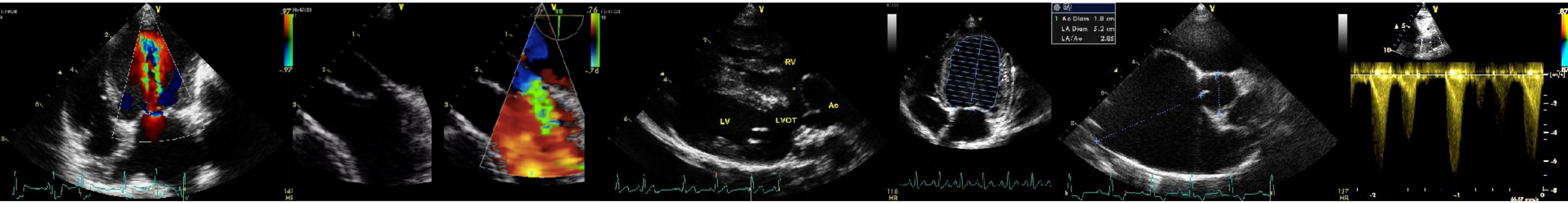
Echocardiography

A window into the soul



Doppler, TDI, Speckle & Bubbles

Dave Dickson
BVetMed DVC MRCVS
RCVS Specialist in Cardiology

HeartVets

Introduction

- Physics of Doppler
- Doppler modes
  - CFM
  - PW
  - CW
  - TDI
- Use and misuse of Doppler
- Speckle Tracking
- Contrast echo

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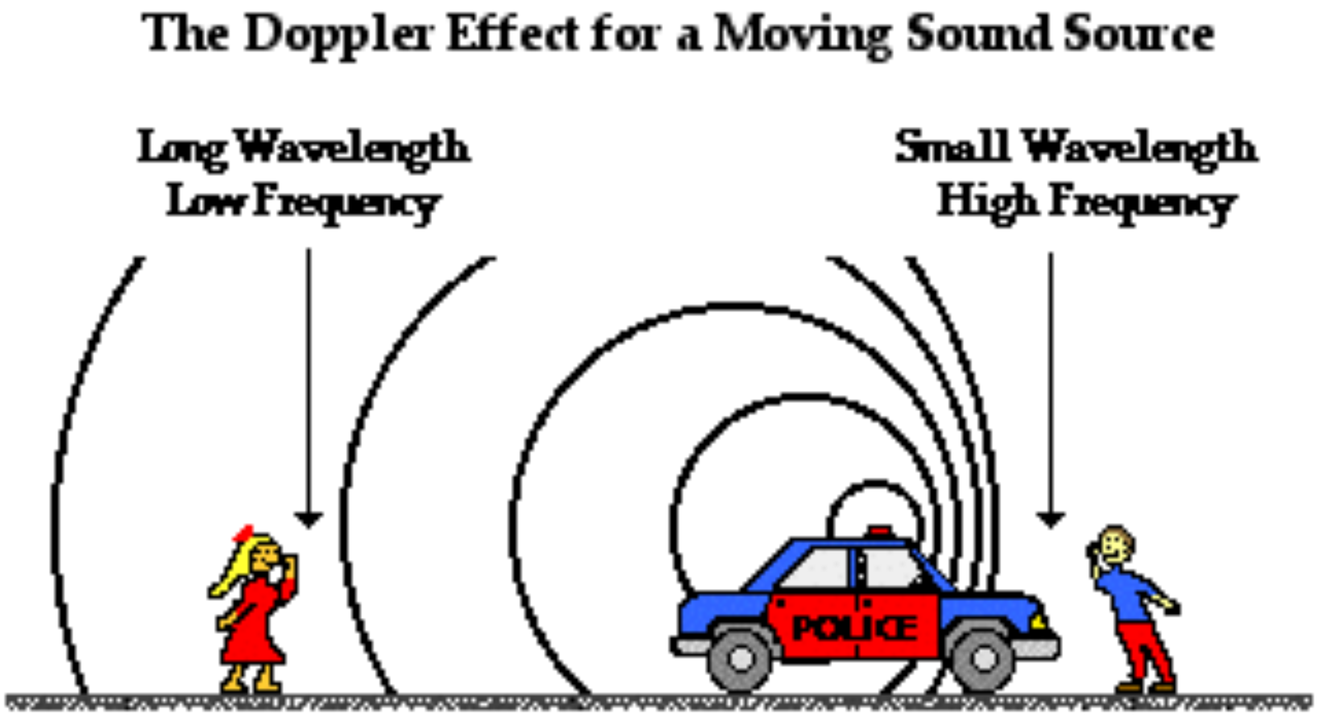
The Doppler effect



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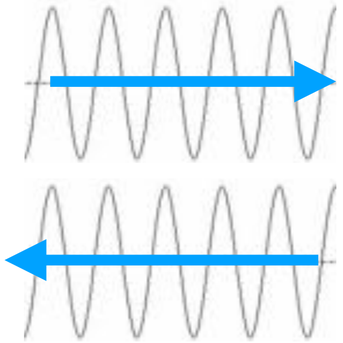
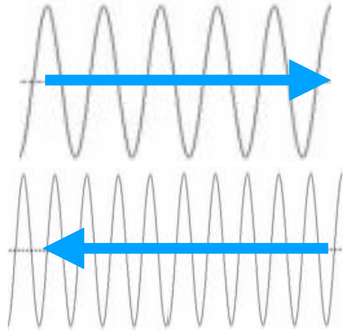
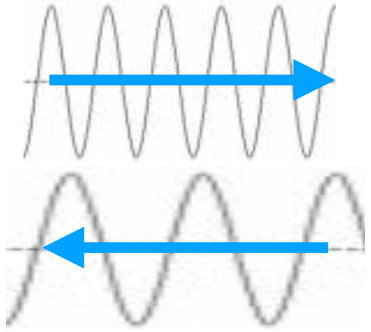
The Doppler shift



ΔF = 0



ΔF = +



ΔF = -

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The Doppler Equation

$$\Delta F = \frac{2 F V \cos\theta}{C}$$

ΔF = Frequency shift

F = transducer frequency

θ = angle of interrogation

C = speed of sound

V = velocity of target

$$\Delta F \propto \text{Velocity}$$

We can influence the

Transducer Frequency

&

Angle of Interrogation

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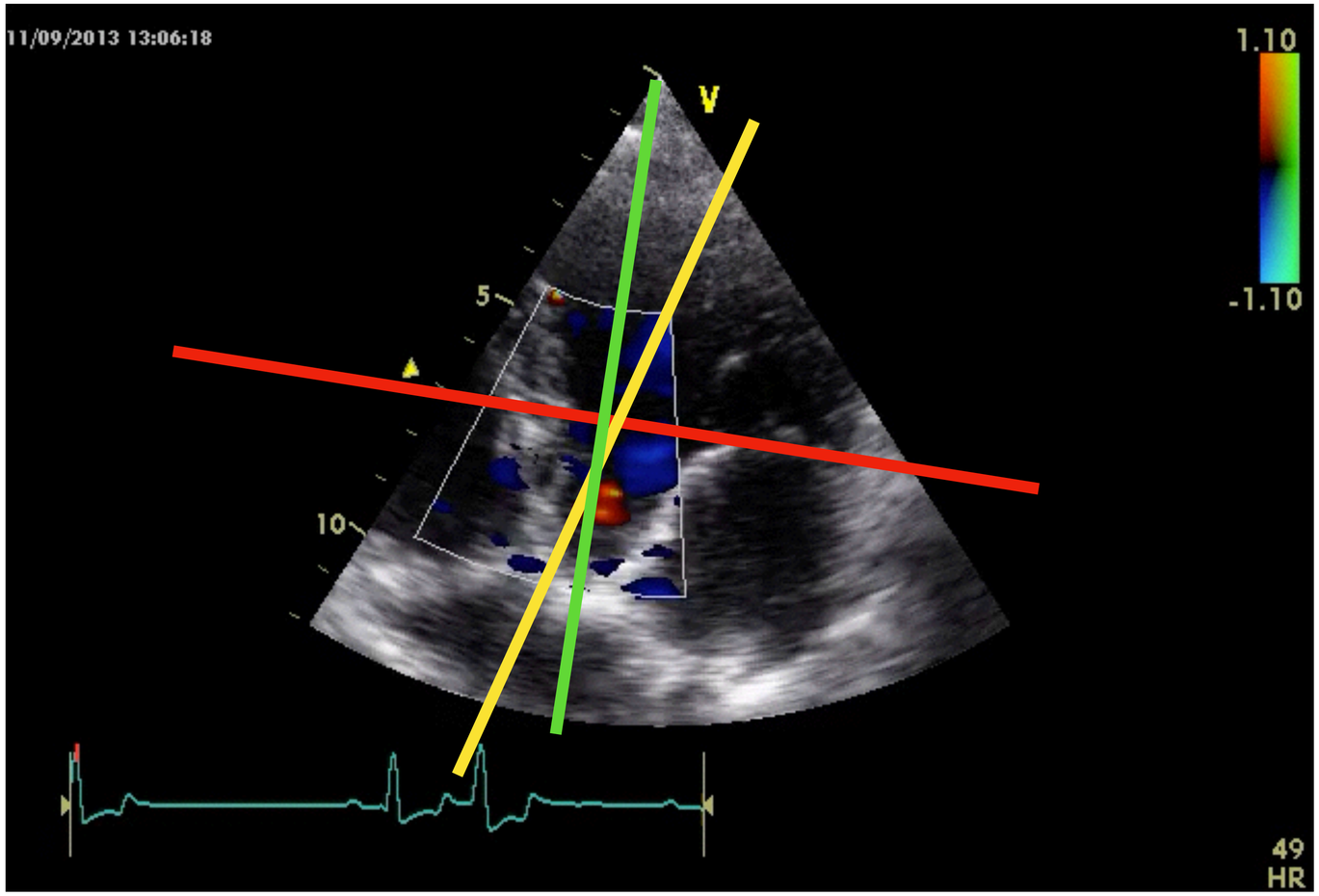
Angle of interrogation



- *cosΘ 0° = 1*
- *cosΘ 10° = 0.95*
- *cosΘ 90° = 0*

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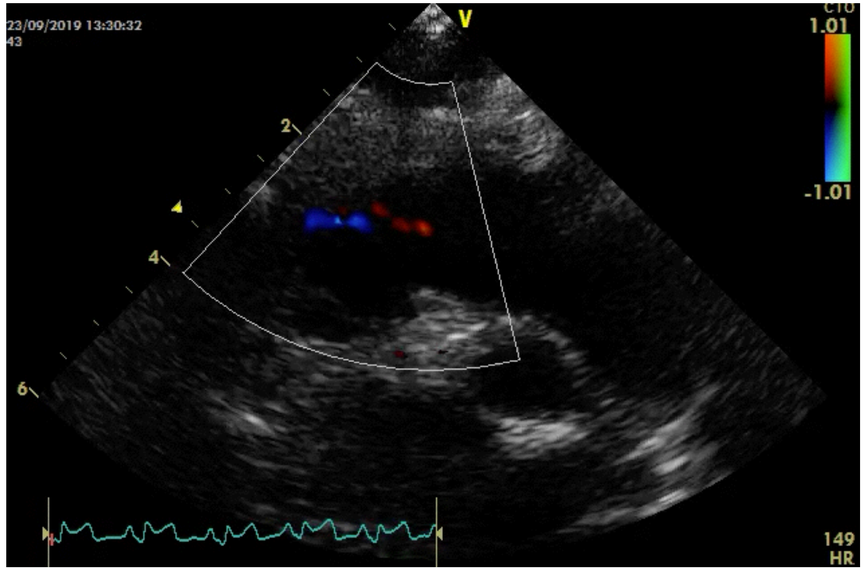
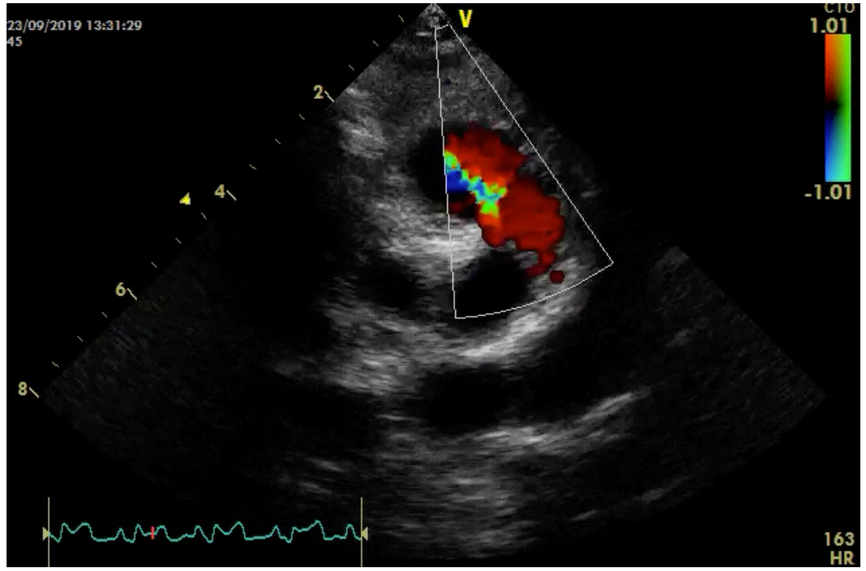
Angle of interrogation





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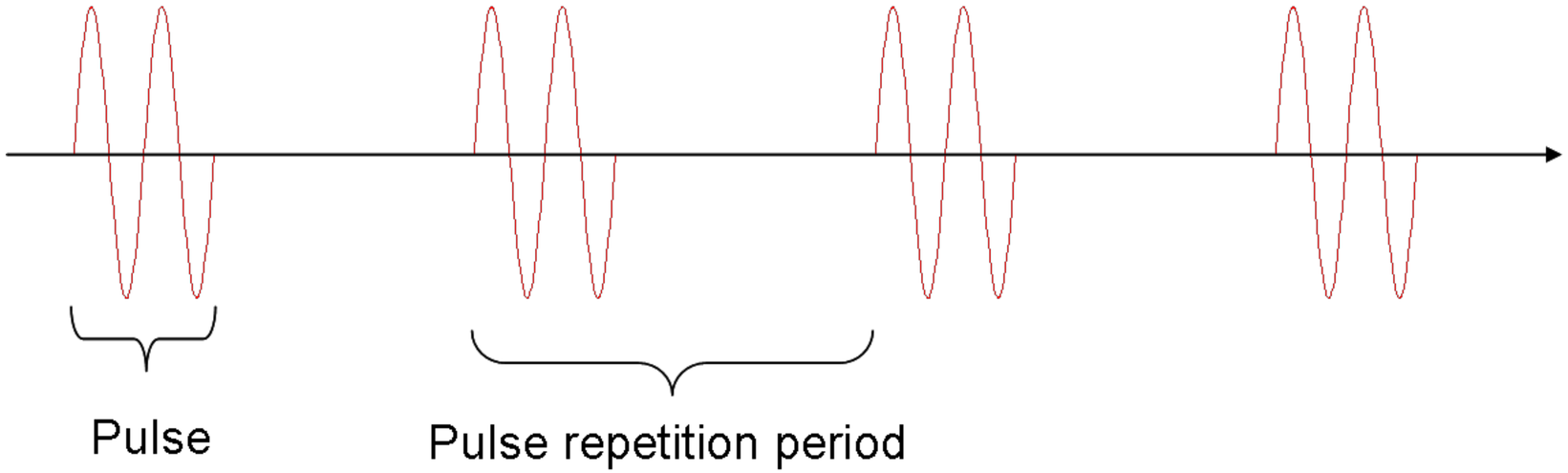
Pulsed-wave Doppler



- PRF = transmit - wait - receive
- Gives depth discretion

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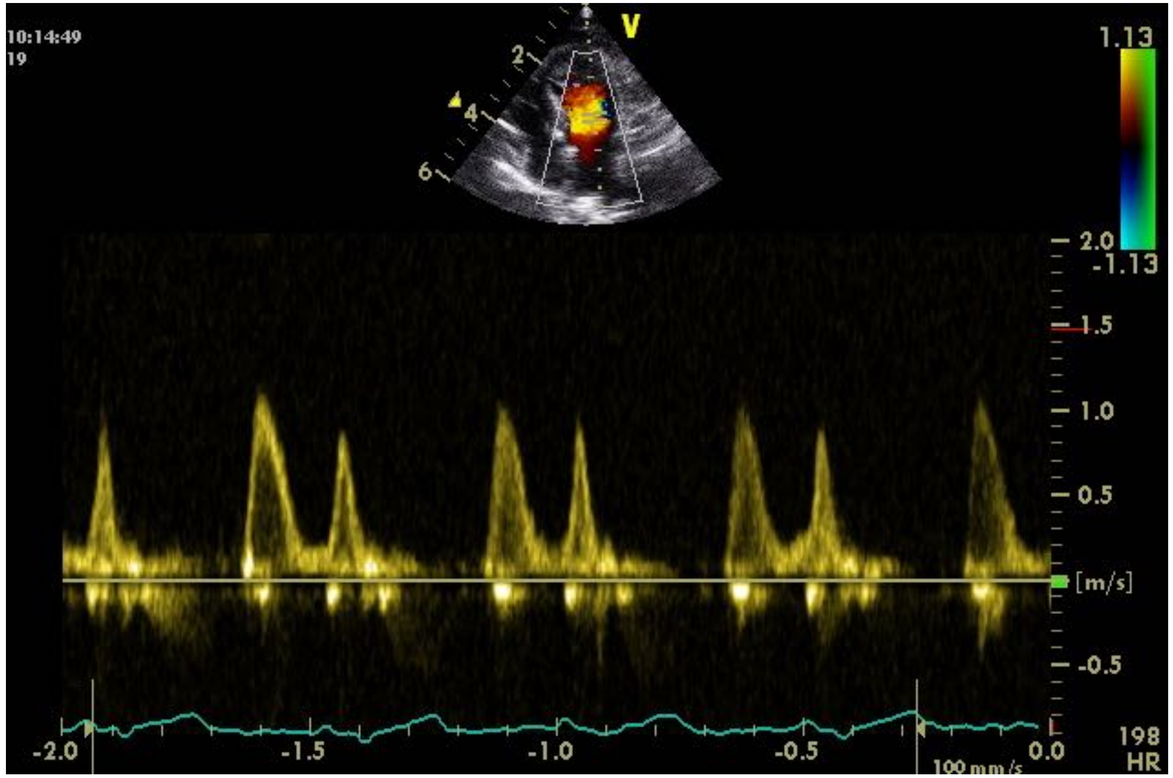
Pulsed-wave Doppler



- Gives excellent depth discretion
- Ideal for measuring velocity at specific location
- Limit is time
  - Deeper = longer
  - Sacrifice velocity for accuracy

