

**Erasmus MC**  
University Medical Center Rotterdam



# Image optimisation

J.S. McGhie

W. B. Vletter

R. Frowijn

No disclosures



## 2D Imaging:



## The Echo machine

### Monitor:

Adjust the contrast and brightness so that both the weakest and strongest gray levels are present on the screen

### System preset:

Standard for your lab to produce uniform appearance of studies.  
A **MUST** in colour Doppler maps

## 2D Imaging: Transducers



The choice of transducer is very important:

Higher frequency - better resolution less penetration

Lower frequency - poorer resolution better penetration

**Change transducer and/or frequency throughout the examination!**

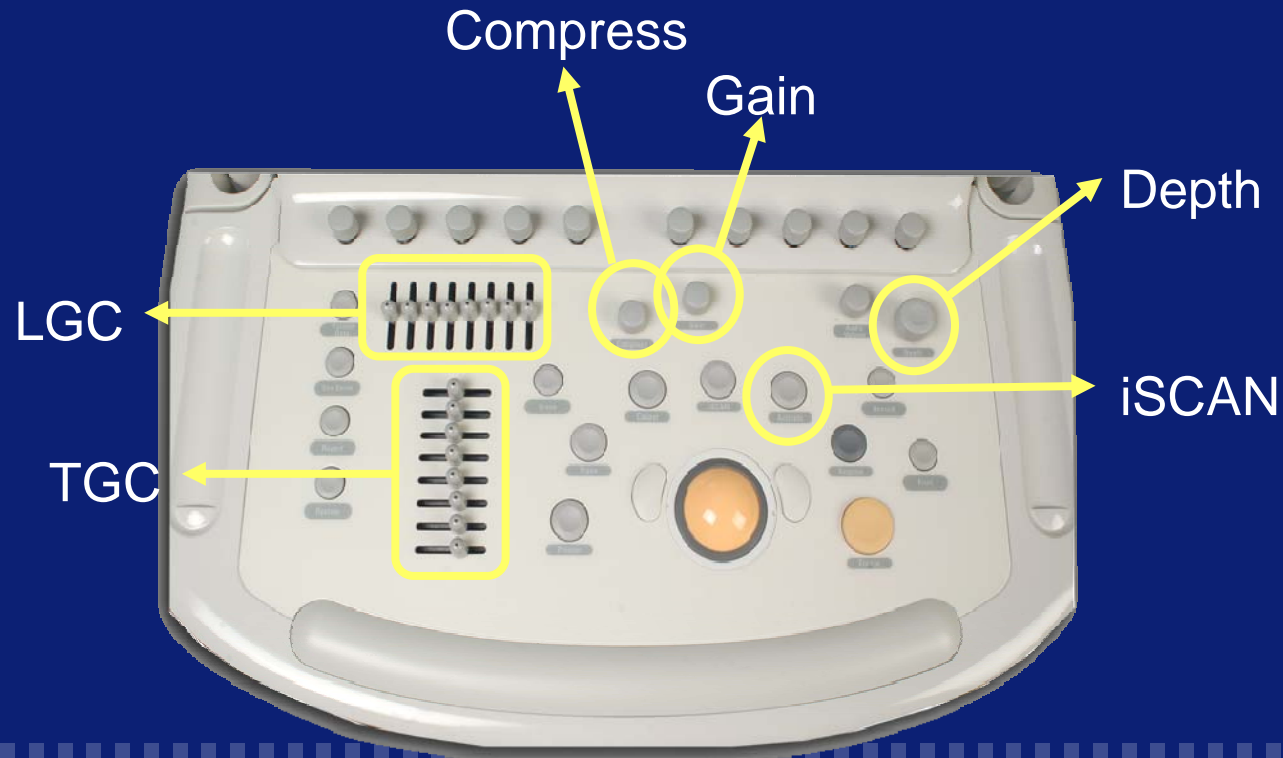
## 2D Imaging

Current machines control much of the image and signal processing

Differences exist in manufactures with respect to how much operator control is allowed.

Several machines have one single button that can adjust and optimize the image

**HOWEVER:** there are some simple adjustments that can fine tune the image



# 2D Imaging

## Gainsetting

- Overall gain

Adjusts the amplitude of the received signals over the total length of the ultrasound beam.

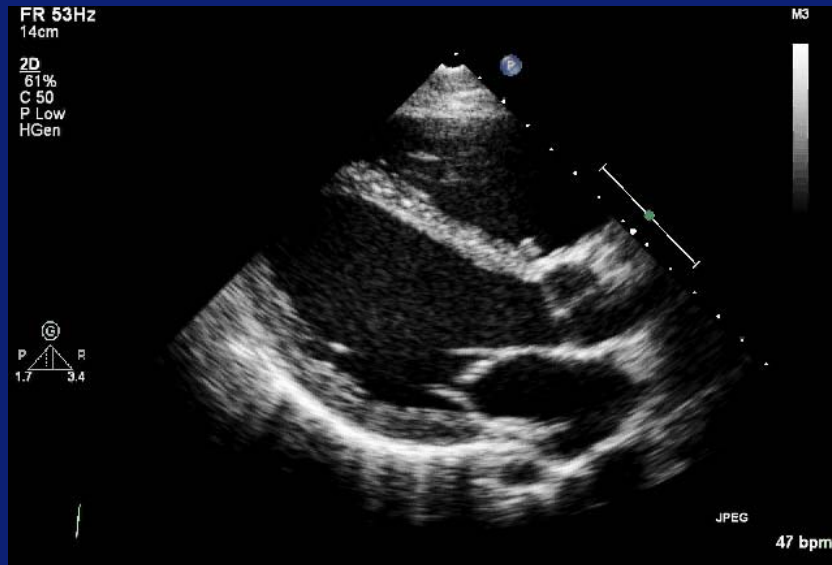
- Time-gain compensation

Allows differential adjustments along this length to compensate for the effect of attenuation

## Framerate

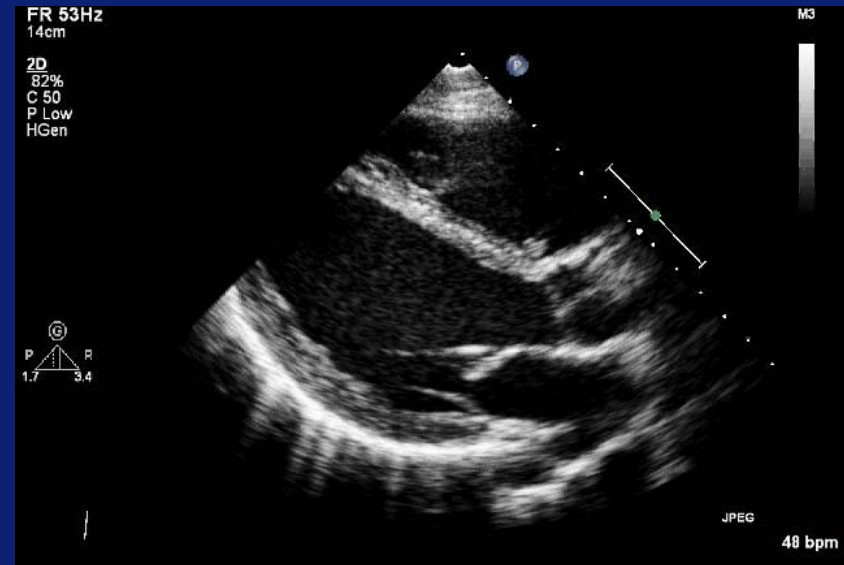
Number of images per second depends on the number of scan lines and adjusted depth (routine setting  $\geq 40$  frames per second)

# 2D Imaging

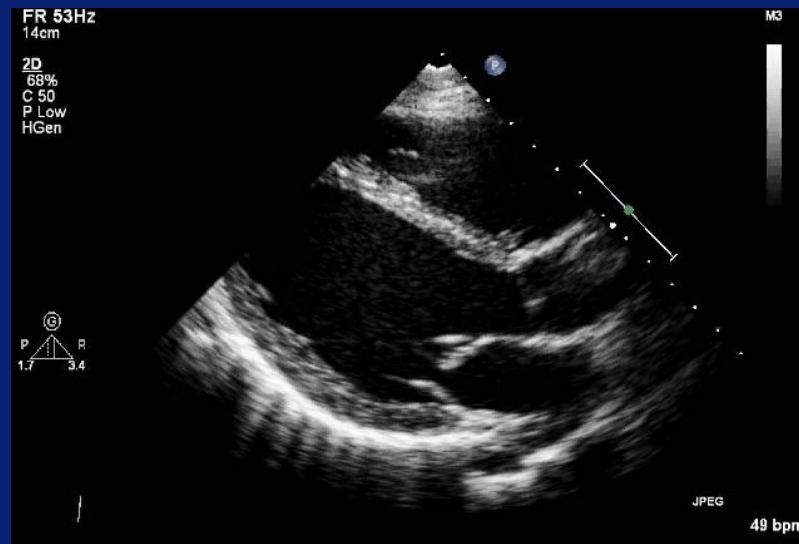


Correct gain setting

# Gain Setting



Overall gain



Time gain compensation (TGC)

# 2D Imaging

## Gainsetting

- Overall gain

Adjusts the amplitude of the received signals over the total length of the ultrasound beam.

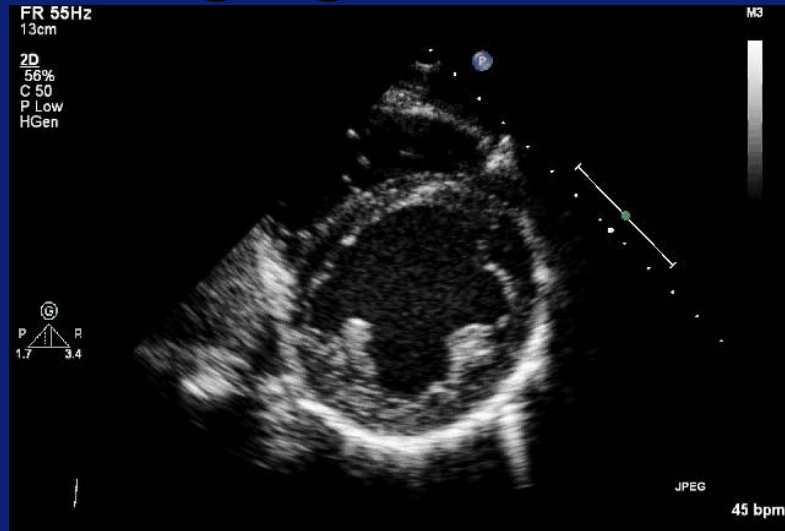
- Time-gain compensation

Allows differential adjustments along this length to compensate for the effect of attenuation

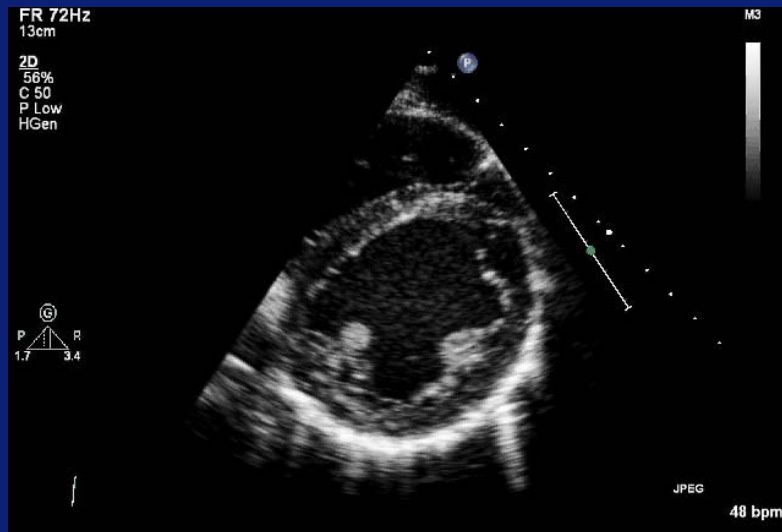
## Framerate

Number of images per second depends on the number of scan lines and adjusted depth (routine setting  $\geq 40$  frames per second)

# 2D Imaging

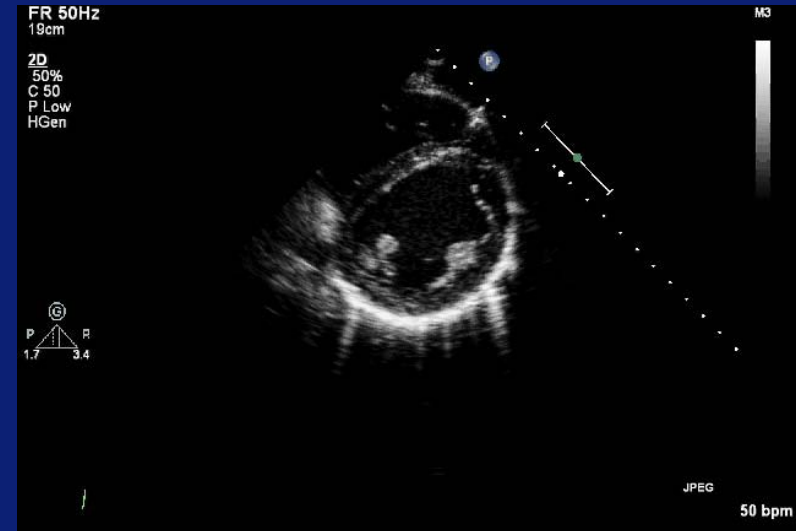


Depth 13cm. FR 55Hz  
The area of interest fills the screen!

