ISUOG Basic Training

Umbilical and Uterine Artery Doppler Studies

Learning objectives

At the end of the lecture you will be able to:

- Describe how to perform, assess and report an umbilical artery doppler examination correctly
- Describe how to perform, assess and report a doppler examination of the uterine arteries correctly

Key questions

1. What technique is required to perform a clinically useful Doppler examination of the umbilical artery ?

2. What are the main pitfalls to be aware of when using Doppler to sample the umbilical artery?

3. What technique is required to perform a clinically useful Doppler examination of both uterine arteries?

4. What are the main pitfalls to be aware of when using Doppler to sample the uterine arteries?

Ultrasound Obstet Gynecol 2013
Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/uog.13208

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RECOMMENDATIONS

ISUOG Education Committee recommendations for basic training in obstetric and gynecological ultrasound

- Umbilical and uterine Doppler

Second and third trimesters

- Determination of fetal position
- Assessment of fetal wellbeing, including fetal movements
- Amniotic fluid volume estimation and conditions associated with abnormal amniotic fluid volume
- Placental assessment, including relation to the internal cervical os
- Standard fetal biometry (biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur diaphysis length (FL)) and estimated fetal weight calculation
- Fetal growth and typical causes of abnormal fetal growth
- Fetal head (intact cranium, head shape, midline falx, cerebral ventricles, cavum septi pellucidi, cerebellum, cisterna magna) and typical anomalies
- Fetal face (orbits, nose and mouth in different planes) and typical anomalies
- Fetal thorax (lung morphology and relationship to heart size) and typical anomalies
- Fetal heart (situs, four-chamber view, outflow tracts, three-vessel view) and typical anomalies
- Fetal abdomen (stomach, liver with umbilical vein, kidneys and urinary bladder, diaphragm, bowel, abdominal wall and cord insertion) and typical anomalies
- Fetal spine in longitudinal and transverse planes and typical anomalies
- Fetal limbs (arms, hands, legs, feet) and typical anomalies
- Umbilical and uterine artery Doppler

ULTRASOUND in Obstetrics & Gynecology

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Published online in Wiley Online Library (wileyonlinelibrary.com). **DOI:** 10.1002/uog.12371

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GUIDELINES

ISUOG Practice Guidelines: use of Doppler ultrasonography in obstetrics

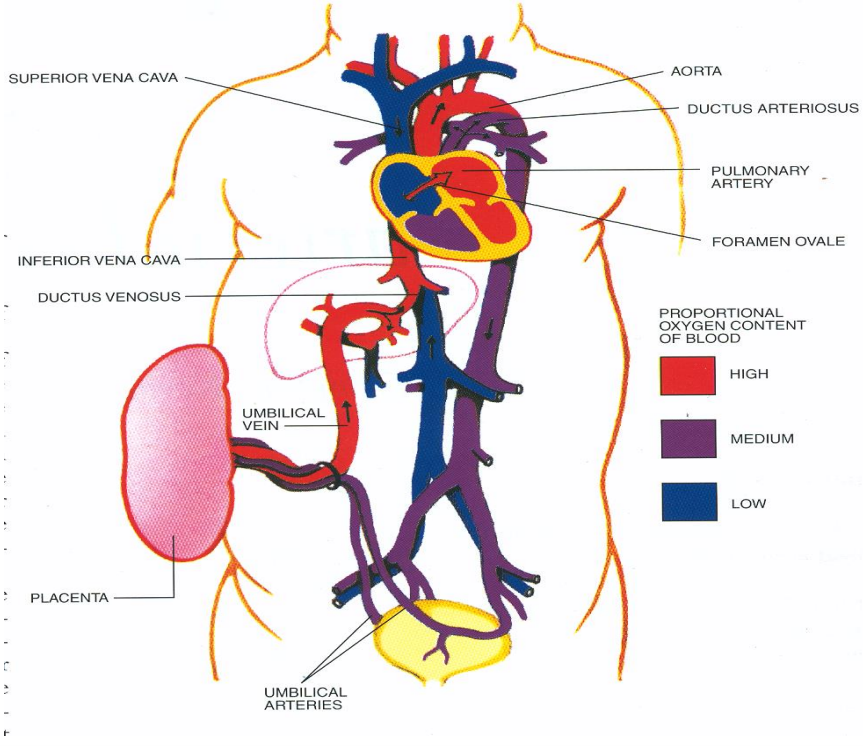
Bhide A, Acharya G, Bilardo CM, Brezinka C, Cafici D, Hernandez- Andrade E, Kalache K, Kingdom J, Kiserud T, Lee W, Lees C, Leung KY, Malinger G, Mari G, Prefumo F, Sepulveda W and Trudinger B. on behalf of the ISUOG Clinical Standards Committee

Some general rules before you start

- Know your US equipment
- Have some knowledge of fluid dynamics
- Have some knowledge of hemodynamics
- Have some knowledge of fetal physiology
- Know what you want to measure
- Know which indices to use
- Know when and when not to use Doppler

Fetal circulation

- High heart rate
- Low blood pressure
- Low peripheral resistance (placenta)
- Placental circulation constant (does not respond to vasoactive substances)
- With advancing gestation fetal BP and arteriolar placental bed flow increase, peripheral resistance decreases

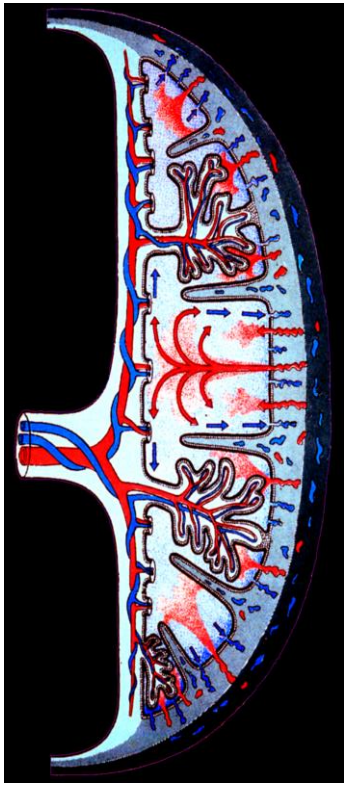


Fetal and maternal vessels

Fetal side

- Umbilical artery
- Middle cerebral artery

- Ductus venosus
- Umbilical vein



Maternal side

- Uterine arteries

Indications for Doppler in pregnancy

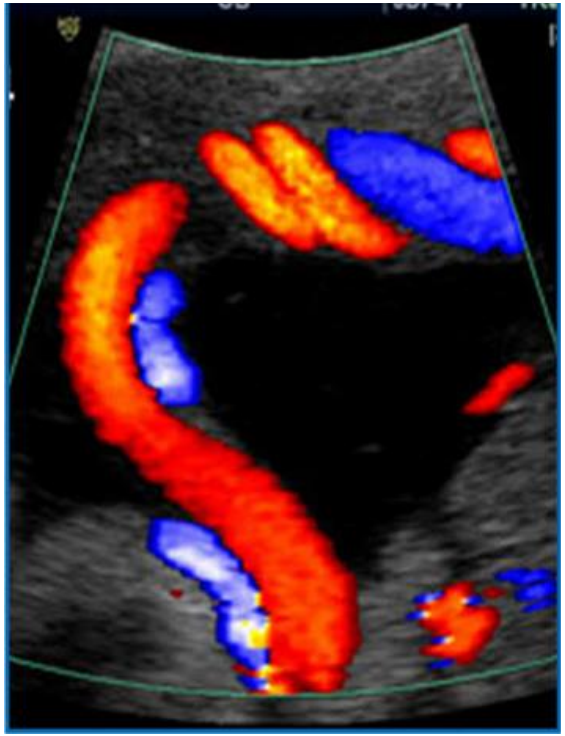
Placentation

- Trophoblast invasion of spiral arteries

Fetal well-being

- Hypoxaemia
- Anaemia
- Chromosomal anomalies (1st trimester)
- Heart anomalies (heart function)
- MC twins
- Placental abruption
- Post-term pregnancies
- Diabetes