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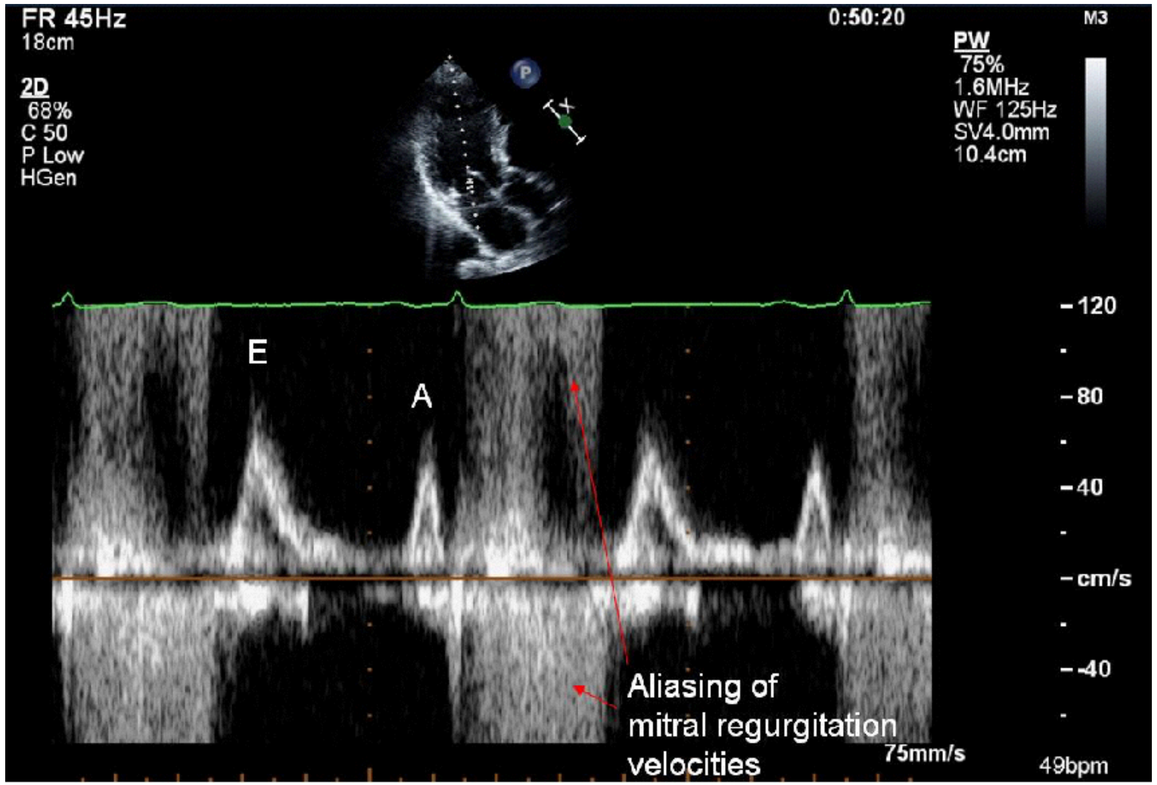
Aliasing & the Nyquist Limit



- If velocity goes above the set scale, machine can't work out direction
- Reached the Nyquist Limit
  - "Aliased"
- Need to increase scale
- Or change to CW
- Lower frequency probes help reduce aliasing

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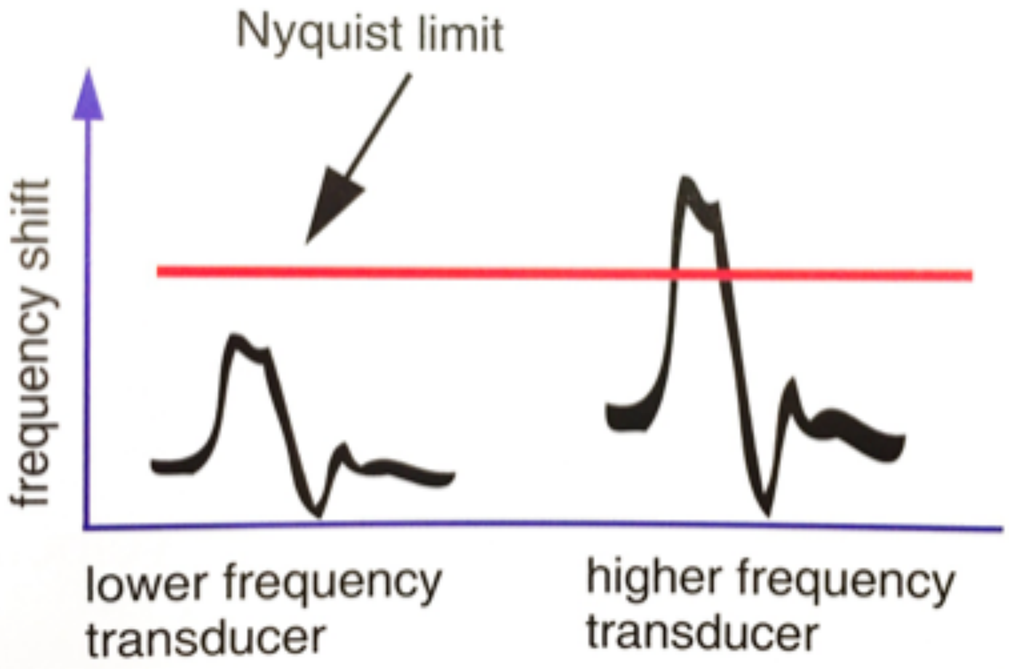
Aliasing & the Nyquist Limit



- Lower shifts less likely to exceed Nyquist limit
- Also can move scale and adjust the Nyquist limit in some modes

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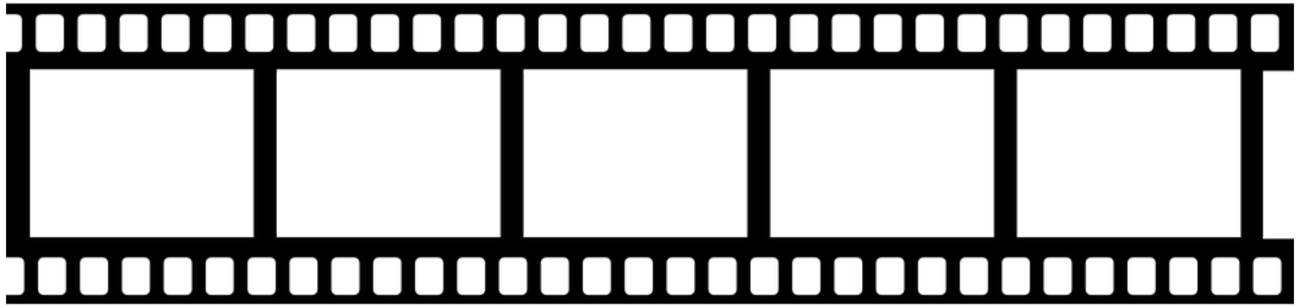
Aliasing



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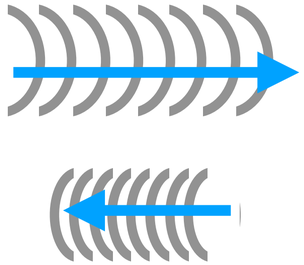
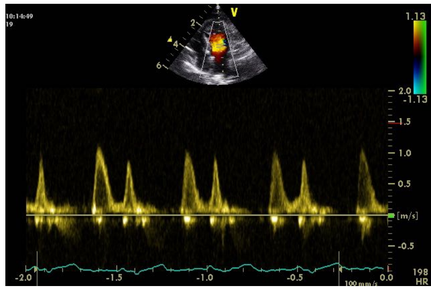
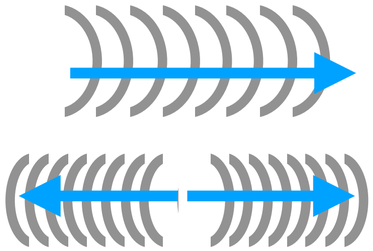
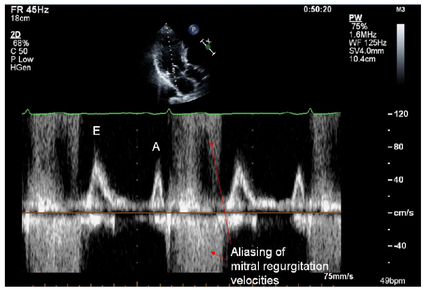
Aliasing









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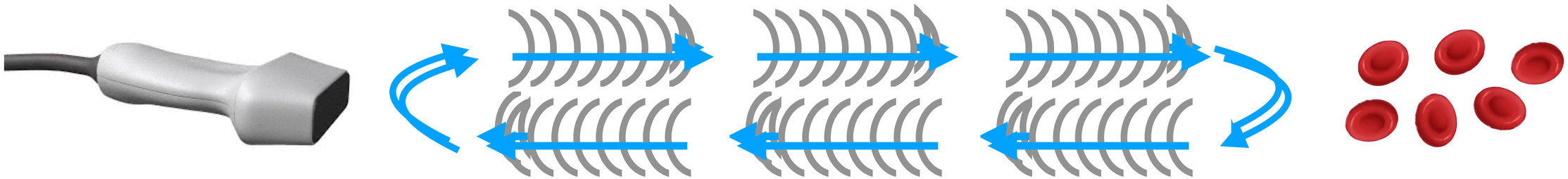
Continuous-wave Doppler



- Advantage = can record much higher velocities c.f. PWD
- Disadvantage = no (or very little) depth discretion

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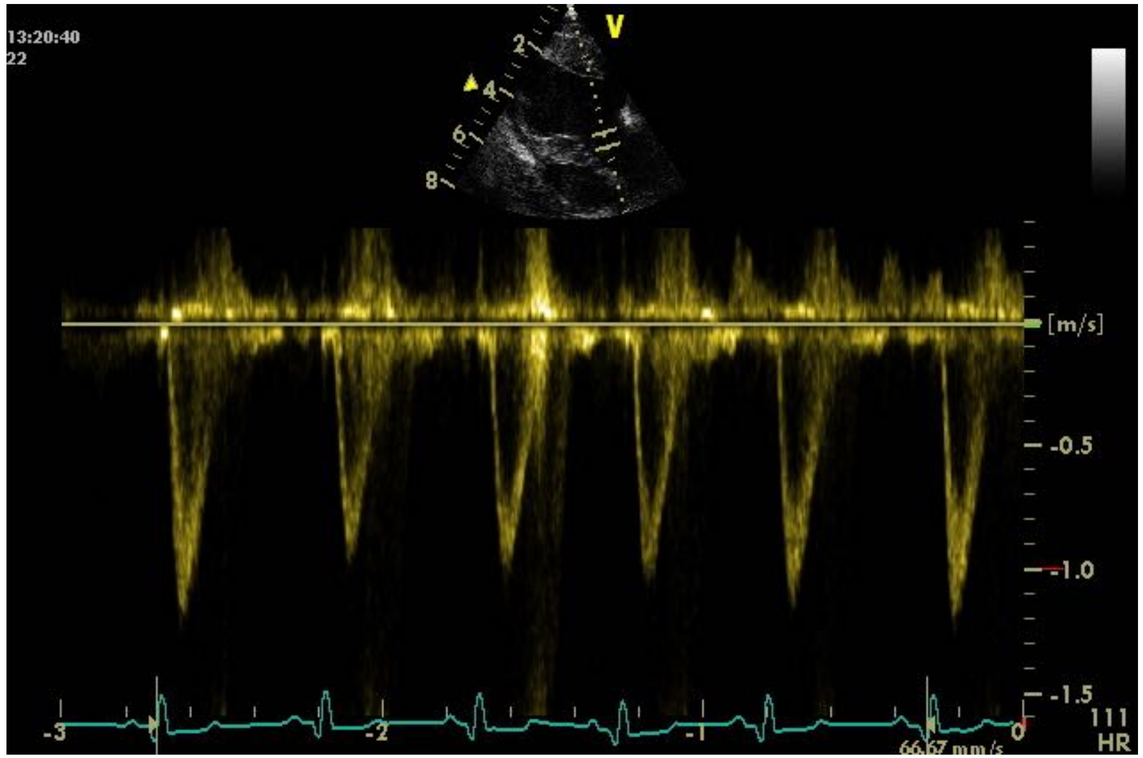
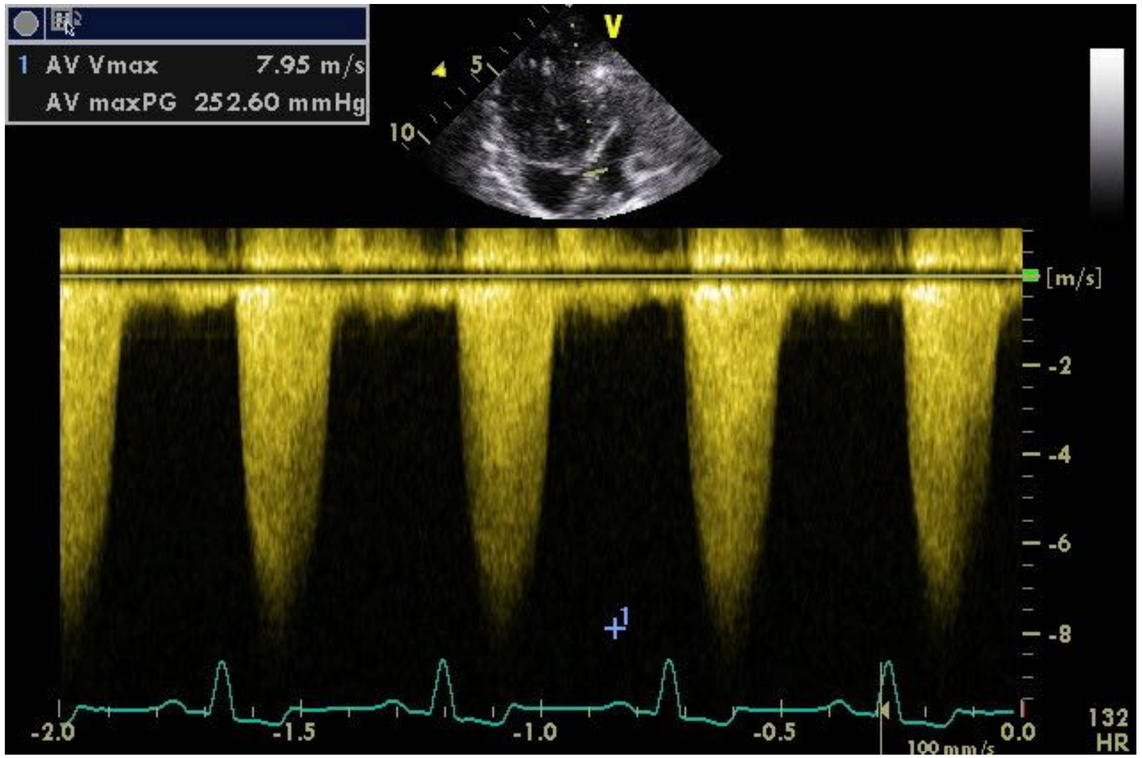
Laminar vs. turbulent flow





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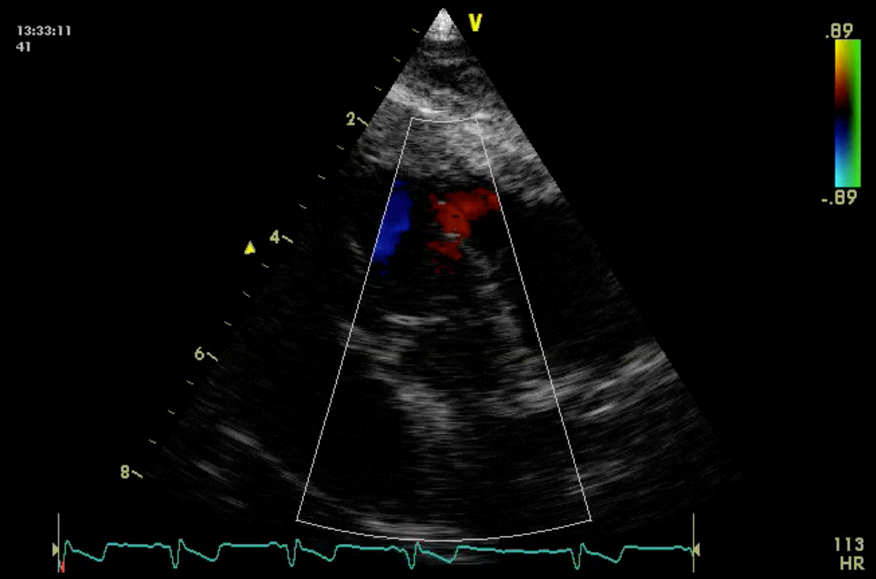
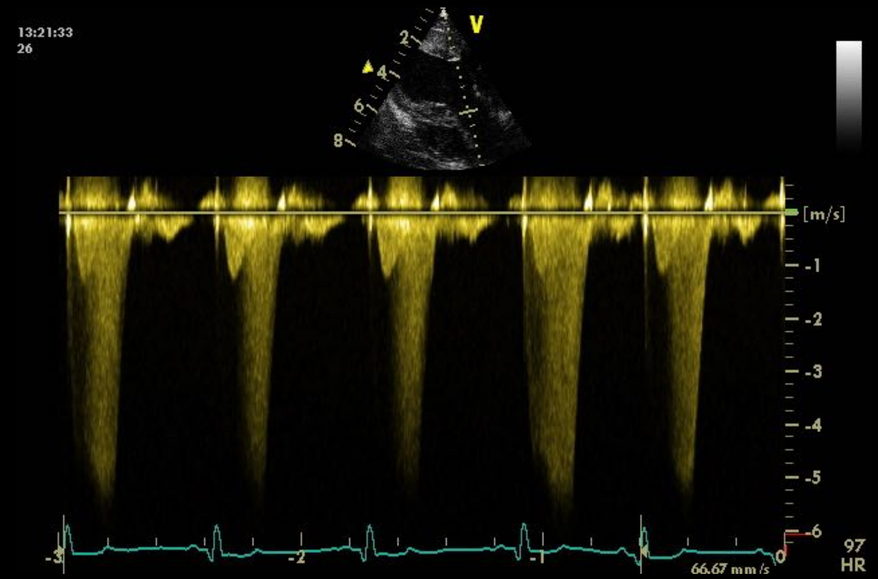
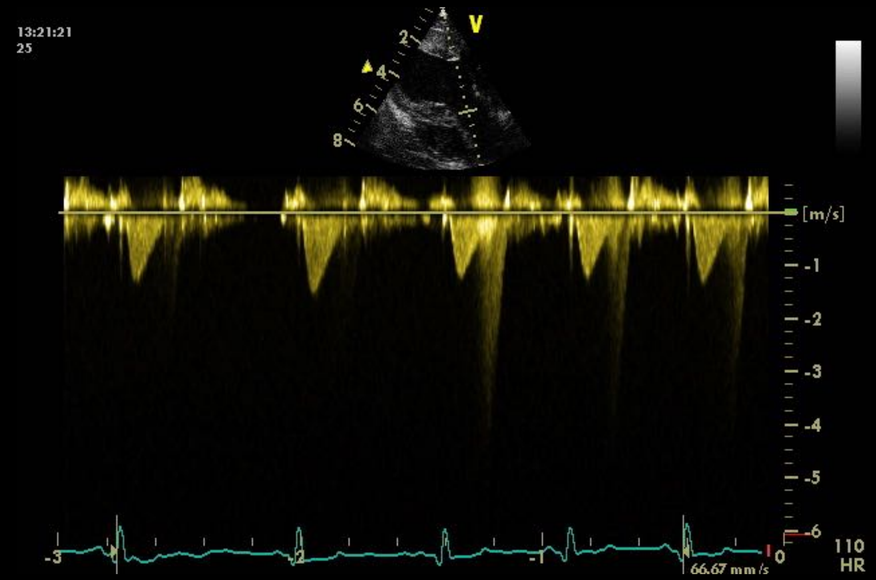
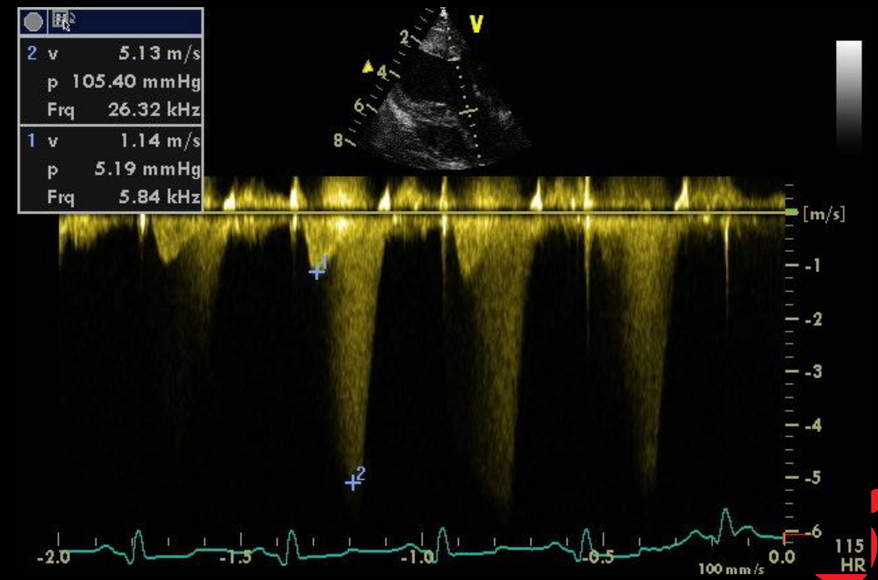
Care with Continuous-wave Doppler









