

# Ultraäänen mahdollisuus ja turvallisuus

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HUS, Naistensairaala

# Evergreen issue

- Diagnostic ultrasound has become widespread and most pregnant women have 2 to 3 (or even more in certain country) ultrasound examination during pregnancy
- Every once in a while the question arise: is all this ultrasound technology safe for the baby?

# AIUM 2005

- Based on the the epidemiological data available and on current knowledge of interactive mechanisms, there is insufficient justification to warrant a conclusion of a casual relationship between diagnostic ultrasound and recognised adverse effects in humans

# Bioeffects

- As a form of energy DUS has the potential to have effects in the tissues it transverses, that is bioeffects
- The 2 most most likely mechanisms to explain these bioeffects are heating and cavitation

# Cavitation

- Cavitation involves the presence of gaseous bubble in a gas-fluid interface.
- The bubble can oscillate back and forth secondary to alternate pressure or implode
- Cavitation has not been documented in mammalian fetuses, as they seem to be no gas-fluid interface .
- MI (mechanical index) indicate the potential to induce cavitation in tissue.

# Hyperthermia

- Hyperthermia is an established teratogen in experimental animals and accordingly is considered teratogenic in human fetuses
- Temperature in the human fetus is higher than maternal body temperature by 0.3 to 0.5C.

# Hypertermia

- As the waveform travels through the tissue, it loses amplitude by absorption and scatter.
- With absorption energy is converted into heat, which can rise the temperature of the tissue being scanned.
- There has be an elevation of 1.5 to 2.0 C before delopmental effect occurs.
- An increase of 2.5C it is possible with 1 hour exposure to ultrasound.

# Hyperthermia

- The sensitivity of the fetus to external insults changes markedly during the 3 trimester of pregnancy.
- The highest sensitivity being during embryogenesis.
- The capacity of an US equipment of increase body temperature is displayed by the Thermic Index (TI)



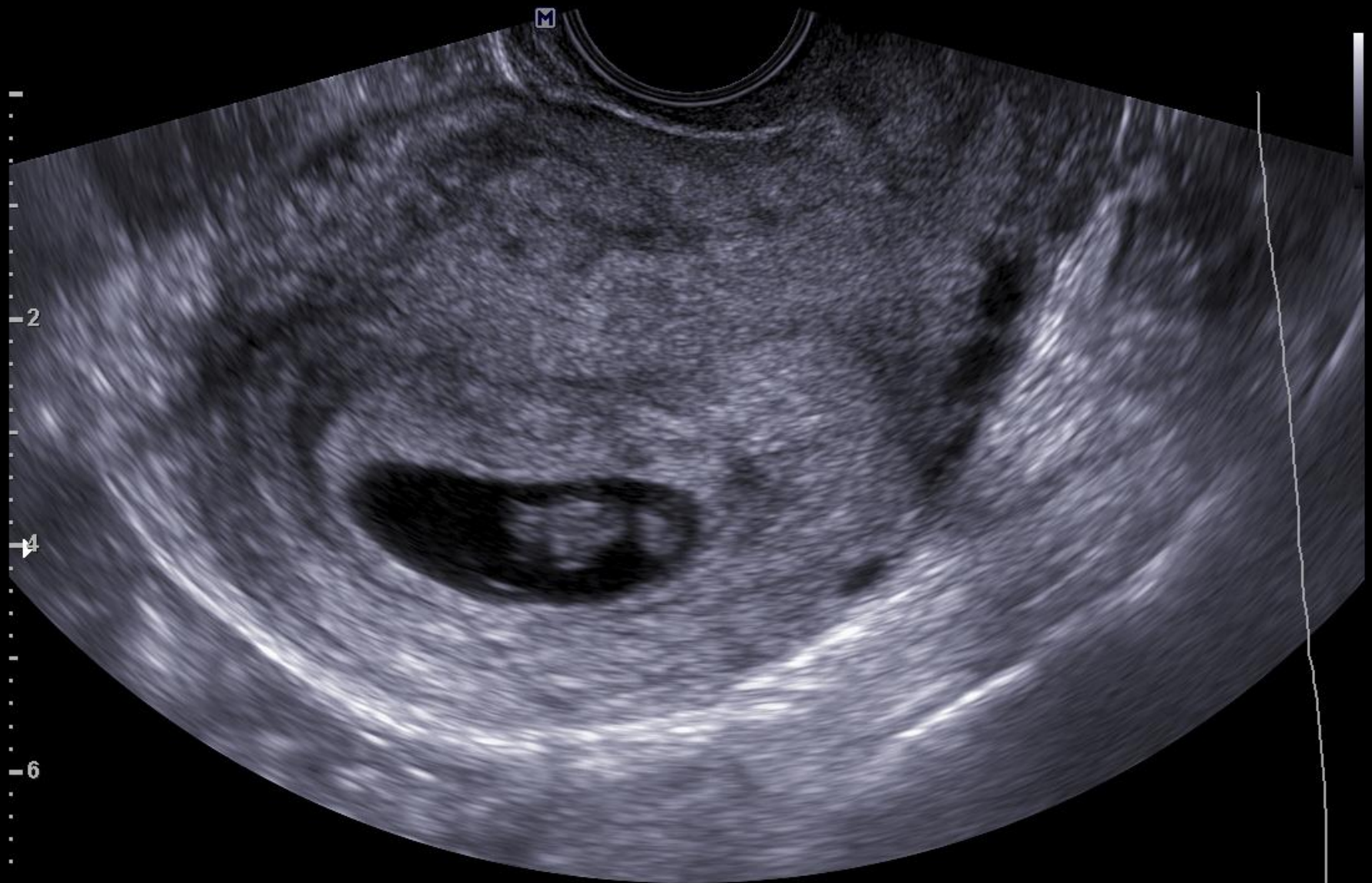
# Thermic Index (TI)