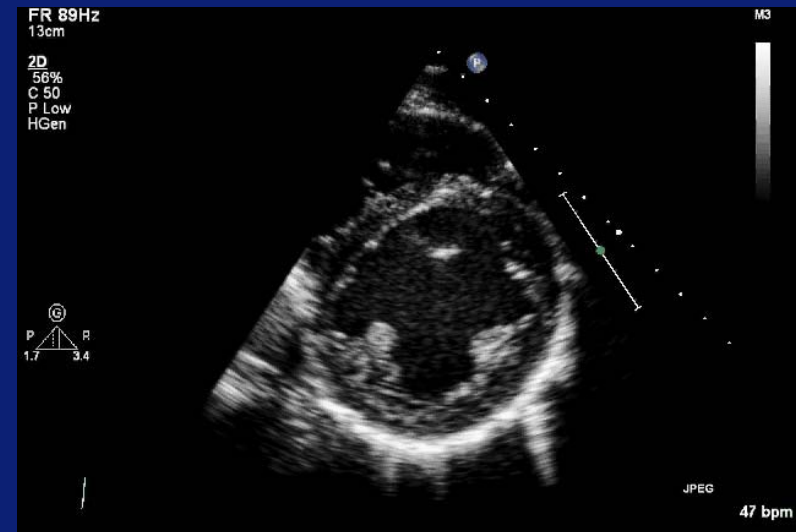


Depth 13cm and < sectorsize = FR 72Hz  
(speckle tracking)

# Framerate



Depth 19cm = FR 50Hz



Depth 13cm. decrease in line density  
and < sectorsize = FR 88Hz

ERASMUS MC  
Café

# 2D Imaging

## Compression

The amplitude range of the reflected signal is compressed into a range of values from white to black

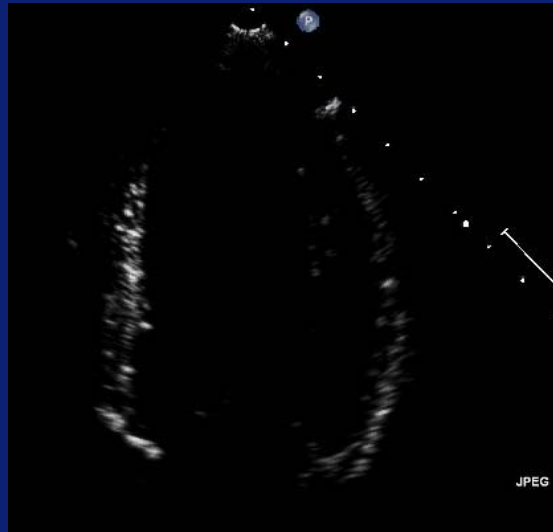
## Tissue Harmonic Imaging

In tissue harmonic imaging the harmonic frequency energy is generated as the ultrasonic wave propagates through the tissue  
By processing the received signals the second harmonic is filtered out and displayed

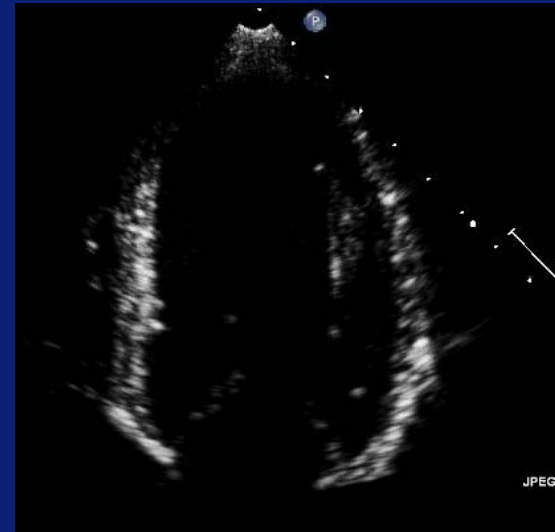
# 2D Imaging

# compression

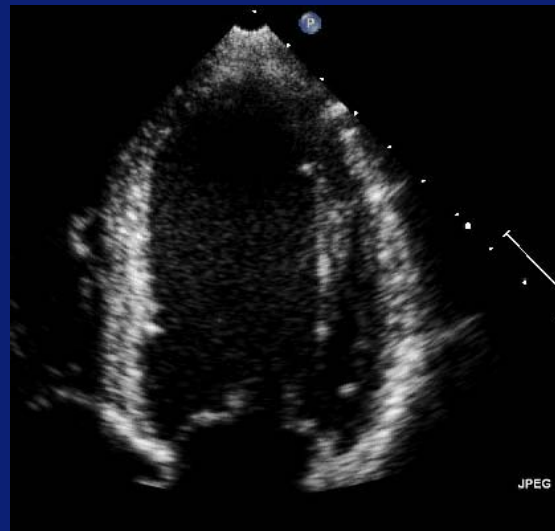
Compress 30  
Gain 62%



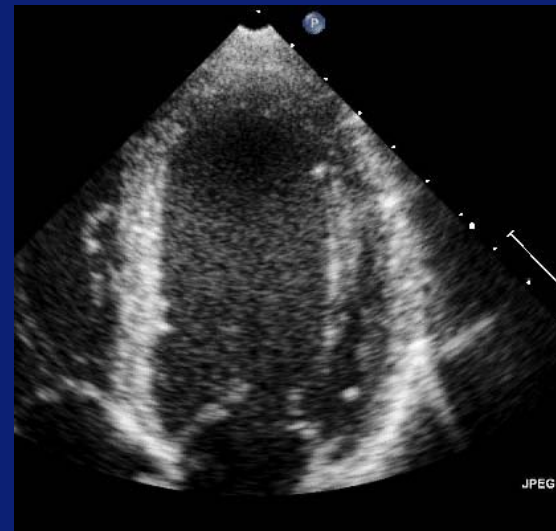
Compress 40  
Gain 62%



Compress 50  
Gain 62%



Compress 60  
Gain 62%



To provide an image with a gradation of gray levels the number of levels of gray can be adjusted by the compress / dynamic range setting

**Default setting 50 – 55 (iE 33)**

# 2D Imaging

## Compression

The amplitude range of the reflected signal is compressed into a range of values from white to black

## Tissue Harmonic Imaging

In tissue harmonic imaging the harmonic frequency energy is generated as the ultrasonic wave propagates through the tissue  
By processing the received signals the second harmonic is filtered out and displayed

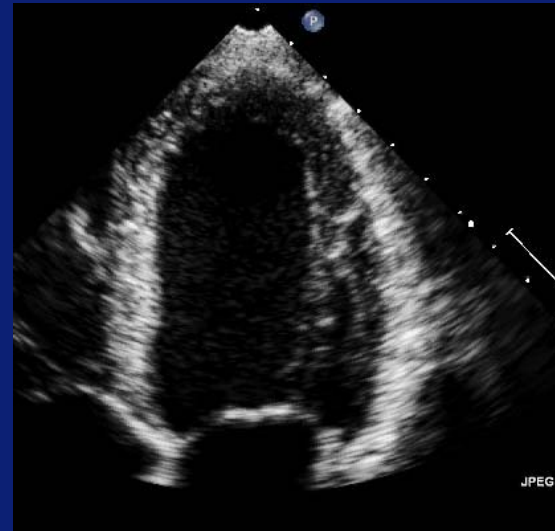
# 2D Imaging

Fundamental  
Gain 44%

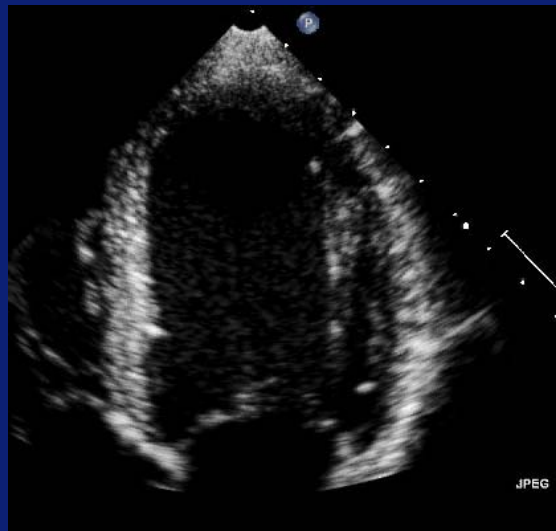


# fundamental – 2<sup>nd</sup> harmonic

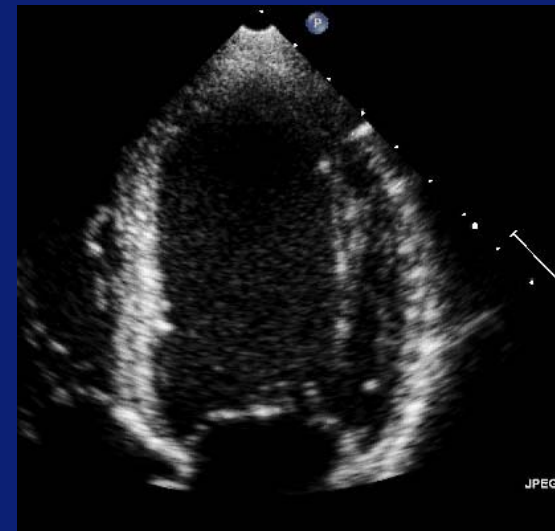
2<sup>nd</sup> Harm. 1.4–2.8Mhz  
Gain 62%



2<sup>nd</sup> Harm. 1.7–3.4Mhz  
Gain 62%



2<sup>nd</sup> Harm. 2.1–4.2Mhz  
Gain 62%

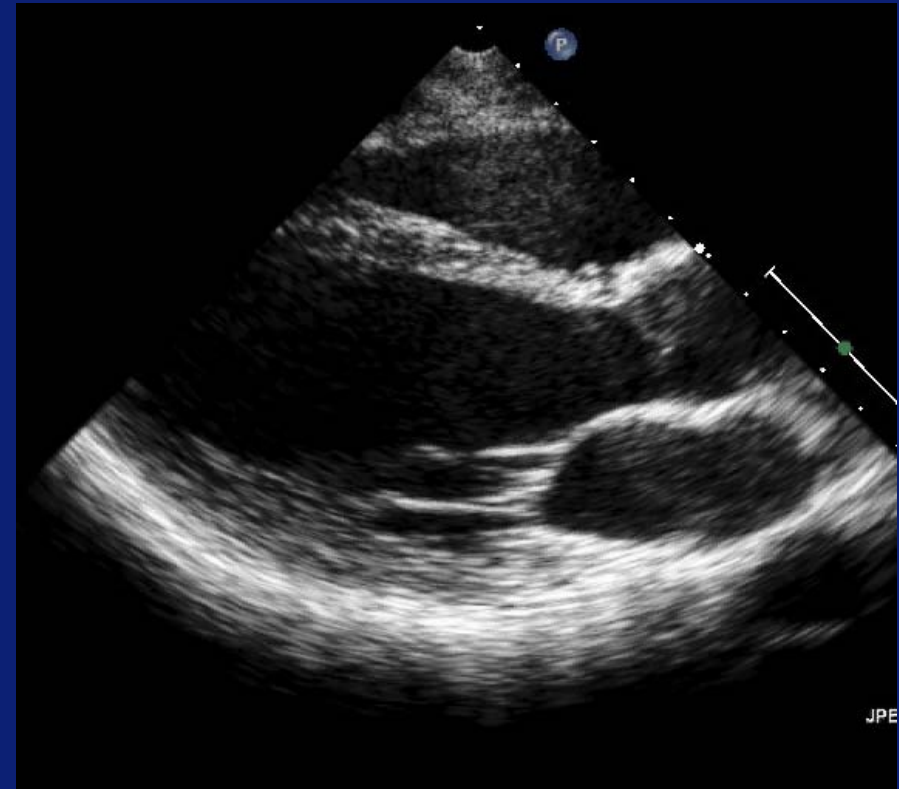
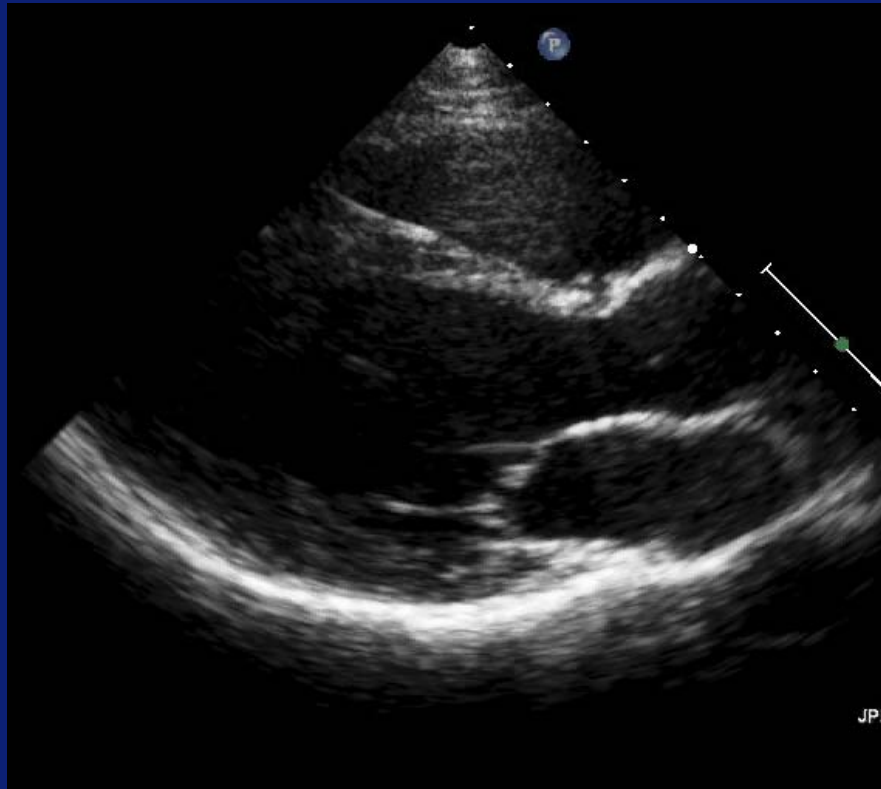


Because high signal strength is required to create harmonics, the harmonic signal is mainly generated in the centre of the ultrasound beam. This results in a narrower beam profile and thus a better lateral resolution

**Default setting second harmonic 1.7 – 3.4 MHz**

## 2D Imaging

## fundamental – 2<sup>nd</sup> harmonic



Normal heart

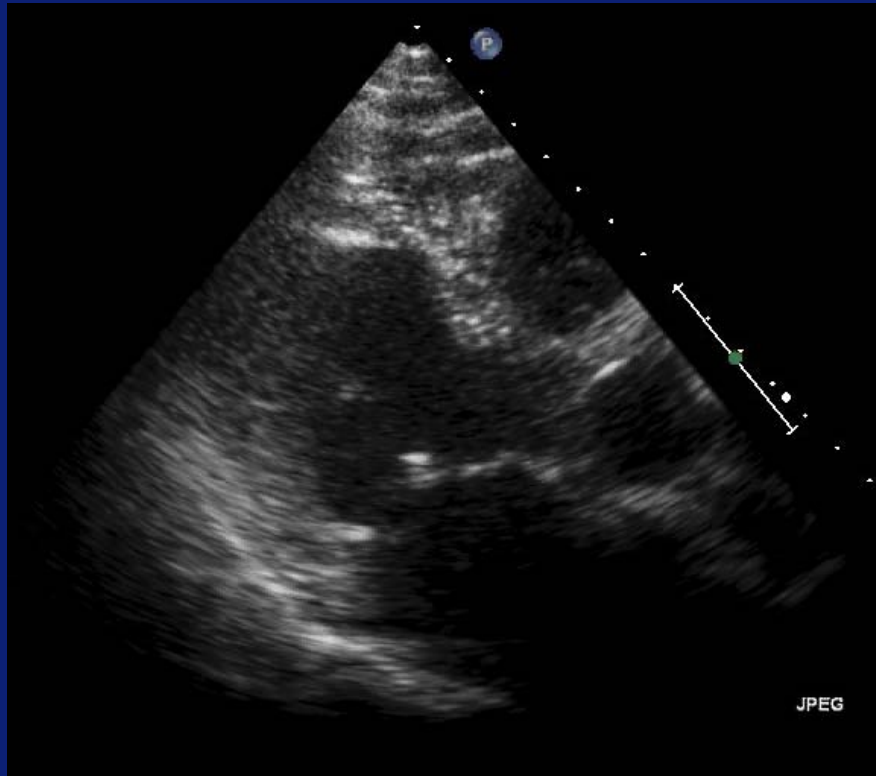
### Important

The type of processing required to filter out the received harmonic signal does make structures within the heart appear slightly thicker in harmonic as compared with fundamental frequency