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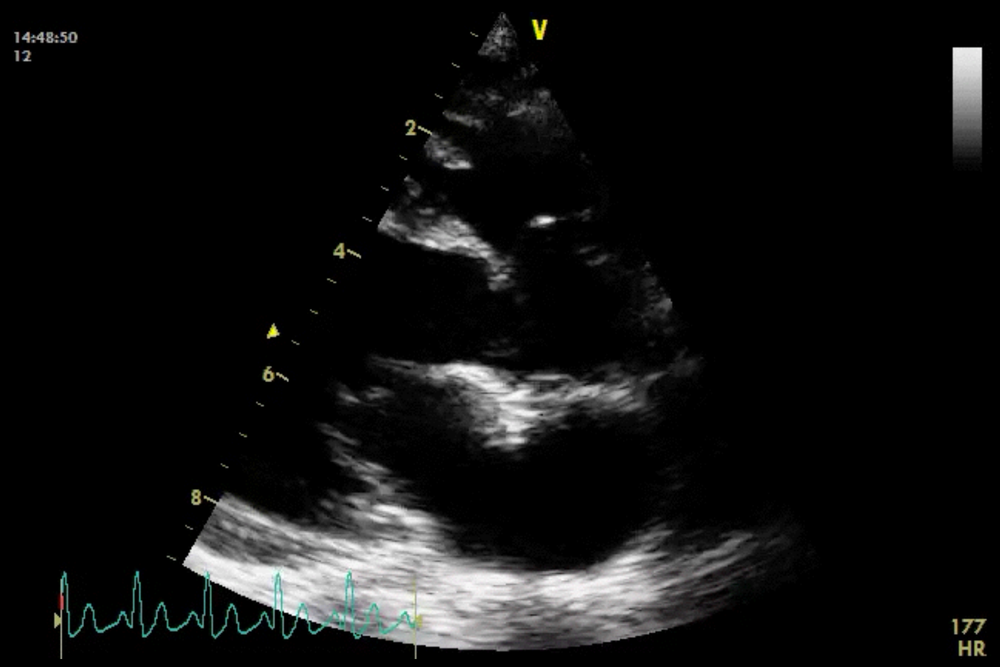
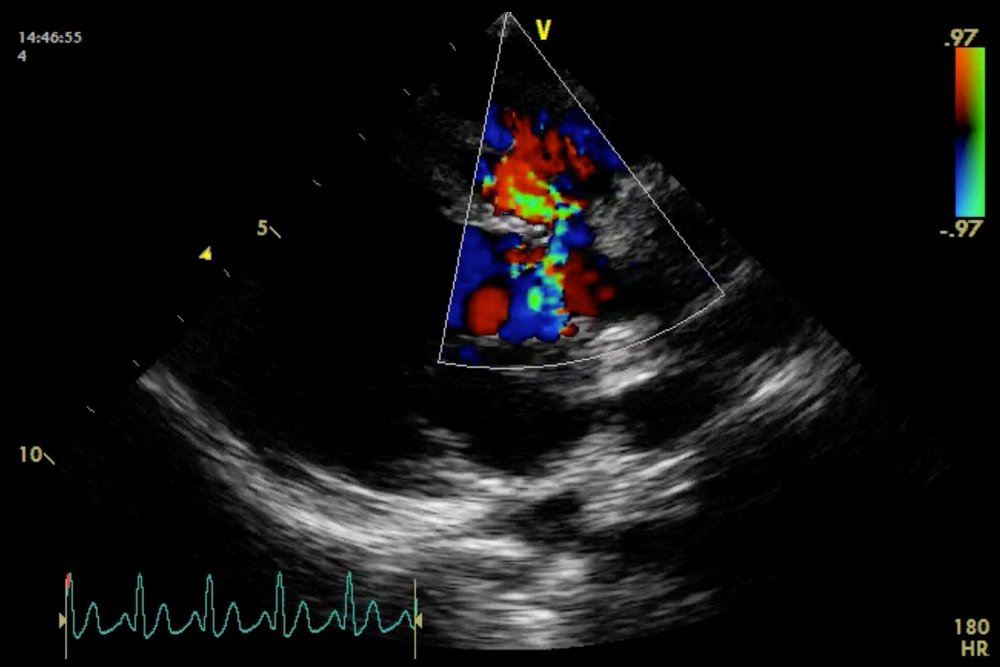
Colour Flow Mapping





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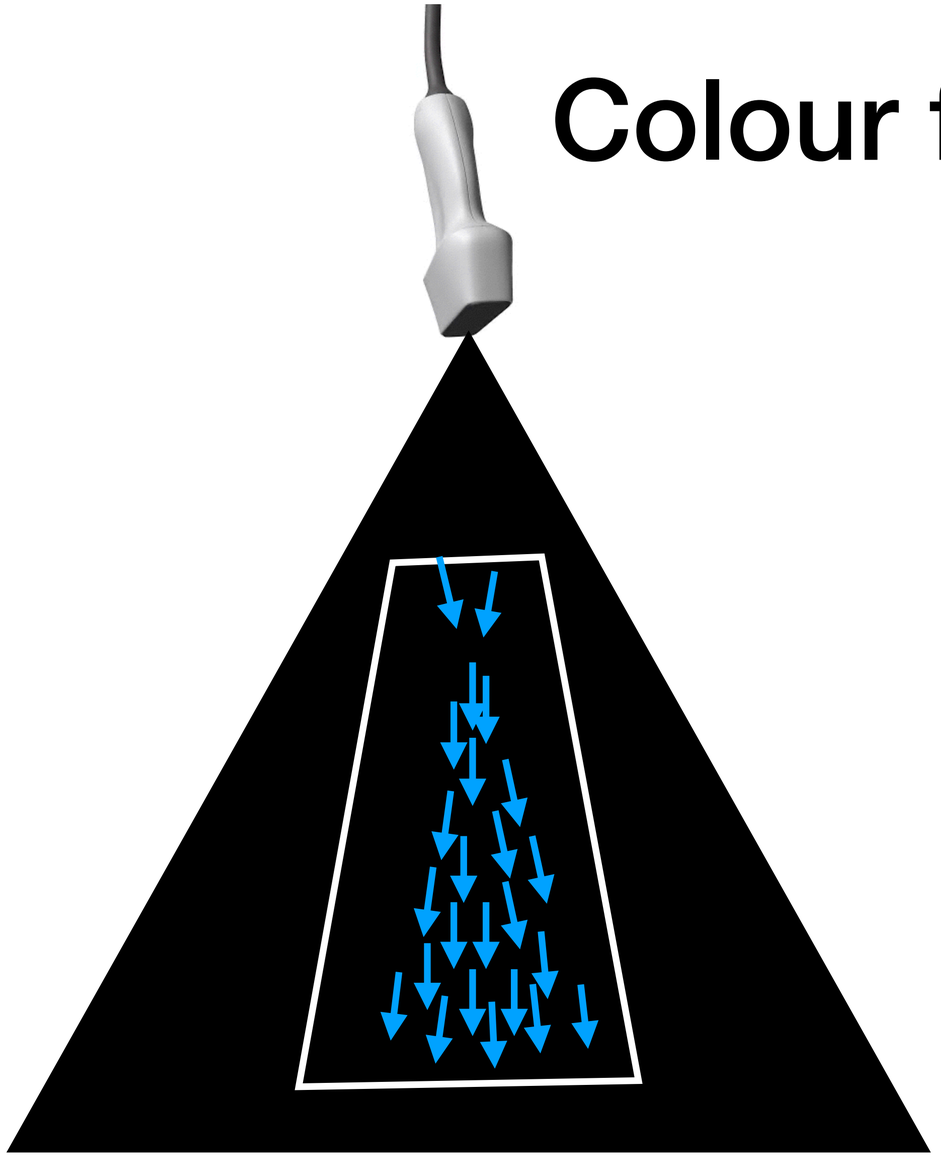
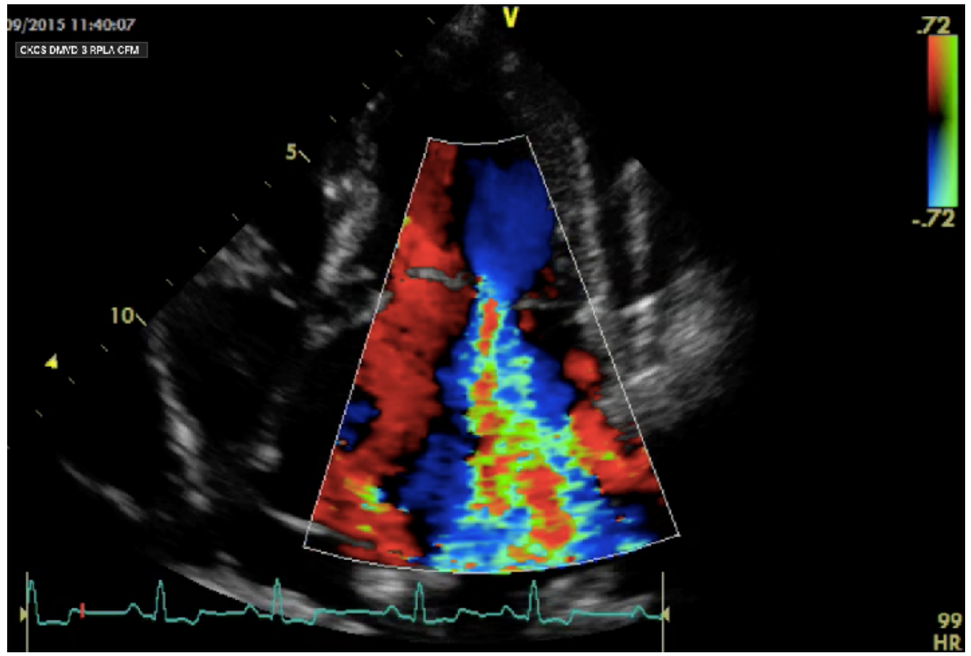
Colour flow mapping





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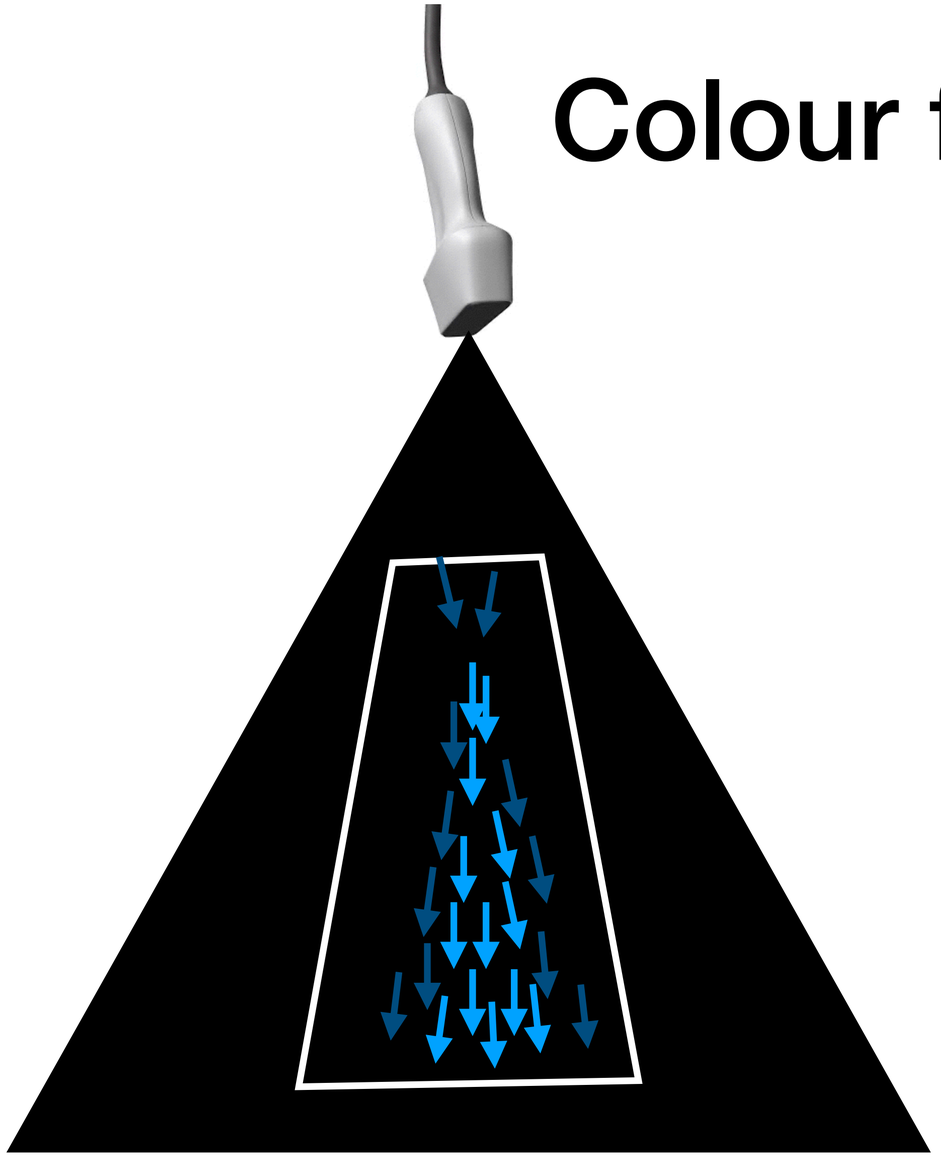
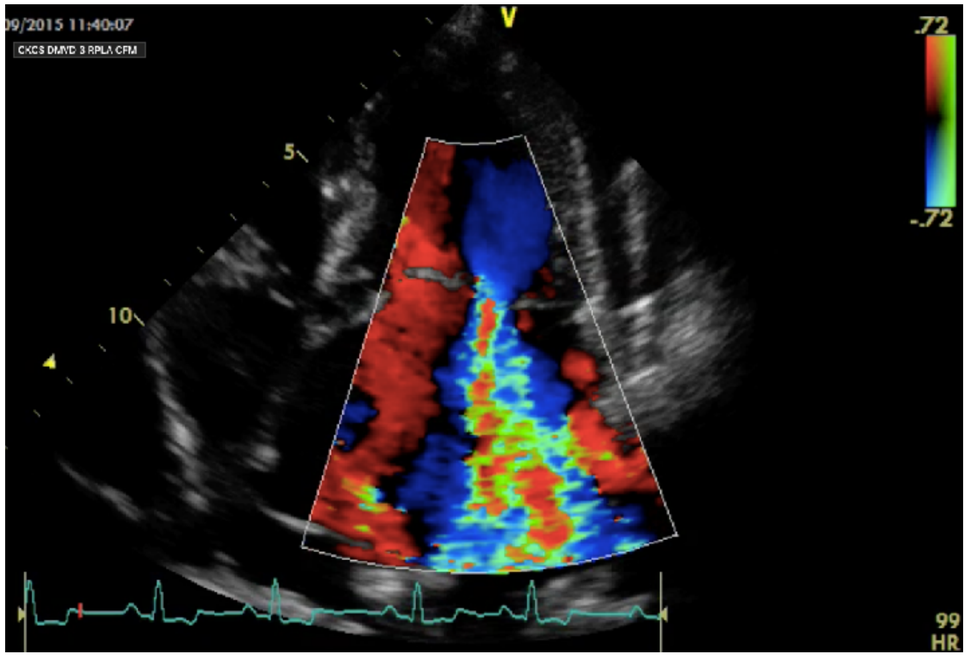
Colour flow mapping





