

# What's new in Fetal Cardiology?



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**National Maternity Hospital, Dublin**



# National Maternity Hospital

- Deliveries annually 9200
- Tertiary level university maternity unit
- 5 x Maternal and Fetal Medicine specialists

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- Deliveries annually 9200
- Tertiary level university maternity unit
- 5 x Maternal and Fetal Medicine specialists
- RCOG Sub-specialisation programme
- National centre for fetal transfusion / laser ablation / fetal therapy
- Fetal cardiac centre



# Fetal Cardiology

- Indications for fetal echocardiography
- 3D
- Fetal cardiac interventions
- First trimester fetal echocardiography
- Cardiac function

# Congenital cardiac defects – why does it matter?



Commonest congenital defect

- 8/1000 babies born in UK with congenital heart disease (Hoffman 1985)
- Congenital heart disease accounts for 40% of perinatal deaths due to congenital defects (Abu-Harb 1994)

# Congenital cardiac defects – why does it matter?

Cardiac defects benefit from prenatal diagnosis

- Neonatal outcome better if cardiac defect known prior to delivery (Crawford 1988, Bonnet 1999, Jaeggi 2001)

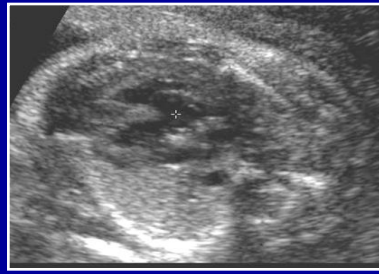
# Congenital cardiac defects – why does it matter?

Cardiac defects benefit from prenatal diagnosis

- Neonatal outcome better if cardiac defect known prior to delivery (Crawford 1988, Bonnet 1999, Jaeggi 2001)
- Appropriate multidisciplinary care
- Association with chromosomal defects
- Pregnancy intervention
- Psychological adjustment for parents

# Congenital cardiac defects – who should be screened?

- Traditional approach – offer detailed echo to ‘high risk’ populations (FmHx, IDDM Mums)
- 95% cases of congenital cardiac defects occur in low risk women



# Congenital cardiac defects – who should be screened?

- 4 chamber view is abnormal in 60% of major cardiac defects (Allan 1992)
- Eurofetus study: detection at general prenatal screening at 18-20 weeks of CHD 39% (Grandjean 1999)
- NMH routine T2 scan (15 mins) – 38% detection of cardiac defects (Lawlor et al 2005)

# Congenital cardiac defects – when should we screen?

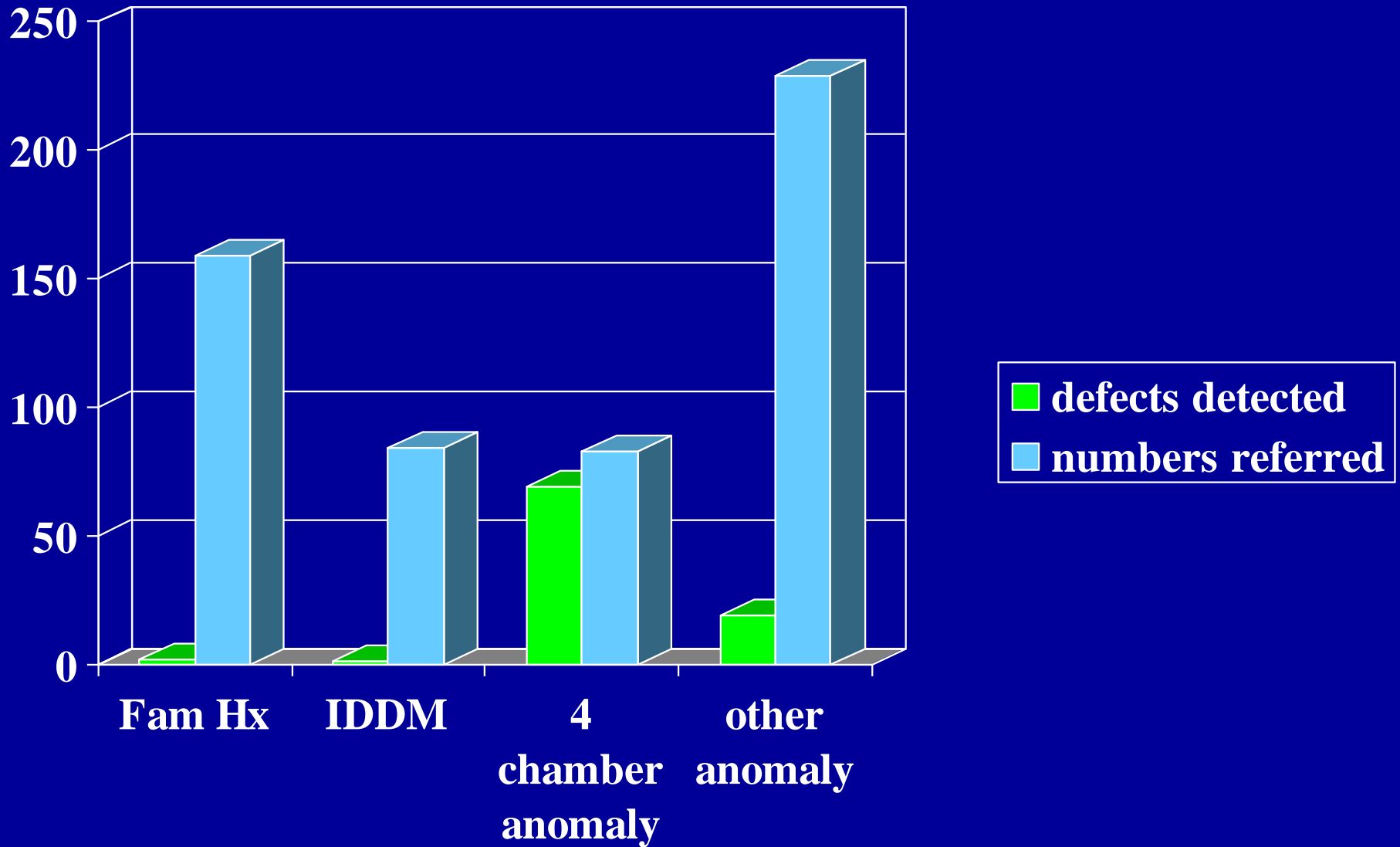
- Routine anatomic survey at 18-22 weeks' gestation for general population
- Refer for fetal echocardiography:
  - Abnormal 4 chamber view
  - Presence of other fetal defect (eg. NT)
  - Family history / medication / DM

# Fetal Cardiac programme at NMH

- N=578 fetal echos (2005-2007)
- 91 cardiac defects (16%)



# Cardiac anomalies (n=91)



# Cardiac anomalies (n=91)

- Ventricular septal defect 21
- Atrio-ventricular septal defect 14
- Hypoplastic left heart syndrome 11
- Teratology of Fallot 5
- Ebstein's anomaly 3

# Cardiac anomalies (n=91)

- Extra-cardiac defects 40% (37/91)
  - CNS 13%
  - GIT 12%
  - Skeletal 11%
  - GUT 4%

# Cardiac anomalies (n=91)

- Chromosomal abnormalities 29% (26/91)
  - Trisomy 18 14%
  - Trisomy 21 10%
  - Trisomy 31 2%
  - Triploidy 2%
  - Turner's syndrome 1%

# Fetal Cardiac programme at NMH

- Highest yield from abnormal four chamber view
- Presence of extracardiac defects (40%)
- Consider karyotyping in the presence of cardiac defects (30%)