# 2D Imaging

# fundamental – 2<sup>nd</sup> harmonic

Fundamental



2<sup>nd</sup> Harmonic



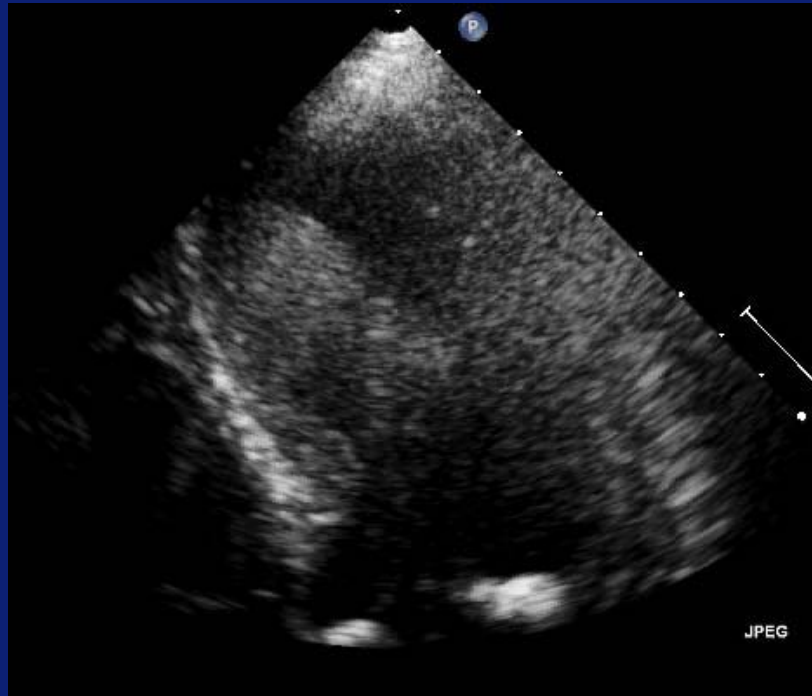
Important

Especially valve leaflets

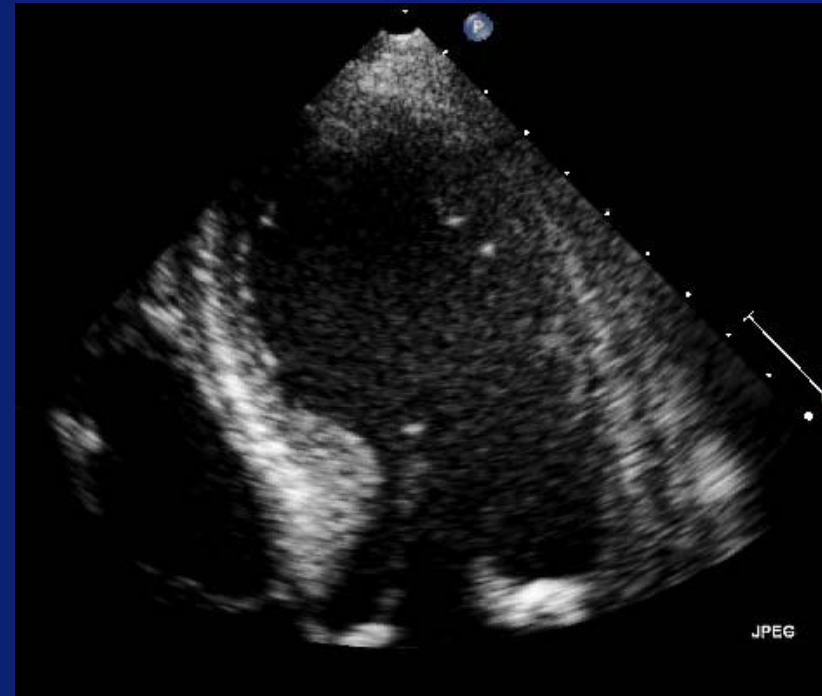
# 2D Imaging

## fundamental – 2<sup>nd</sup> harmonic

Fundamental



2<sup>nd</sup> Harmonic



A beam profile consists of a strong central – lobe and weaker side – lobes

The second harmonic frequency produced by these side – lobes are of less energy with respect to the central beam

**Result: less artifacts caused by side – lobes in second harmonic mode**

# Color Doppler Flow Imaging

## Gain Setting

Adjusts the degree of amplification of received Doppler signals

To optimize the flowsignal the gain setting is just below the level of random background noise

## Framerate + Velocity range

Sector depth

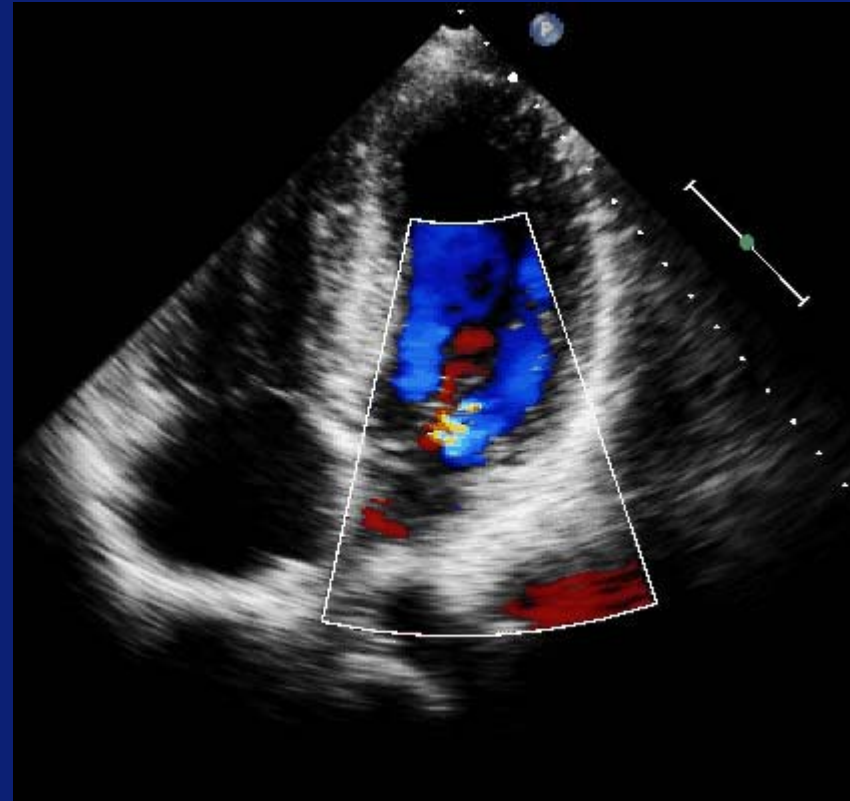
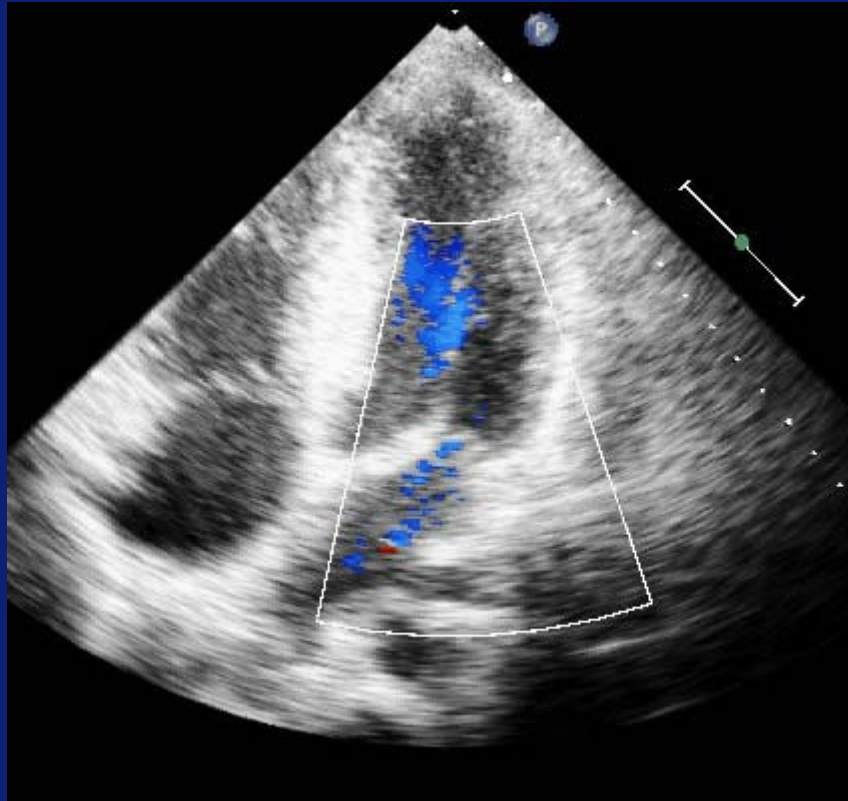
Sector width

Line density

Pulse repetition frequency (PRF)

# Color Doppler Flow Imaging

2D gain



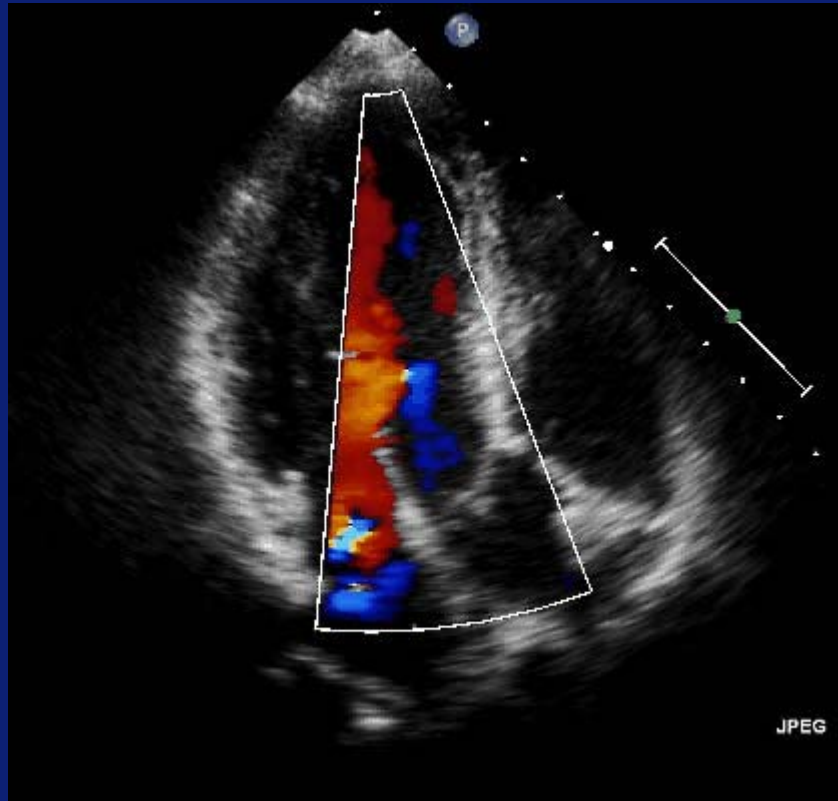
## Reduce 2D gain!

Color flow data is not displayed on the top of structures (including noise due to excessive gain)

