Recent Advances in Fetal Cardiology

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Recent Advances

- Diagnosis
  - Three Dimensional Echocardiography
  - Tissue velocity/ Vector velocity imaging
  - Magnetic Resonance Imaging, Others

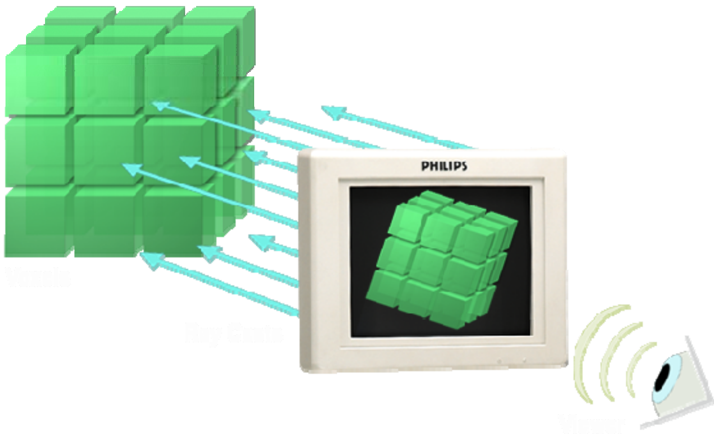
- Interventions
  - For Aortic stenosis and
  - Pulmonary atresia with intact ventricular septum,
  - Obstruction of Interatrial opening

Three Dimensional Echo

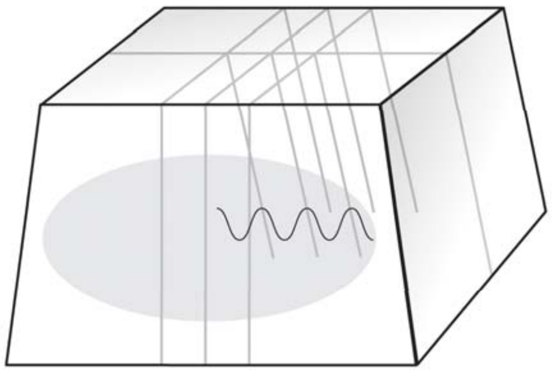
- 3 D: Image, Flow
- Difficulties
  - Small heart
  - Rapid heart beat
  - Not easy gating

* Courtesy of Philips

Two Methods of 3D Image Acquisition

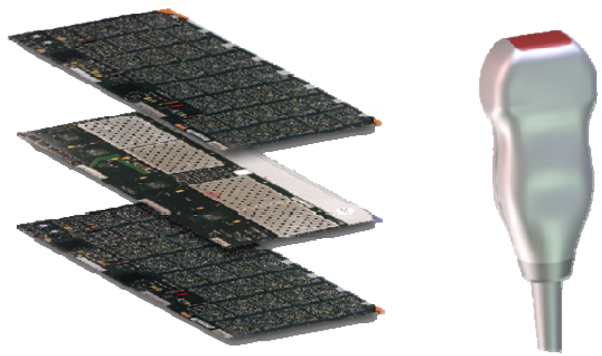


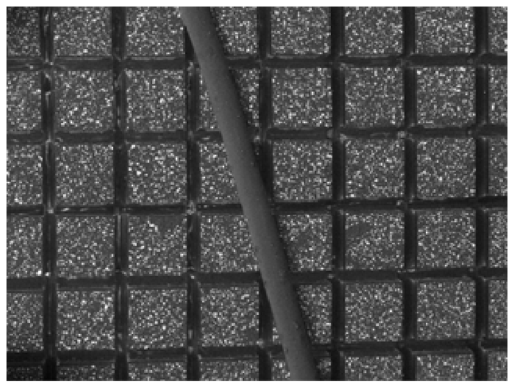
Real time



Reconstruction

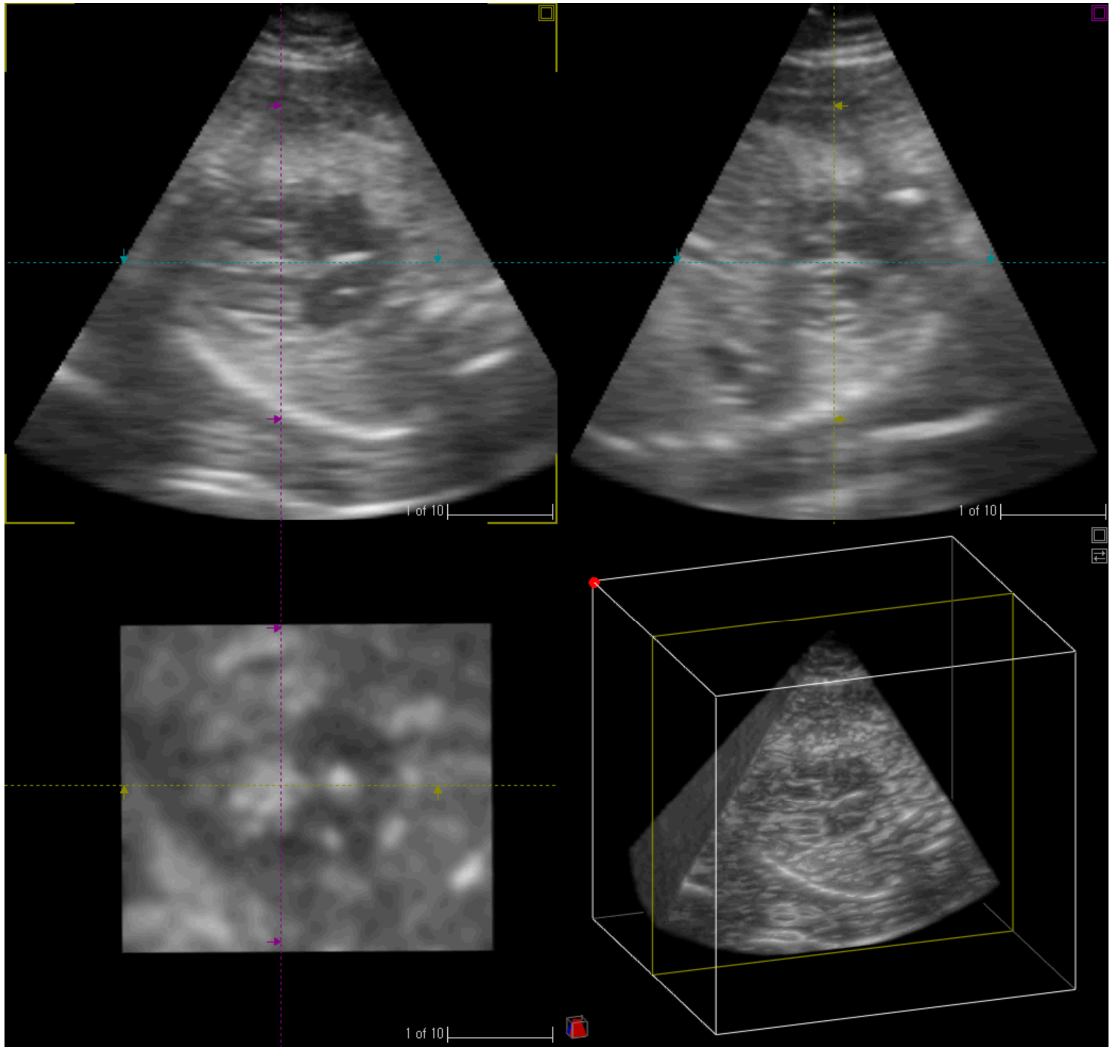
Real time 3 D





- Real time acquisition
  - Special matrix probe
  - Theoretically better
  - Less availability
  - Poor image quality

Real time 3 D

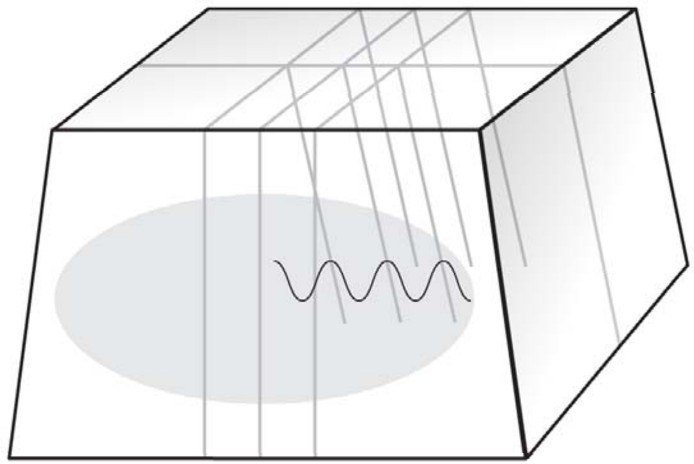


Reconstruction 3D

- Gated versus Non-gated
- Various ways of gating
  - STIC (spatio-temporal image correlation)
  - Predetermined Heart rate
  - Doppler probe
  - Cardiotocography

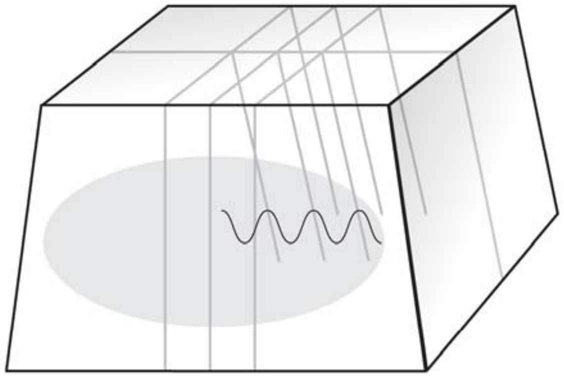
How STIC works

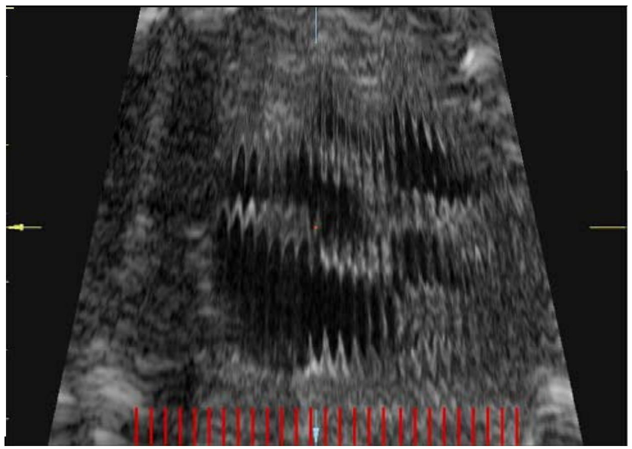
- Acquisition time: 6-15 sec.
  - 300 to 1500 images
  - Artifact reducing algorithms
- Gating algorithms
  - Determines systole and diastole
  - Rearranges frames
  - Presents one complete heart cycle
- Visualization & manipulation
  - Endless cine loop, stop, speed up or slow down
  - Multi-planar view or rendered
- Post processing
  - Evaluated on the Voluson or with 4D View software.