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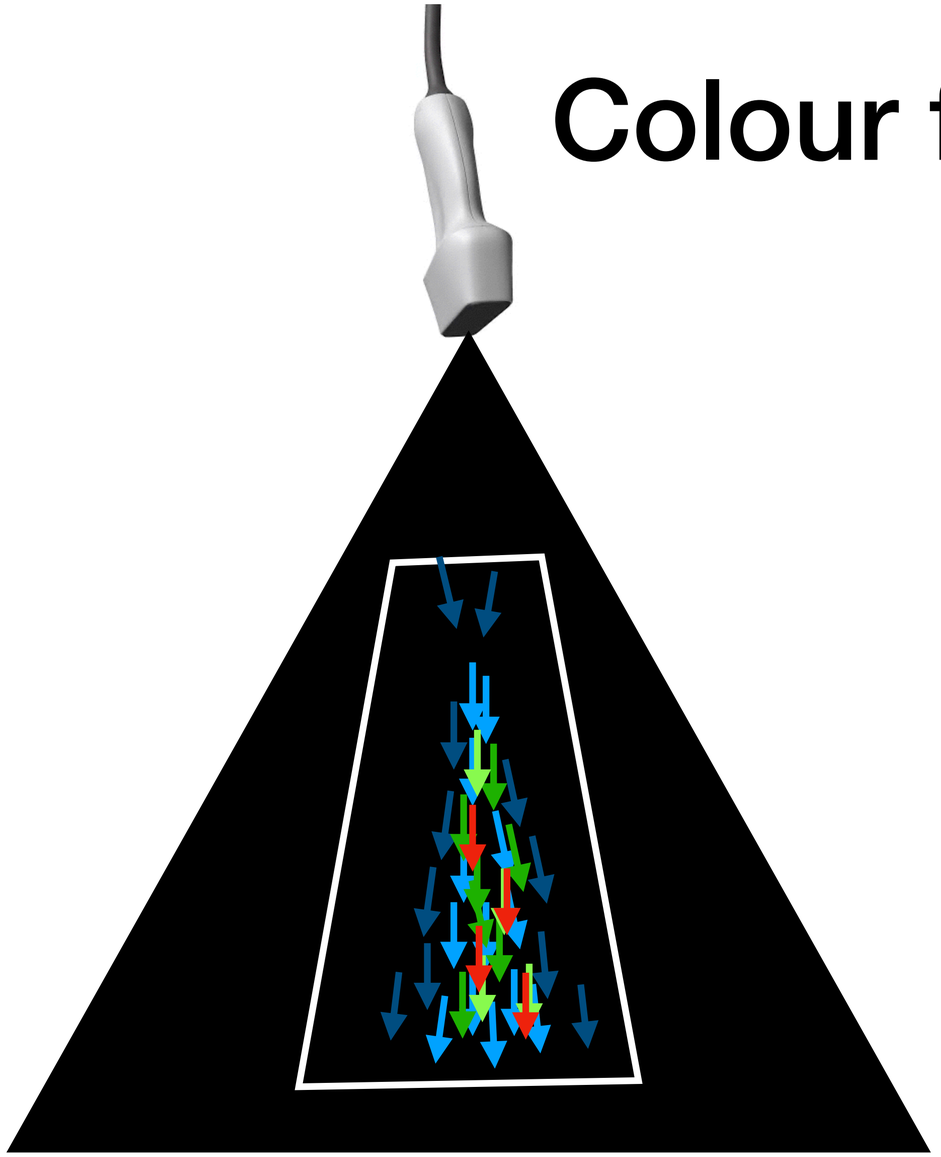
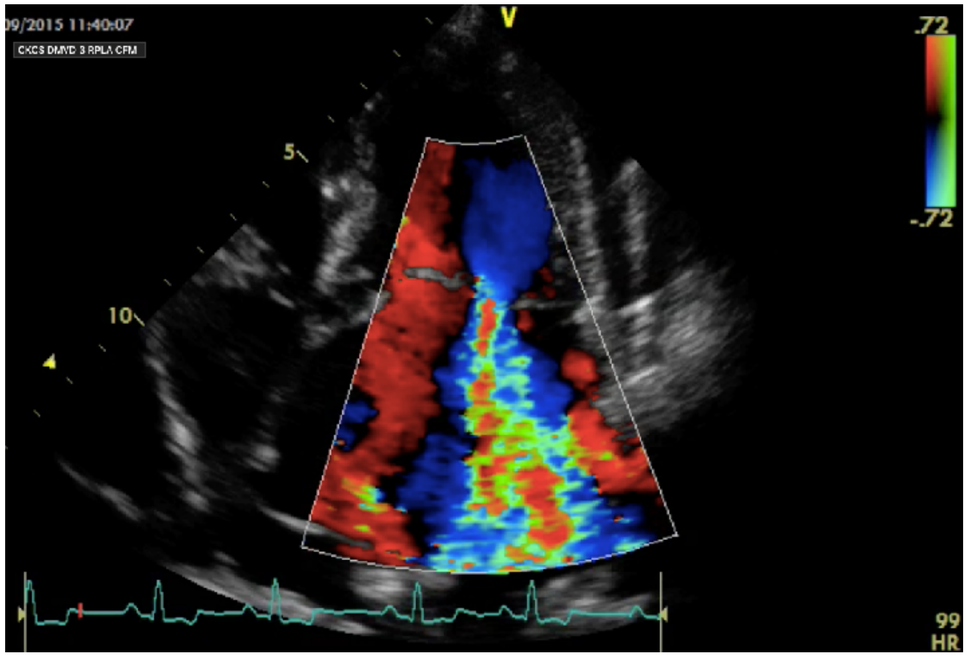
Colour flow mapping





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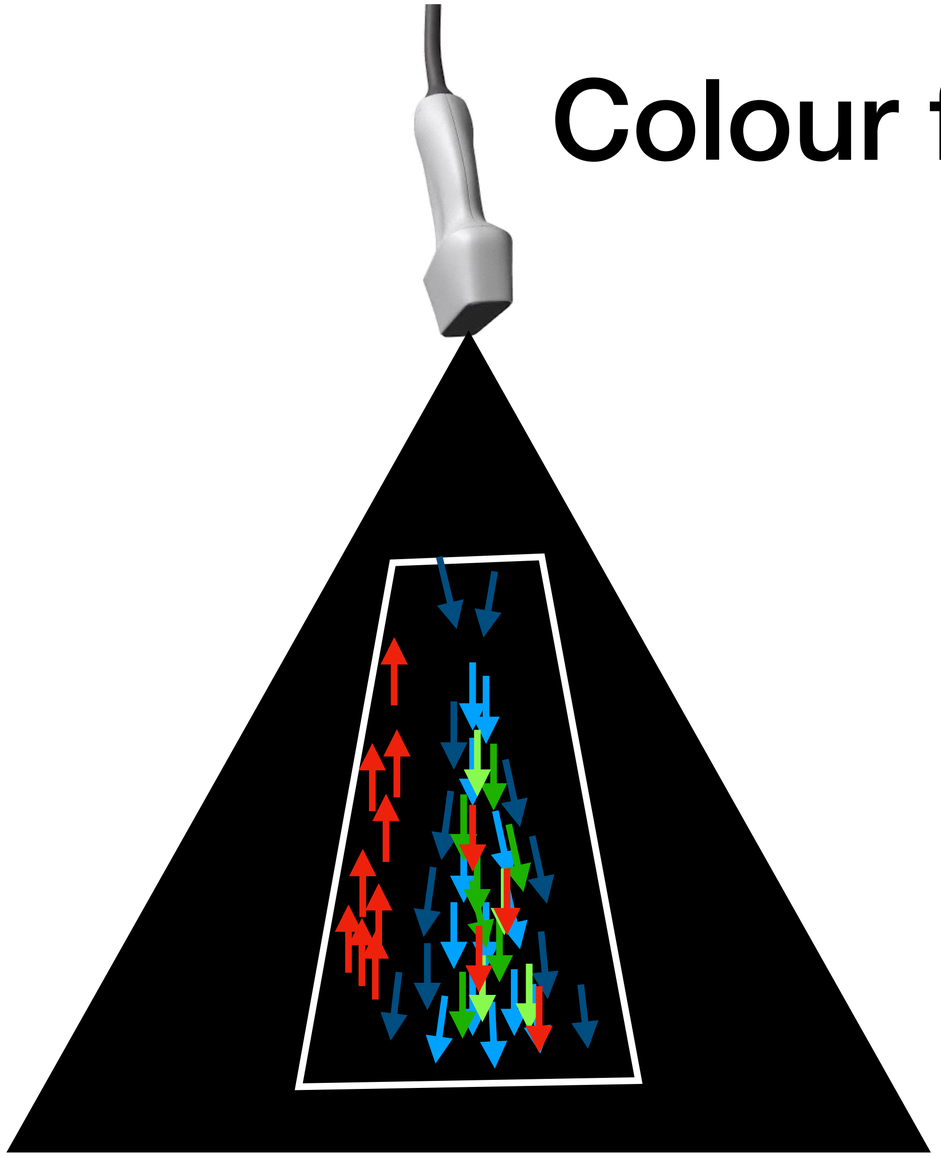
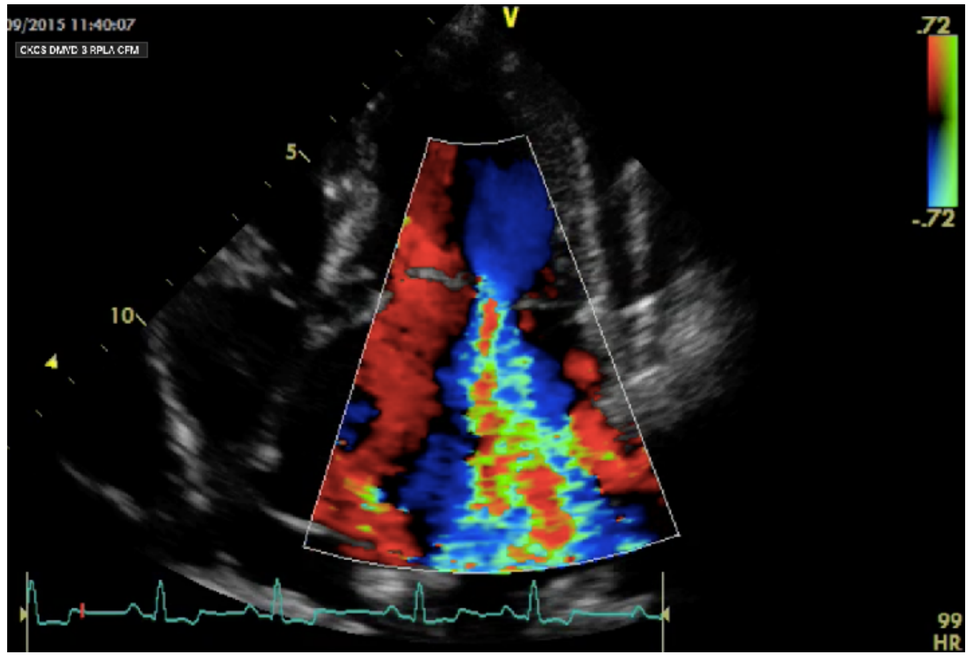
Colour flow mapping





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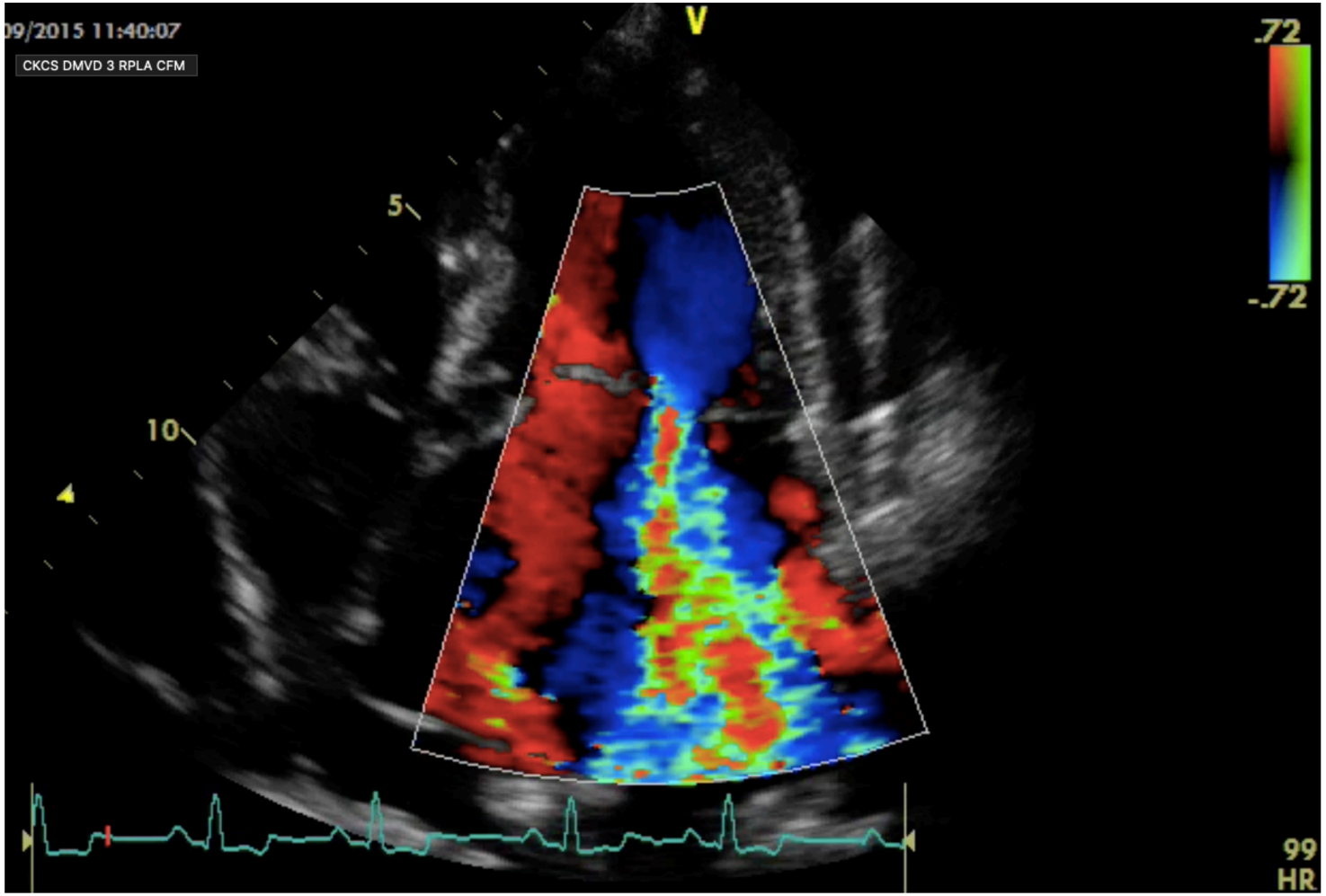
Colour flow mapping



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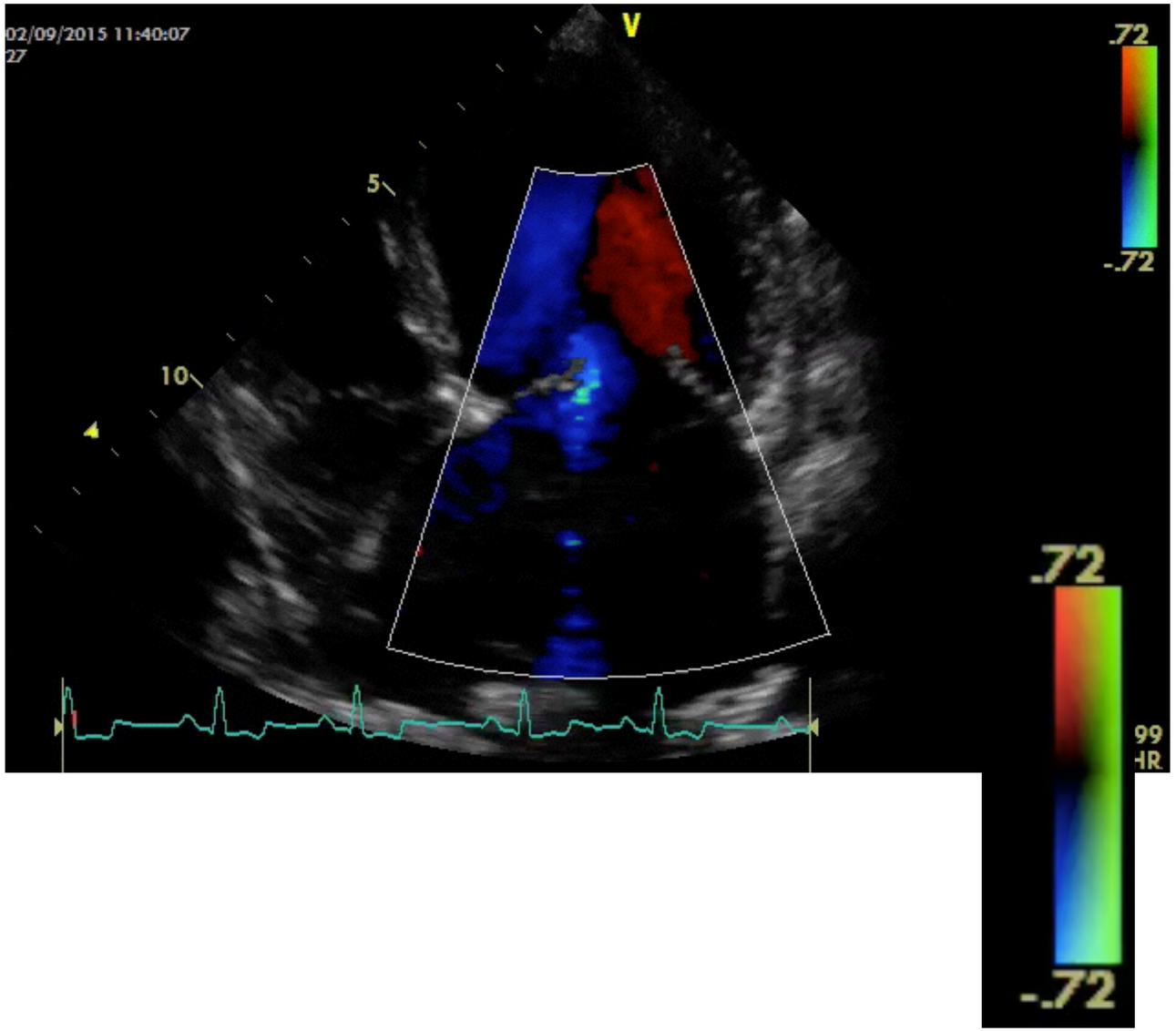
Colour flow mapping



- Uses a huge amount of processing time
- Doppler freq dependent - low freq better
- Wider 2D sector = lower FR
- Larger colour box = lower FR
- Make sure aliasing velocity set high for high velocity flow

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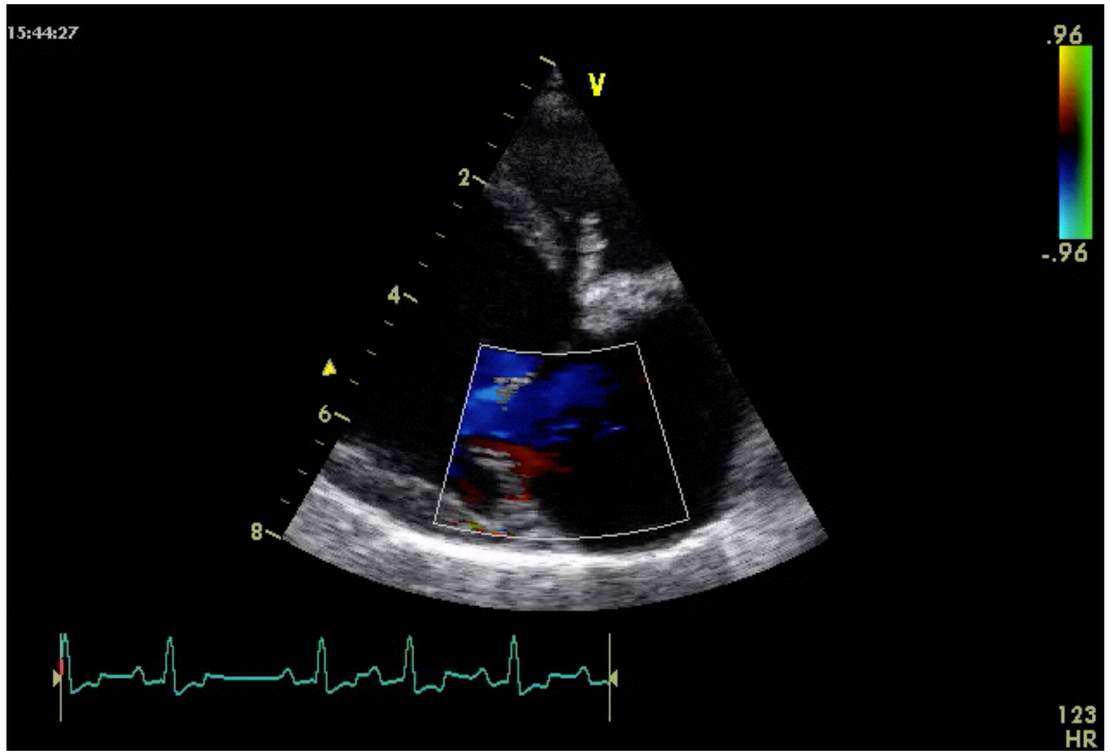
Colour flow mapping