T



4

6

8

10

6C1  
T5.0

36 fps





0

5

10

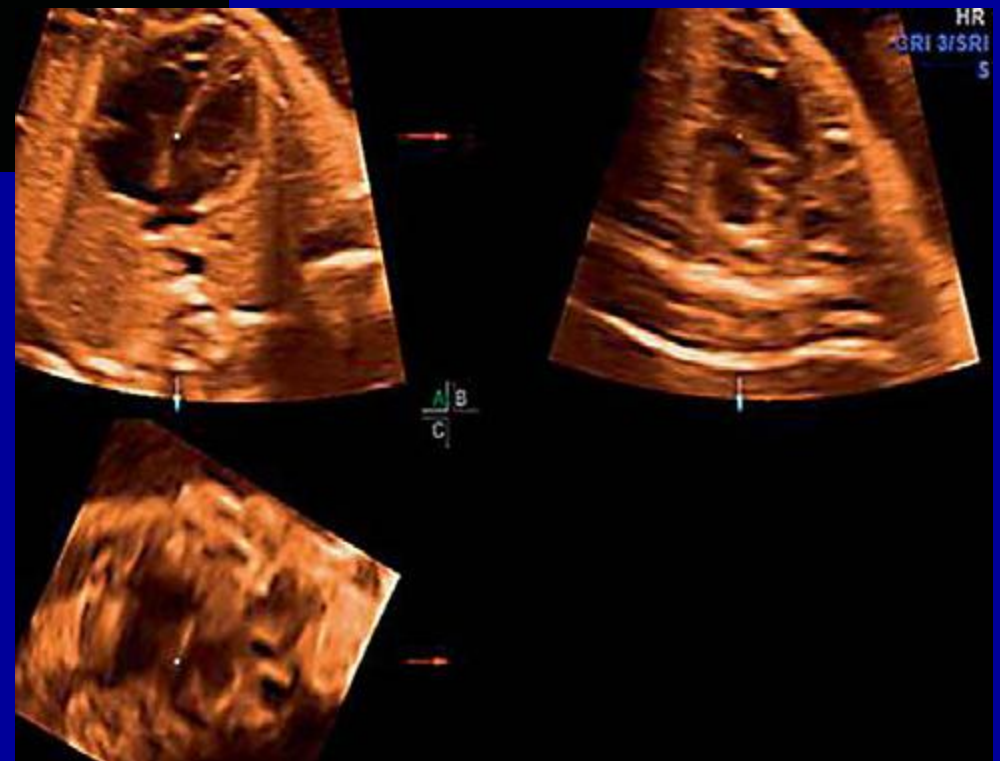
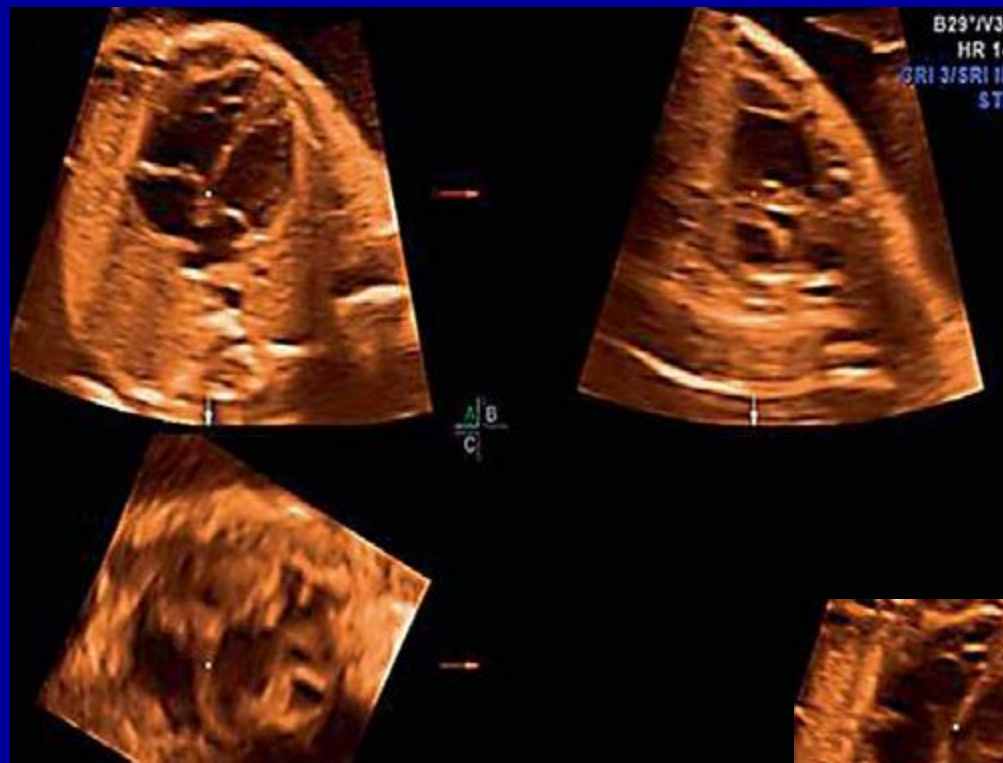
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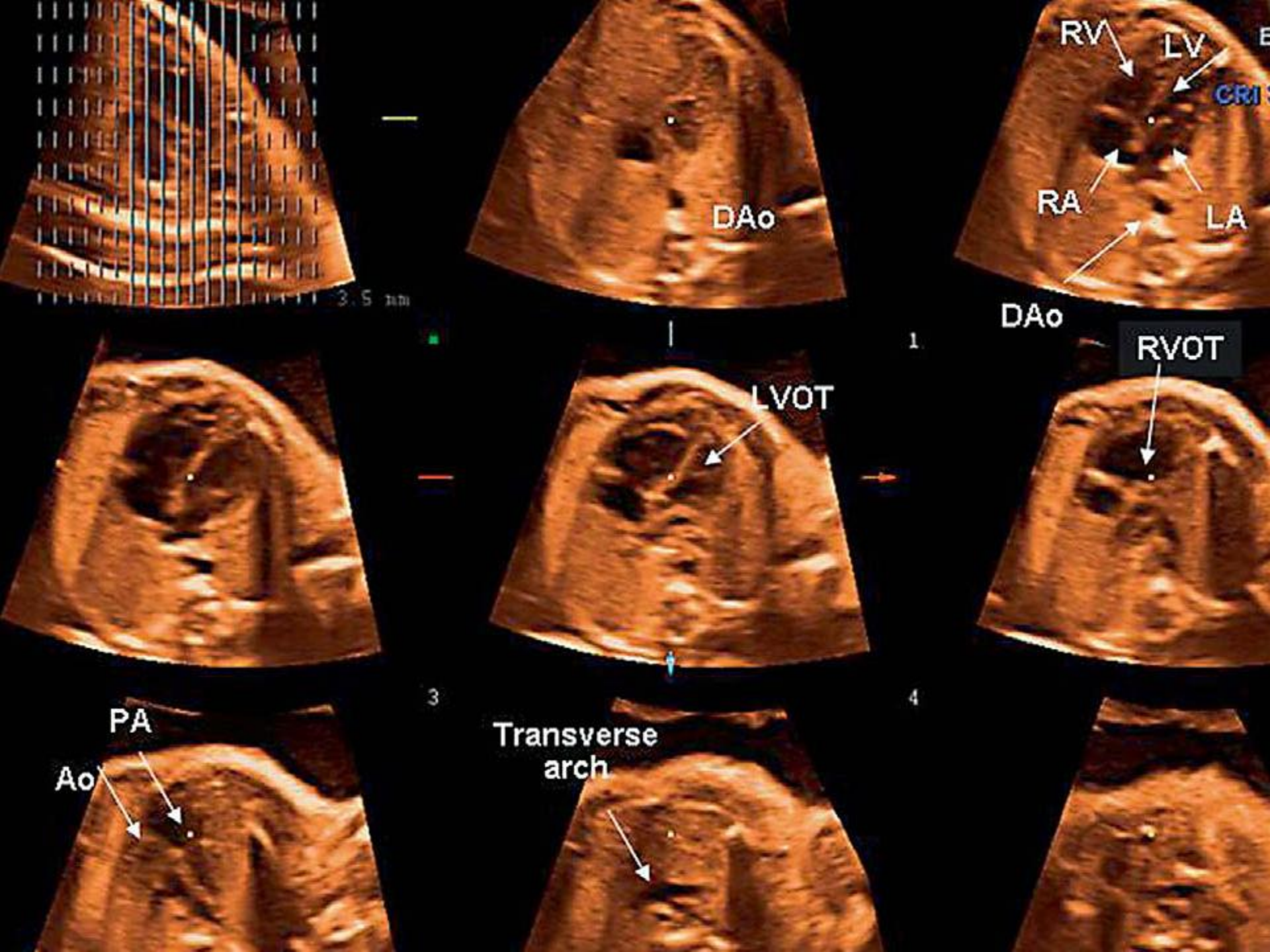
6C1  
T5.0

