TRAUNKREIS CARDIO

Doppler applications, optimal adjustment, practical Doppler exam, pitfalls

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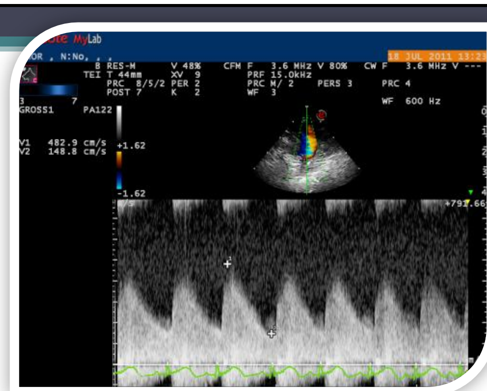
IVUSS Meeting 2011, Bologna

Doppler – Use in Cardiology



- Pulse wave Doppler
- Continuous wave Doppler
- Color doppler

Austrian guy!

Direction of blood flow
Velocity within Sample volume or along Cursor
Detection of turbulence

Identify abnormal patterns of flow
Systolic/diastolic function
Quantify severity of lesion

Confirm findings obtained by PE, rads and 2D
Staging of disease

CW

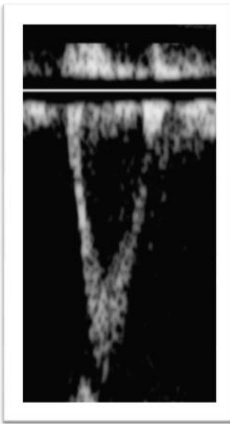
- Continuous sampling (separate crystals)
- Along line of Interrogation
- No information about blood sample
- High Nyquist
- Maximal velocities

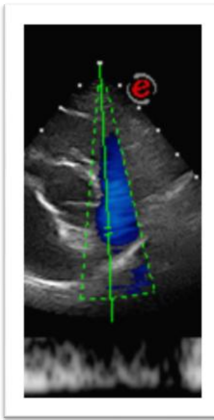
PW

- Range gating (wait for signal echo)
- Along line of Interrogation
- Information about velocity/direction of sample
- Low Nyquist
- Flow patterns at specific locations

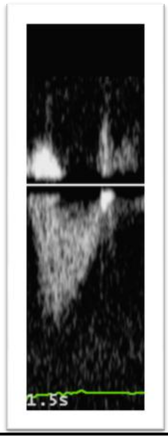
Spectral Doppler

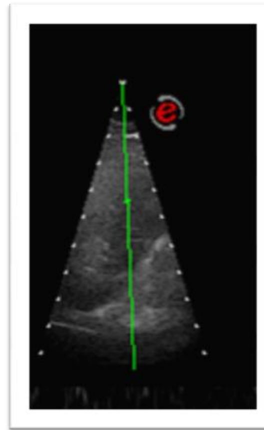
PW-Doppler





CW-Doppler

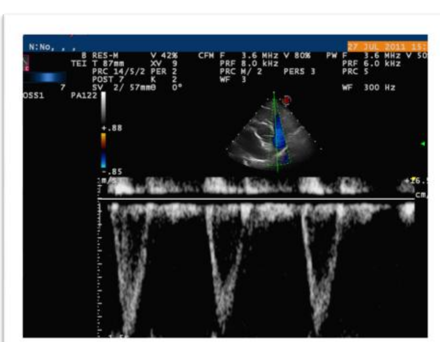




Blood cells of a certain sample volume shoud have similar velocities

PW

Envelope Curve
Place sample volume

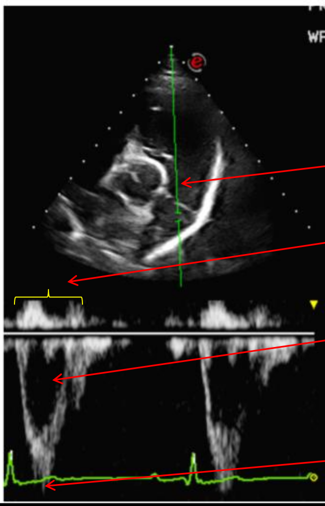


Applications

- Velocity of sample volume
- Envelope curve
- Search for turbulence

- Lower Nyquist limit (wait for echo from a certain depth)
- Not to be used for vmax

What tells us this curve?



We´re examining a sample volume behind the pulmonic valve

The flow profile is quite symmetric, which is typical of normal pulmonary flow

Envelope: only small local differences in velocity -> no turbulence

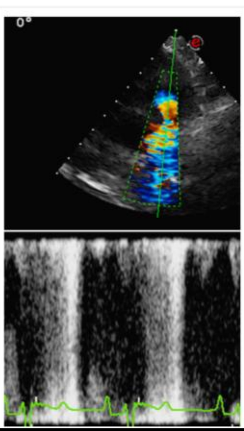
We can measure the local velocity

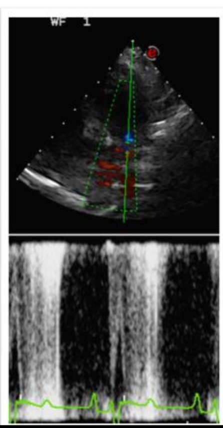
And this one?

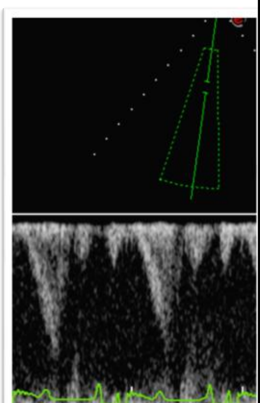
Acceleration and turbulence immediately distal to PV

Also at the level of the PV

Proximal to the PV
There is some DRVOTO
But only mild turbulence

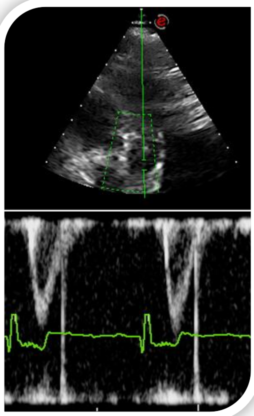




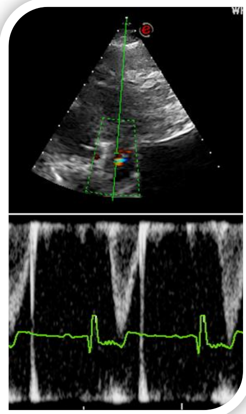


Normal?