- Angle dependent
  - Exactly the same as PW/CW
- Flow travelling perpendicular to the beam is harder to detect
- Optimise alignment with flow

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Using Doppler in the echo exam

- Be critical of image quality before applying Doppler
  - Optimise 2D image
  - Optimise frame rate - depth, frame rate
- Use Doppler in a consistent way
  - “2D, Colour Flow, Spectral”

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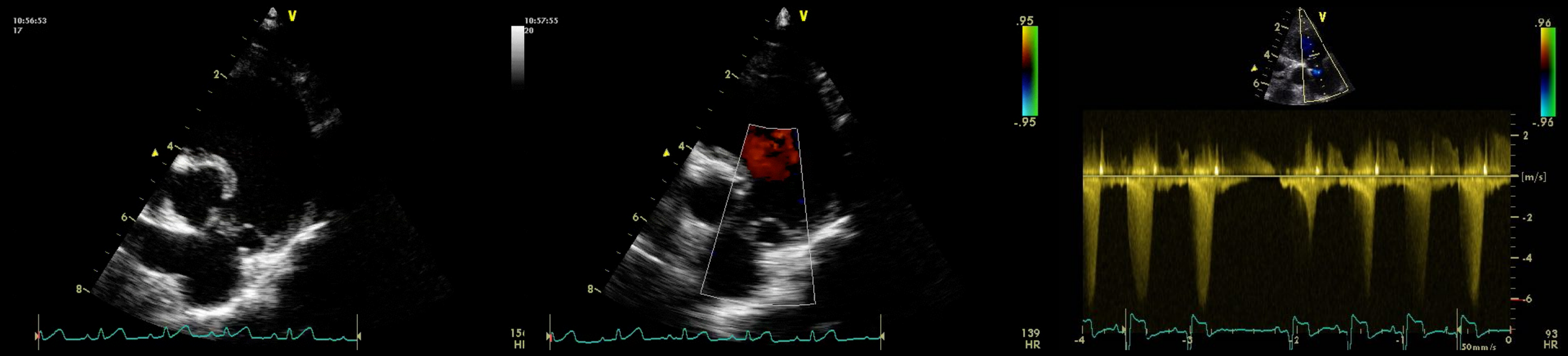
2D, Colour flow, Spectral



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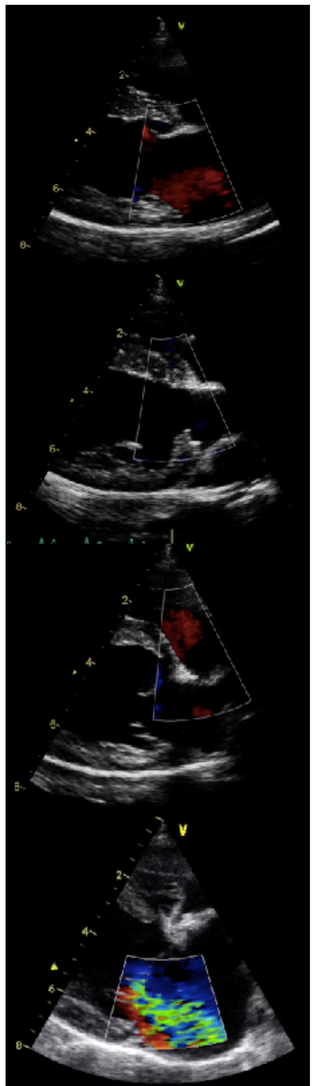
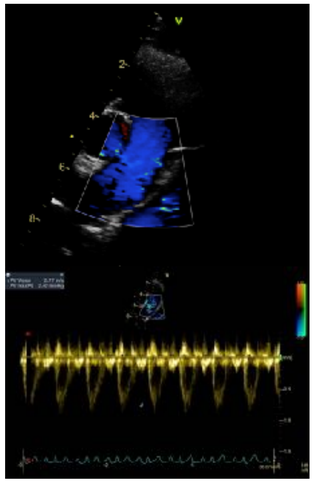
The Doppler study

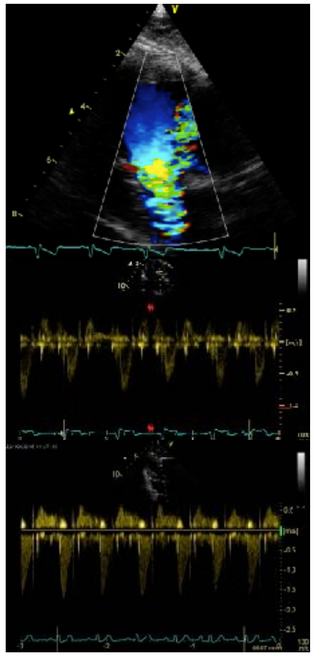
RPLA



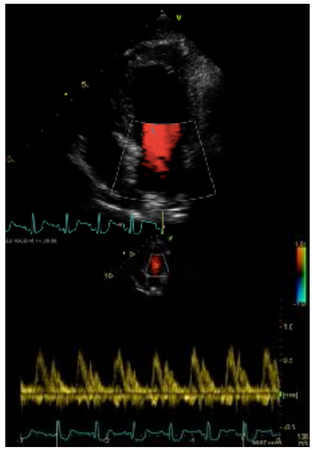
RPSA PA



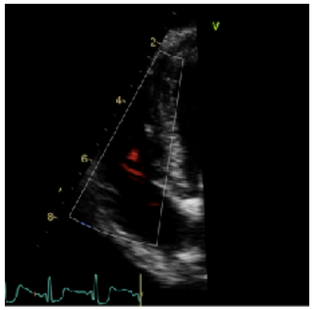
SubCost Ao



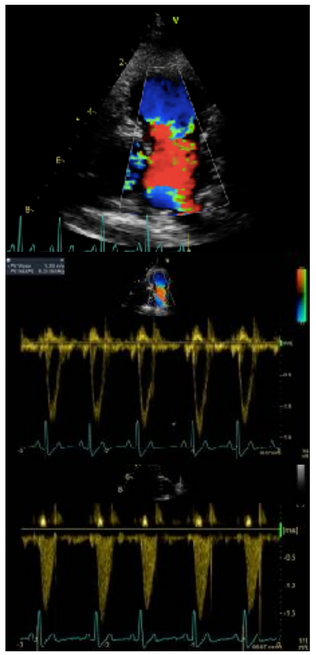
LA4C MV



LA4C TV



LCr PA



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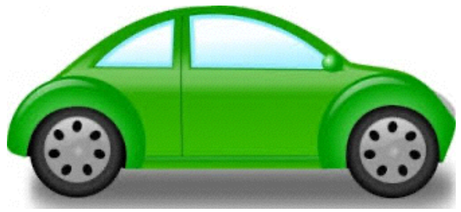
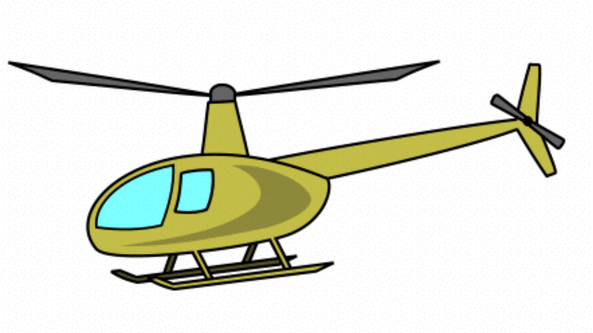
Use and misuse of Doppler

- Doppler is a great tool
- BUT it requires rigorous technique, an excellent understanding of cardiac physiology and attention to detail to use properly





- Need to practice and see a lot of cases
- Need to know when to believe and when not to
- It doesn’t replace a good clinical examination or good basic echo technique

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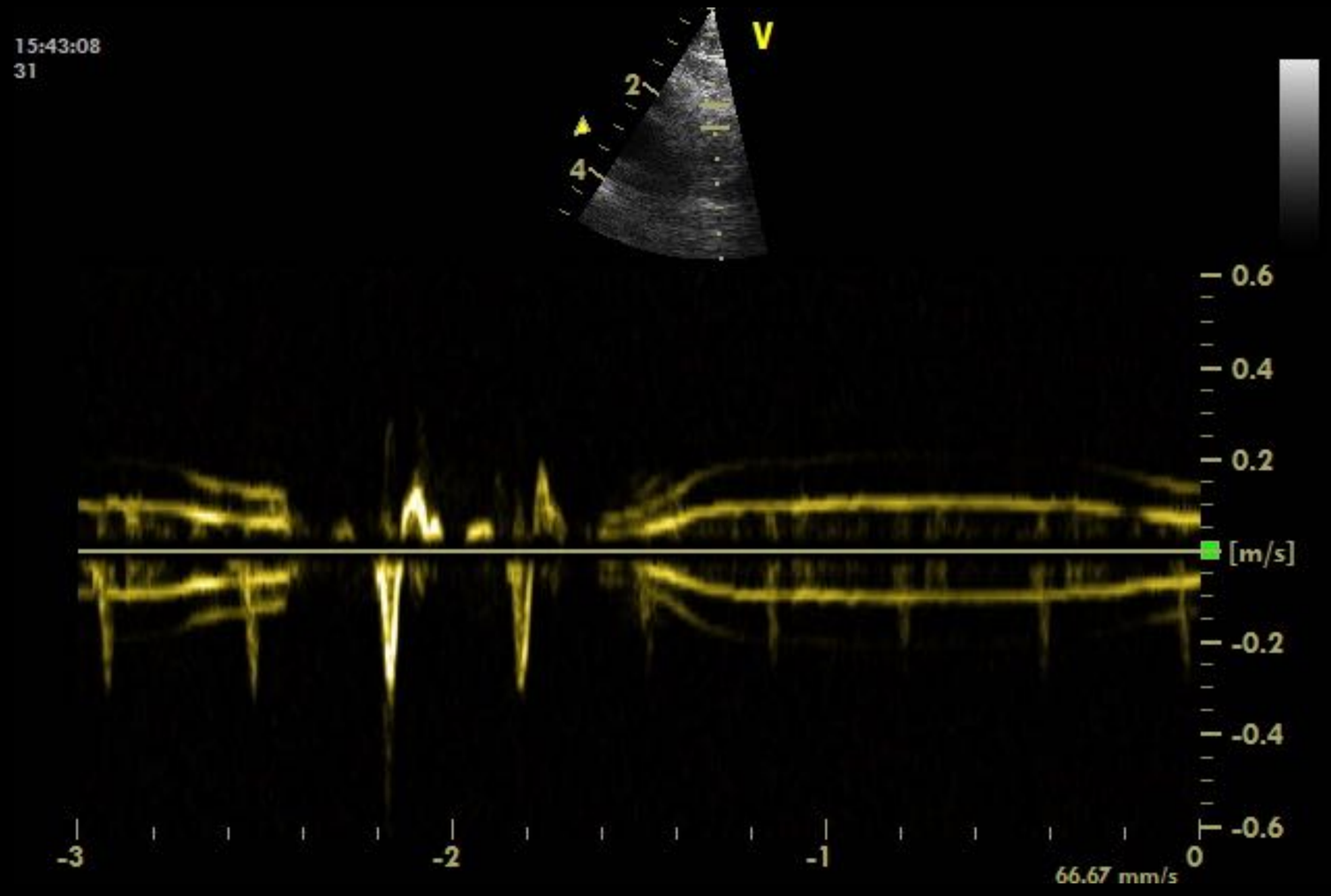
What’s your diagnosis?



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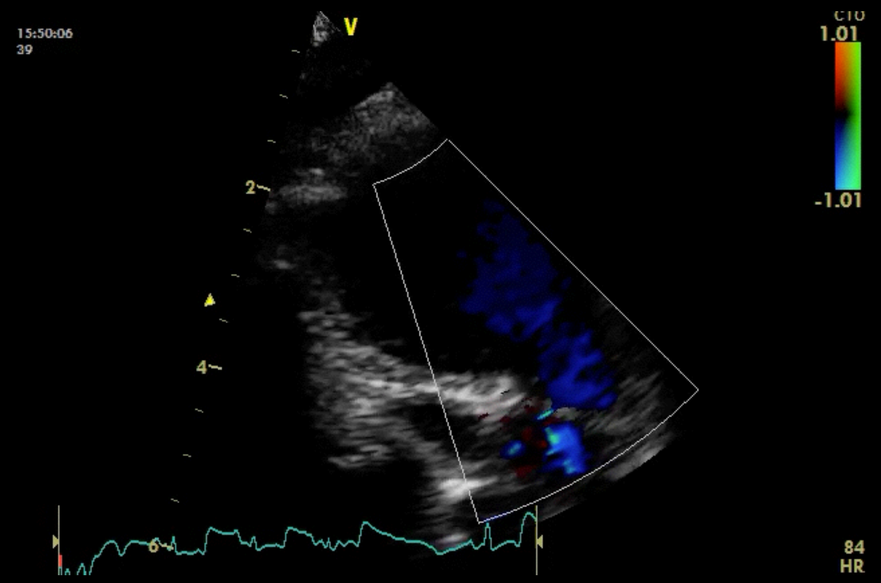
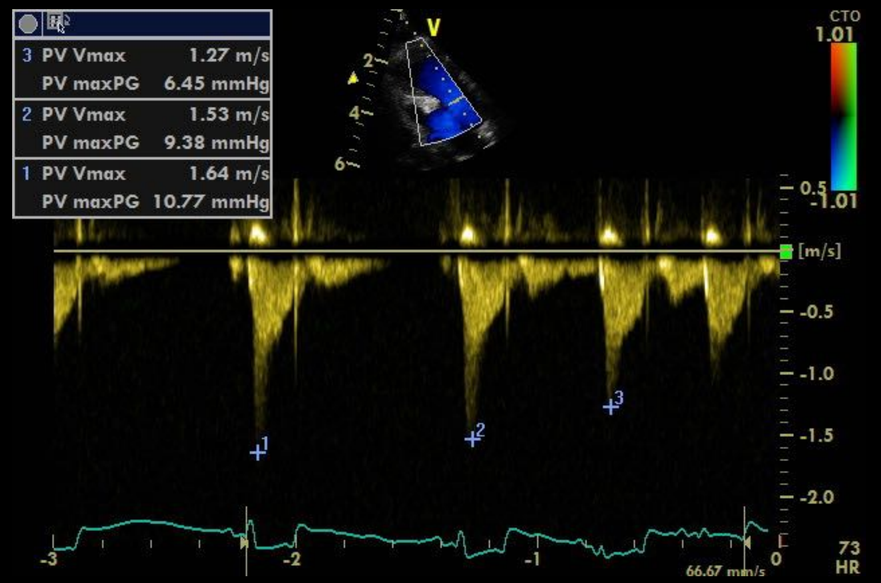
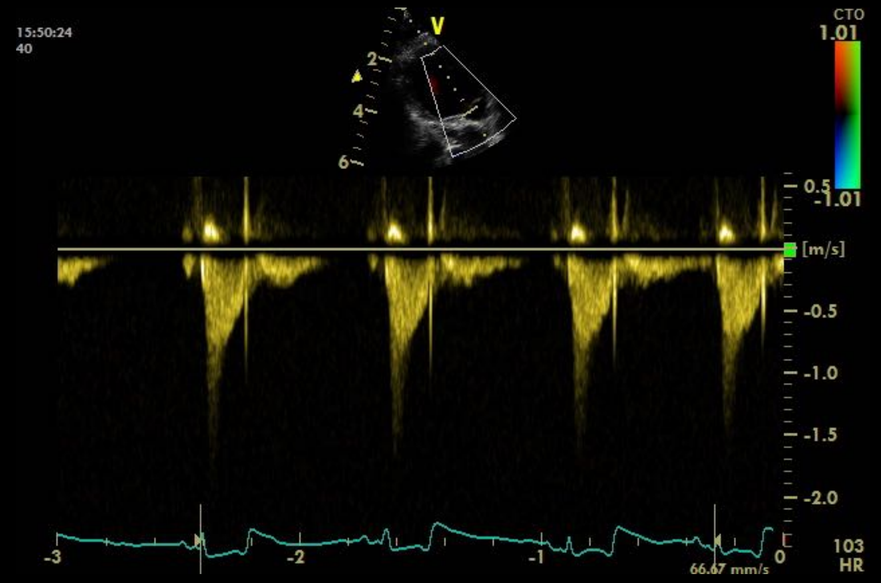
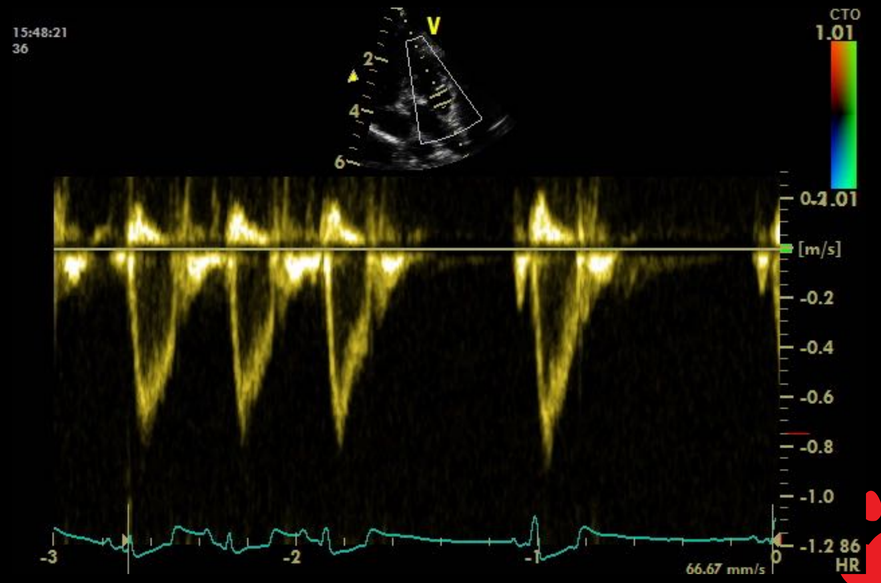
Misaligned flow in PA









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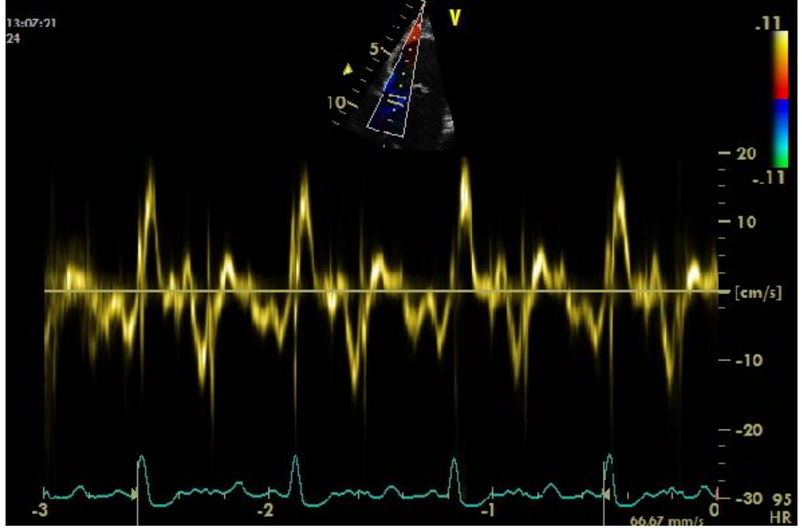
TDI