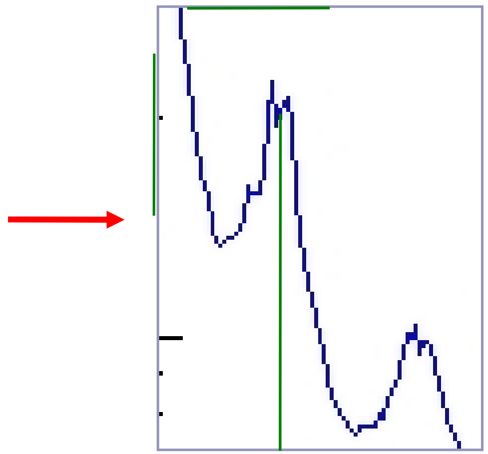


STIC – Postprocessing 1

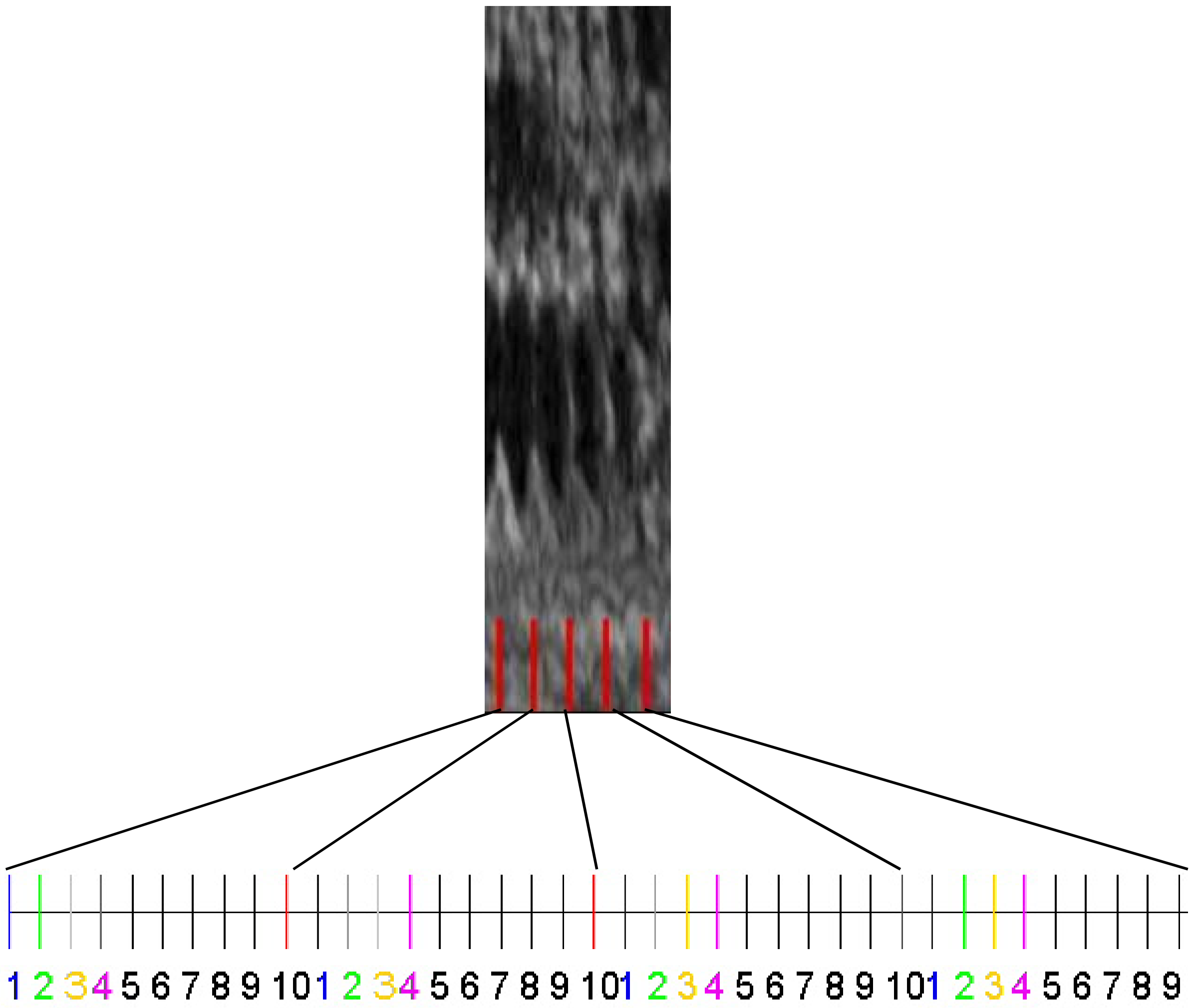
- automatic detection of the fetal heart rate (no external trigger)