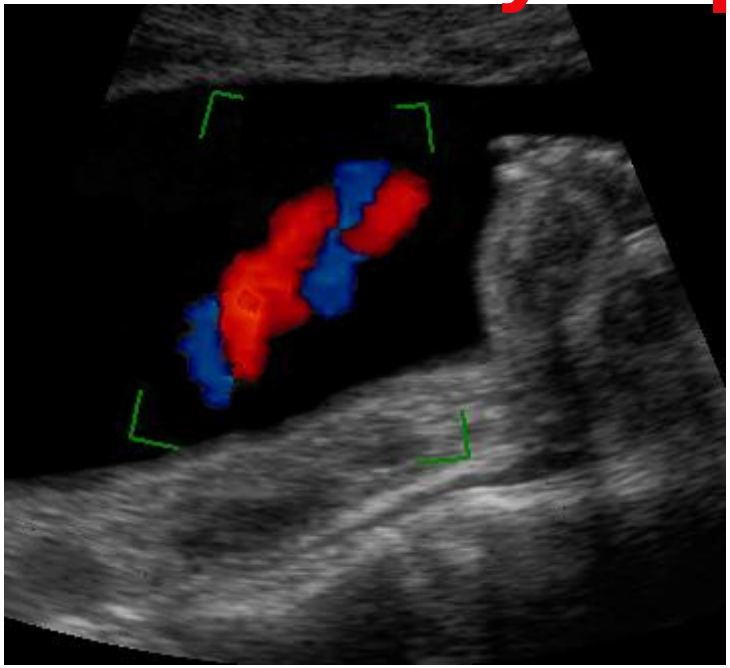
Umbilical artery Doppler



Umbilical artery Doppler

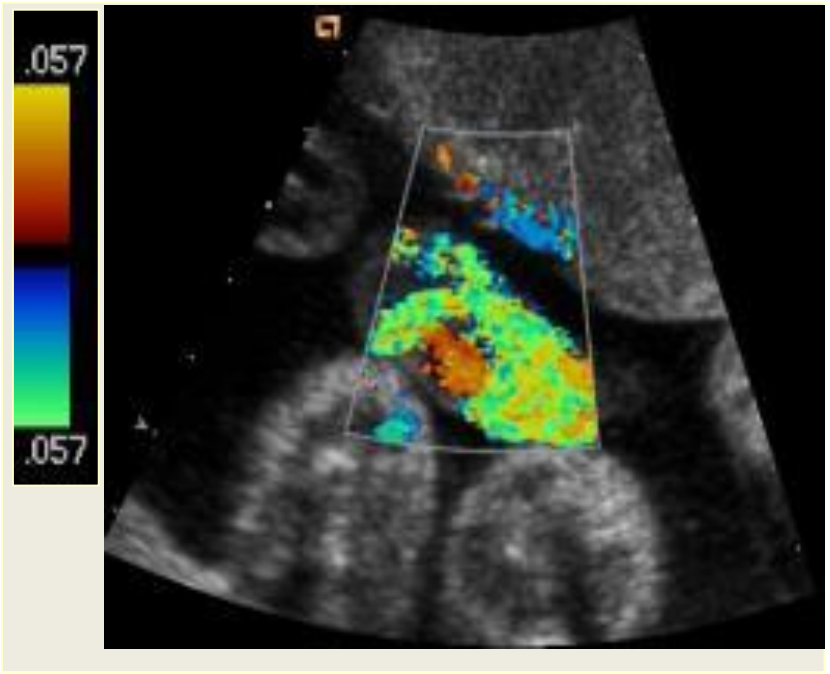
1. Visualise the cord, select a free loop, not too close to the fetal cord insertion or the placental insertion
2. Zoom up/magnify the area of cord

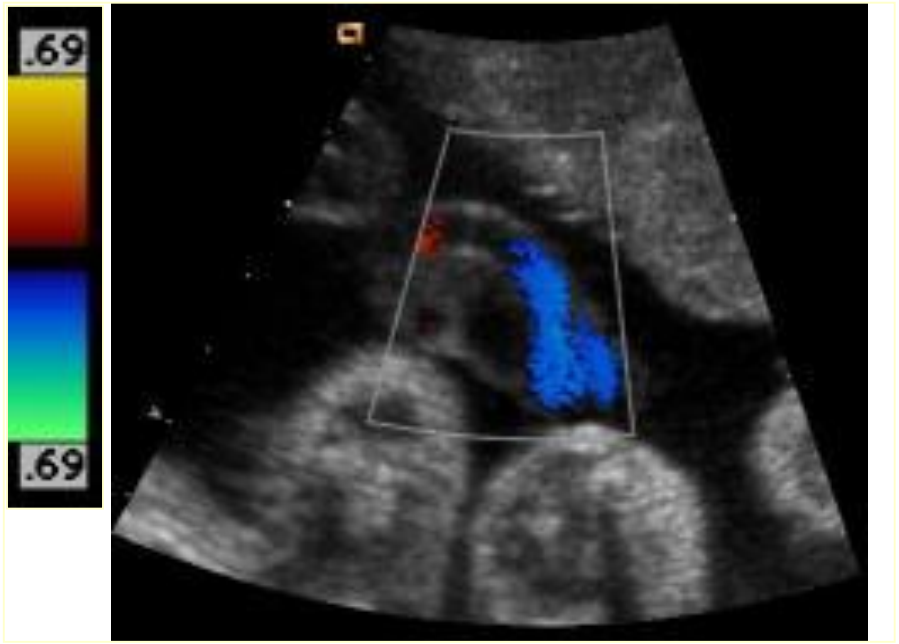
Umbilical artery Doppler



3. Switch on the colour Doppler modality (not compulsory)

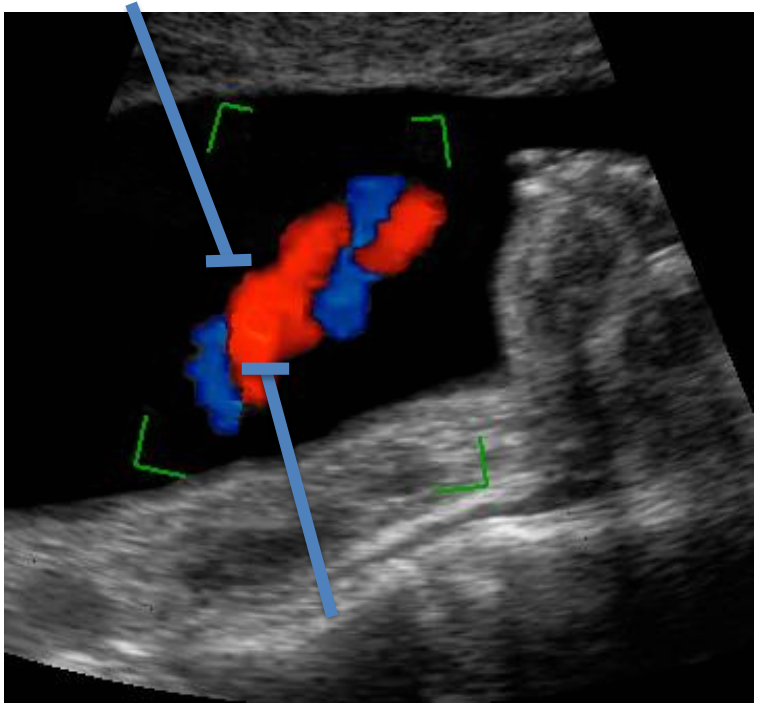
Umbilical artery Doppler





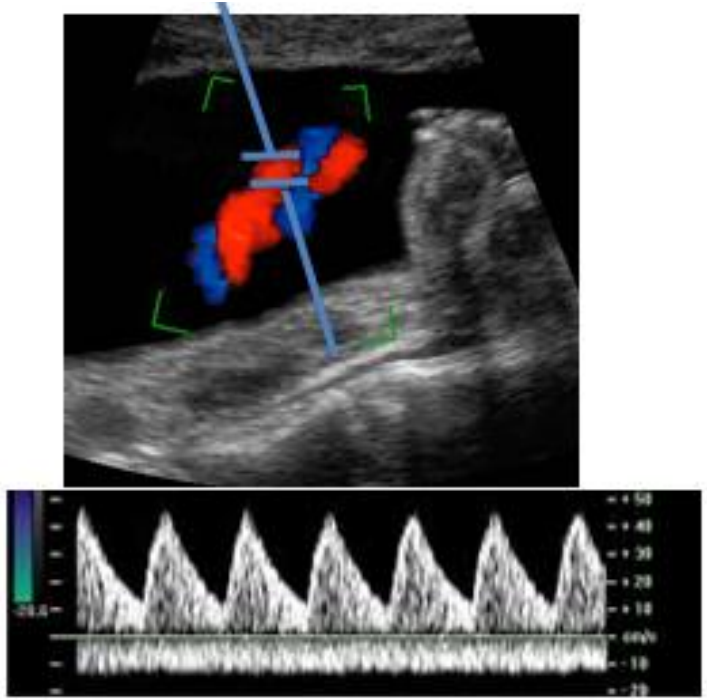
3a. Optimize the colour flow mapping (CFM) scale