- It can be used to assess the potential for harm by a thermal mechanism but not as a direct measurement of actual rise.
- The higher the TI the higher this potential
- TIs for soft tissue (1st trimester), Tib for bone (2nd and 3rd trimester)

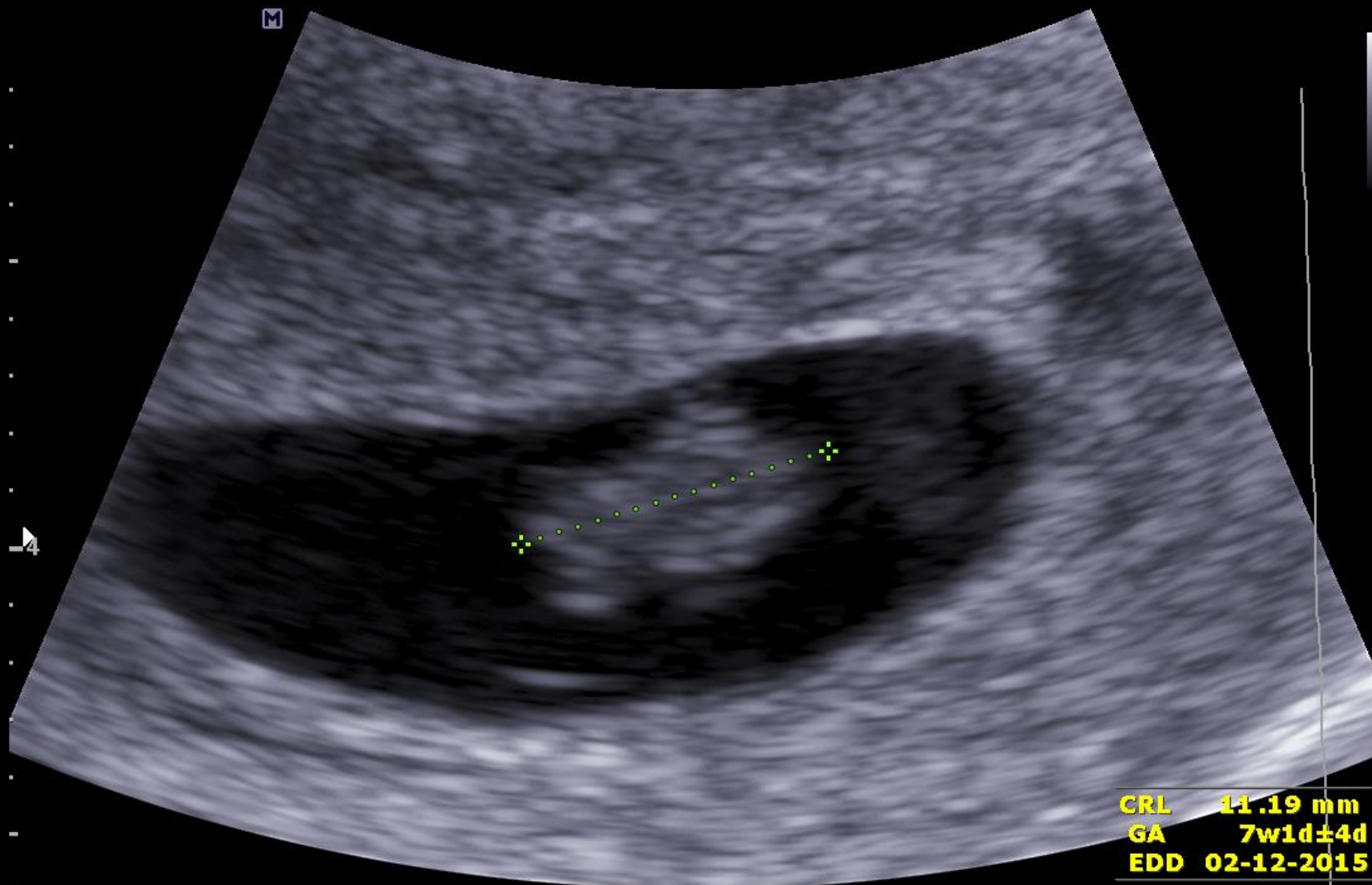
# TI and MI during first trimester ultrasound

- Viability scan
- 52 patients, mean GA 8.9 weeks, mean duration of scan 8.1 minutes
- TI variation  $0.2 \pm 0.1$ .
- MI variation  $0.9 \pm 0.3$
- First trimester US are associate to a negligible rise in TI
  - Sheiner et al J Clin Ultrasound 2007