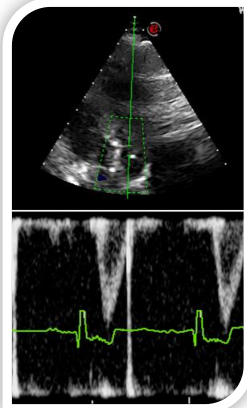
Distal to PV



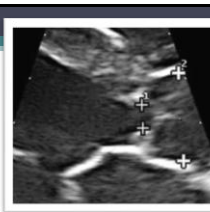
Level of PV

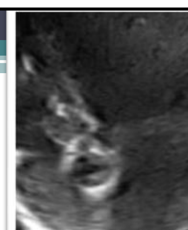


Proximal to PV

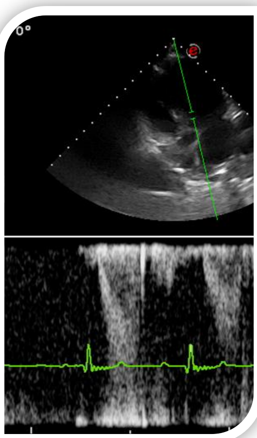


Another one

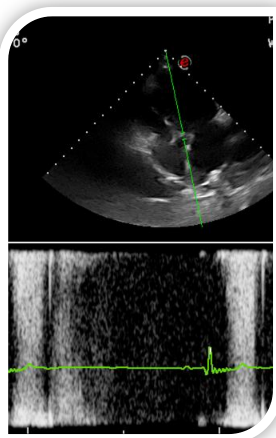




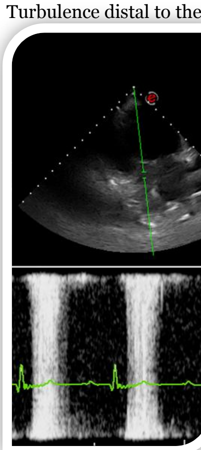
Turbulence begins at the level of the stenosis



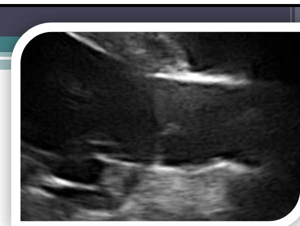
Tubulence and acceleration at the level of the valve



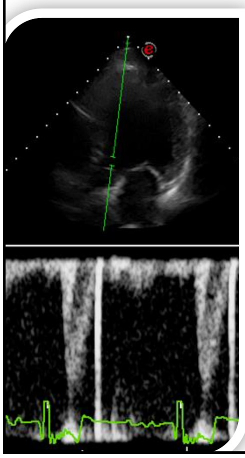
Turbulence distal to the AV



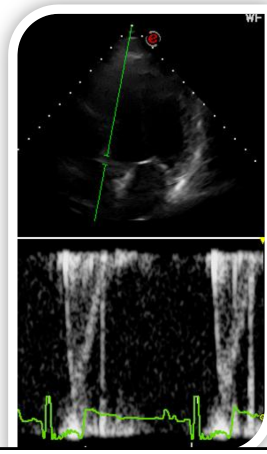
And here?



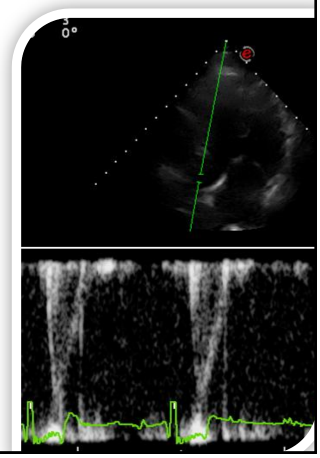
proximal



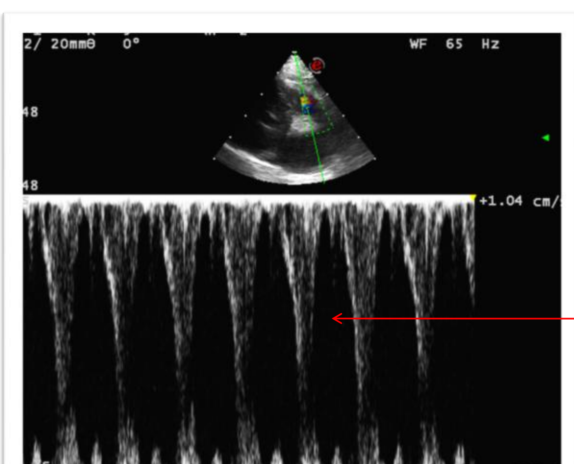
Level of AV



Distal to AV



Timing of acceleration

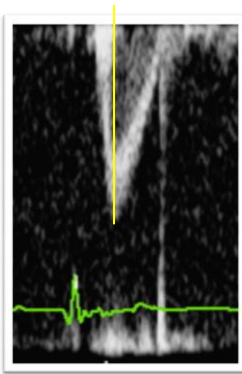


Cat:
Dagger shaped profile
Sample volume within RVOT

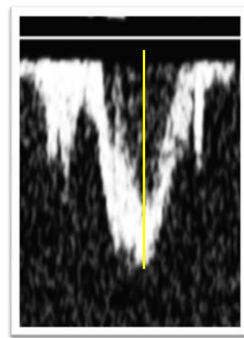
Dynamic obstruction of
right ventricular outflow tract

Difference Aorta/Pulmonary flow

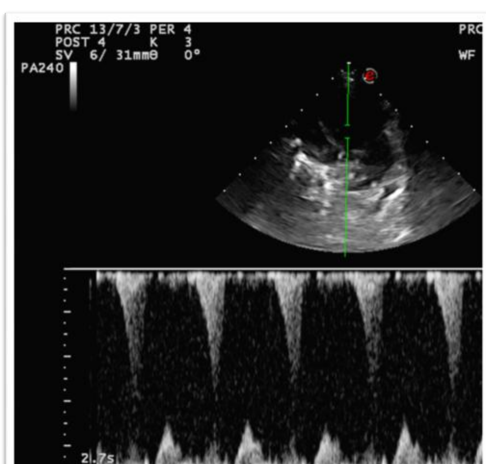
Aorta	Pulmonary



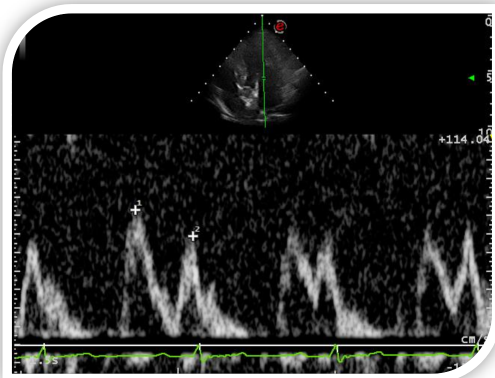
Acceleration Time
Decerleration Time
Ejection Time



Cat with DLVOTO



Mitral inflow profiles

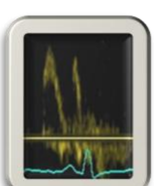


- Sample volume at tips of MV leaflets
- Always consider the pathophysiology
- Left atrial enlargement???
- Frequently measurement errors!