Umbilical artery Doppler



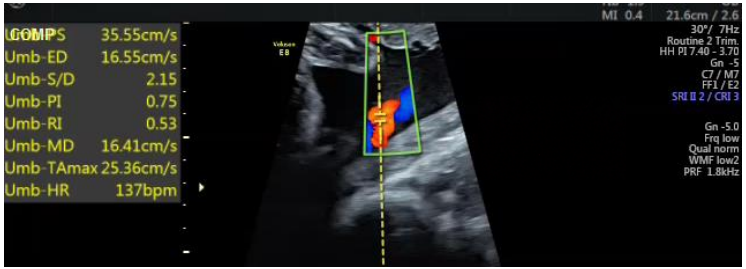
4. Place the sample gate on the umbilical artery

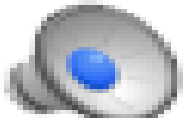
Umbilical artery Doppler

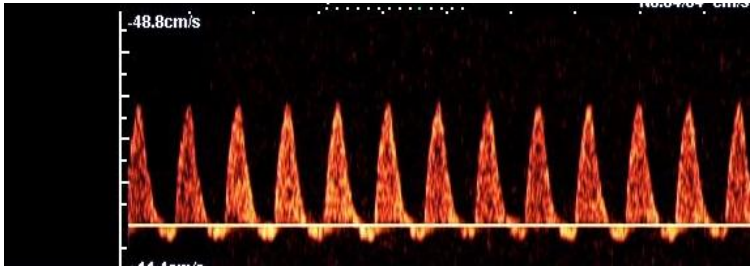


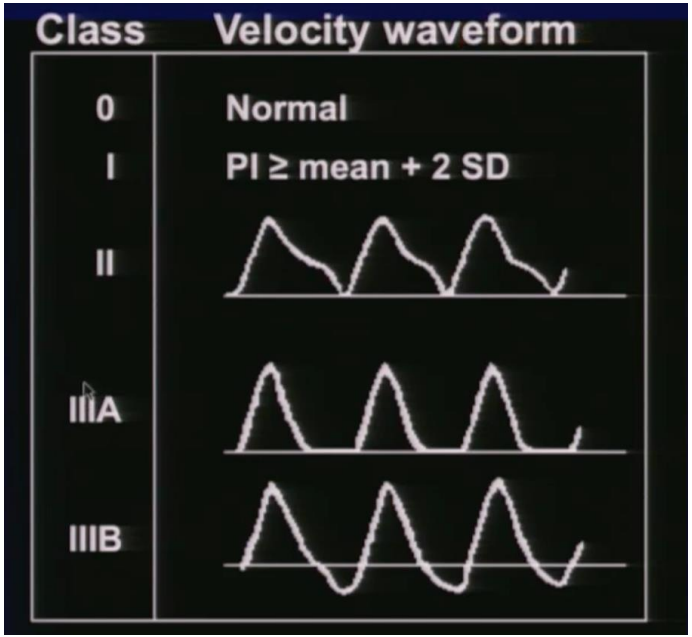
5. Start the pulsed Doppler function

Umbilical artery Doppler



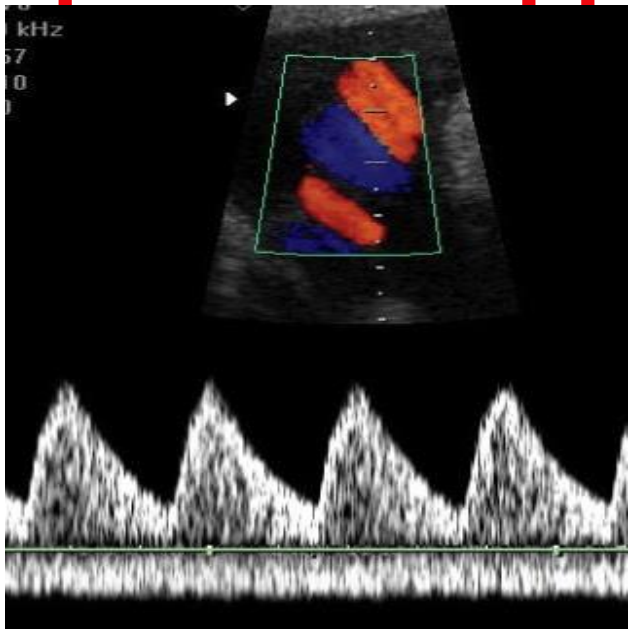






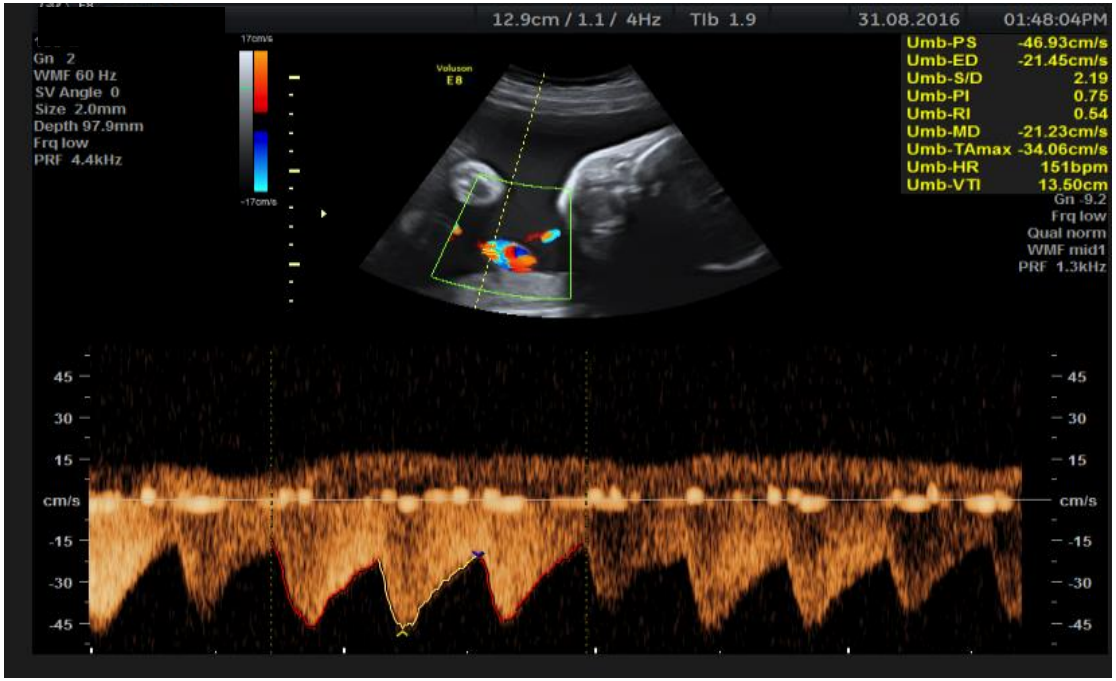
Laurin 1987

2D/pulsed Doppler

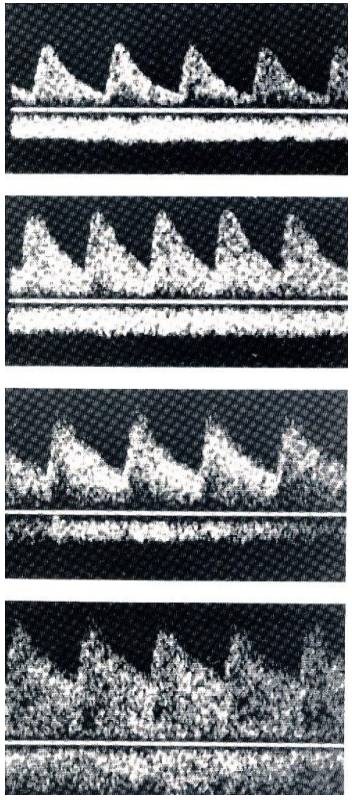


- 2D image in freeze mode provides better Doppler signals

Irregular umbilical artery flow velocity pattern due to fetal breathing movements