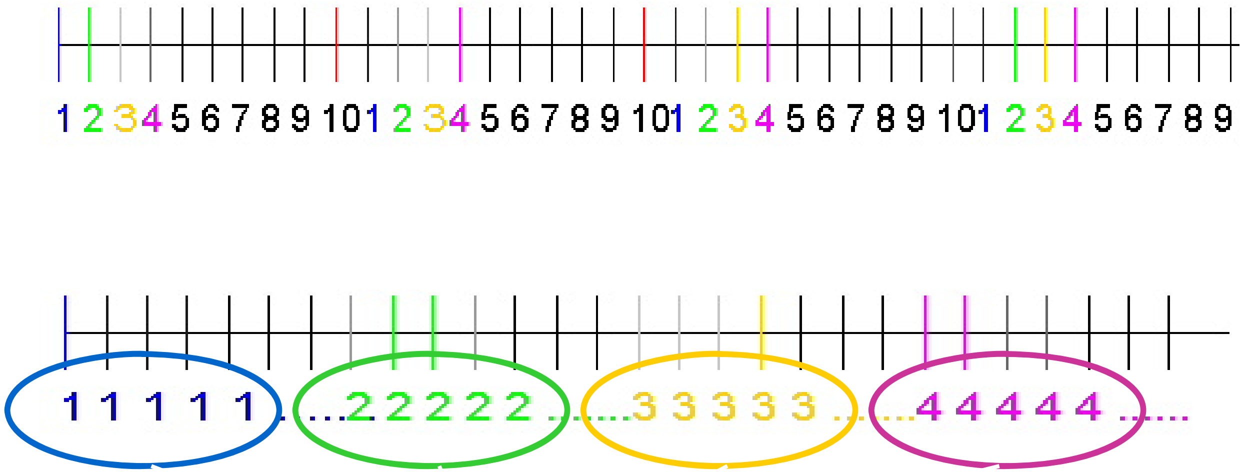


STIC – Postprocessing 2

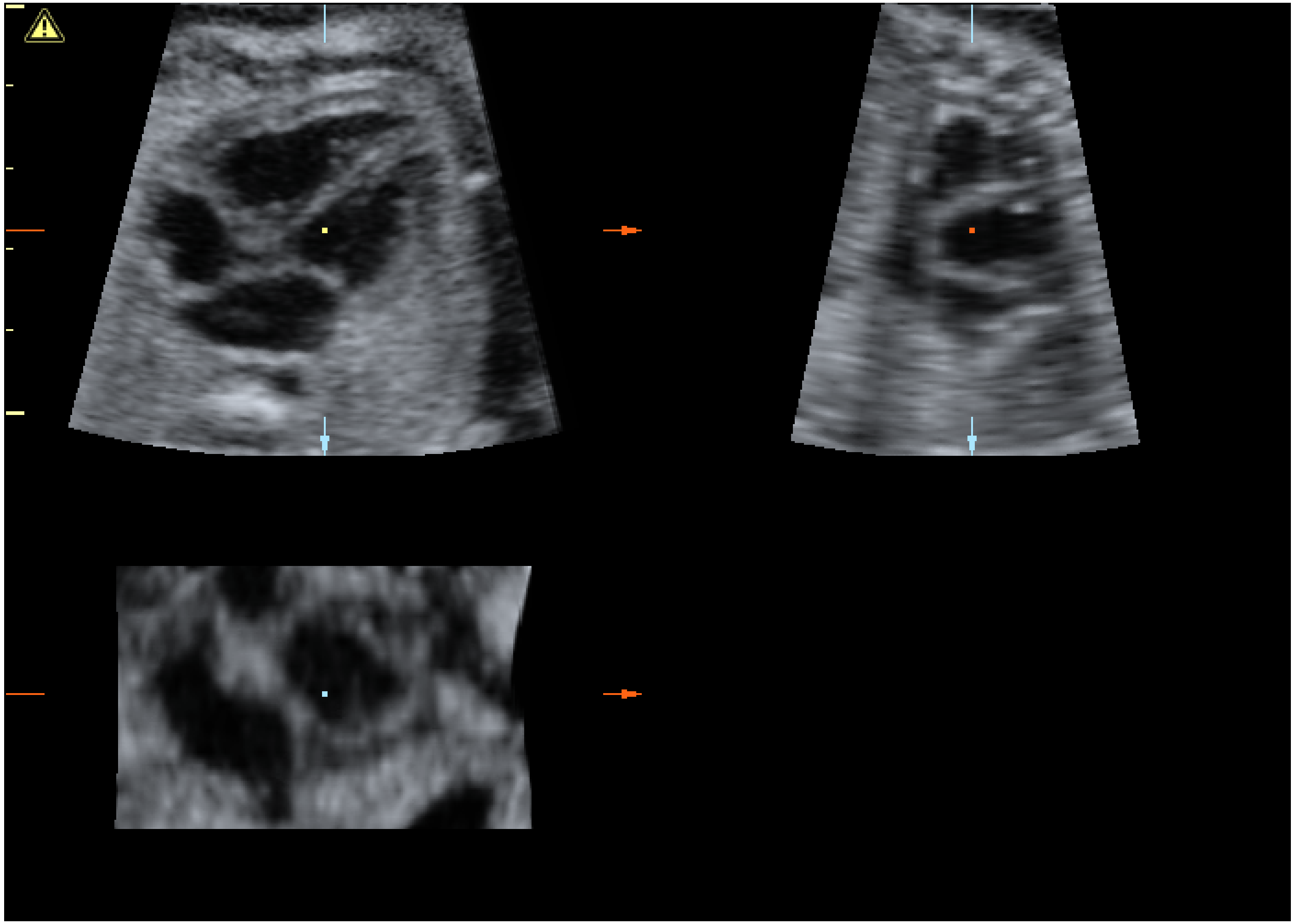


STIC – Postprocessing 3

- rearrangement of acquired images



STIC

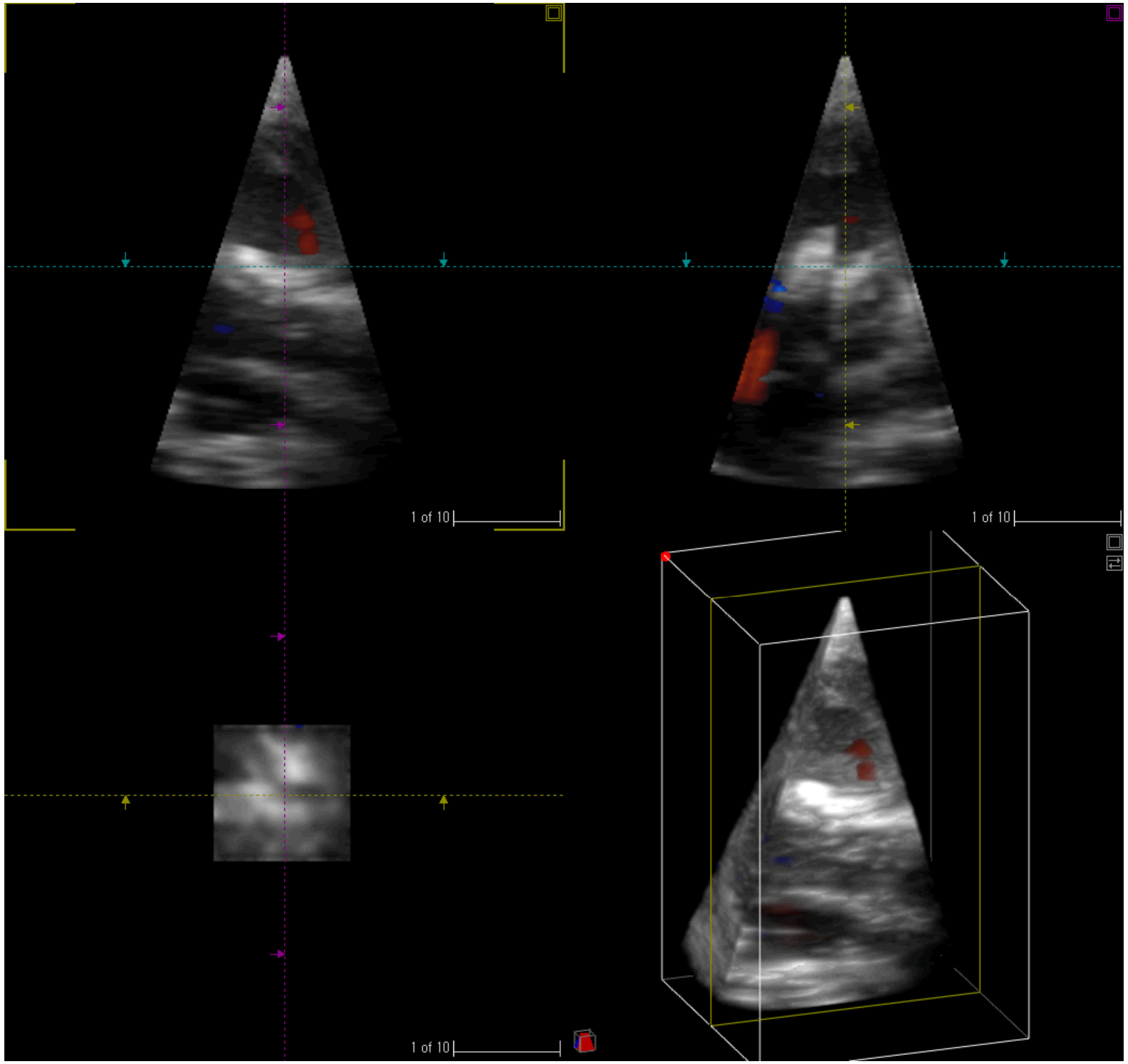


* Courtesy of GE

3D Flow

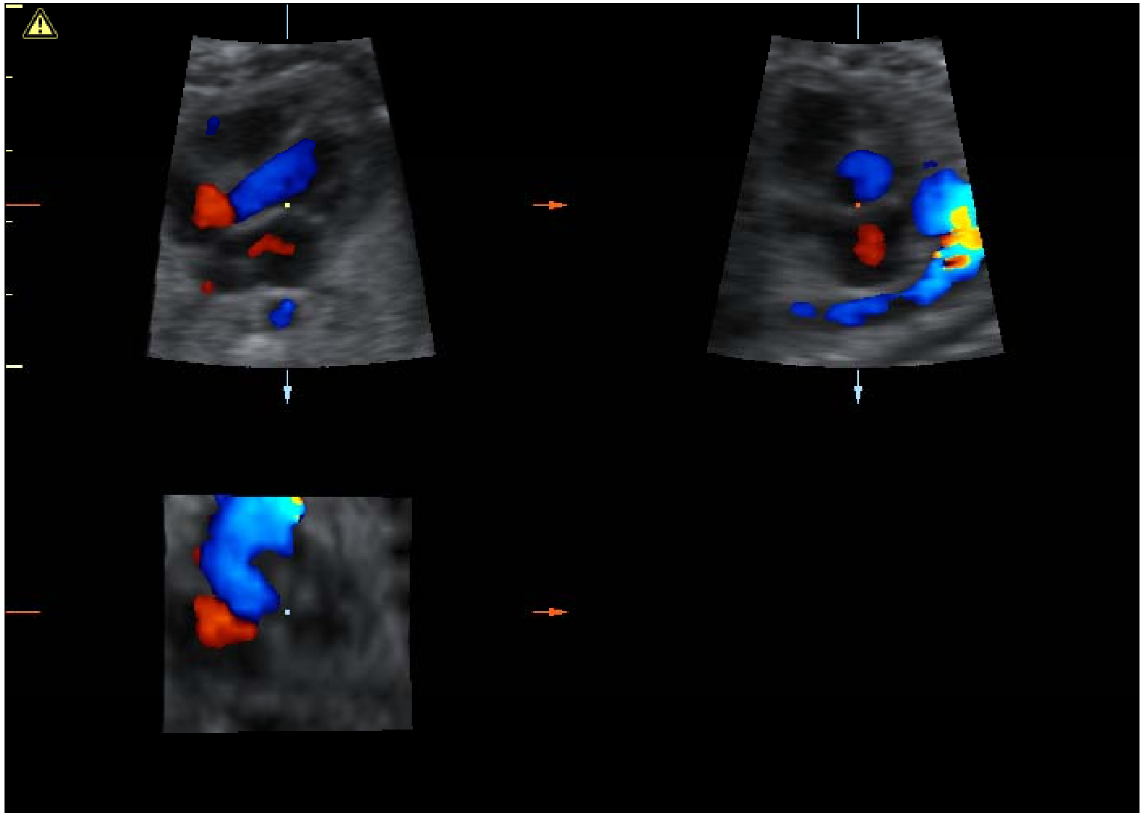
- Real time 3 D flow
- Reconstruction

Real time 3D Flow



3D Flow Reconstruction

- Gated by
  - STIC
  - 2nd Doppler



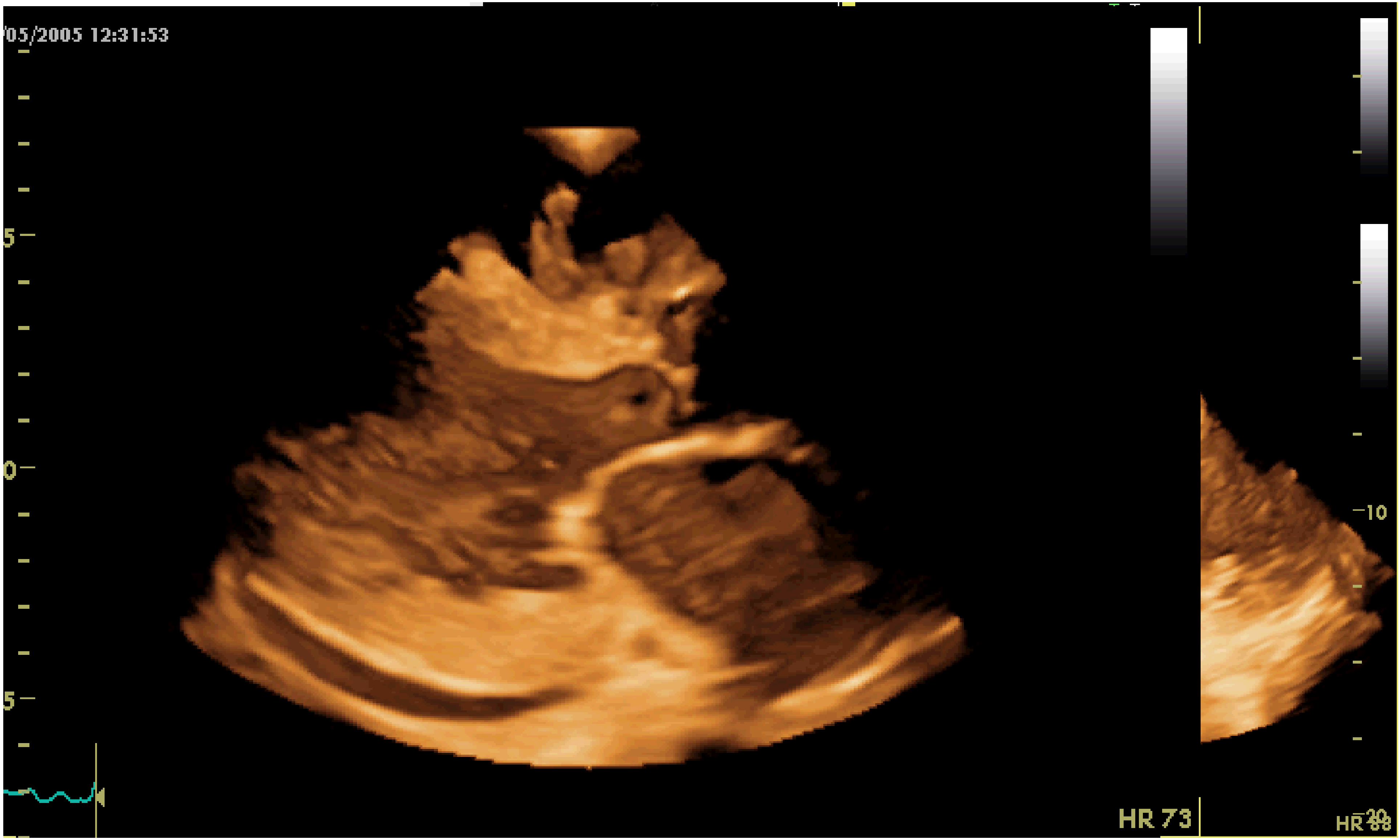
STIC 3 D flow

* Courtesy of GE

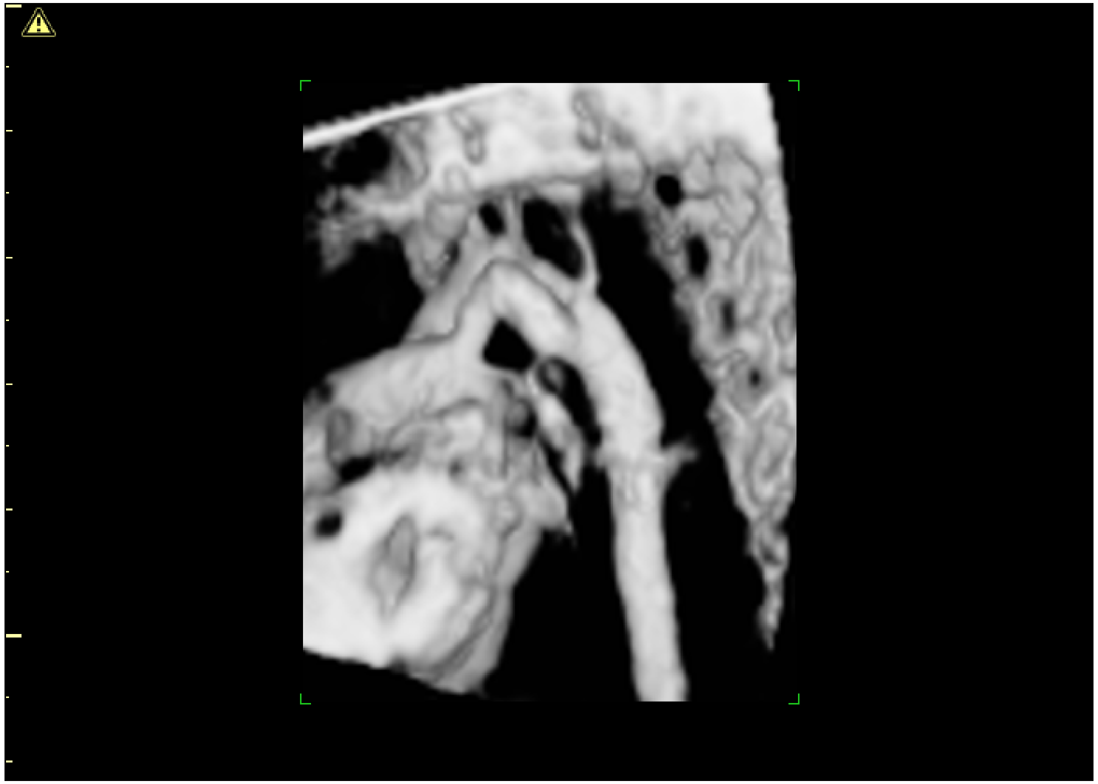
3D Structure, Flow: Implication

- View and Diagnose better
- Ventricular Volume, Function/ Flow
- Telemedicine, Intervention guidance