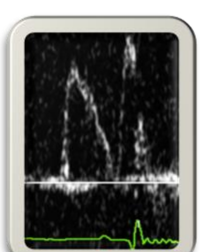
Mitral inflow profiles –

frequently measured – frequently misinterpreted

normal



impaired relaxation

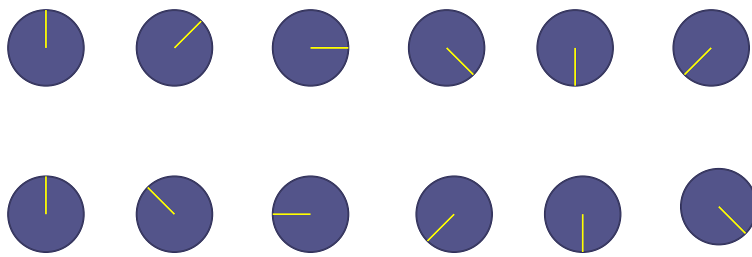


restrictive

All patterns except the normal one are associated with LAE!

Nyquist Limit

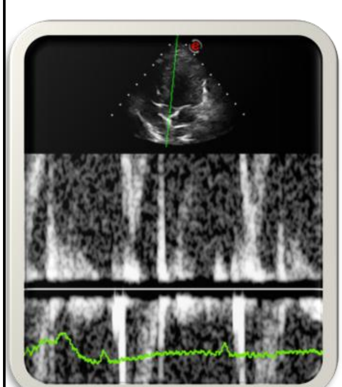
Wheel - 8 seconds per turn



Picture every second

Picture every 7 seconds

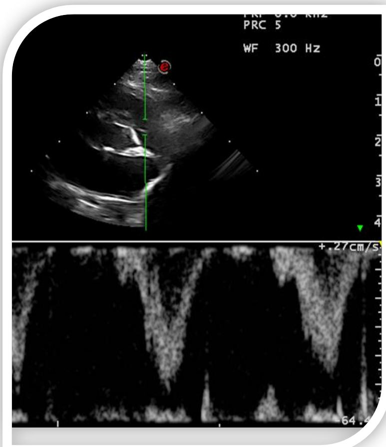
Aliasing



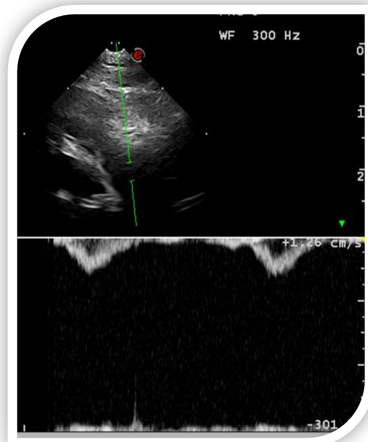
Signals that exceed the Nyquist limit

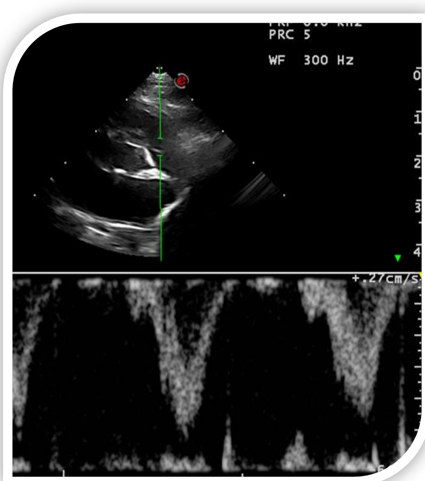
Direction of flow wrong

How can the Nyquist limit be influenced?

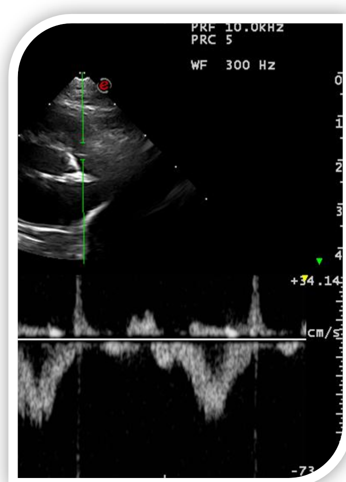


Pulse repitition frequency



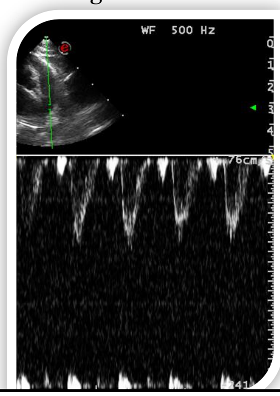


Zero base line

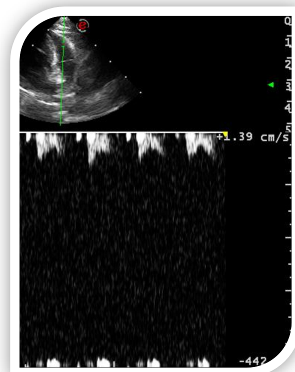


Position of sample volume

Long distance

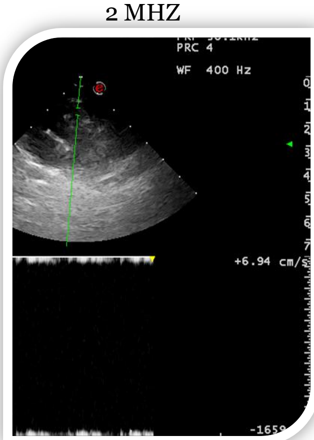


Short distance

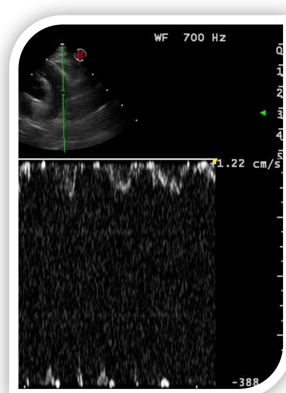


Frequency of transducer (carrier frequency)

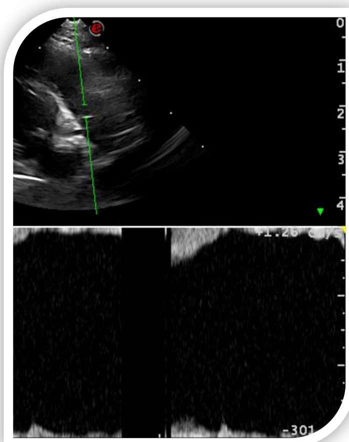
2 MHZ

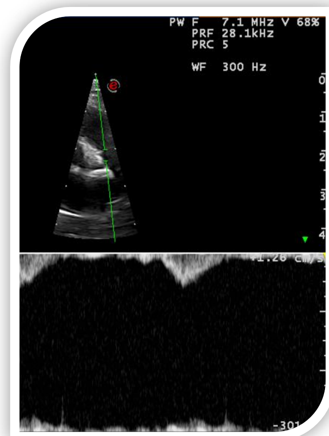


7.5 MHZ



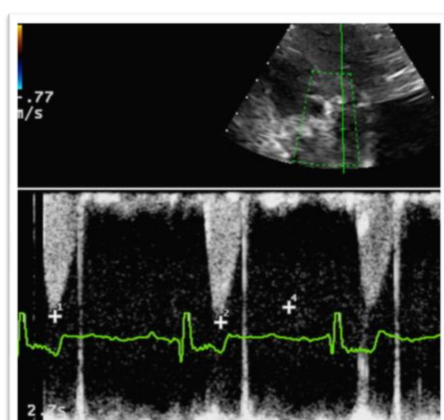
And does the sector matter?





