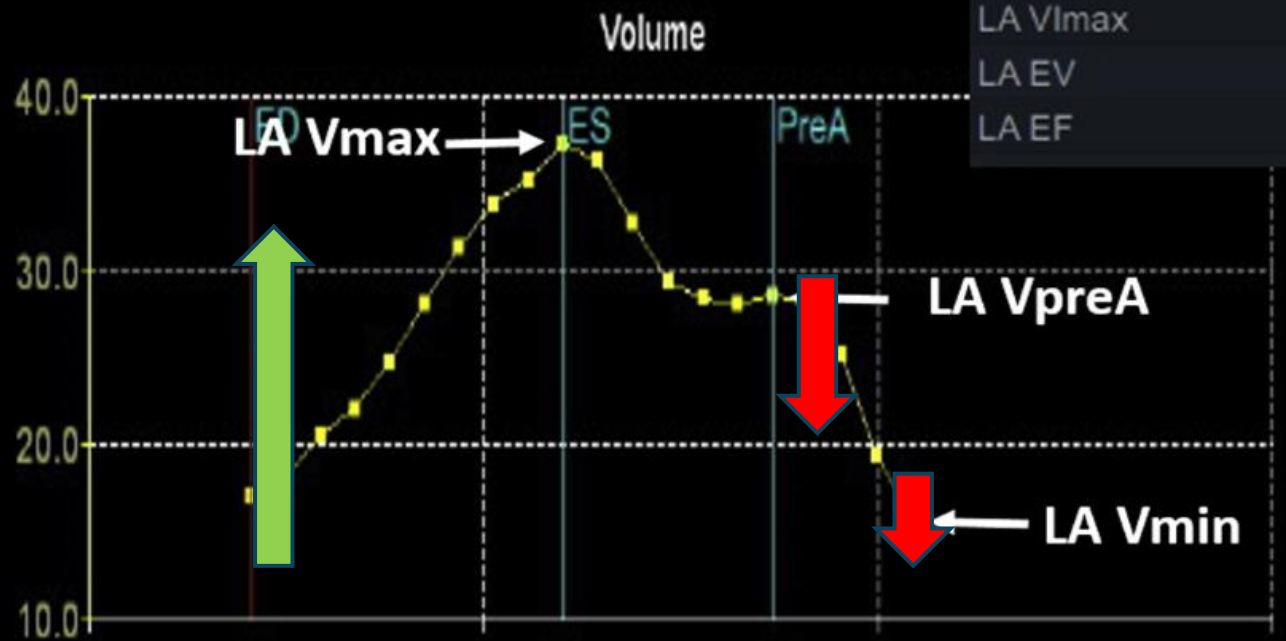
Reference ED | Reference

LASr_ED: 38.9 %

LAScd_ED: -29.1 %

LASct_ED: -9.9 %

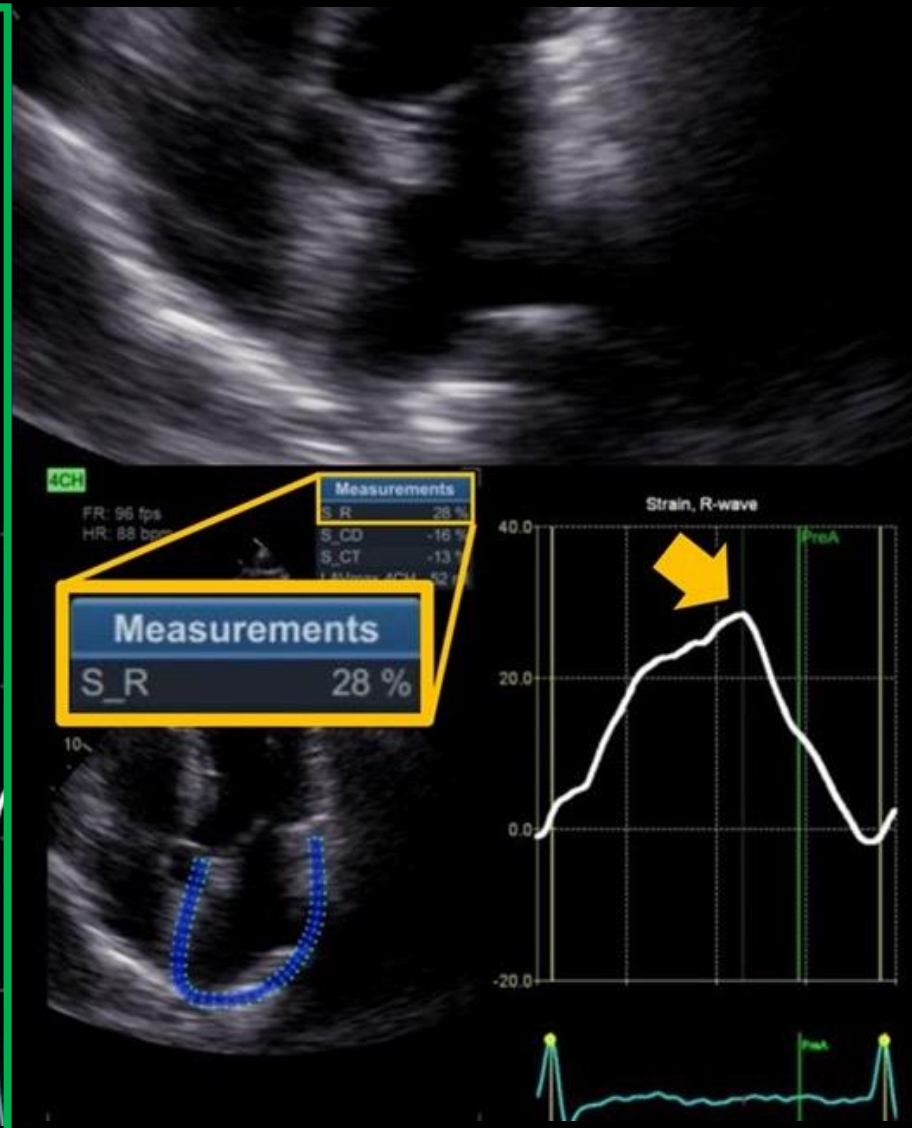
LA Vmin	16 ml
LA Vmax	37 ml
LA VpreA	29 ml
LA VImax	23 ml/m2
LA EV	22 ml
LA EF	58 %



Thomas et al J Am Soc Echocardiogr 2020,33:934-52

Optimize Images

- Narrow the sector to increase frame rate, line density and resolution
- Quality ECG and P wave



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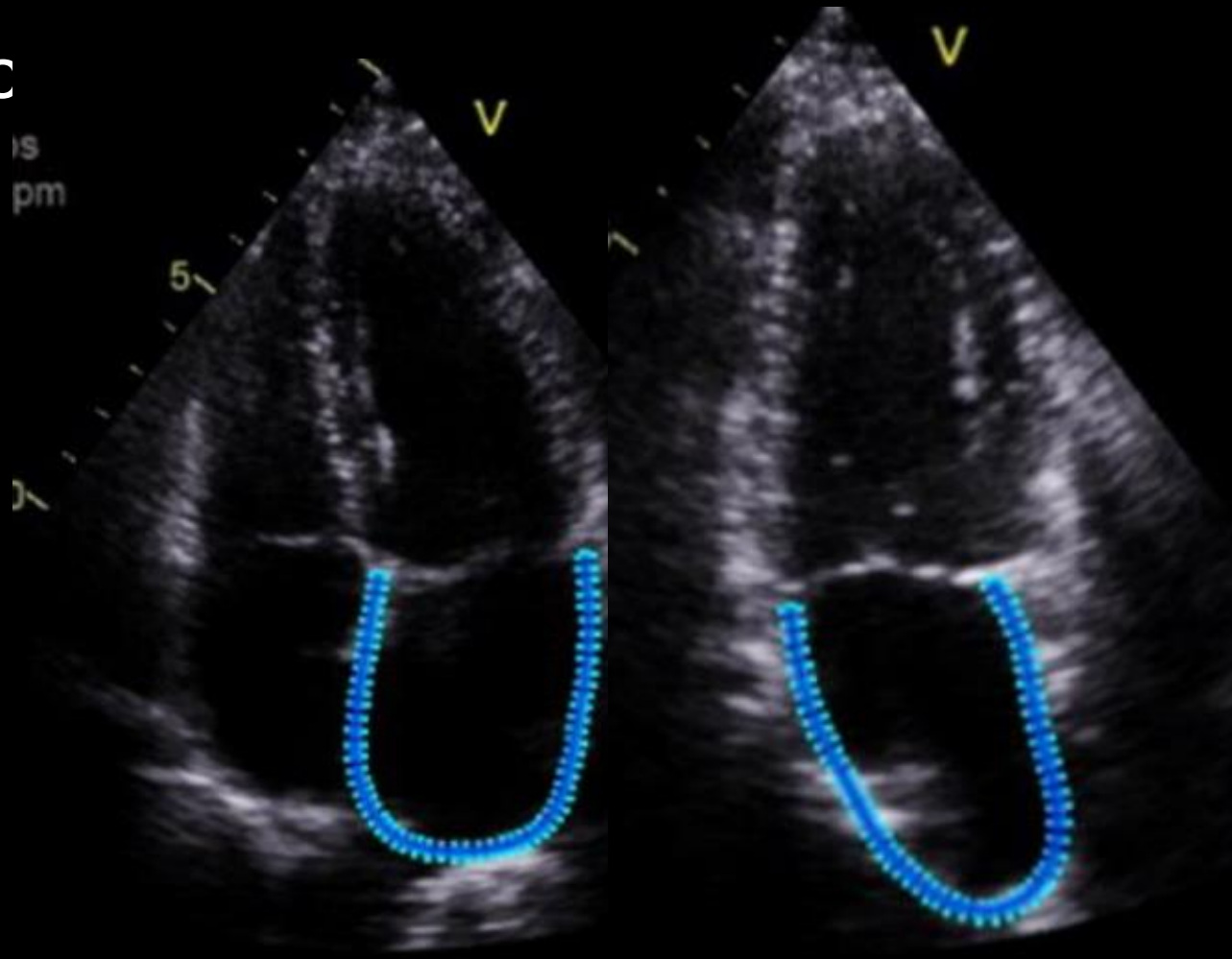
LA Fxn/Strain: **On-axis**, unzoomed, optimized images

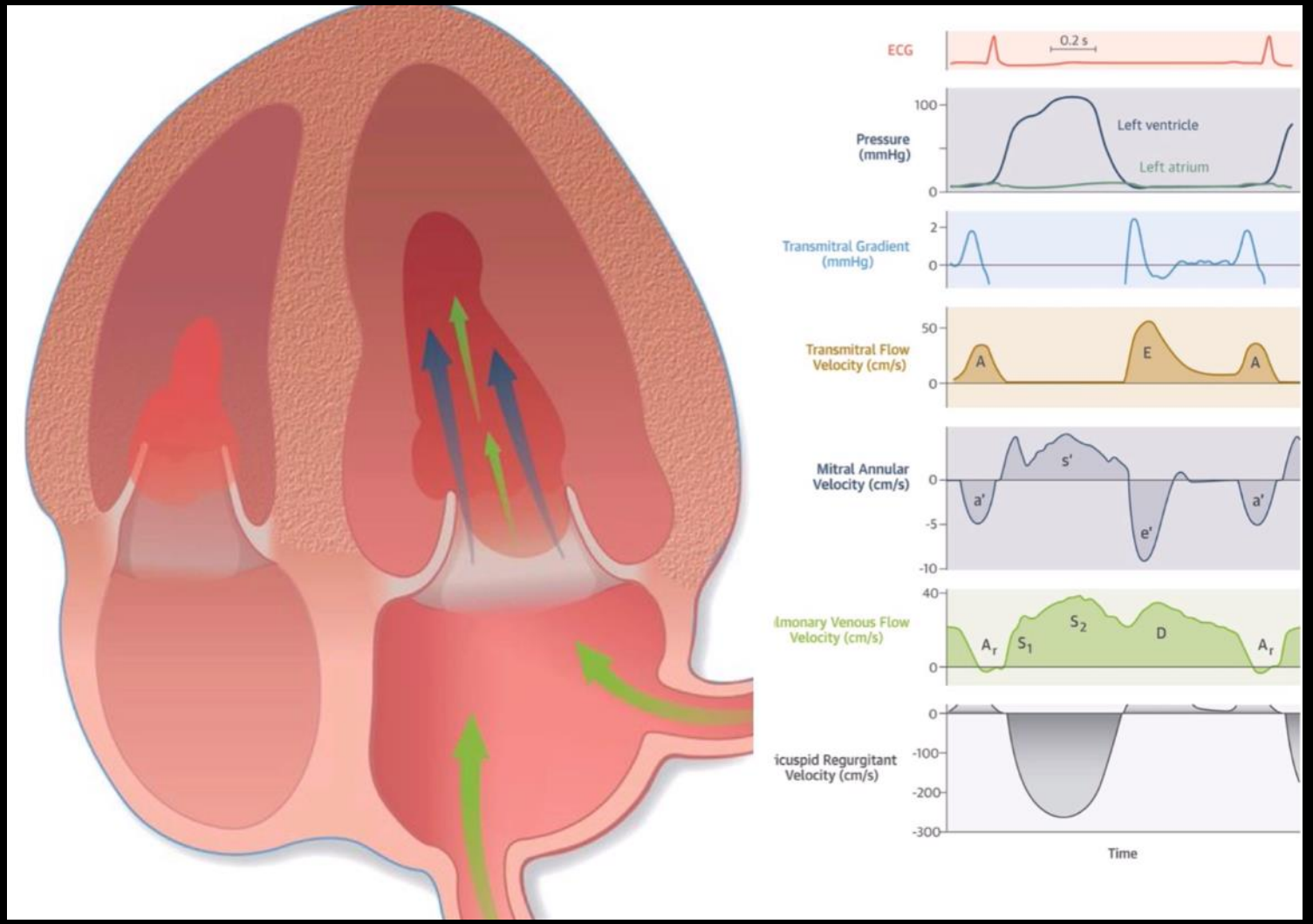
- Decrease gain and compression tc optimize clean blood pool LA tissue border throughout entire cardiac cycle
- Narrow sector for high frame rate (50-70 fps)
- 3-5 bt clip, ensure similar ht rt between views
- High-quality ECG with P wave
- Watch tracking!



Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

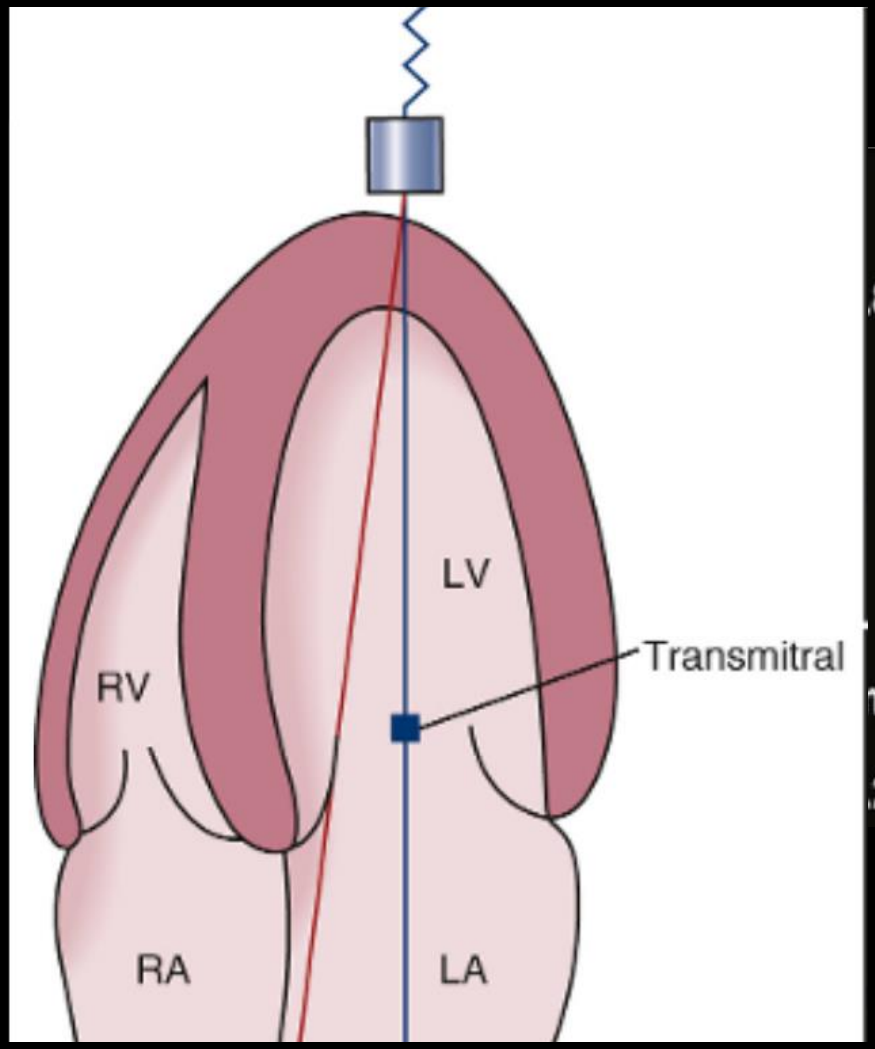
2) Assess LV relaxation, compliance

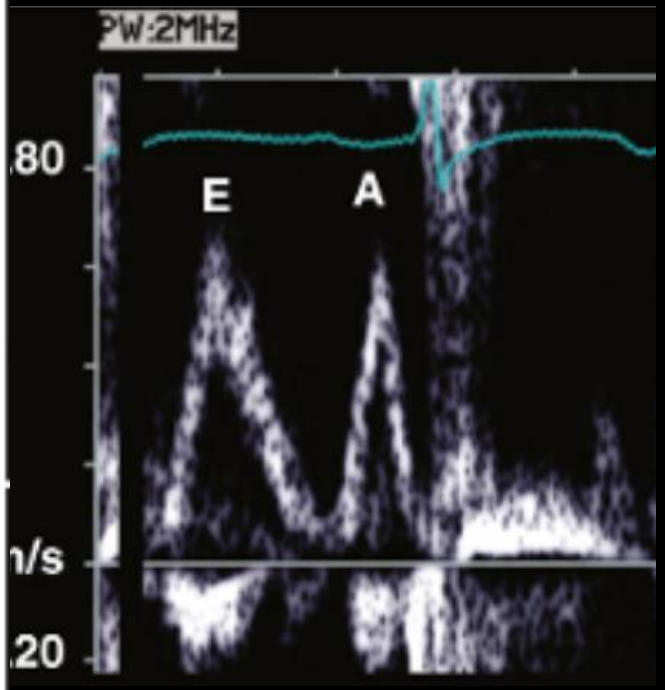
Doppler flow at MV leaflet tips reflect maximal pressure difference between LA and LV



Flachskampf, F.A. et al. J Am Coll Cardiol Img. 2015;8(9):1071-93

Apical 4C view, PW @ mitral leaflet tips





- Low wall filter (100-200 MHz)
- 2-3 mm sample volume
- Parallel to flow
- Normal expiration
- Decrease gain as needed
- Measure peak at leading edge of spectral waveform
- Goal as always is nice clean waveform

Otto CM, ed. *Textbook of Clinical Echocardiography, 6th edition.* Elsevier Saunders, Philadelphia, Pennsylvania 2018

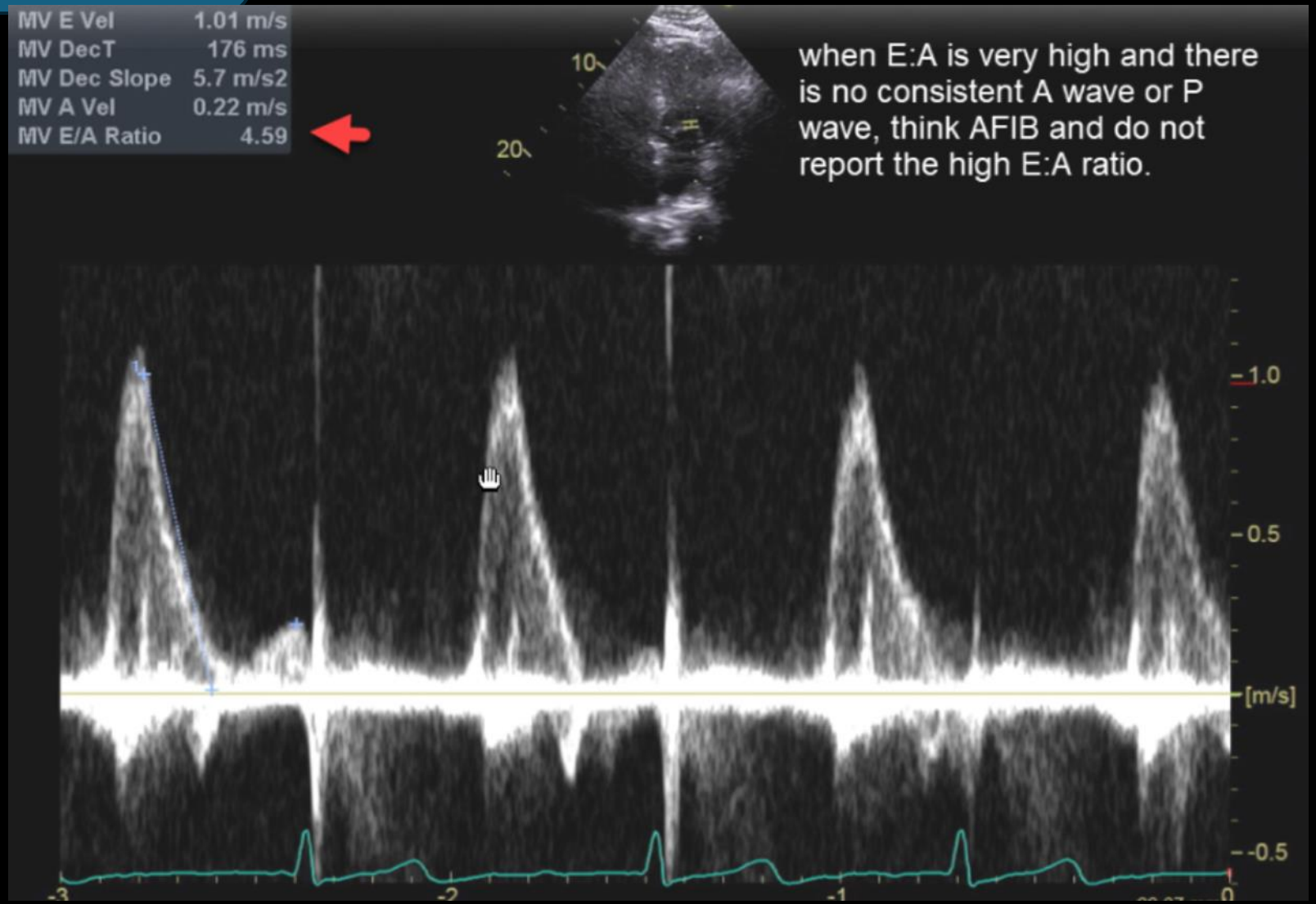
Transmitral Inflow: E and A

- Minimal spectral broadening or feathering
- Info obtained:
  - E
  - A
  - Deceleration time
  - E/A ratio
  - A duration

Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

To fib or not to fib?

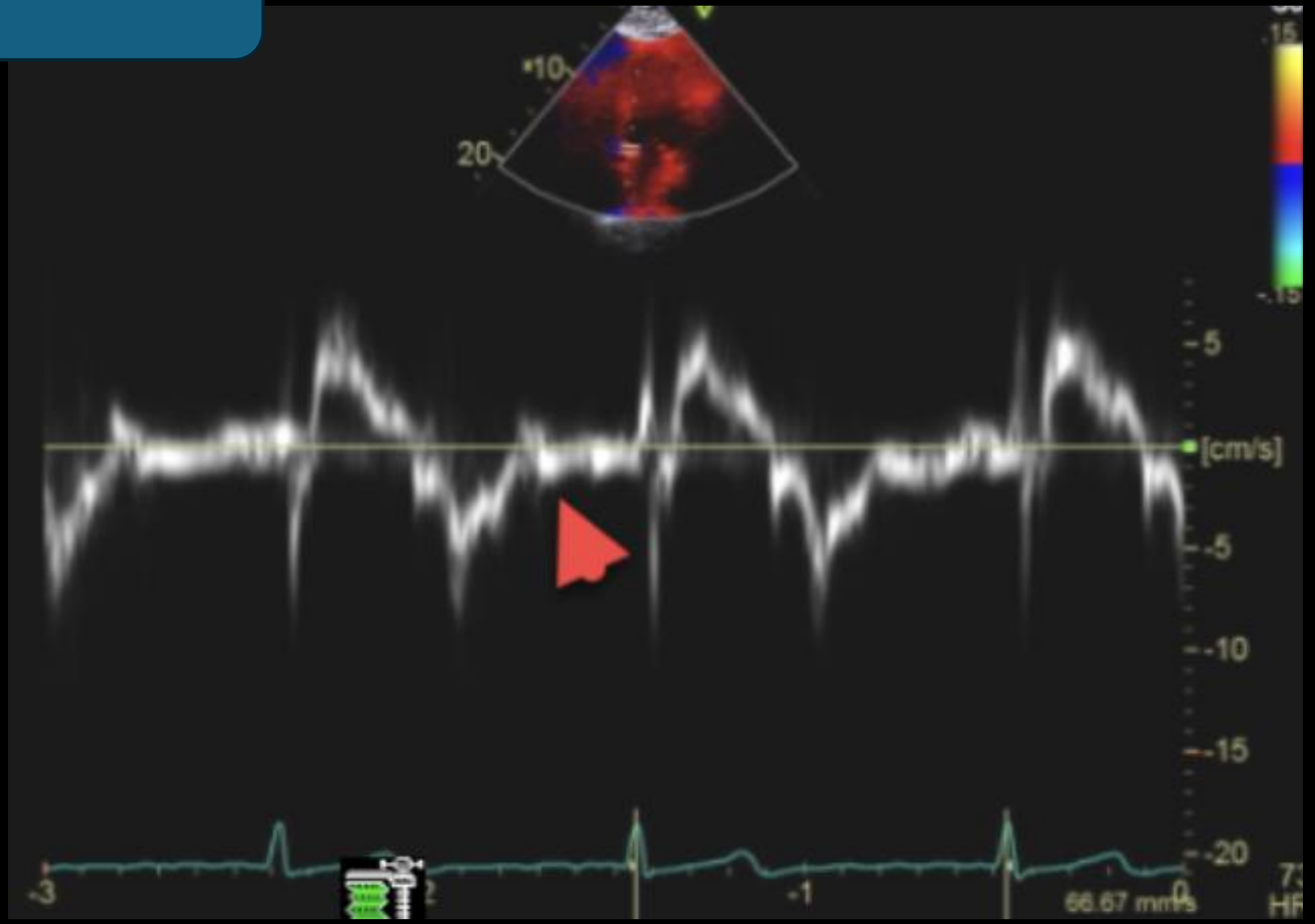
If no clear consistent A wave, don't measure and don't report E/A ratio



Courtesy of Dr. Gerald Cohen

To fib or not to fib?