View and diagnose better



Exponential STIC

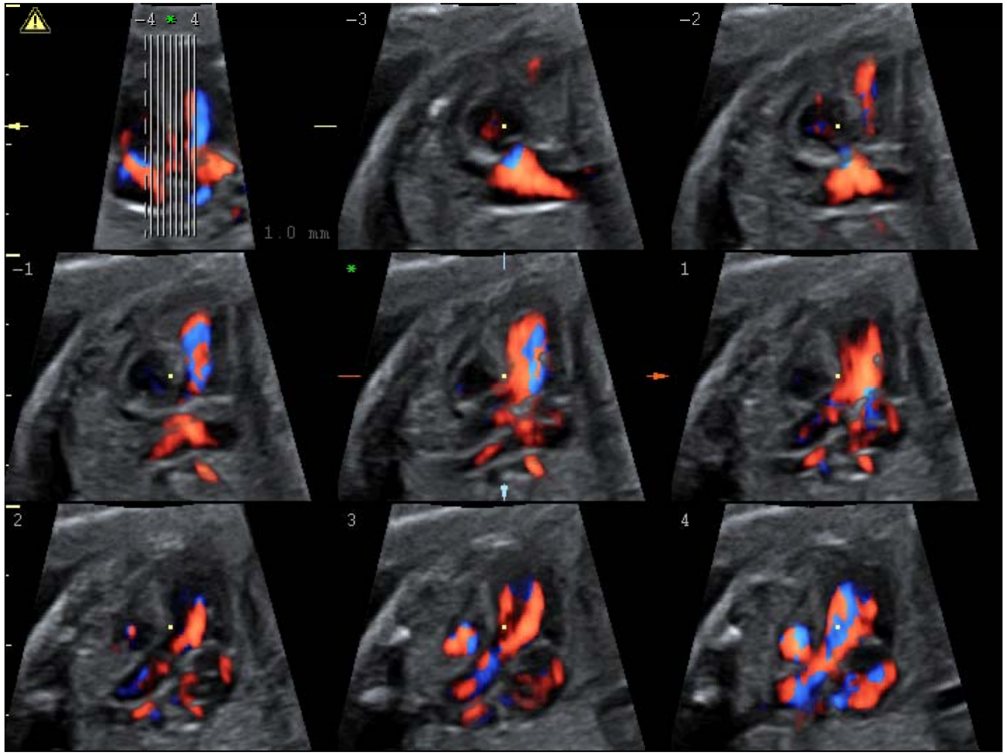


STIC + Inversion Mode

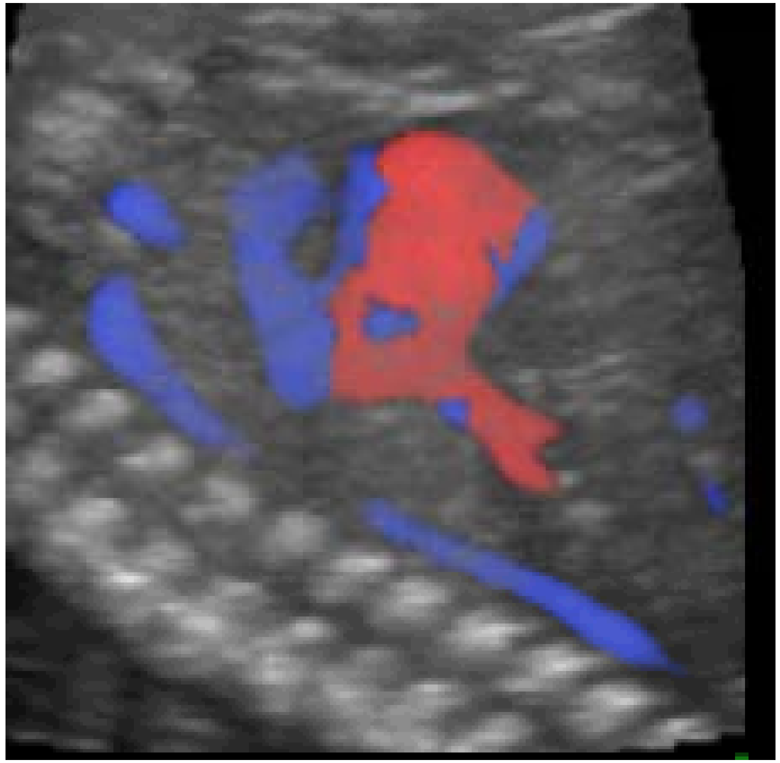
STIC + B-Flow

* Courtesy of GE

Exponential STIC



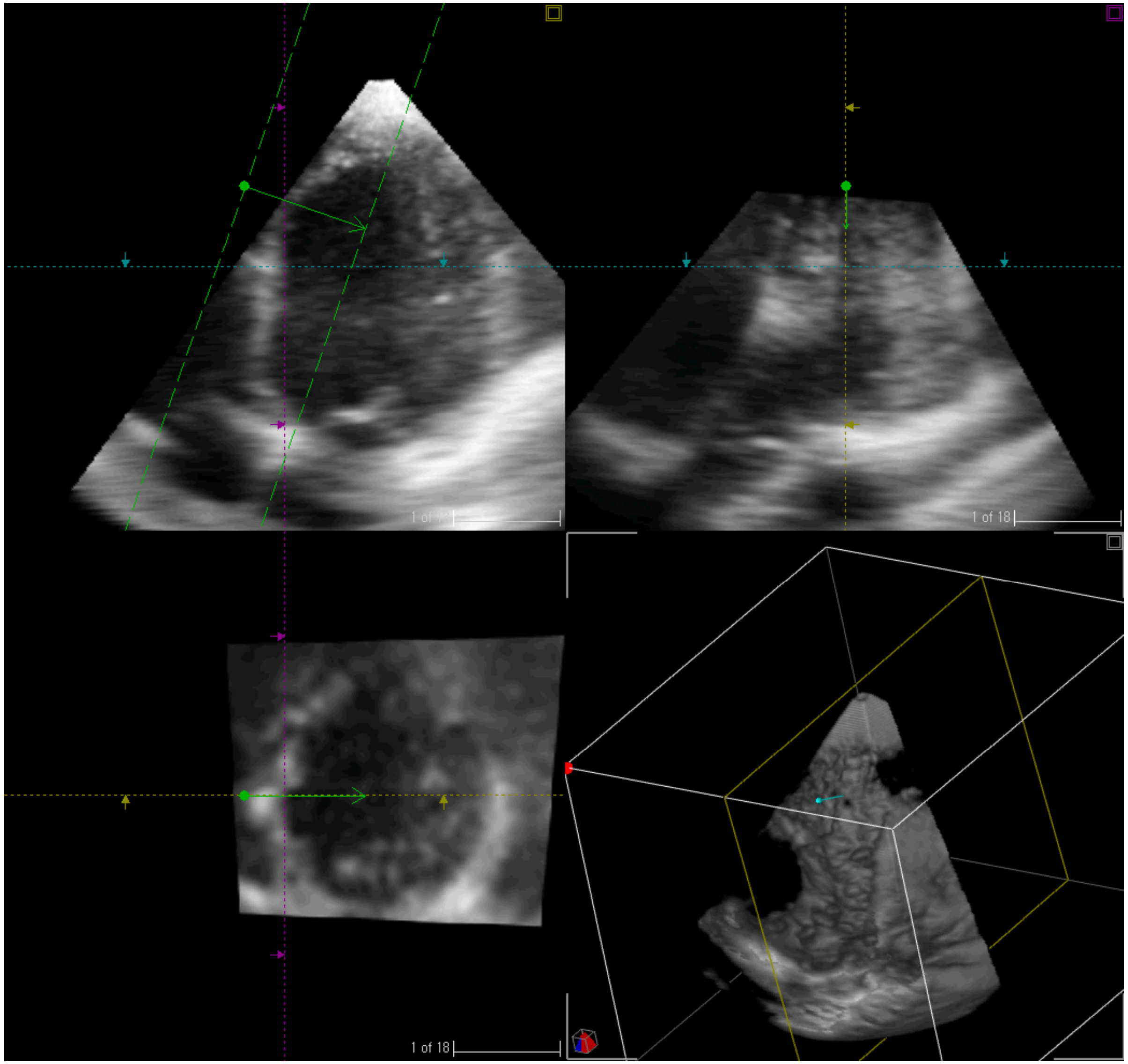
STIC + TUI



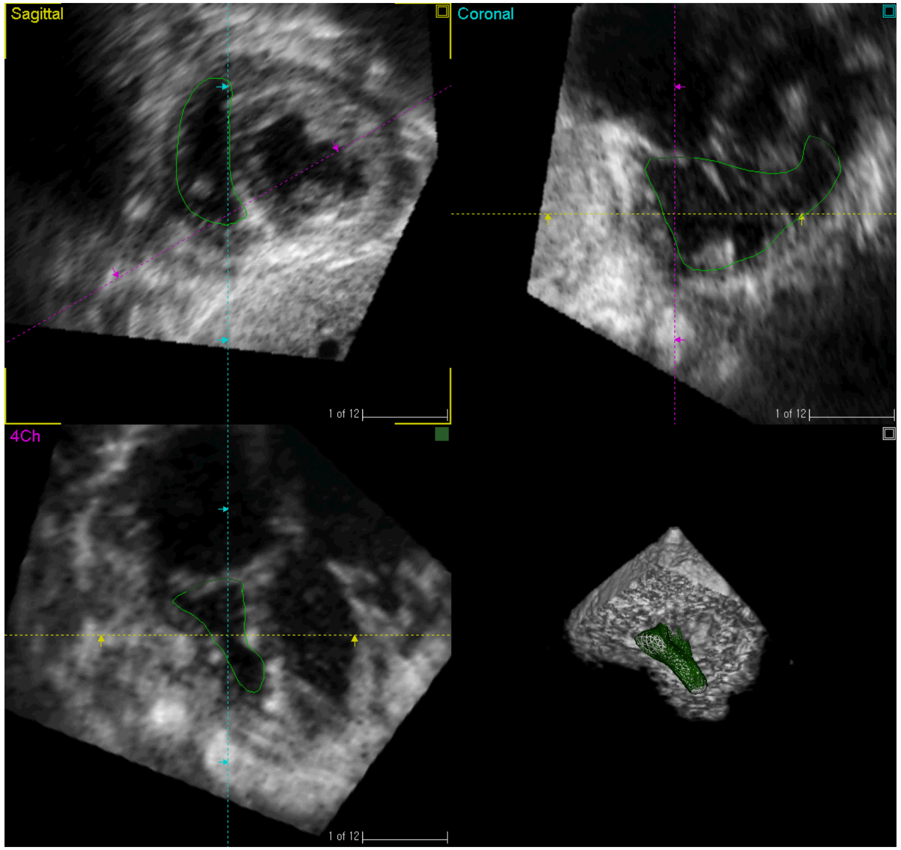
STIC + Glass Body

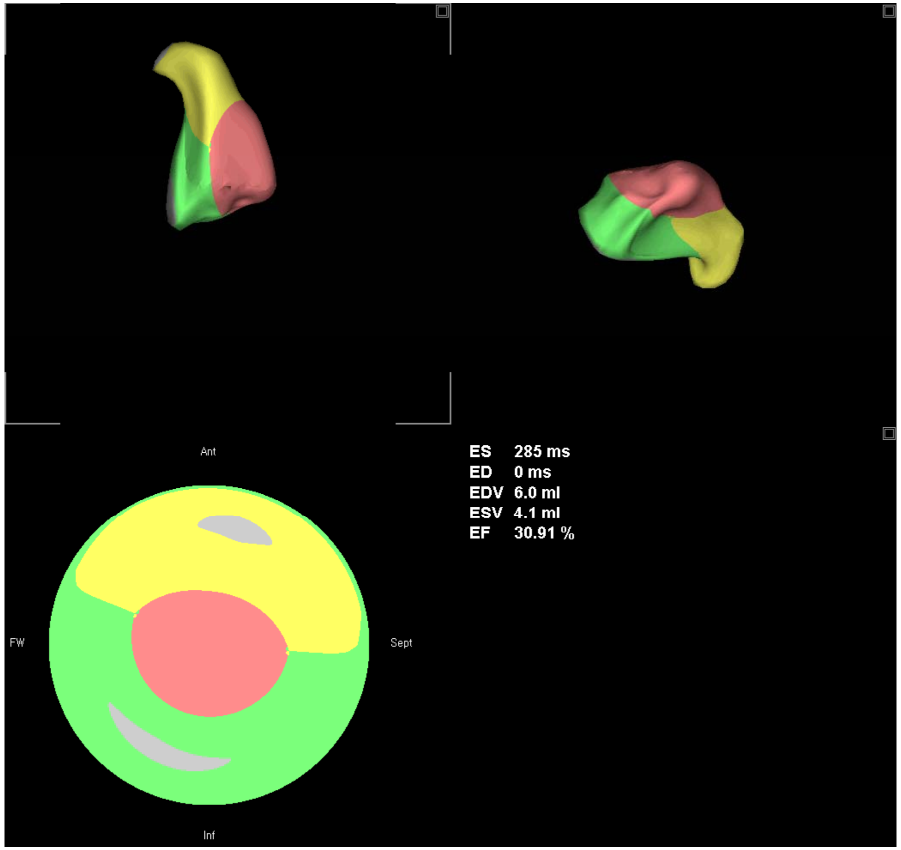
* Courtesy of GE