- Samples tissue, not blood
- Looks at velocity of a small segment of the myocardium at standard locations
  - LA4C - mitral annulus (lateral); lateral annulus (septal); tricuspid annulus (lateral)
  - Used to look at systolic and diastolic function
  - Diastolic function most widely used/useful
  - Can do “real-time” PW TDI and “off-line” CFM TDI
  - Dependent on angle of interrogation (same as any Doppler)

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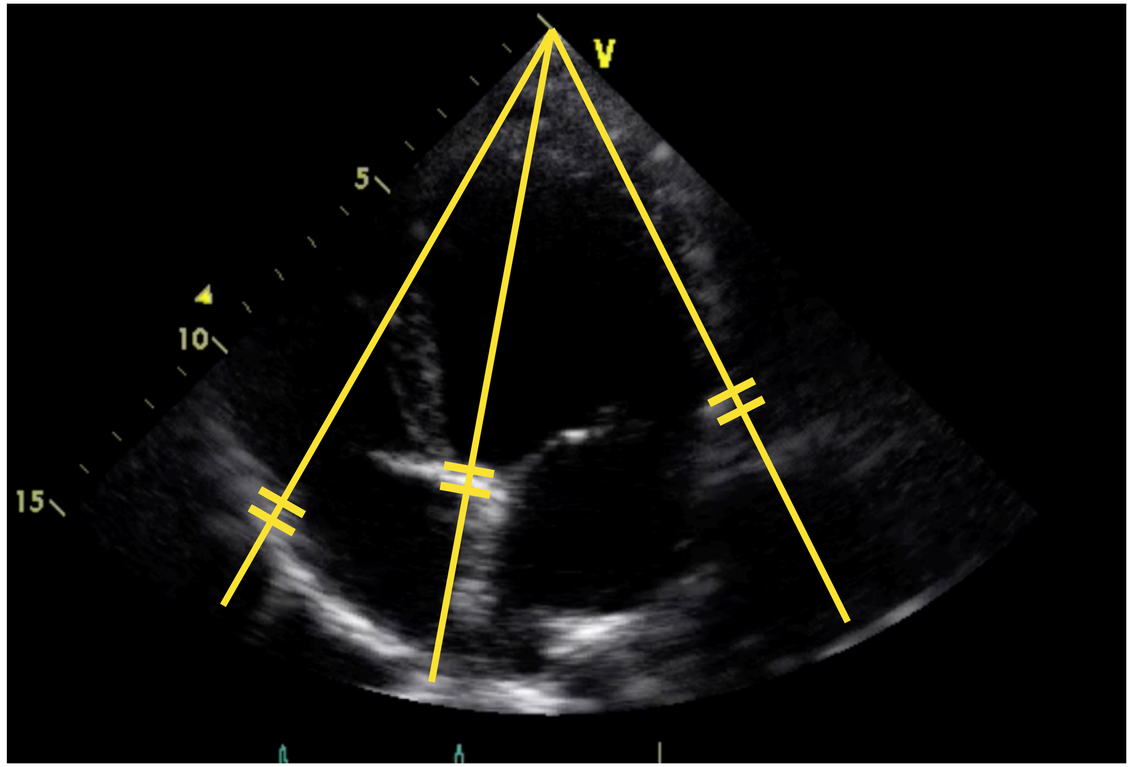
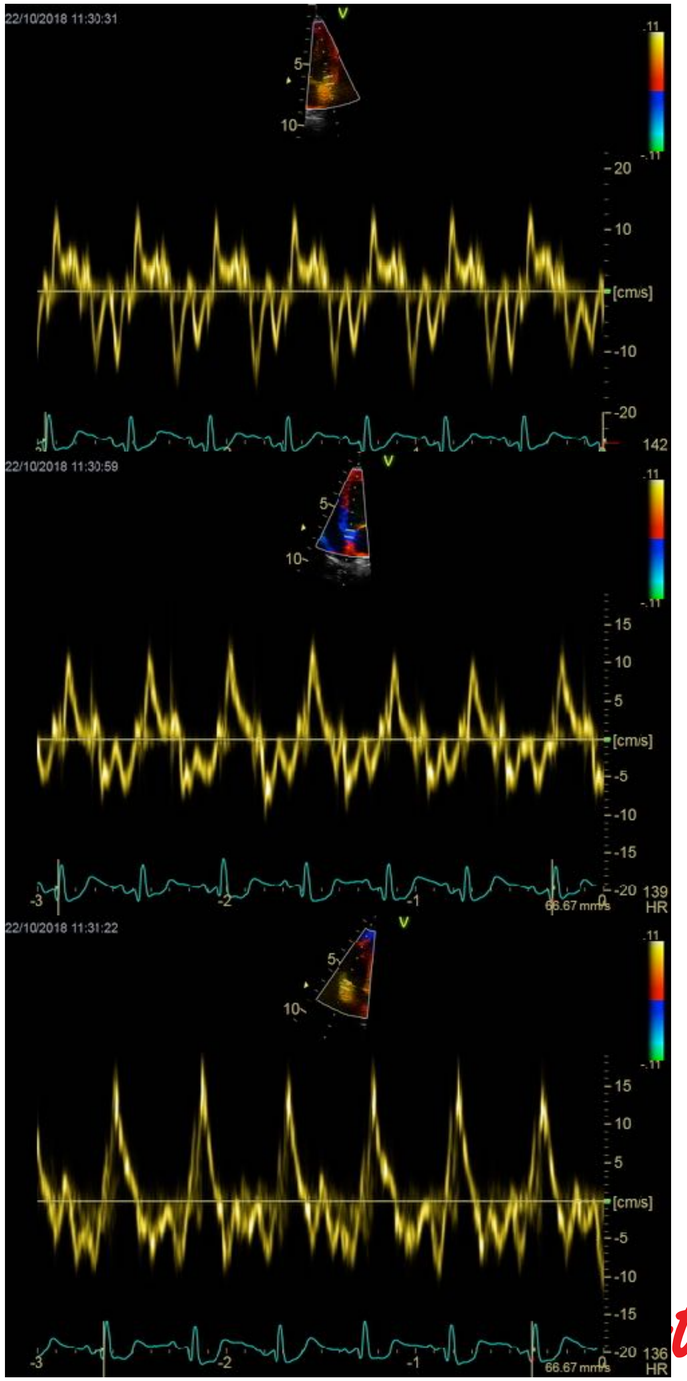
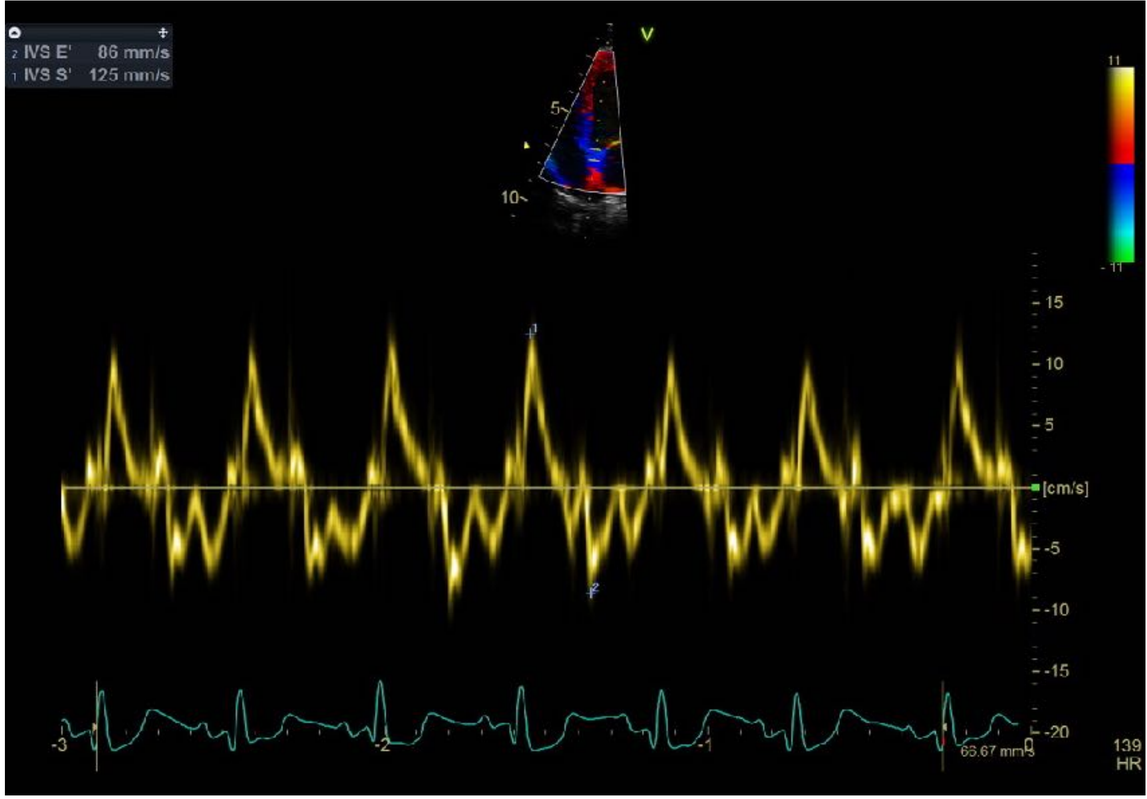
TDI


V
5
10
15


22/10/2018 11:30:31
22/10/2018 11:30:58
22/10/2018 11:31:22
[cm/s]
HR
66.67 mm/s

PW-TDI



Assesses myocardial velocity

Systolic wave (S’)

Diastolic waves (E’, A’)

Useful in people - E’ and E/E’ predict outcome in HF patients

Well studied in VetMed

BUT few (any?) papers showing clinical utility

Main use for me is in cats to figure out class of diastolic dysfunction

&

changes in LV function over time

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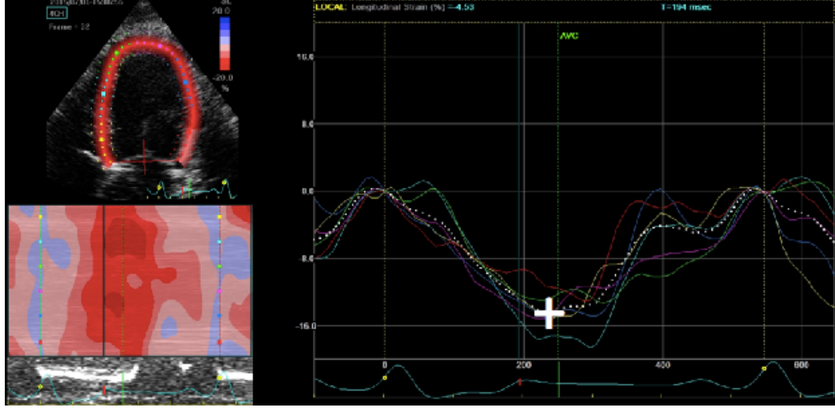
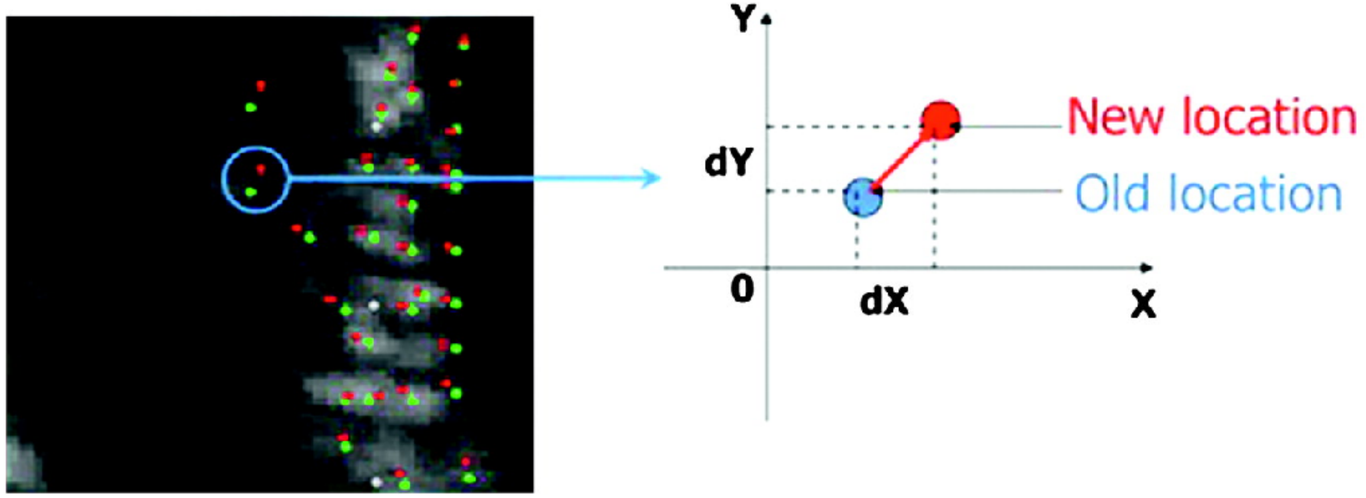
STE



Tracks movement of a set of echo “speckles”



Measure movement of the myocardium in multiple directions

Not dependent on insonation angle unlike TDI

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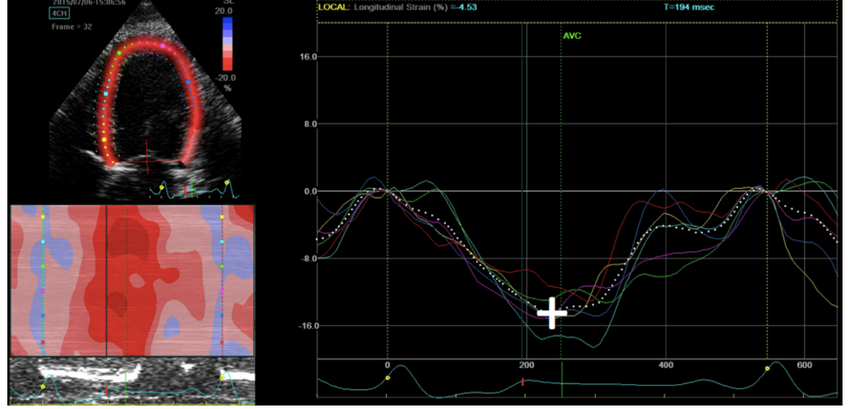
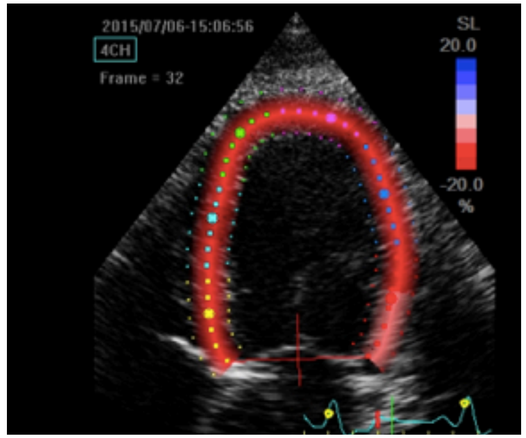
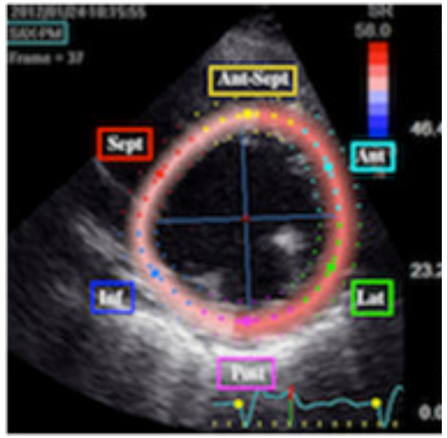
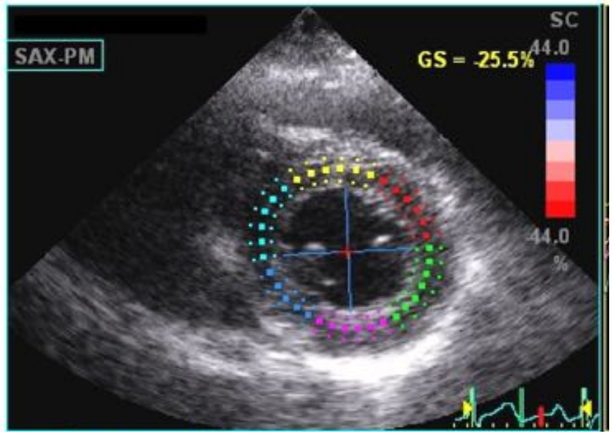
STE



Measure longitudinal, radial and circumferential movement







Can also measure Torsion - twist from apex to base

Strain - change in length

Strain rate - rate in change of length (myocardial velocity)

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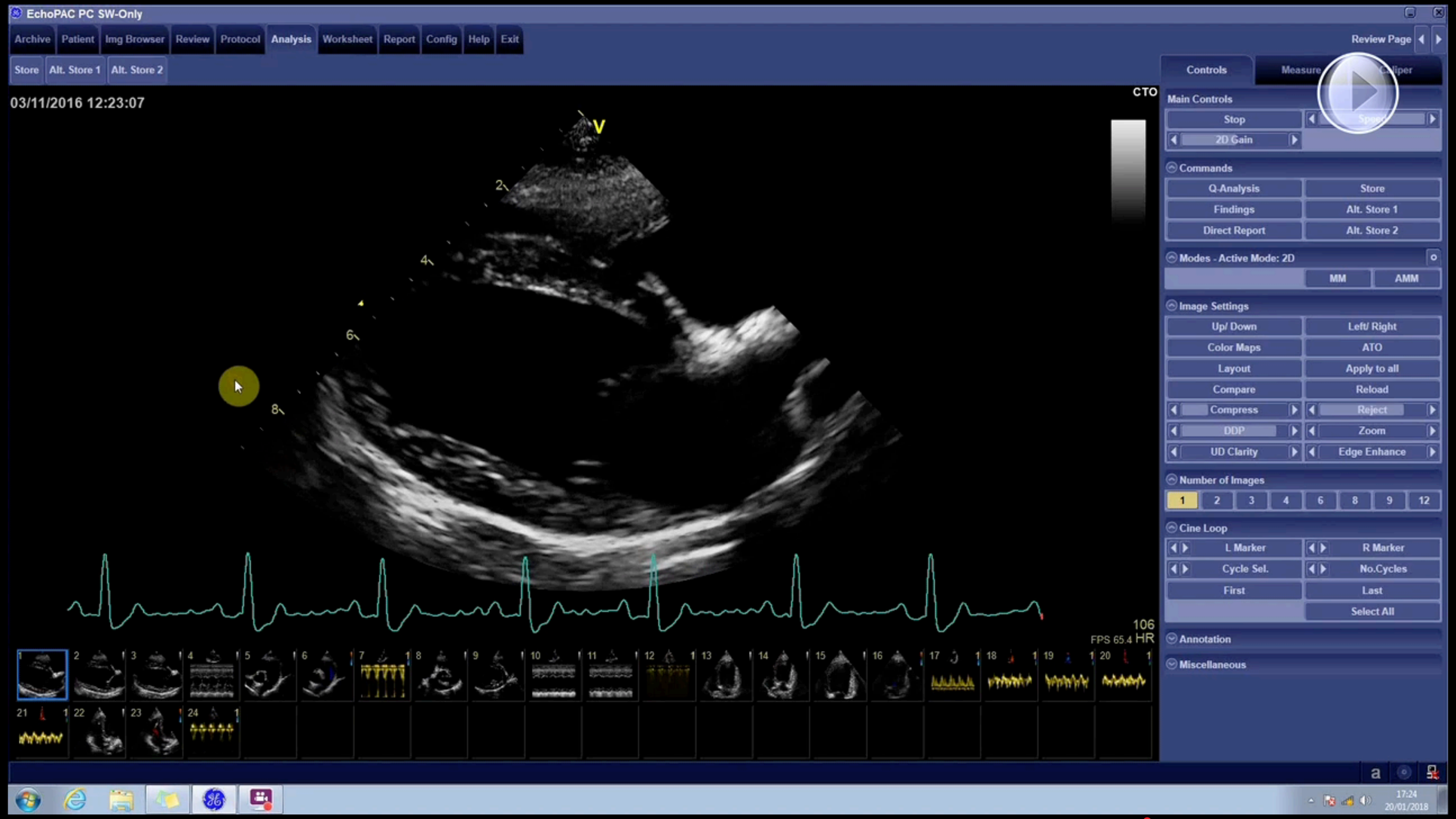
Measuring STE