CW

- Only maximal velocities
- No information about turbulence
- Take low frequency transducers
- Adjust O-Line and PRF



Angle of incidence

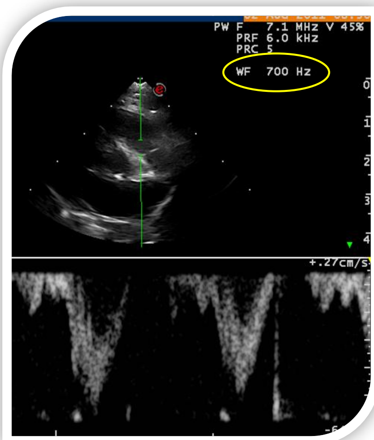
- **ALWAYS OPTIMIZE ALIGNMENT WITH DOPPLER BEAM**
- **ANGLE OF INCIDENCE HAS TO BE <20°**
- **NEVER USE ELECTRONICAL ANGLE CORRECTIONS!**

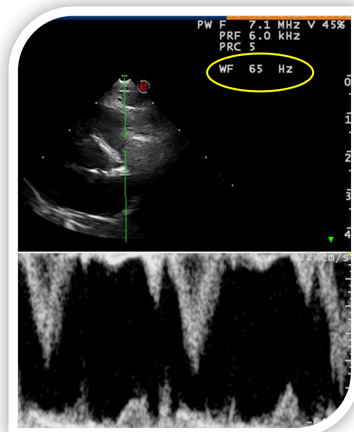
What else can be adjusted?

- Baseline filter
  - Valve artifacts
- Sample volume in PW
  - 2-3 mm
- Doppler gain
  - There should be some speckles around

Baseline Filter

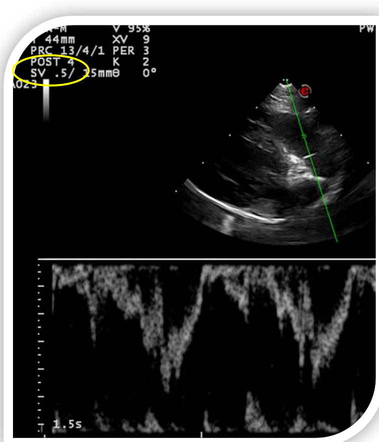
Mostly around 300 Hz





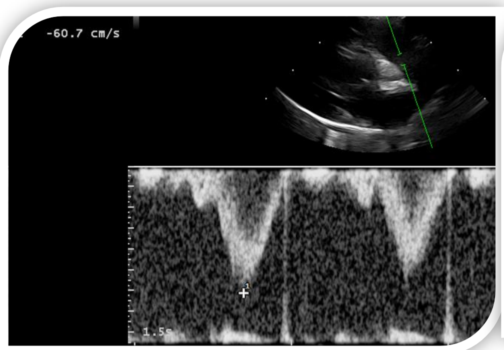
Sample Volume (only PW)

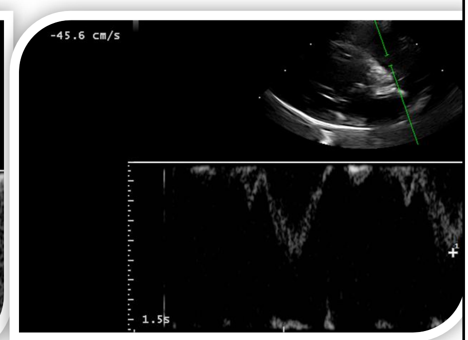
Typically 2-4 mm



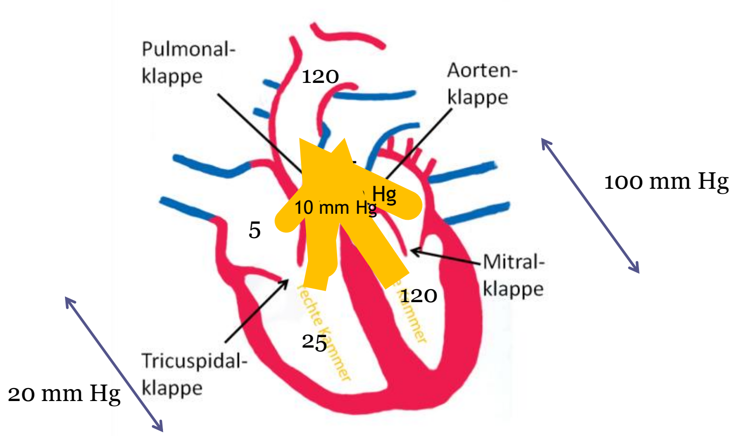
Doppler Gain

Adjust so that few specles are seen around the curves!

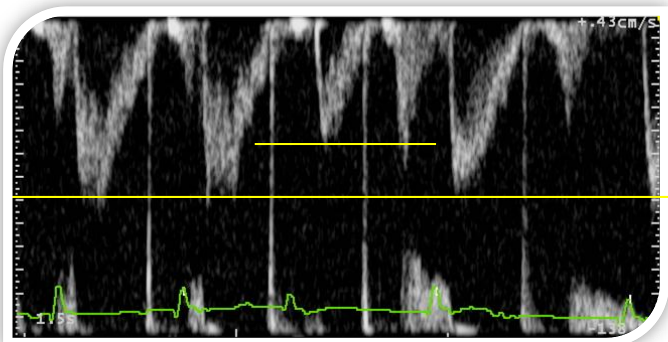




Pressure gradients – pathophysiological Considerations



Outflow profil VTIs represent stroke volume!



CAVE

- Abnormal pressure gradients should always be seen in context with the 2D image and the PE

Always consider the pathophysiology!