Image modification



Real time RV volume

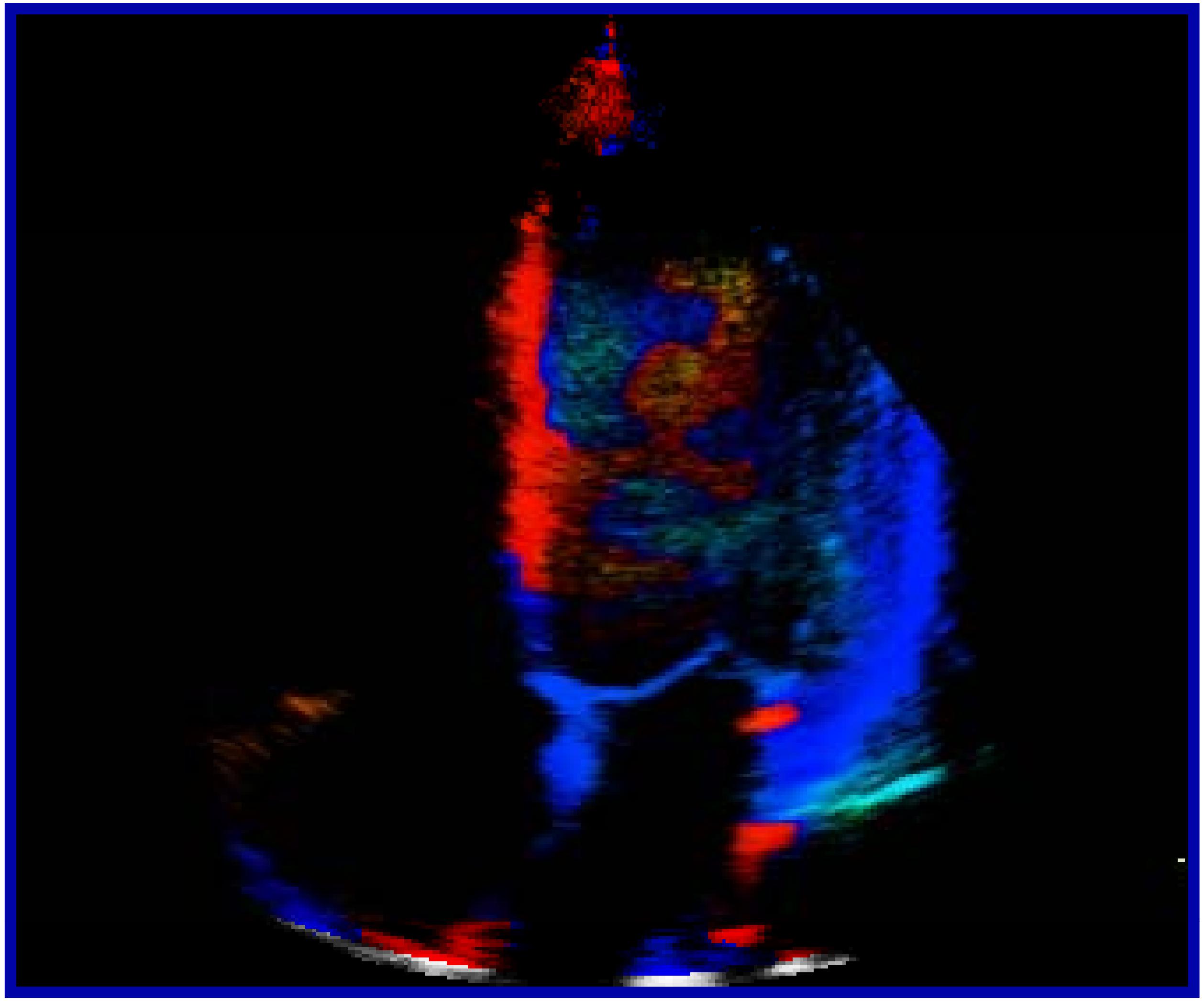




Wall motion quantitation

- Tissue Doppler velocity
- 2D speckle tracing
- Vector velocity imaging

Tissue Doppler velocity



* Courtesy of GE

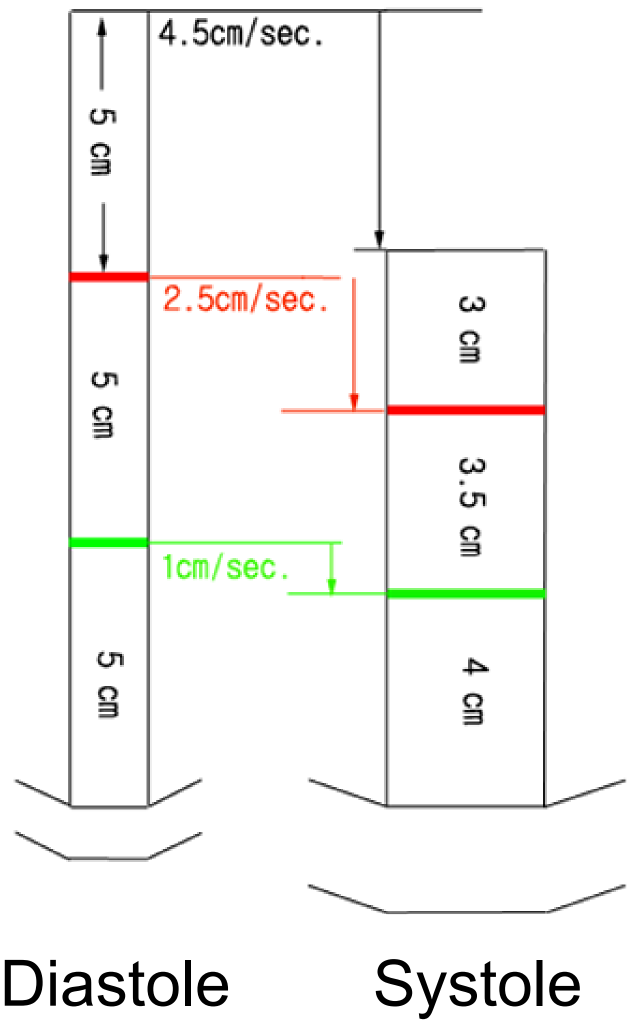
Velocity, Displacement, Strain

Velocity: measured

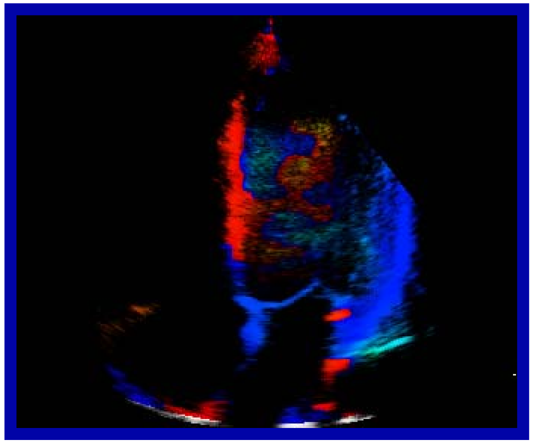
Displacement:

Strain Rate:

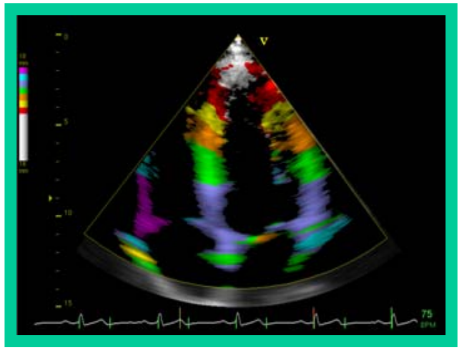
Strain:



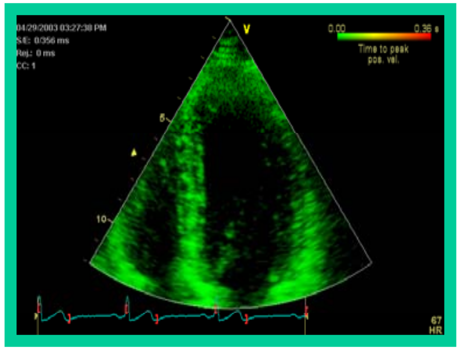
Tissue Doppler velocity



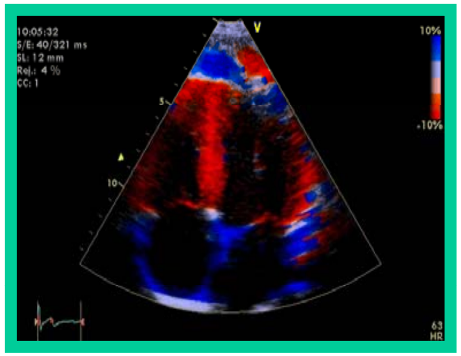
TVI
Tissue Velocity Imaging
Measures Myocardial
Long. Velocity [m/sec]



TTI – Tissue Tracking
Measures Myocardial
Longitudinal
Displacement [mm]



TSI – Tissue Synchronisation Imaging
Measures Timing;
Time-to-Peak Systolic
Velocity [msec]



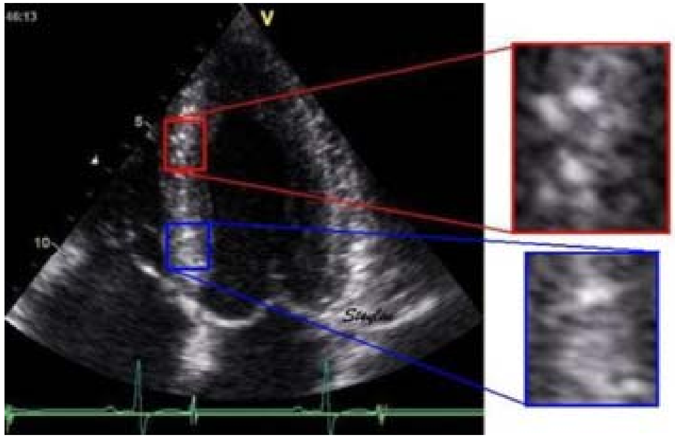
SI – Strain Imaging
Measures Myocardial
Longitudinal
Deformation [%]

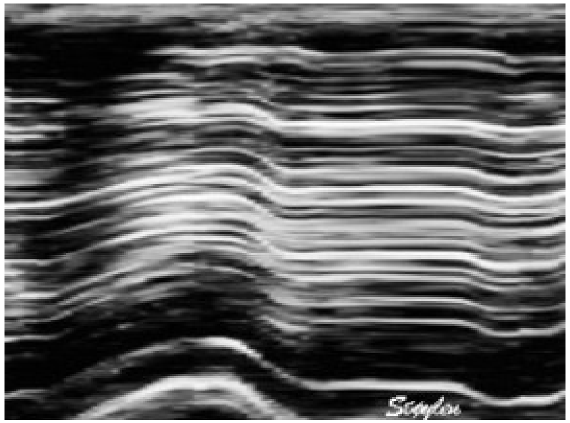
* Courtesy of GE

Tissue Doppler velocity

- Angle dependency
- Not applicable to short axis view
- Difficult to see apex

2D Speckle Tracing





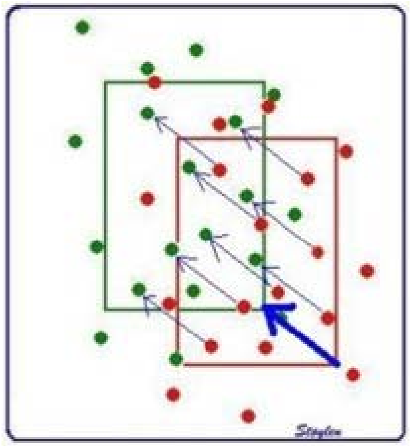
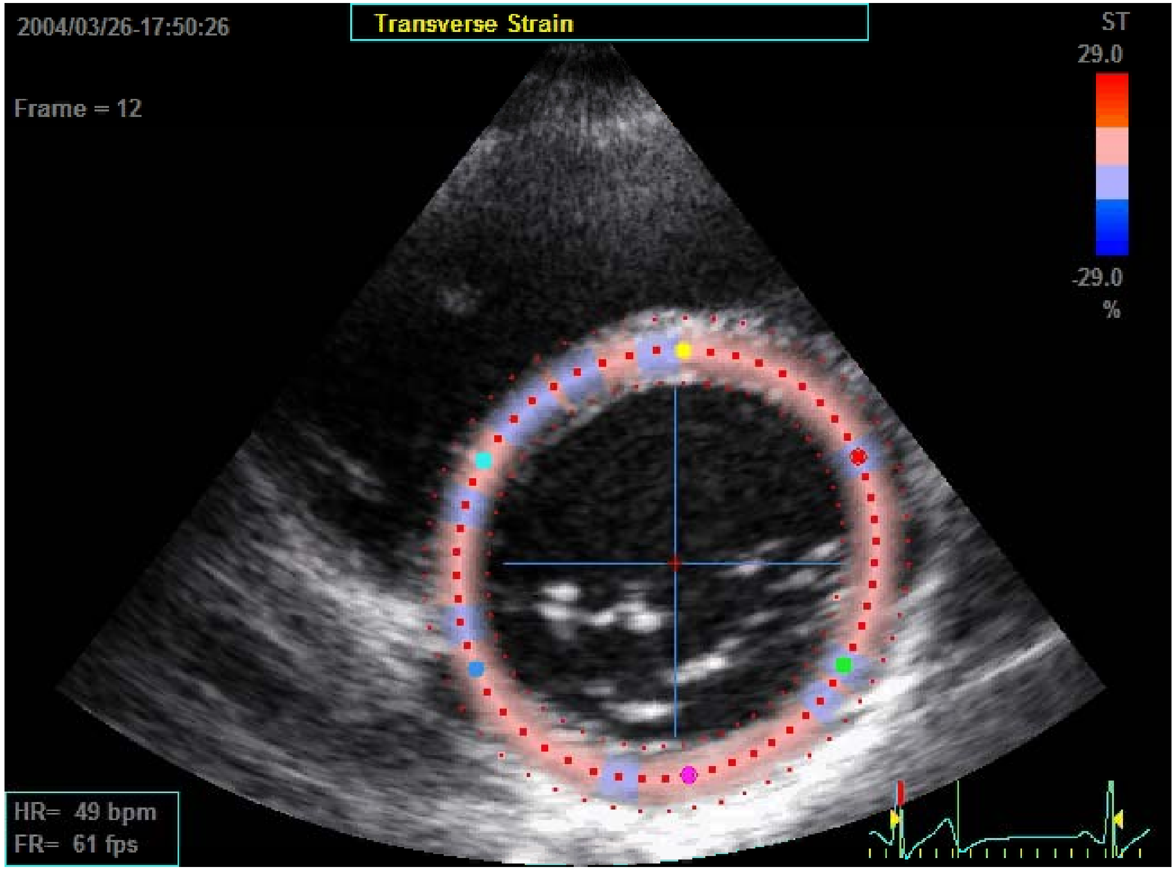


Fig 12 a. Typical speckle pattern in the myocardium. The two enlarged areas show completely different speckle patterns, which is due to the randomness of the interference. This creates an unique pattern for any selected region that can identify this region and hence, the displacement of the region in the next frame.

Fig. 12 b. When the speckle pattern is followed by an M-mode in the wall, the alternating bright and dark points are seen as alternating bright and dark lines. The lines remaining to a large degree unbroken, shows the pattern to be relatively stable, the speckles moving along with the true myocardial motion, and thus myocardial motion can be tracked by the speckles.

Fig 12c. Speckle tracking. Defining a kernel in the myocardium will define a speckle pattern within. The initial frame is shown in red. Within a defined search area (marked in blue), the new position of the kernel in the next frame (green) can be recognised by finding the same speckle pattern in a new position, indicating that each speckle has moved the same distance in the same direction (thin blue arrows), and the movement of the whole kernel then will be the same (thick blue arrow) which can be measured.