Tip:
Fibrillatory signals in the tissue Doppler = no consistent a’

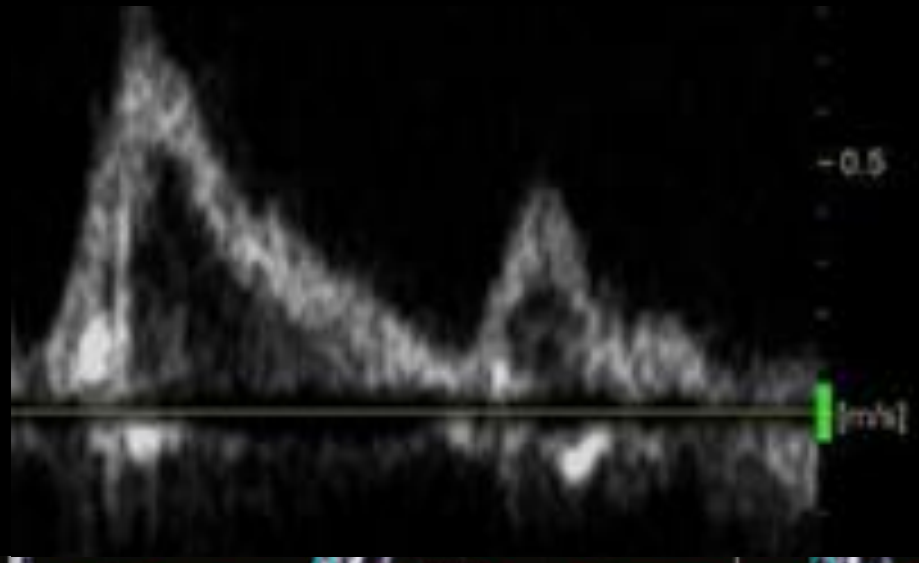


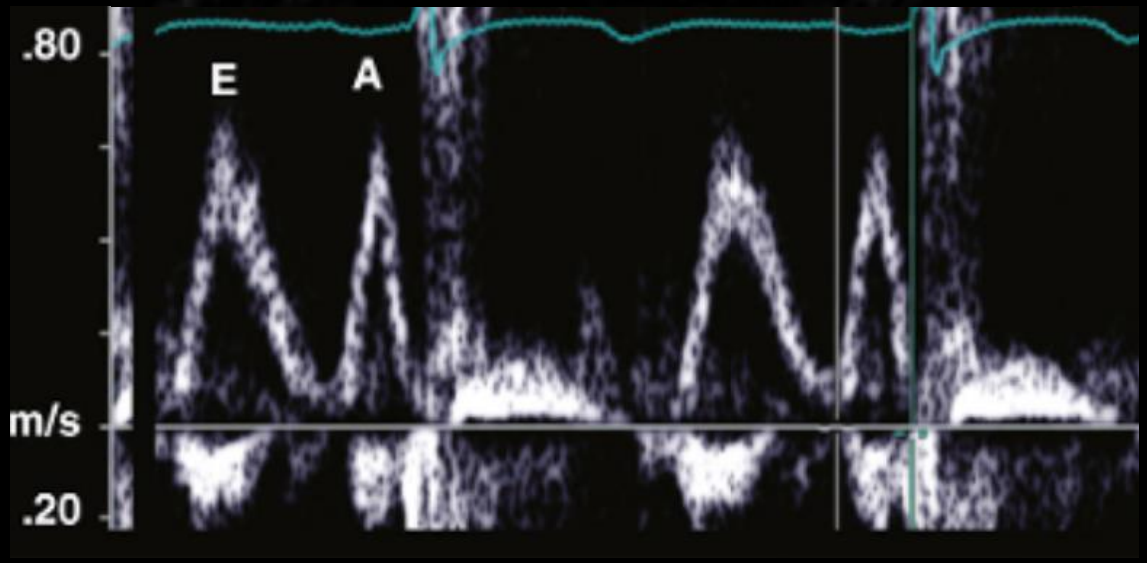
Courtesy of Dr. Gerald Cohen

Importance of E/A ratio

- Both examples show E > A, which is a requirement for normal MV inflow pattern
- Notice how much bigger the E is in this first normal MV inflow pattern
- Does that make a difference?
- This is where the importance of the Valsalva maneuver comes in…

Both look pretty normal right?

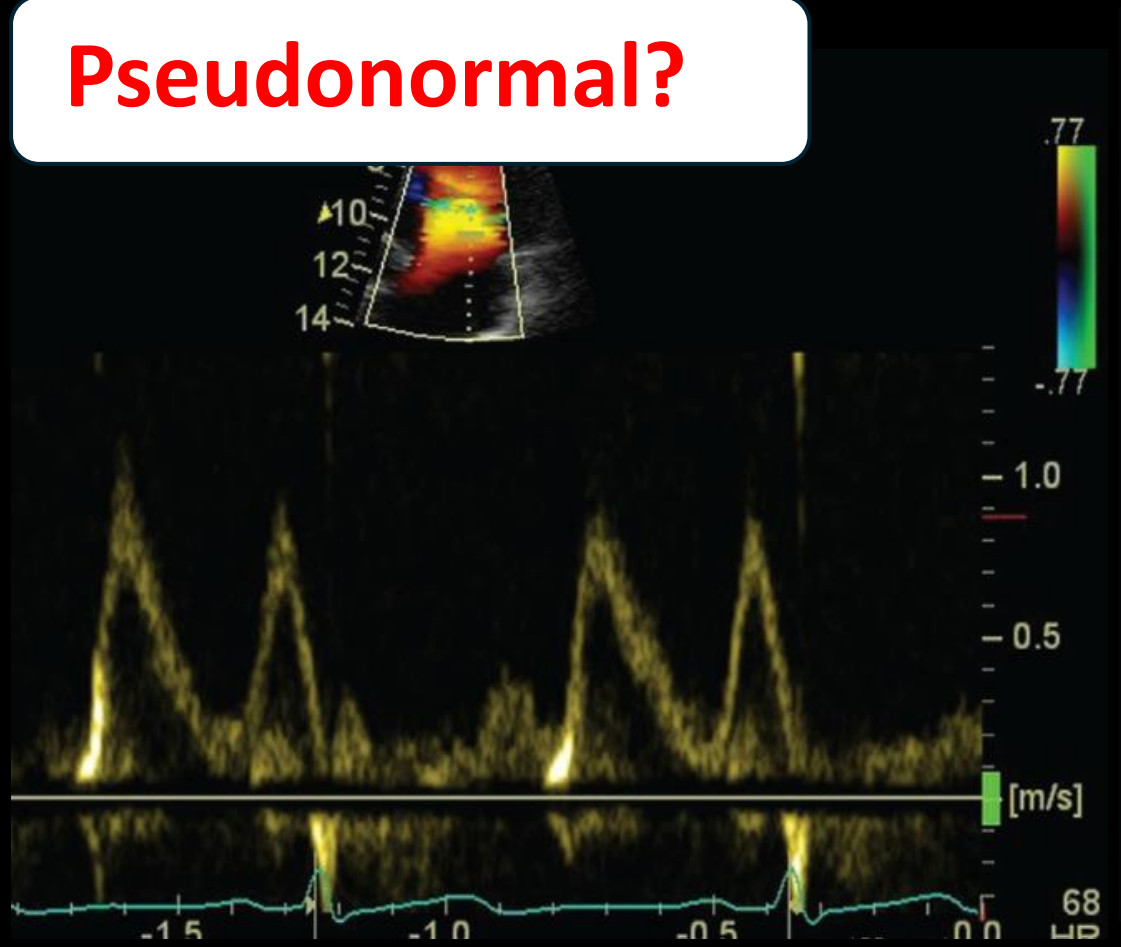




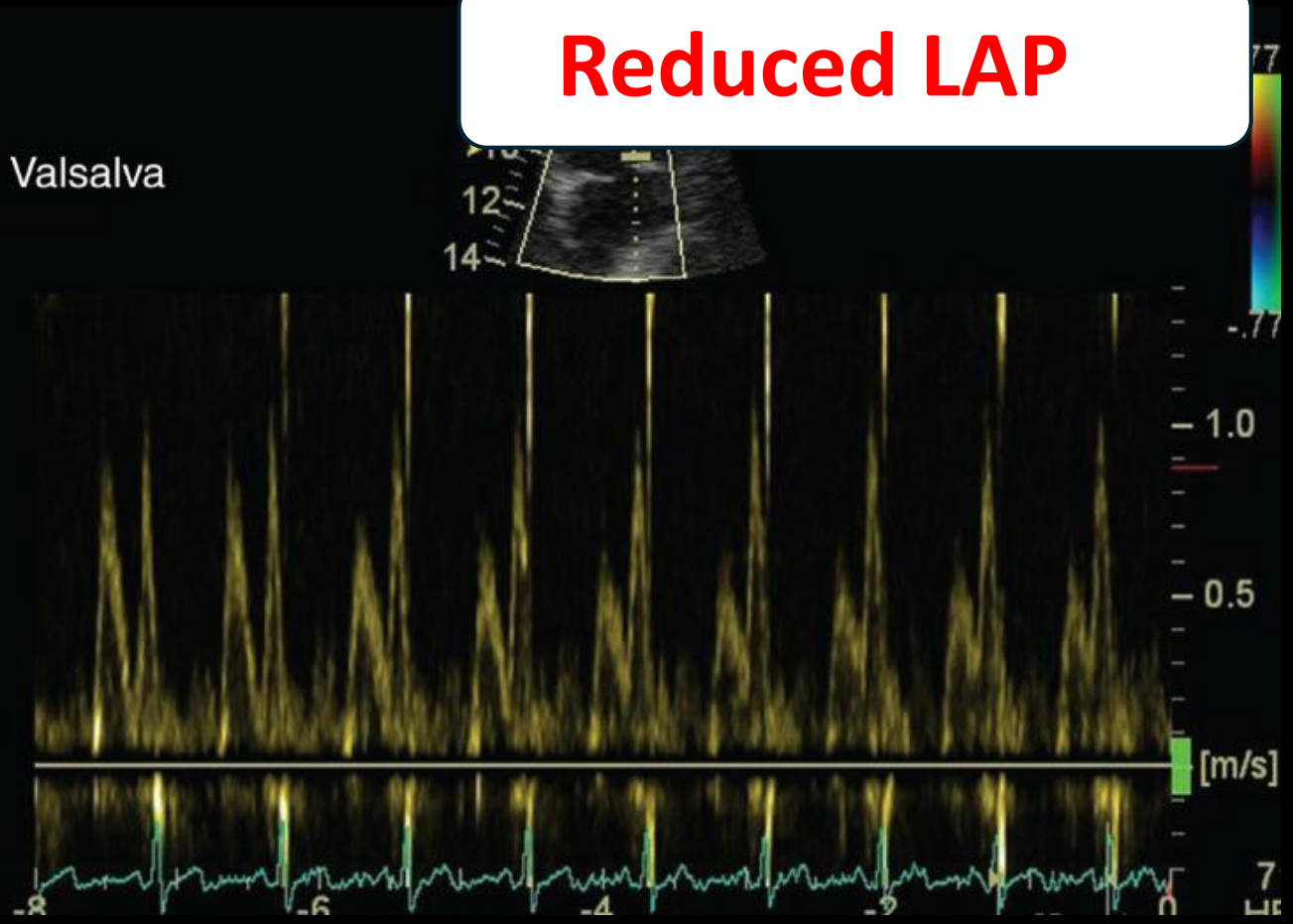
MV inflow assessment **includes** a Valsalva maneuver

- Decrease preload to see if this is the real pattern

Pseudonormal?



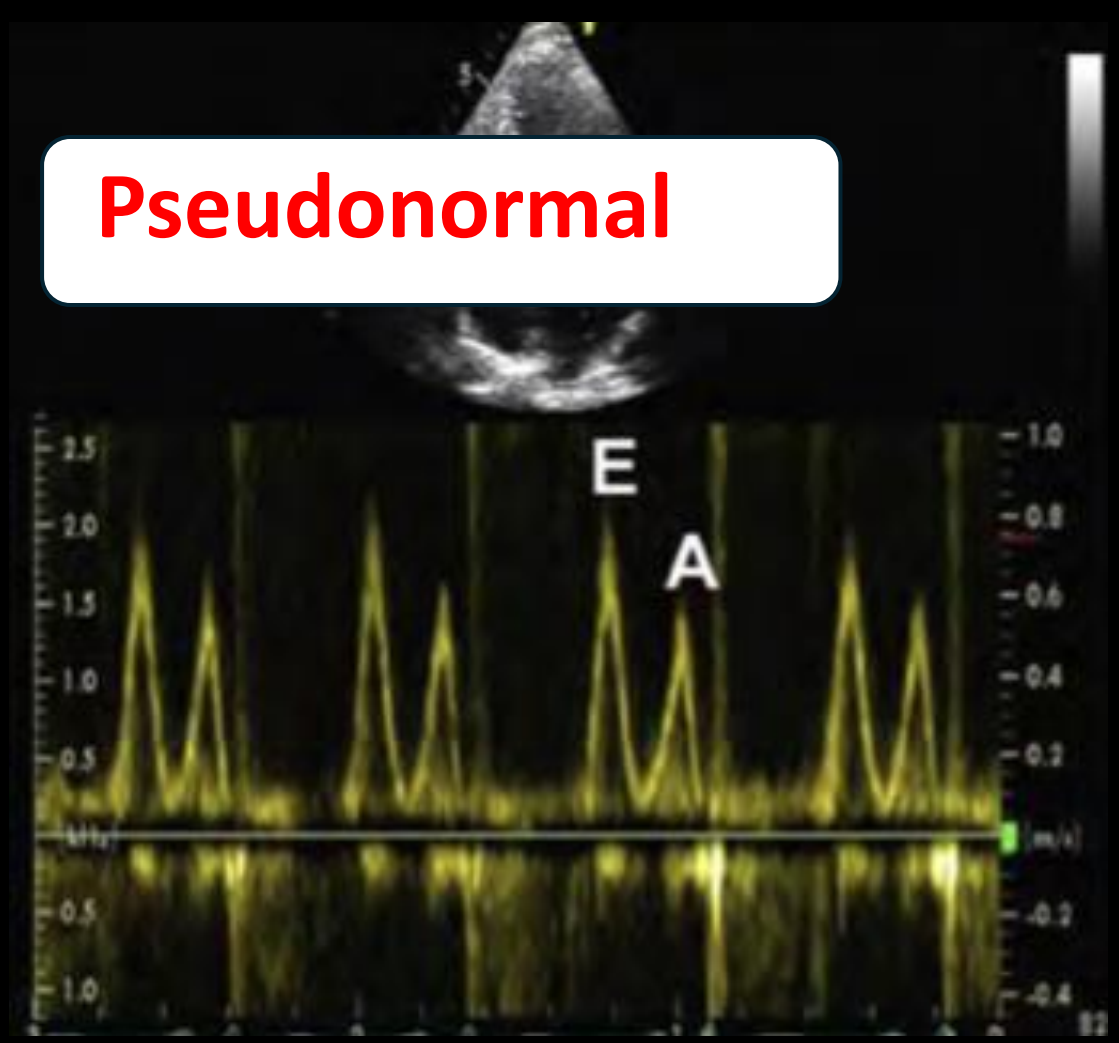
Reduced LAP

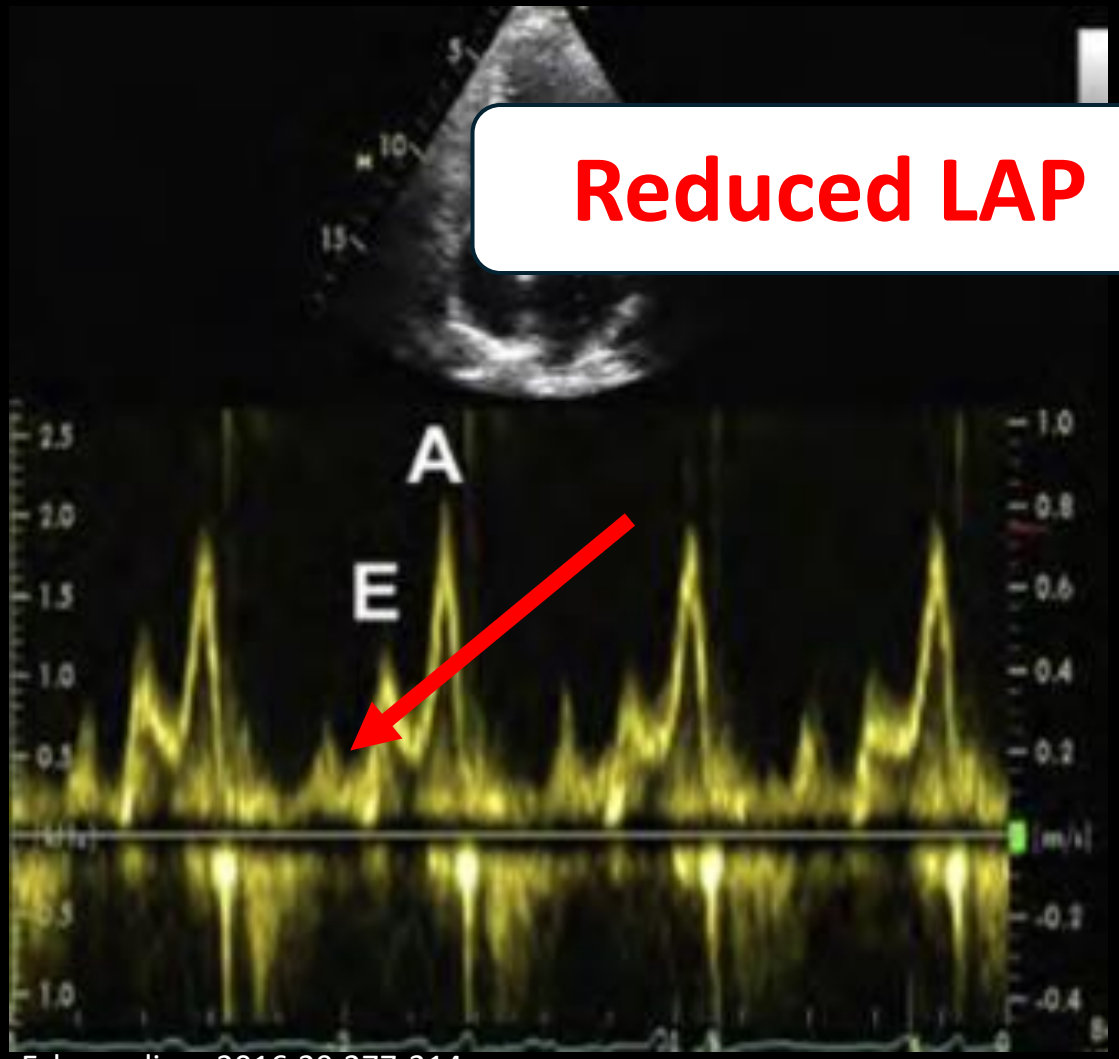


Anderson BA Burstow DJ Diastolic Echocardiographic Examination 2021

Valsalva reduces LA pressure

- E and A reversal confirms impaired filling



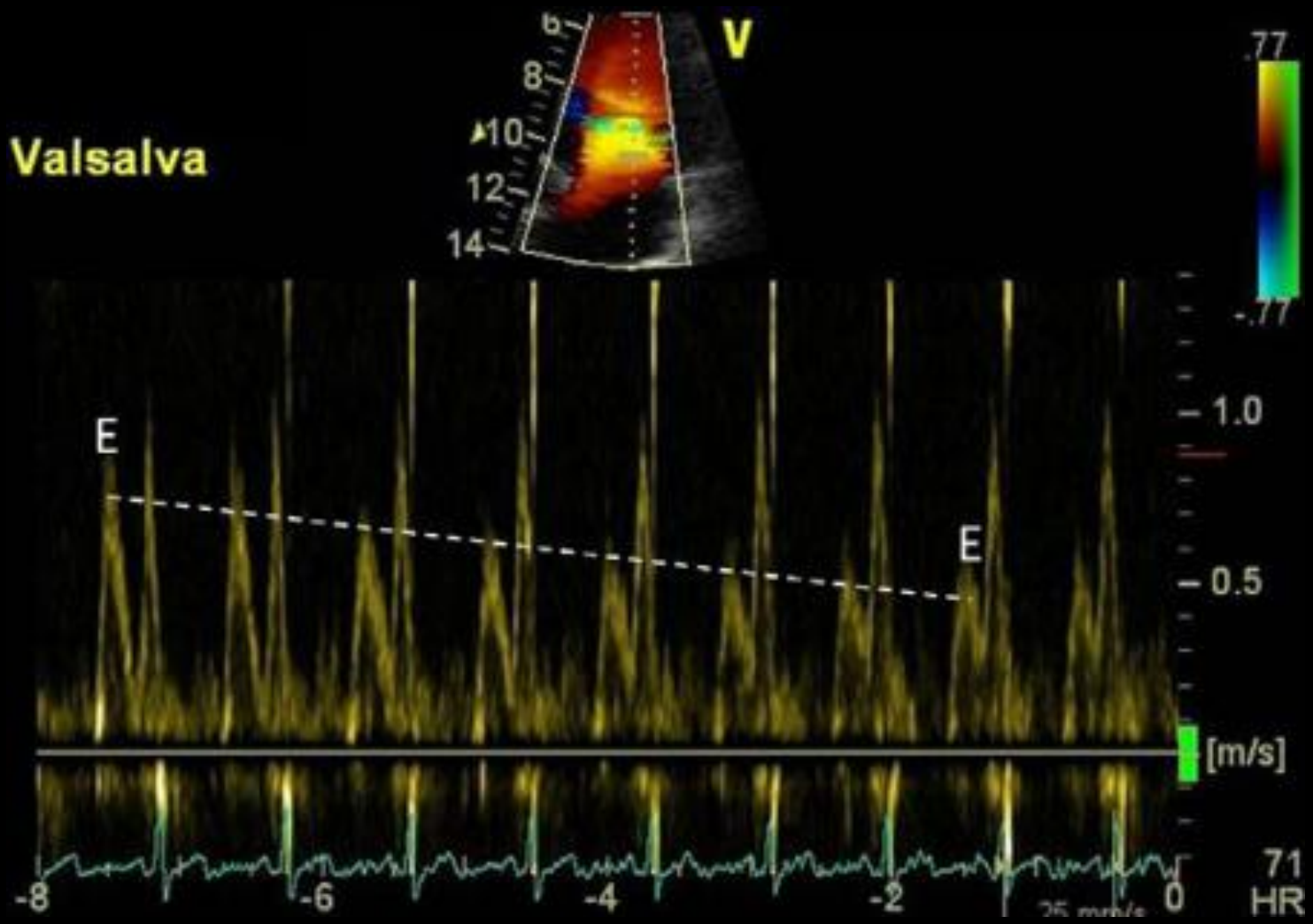


Nagueh, S F et al. J Am Soc Echocardiogr 2016:29:277-314

Valsalva Maneuver

See Vlad if want more details

- Transmitral flow signal recorded for 10-12 sec during strain phase of maneuver
- Decrease sweep speed
- Adequate Valsalva may be defined as a > 10% reduction in max E-wave velocity from baseline
- And…



Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Valsalva Maneuver

- **Decrease of greater than or equal to 50% in E/A ratio, is highly specific for increased filling pressures**
- Valsalva is most useful to differentiate stage 2 dd from normal

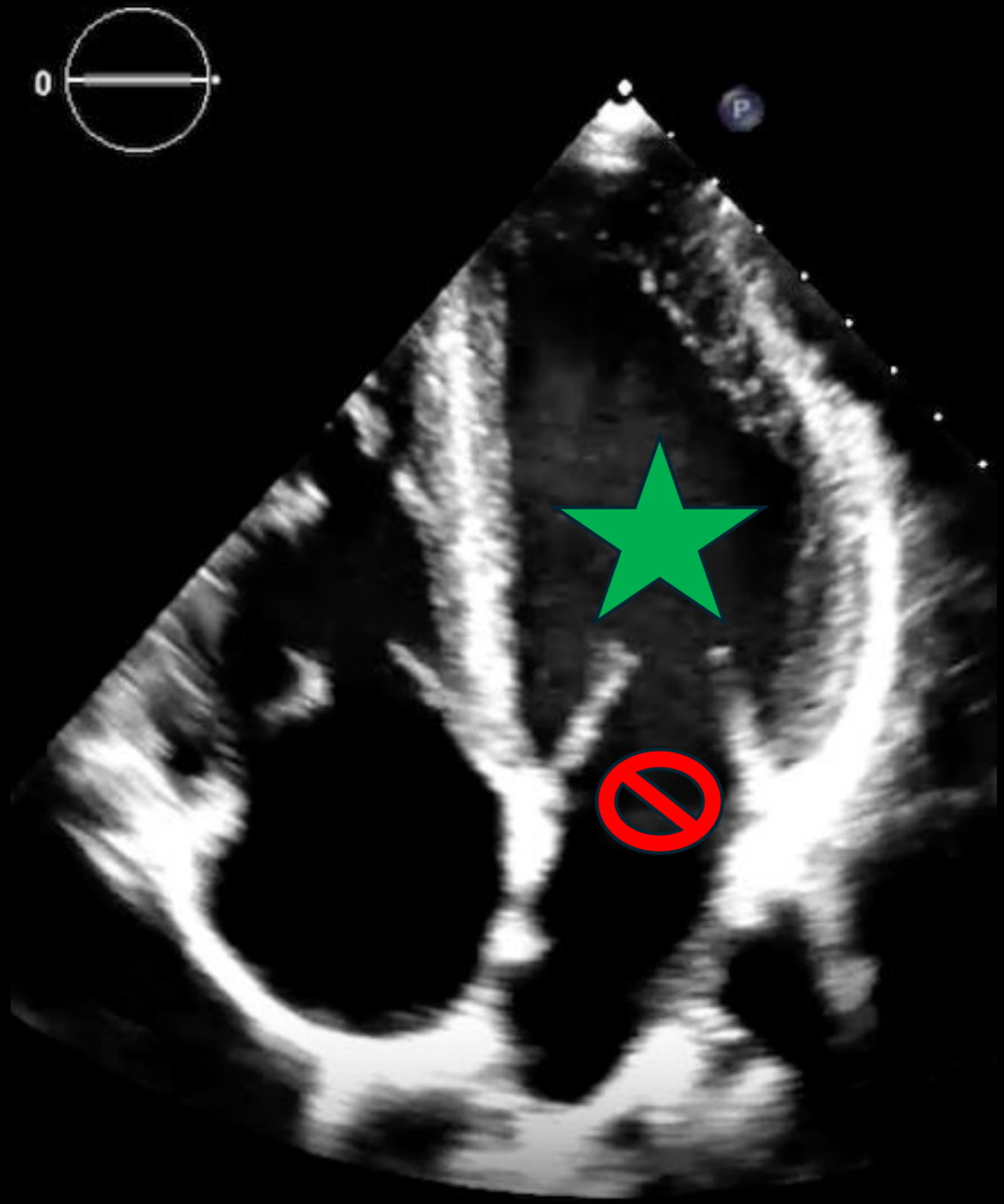
Pattern	Baseline	Valsalva	Assessment
Normal			Normal
Stage 1A			Normal filling pressures
Stage 1B			↑LV A wave, ↑EDP
Stage 2			Pseudonormal
Stage 3			Reversible restrictive
Stage 4			Irreversible restrictive

Anderson, BA Basic to Advanced Clinical Echocardiography: A Self Assessment …2021 Wolters Kluwer.