The measurement of pressure gradients is the most common cause of misdiagnosis

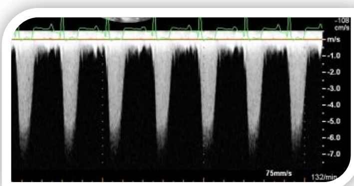
Interrogation of Regurgitant Jets

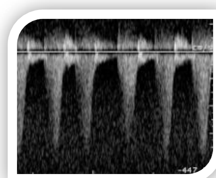
Mitral CW

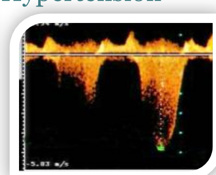
- Normal: 5-6 m/s
  - (100-144 mm Hg)
- Elevated when:
  - Greater pressure difference
  - SAS
  - Systemic Hypertension

Tricuspid CW

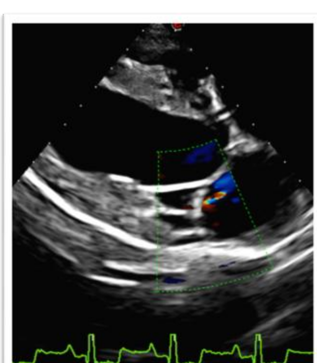
- Normal: 2.2-2.4 m/s
  - (20-25 mm Hg)
- Elevated when:
  - Increase in pressure difference
  - PS
  - Pulmonary Hypertension



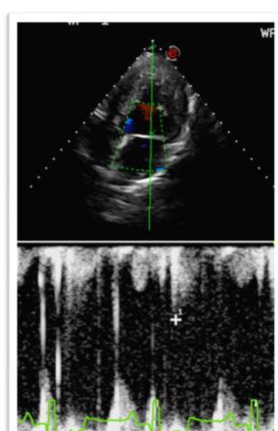




Mitral insufficieny – Interpretation...



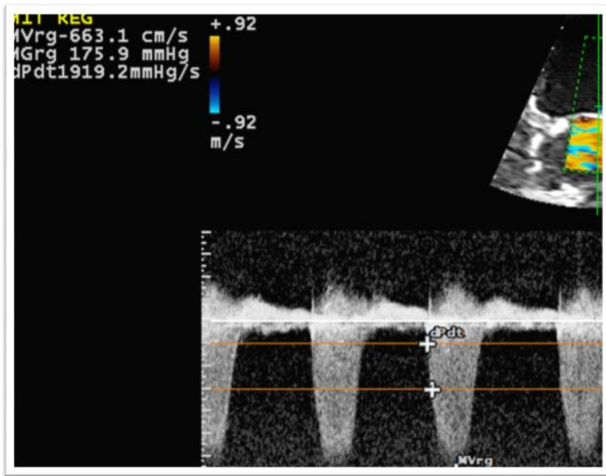
Always think of
•physics and
•pathophysiology!



Mitral regurgitation - dp/dt

One tool for estimation of LV systolic function (Schober, 2009)

No precise data availabe



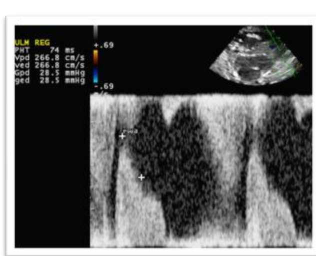
Interrogation of Regurgitant Jets

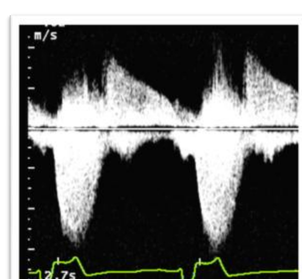
Aorta (confirm with PW, measure with CW)

- „Normally“ 4.5-5m/s
  - 80-100mm Hg
- Rapid decline in velocity
  - Worse insufficiency
  - Pressure equalization

PV (confirm with PW because of PDA, measure with CW)

- Normally 2.2 m/s
  - 20 mm Hg
- Rapid decline in velocity
  - Worse insufficiency
  - Pressure equalisation





Interrogation of Stenoses

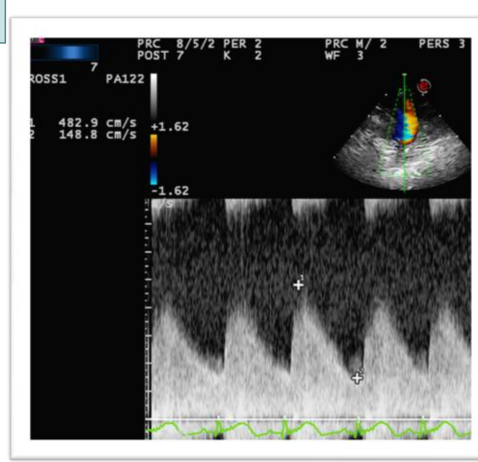
Normal impulse gradient ~10 mm Hg

- Higher pressures are indicative of stenosis
- Consider pseudostenosis in high output cases (e.g. PDA)
- Type of stenosis
  - Fixed
  - dynamic

Interrogation of Shunts

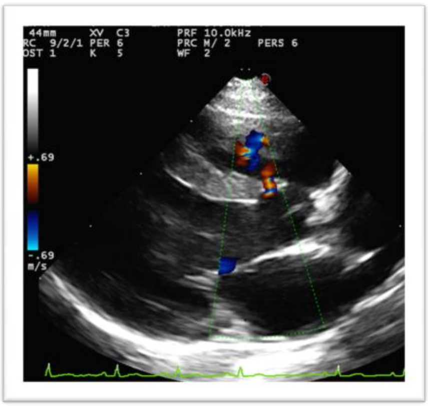
Always think of Pathophysiology

- Normal pressure difference in VSD and PDA should be ~100 mm Hg
- Decrease with PS or PHT

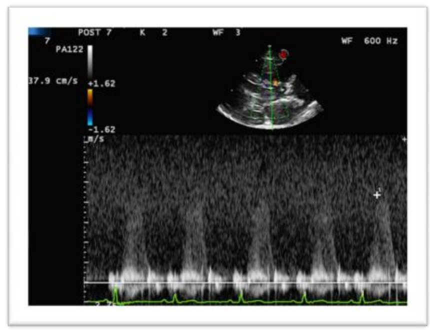


Interrogation of Shunts

VSD

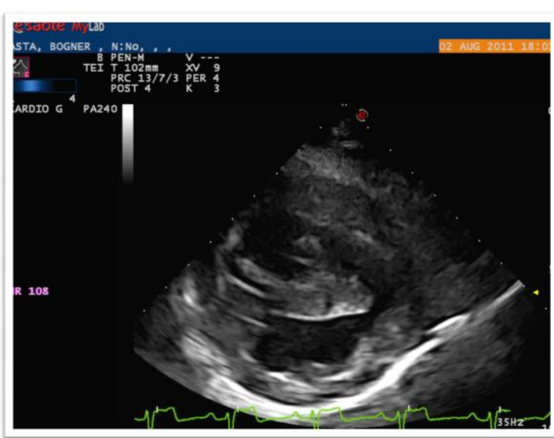


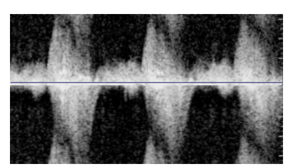
CW across VSD

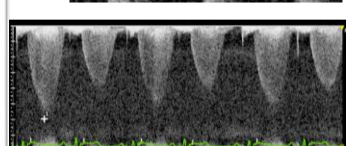


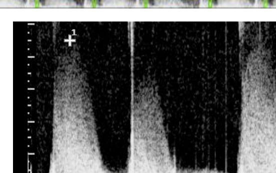
Choose your profile!

What would you expect?