2D Speckle Tracing



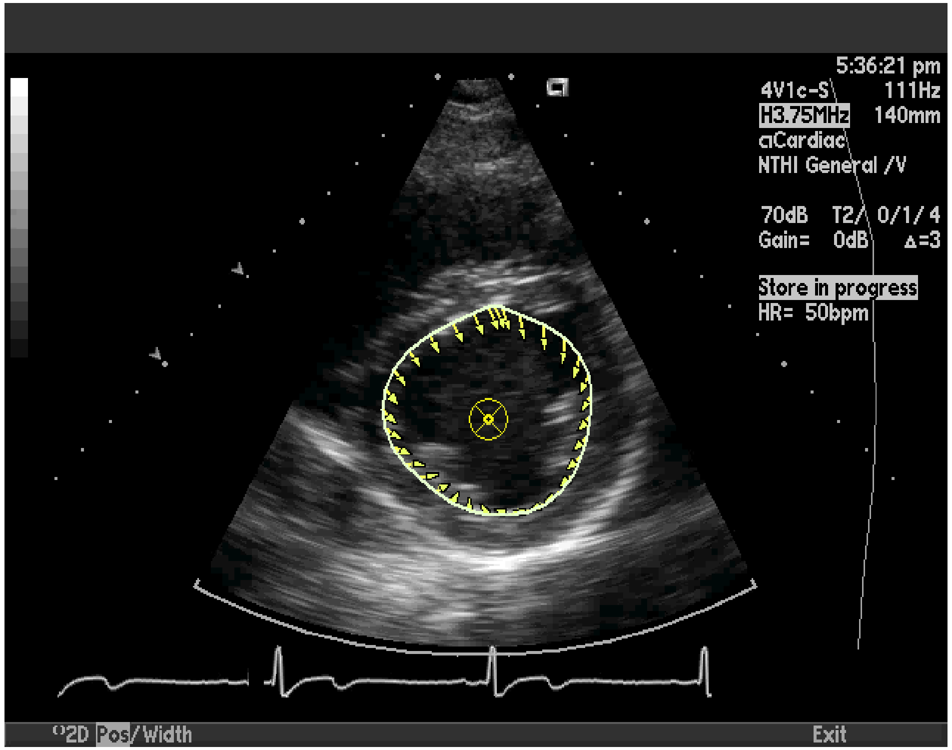
* Courtesy of GE

Tissue Doppler versus Speckle Tracing

	TDI Strain	2D Strain
Source	Tissue Doppler	2D Images
Measure	Velocity along with acoustic beam line	Direct measurements of 2 D movement
Angle dependency	YES	NO
Limitation of scan plane	YES Difficult for APEX, SAX	NO
Index	Velocity Strain Strain Rate TT, TSI	Radial, Circum S. Peak Strain Peak Strain Rate Torsion

Velocity Vector Technology

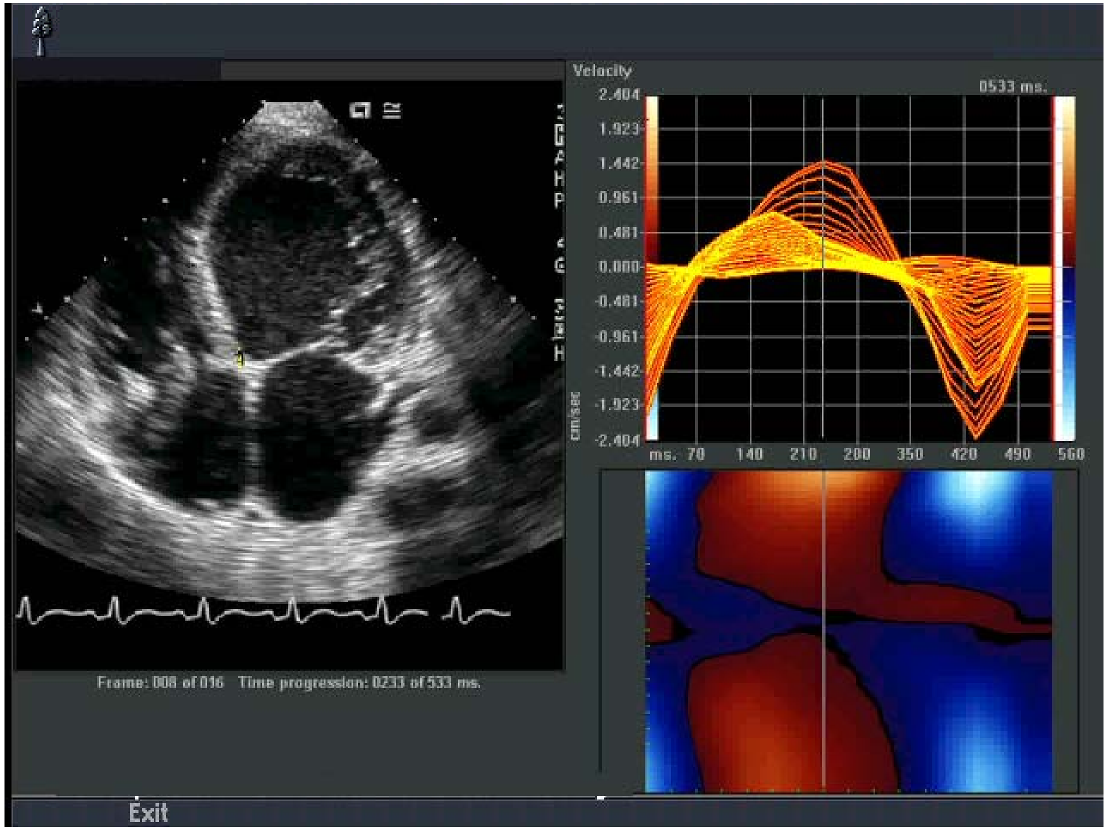
- Uses grayscale images and a sophisticated tracking algorithm to determine the velocity of the myocardium
- The yellow vectors point in the direction the tissue is moving
- The length of the vector indicates how fast the tissue is moving



* Courtesy of Siemens

Velocity Vector Technology

Axius VVI is a dynamic method to visualize, measure, and display myocardial motion and mechanics

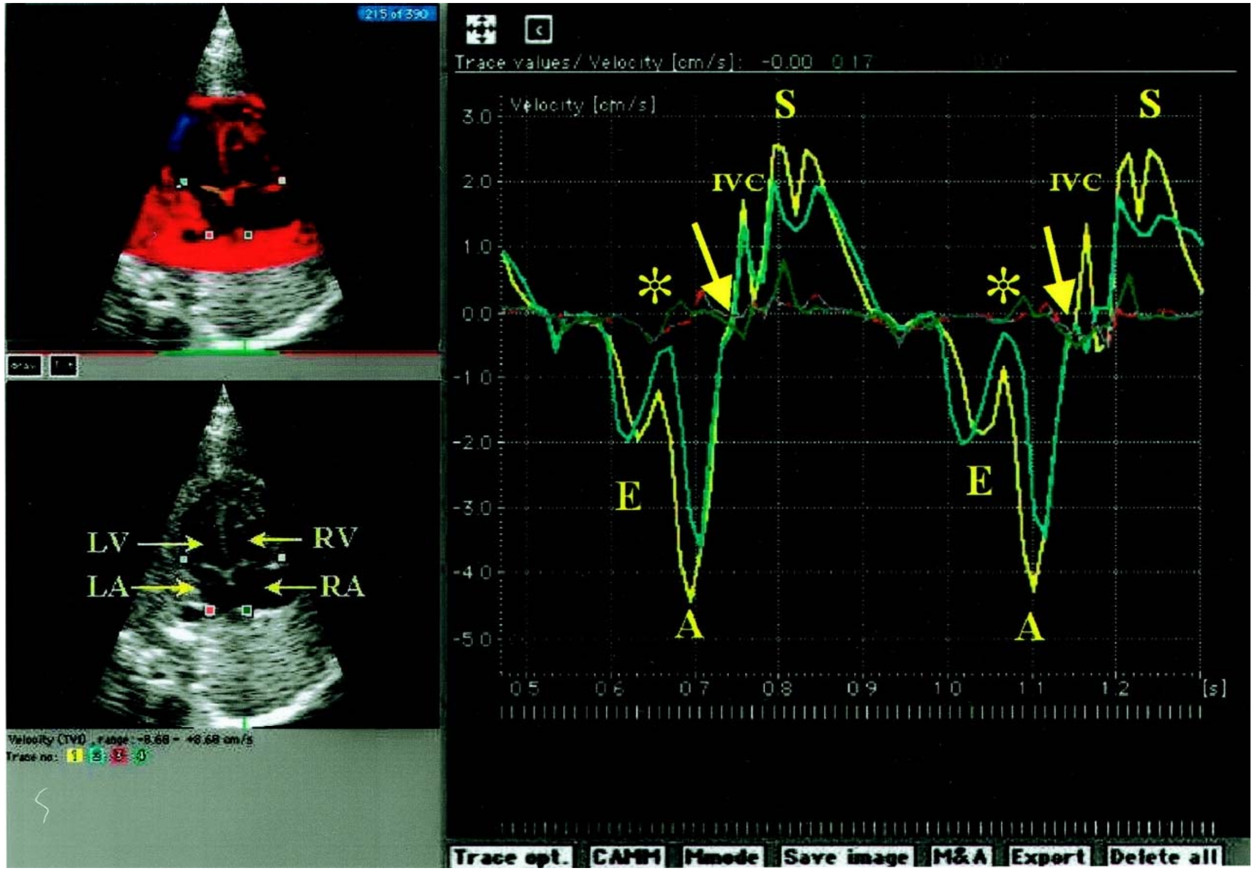


* Courtesy of Siemens

Wall motion: Implication

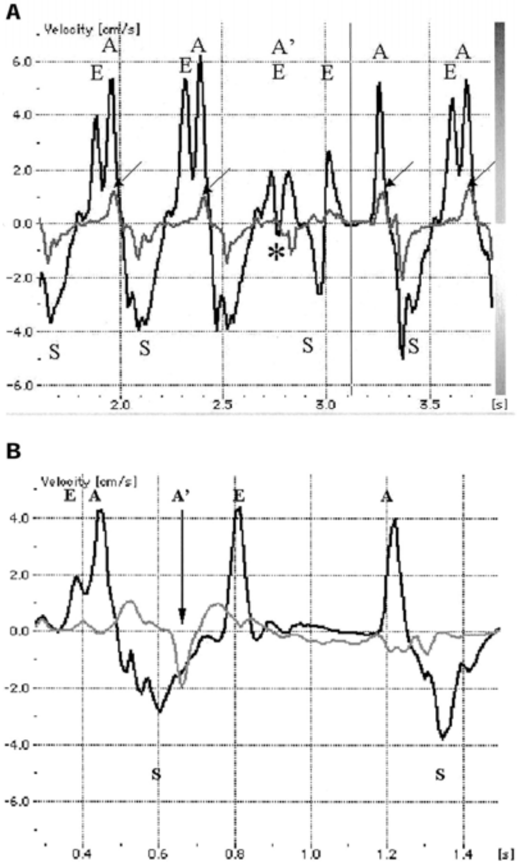
- Myocardial mechanics
- Arrhythmia diagnosis

Arrhythmia diagnosis



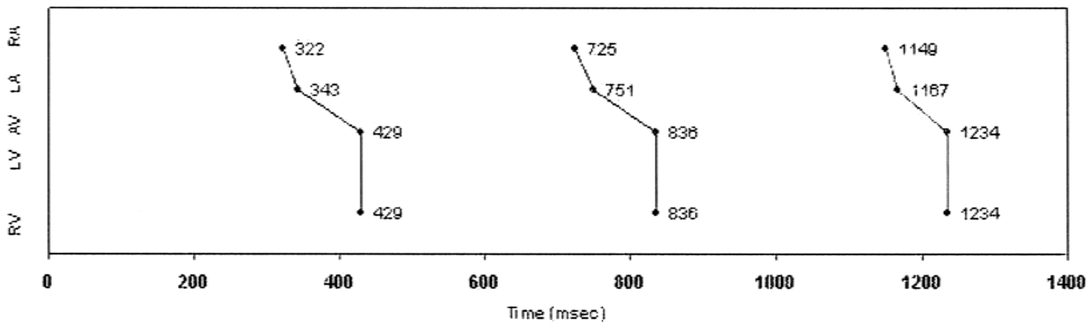
Circulation, 2002:106:1827-1833

Arrhythmia diagnosis



Name		ROI	Cycle1	Cycle2	Cycle3	Cycle4	Cycle5	Cycle6	Cycle7	Cycle8	Cycle9
#		RA	322	725	1149						
Date		LA	343	751	1167						
Study		AV	386	794	1201						
Dx	Normal	LV	429	836	1234						
Comments		RV	429	836	1234						