20 fps

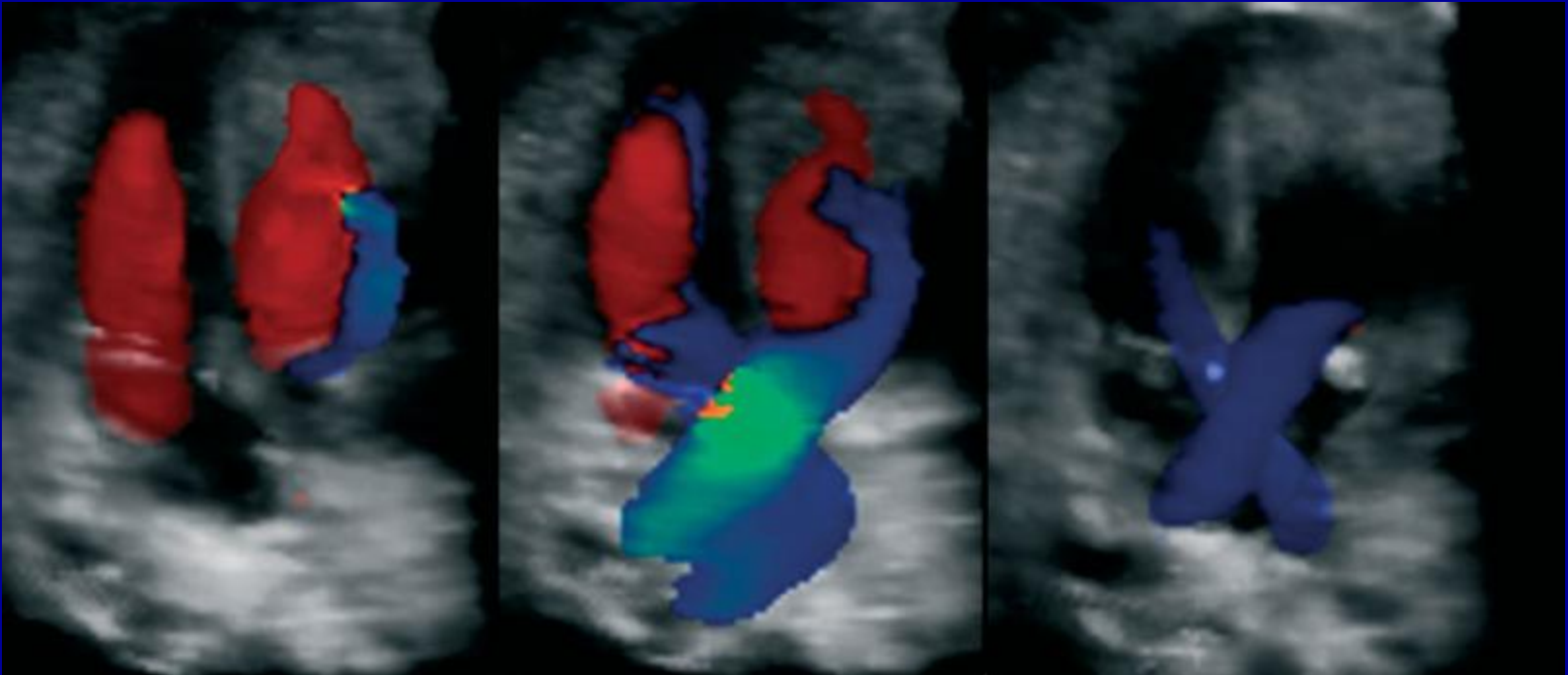
3D

# Spatial temporal image correlation (STIC) in systole and diastole



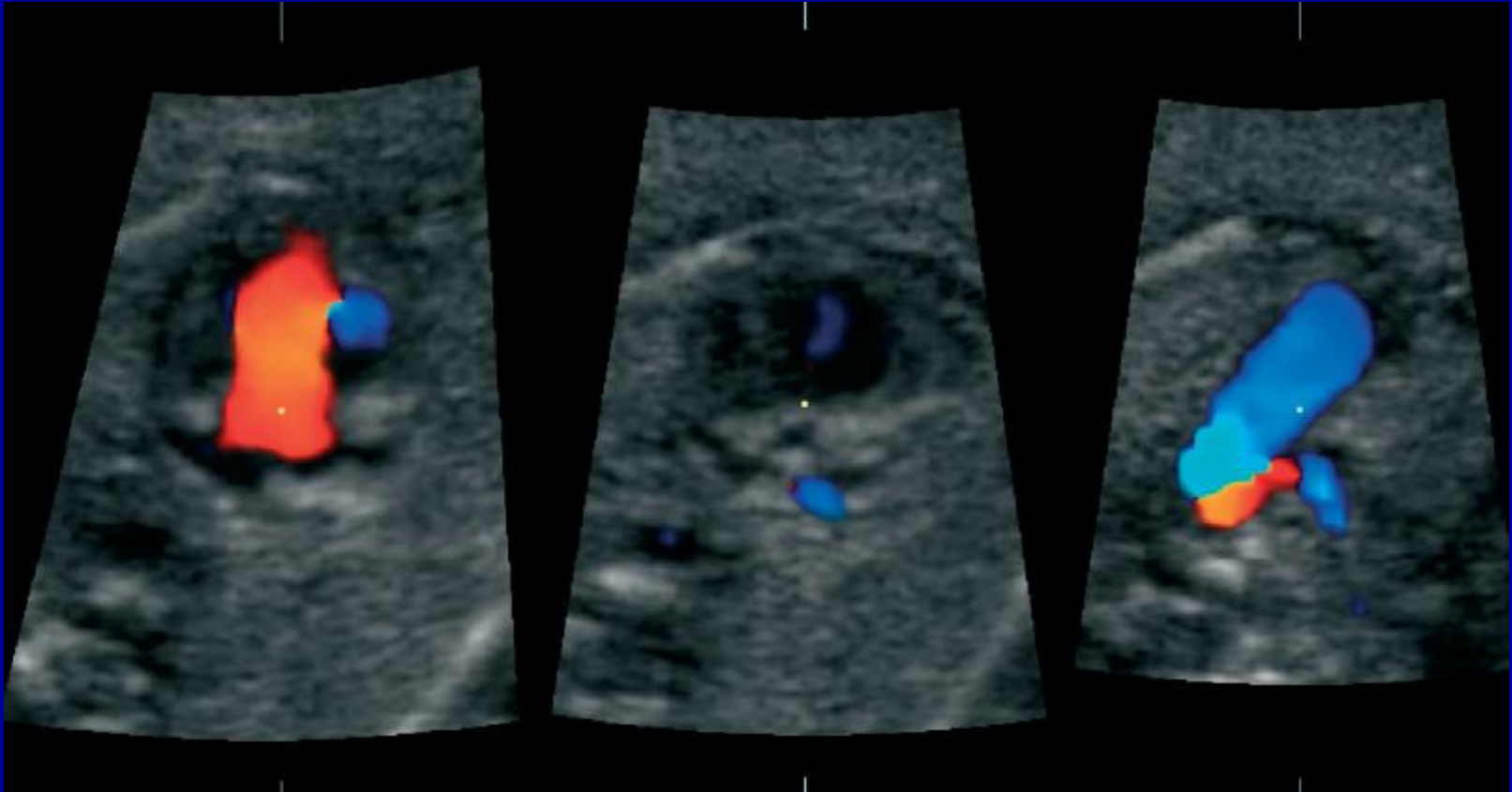


# Normal



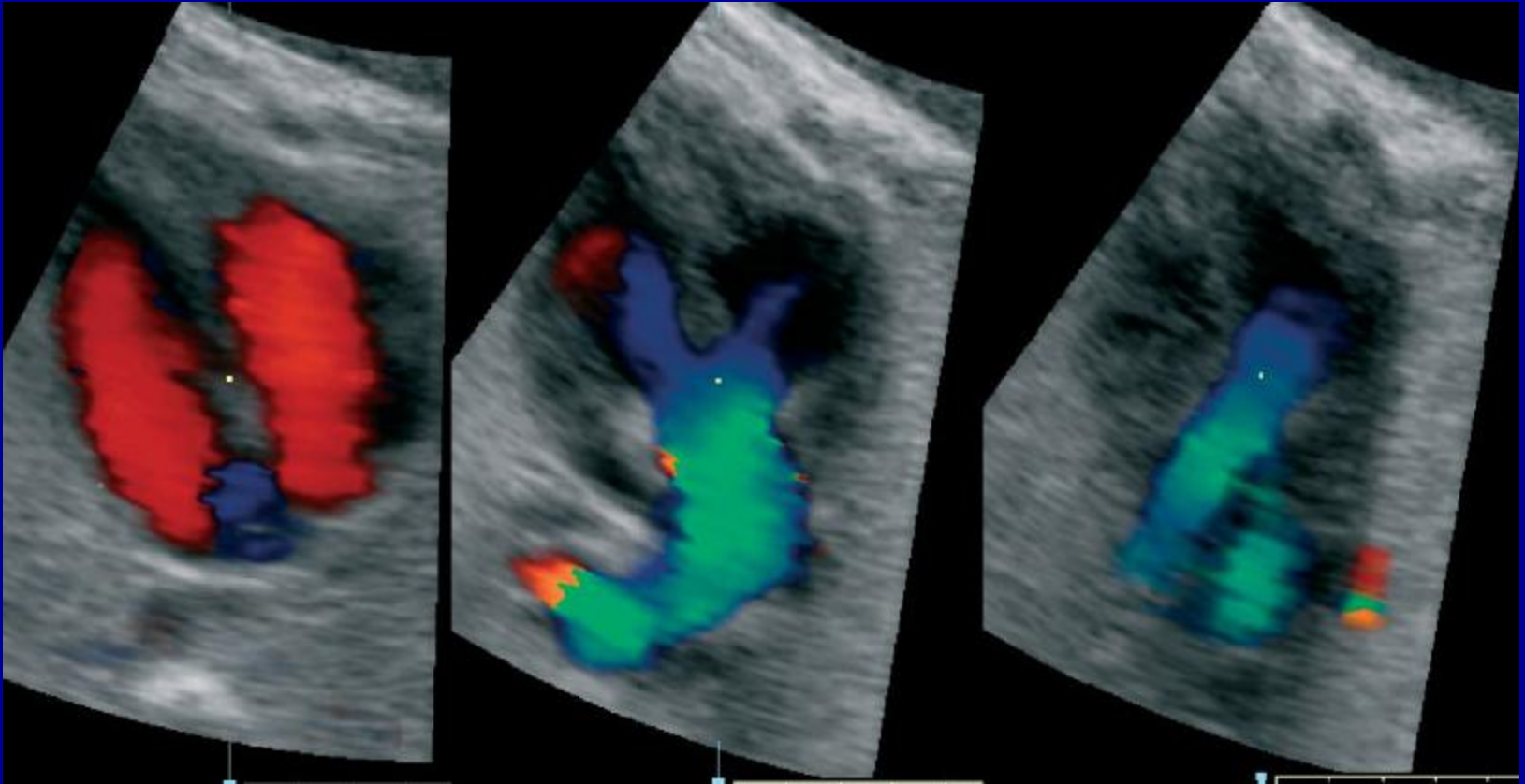
*Chaoui UOG 2004*

# HLHS



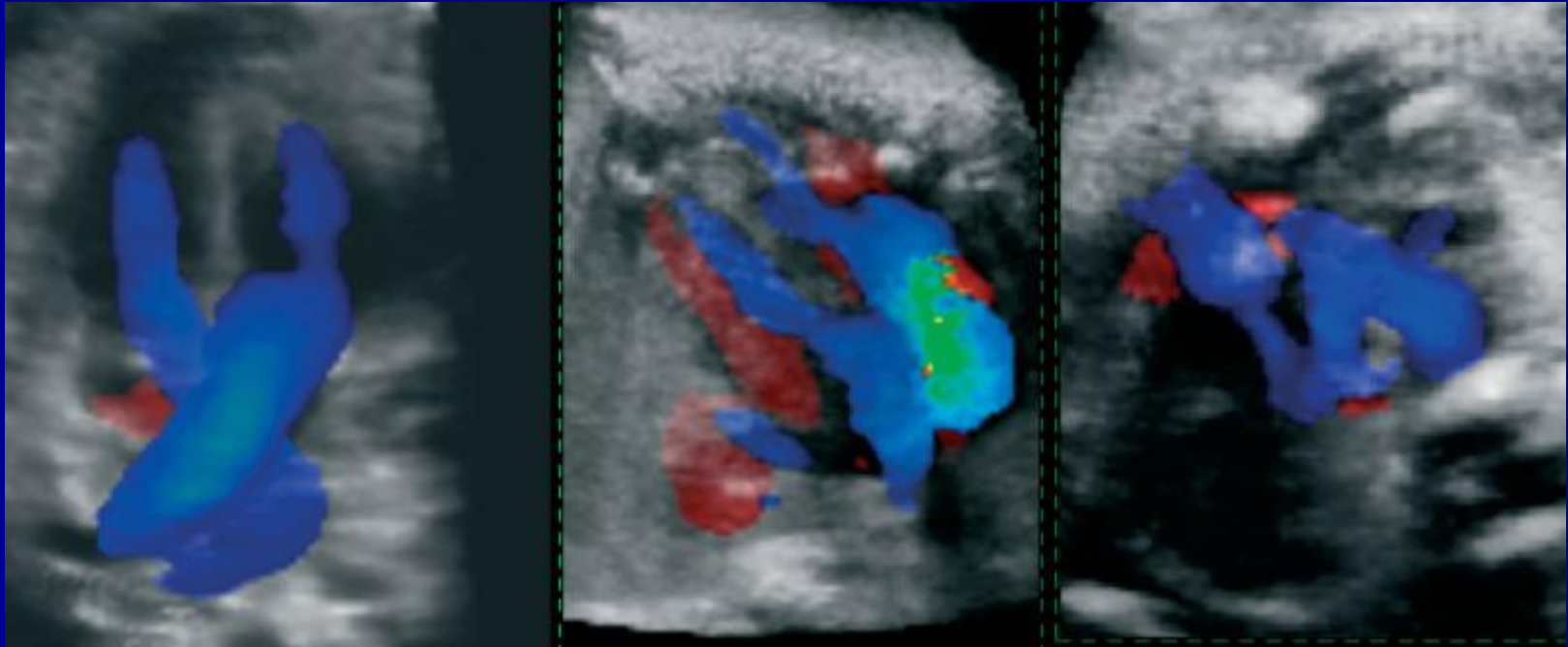
*Chaoui UOG 2004*

# Tetralogy of Fallot

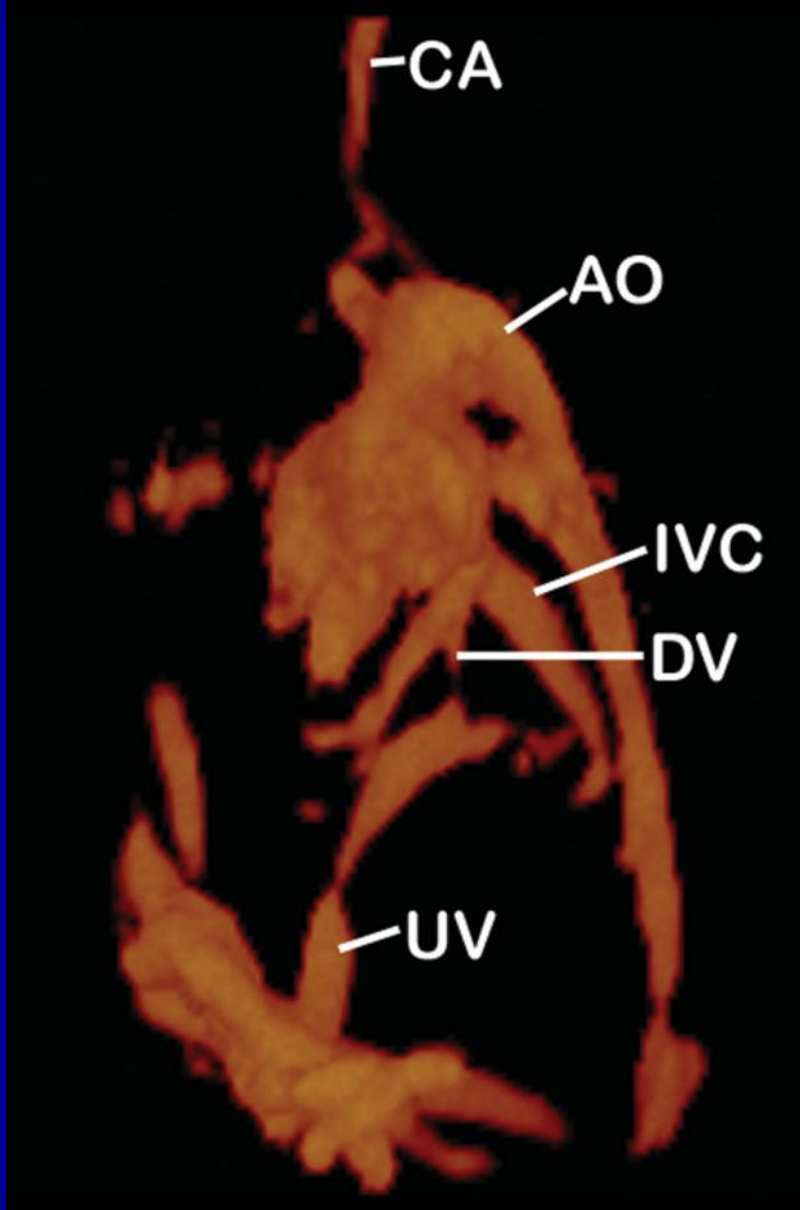


*Chaoui UOG 2004*