Common Errors

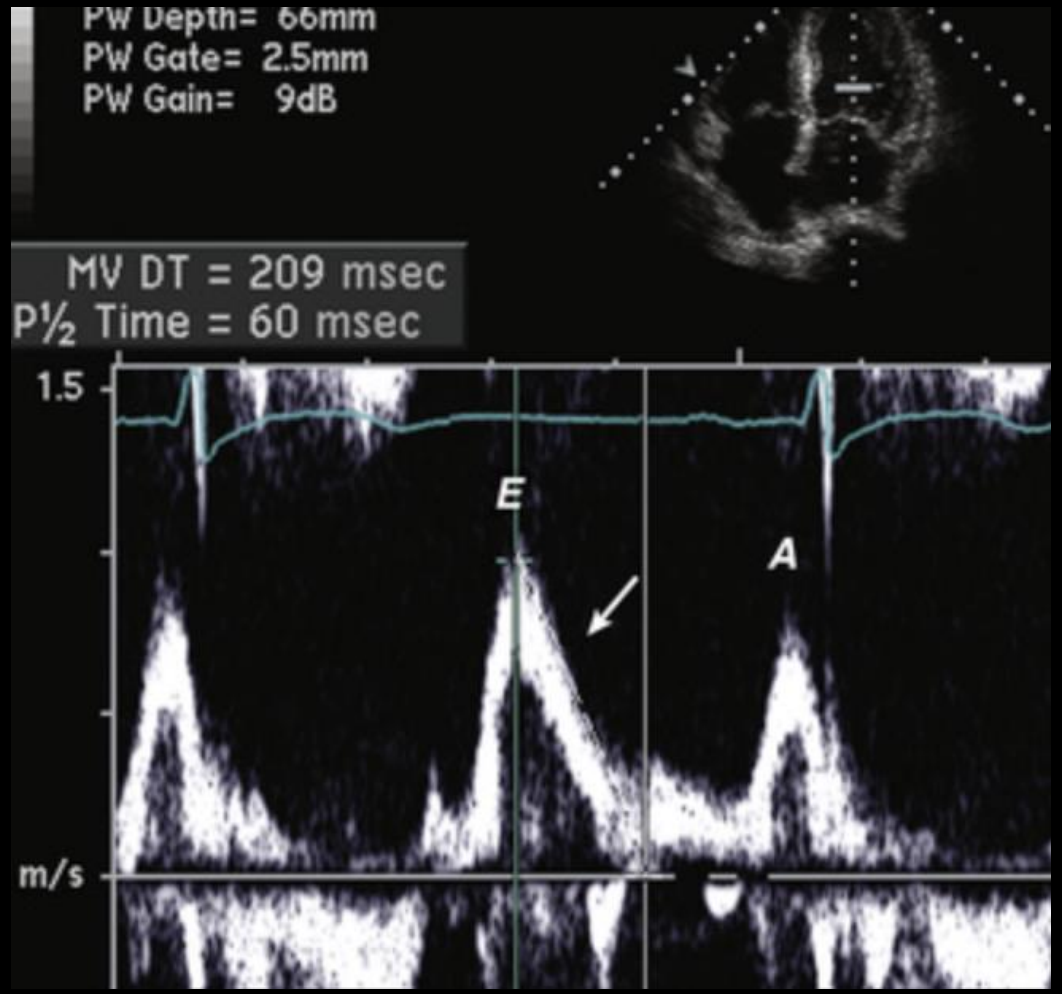
PW Sample Location!

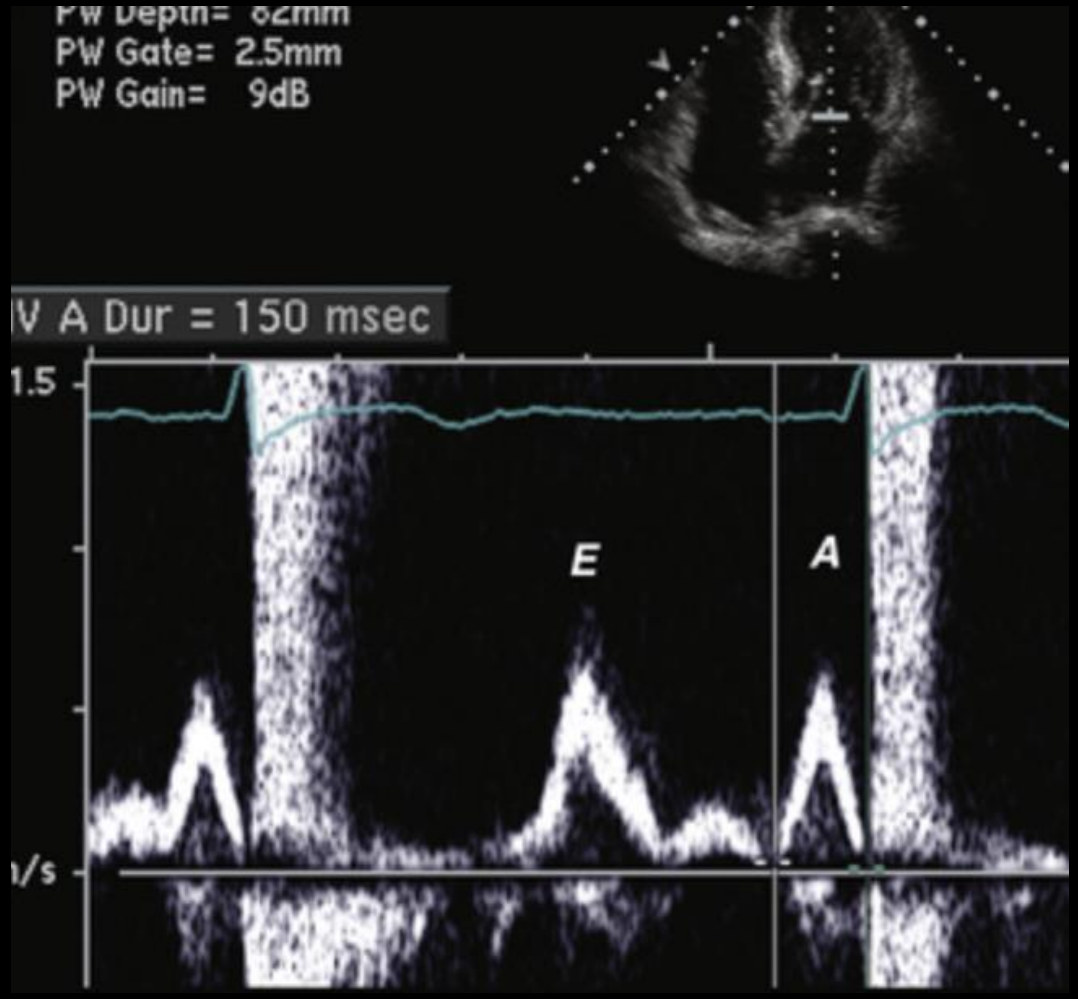
- Orifice is smaller at leaflet tips, which is in the LV we are trying to assess
- Orifice at annulus is larger and used for stroke volume



Leaflet tips smaller orifice = higher velocity

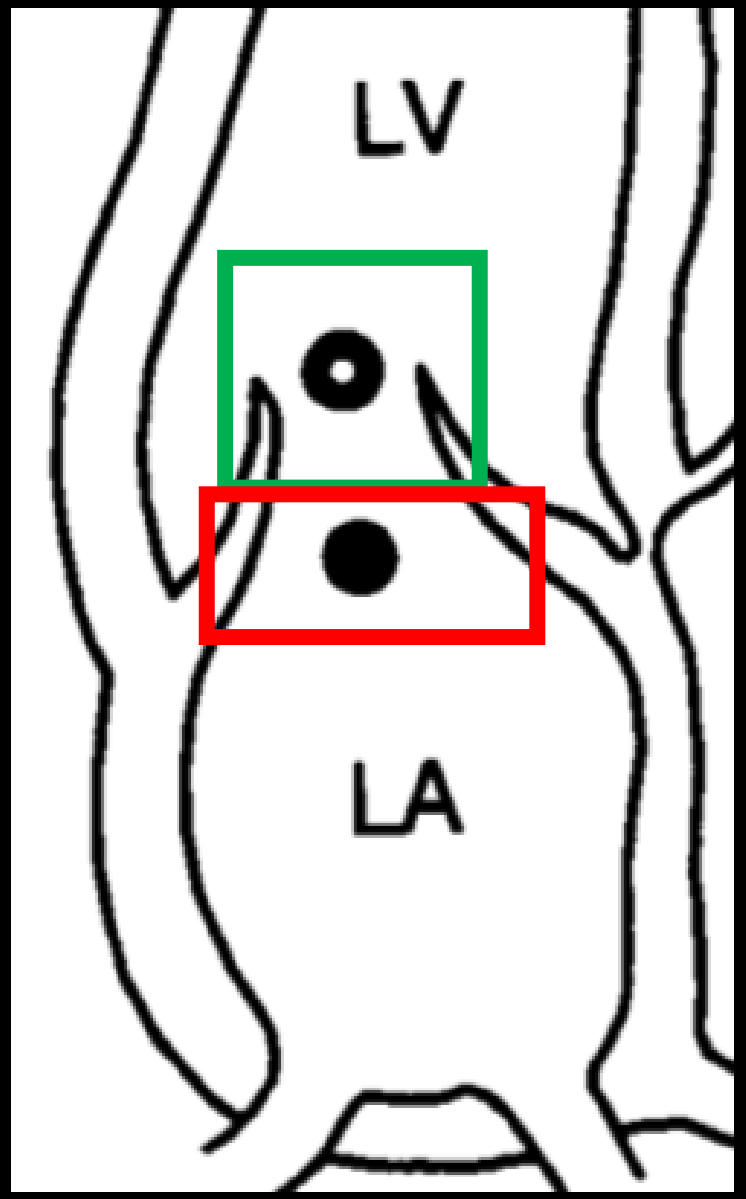
MVA bigger orifice = lower velocity





Otto CM, ed. *Textbook of Clinical Echocardiography, 5th edition.* Elsevier Saunders, Philadelphia, Pennsylvania 2016

Sample Placement Matters!

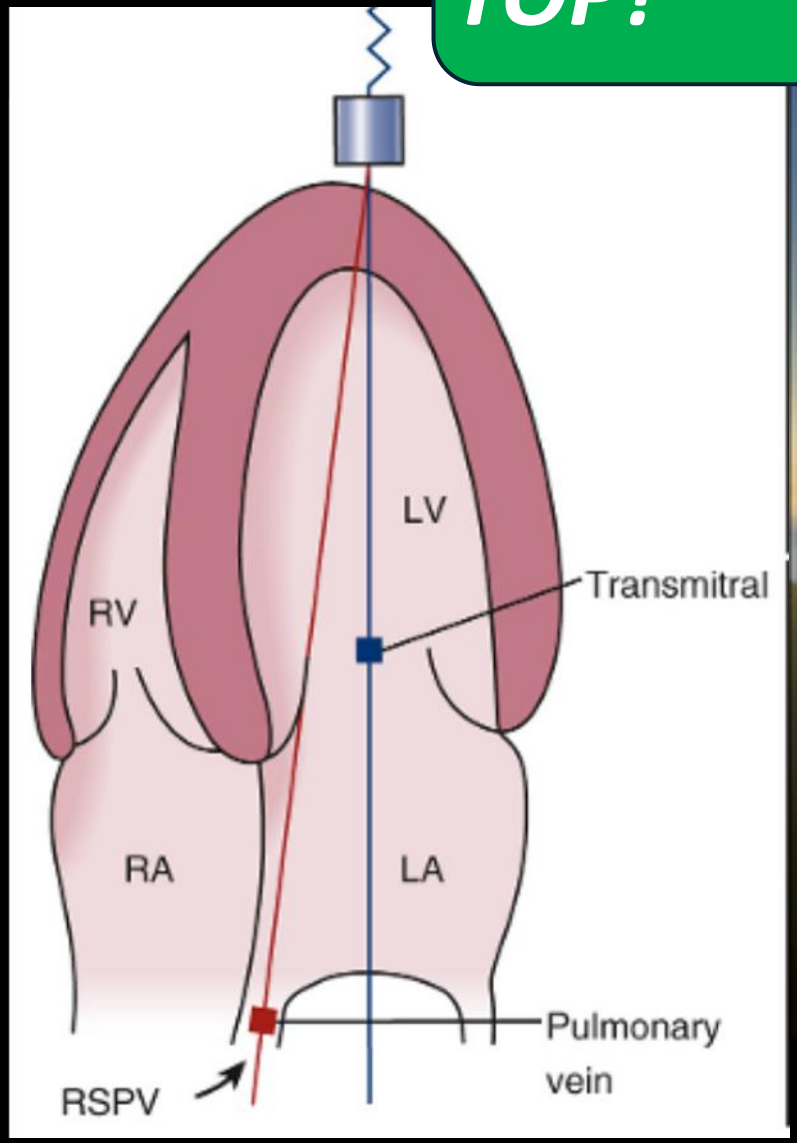


Higher velocity through smaller area

Velocities are *significantly* higher at leaflet tips, (smaller area)

Ding et al J Am Soc Echocardiogr 1991;4:451-6

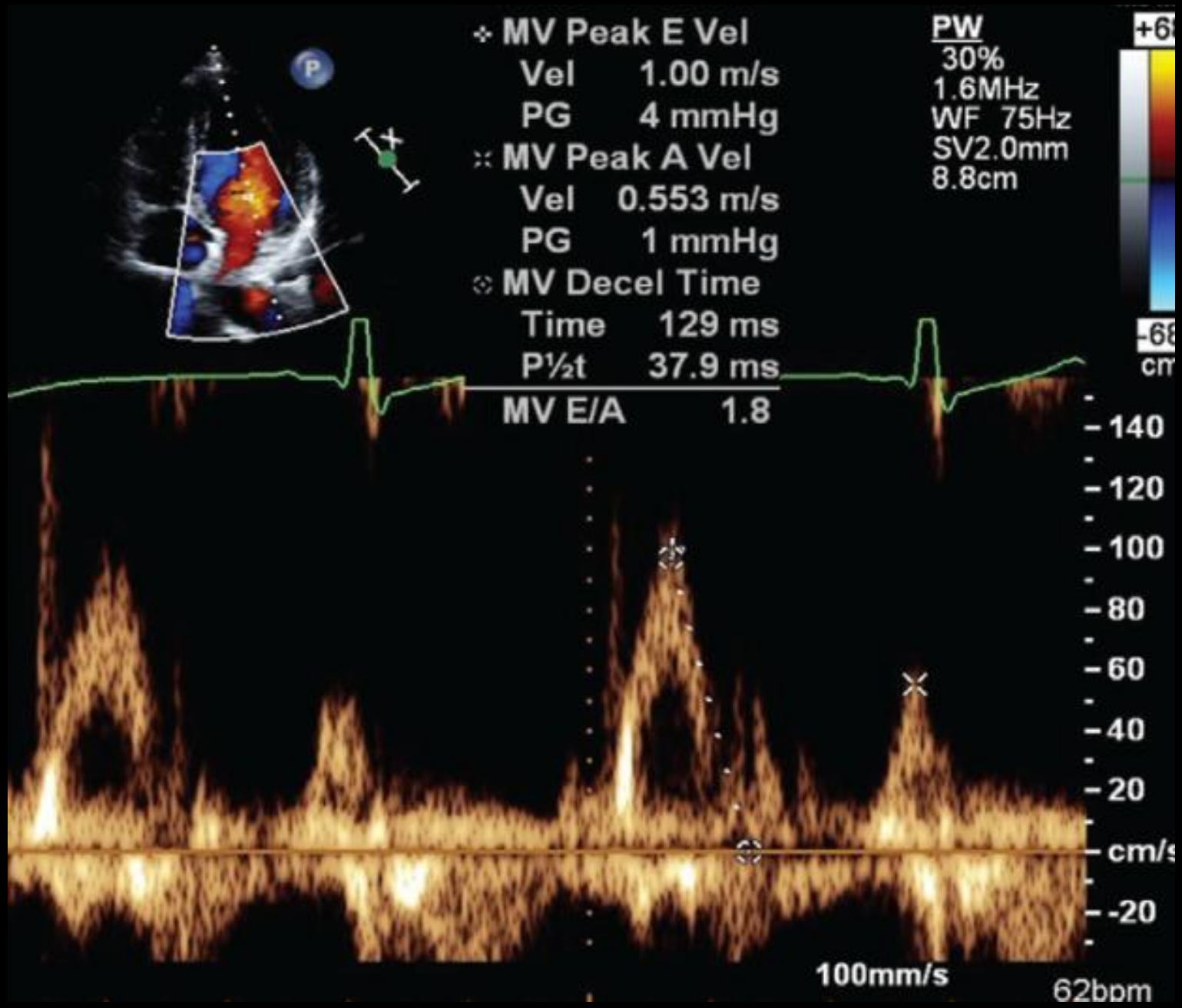
Remember for MV inflow….***take it to the TOP!***



Otto CM, ed. *The Practice of Clinical Echocardiography, 5th edition.* Elsevier Saunders, Philadelphia, Pennsylvania 2016

Common errors

- Poor alignment, less accurate (shaggy and bent? clues)

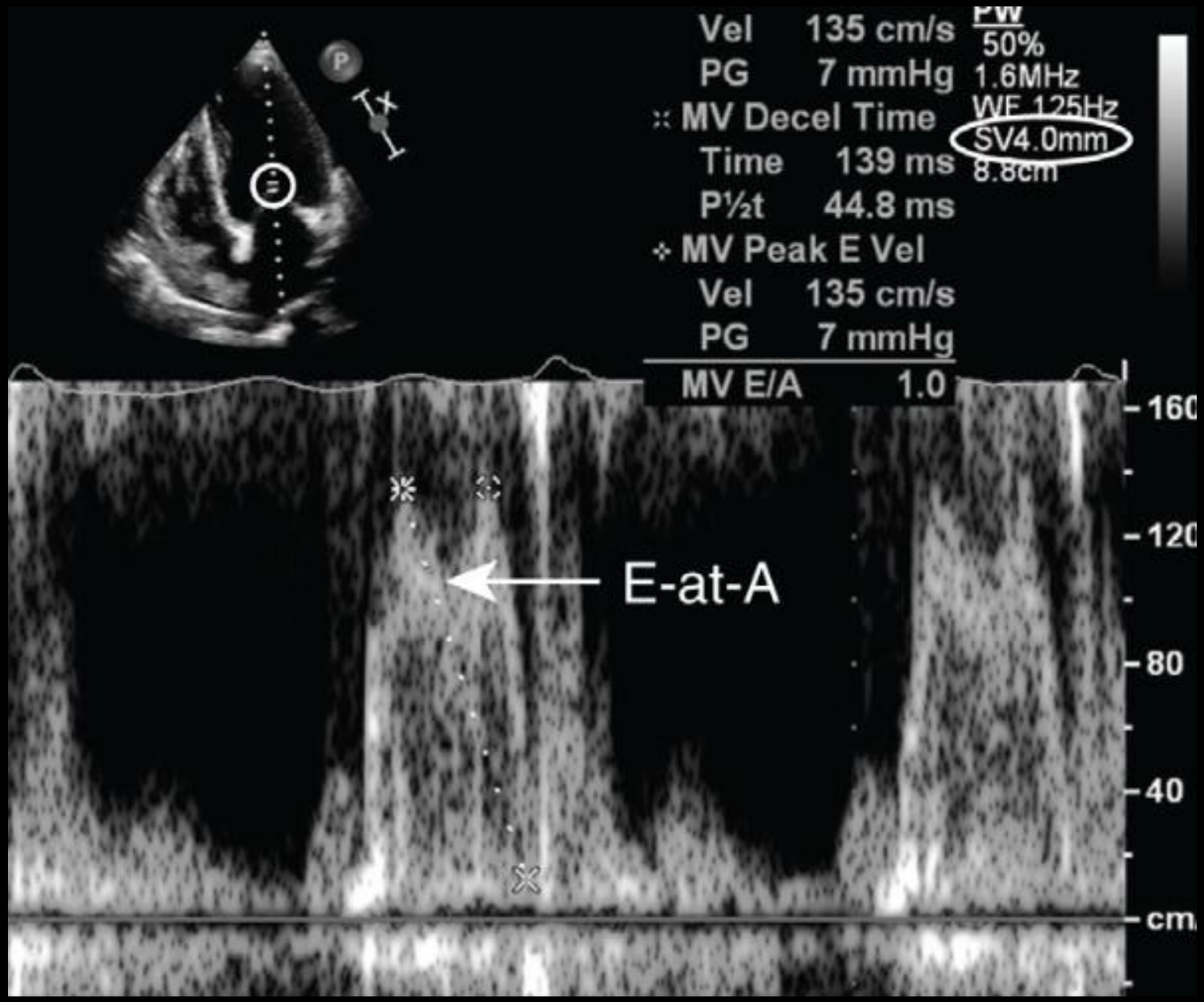


Anderson BA Burstow DJ Diastolic Echocardiographic Examination 2021

Common errors

- SV of 4mm (too wide resulting in spectral broadening-should be < 3 mm)