2D G51/DR105dB/FA10/P90/Frq Res./7.0cm



2D G51/DR105dB/FA10/P90/Frq Res./2.8cm



**CRL 11.19 mm**  
**GA 7w1d±4d**  
**EDD 02-12-2015**

# TI and MI during NT scan

- 11+0 – 13.6 weeks
- 50 fetus (malformations excluded)
- Mean GA 12.6 weeks
- Mean duration 11.6 min
- Mean NT 1.4 mm
- Mean TI 0.2 (0.1-0.7)
- Mean MI 1.1 (0.7-1.3)
- MI and TI are low during NT scan
  - Sheiner E et al fetal diagn Ther 2009



2D G37/DR103dB/FA6/P90/Frq Res./4.5cm

PI 



D1 1.64 mm

Voluson™  
E10

E60164-14-12-29-1

29.12.2014

KOS NPKL

08:50:02

TIs 0.2

Tib 0.2

MI 0.6

RM6C

OB

8.6cm / 1.1

32° / 53Hz

NT

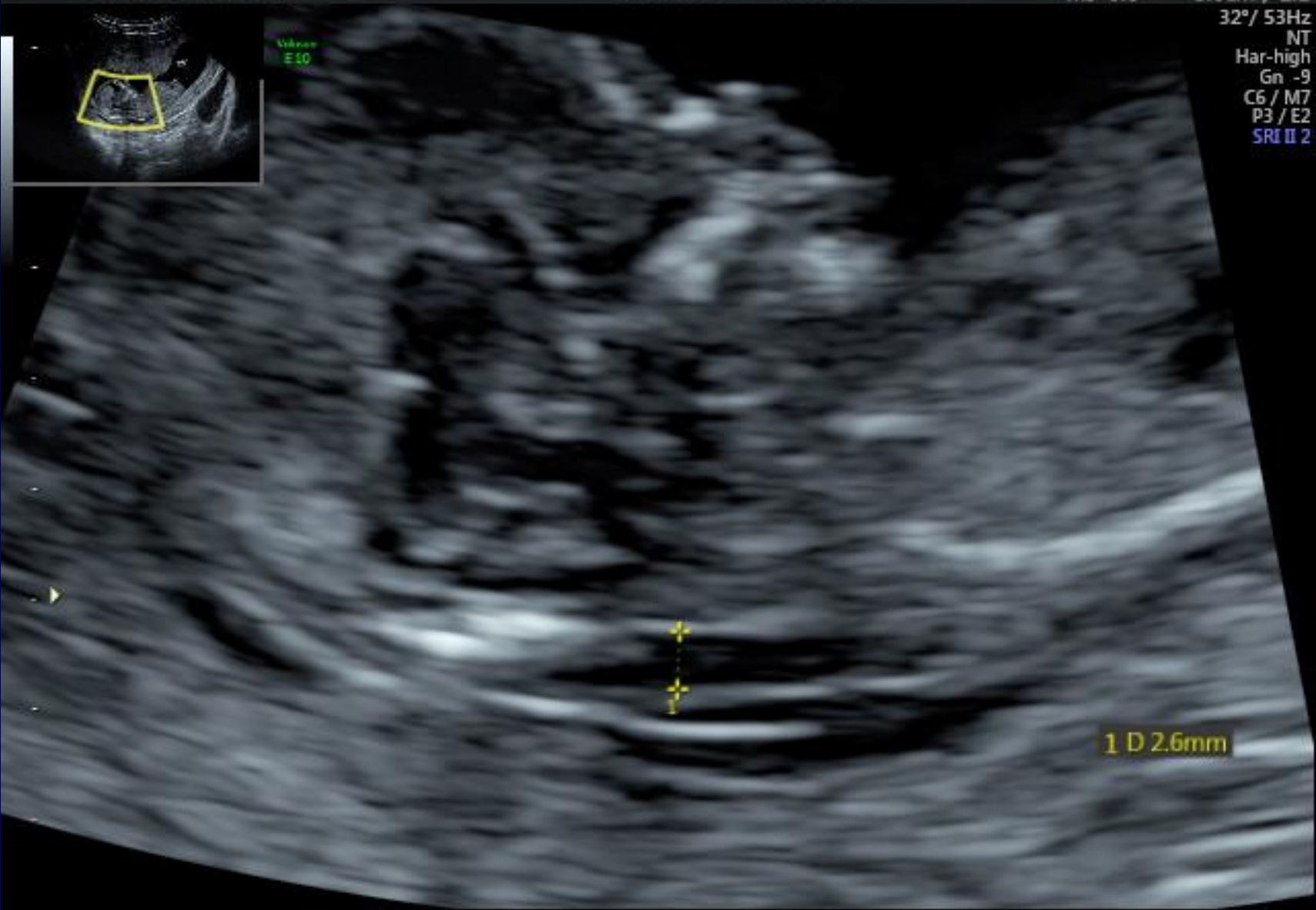
Har-high

Gn -9

C6 / M7

P3 / E2