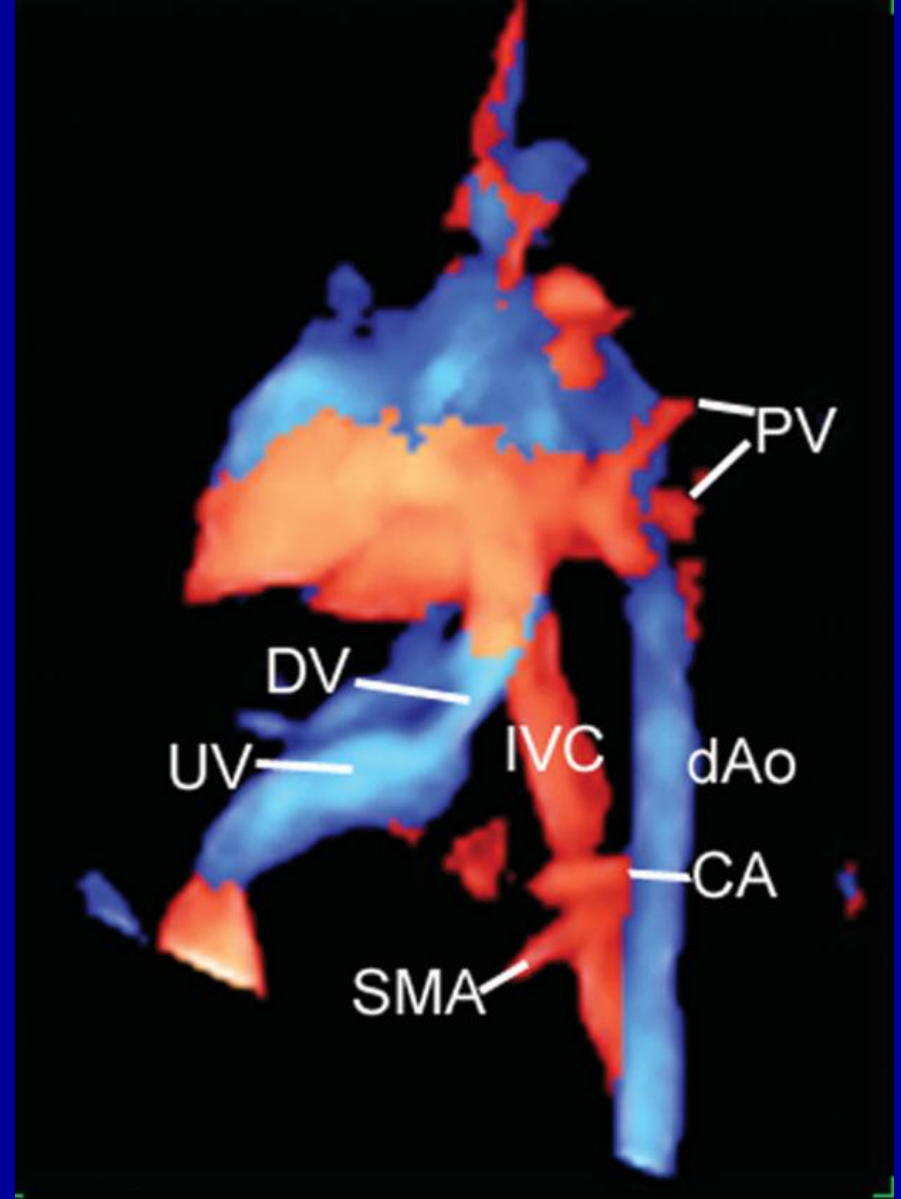
# Normal, TGA, double ao arch



*Chaoui UOG 2004*



3D power Doppler of heart and vessels



STIC acquisition with power flow Doppler

# Fetal Cardiology – 3D

- Improved fetal heart imaging
- Offline analysis - post processing evaluation
- Allows for in-depth analysis of cardiac morphology
- Compares well with 2D – additional views with 3D