Umbilical cord Doppler



16 weeks

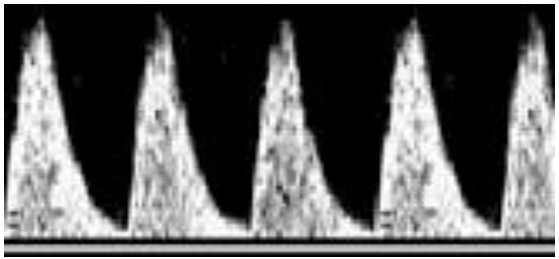
24 weeks

32 weeks

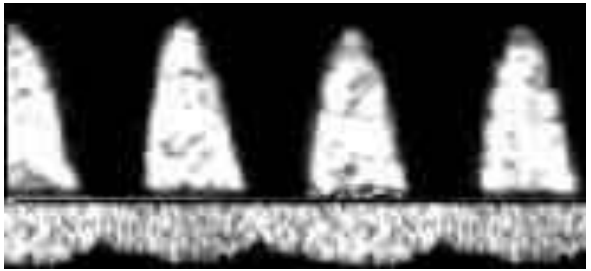
40 weeks

Resistance in the placenta falls progressively with advancing gestation

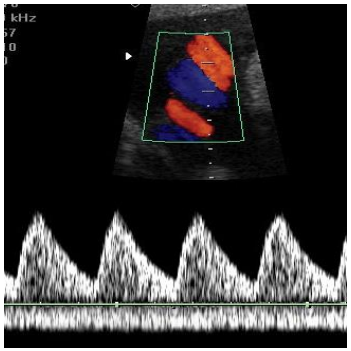
Umbilical artery in pathological pregnancies

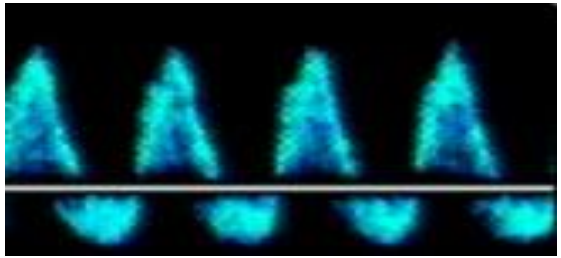


High PI



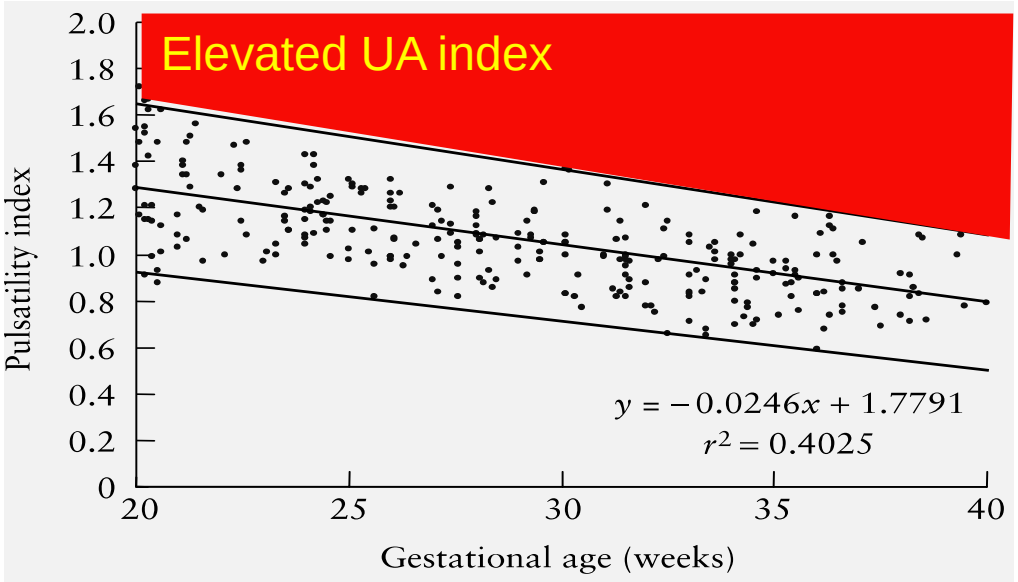
Absent end diastolic flow

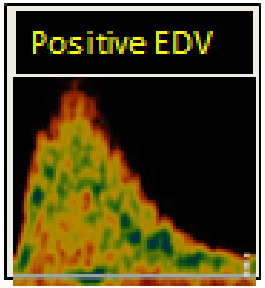




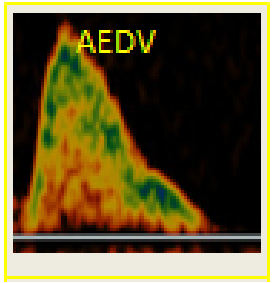
Reversed end diastolic flow

Abnormal UA findings

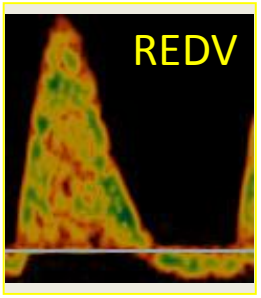




30% of villous vessels are underperfused



50% of villous vessels are underperfused



70% of villous vessels are underperfused

Baschat AA, Gembruch U, UOG 2003; 21: 124-7

Trudinger BJ, Giles WB, Br J Obstet Gynaecol, 1996; 105: 487-9.

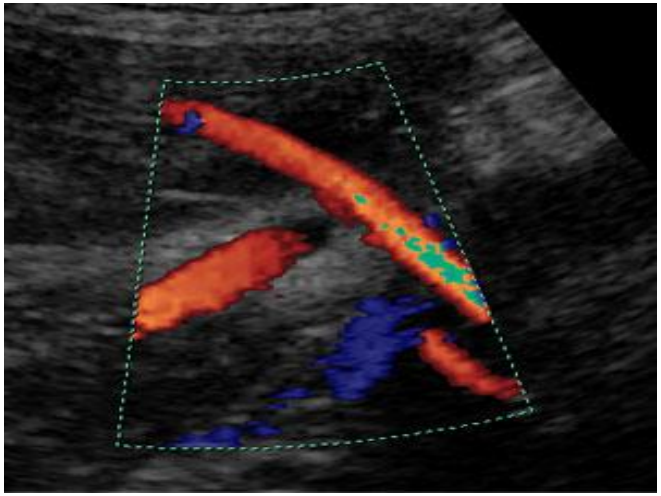
Variation in umbilical artery waveforms

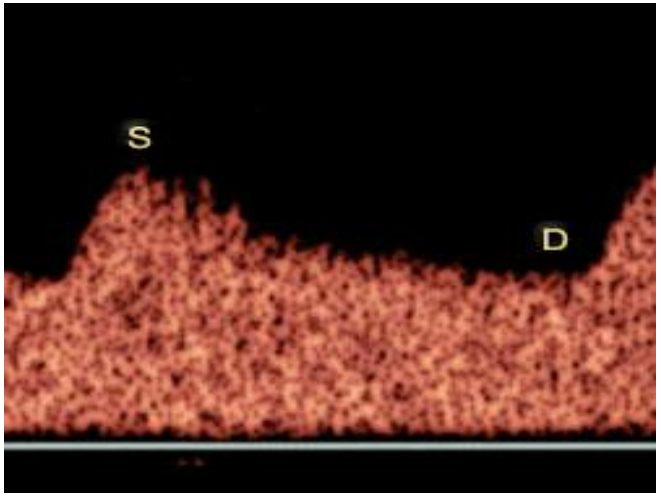
- There is a significant difference in doppler indices when measured at the fetal end, in a free cord loop or at the placental end of the umbilical cord
- For the sake of simplicity and consistency, measurements should be made in a free cord loop
- In multiple pregnancies, and/or when comparing repeated measurements longitudinally, recordings from fixed sites (fetal end, placental end or intra-abdominal portion) may be more reliable
- Reference ranges used should be appropriate for the site of interrogation

When is umbilical artery assessment indicated?

- Reduced fetal growth velocity/fetal growth restriction (FGR)
- MC twins
- Fetal hydrops
- EDF (+ve, absent or reversed) more sensitive than PI

Uterine artery Doppler





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Originally published as Volume 2, Issue 8351

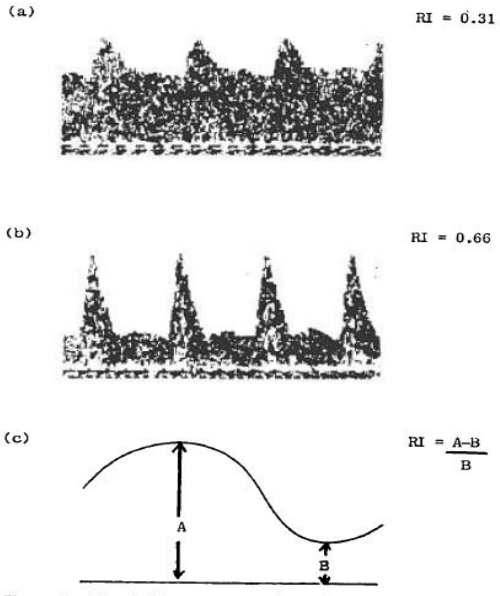


Figure 1. (a) and (b) arcuate artery flow velocity waveforms from two study patients; (c) diagrammatic representation of the resistance index.