SRI II 2



# TI and MI during Doppler studies

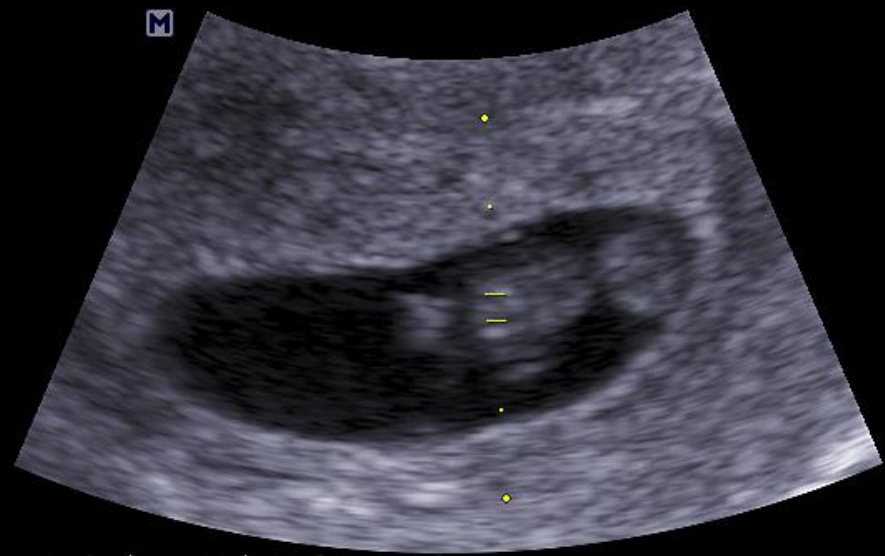
- Doppler studies mostly done in patients at risks (IUGR, cardiac malformation).
- 1-5 minute of pulsed Doppler but not 5-10 minutes of 2D US of chicken eggs at day 19 of day 21 incubation impaired ability to learn and short and long term memory.
  - Schneider-Kolsky ME et al In J dev Neurosci. 2009



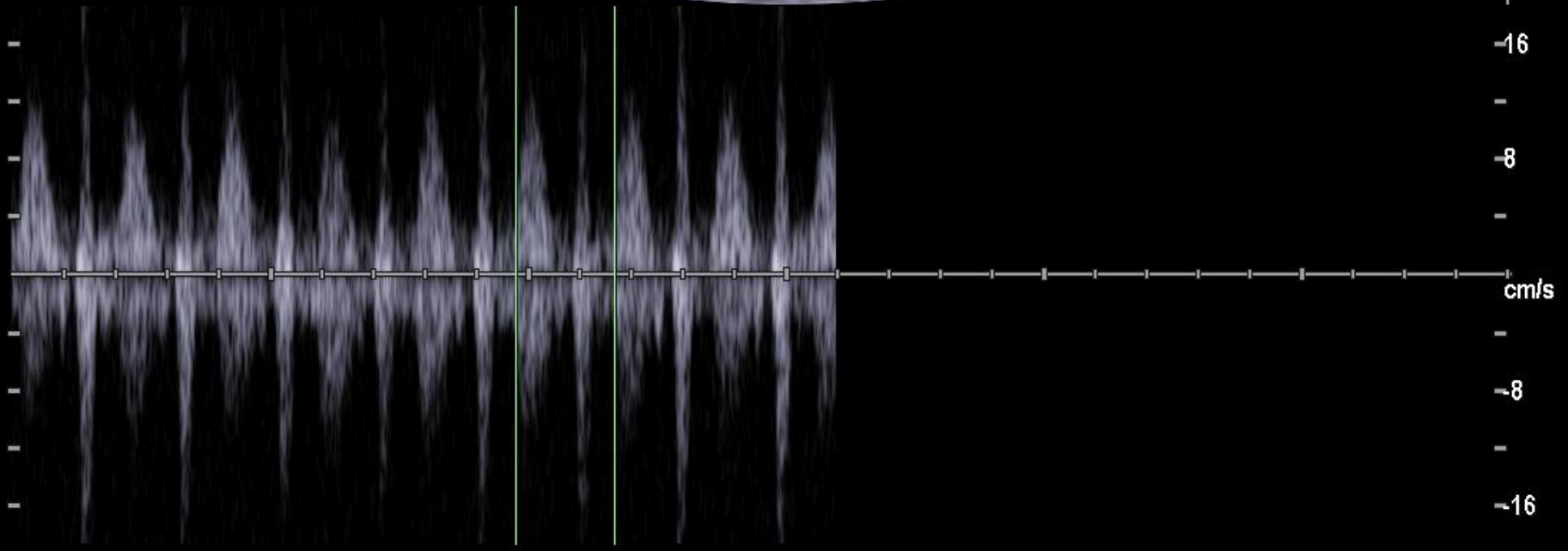
# TI and MI during Doppler studies

- 63 exams
- 2nd half of pregnancy Doppler vs B mode
- Mean duration 17.6 min (Bmode) 0.9 min (Doppler)
- Ti significantly higher during pulsed (mean 1.5) and color Doppler (mean 0.8) than with Bmode (mean 0.3)