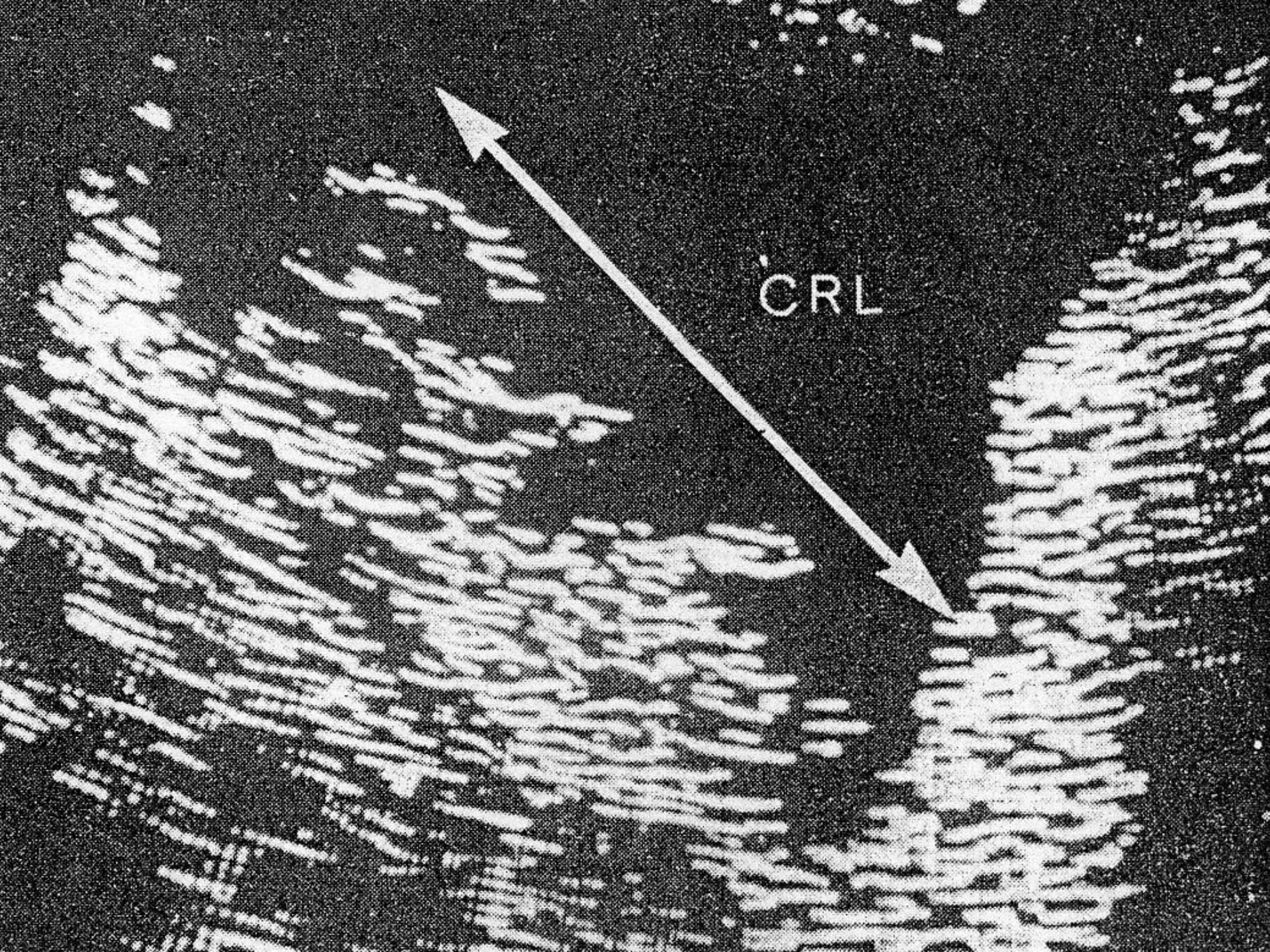
# Fetal Cardiology – 3D

- Role of 3D in cardiac defects
- 3D, STIC – improve understanding of cardiac morphology
- Better Dx of ASD / VSD (Yagel 2006)
- Superior to 2D for vascular anatomy (Baschat 2009)
- Role will expand over time

# Fetal Cardiology – 3D

- Role of 3D in routine population
- Views can be obtained by sonographers – available for off line analysis (Vinals 2003)
- Images acquired by a generalist can be analysed by a fetal echo expert
- Routine use still uncertain (Uittenbogaard 2009, Tonni 2009)





CRL

# Early Fetal Echocardiography

- 'Gold standard' for fetal echo 18-22 weeks' gestation
- Early trimester fetal echocardiography has a role for high risk groups (increased NT, other defects)



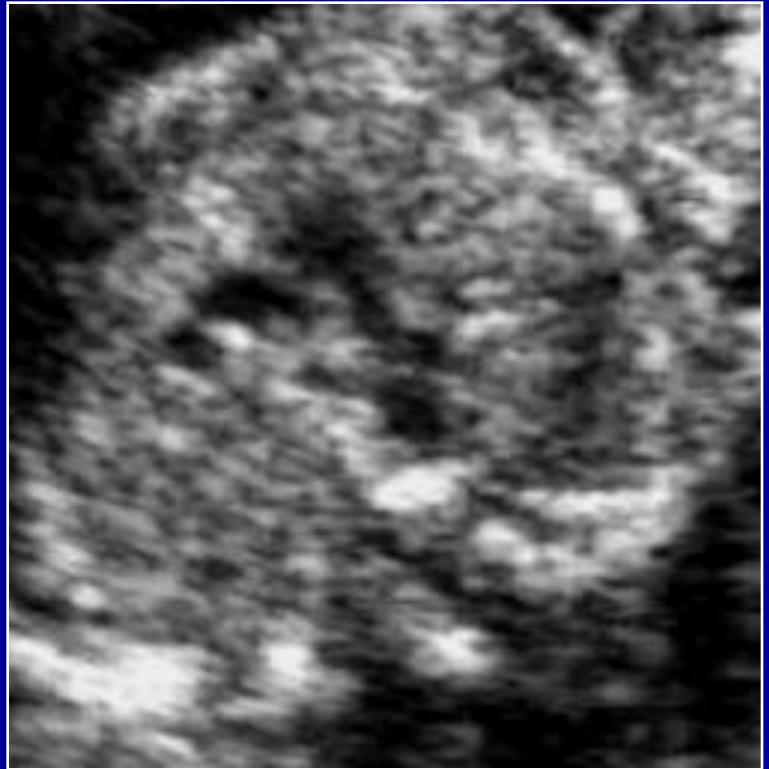
# Fetal NT and cardiac defects

Table II Prevalence of major defects of heart and great arteries in fetuses who were chromosomally normal

Nuchal translucency thickness	No. of fetuses	No. of major cardiac defects	Prevalence per 1000 fetuses
≥ 95th percentile	263	13	49.4
≥ 99th percentile	75	8	106.7
2.2-2.9 mm	91	0	0*
3.0-3.4 mm	80	5	62.5*
3.5-4.9 mm	58	6	103.4*
≥ 5.0 mm	18	2	111.1*

\* Chi-squared linear trend test,  $P < .01$ .







6C1  
T5.0  
46 fps

MI:1  
2D  
6  
D  
5



6C1  
T5.0  
46 fps

MI:1  
2D  
6  
D  
5

**Table 1.** Cardiac Anatomy Visualization in the First Trimester (n = 32)

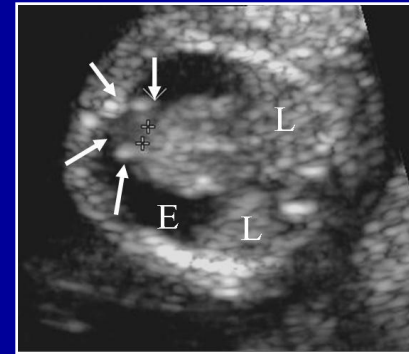
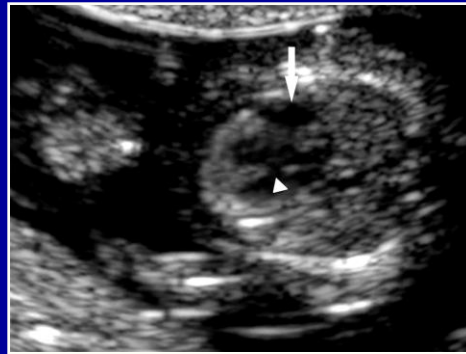
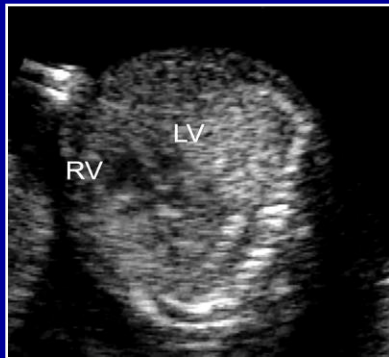
<b>Anatomic Feature</b>	<b>Visualization, % (n)</b>
Normal general anatomy	100 (32)
4-chamber view	100 (32)
3-vessel view	81 (26)
Ventricular function	100 (32)
Tricuspid valve	100 (32)
Mitral valve	100 (32)

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Ventricular function	100 (32)
Tricuspid valve	100 (32)
Mitral valve	100 (32)
Aortic root	84 (27)
Main pulmonary artery	75 (24)
Left branch pulmonary artery	15 (5)
Right branch pulmonary artery	9 (3)
Pulmonary vein	3 (1)
Aortic arch	81 (26)
Ductal arch	69 (22)
Inferior vena cava	88 (28)
Superior vena cava	88 (28)

# Early Fetal Echocardiography

- N=160 fetal echo < 16 week's gestation (20 defects – 12.5%)
- Sensitivity 70%, Specificity 98%
- Highest yield in those cases where cardiac or extra cardiac defects suspected.