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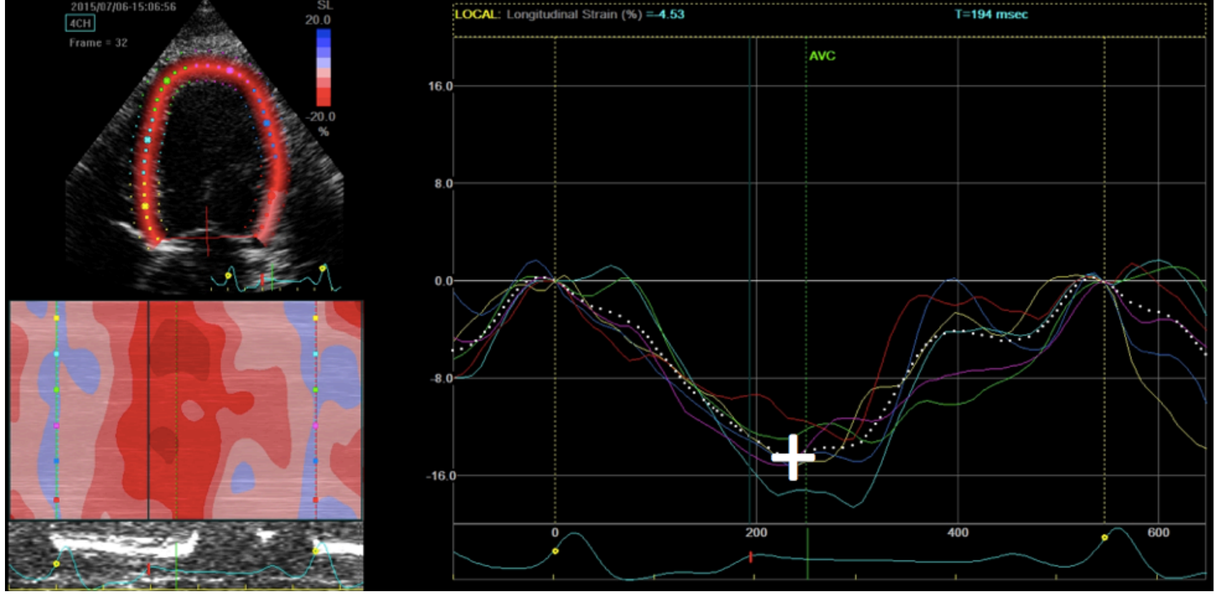
STE

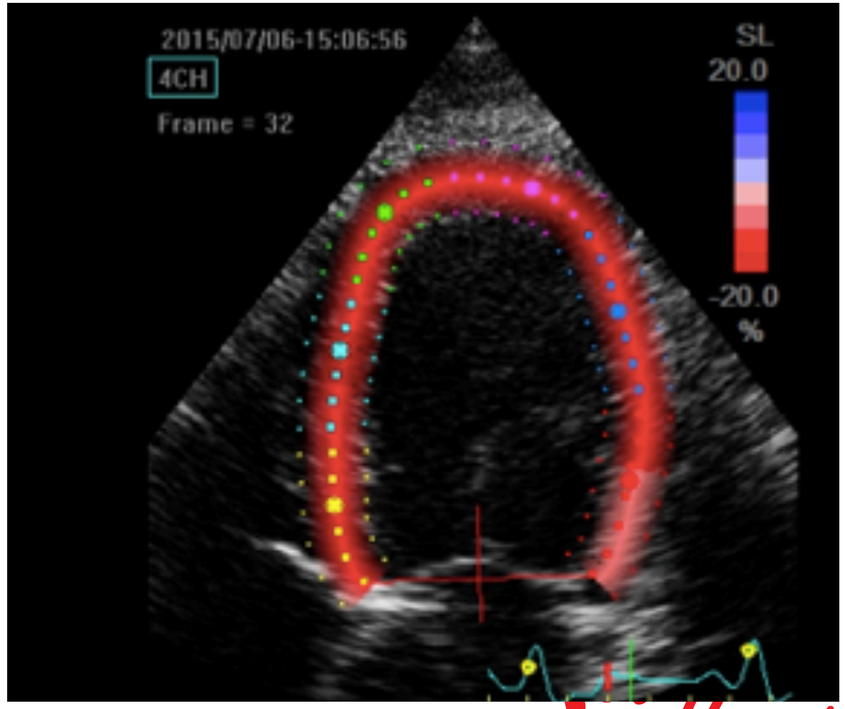


Global longitudinal strain

- Amount of movement toward the probe
- Fibres shorten so GLS is negative

GL Strain Rate

- Rate of movement toward the probe
  - Similar to TDI
  - GLSs - negative
  - GLSe and GLSa - positive (during diastole)



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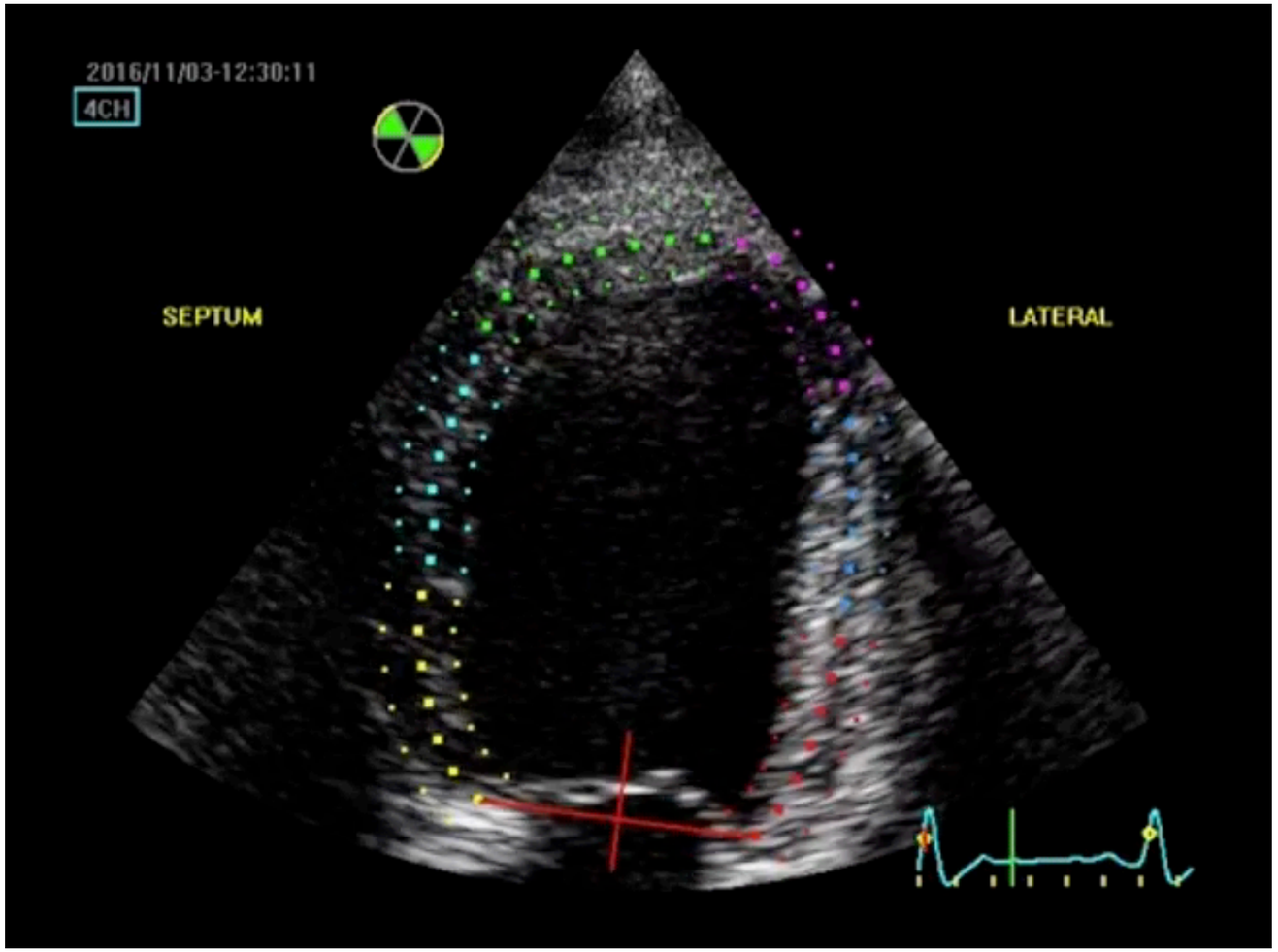
STE - GLS



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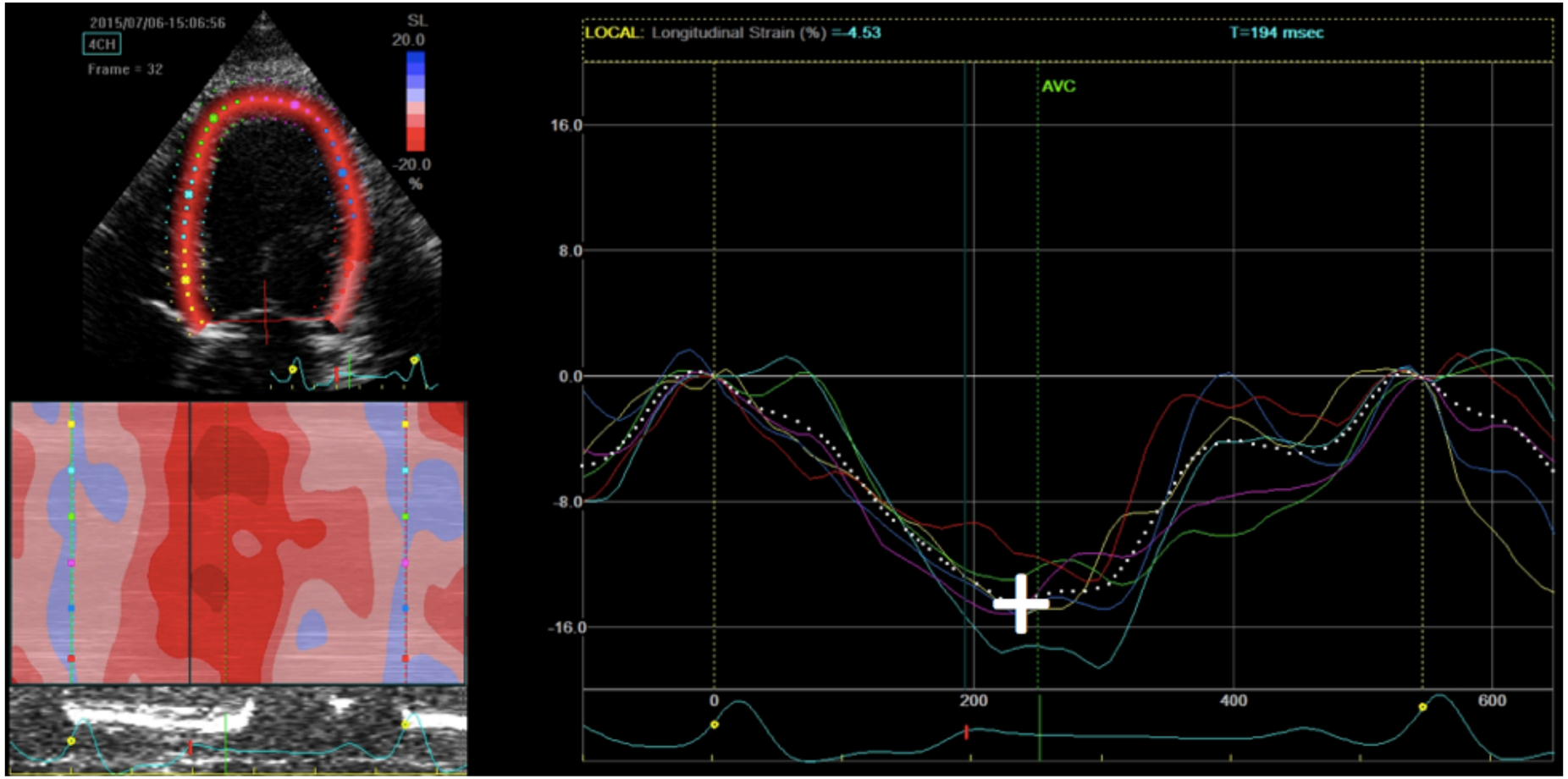
Global Longitudinal Strain



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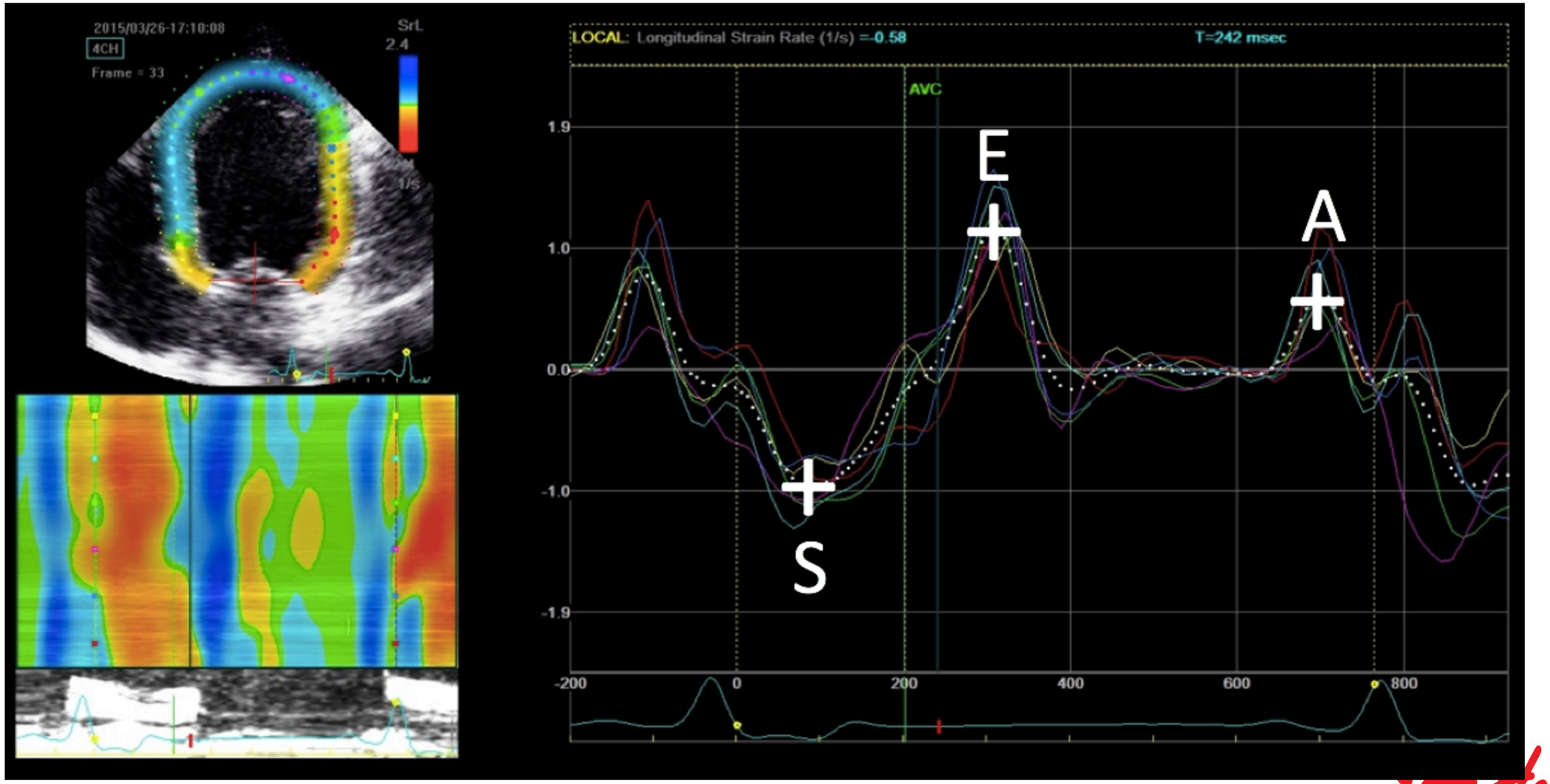
GL Strain Rate



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STE

- Currently a research tool
- But - gaining popularity in human medicine
- VetMed will start to catch up
- This may become something we all start to use routinely
- …or it may not!