New doppler technique for assessing uteroplacental blood flow.

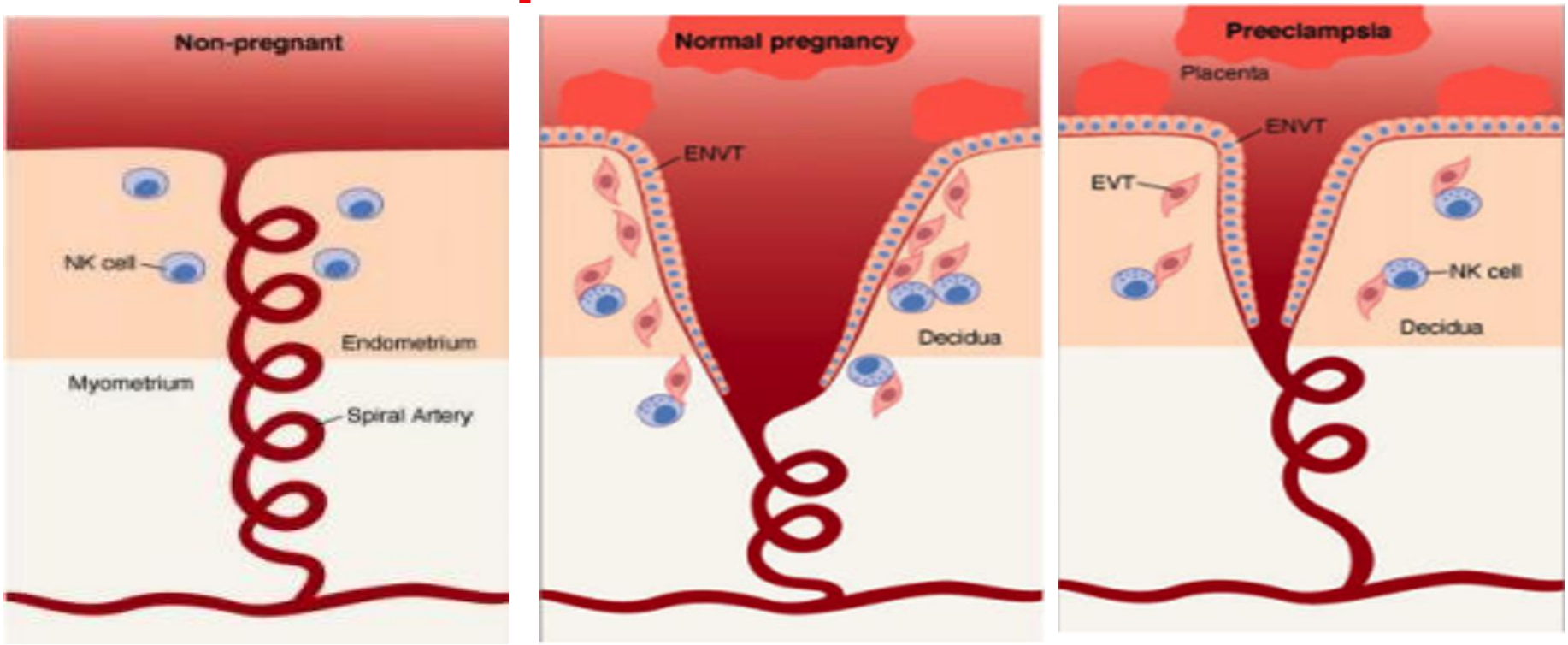
Campbell S, Diaz-Recasens J, Griffin DR, Cohen-Overbeek TE, Pearce JM, Willson K, Teague MJ.

Abstract

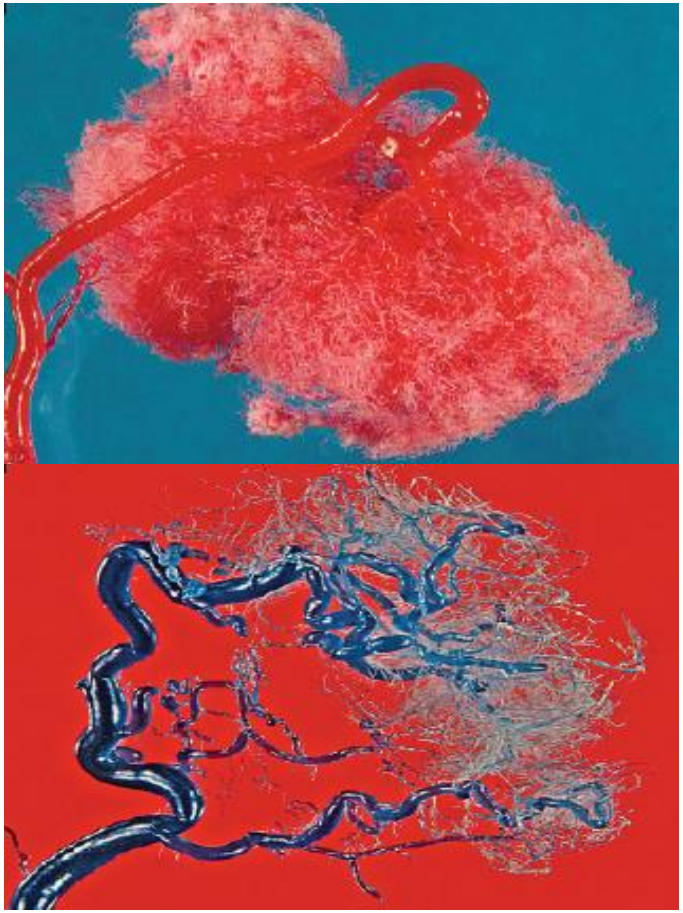
Gated, pulsed, doppler ultrasound was used to study blood flow velocity profiles in the uterine vessels (arcuate arteries) during the second and third trimesters of pregnancy. A frequency index profile nomogram was constructed from 30 normal pregnancies; this demonstrated high diastolic velocity and low pulsatility. Among 31 pregnancies with complications 14 showed waveform changes suggesting raised vascular resistance; these pregnancies were complicated with a high frequency of proteinuric hypertension, poor fetal growth, and fetal hypoxia. This non-invasive technique may give early warning of impaired uteroplacental perfusion and can be used to evaluate methods of improving uterine blood flow.

PMID: 6132039 [PubMed - indexed for MEDLINE]