# Fetal valvuloplasty for severe AS

- 1991 first reports percutaneous ultrasound-guided balloon valvuloplasty
- Selection of severe cases with poor prognosis
- Significant technical issues
- Emergency CS
- Research / experimental tool



*Kohl et al 2000*

# Fetal valvuloplasty for severe AS

- Boston 2009
- 2000-2008: 70 cases valvuloplasty for severe AS
- Successful in 52/70 (74%), mean GA 23 weeks
- Loss rate 9/70 (13%)

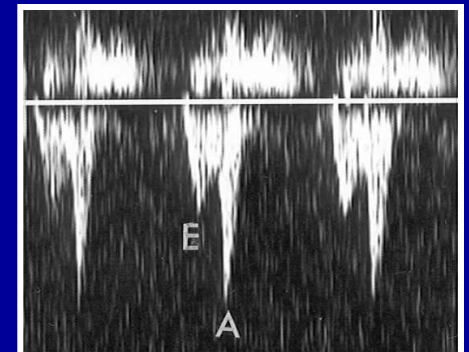
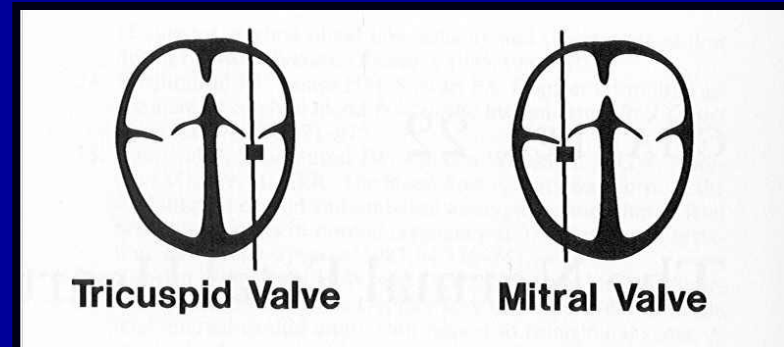
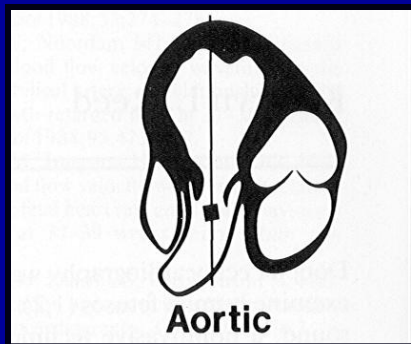
# Fetal valvuloplasty for severe AS

- Boston 2009
- 2000-2008: 70 cases valvuloplasty for severe AS
- Successful in 52/70 (74%), mean GA 23 weeks
- Loss rate 9/70 (13%)
- Compared with a series (n=21) without fetal intervention MV and AV showed better prenatal growth, but not LV growth
- In a subset fetal intervention increases chance of biventricular outcome postnatally



# Fetal cardiology - function

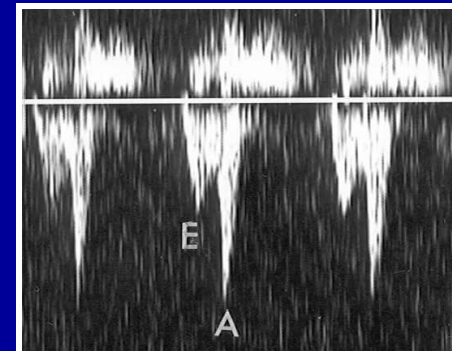
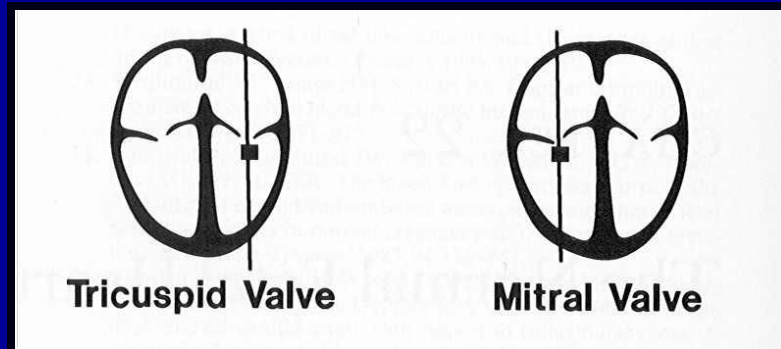
- Systolic function: 'pumping' function of the heart during ventricular contraction and ejection (dilated ventricles)
- Diastolic function: ability of the ventricle to fill (abnormal venous Dopplers)



# Fetal cardiology - function

- TEI index: composite of diastolic and systolic function – Myocardial Performance Index

$$\text{MPI} = \text{IVRT} + \text{ICT} / \text{ET}$$



**Normal**

**Abnormal**

**IVC**



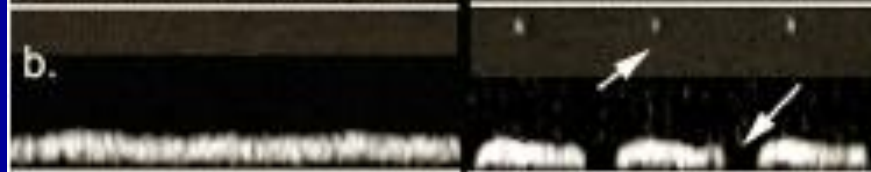
a.

**DV**



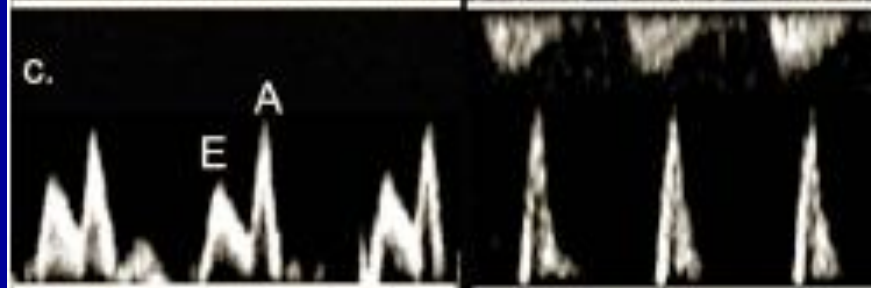
b.

**UV**



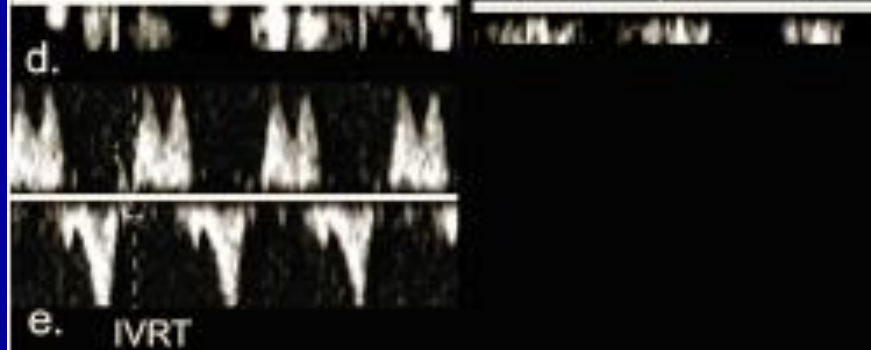
c.

**E/A wave**



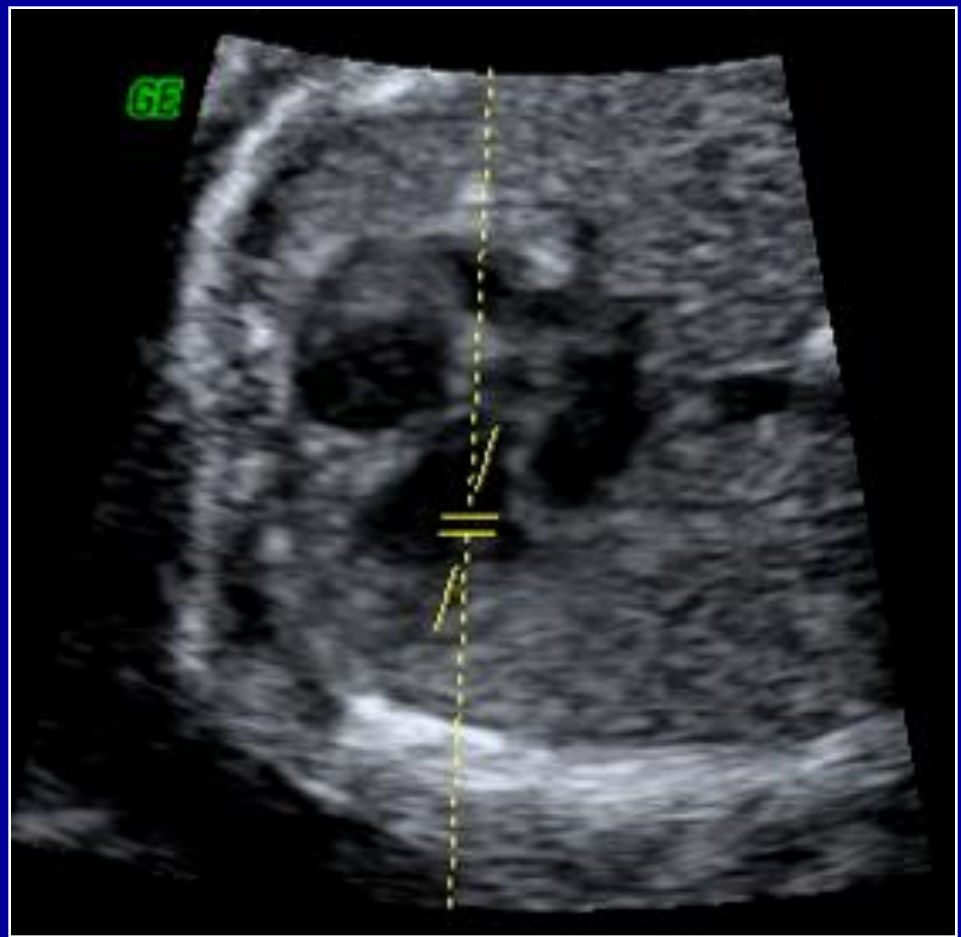
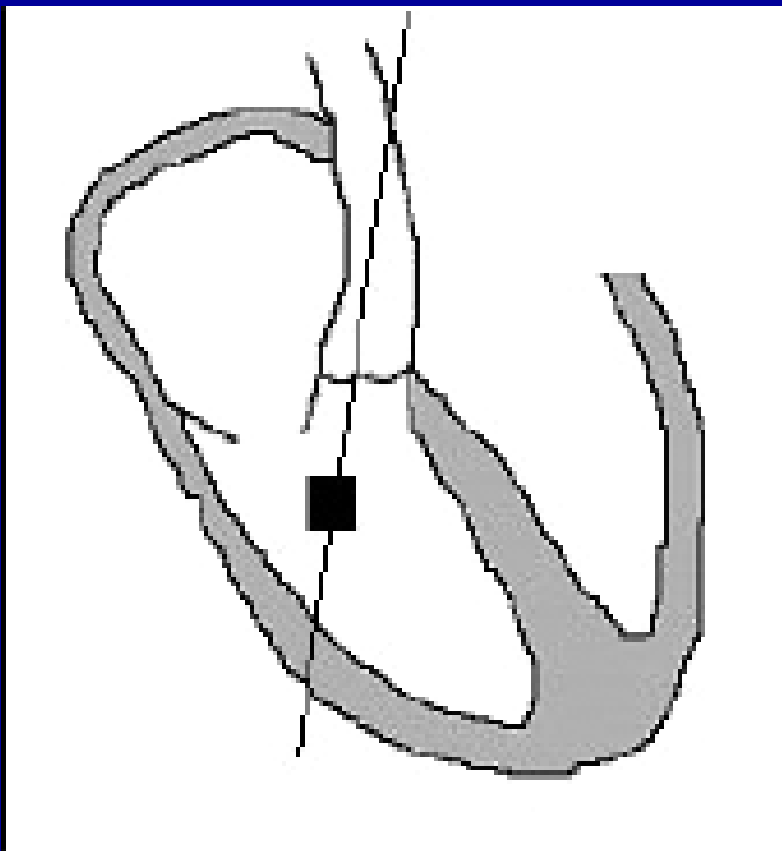
d.