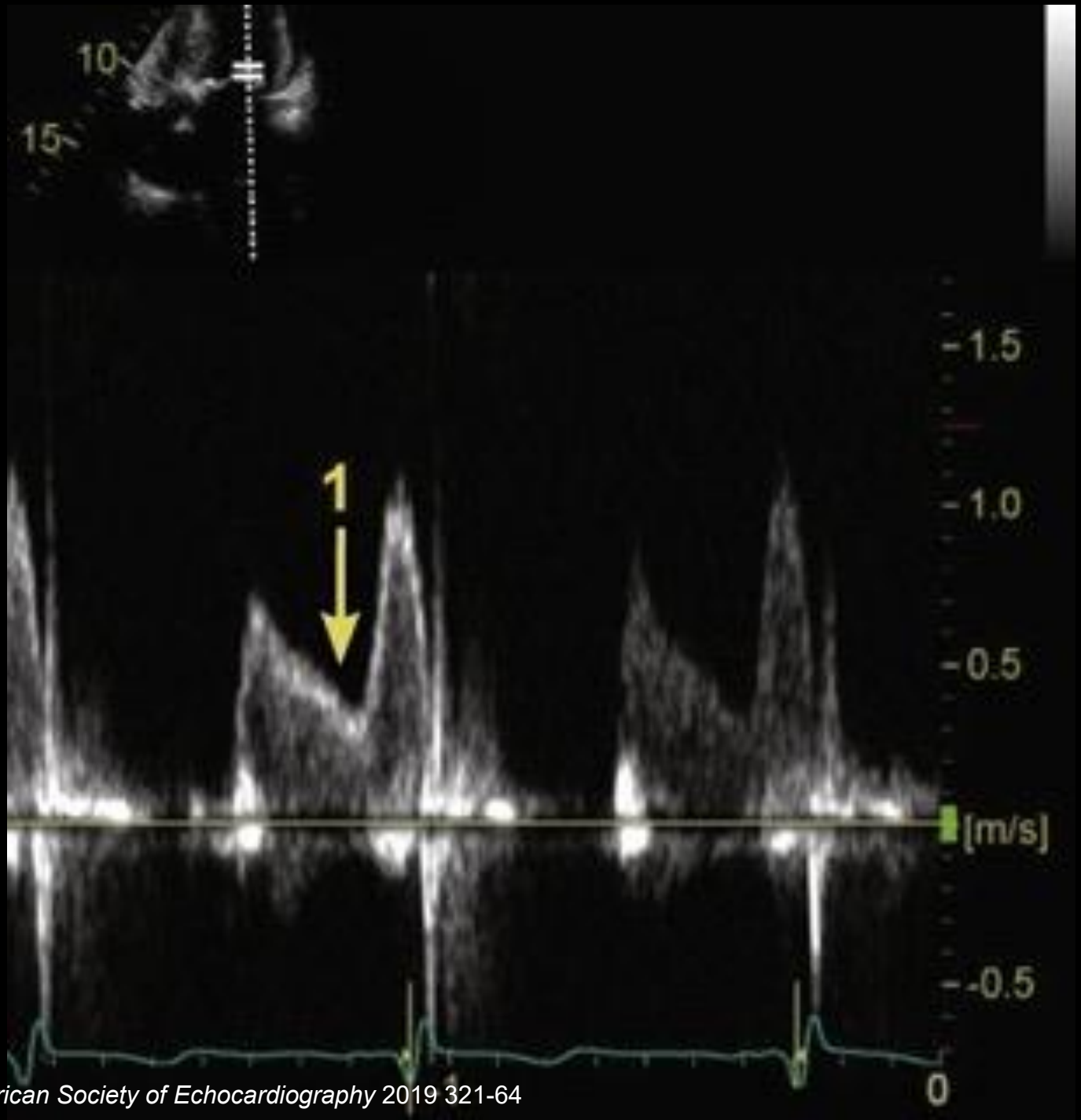
- Fused E/A interrupts DT



Anderson BA Burstow DJ Diastolic Echocardiographic Examination 2021

Q Tip

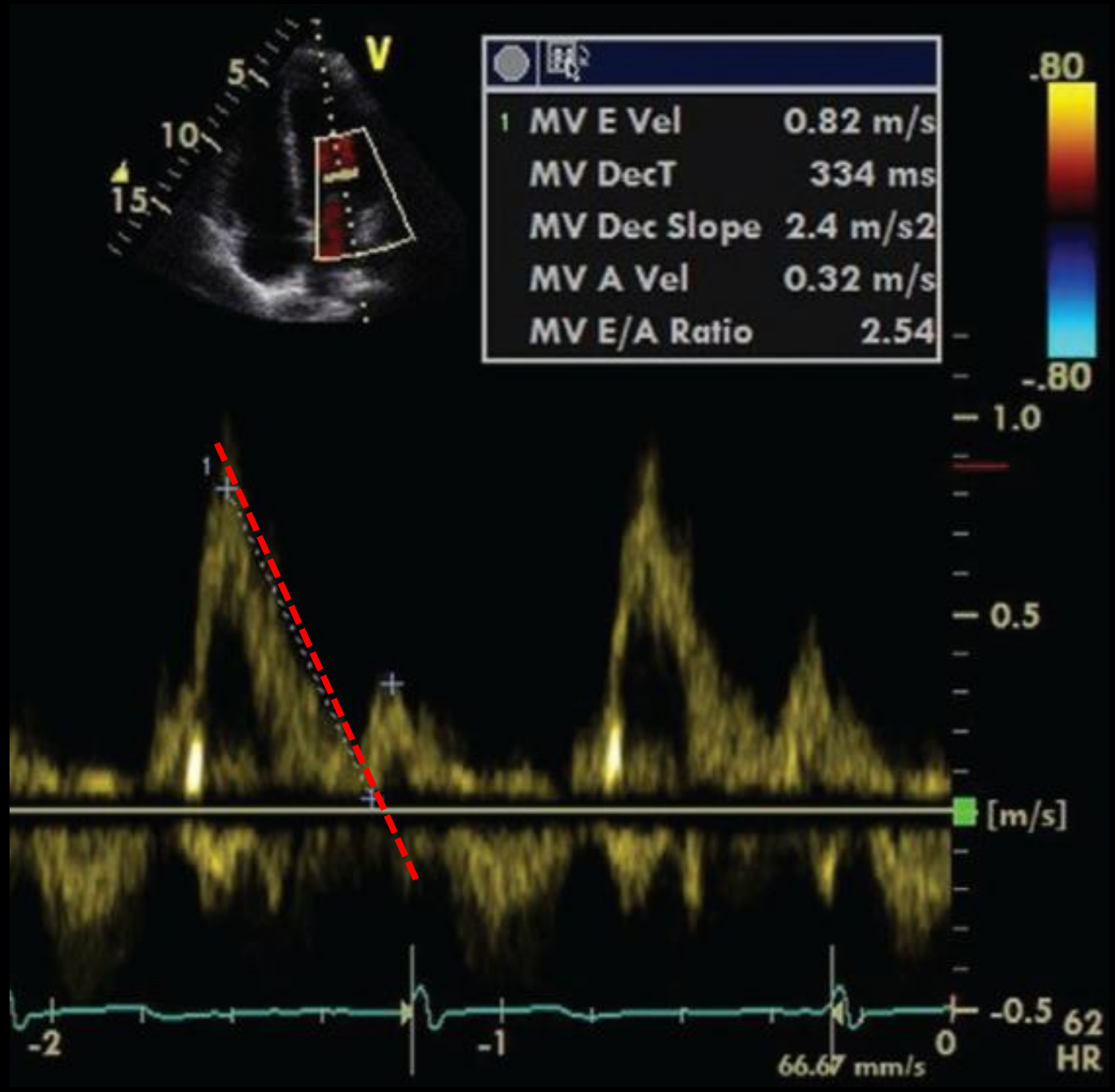
Increase sweep speed to spread out waveform



Mitchell et al Journal of the American Society of Echocardiography 2019 321-64

Common errors

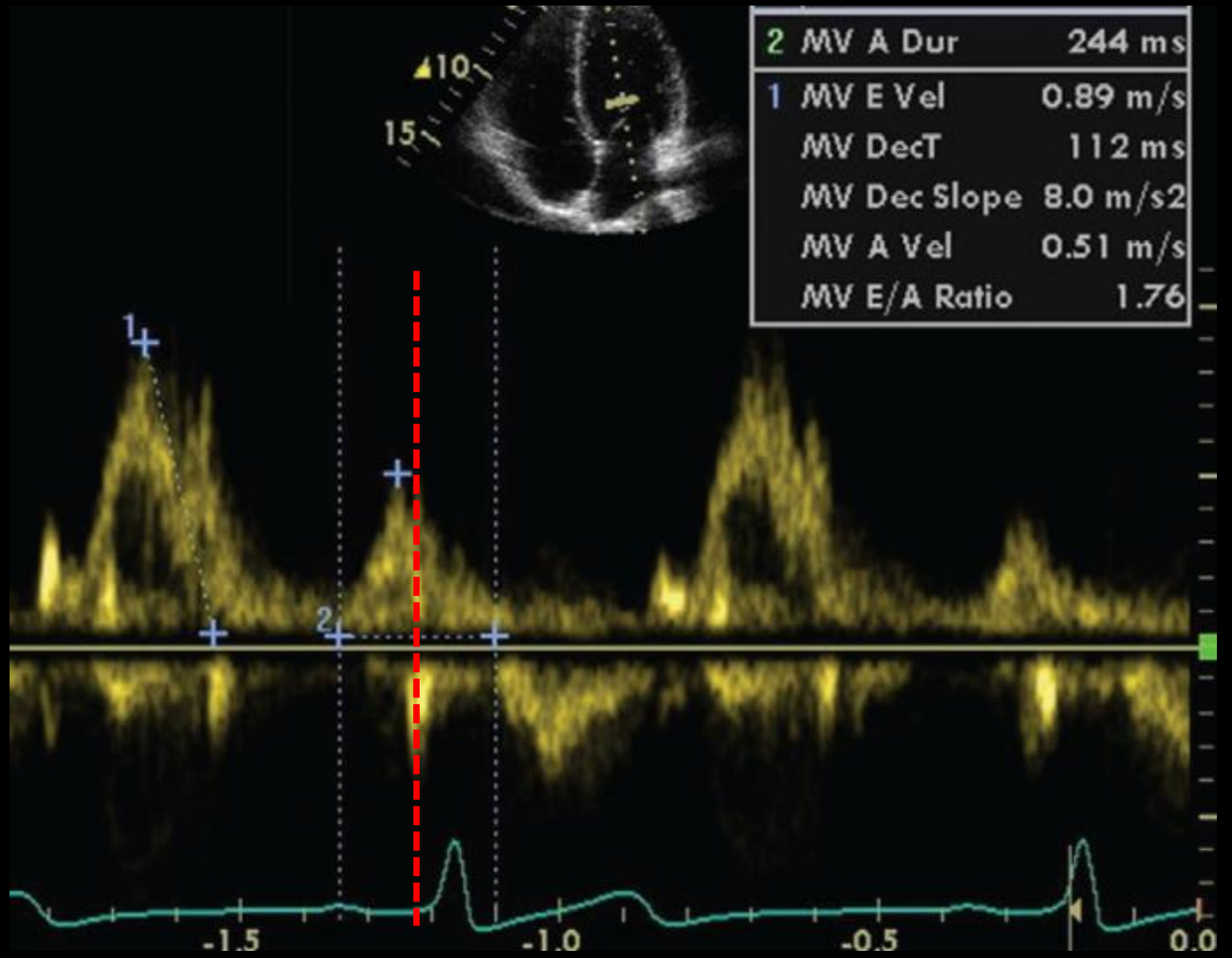
- Tracing outside the slope
- DT is overestimated (traced outside the slope)



Anderson BA Burstow DJ Diastolic Echocardiographic Examination 2021

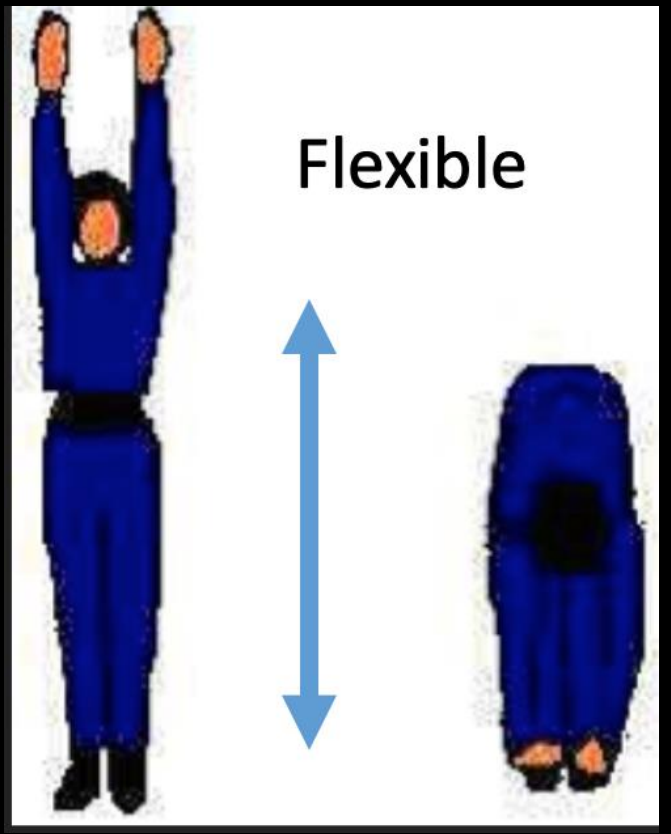
Common errors

A Dur is overestimated (rt caliper placed beyond mv closing click)



LV Relaxation: Tissue Doppler Interrogation:

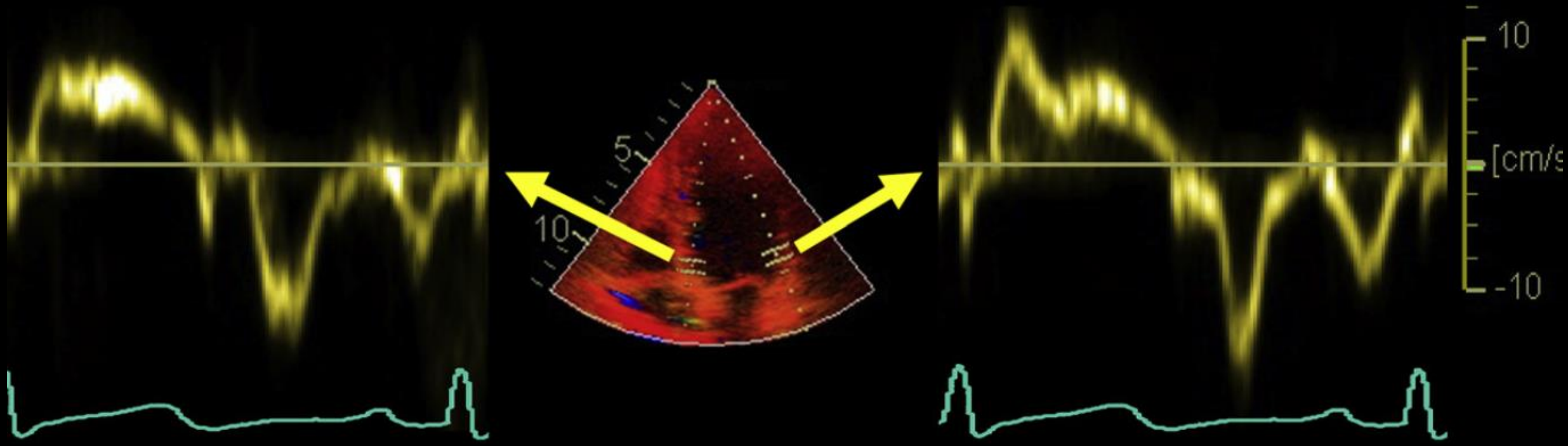
- Quick, easy and reliable
- Less preload dependent
- MUST BE PARALLEL TO PROBE
- Measures one direction of stretch
- <u>Very angle dependent</u>



Gorcsan J MSE 2017

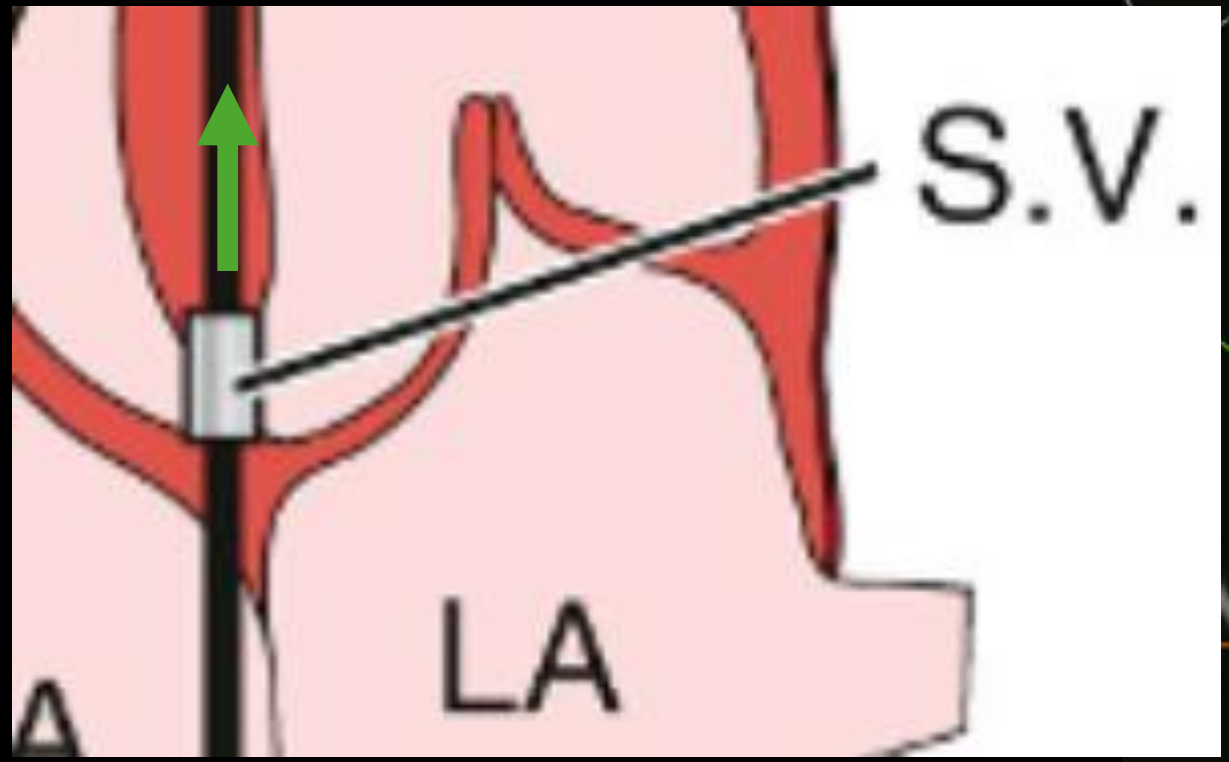
Tissue Doppler Interrogation:
Assessing Tissue, tracking stretch, compliance of LV

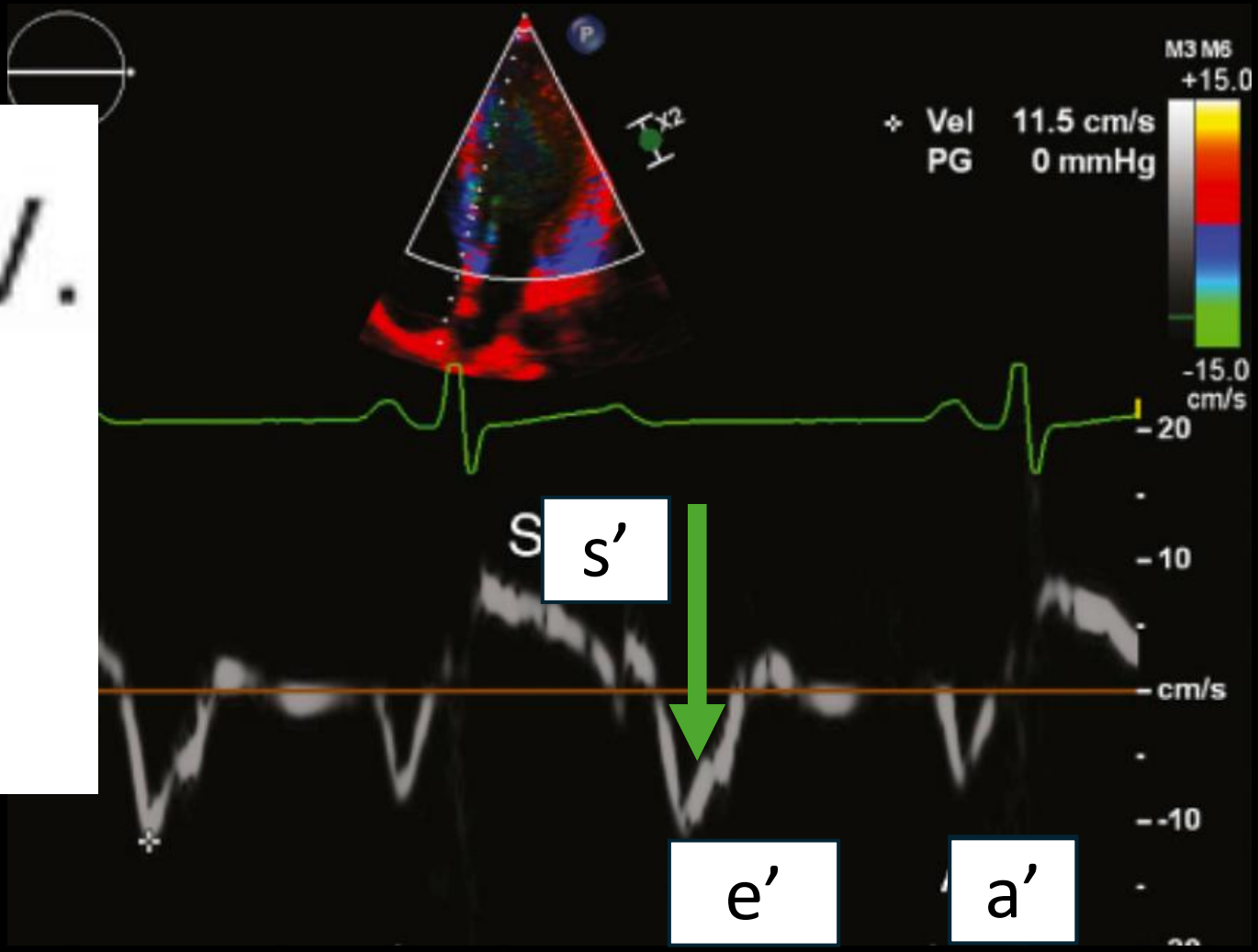
- PW TDI gate at septal and lateral mitral annulus IN the myocardium



Mor-Aviet al. J Am Soc Echocardiogr 2011;24:277-313

Curser is placed in the tissue at the mitral annulus (5-10mm), on LV Side (assessing the LV TISSUE)



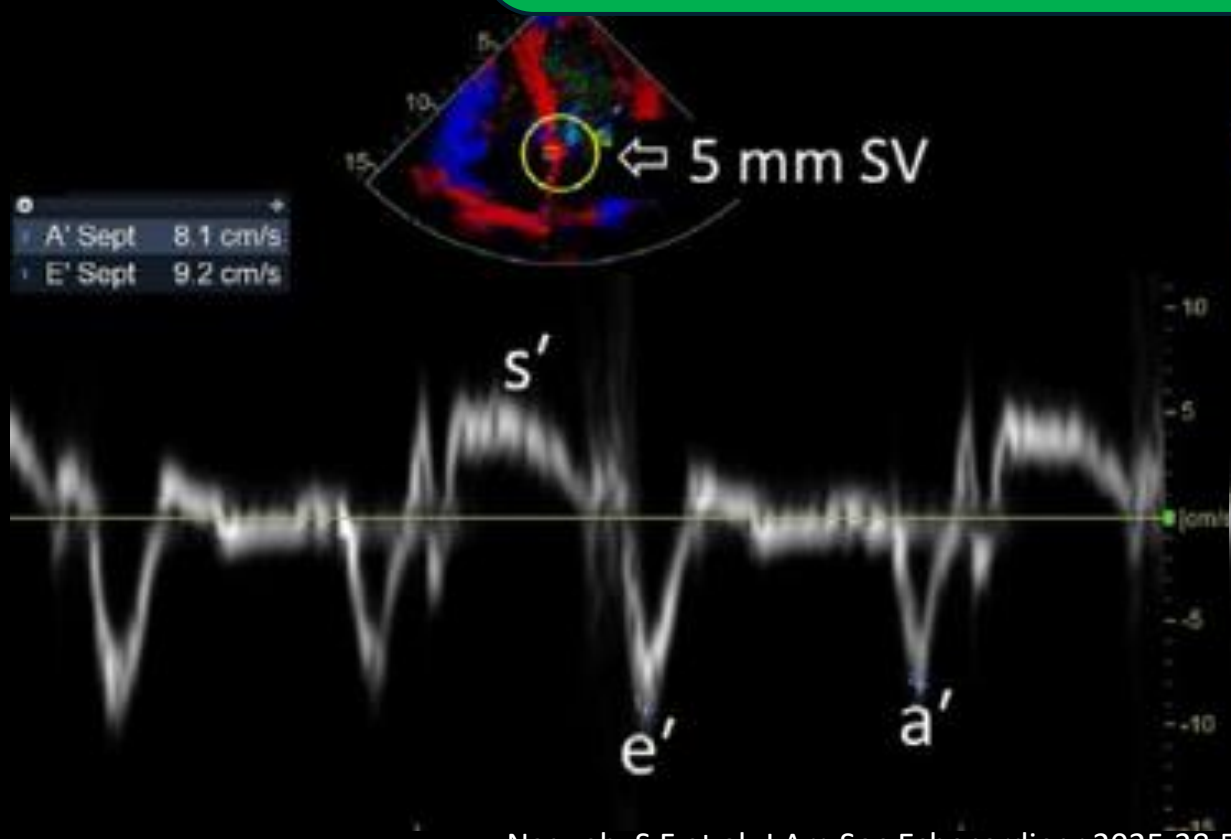


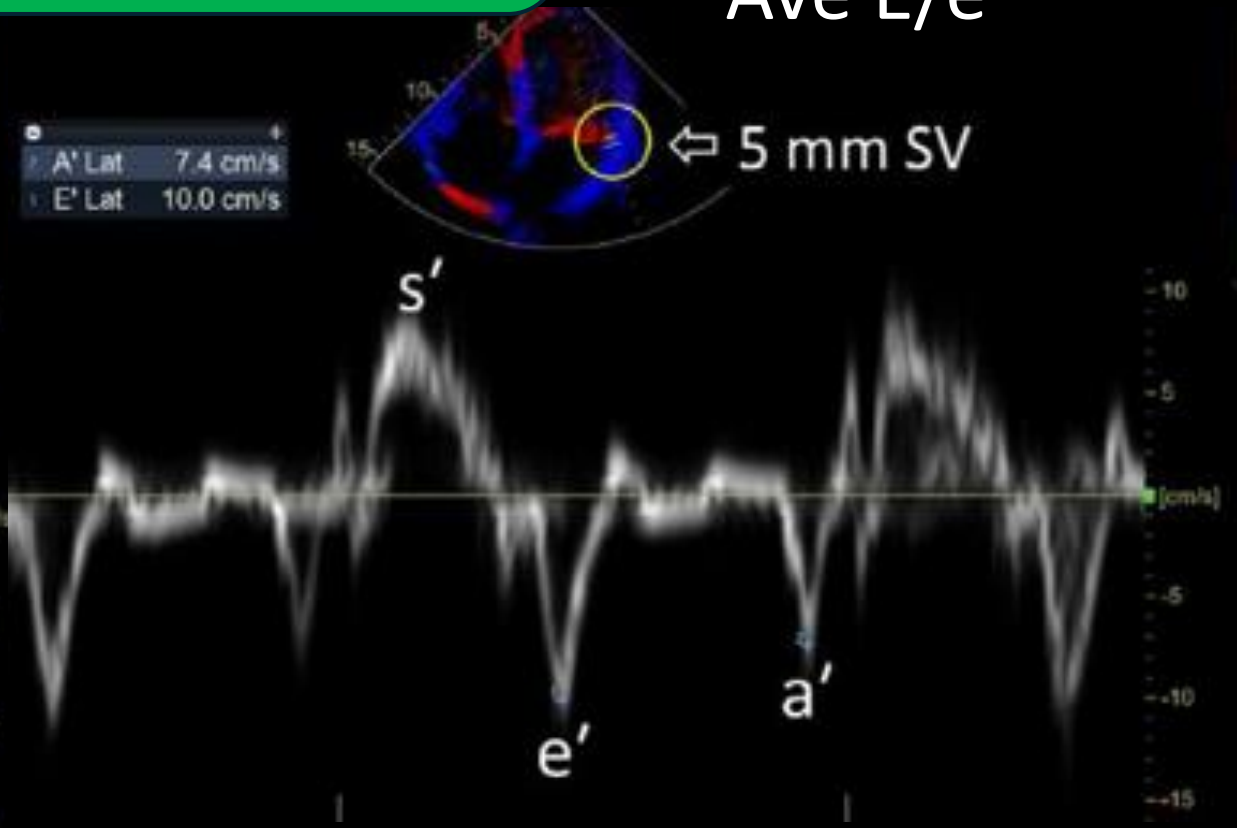
Otto CM, ed. *Textbook of Clinical Echocardiography, 6[6h] edition.* Elsevier Saunders, Philadelphia, Pennsylvania 2018