Trophoblast invasion



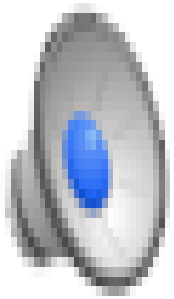
Uterine artery

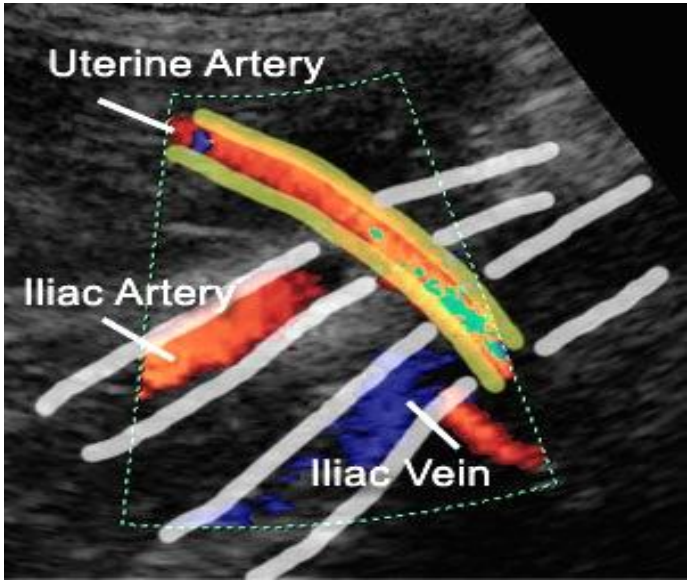


Uterine artery Doppler - technique

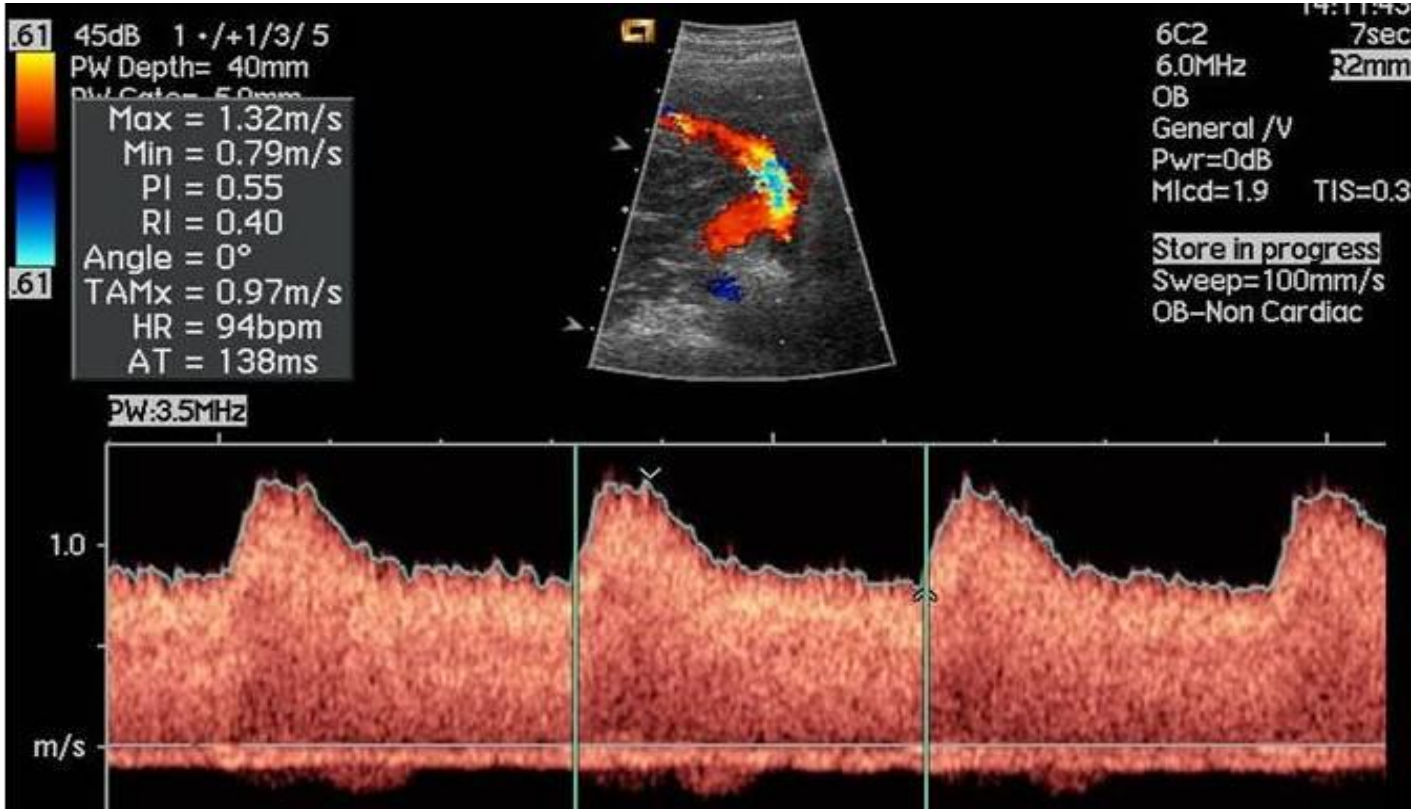
- Trans-abdominally, the probe is placed longitudinally in the lower lateral quadrant of the abdomen, and angled medially
- Colour flow mapping is useful to identify the uterine artery as it appears to cross the external iliac artery
- Sample volume is placed ~1 cm downstream from the crossover point
- If the uterine artery branches before the intersection of the external iliac artery, the sample volume should be placed on the main artery just before the bifurcation