# Color Doppler Flow Imaging

frame rate – sector size

Frame rate 20 Hz



Frame rate 12 Hz

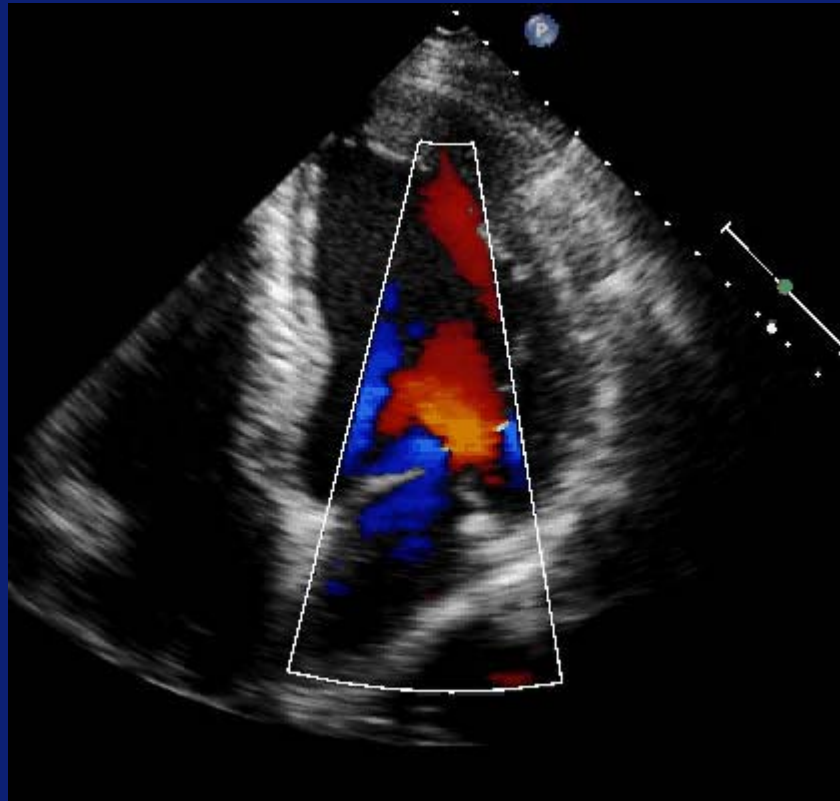


Increased sector width requires more scan lines resulting in slower frame rate

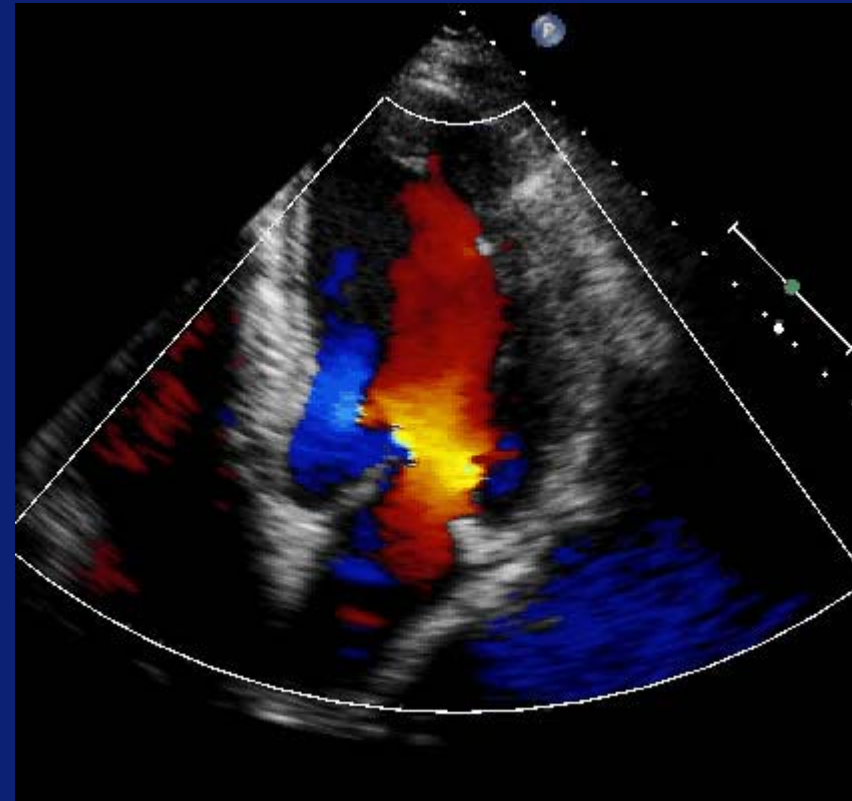
# Color Doppler Flow Imaging

frame rate – sector size

Frame rate 21 Hz



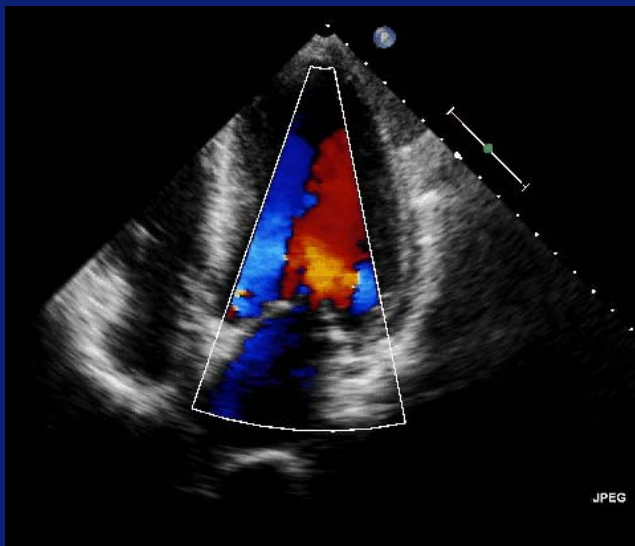
Frame rate 8 Hz



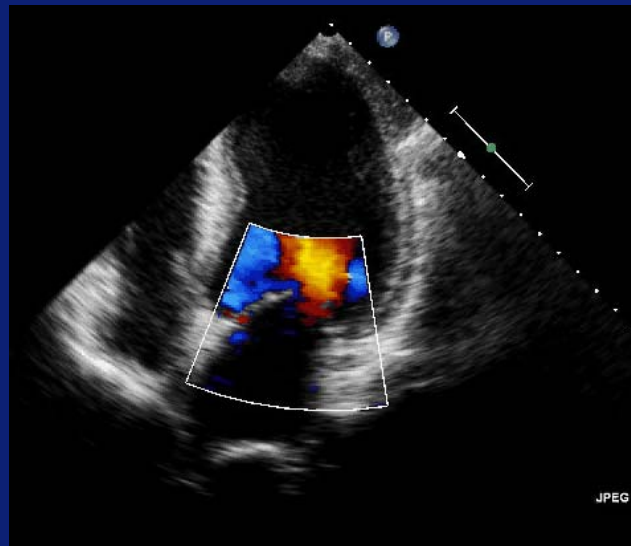
# Color Doppler Flow Imaging

frame rate – sector depth

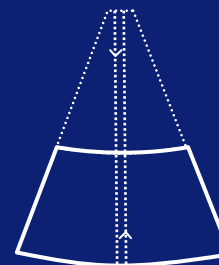
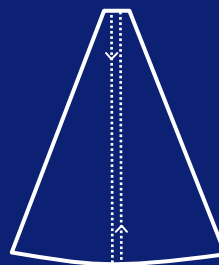
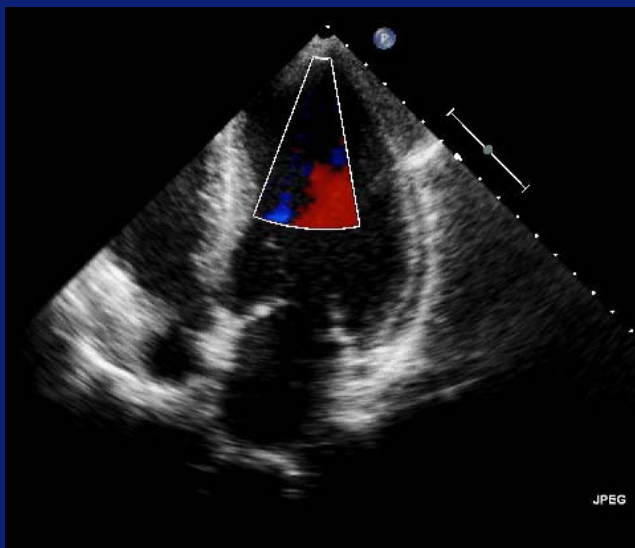
FR 17 Hz



FR 17 Hz



FR 29 Hz



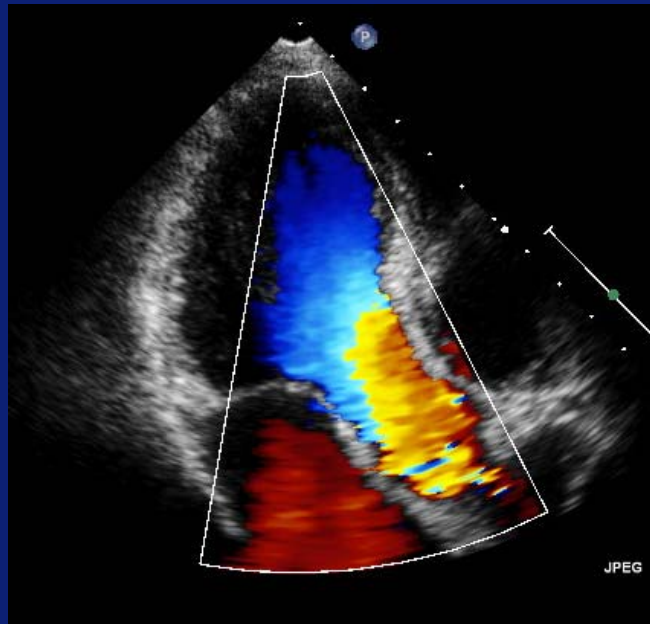
Same transmit-receiving time  
No difference in frame rates

Less transmit-receiving time  
Higher frame rate

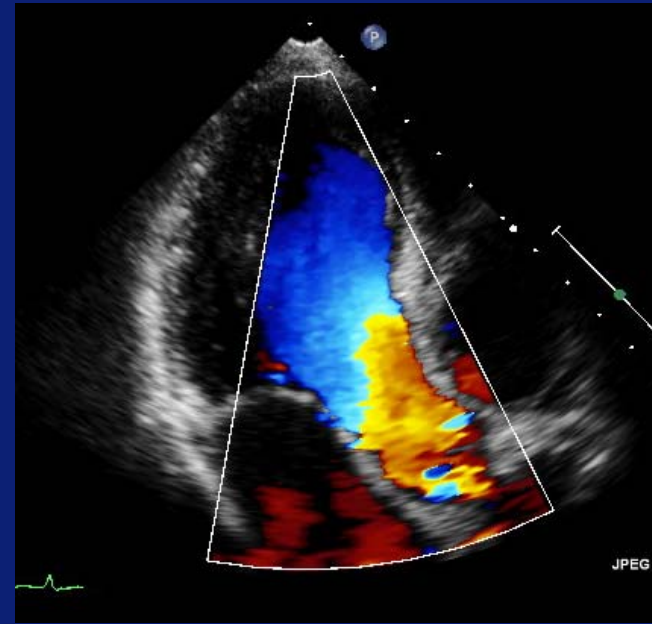
# Color Doppler Flow Imaging

## frame rate – line density

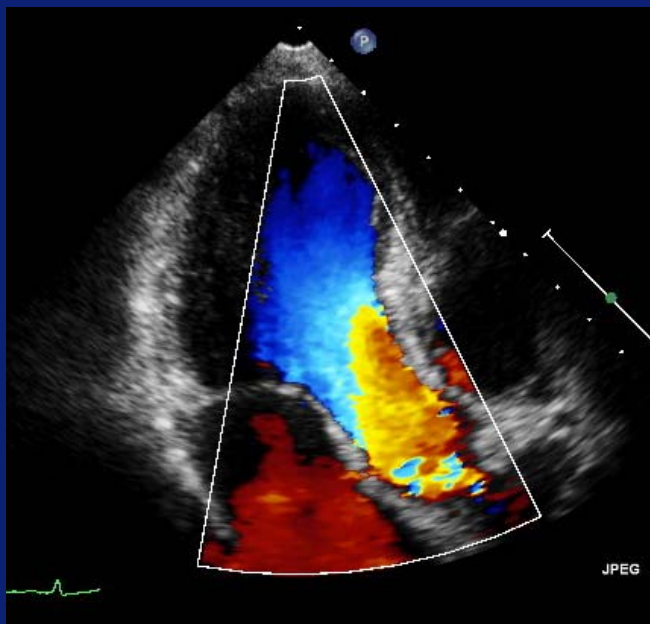
Low density  
FR 19 Hz



Mid density  
FR 17 Hz



High density  
FR 12 Hz

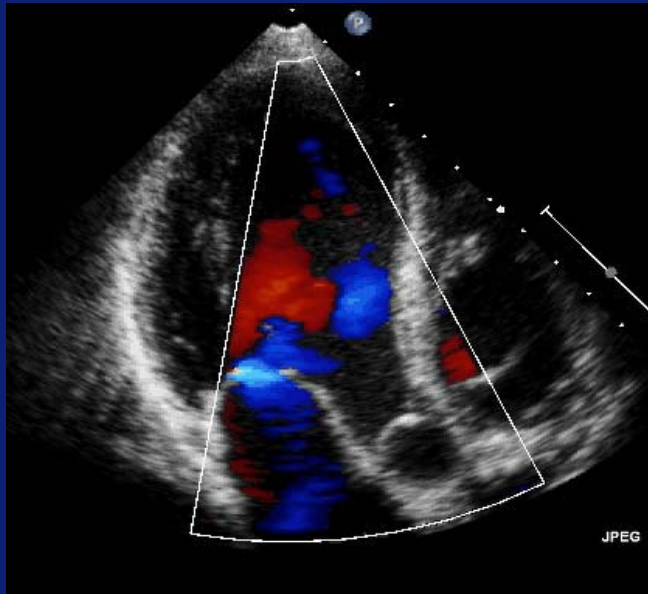


A greater number of scanlines results in denser Doppler data but reduces frame rate

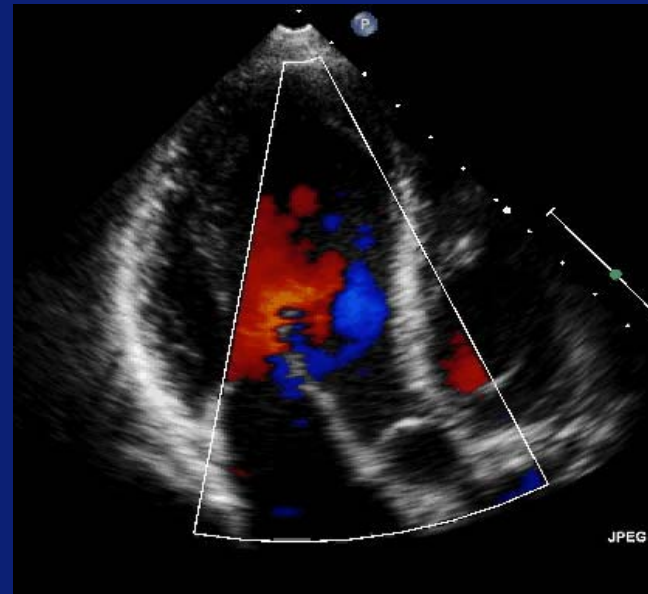
# Color Doppler Flow Imaging

## frame rate – line density

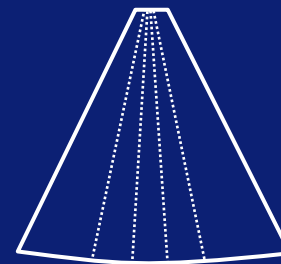
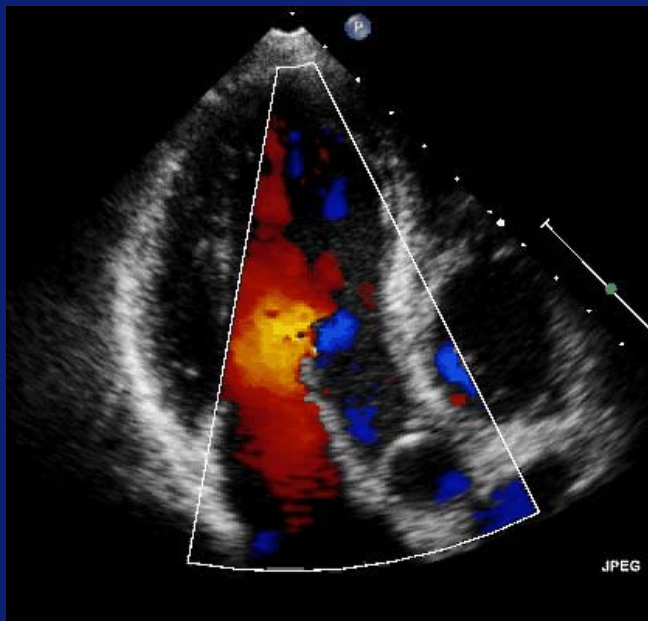
Low density  
FR 19 Hz



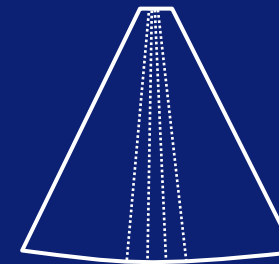
Mid density  
FR 17 Hz



High density  
FR 12 Hz



Low density  
High frame rate



High density  
Low frame rate

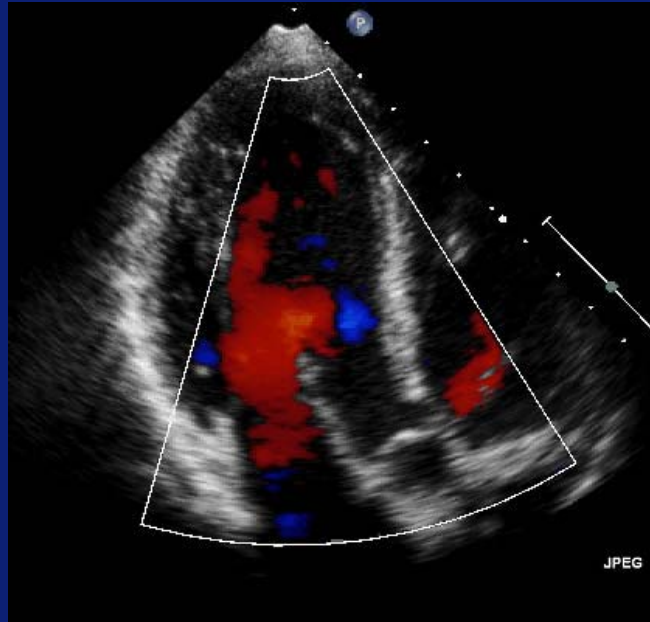
Default setting mid density

Erasmus MC  
*Erasmus*

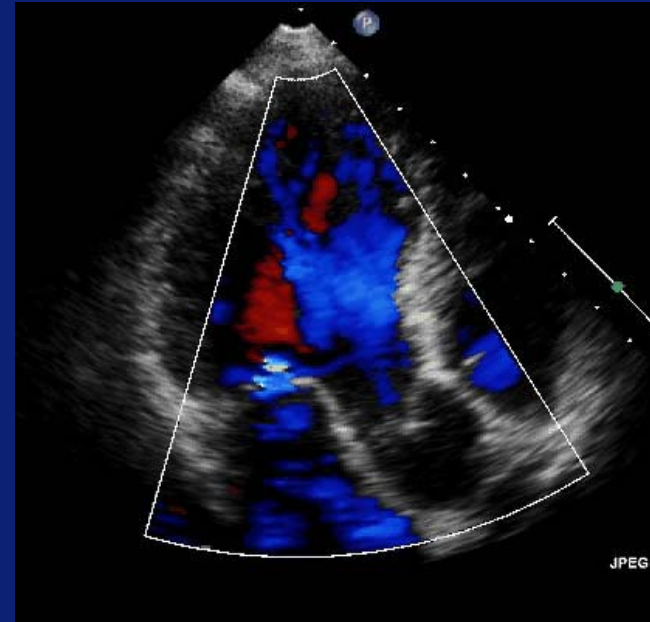
# Color Doppler Flow Imaging

velocity range

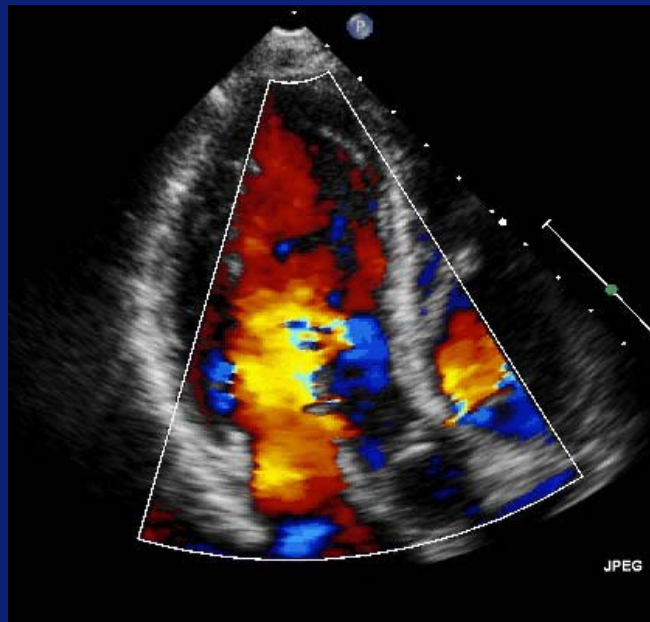
VR 87 cm/s



VR 61 cm/s



VR 38 cm/s

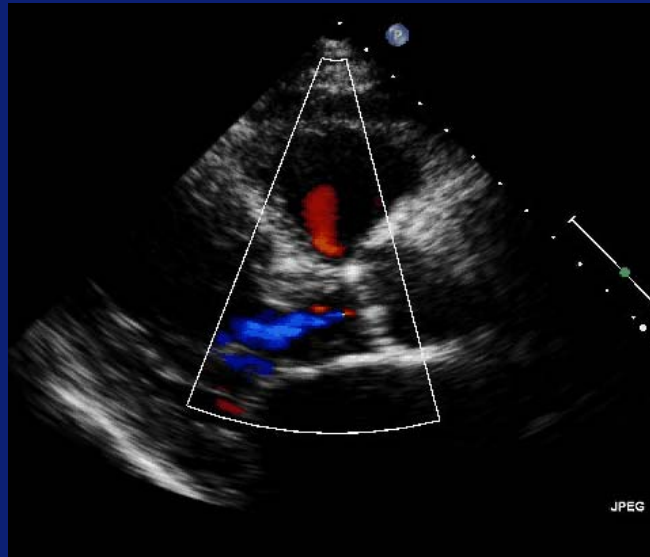


Low velocity scale causes aliasing of low velocity flow in the color display and can create a variance display even in laminar flow