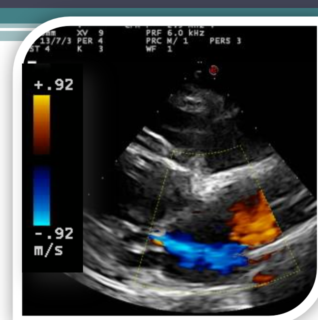
Use of Color Doppler Imaging

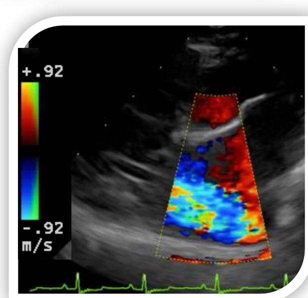
Examination of flow across specific regions
Recognition of normal flow
Detection of abnormal flow
Quantitation of blood flow (velocity information)

- ➢Different imaging planes provide complementary views of blood flow
- ➢Sometimes use of non standard views
- ➢Every abnormal flow detected has to be reexamined by use of Spectral Doppler

Color Doppler Imaging (CDI)

- Type of PW Doppler
- Overlays PW-information onto 2D-Image
- Screening for areas of abnormal flow
- Same rules as for PW
  - Nyquist Limit
  - Aliasing
  - Angle of incidence





Always increase frame rate

Cat with HR of 240
12 frames per second

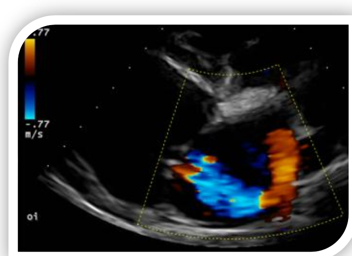
↓

Only 3 frames per cardiac cycle

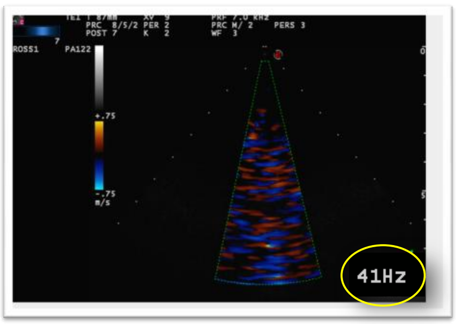
- Narrow color sector size
- Decrease sector lenght
- Narrow 2D sector size
- Line density
- Depth
- Transducer frequency

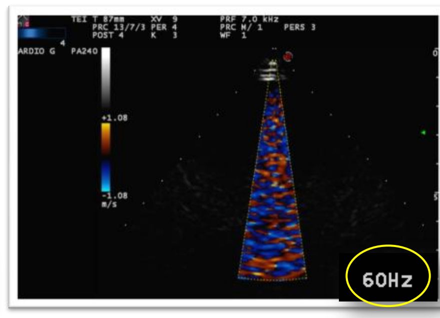
Other important adjustments

- PRF – Nyquist Limit
- Zero Baseline
- Select color map
- Take a lower frequency transducer
- Reduce grayscale (only black pixels can be colored)
- Increase color gain until artifacts occur then reduce again