2D G51/DR105dB/FA0/P100/Frq Res./2.8cm  
PW G50/2.50kHz/F1/ 1.5mm:0°@3.9cm



**Fetal HR 157 bpm**





E60164-14-12-29-1

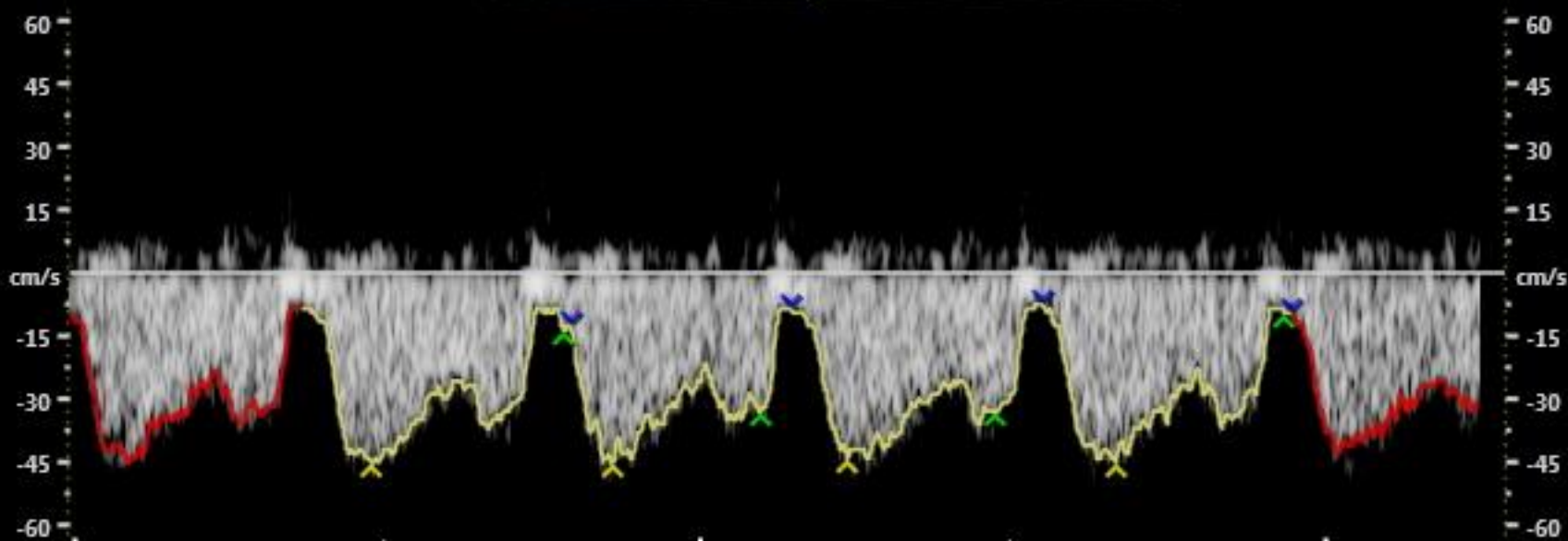
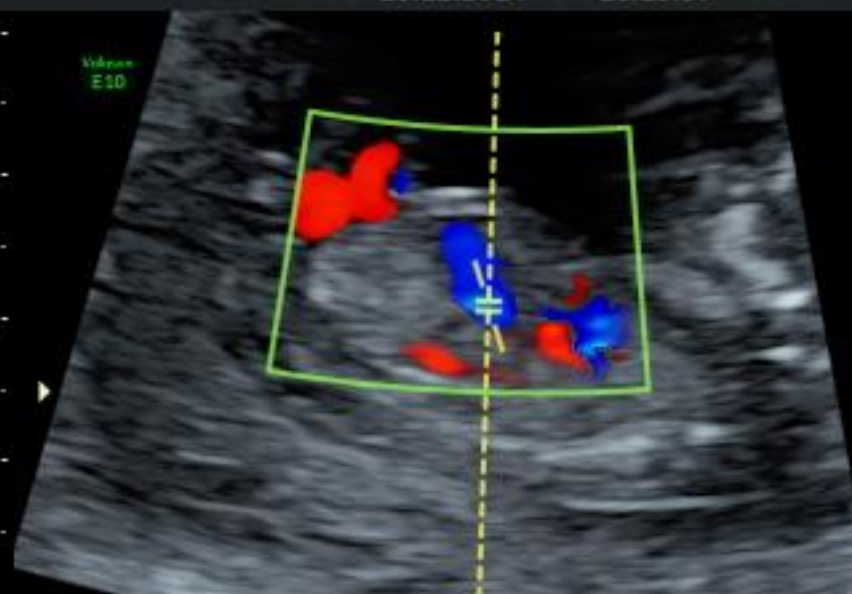
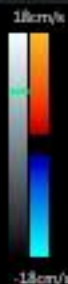
29.12.2014

KOS NPKL

10:19:07

TIs	0.5	RM6C
TIb	0.8	OB
MI	0.5	7.8cm / 1.5
DV-S	-44.43cm/s	
DV-D	-22.70cm/s	
DV-a	-7.73cm/s	
DV-TAmax	-28.51cm/s	
DV-S/a	5.75	
DV-a/S	0.17	
DV-PI	1.29	
DV-PLI	0.83	
DV-PVIV	1.62	
DV-HR	150bpm	

Gn 5  
WMF 90 Hz  
SV Angle 19  
Size 0.7mm  
Depth 54.8mm  
Frq low  
PRF 4.4kHz