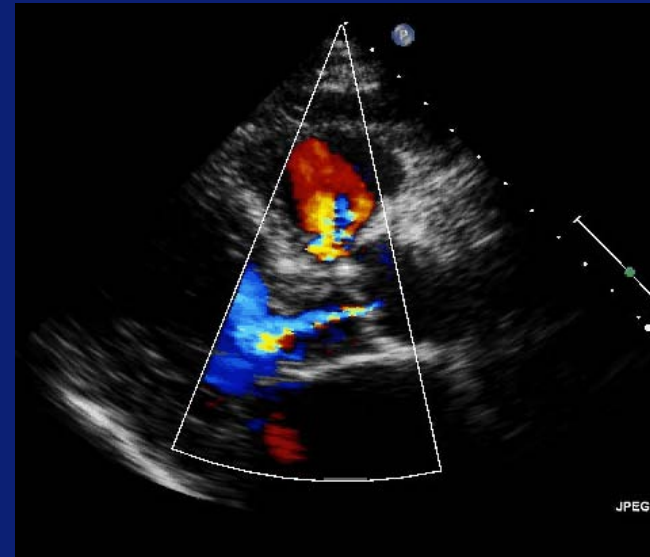
# Color Doppler Flow Imaging

velocity range

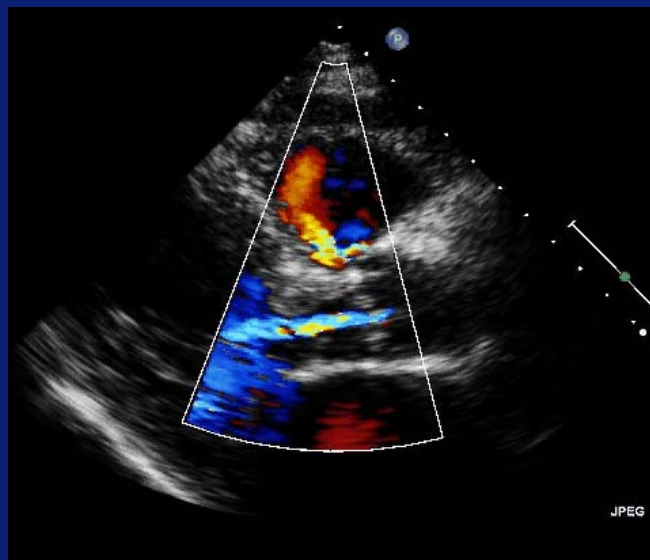
VR 91 cm/s



VR 61 cm/s



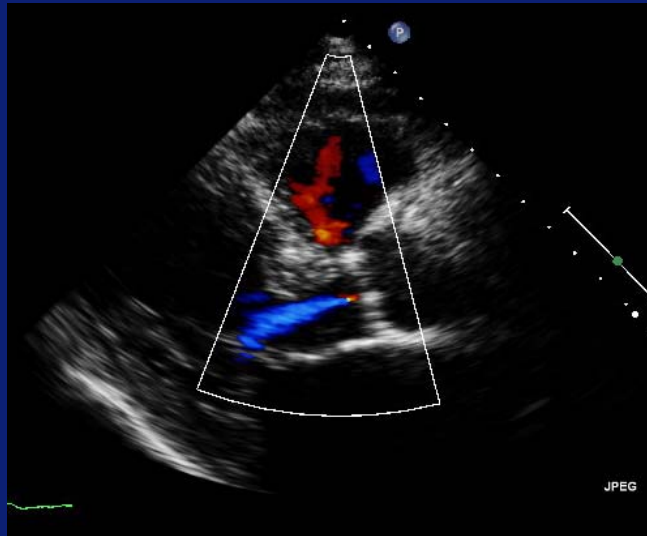
VR 30 cm/s



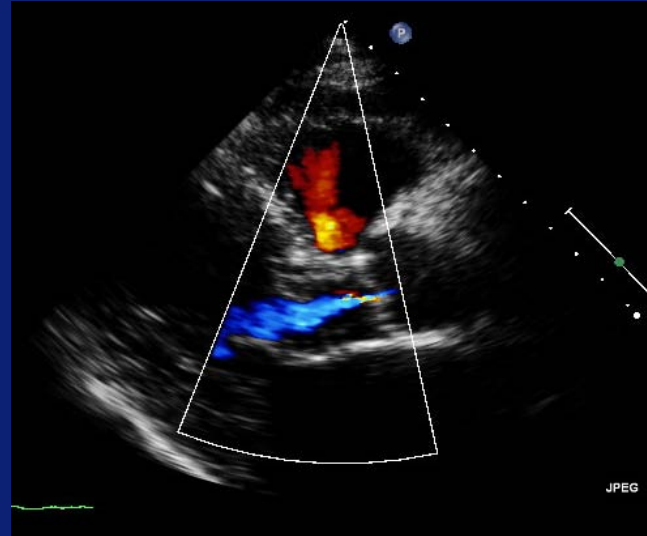
# Color Doppler Flow Imaging

velocity range

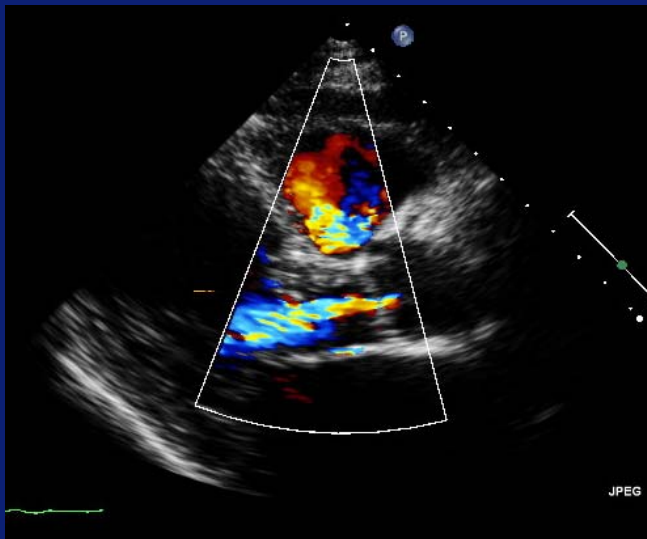
VR 91 cm/s



VR 61 cm/s



VR 30 cm/s

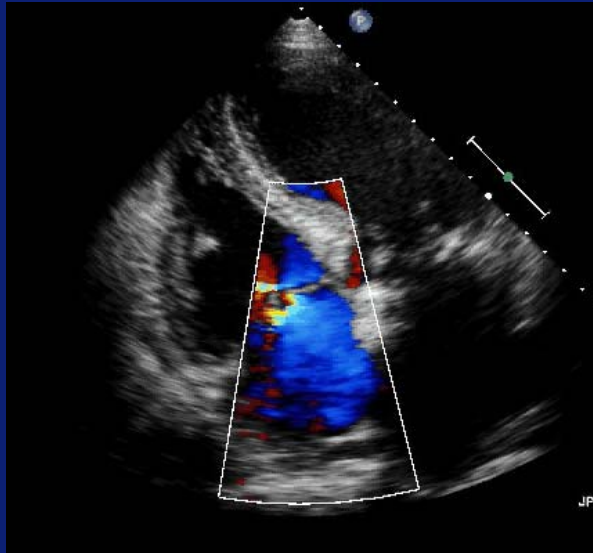


Default setting velocity scale 60 cm/s

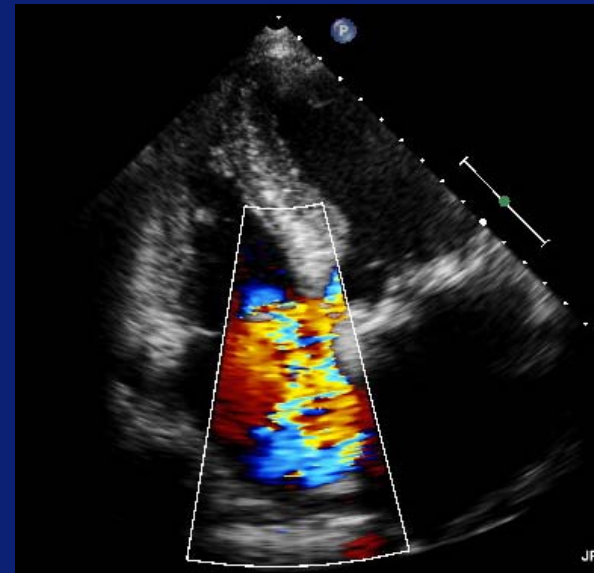
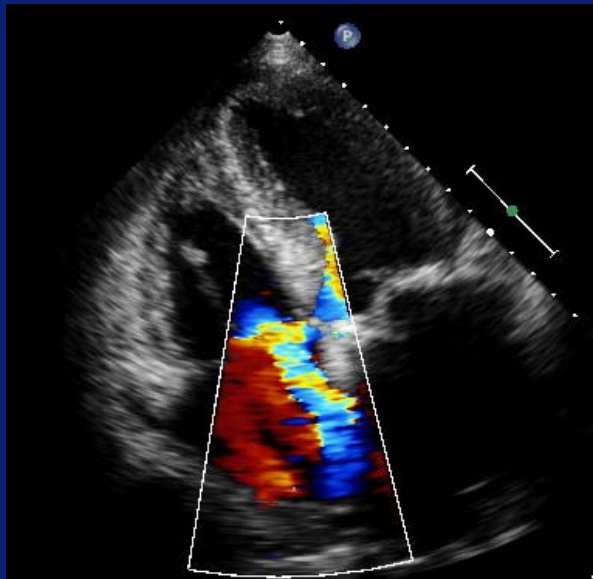
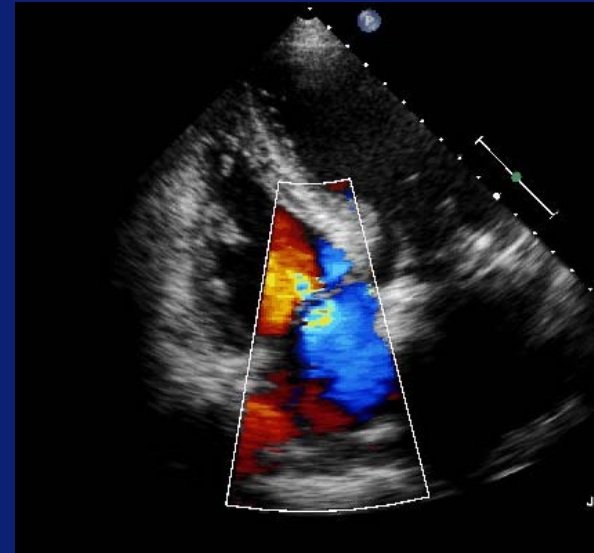
# Color Doppler Flow Imaging