Uterine artery measurement

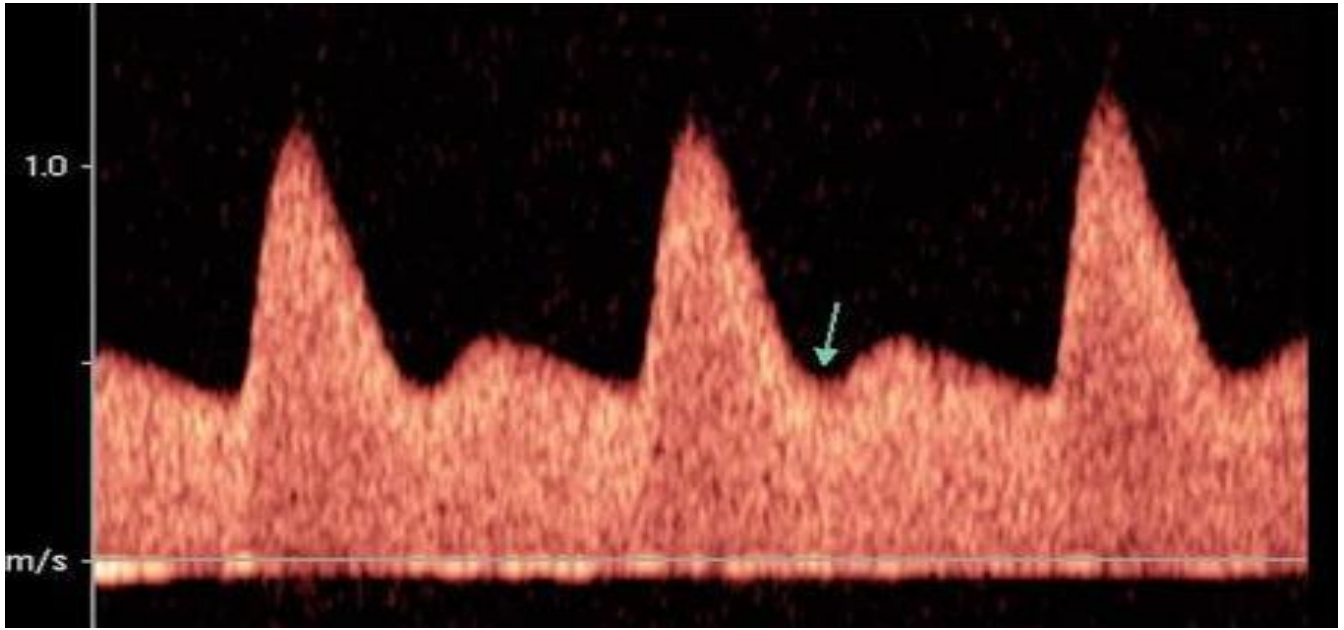




Normal uterine artery waveform

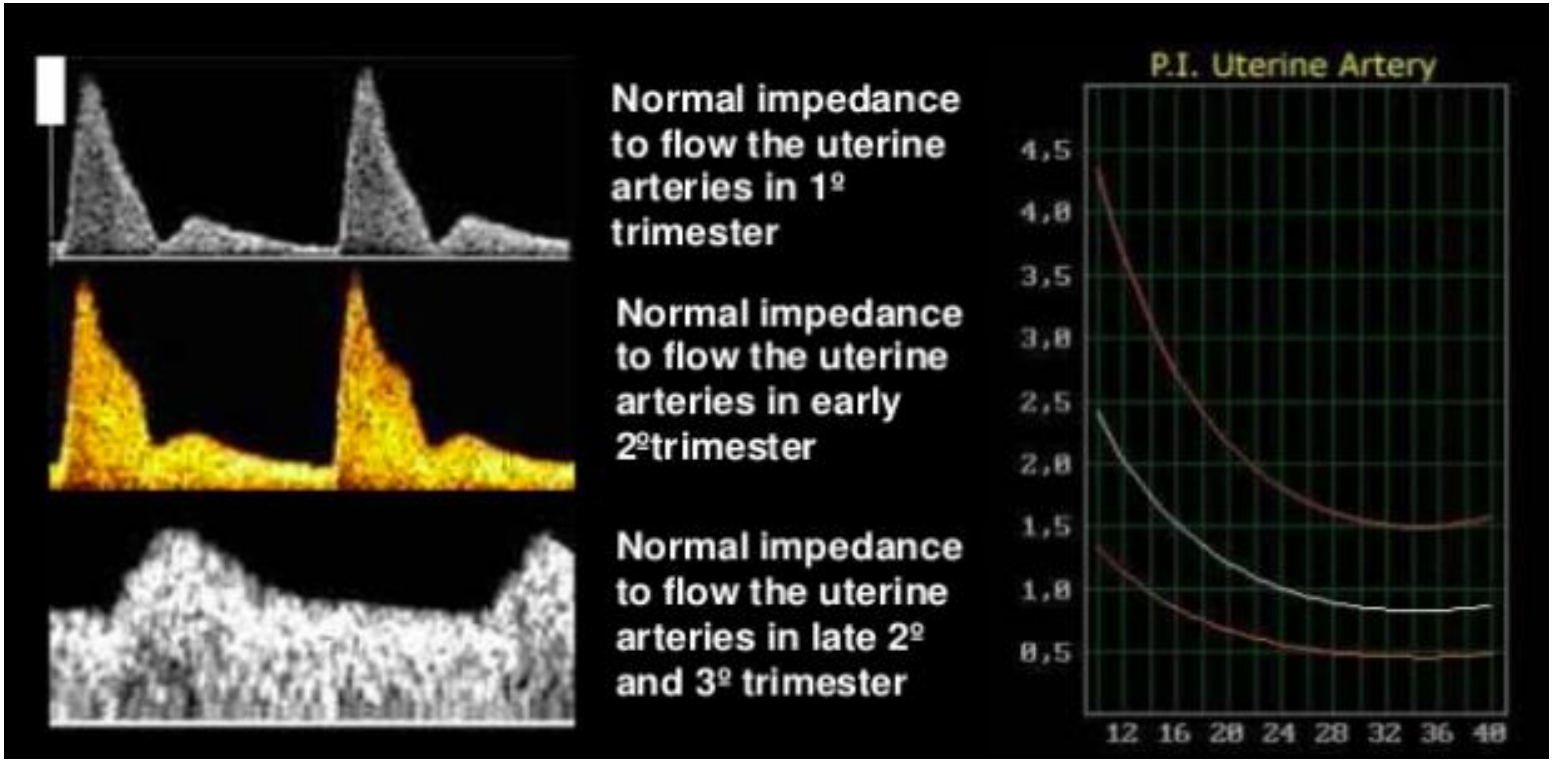


Abnormal uterine artery waveform

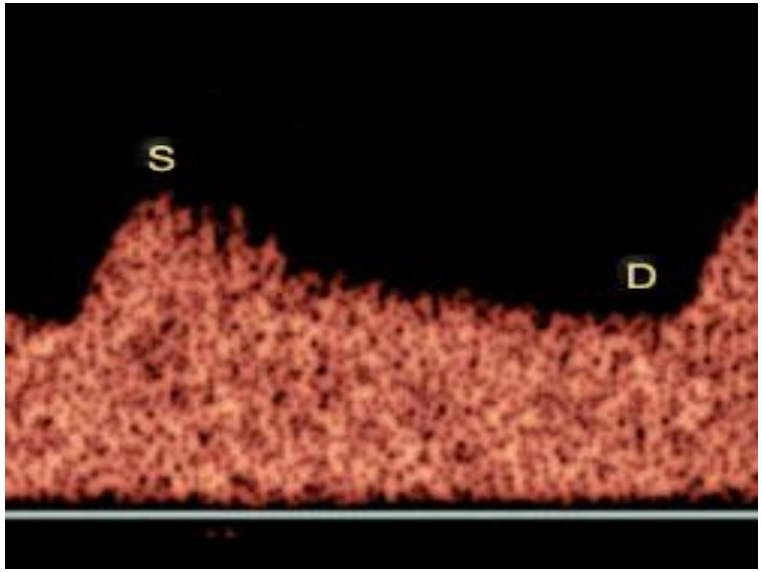


Note notch (arrow) implying increased resistance in the uterine artery

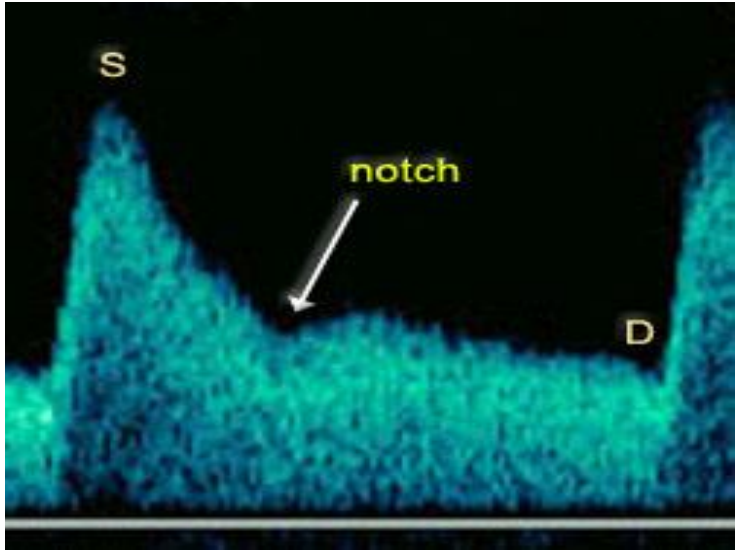
Normal range uterine artery PI



Uterine artery screening at 22-24 wks

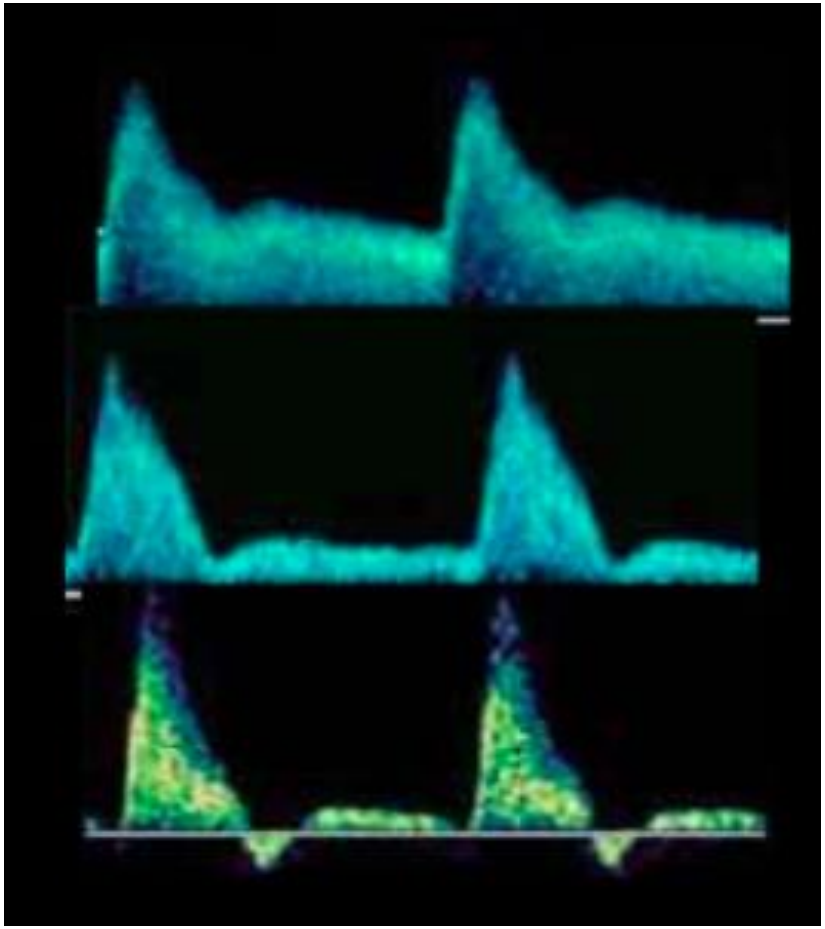


Low risk for PE and IUGR

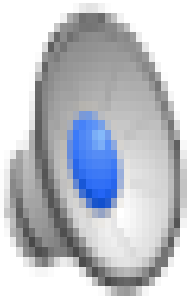


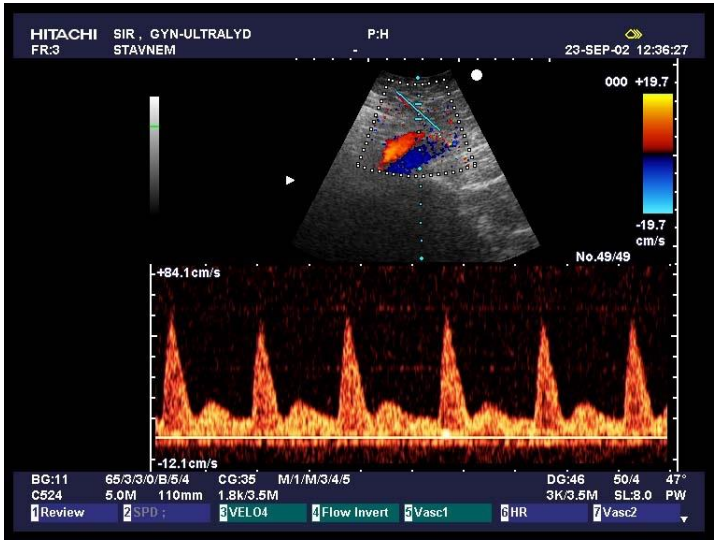
High risk for PE and IUGR

Abnormal uterine artery waveforms after 20-24 weeks

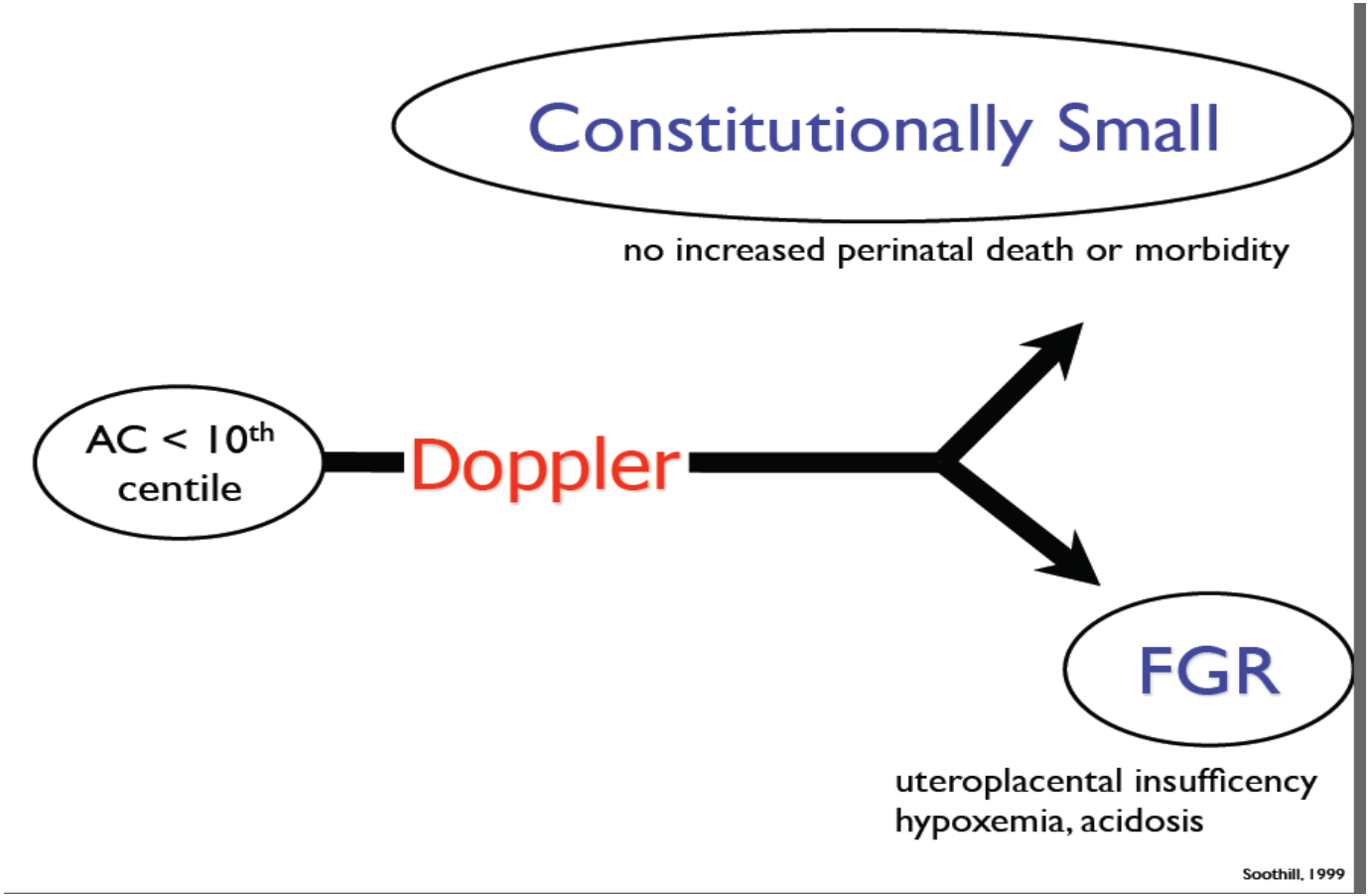


Uterine artery

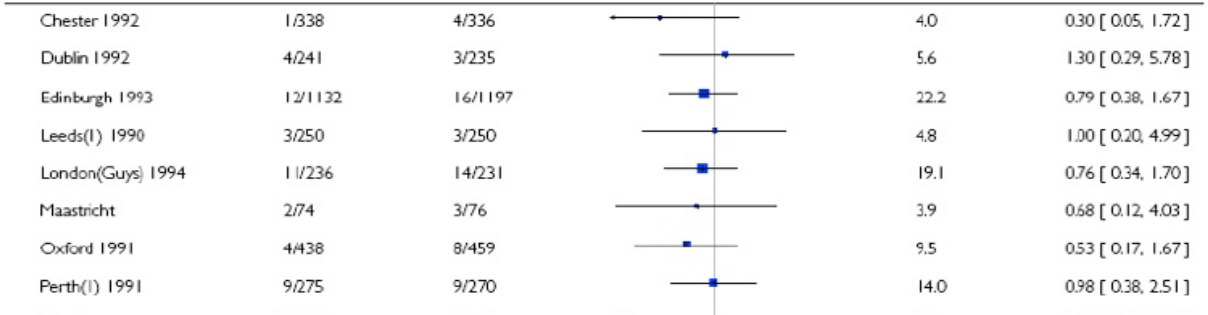




Clinical applications


Constitutionally Small
no increased perinatal death or morbidity
AC < 10th centile
Doppler
FGR
uteroplacental insufficency
hypoxemia, acidosis
Soothill, 1999

Doppler is associated with a 38% reduction in perinatal deaths



Neilson JPThe Cochrane library 2005, Issue 1

When are uterine artery measurements indicated?

- Suspicion of placental insufficiency / FGR
- FGR in previous pregnancy