Voluson



E8

D00309-12-11-22-1

IC5-9-D/OB

MI 0.4 NKL

6.5cm / 2.8 / 16Hz

TIs 0.4

22.11.2012

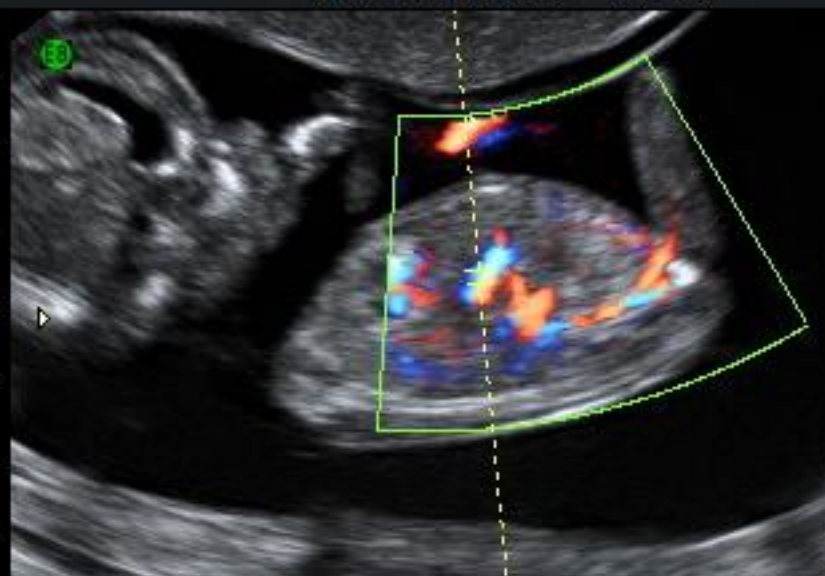
11:16:06 AM

Pwr 95 %  
Gn -7  
WMF 90 Hz  
SV Angle 0  
Size 1.0mm  
Frq mid  
PRF 5.5kHz

8cm/s

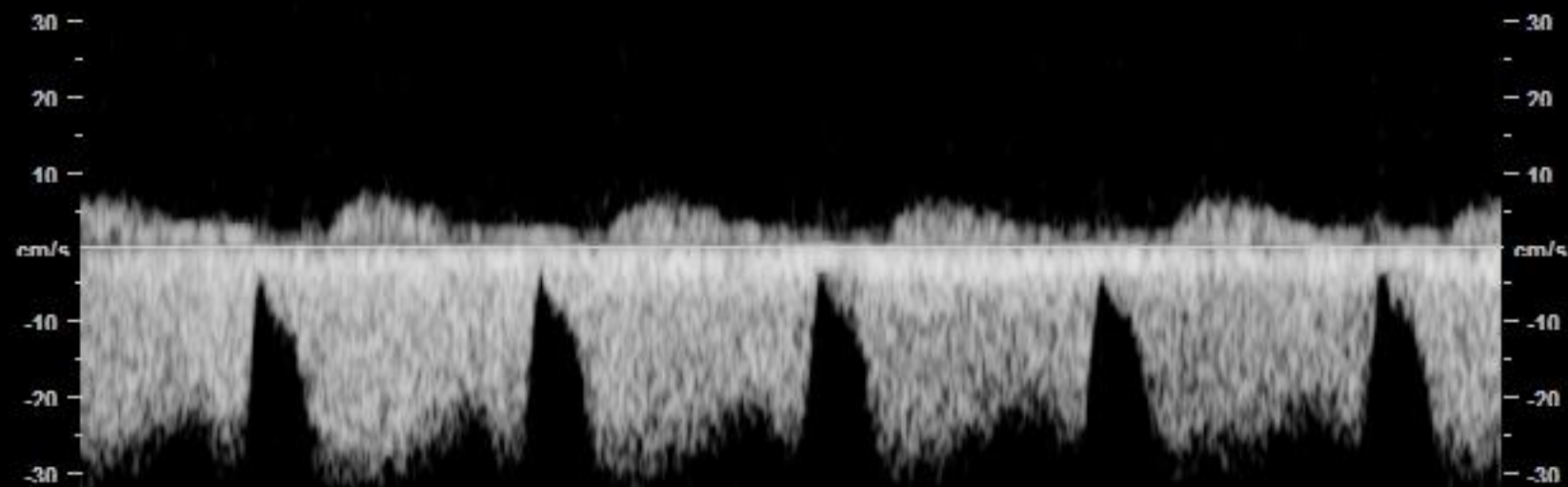


-8cm/s



1.Trim Rout.  
Har-high  
Pwr 94 %  
Gn -1  
C7 / M5  
P3 / E3  
SRI II 3

Pwr 100 %  
Gn -2.2  
Frq mid  
Qual norm  
WMF low1  
PRF 0.9kHz



# Doppler ultrasound

- Exposure to Doppler ultrasound increases temperature because of high intensity and transducer motionless.
- The threshold for irreversible damage of fetal brain is exceeded when an increase of 4 C is maintained for 5 minutes.
- Doppler studies usually are for less than 1 minutes

# How many dimensions do we need?

- 2D
- 3D
- 4D
- 5D
- ?