Mitral e’ best indicator of diastolic dysfunction

Sample volume gate 5 mm
Sweep speed 100 mm/s

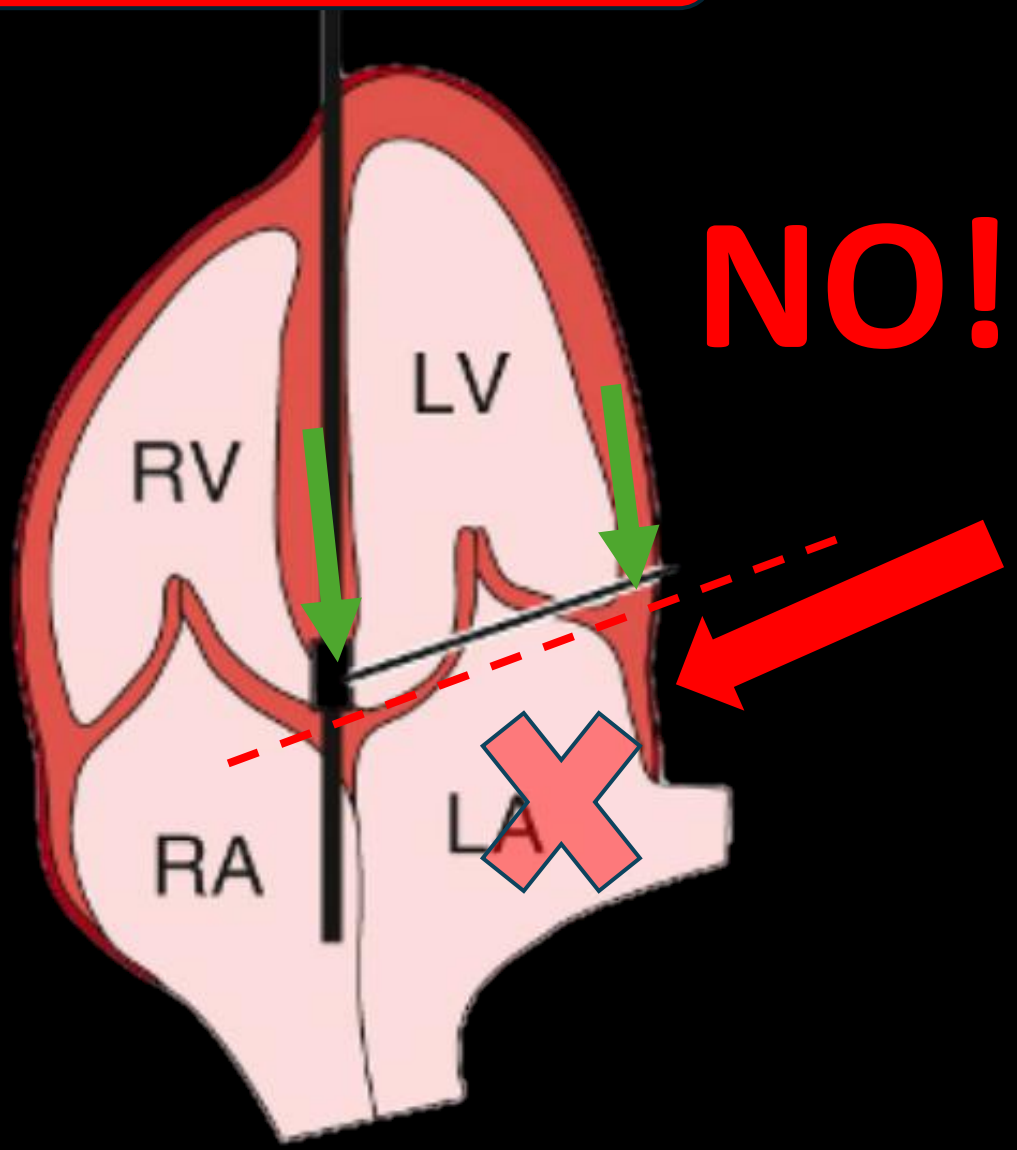
- e’
- a’
- MV E/e’
- Ave E/e’





Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Common errors



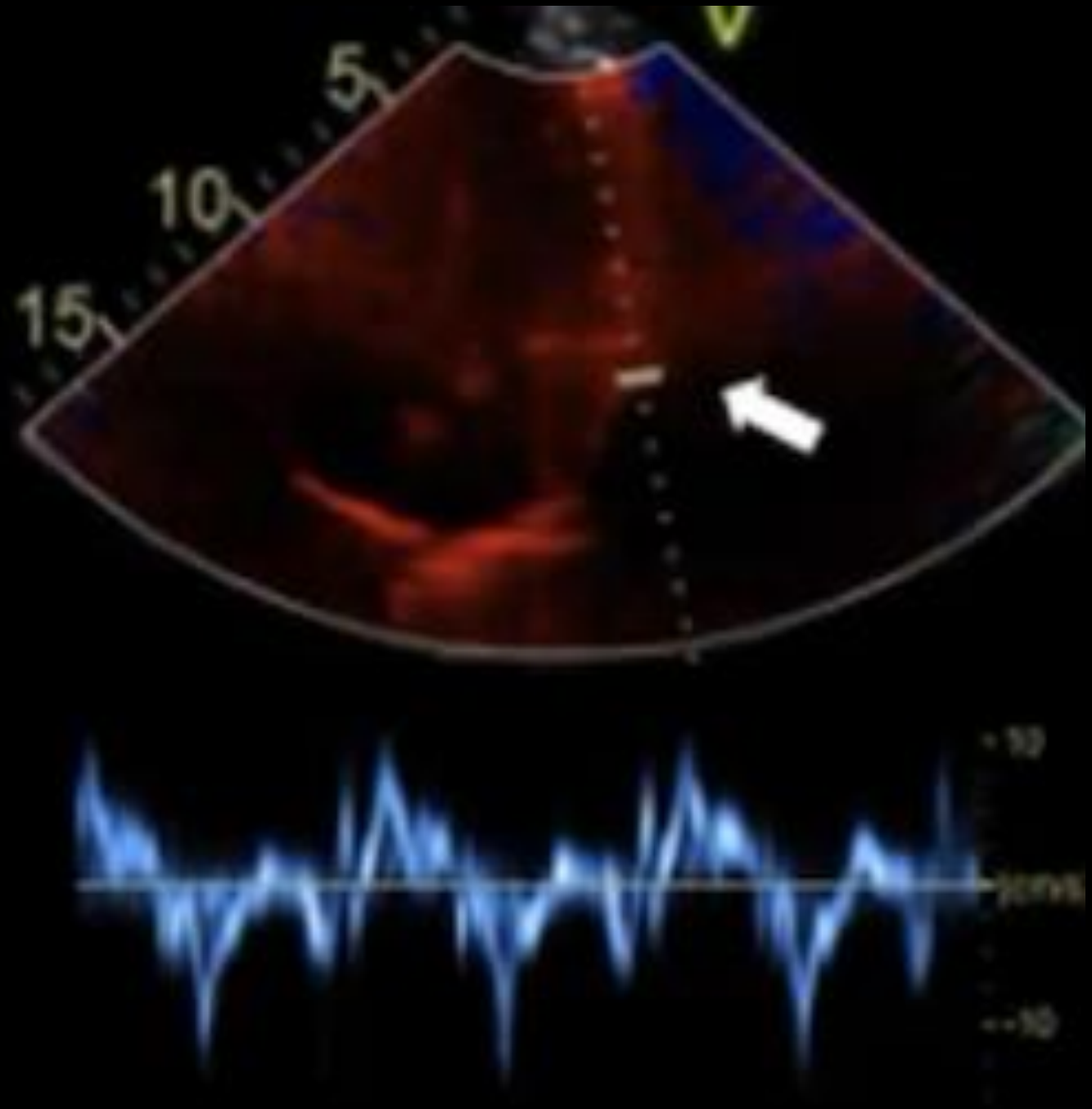
NO!

#1 Error is Placement on LA side of Annulus!

Remember it is all about the compliance of the LV myocardium!

Common errors

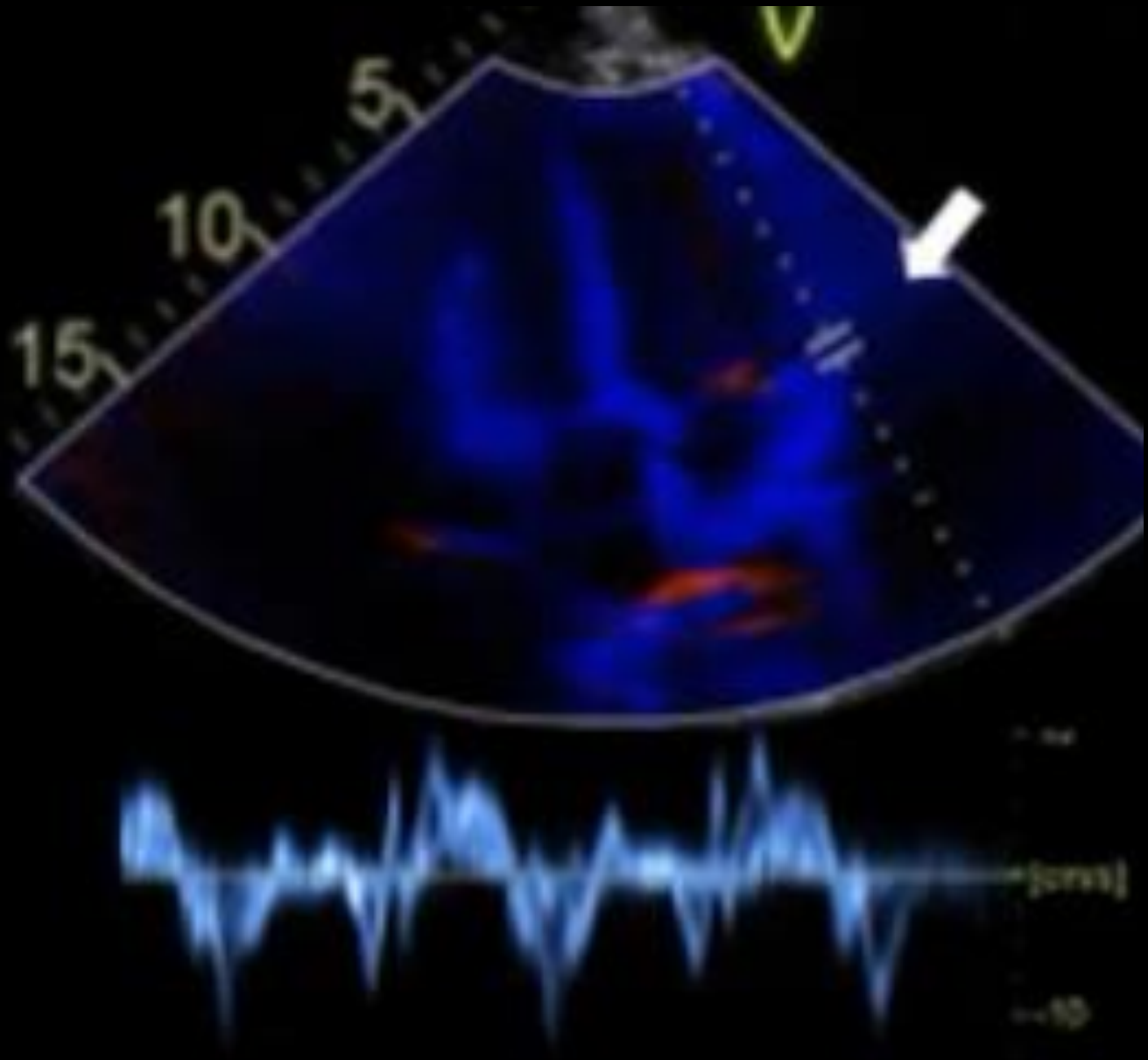
- Incorrect sample volume size, too small is a little messy
- TDI recommends 5 mm



Cuddy et al. J Am Soc Echocardiogr 2022;35:9:31A-40A

Common errors

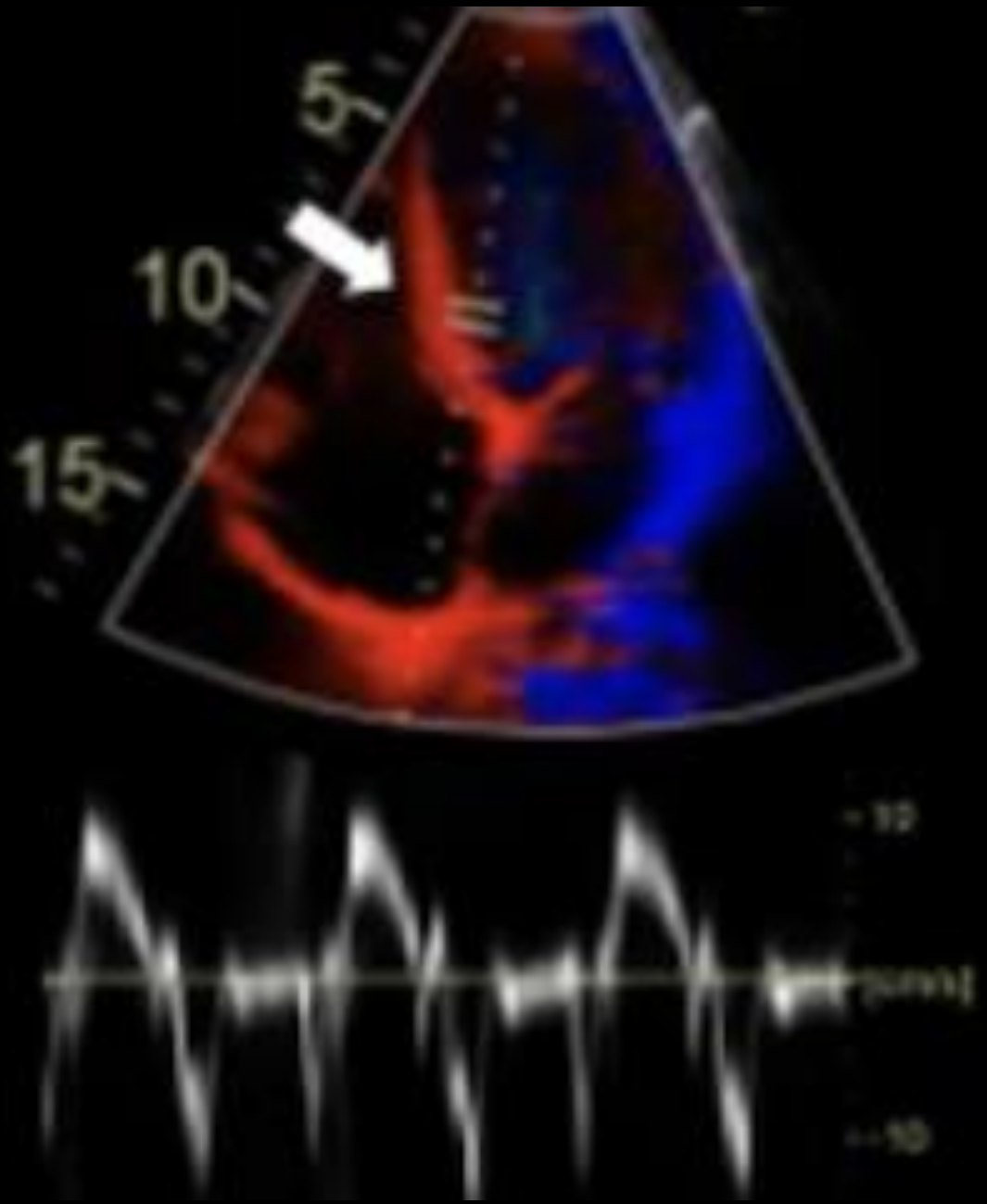
- Poor angle is common for lateral wall, need to move to realign to be parallel to flow



Cuddy et al. J Am Soc Echocardiogr 2022;35:9:31A-40A

Common errors

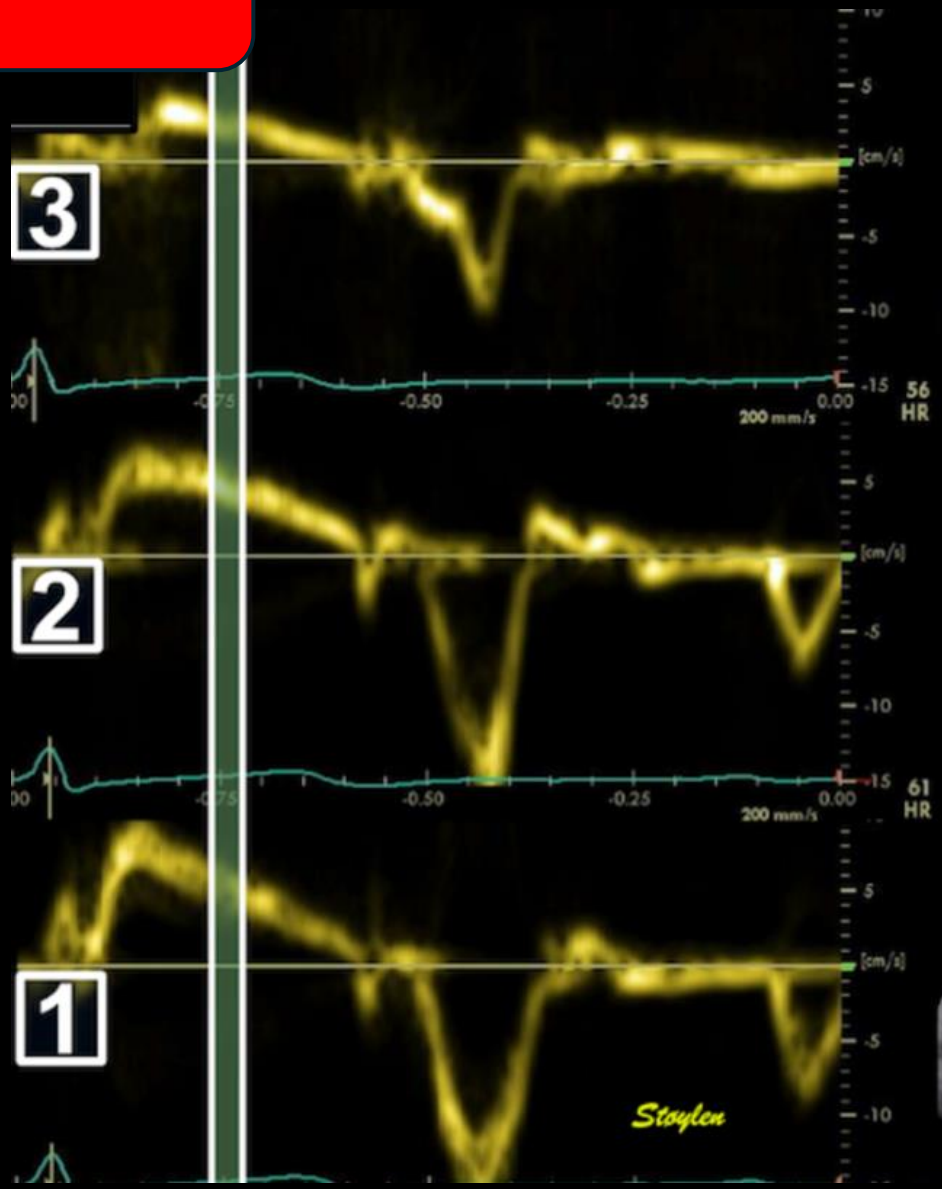
- Incorrect sample placement too far from mitral annulus
- Should be 5-10 mm away

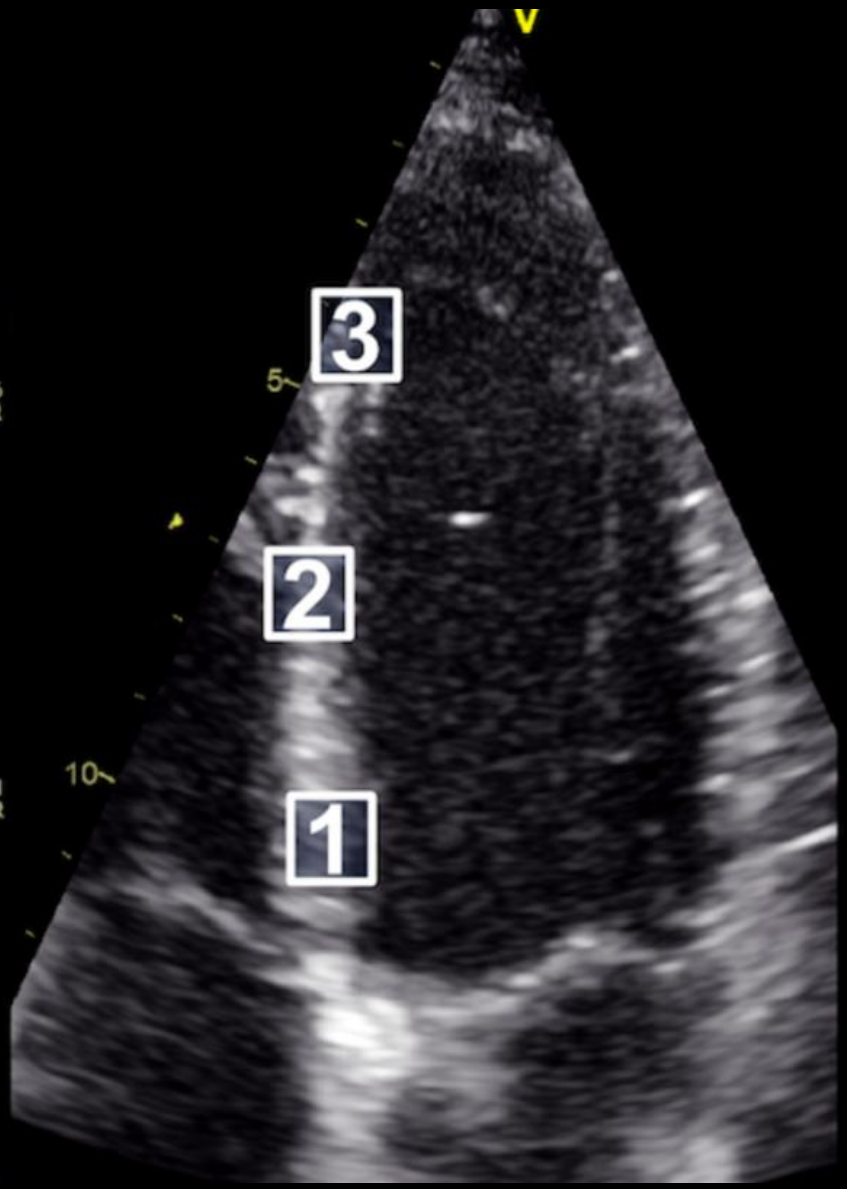


Cuddy et al. J Am Soc Echocardiogr 2022;35:9:31A-40A

Common errors

Velocities decrease closer to the apex





https://stoylen.folk.ntnu.no/strainrate/Basic_physiology.html

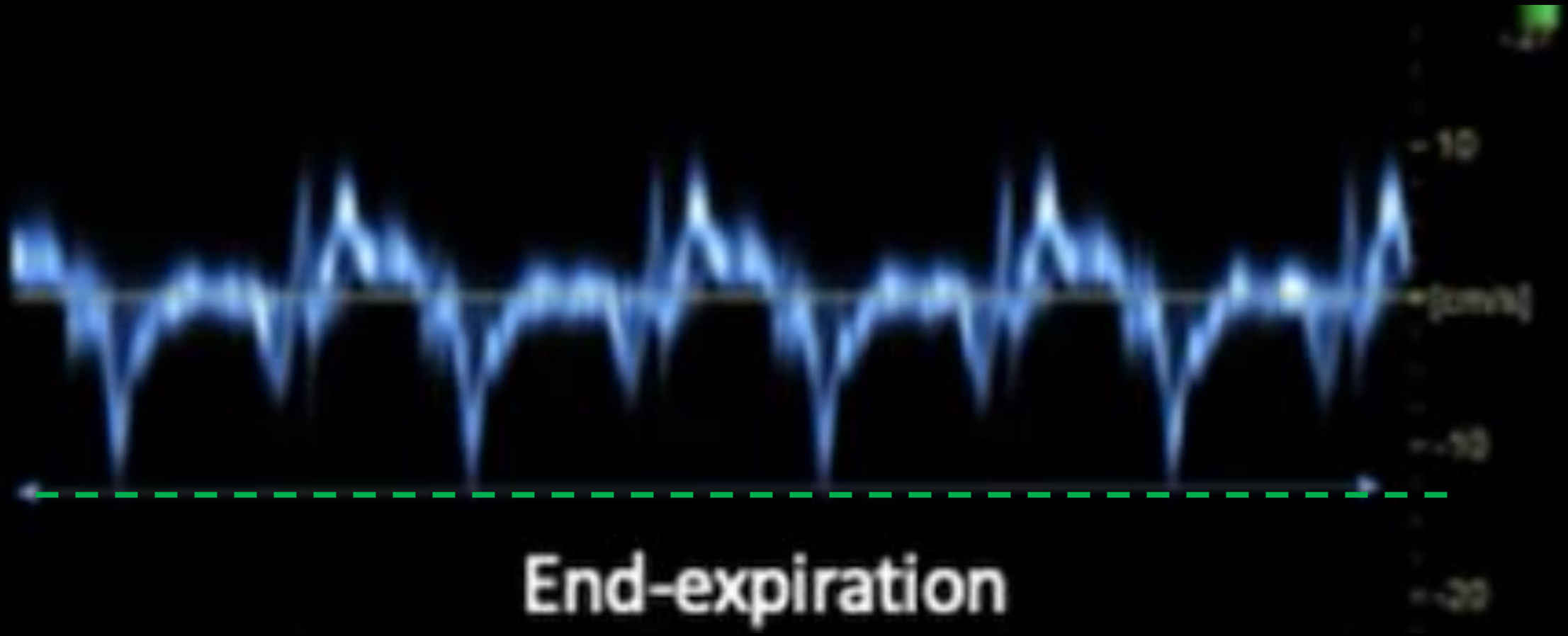
Common errors

Respiration can make things too variable, giving different values on different cardiac cycles