velocity range

VR 61 cm/s

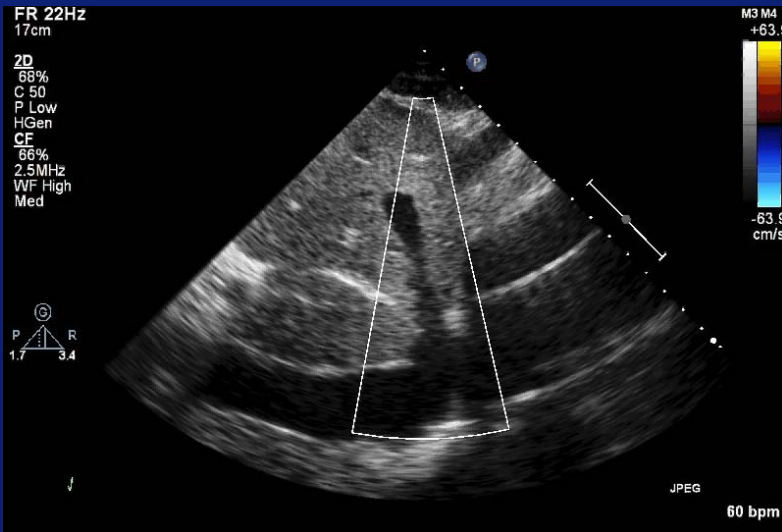


VR 38 cm/s

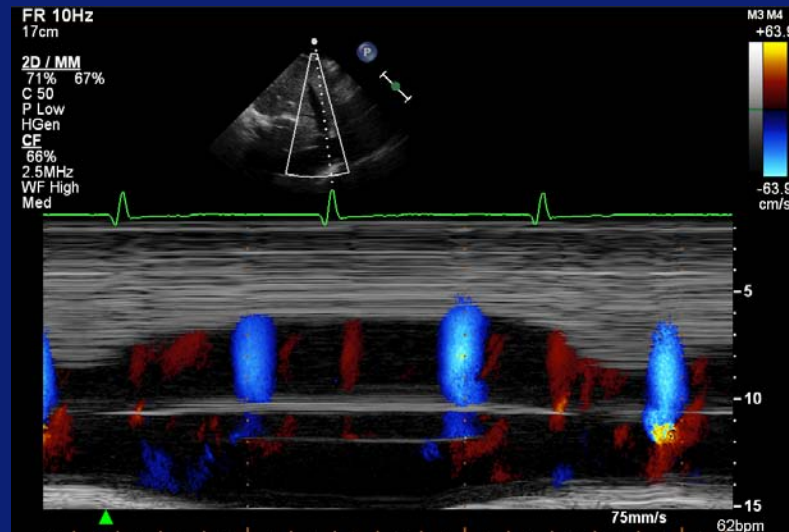


# Color Doppler Flow Imaging

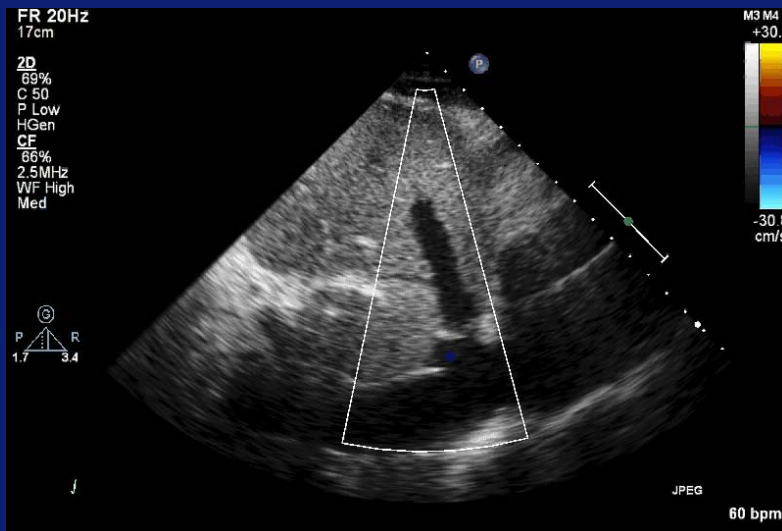
velocity range



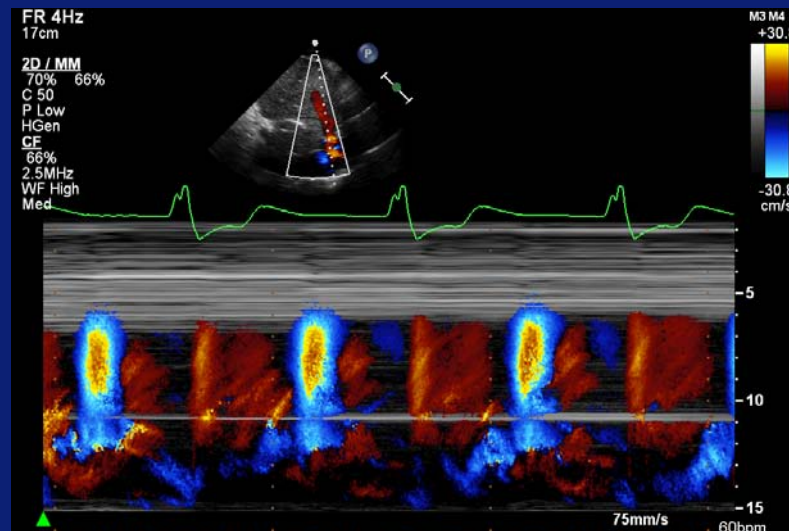
VR 63.9 cm/s



VR 63.9 cm/s



VR 30.8 cm/s



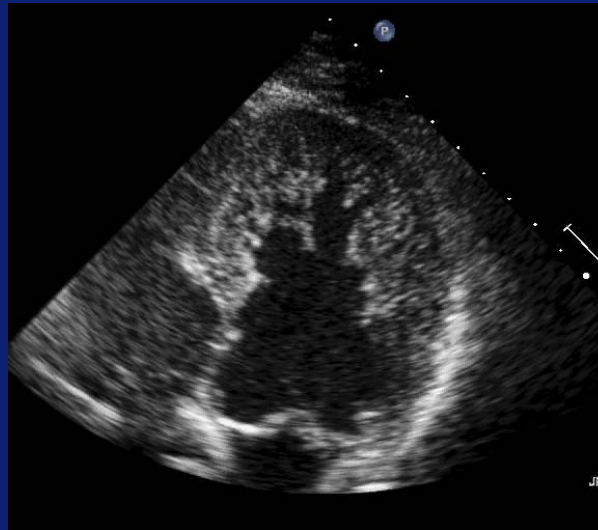
VR 30.8 cm/s

is MC

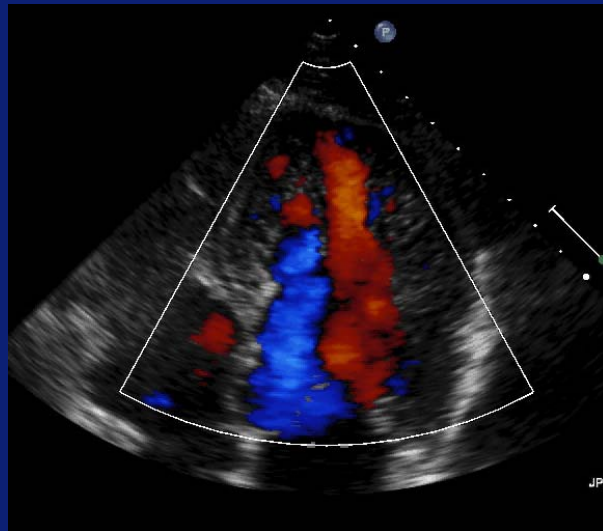
*Cafer*

# Color Doppler Flow Imaging

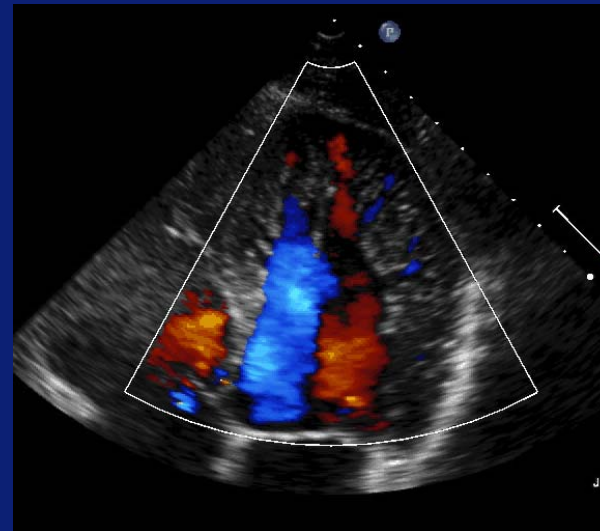
velocity range



VR 61 cm/s



VR 38 cm/s

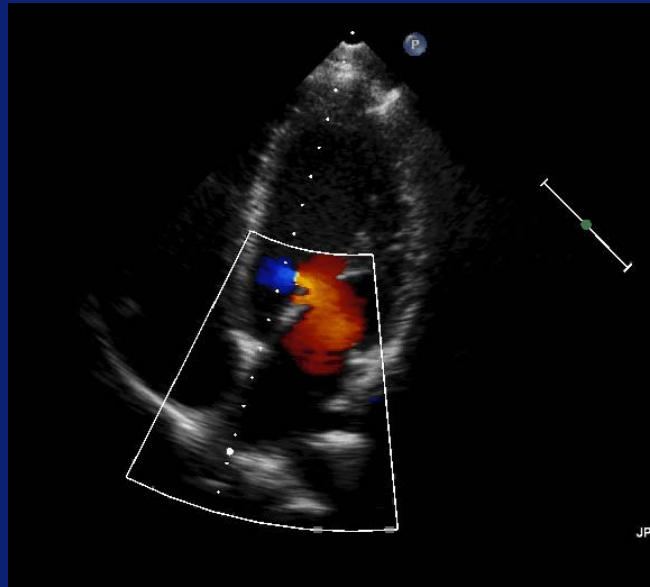


Ventricular flow filling the trabeculated sections of the myocardium

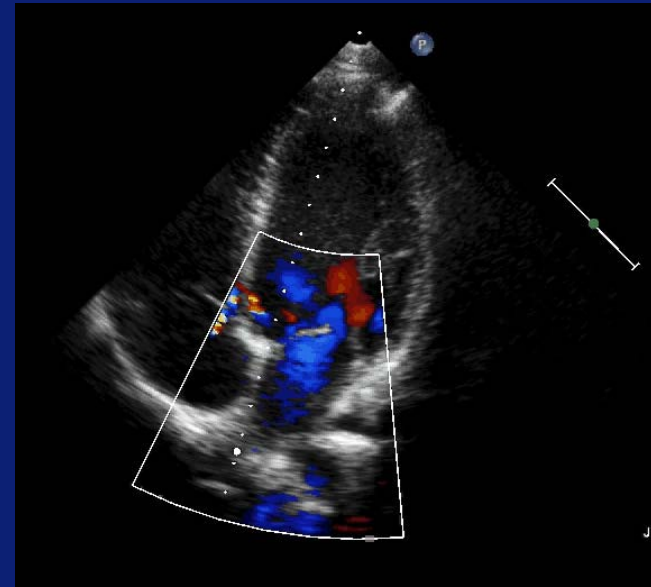
# Color Doppler Flow Imaging

## velocity range – line density

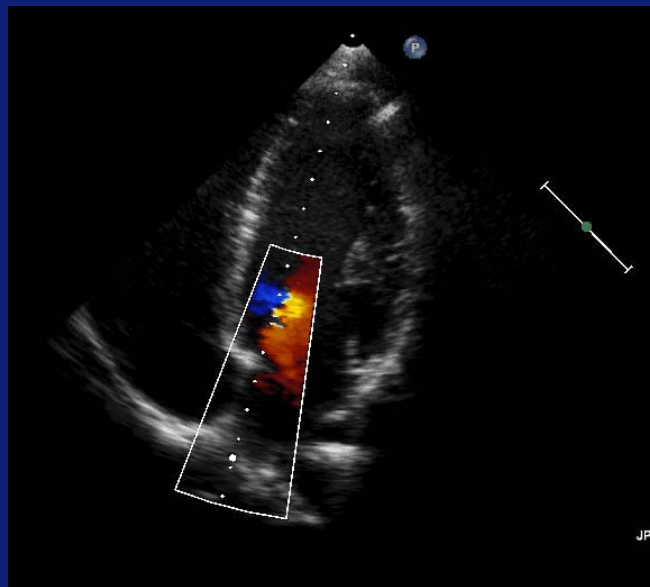
VR 63 cm/s  
Mid line density  
FR 17 Hz



VR 46 cm/s  
High line density  
FR 11 Hz



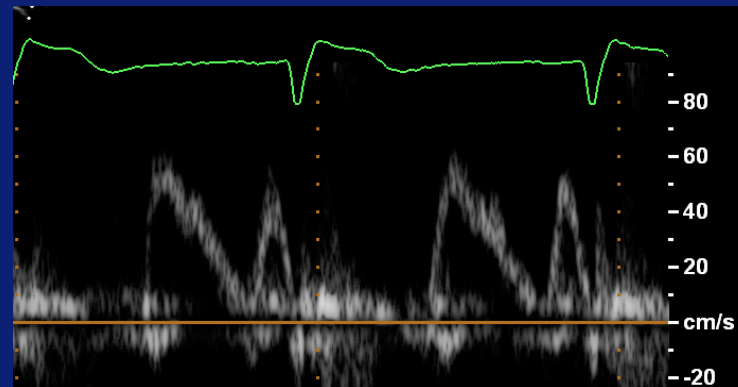
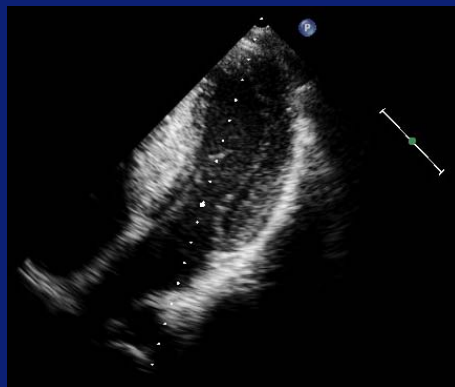
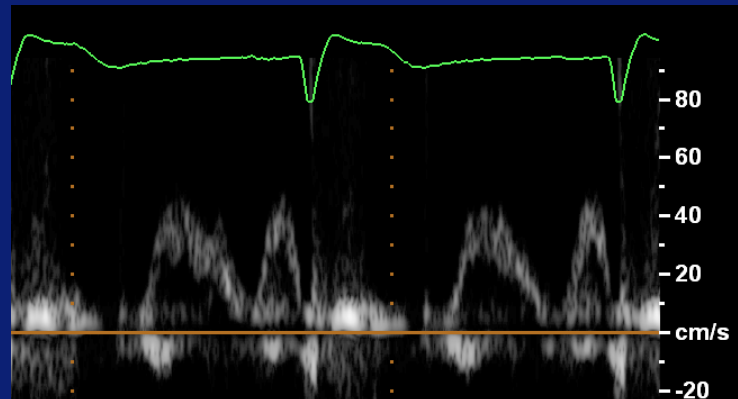
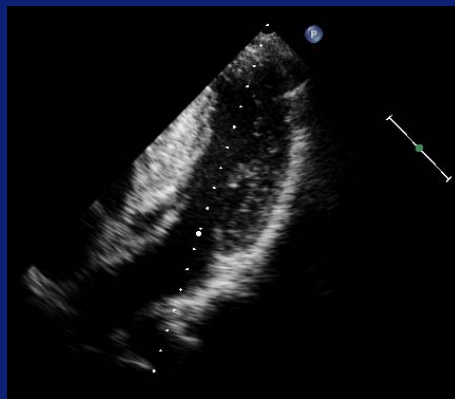
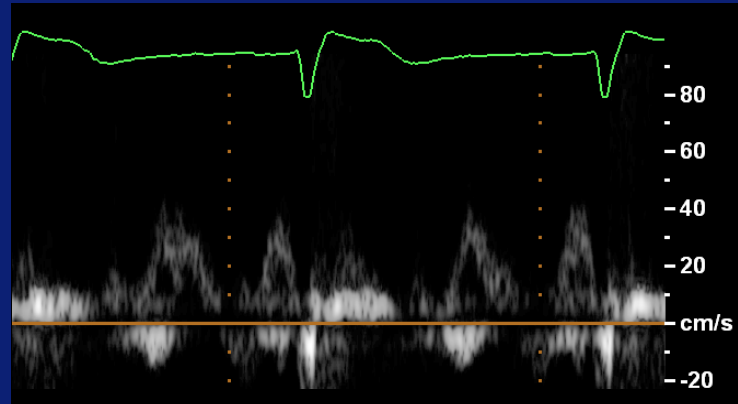
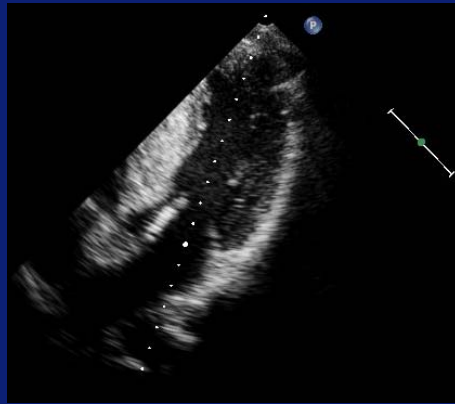
VR 46 cm/s  
High line density  
FR 17 Hz



To optimize low velocity flow  
reduce velocity scale  
increase line density  
decrease sector width

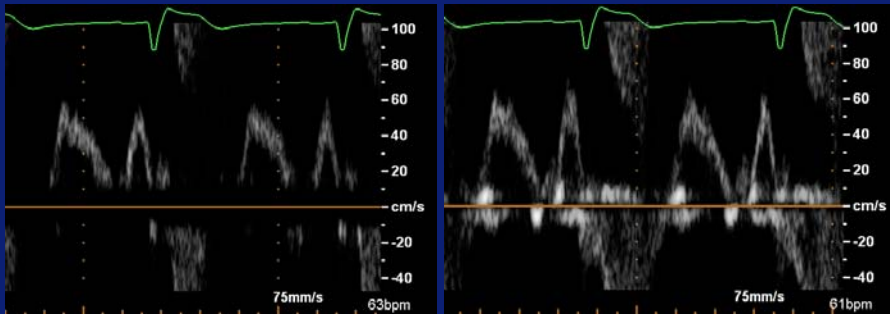
# Pulsed Wave Doppler

sample volume position



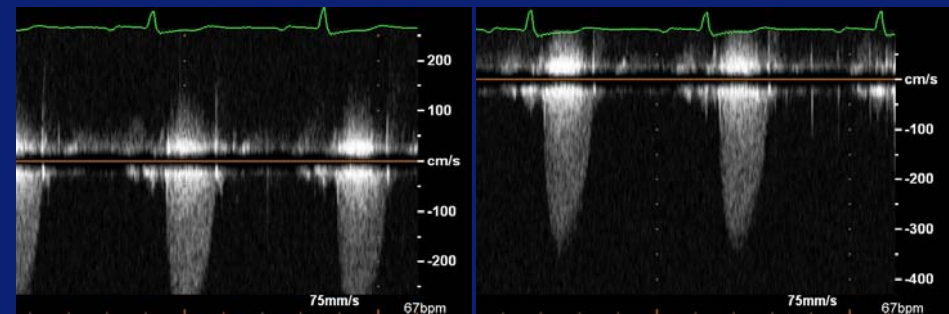
# Standard settings pulsed – continuous wave Doppler