# 3D ultrasound

- 3D ultrasound is gaining popularity in prenatal diagnosis.
- Post-imaging reconstruction helps in detection of a wide range of anomalies (face, skeleton, extremities)
- Ultra-fast acquisition enables live 3D or real time update of the 3D volume, also know as 4D ultrasound



# Is it 3D/4D ultrasound more dangerous of 2D US

- 40 patients
- Gestational age 31.1+-5.8 (18-40)
- Duration exam (min) 20.1+-9.9 (5-55)
- Duration 3D 2.0+-1.8 (0.3-6)
- Duration 4D 2.2 +-1.2 (1-5)
- Voluson 730 expert, iU22 (Philips)  
Prosoind alfa-10 (Aloka)

– Sheiner E et al Ultrasound Obstet Gynecol  
2007

# Ultrasound bioeffects

Bioeffects	Bmode	3D	4D
• TI	0.28+-0.1	0.27+-0.1	0.24+-0.1
• MI	1.12+-0.1	0.89+-0.2*	1.11+-0.2

– P 0.018.



EB  
Exp

D00309-14-11-25-2

RIC6-12-D/GYN

MI 1.1

NKL

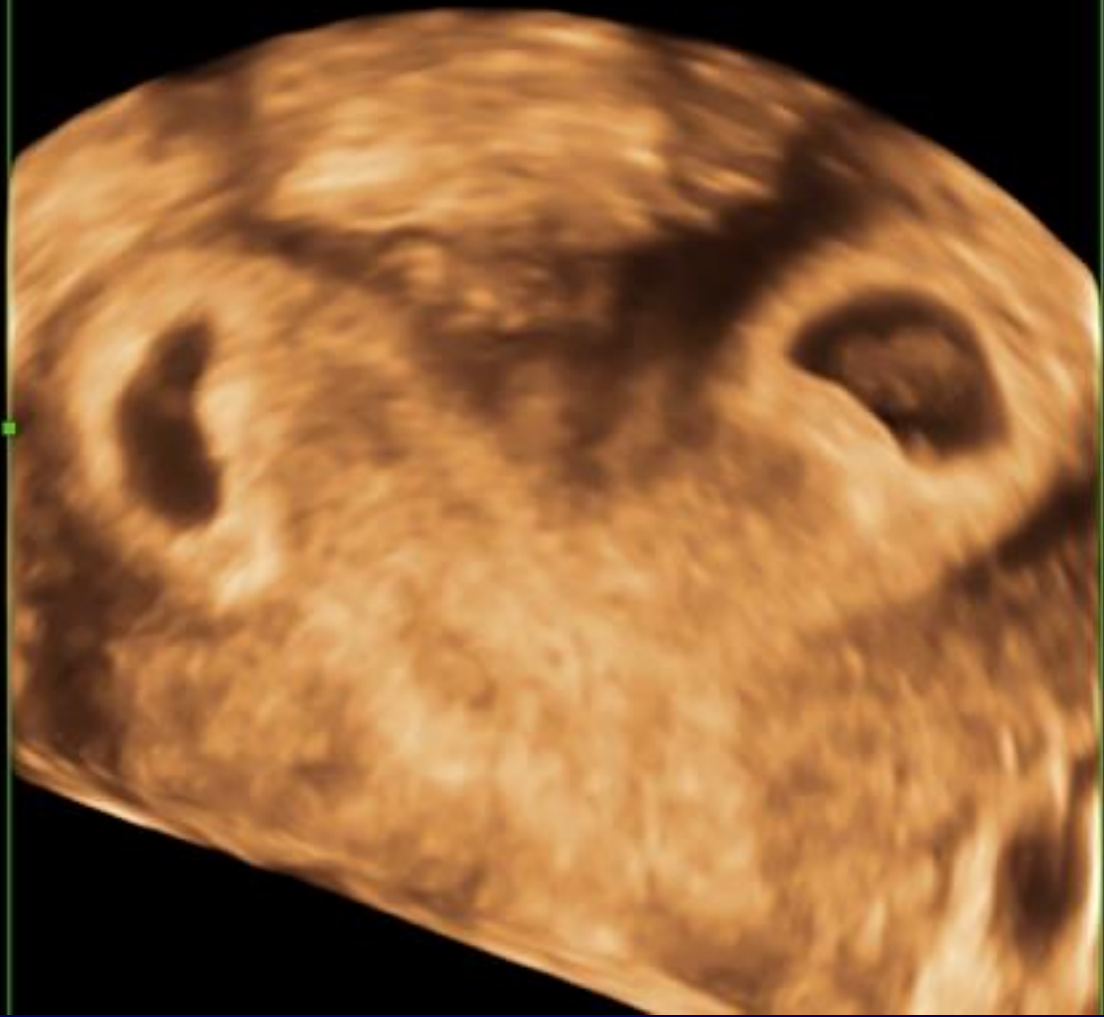
6.2cm / 1.1 / 47Hz

TIs 0.6

25.11.2014

12:56:41PM

Gyn Render  
Th20/Qual max  
B181°/V120°  
Mix100/0  
CRI 3/SRI 3D 1  
3D Static



3D















Voluson™  
E10

HDlive,  
VE10-BT15-0003

TIs 0.2  
TIIb 0.2  
MI 1.1  
RIC6-12-D  
GYN  
4.8cm / 2.0  
B97/V120  
26 Hz  
Default  
Qual high2  
Mix42/58  
VSR1 4  
3D Static