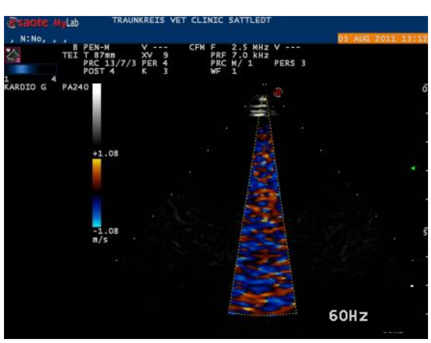


Influence of transducer frequency

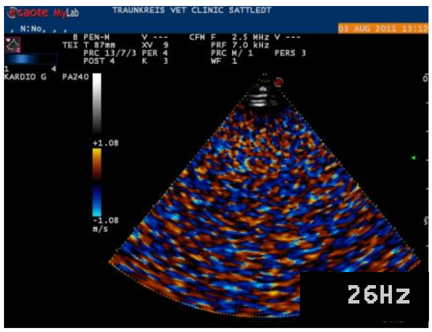


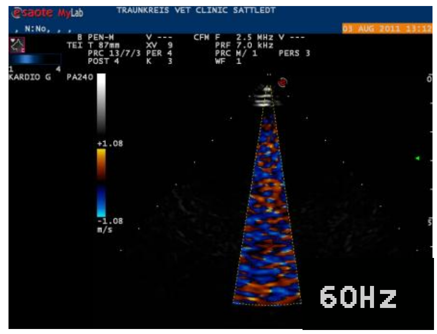


Influence of sector lengh

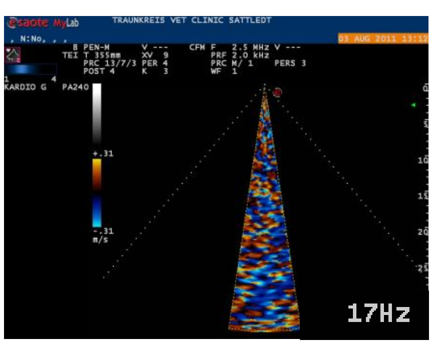


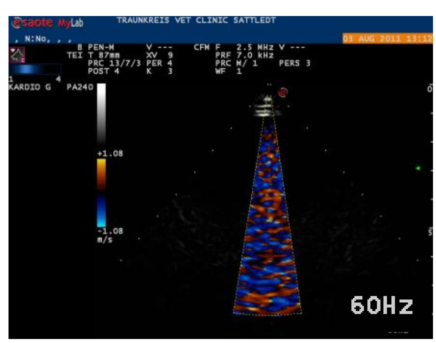
Influence of sector width



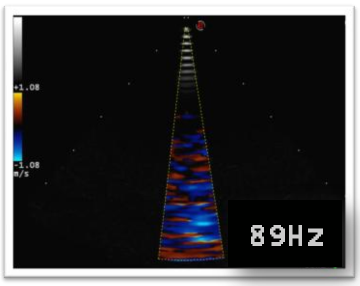


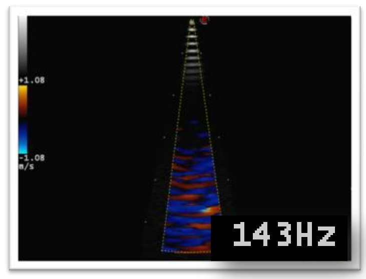
Influence of depth



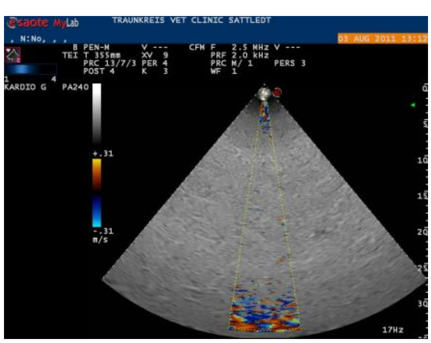


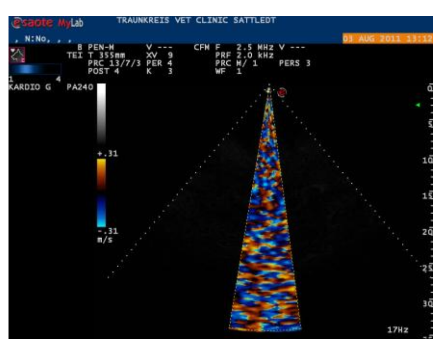
Influence of 2D sector width



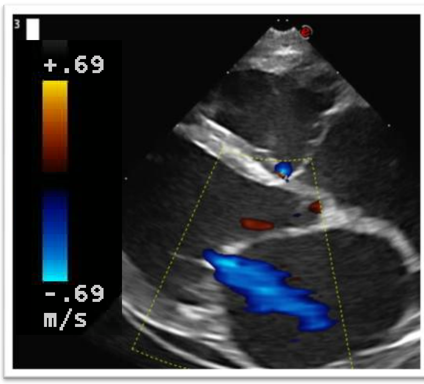


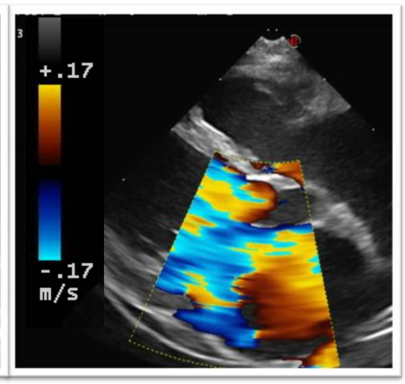
Influence of 2D gain





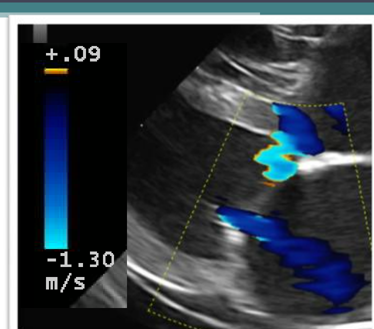
Adjusting CDI (PRF, Gain, o-line)

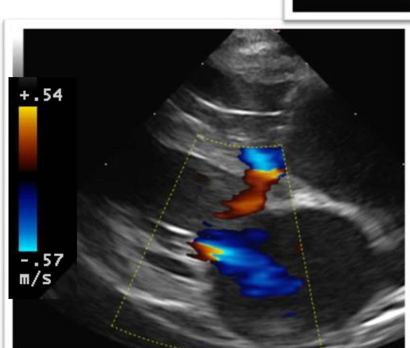


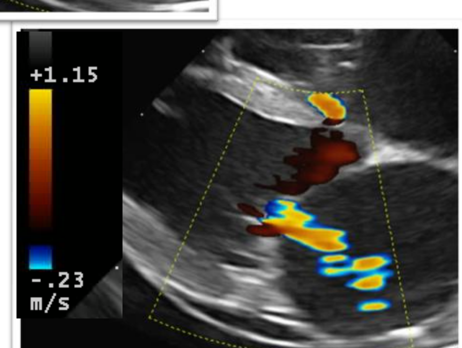


PRF-adjustment: too low -> too much information
too high -> too less information

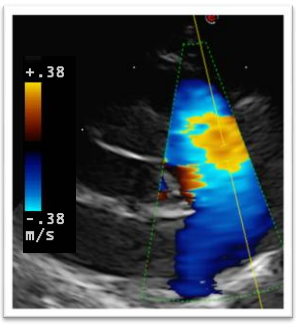
PRF

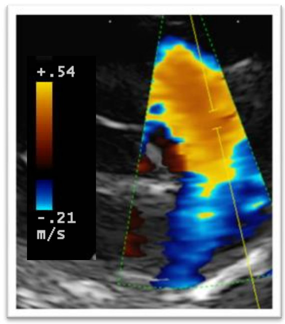


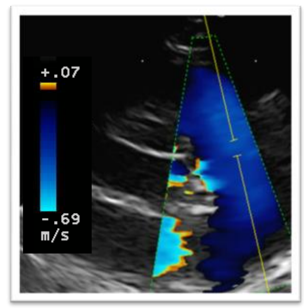




Influencing the Nyquist Limit by adjusting the zero baseline

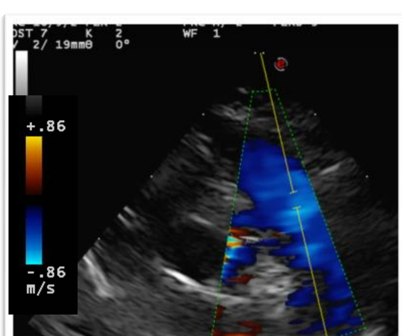


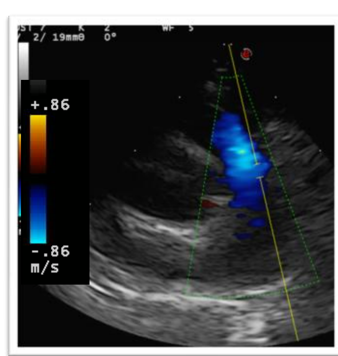




Influence of wall filter

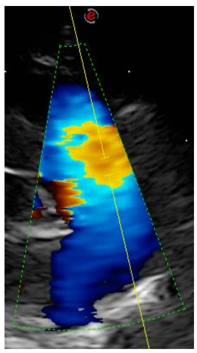
Low frequency signals are rejected

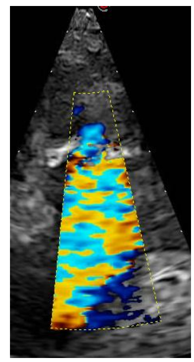




Aliasing vs Turbulence

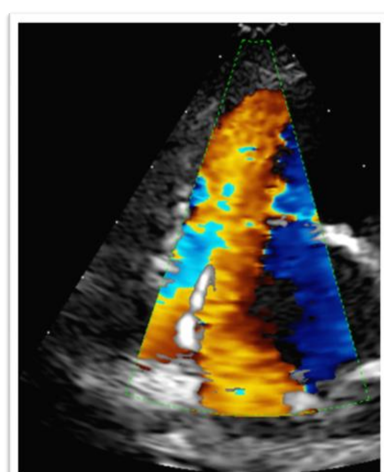
ailasing	Turbulence (without spec. Enhanced mapping)



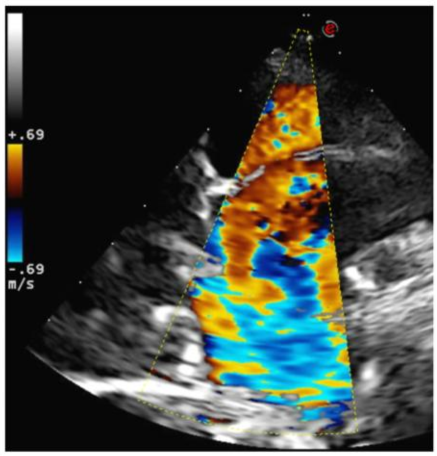


Pitfalls…

- If you´re not really experienced, you need a cine loop!
- Every abnormal flow has to be further interrogated with PW/CW Doppler
- Be aware of artifacts (especially color bleeding)