Cuddy et al. J Am Soc Echocardiogr 2022;35:9:31A-40A

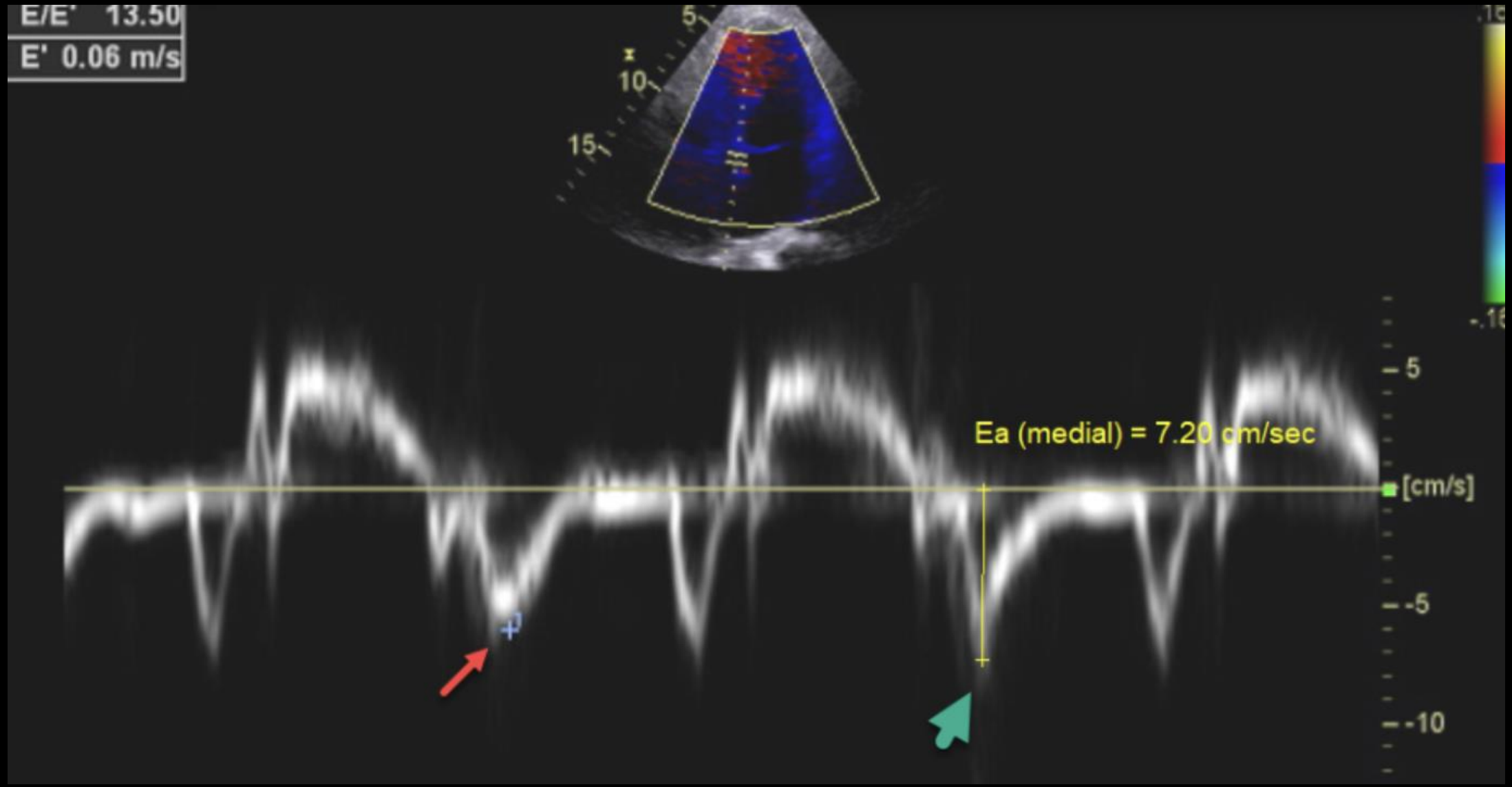
Q Tip

Stop breath at end-expiration, to smooth things out



Cuddy et al. J Am Soc Echocardiogr 2022;35:9:31A-40A

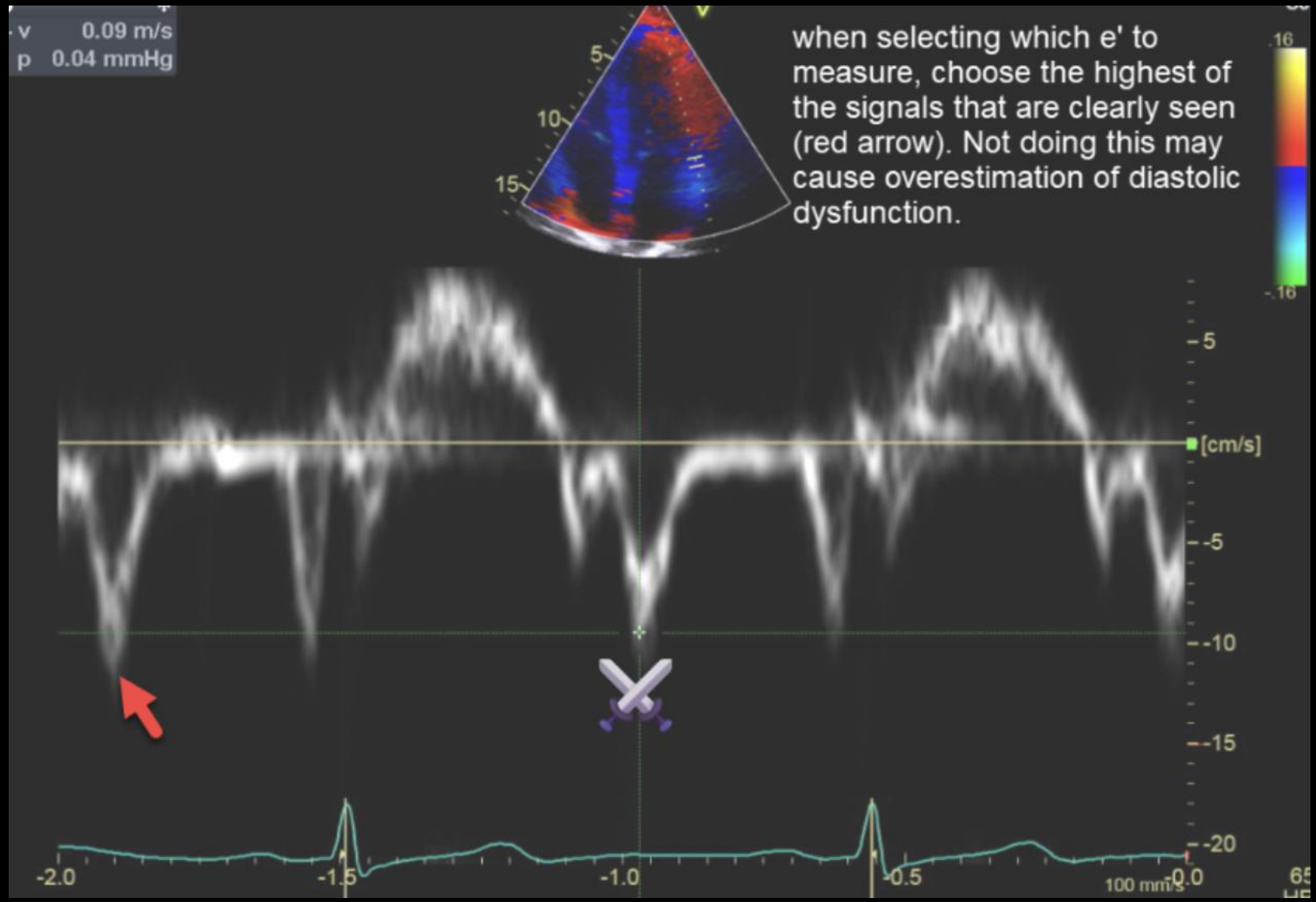
Goal is the highest clean velocity without fuzz



Courtesy of Dr. Gerald Cohen

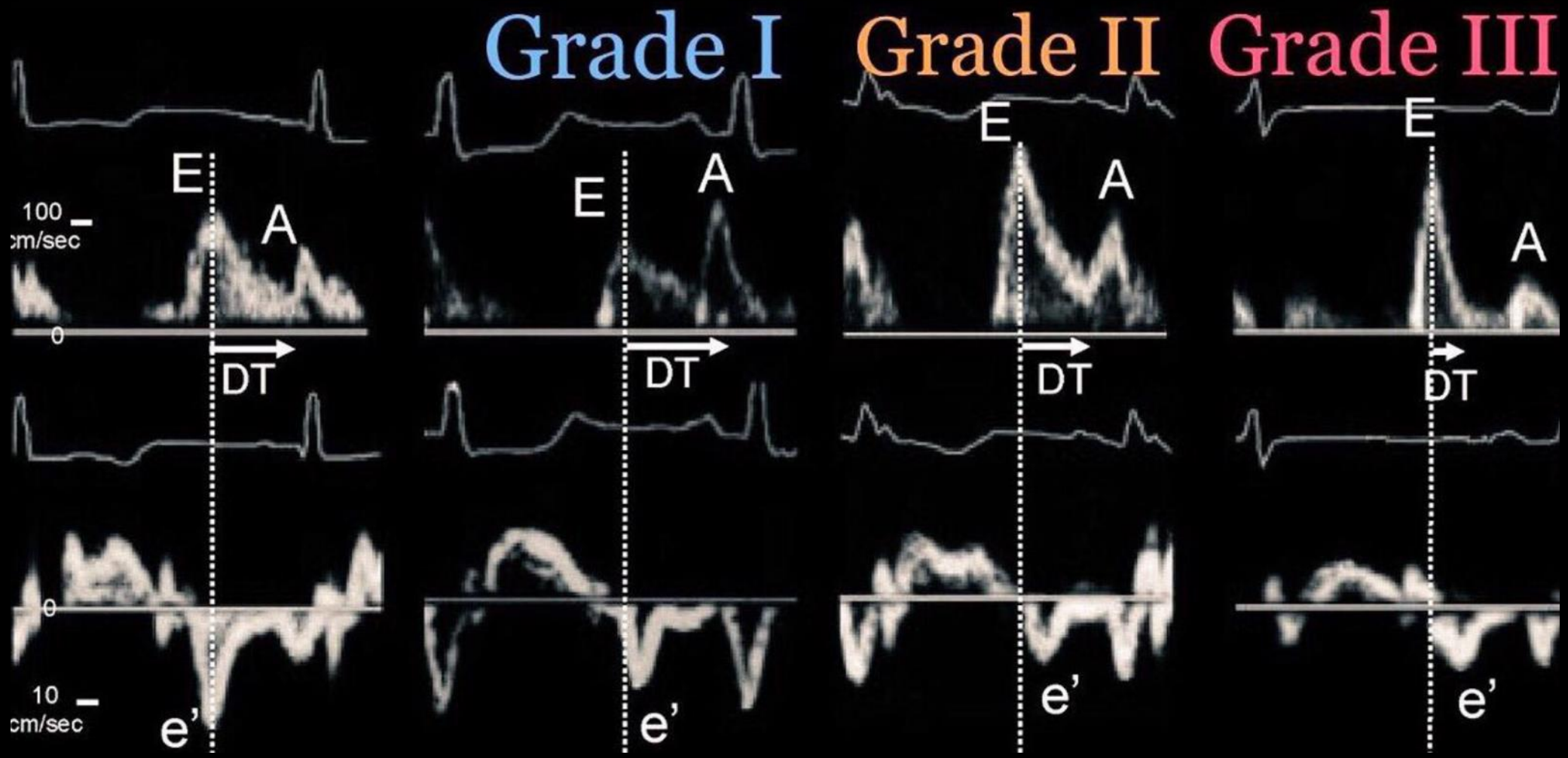
Goal is the highest clear velocity without fuzz

Choosing an unclear signal may cause overestimation of diastolic dysfunction



Courtesy of Dr. Gerald Cohen

Grades of Diastolic Dysfunction Detected by Doppler Imaging

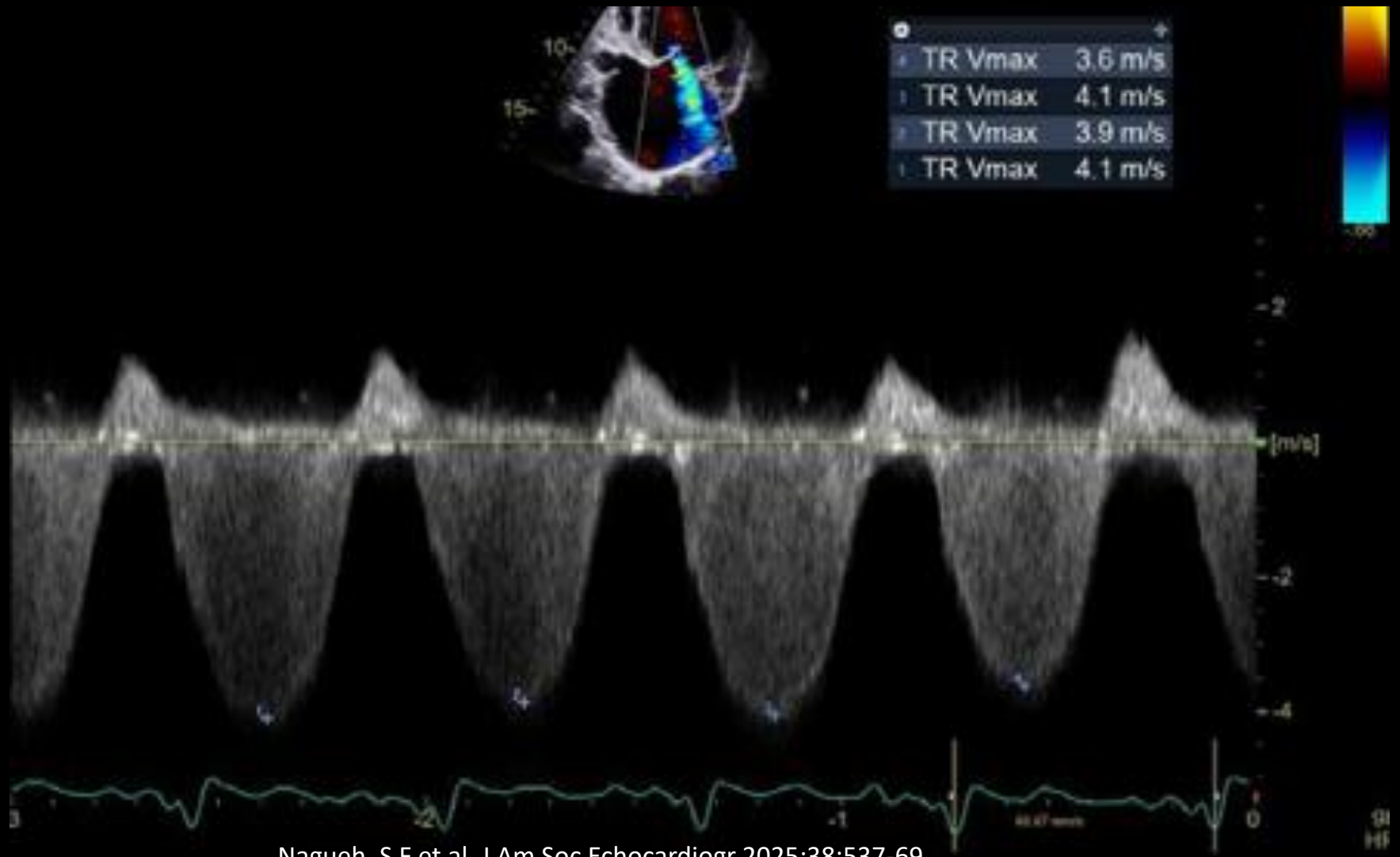


Complementary Parameters

- There are supporting parameters that can be used in conjunction with the others
- These parameters should never be used alone

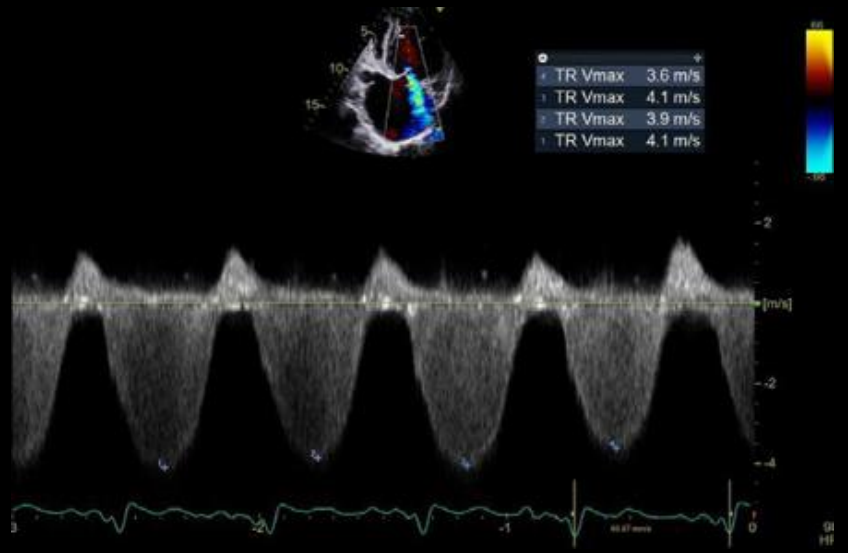
Complementary parameters

- Peak TR jet velocity



Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Complementary parameters



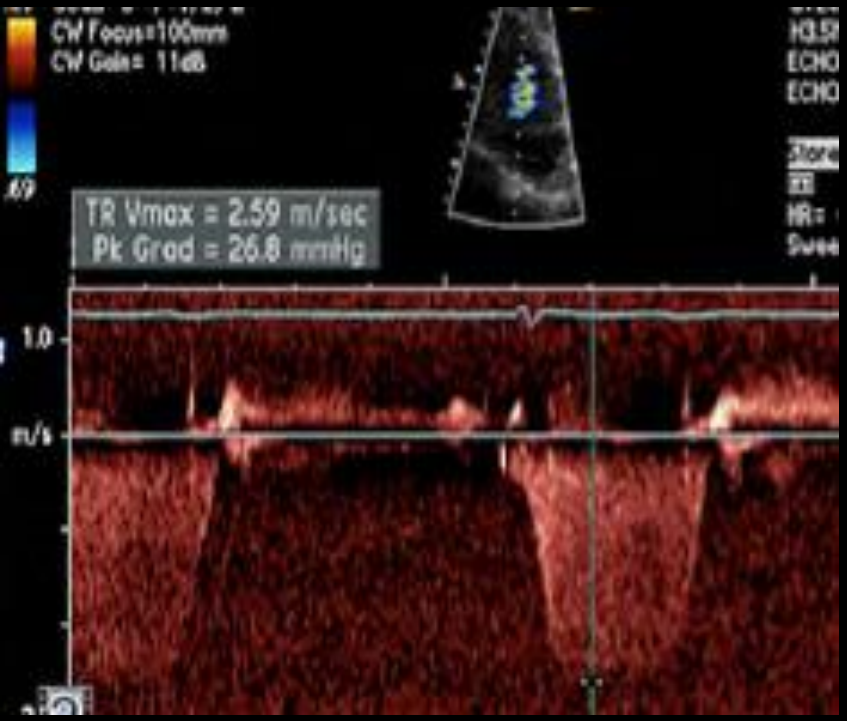
TR jet optimization

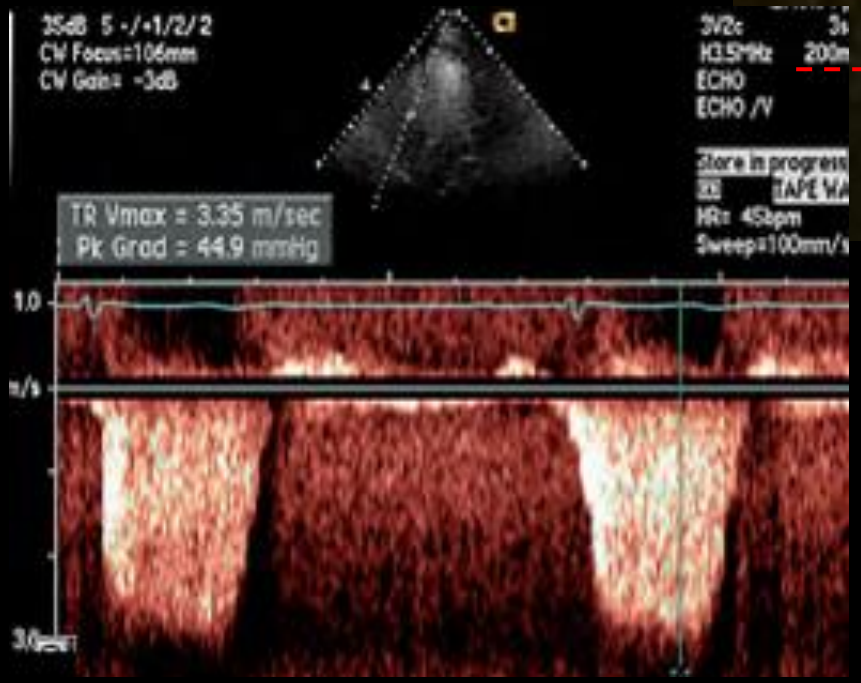
- Align parallel with US beam
- Adjust baseline to display entire jet
- Optimize gain (turn gains down)
- Avoid scraggly edges
- Sweep speed 50-100 mm/s
- Average over respiratory cycle

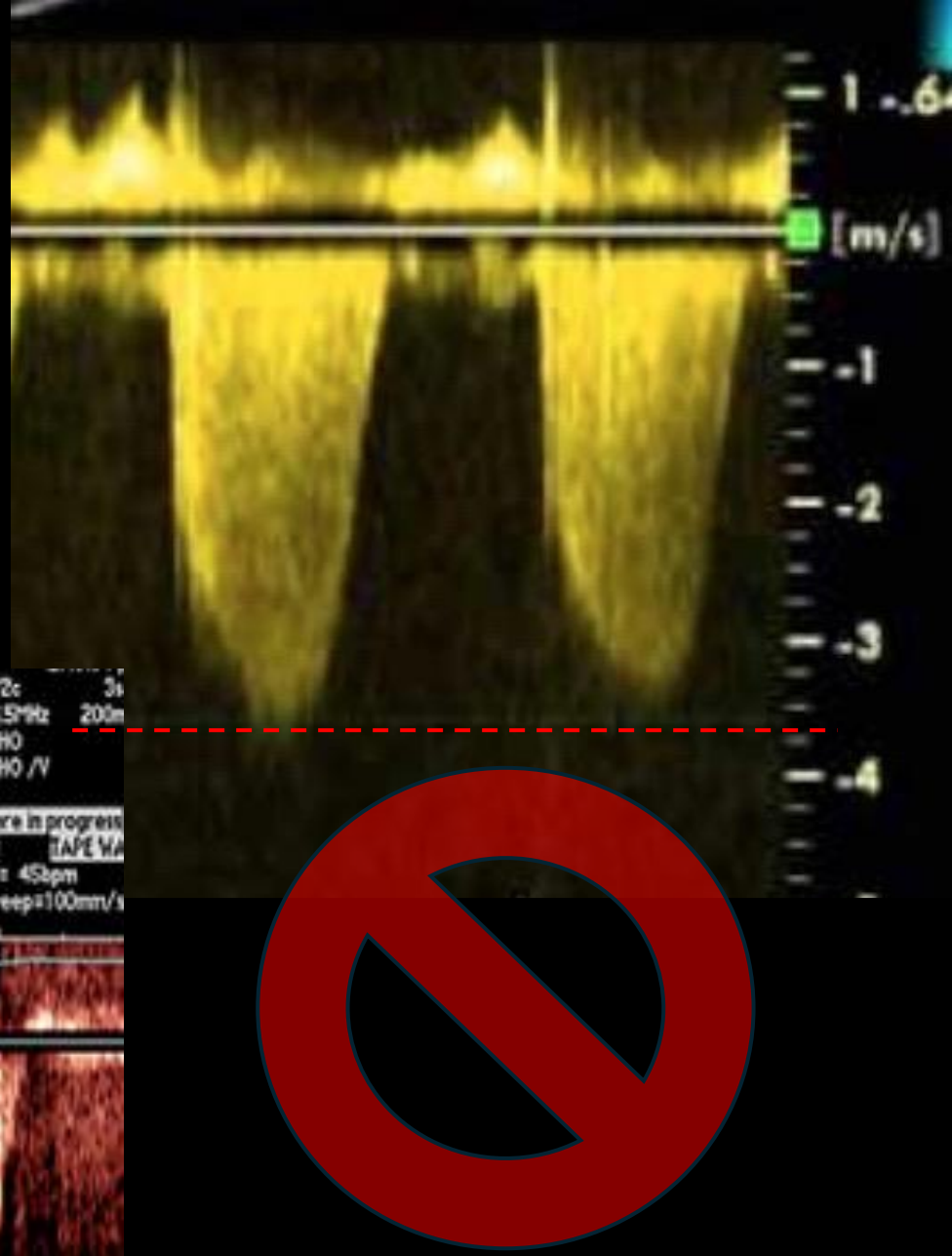
Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Q Tip