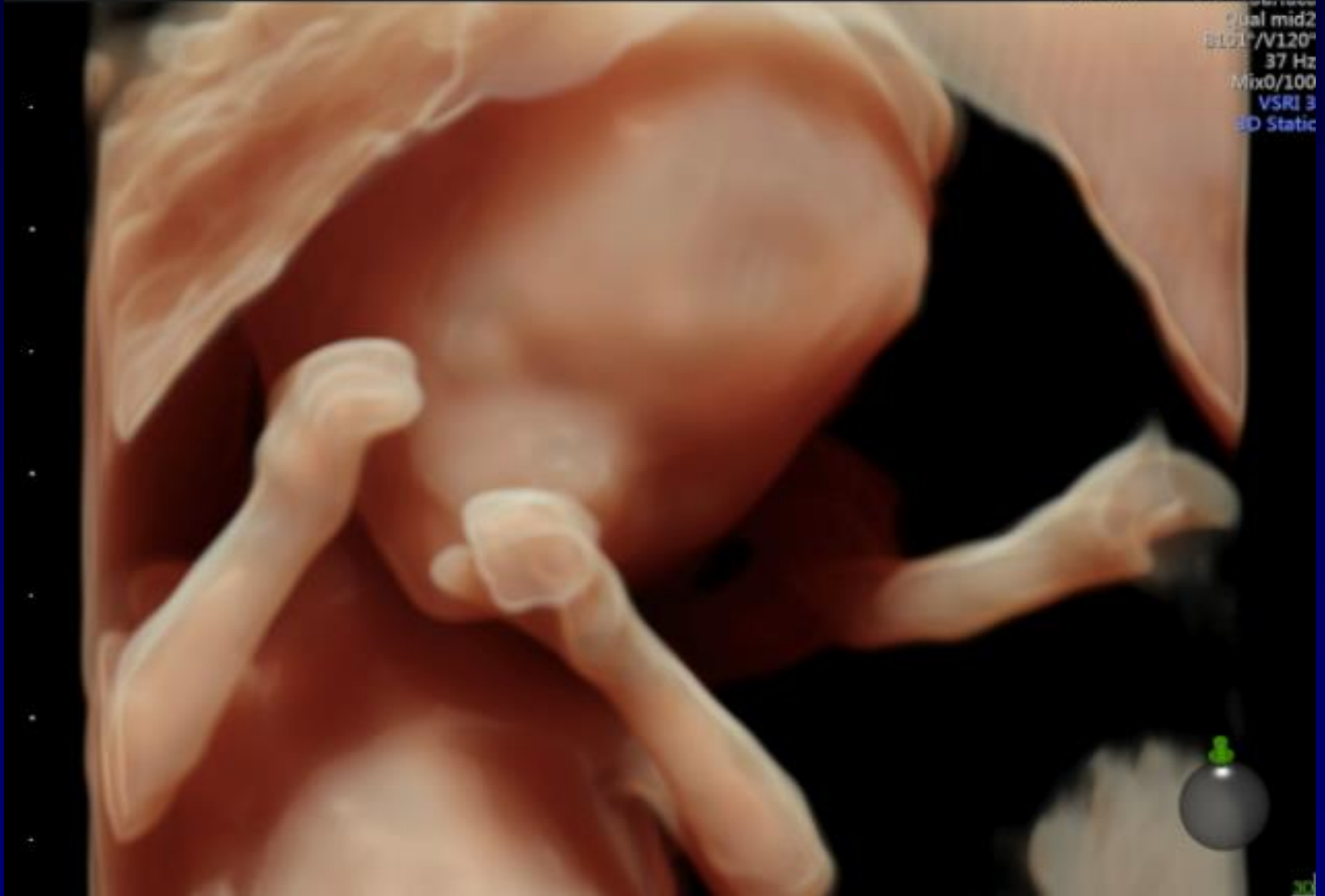




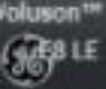
HDlive,  
VE10-BT15-0003  
VCAU-D113-0003

TIa	0.3	RIC6-12-D
TIb	0.3	OB
MI	1.1	5.2cm / 1.5
MI	1.1	5.2cm / 1.5

Dual mid2  
B101°/V120°  
37 Hz  
Mix0/100  
VSRI 3  
3D Static







Poluson™ HDlive.

RM6C/OB

MI 0.9

VE10-BT15-0003

11.1cm / 1.4 / 40.0Hz Tib 0.5

surface bb  
Qual mid2  
B46°/V65°  
Mix86/14  
V-SRI 6  
3D Static



# Conclusion

- 3D/4D scan acoustic output as expressed as MI and TI is comparable to that of 2D scan
- Not clear why MI was lower in 3D
- Lacks clinical significance since cavitation does not occur in mammalian fetuses.
- May the acquisition of a "beautiful" 3D picture increase fetal exposure time to ultrasound?
- Experience operator.

# ALARA

- As Low As Reasonably Achievable