**IVRT**

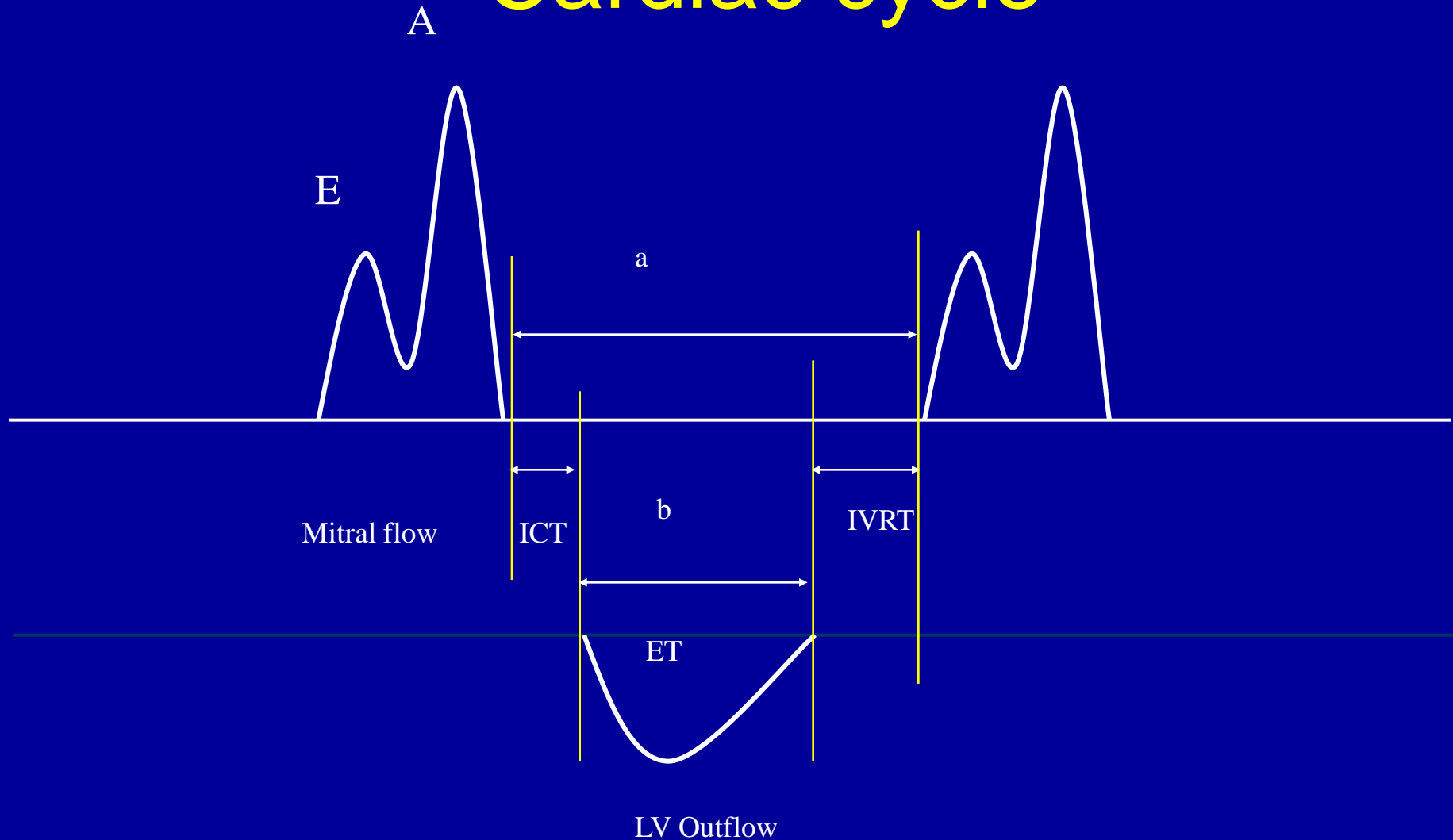


e.

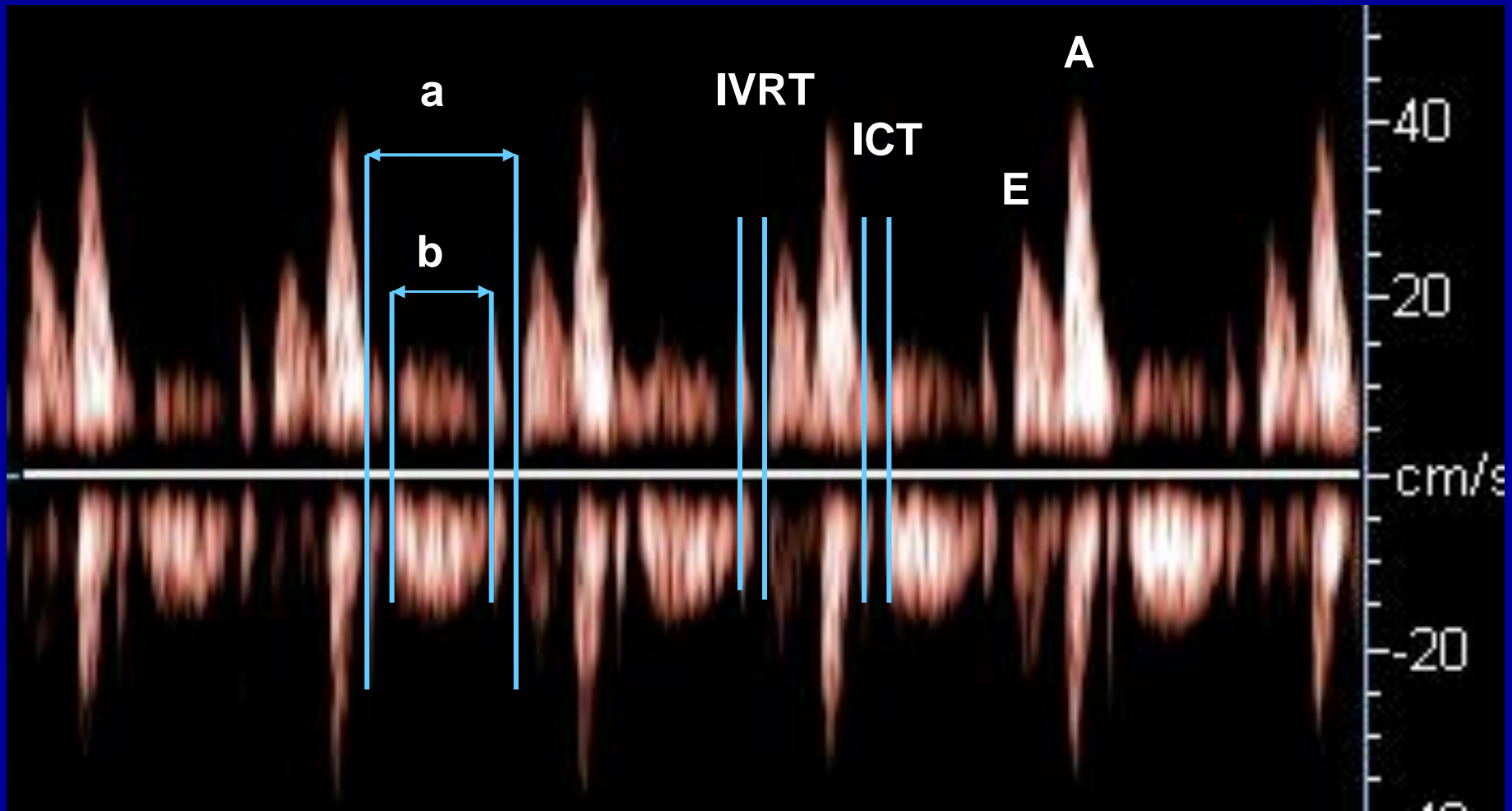
IVRT



# Cardiac cycle



ICT, isovolumic contraction time / RR  
IVRT, isovolumic relaxation time / RR  
ET, ejection time