- Avoid feathery edges
- Turn gains waaayyy down, especially after contrast



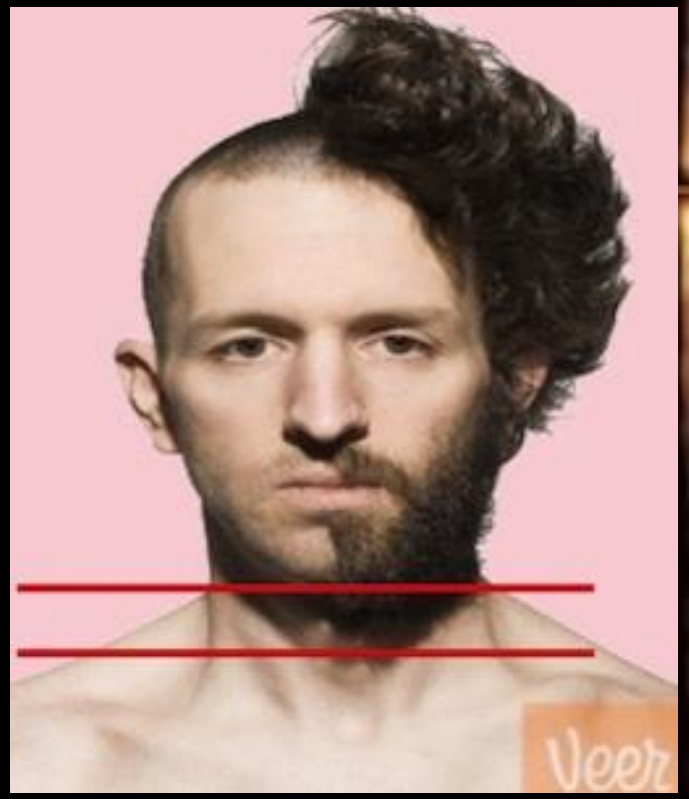


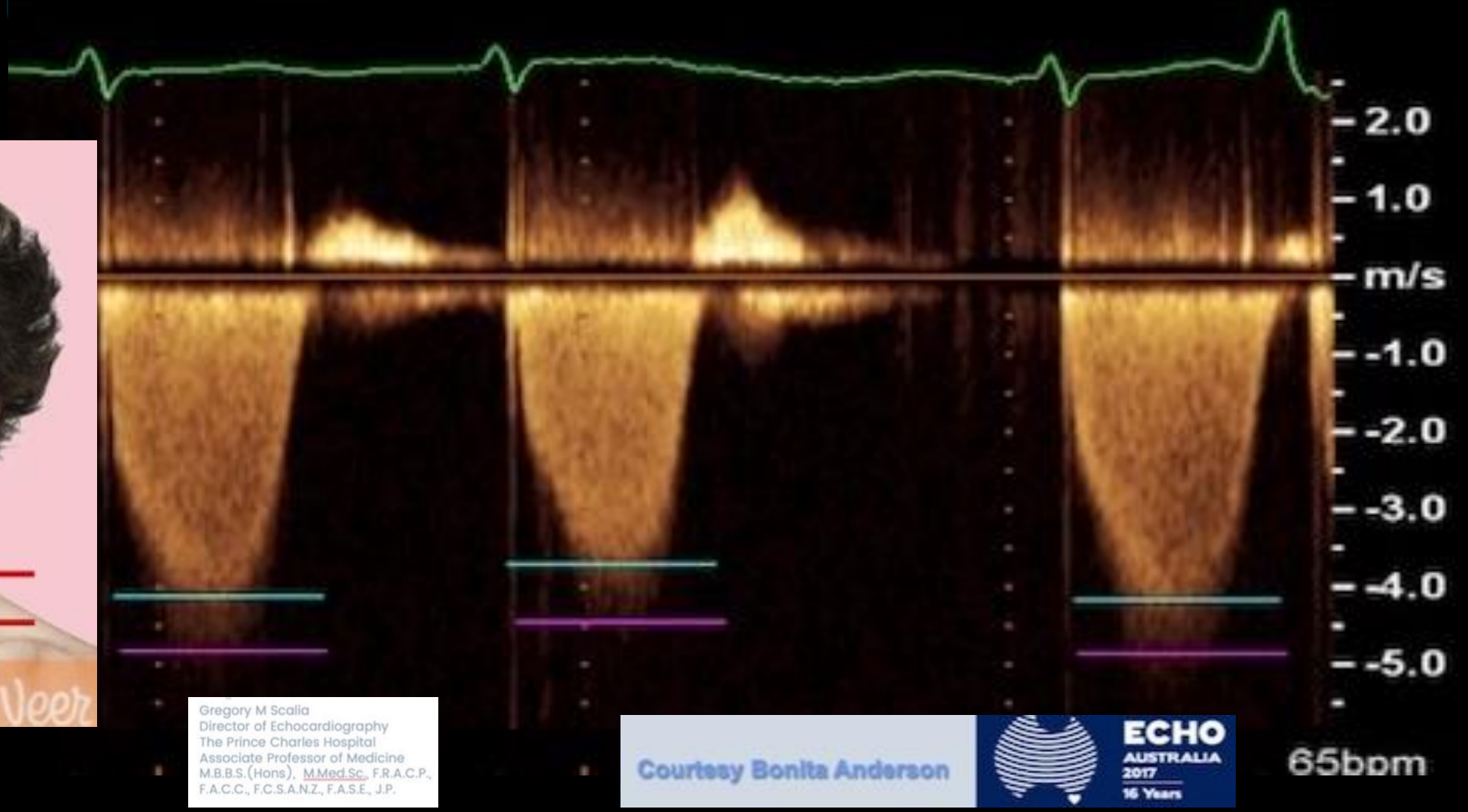


Rudski et al J Am Soc Echocardiogr 2010;23:685-713.

Q Tip

TR jet: Remember: Chin to Win!

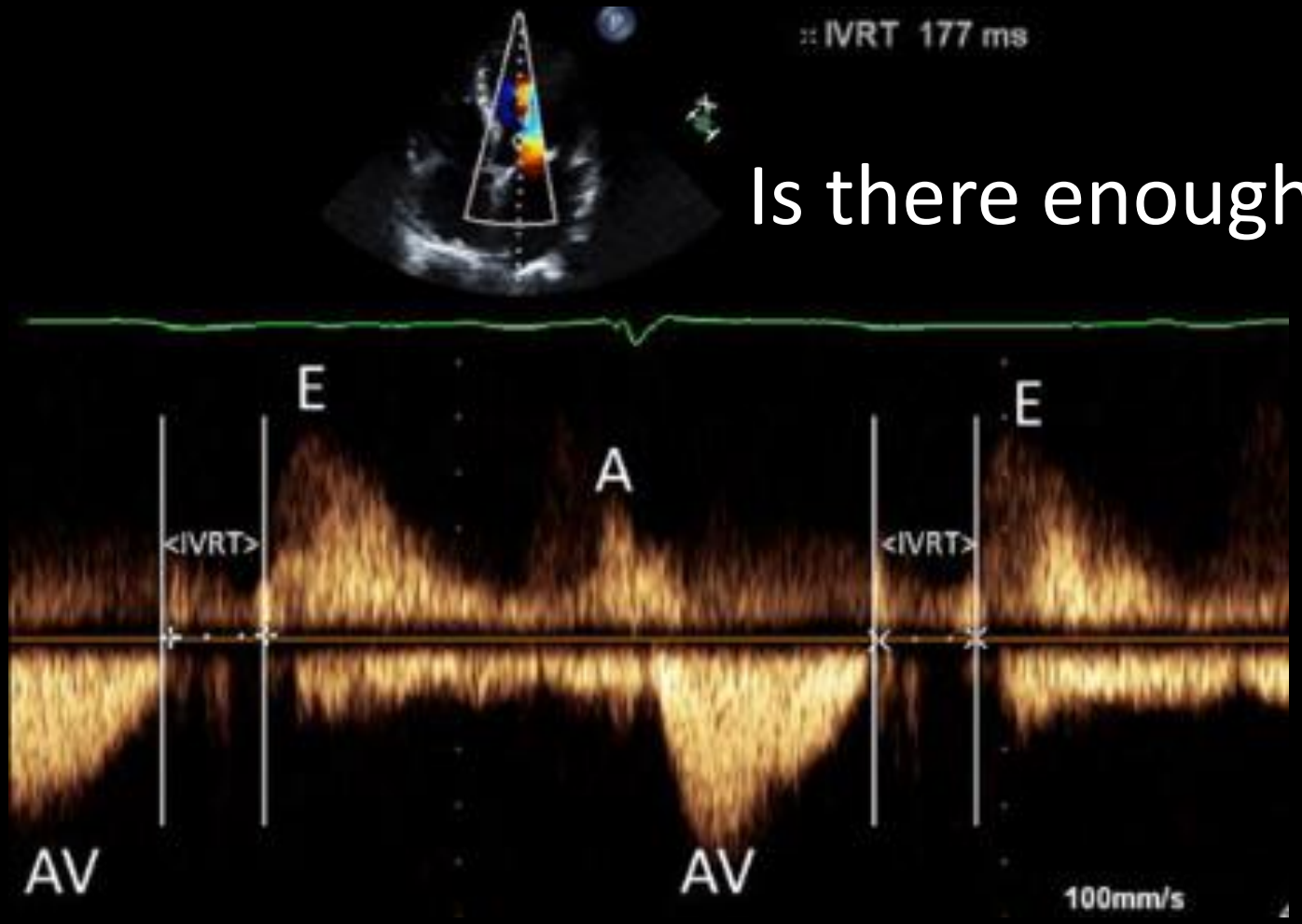




Gregory M Scalia
Director of Echocardiography
The Prince Charles Hospital
Associate Professor of Medicine
M.B.B.S.(Hons), M.Med.Sc., F.R.A.C.P.,
F.A.C.C., F.C.S.A.N.Z., F.A.S.E., J.P.

Complementary parameters

Isovolumic Relaxation Time (IVRT)



Is there enough time to relax?

Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

IVRT(ms): time interval between AV closure and MV opening

Trick is seeing the clicks!

CW thru aortic-mitral curtain to catch closing **click at end of aortic ejection and onset MV opening click**

Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

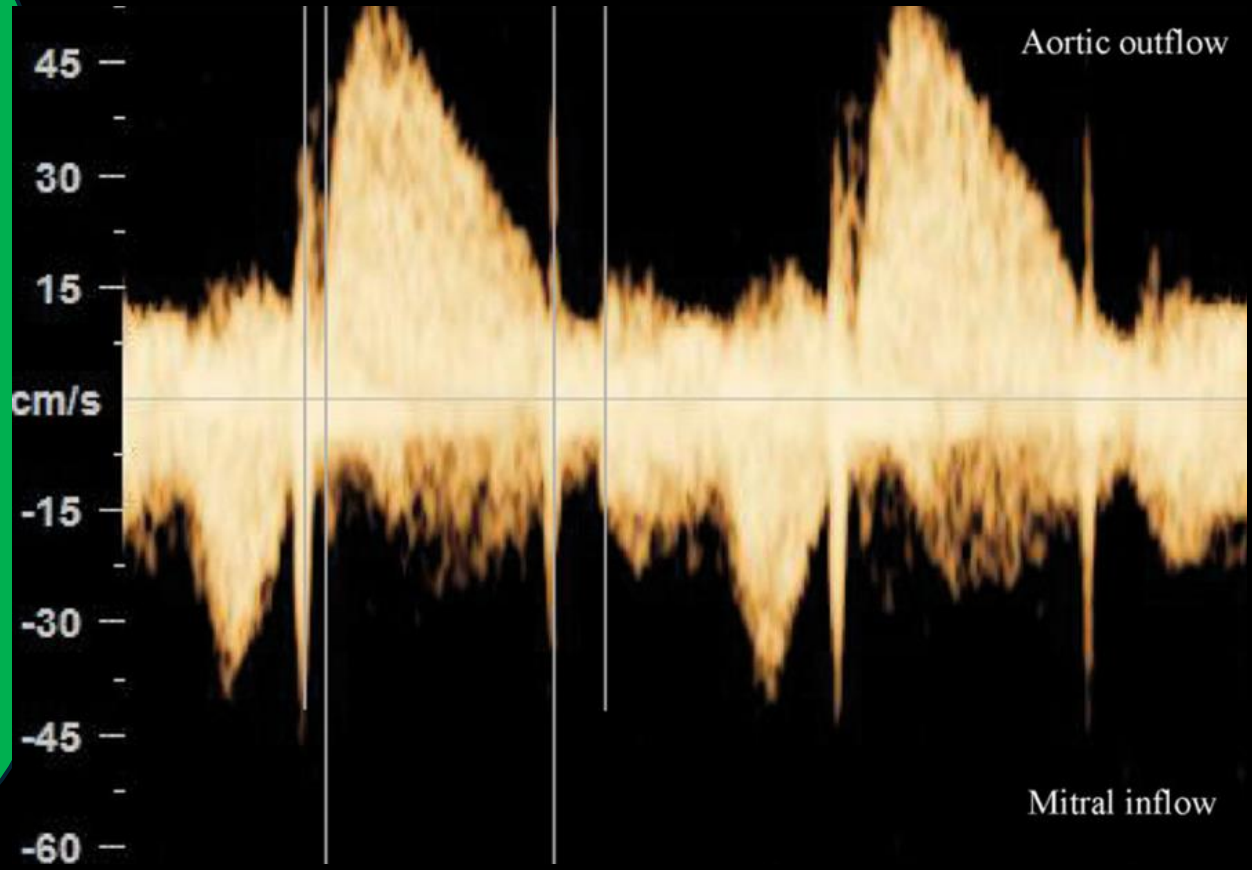
IVRT: Issues with guideline recommended CW Assessment

In the real world we most likely get something like this!

A Mess!

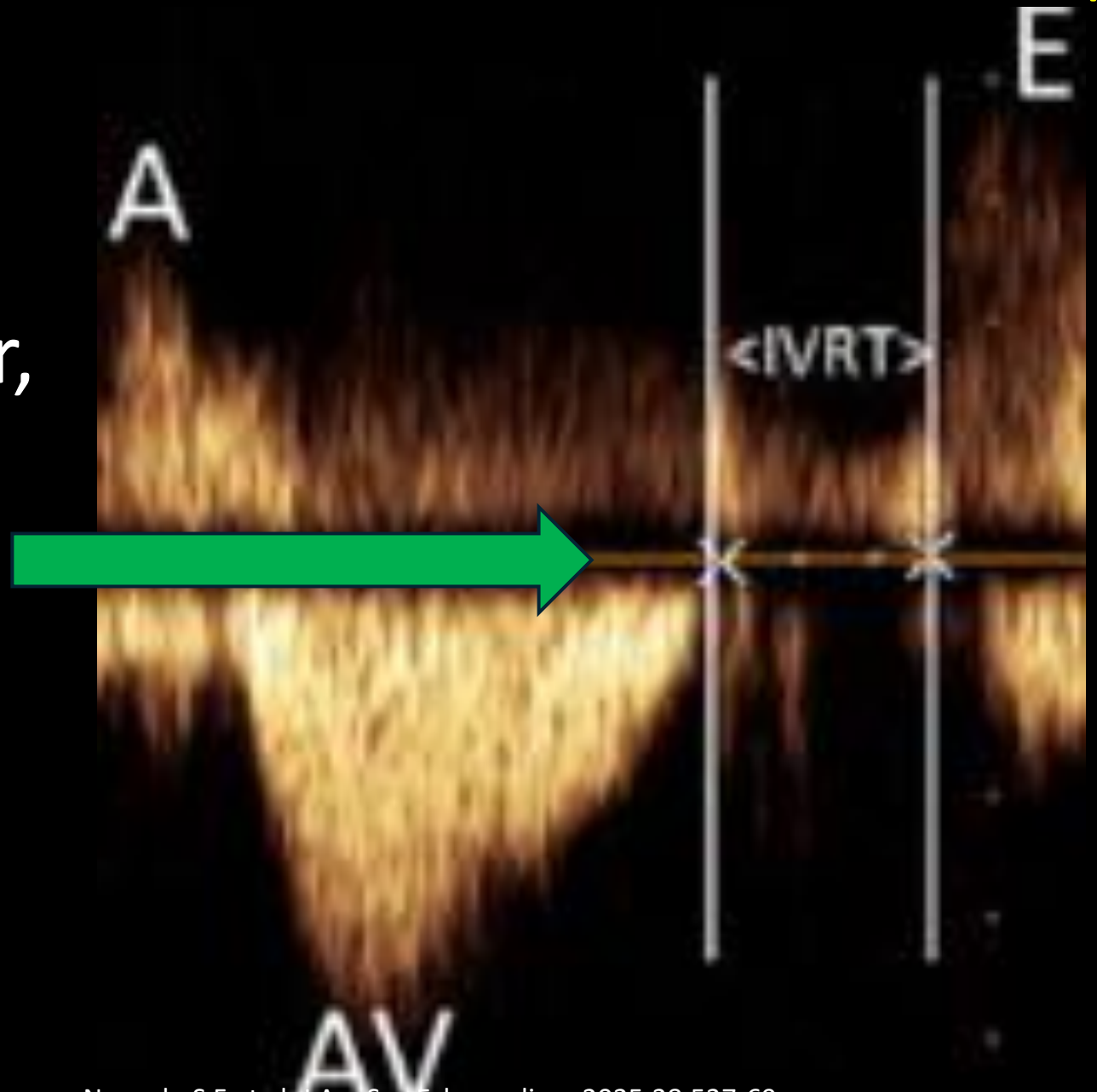
Tip: For CW, couple of adjustments we can make:

- Turn gains waaaaay down
- Be as parallel (0')as possible to have as little noise as possible
- Inc sweep speed
- Low wall filter (100-200 Hz)



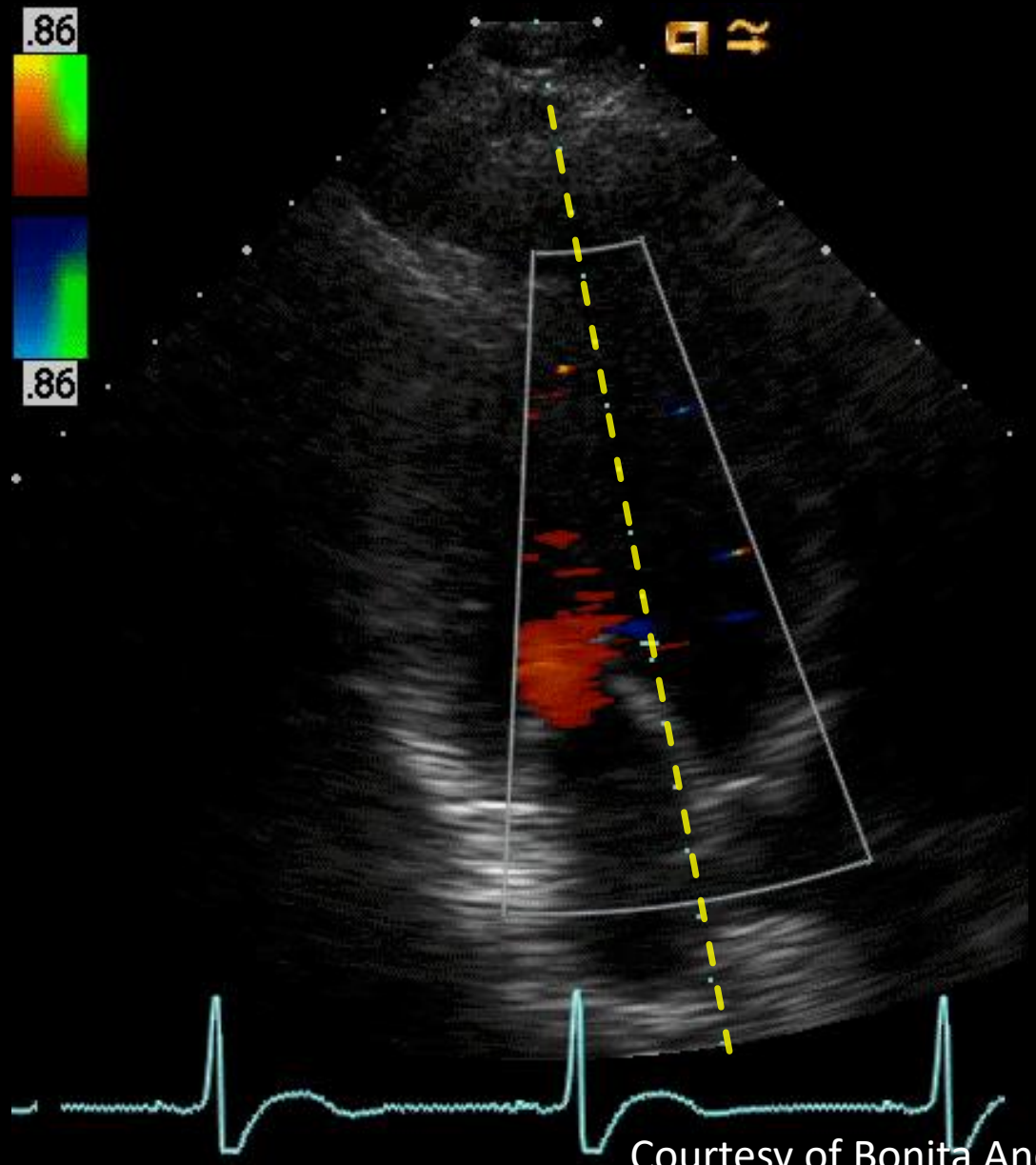
IVRT(ms): time interval between AV closure and MV opening

Low wall filter, cleans up noise at baseline



Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Isovolumetric Relaxation Time (Technique)



View: APLAX (or AP 5ch)

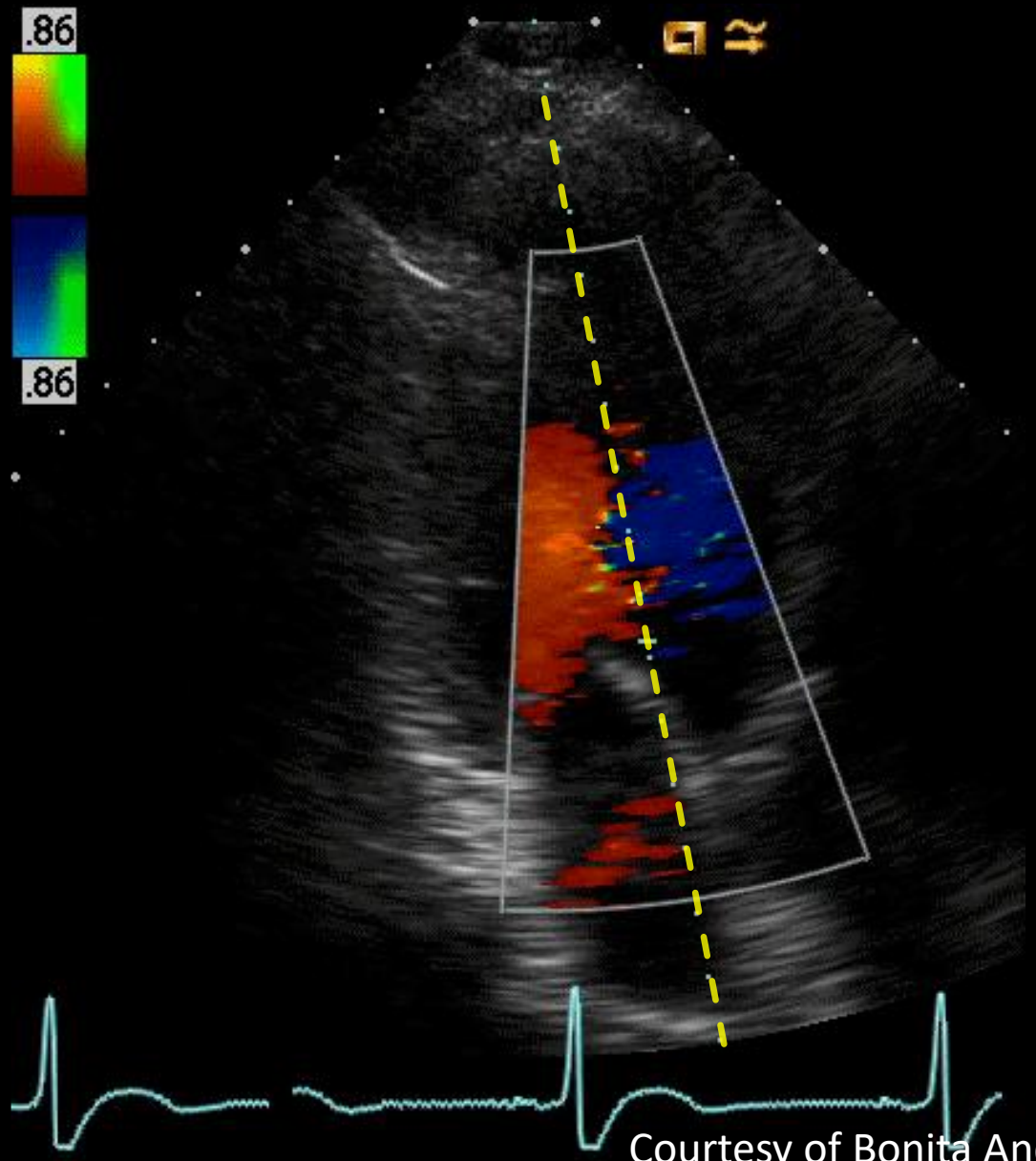
Continuous-wave Doppler

Alignment: between mitral inflow & LV outflow

Tip: use colour Doppler & align CW cursor at the red-blue interface

Courtesy of Bonita Anderson Extraordinaire! DMU, MAppSc, ACS, AMS, FASE, FASA

Isovolumetric Relaxation Time (Technique)