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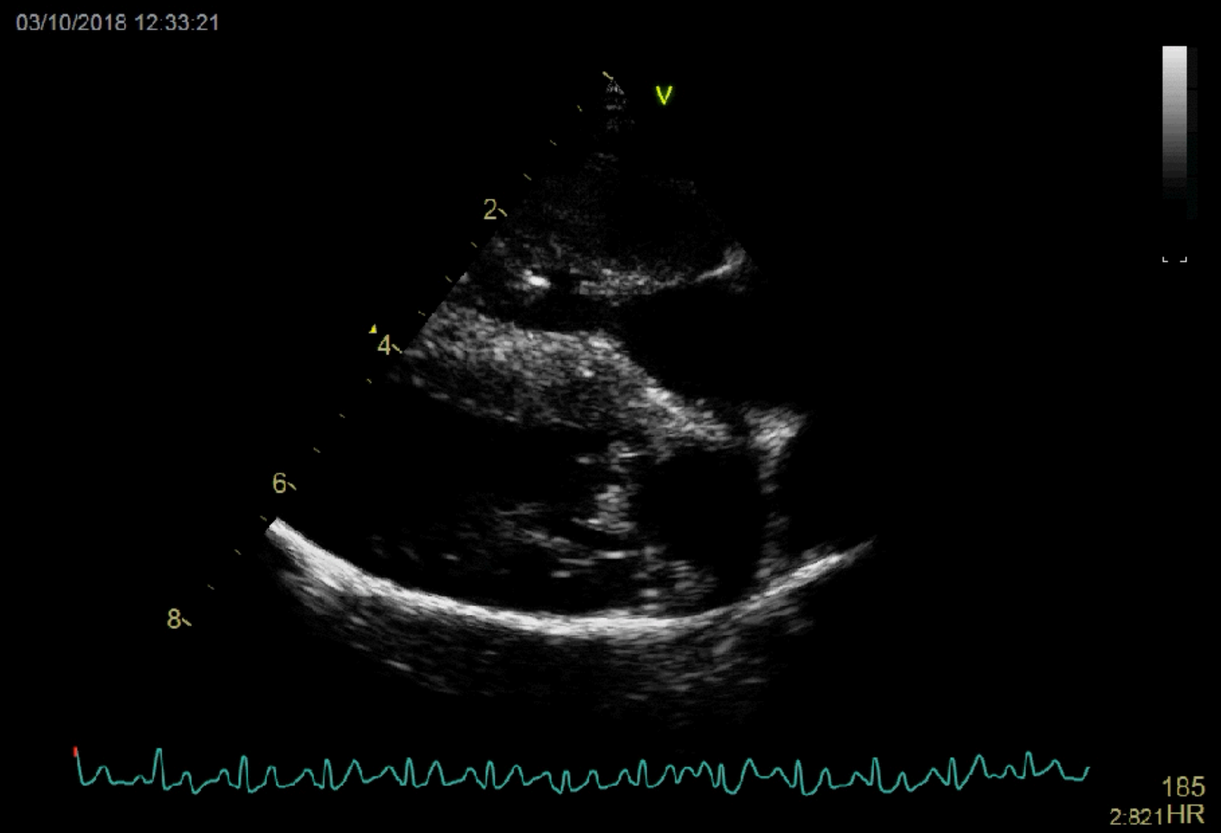
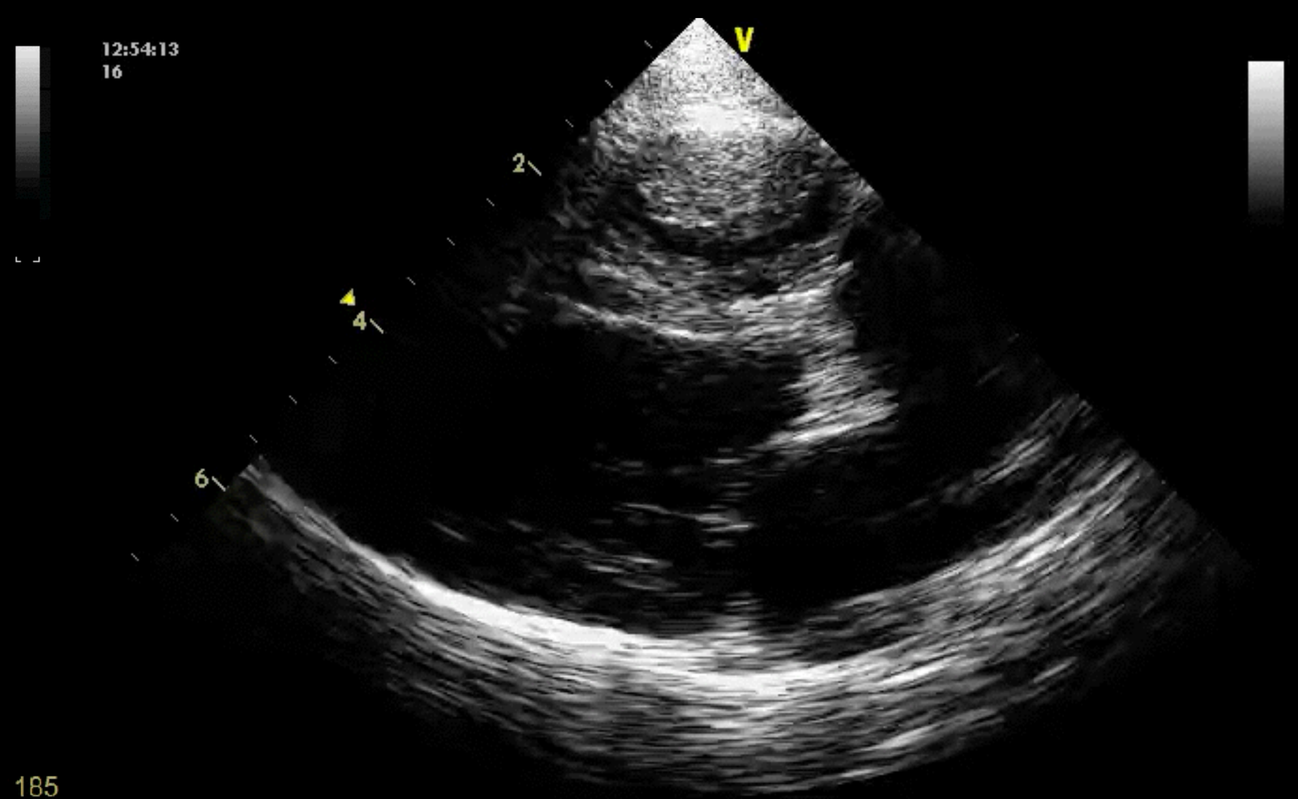
Contrast Echo

- Sometimes, Doppler isn't enough to look carefully at flow
- Also, can be useful to alter reflection of blood pool to look at changes in myocardium
- Several techniques for contrast echo
- Most often, I use a Bubble study
- Especially useful to look for R-L shunts

- Place IV cannula in R/L cephalic (left easier if in R lateral), occasionally saphenous
- Inject contrast
  - 1ml/10kg of a 50/50 mix of glucose and saline
  - Rapidly inject via catheter
  - Image RPLA then other views as needed (LA4C, outflow, abdomen)
  - Store a nice long loop so use ECG

Contrast Echo





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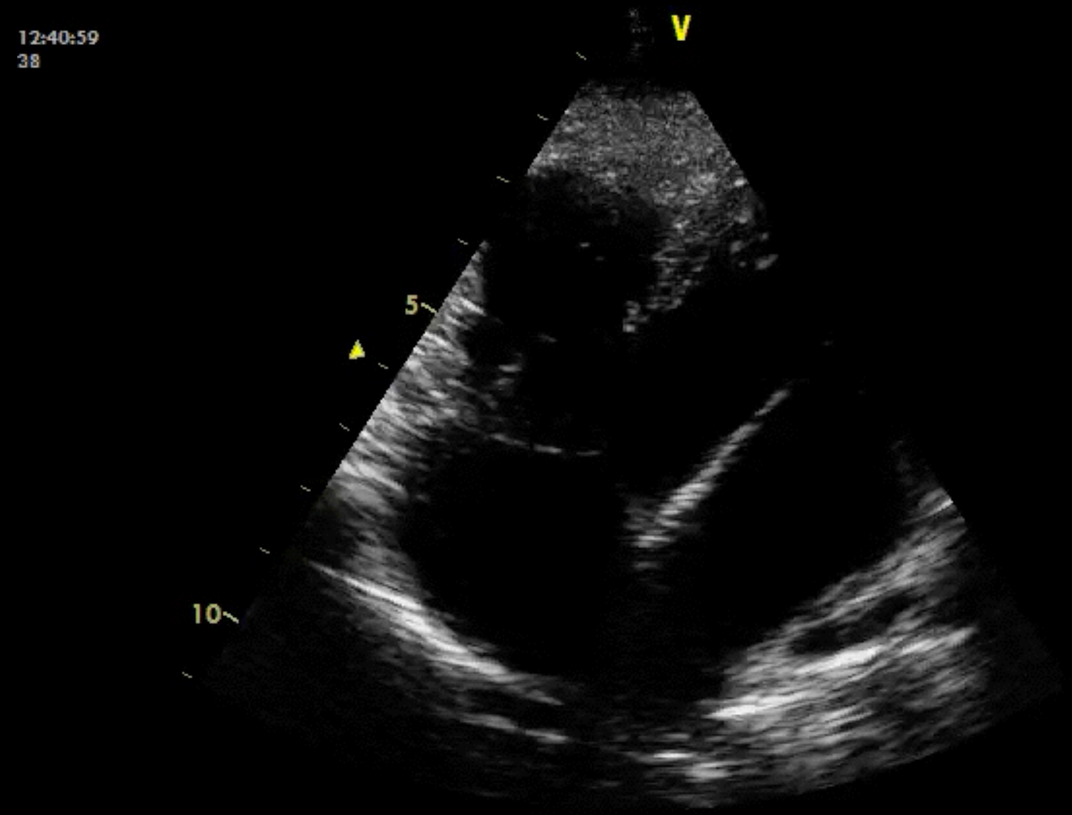
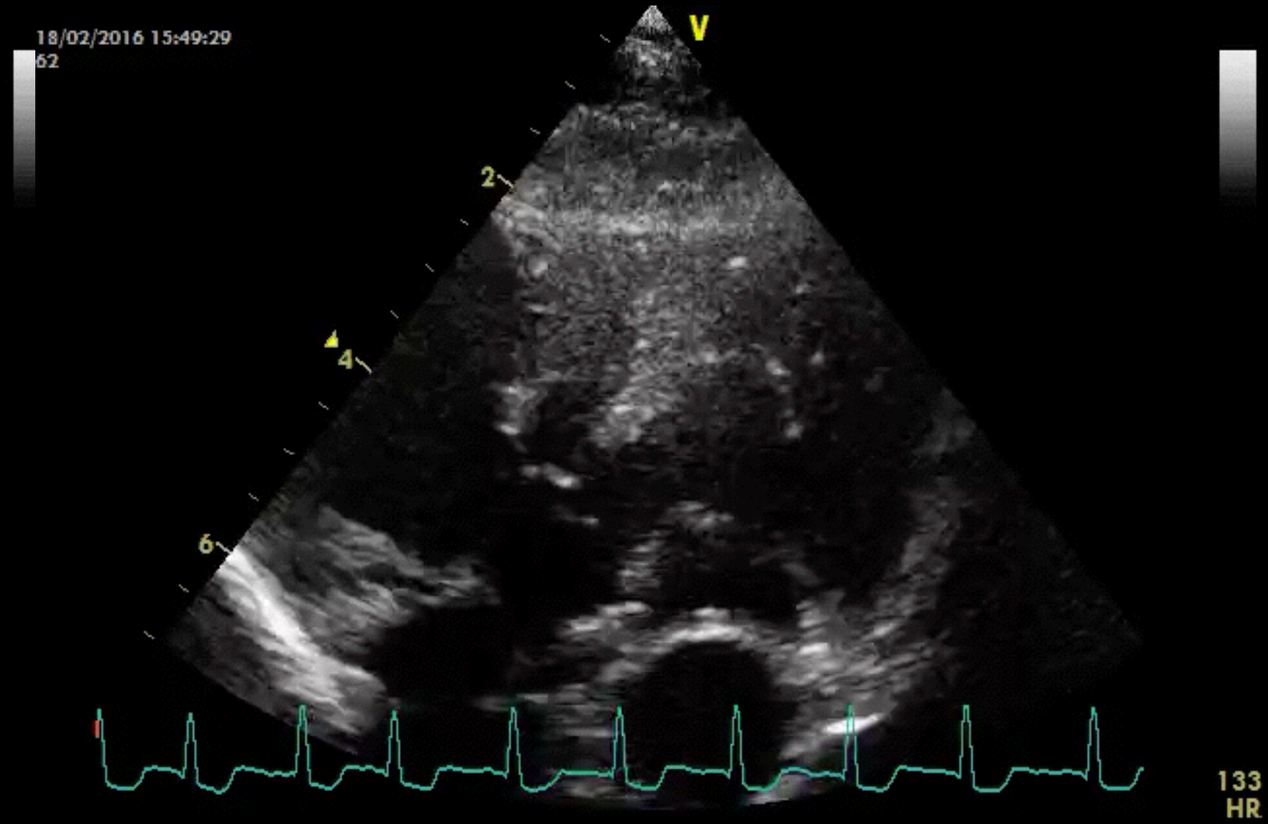
Contrast Echo





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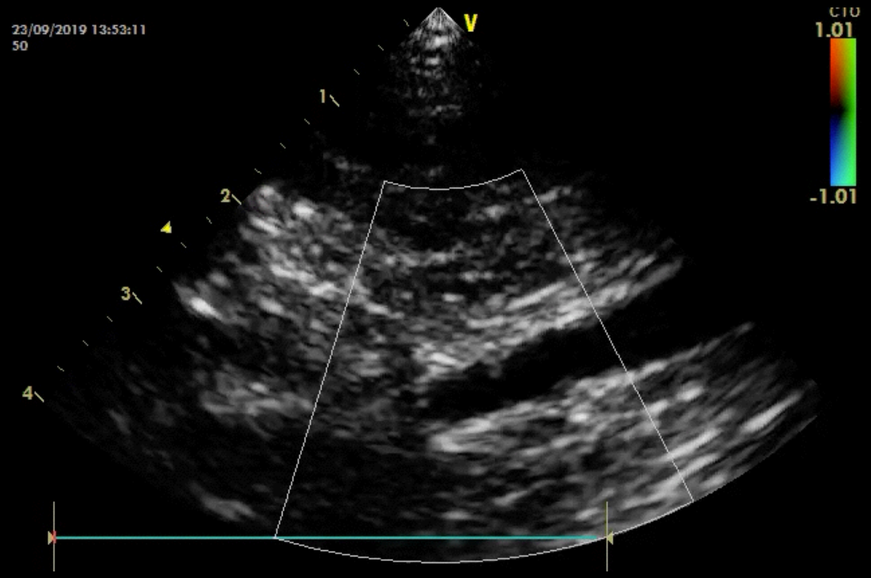
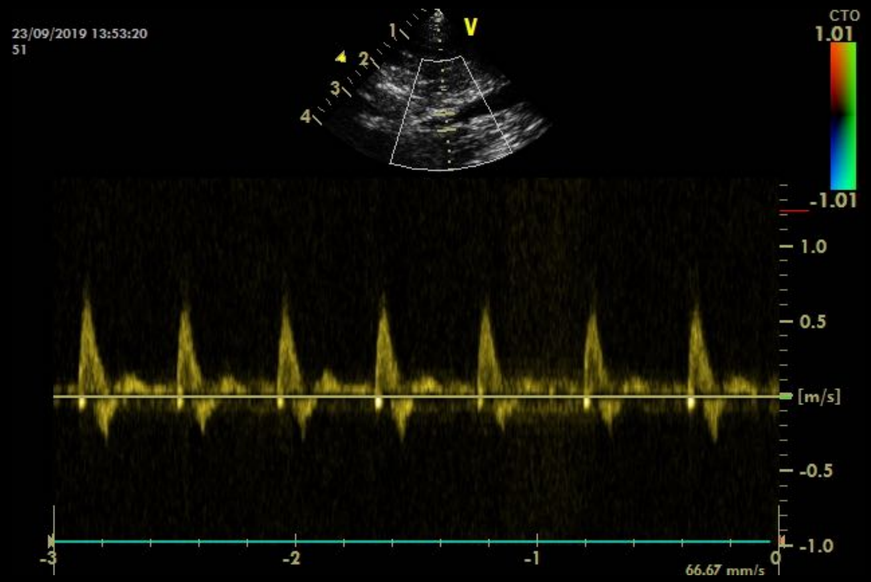
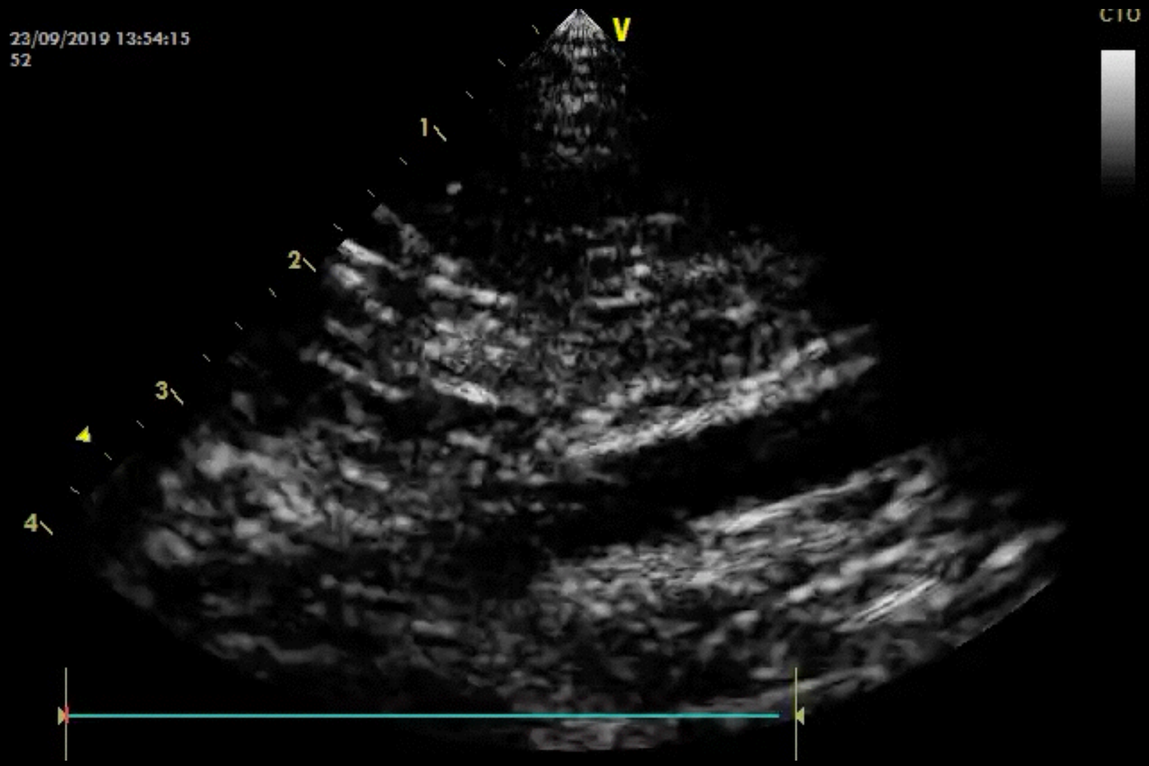
Contrast Echo







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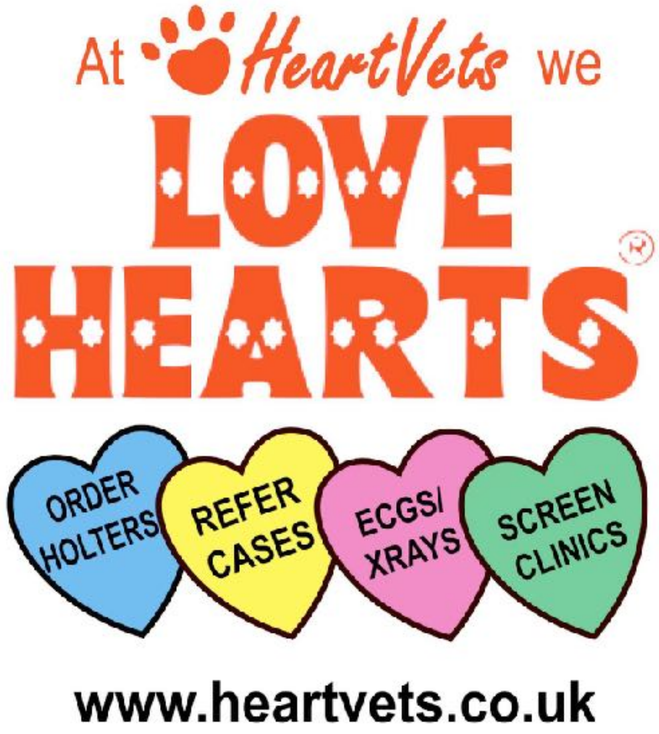
Any questions?



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