Color Bleeding

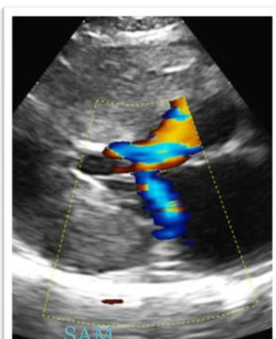


Higher frame rate
Higher 2D gain
Spectral Doppler
Contrast media (bubbles, Sonovue)

Timing

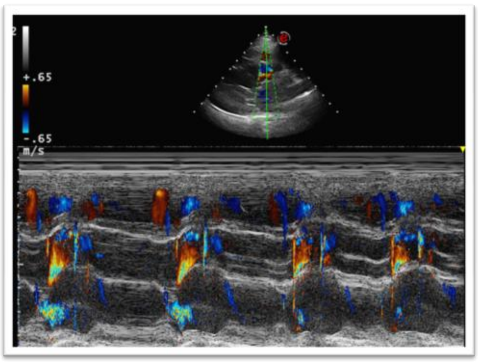
CDI is usually delayed!
Frame rate limits temporal resolution

If unclear use Color M-Mode
Use Spectral Doppler
Combine with findings of PE, rads, 2D
Combine e.g. mitral with aortic flow

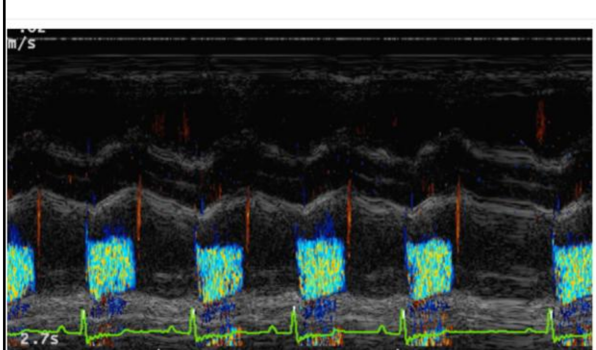


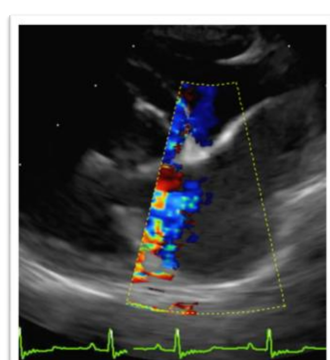
Color M-Mode

- Frame rate ~5000!!!
- Accurate timing in combination with ECG, myocardial or wall motion

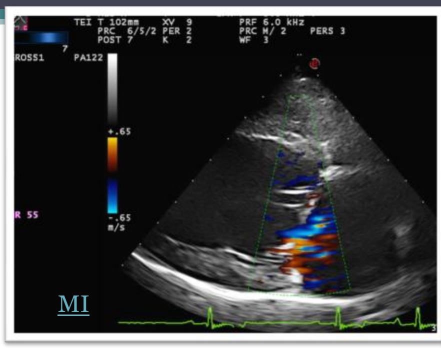


Color M-Mode/Timing



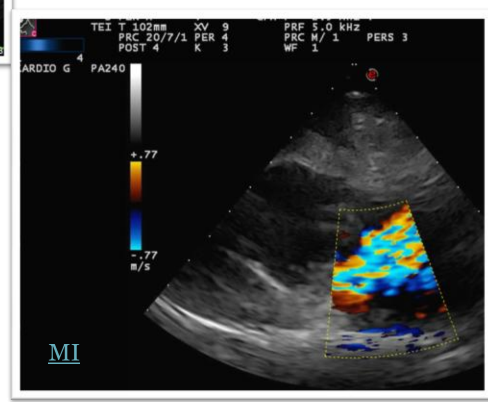


Delay in 2D CDI



What makes the difference?

Too less information

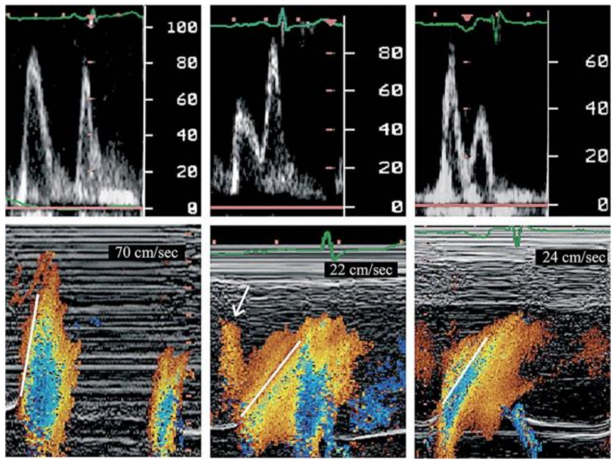


Grayscale
Frequency
Filter
PRF
Frame rate

Why examine mitral valve also from parasternal lax views?

- Massive underestimation of velocity
- Any high velocity/turbulence is abnormal
- Eccentric jets

Functional Information
Flow Propagation (mitral inflow)



De Boeck B W et al. Eur J Heart Fail 2005;7:19-28

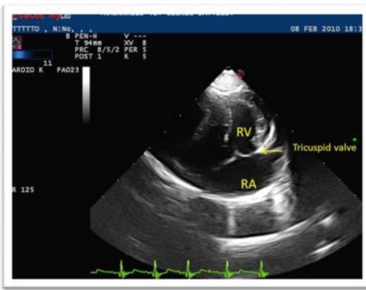
Views for Evaluation of Mitral Valve

CDI

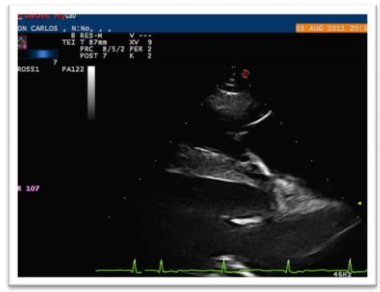
CDI + Spectral

CDI + Spectral

Tricuspid Valve



CDI + Spectral



CDI

Aortic Valve

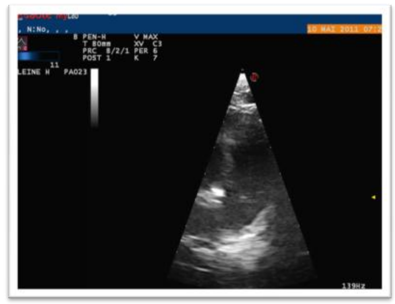
CDI

CW

CDI + Spectral

Pulmonic Valve

CDI + Spectral



CDI + Spectral