View: APLAX (or AP 5ch)

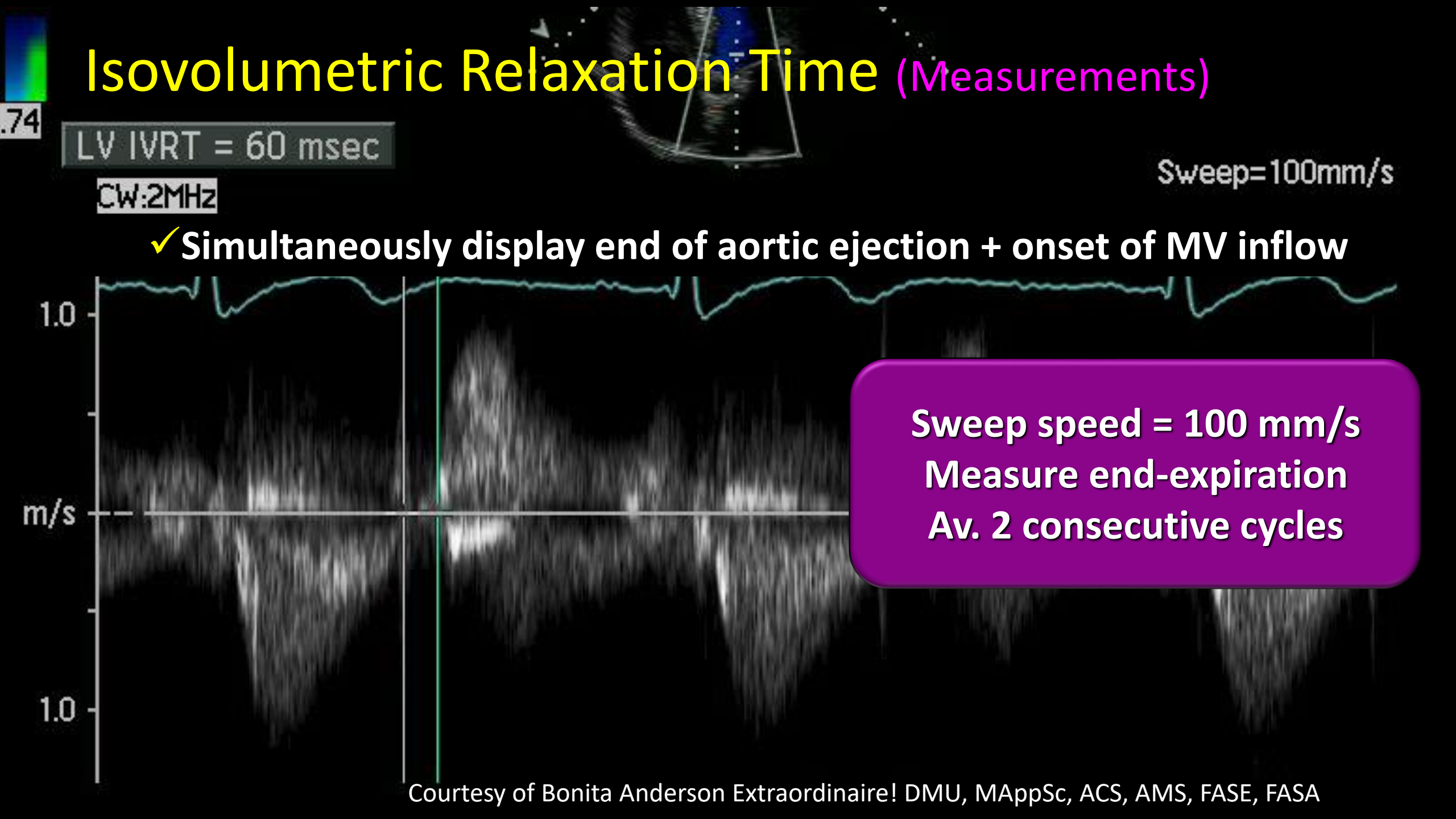
Continuous-wave Doppler

Alignment: between mitral inflow & LV outflow

Tip: use colour Doppler & align CW cursor at the red-blue interface

Courtesy of Bonita Anderson Extraordinaire! DMU, MAppSc, ACS, AMS, FASE, FASA

Isovolumetric Relaxation Time (Measurements)



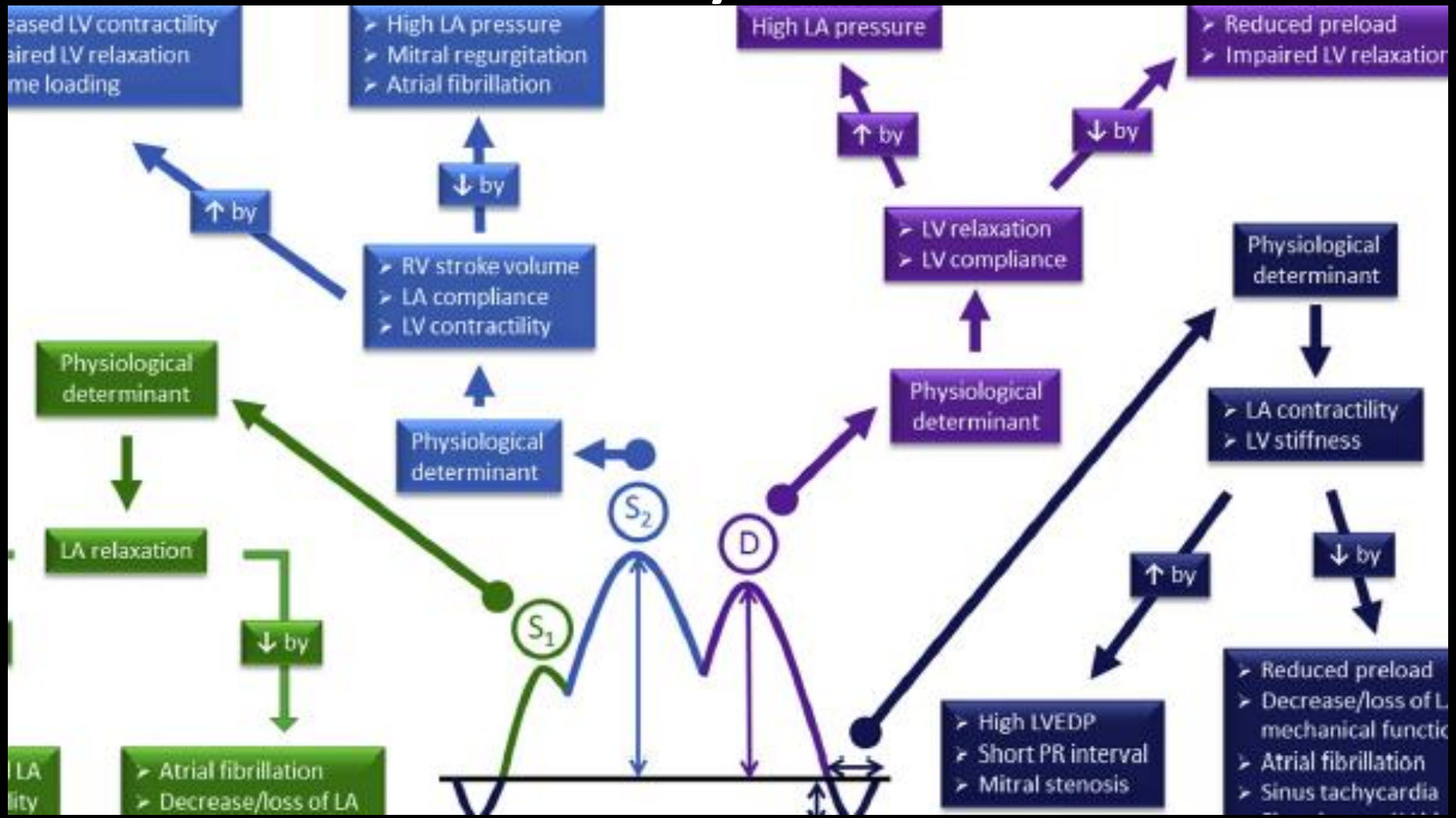
✓Simultaneously display end of aortic ejection + onset of MV inflow

Sweep speed = 100 mm/s
Measure end-expiration
Av. 2 consecutive cycles

Courtesy of Bonita Anderson Extraordinaire! DMU, MAppSc, ACS, AMS, FASE, FASA

Complementary parameters

Pulmonary Vein Flow



Fadel et al. J Am Soc Echocardiogr 2021;34:223-36

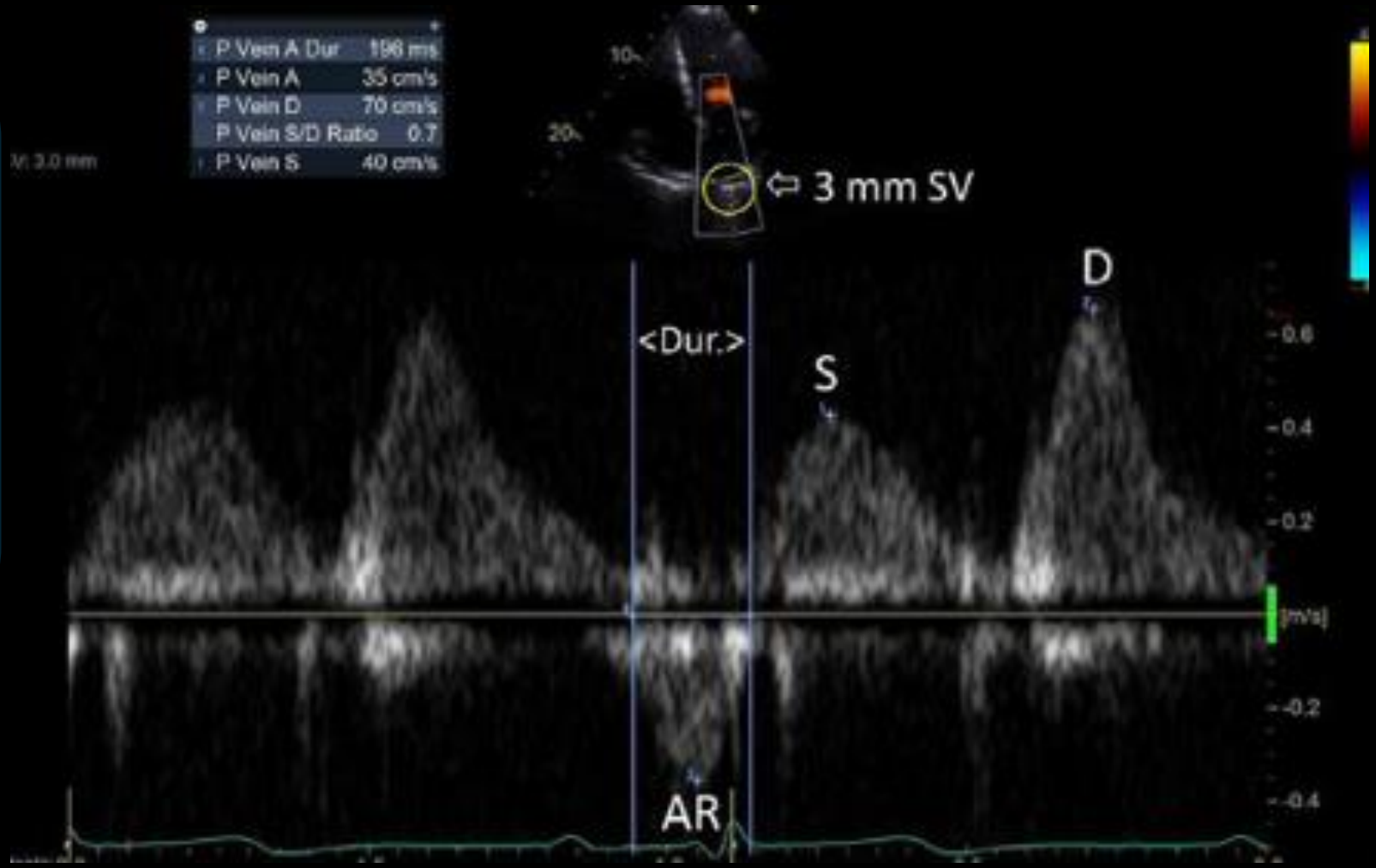
Complementary parameters

Pulmonary Vein Flow = Filling of the LA

S = Systole

D = Diastole

AR / A Dur = atrial contraction

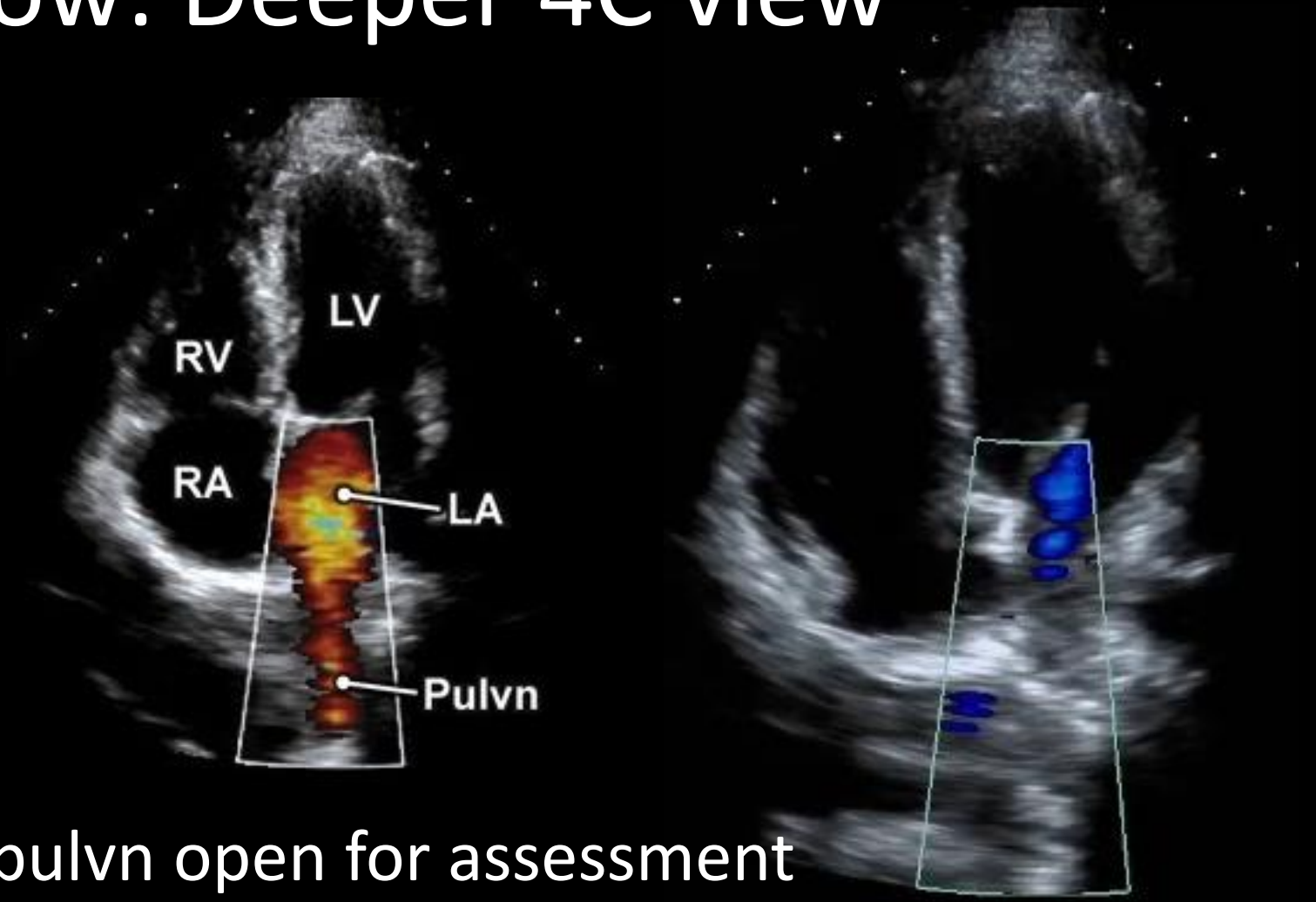


Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Complementary parameters

Pulmonary Vein Flow: Deeper 4C view

- Adjust
  - Position
  - Scale
  - Baseline
  - Gains to bring in color pulmonary vein flow



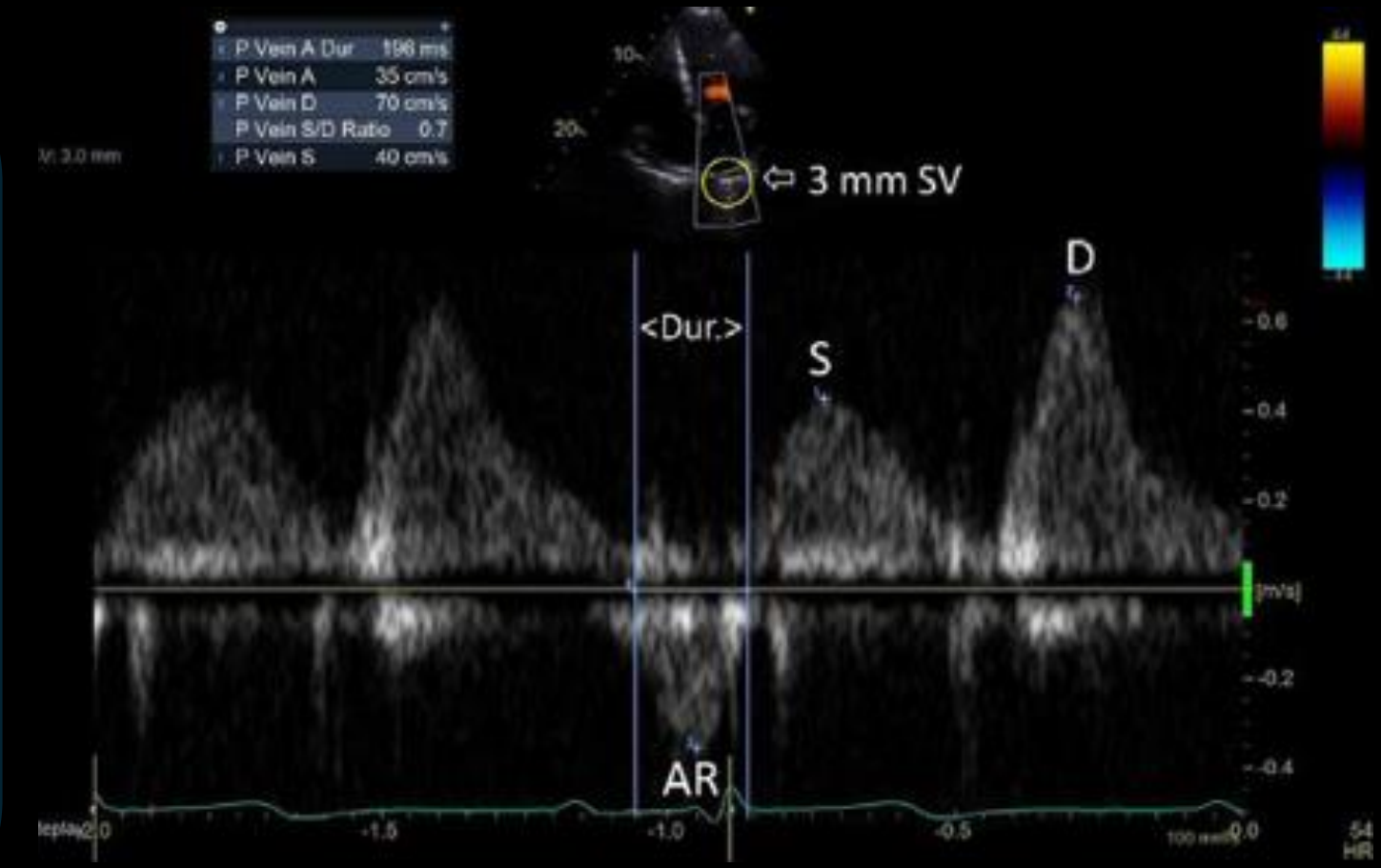
The challenge is keeping the pulvn open for assessment

Mitchell et al Journal of the American Society of Echocardiography 2019 321-64

Complementary parameters

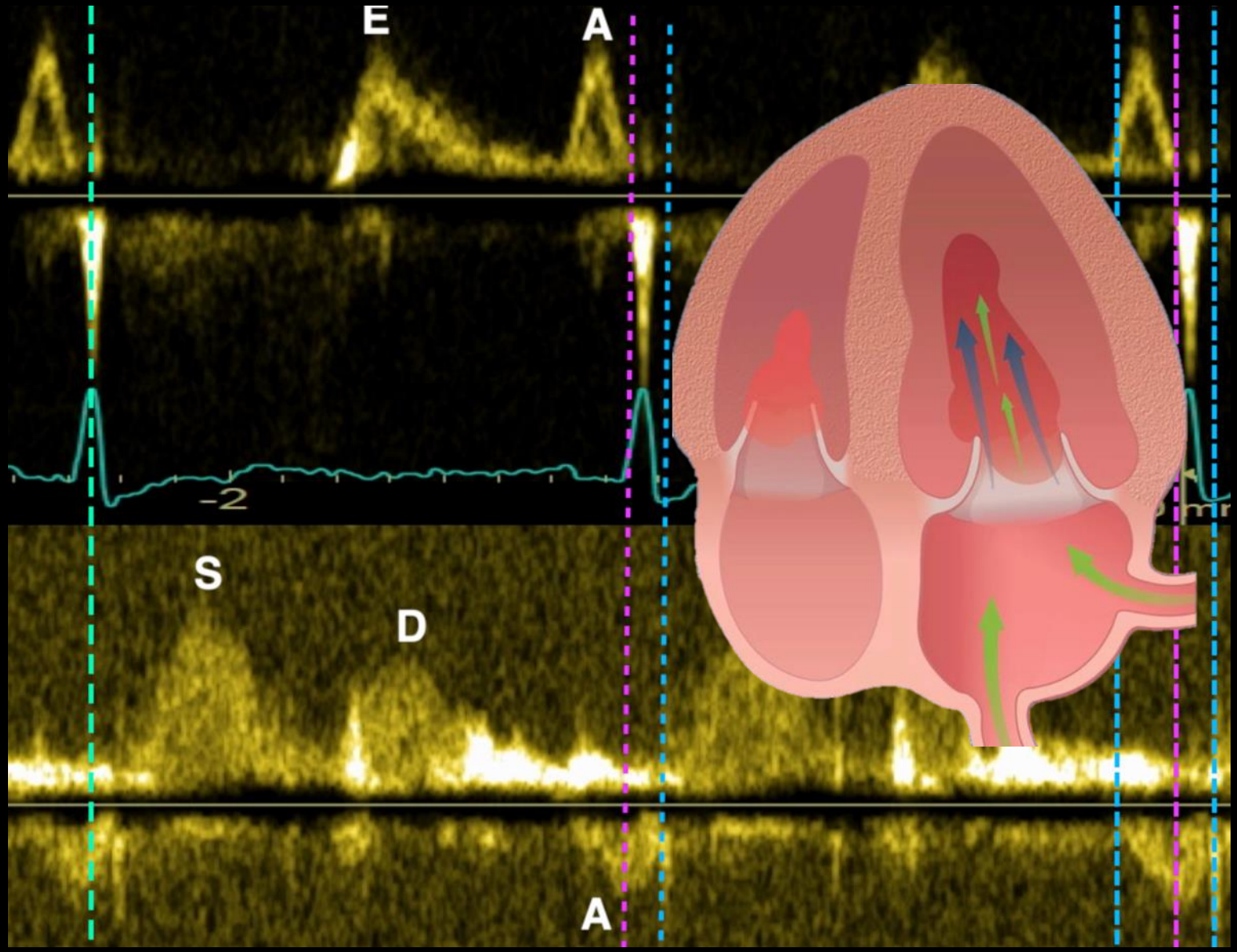
Pulmonary Vein Flow Optimization

- PW sample 3-5 mm placed 5-10 mm into pulm veins (while trying not to hit the walls)
- Low wall filter (100-200 MHz)
- Decrease gain
- Sweep speed 100 mm/s



Nagueh, S F et al. J Am Soc Echocardiogr 2025;38:537-69.

Keep in mind the whole picture, relationships and how nothing can work in isolation



https://stoylen.folk.ntnu.no/strainrate/Basic_physiology.html

Bottom Line: Attention to Detail- Alignment and Cursor Placement Matter!

The power is in our hands! Thank you!