Filter setting



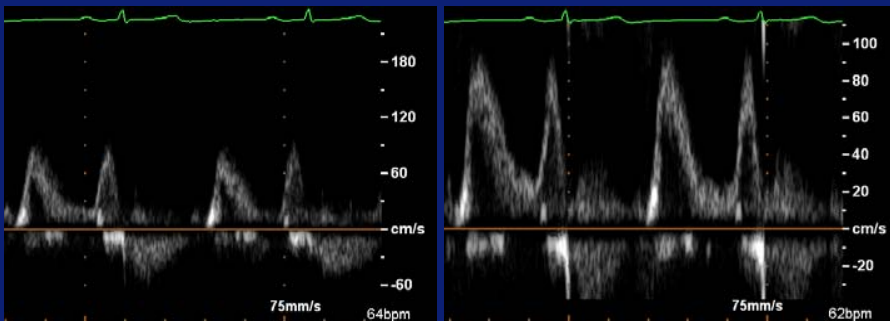
High pass filters eliminate low frequency Doppler shifts

Baseline shift



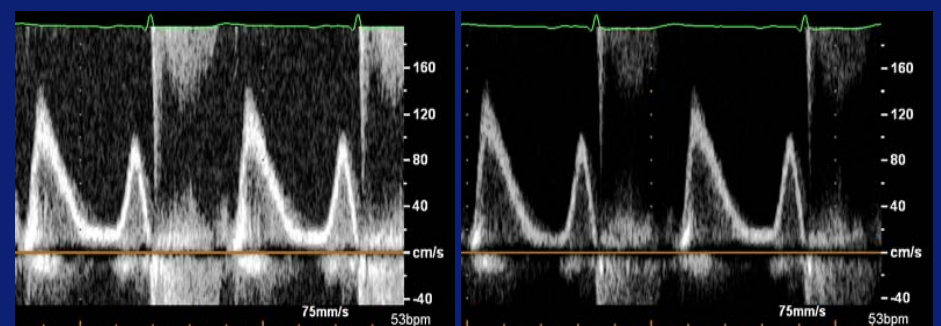
Baseline shift resolves aliasing

Velocity range



Optimize for precise velocity measurements

Gain setting



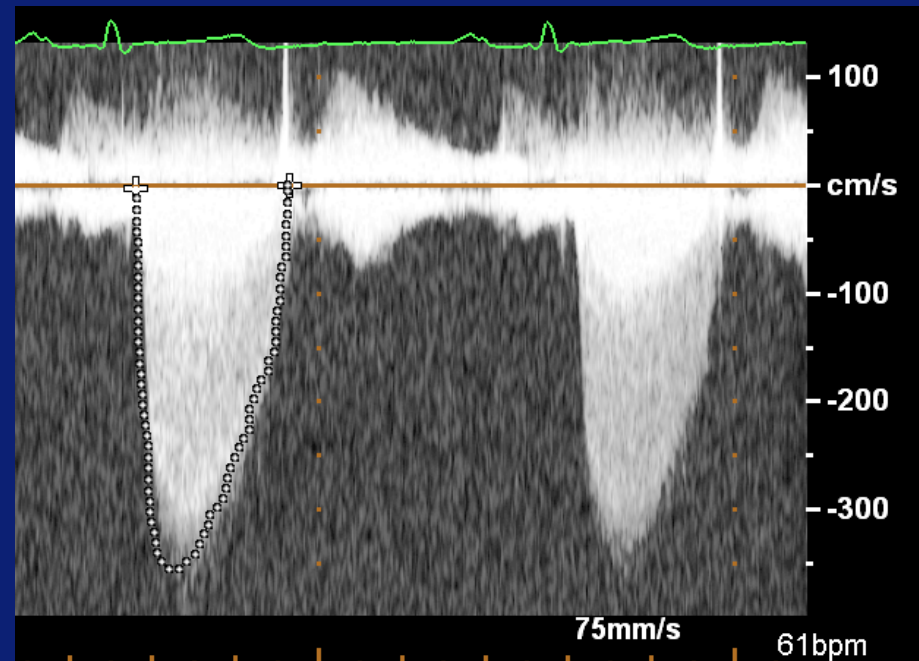
Too high gain setting overrate velocity measurements

# Continuous Wave Doppler

gain setting



Vmax 3.2 cm/s  
Max PG 41 mmHg  
Mean PG 24 mmHg  
VTI 83 cm

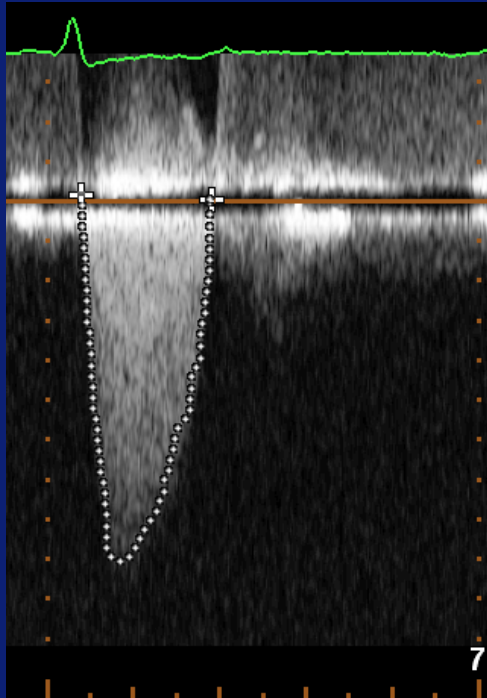


Vmax 3.5 cm/s  
Max PG 50 mmHg  
Mean PG 29 mmHg  
VTI 94 cm

# Pulsed Wave Doppler

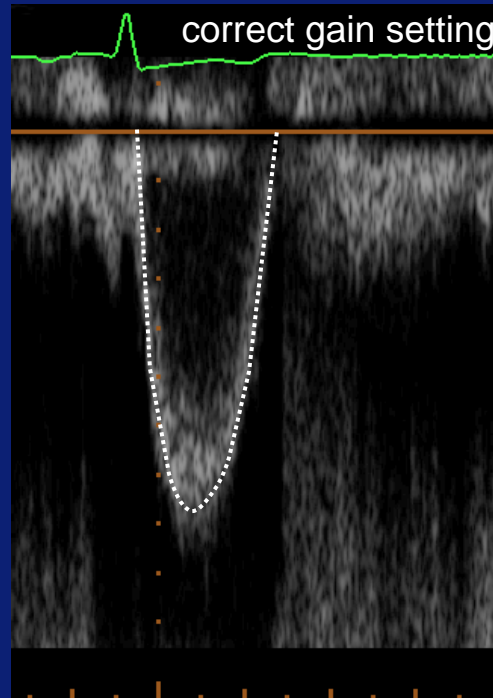
gain setting

CWD Aortic valve



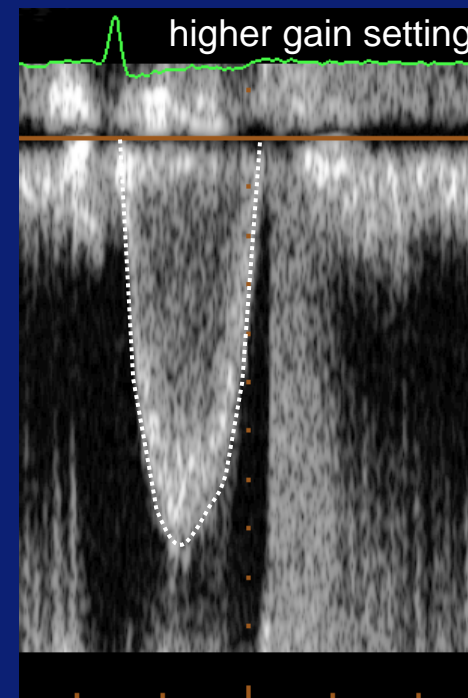
PG 82 mmHg  
VTI 96.1 cm  
(LVOT 17 mm)