# Fetal cardiology - function

- Systolic function: 'pumping' function of the heart - isovolumetric contraction time; ICT/RR, % ejection fraction
- Diastolic function: ability of the ventricle to fill - E/A ratio, isovolumetric relaxation time; IVRT/RR
- Ejection fraction  $(EDV-EDS)/EDV \times 100\%$

**TABLE 1****Effect of gestational age on cardiac function in normal pregnancy**

<b>Variable</b>	<b>First trimester (T1; n = 30)</b>	<b>Second trimester (T2; n = 30)</b>	<b>Third trimester (T3; n = 30)</b>
Left E/A ratio	0.60 ± 0.07	0.58 ± 0.08	0.86 ± 0.15
Left IVRT (msec)	41 ± 6	41 ± 6	52 ± 8
Left ICT (msec) <sup>a</sup>	36 ± 9	34 ± 6	35 ± 6
Left MPI <sup>b</sup>	0.49 ± 0.10	0.53 ± 0.10	0.58 ± 0.10
Right E/A ratio	0.61 ± 0.05	0.62 ± 0.05	0.81 ± 0.14
Right MPI	0.52 ± 0.09	0.54 ± 0.12	0.60 ± 0.11

Reproducibility L MPI 4.6%, R MPI 3.3%

*Russell & McAuliffe JUM 2008*  
*Russell, McAuliffe et al AJOG 2008*

# Cardiac Function

- IUGR
- Twin-to twin transfusion syndrome
- Monitoring function in cases of CHD and heart block (Gembruch 2003)



# Cardiac Function - TTS

- Twin-to twin transfusion syndrome (Barrea 2006)
- Impact of laser on recipient cardiac function (n=22)
- Pre-laser
  - RV systolic dysfunction 59%
  - LV dysfunction 27%
  - Diastolic dysfunction 73%
- Improvement of bi-ventricular systolic function post laser

# Cardiac Function - TTS

- Ville 2010 (n=63)
- MPI, %FS, DV PI
- Stage 1 Quintero – 55% alterations in cardiac function the recipient twin

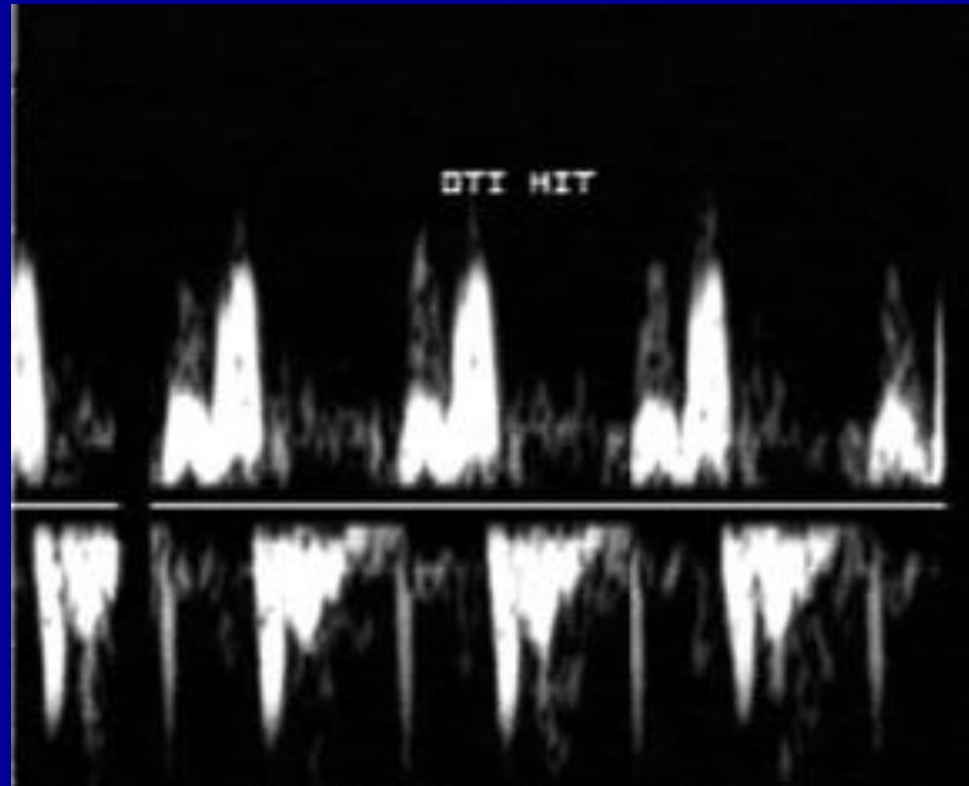
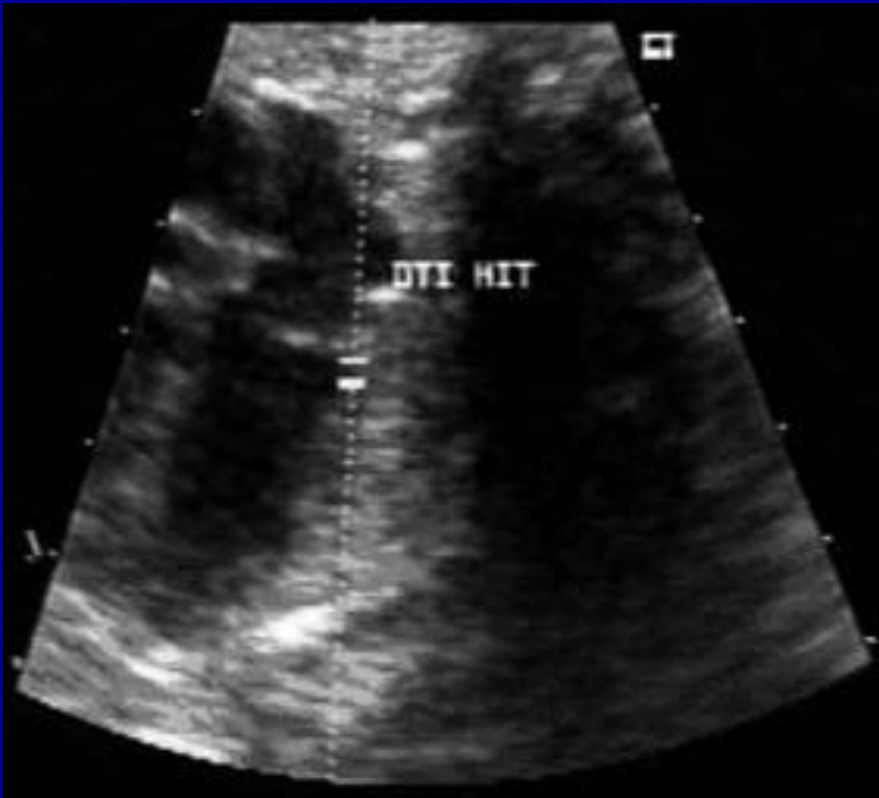
# Cardiac Function - TTS

- Ville 2010 (n=63)
- MPI, %FS, DV PI
- Stage 1 Quintero – 55% alterations in cardiac function the recipient twin
- Progressive cardiomyopathy detectable as part of TTS
- However no correlation with pregnancy outcome with laser ablation

# Cardiac Function - IUGR

- Prediction of perinatal death in preterm IUGR (n=97, 22 deaths GA 24-34/40)
- DV-PI and MPI independent predictors of perinatal death
- IUGR < 28/40 – both abnormal risk of death 97%
- IUGR > 28/40 - both abnormal risk of death 45%

# Myocardial Tissue Doppler



Naujorks 2009

# Cardiac Function - IUGR

- Naujorks 2009
- IUGR n=14, PIH AGA n=13, AGA n=29
- IVS, LV and RV AV velocities
- IUGR associated higher 'E/A' ratios at IVS and LV
- Myocardial tissue Doppler sensitive tool in assessment of ventricular dysfunction in IUGR

# Cardiac Function - IUGR

- Gratacos 2010
- L MPI increased in cases with severe IUGR
- Tissue Doppler assessment showed more changes than with conventional Doppler
  - Higher 'E/A', higher septal MPI
- Tissue Doppler – a more sensitive tool than conventional echo to evaluate cardiac dysfunction in IUGR

# OPORTO – Perinatal Ireland

- RCT - optimum time to delivery IUGR with absent EDF
- Delivery on CTG or DV abnormalities
- UA, MCA, DV, MPI and aortic isthmus
- Correlation of MPI with other Doppler parameters in IUGR

TABLE 3

### Comparison between fetal cardiac function and structure in diabetic and normal pregnancy

Variable	Normal	Type 1 diabetes mellitus	Statistical differences
Gestational age			
<b>Left MPI</b>			
T1	0.49 ± 0.10	0.56 ± 0.14	.042
T2	0.53 ± 0.09	0.49 ± 0.13	NS
T3	0.57 ± 0.09	0.57 ± 0.10	NS
<b>Right MPI</b>			
T1	0.52 ± 0.09	0.58 ± 0.21	NS
T2	0.52 ± 0.10	0.54 ± 0.21	NS
T3	0.60 ± 0.11	0.53 ± 0.14	.045

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# Conclusion

- Routine examination of fetal heart in second trimester results in prenatal detection of cardiac defects and improved perinatal survival
- Echocardiography for selected patients
  - Abnormal 4Ch
  - Other defects
  - Family history / DM

# Conclusion

- 3D additional information in congenital cardiac defects, role in low risk pregnancy requires further evaluation
- First trimester fetal echocardiography for high risk groups (NT, other defect)
- Cardiac function: fetal physiology and pathology (IUGR, TTS)