	Mean	Cycle1	Cycle2	Cycle3
PP interval (msec)	414	403	424	
RR Interval (msec)	403	407	398	
Atrial rate min⁻¹	145			
HR (ventricular) min⁻¹	149			
AVr (in NSR) (msec)	98	107	111	85
AVl (in NSR) (msec)	76	86	85	67



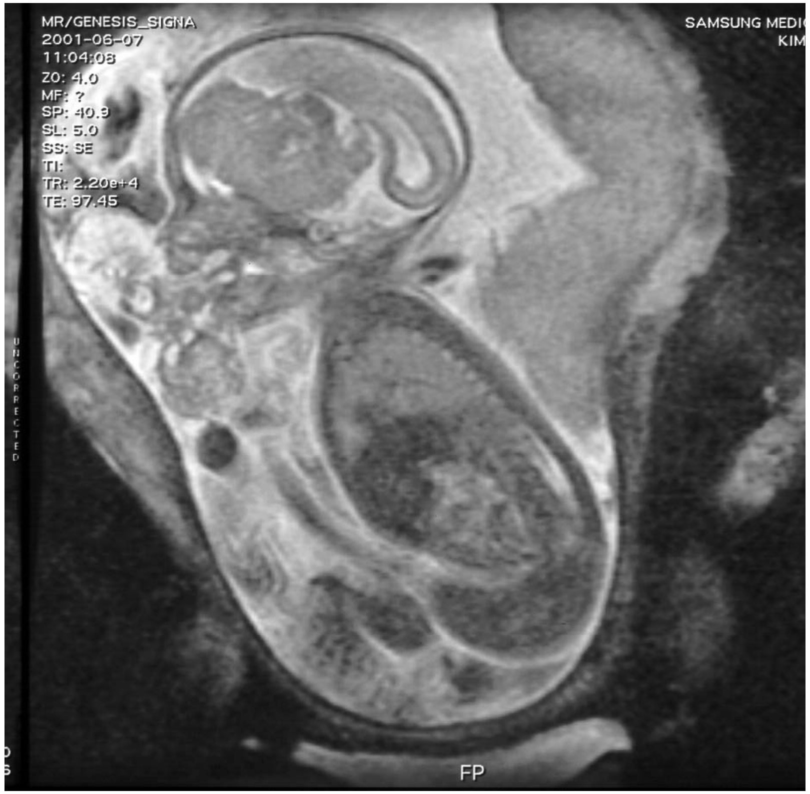
Circulation, 2002:106:1827-1833

Future Technology

- Ultrasound catheter for amniotic cavity
- Fetal transesophageal echocardiogram
- Very high frequency transducer for embryo
- Multimodal, multifunctional catheter

Some Other Things

- Magnetic Resonance Imaging (MRI)
- Magnetocardiography

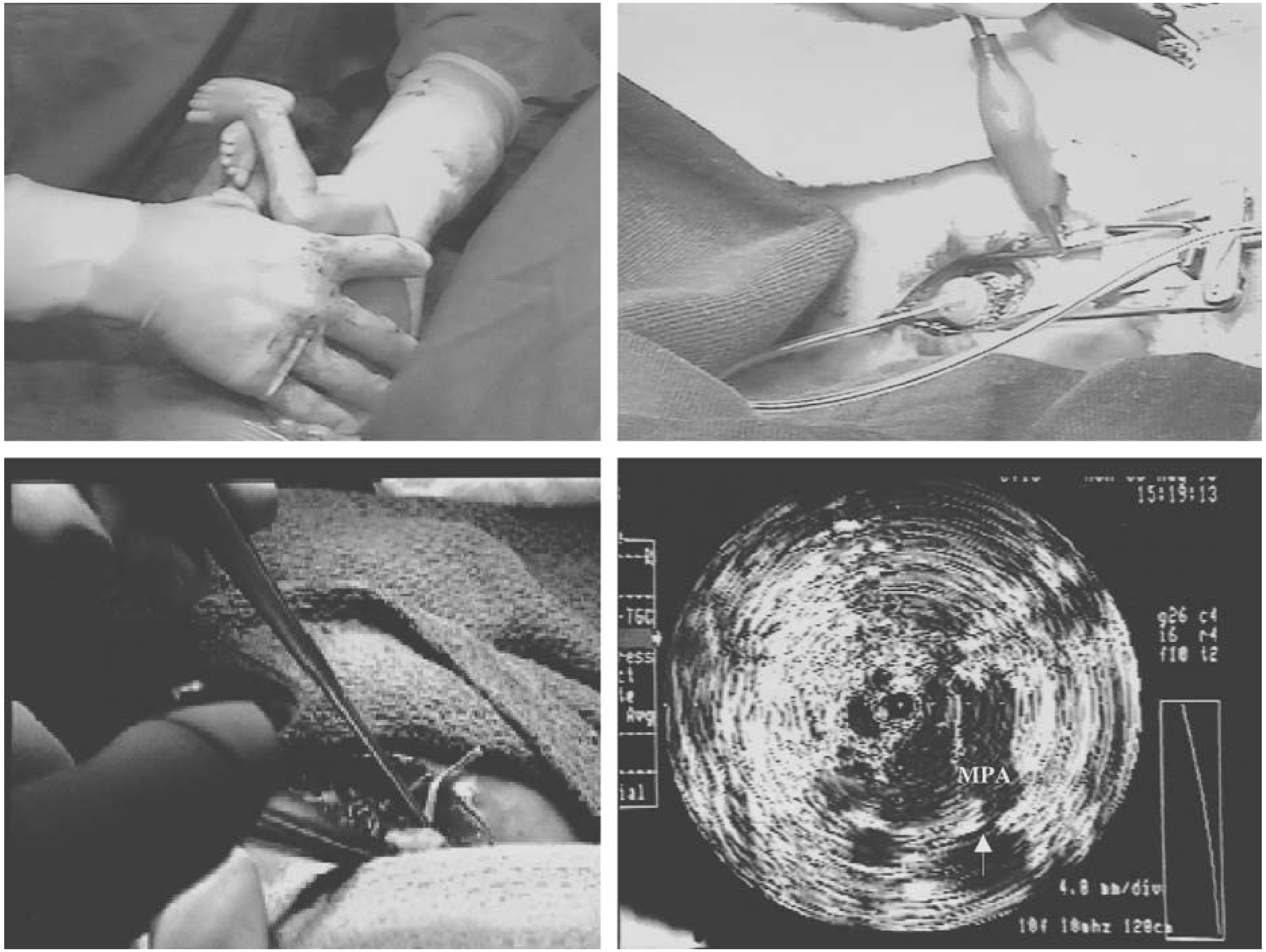


* courtesy of Dr Lee

Fetal Intervention

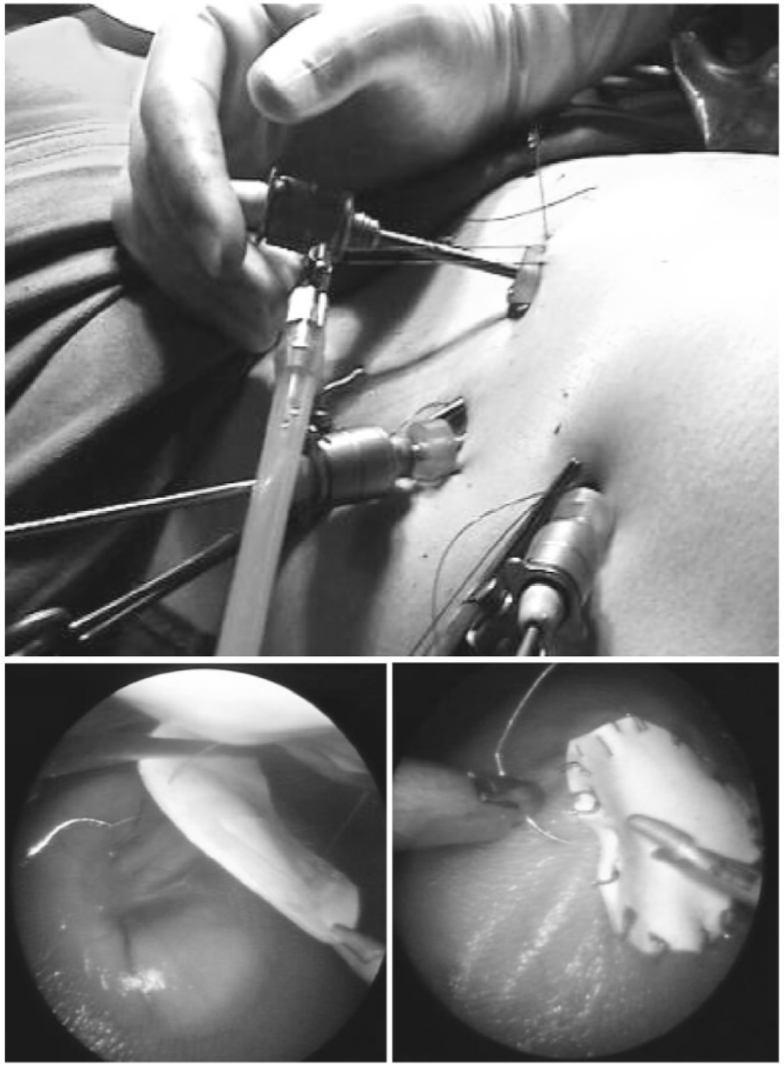
- Open Fetal surgery
- Fetoscopic surgery
- Catheter intervention

Open Fetal surgery



* Adopted from Current Opinion in Anaesthesiology

Fetoscopic surgery



* Adopted from Pediatric Cardiology

Cardiac Intervention: necessary?

- To prevent in-utero progression to single ventricle
- To prevent vascular damage to pulmonary artery and vein
- To prevent fetal hydrops or loss

Cardiac intervention

- Ultrasound, Fetoscope guidance
  - Balloon catheter: AS, PS or atresia
  - Laser or HIFU: restrictive PFO
  - Electric catheter: arrhythmia Dx and Tx

Balloon aortic valvuloplasty

- In 1991, Lindsay Allan group, first performed fetal BAV
- To prevent progression to HLHS
- Benefit not proven

* Adopted from Pediatric Cardiology

Other Interventions

- Pulmonary Atresia with IVS
  - To prevent HRHS
  - Needle or Laser followed by BVP

- Restrictive foramen ovale
  - HLHS with intact atrial septum
  - Restrictive foramen ovale → HLHS
  - TGA with intact atrial septum

Results of Intervention

- Technically feasible, but should do it ?

- Risks and benefits: not proven
- Which cases are benefited ?
- Which cases are (not) indicated ?

- Many things need to be done

Summary

- Fetal cardiology is at very early stage
- For diagnosis,
  - Echo has been an invaluable tool
  - Other imaging modalities will be used
- For treatment,
  - Limited diseases and methods
  - Will change very rapidly in many ways

Thank You For Your Attention