PWD LVOT



VTI 36.5 cm  
AVA 0.86 cm<sup>2</sup>

higher gain setting



VTI 44.3 cm  
AVA 1.04 cm<sup>2</sup>

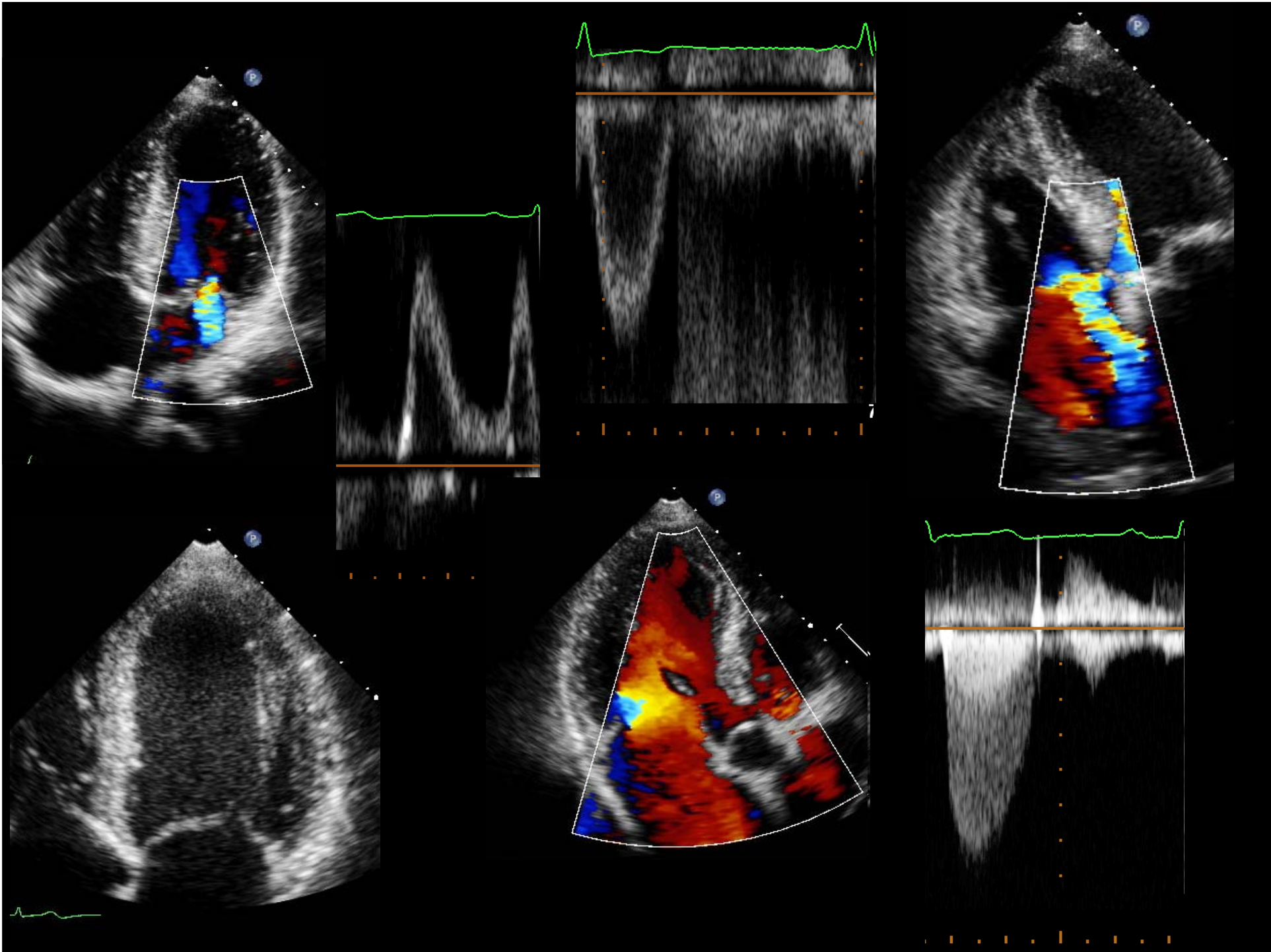
As a sonographer you should be

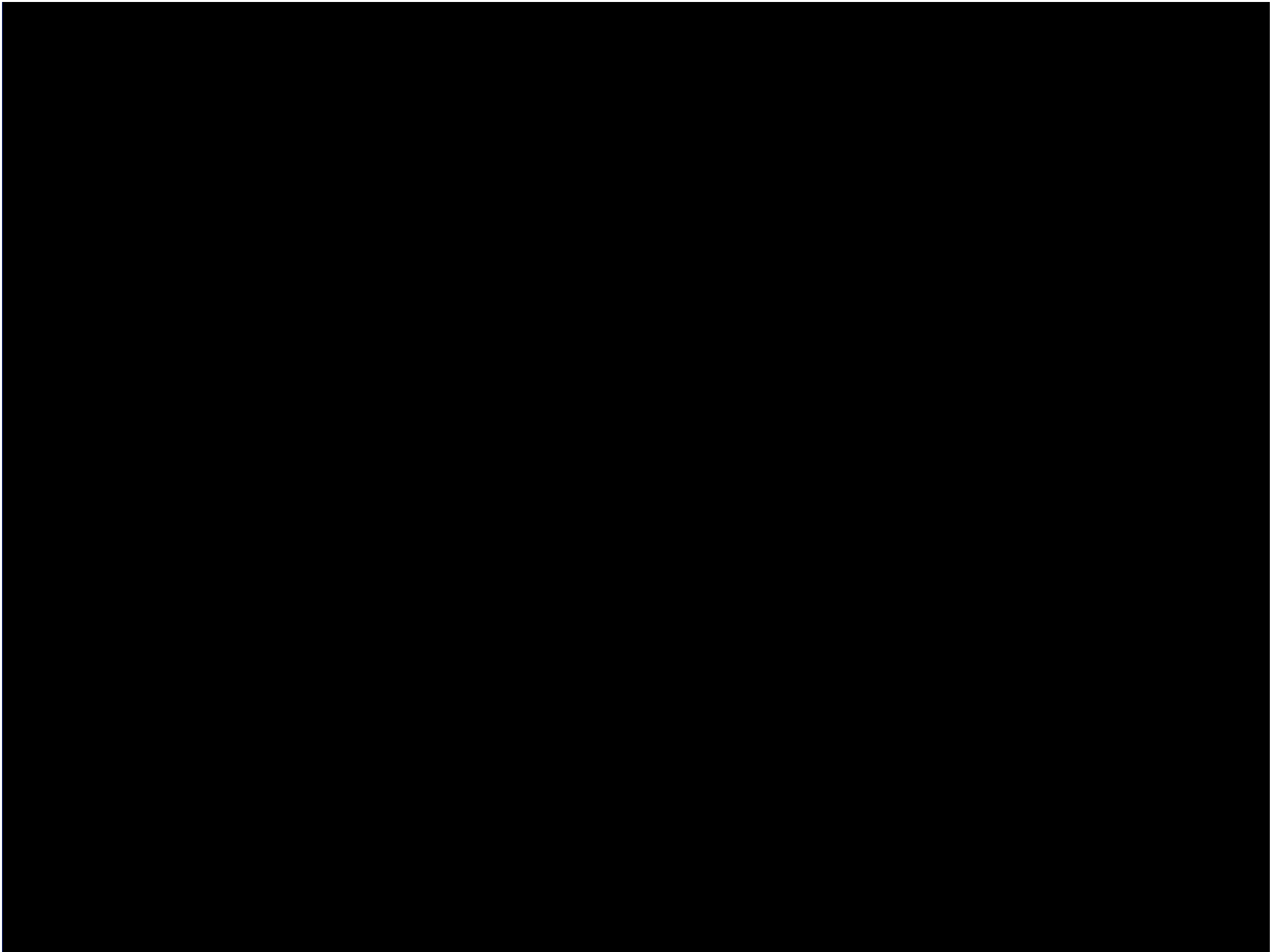
CONTINUALLY CHANGING

the system settings and transducer frequency

TO OPTIMISE

the image throughout the echocardiographic examination

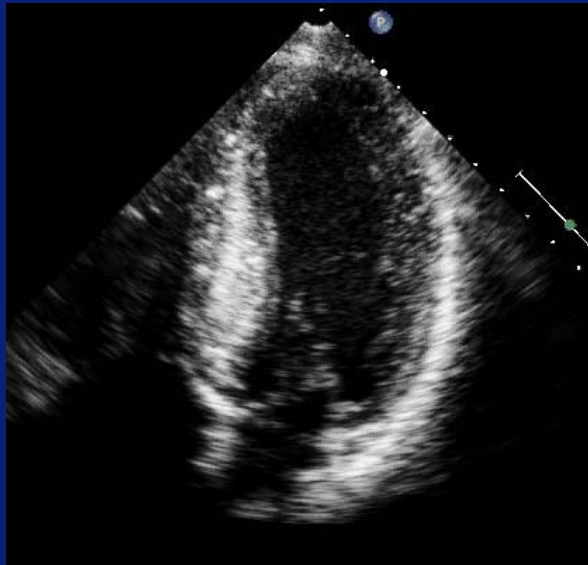




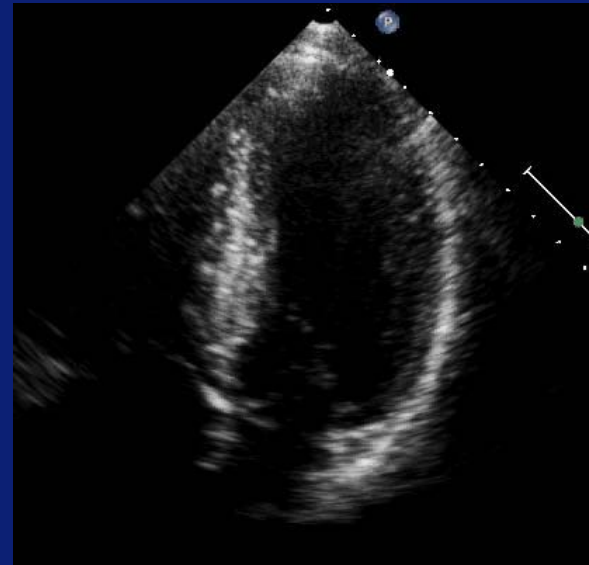
# 2D Imaging

## fundamental – 2<sup>nd</sup> harmonic

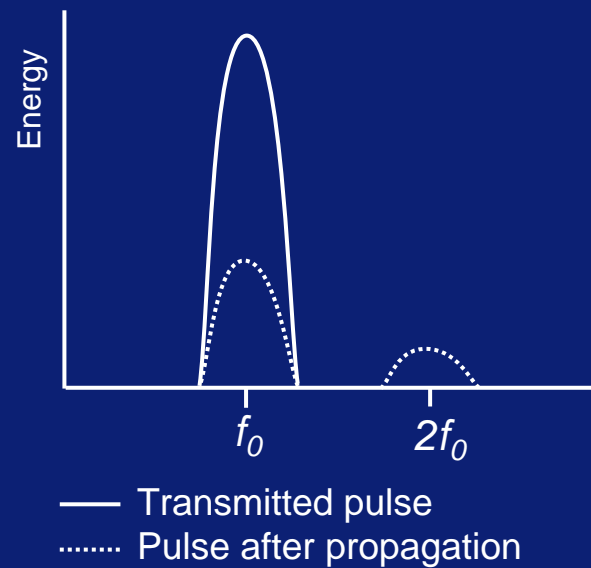
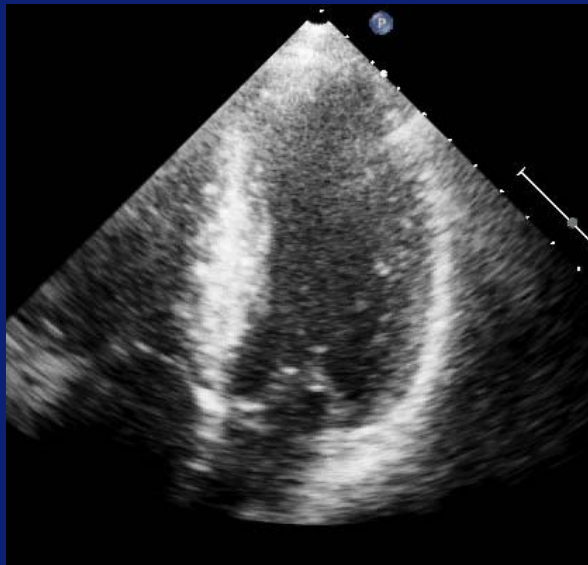
2<sup>nd</sup> Harmonic  
Gain 63%



Fundamental  
Gain 49%



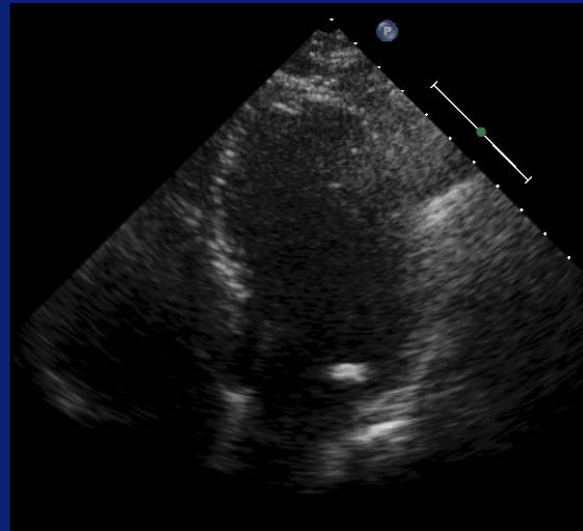
Fundamental  
Gain 63%



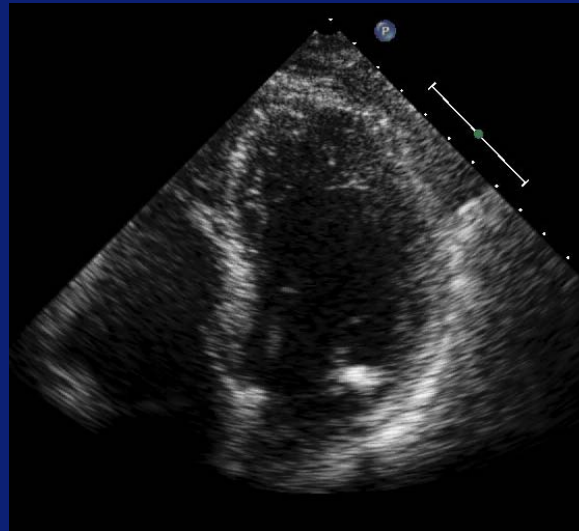
# 2D Imaging

## fundamental – 2<sup>nd</sup> harmonic

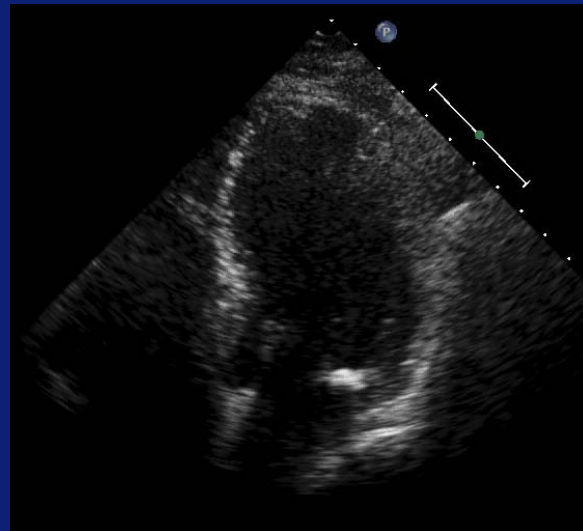
Fundamental



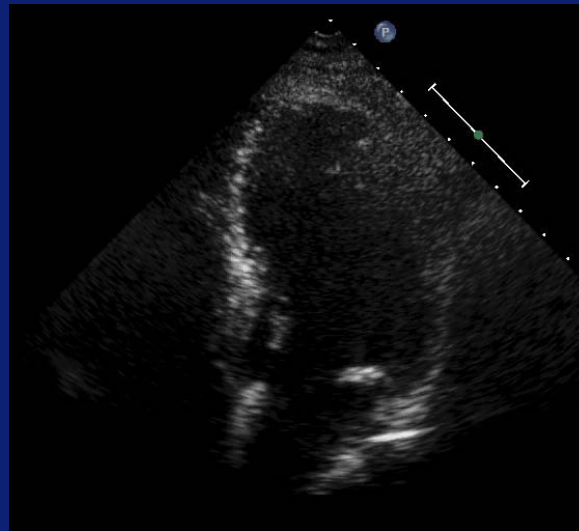
2<sup>nd</sup> Harm. 1.4–2.8Mhz



2<sup>nd</sup> Harm. 1.7–3.4Mhz



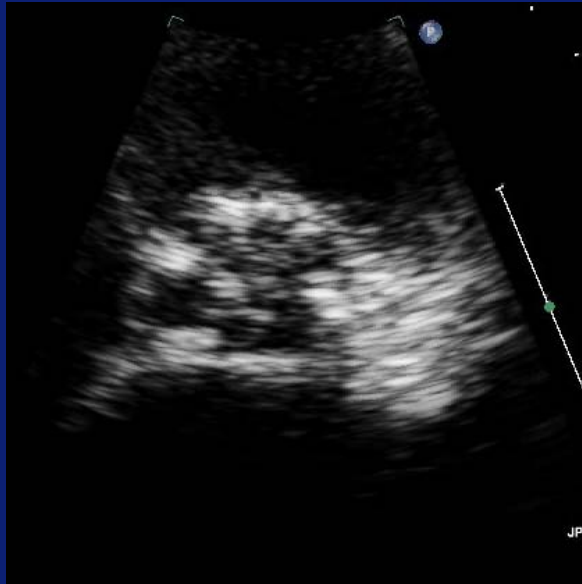
2<sup>nd</sup> Harm. 2.1–4.2Mhz



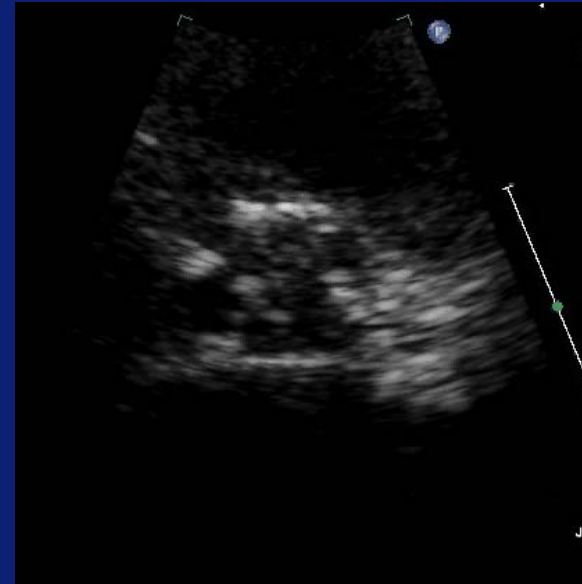
# 2D Imaging

## fundamental – 2<sup>nd</sup> harmonic

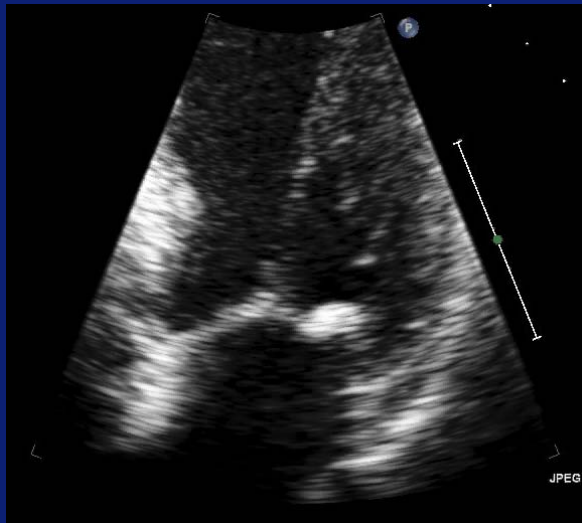
2<sup>nd</sup> Harmonic



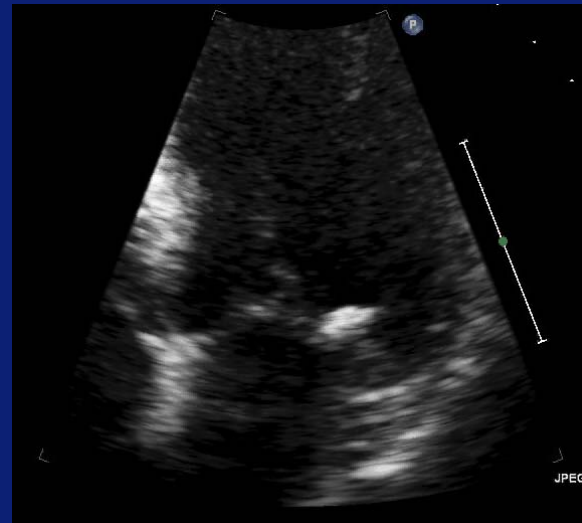
Fundamental



2<sup>nd</sup> Harmonic



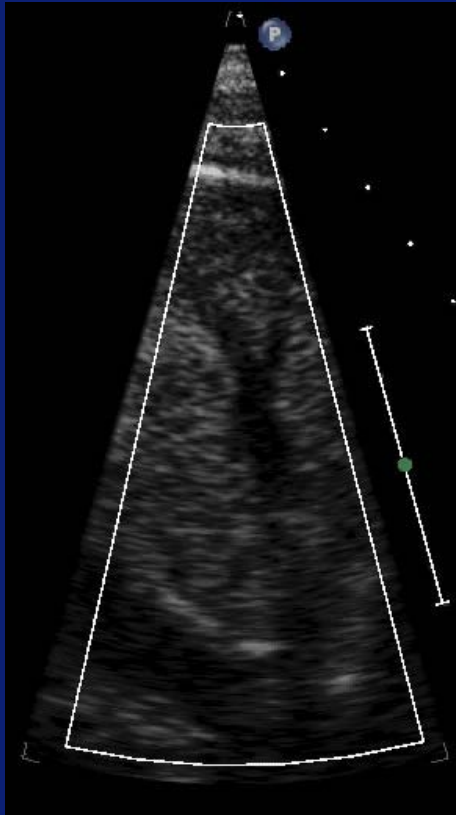
Fundamental



# Color Doppler Flow Imaging

velocity range

VR 91 cm/s  
FR 23 Hz



VR 31 cm/s  
FR 39 Hz mid density



VR 31 cm/s  
FR 28 Hz high density



PRF (velocity range) and wall filters are linked controls

Low PRF setting use a low wall filter and therefore low velocity flow is visible