- Mothers with les, factor v leiden or other factors related to poor placentation

Repeatability of transabdominal uterine artery measurement

Table 1 Studies assessing repeatability of uterine artery Doppler during pregnancy

Reference	n	*Doppler technique*	*Doppler index*	*Repeatability*	*Statistical method*
Intraobserver					
Schulman *et al.* 1986[10]	NR	CW	S/D	4%	NR
Mulders *et al.* 1988[11]	21	PW	PI	6.4%	CV
Gagnon *et al.* 1988[12]	11	CW	S/D	6.1%	CV
Long *et al.* 1988[13]	20	CW	PI	6%	CV
Oosterhof *et al.* 1992[14]	15	PW	PI	10.8%	CV
Bower *et al.* 1993[15]	5	Color	RI	7%	CV
Ferrier *et al.* 1994[16]	5	Color	RI	4%	CV
Weissman *et al.* 1995[8]	20	TV, CW	S/D	5%	CV
Chan *et al.* 1995[17]	9	CW	RI	5.9%	CV
Harrington *et al.* 1997[18]	10	TV, Color	PI	2.6%	CV
Liberati *et al.* 1997[19]	5	Color	RI	5.1%	CV
Interobserver					
Trudinger *et al.* 1985[20]	10	CW	S/D	No difference	CV
Schulman *et al.* 1986[10]	NR	CW	S/D	4%	NR
Mulders *et al.* 1988[11]	13	PW	PI	11.1%	CV
Oosterhof *et al.* 1992[14]	10	PW	PI	10.1%	CV
Bower *et al.* 1993[21]	10	CW	RI	−0.24 to 0.28	95% prediction interval
Bewley *et al.* 1993[22]	20	CW	RI	−0.18 to 0.22	95% prediction interval
Ferrier *et al.* 1994[16]	8	Color	RI	6.6%	CV
Yan *et al.* 1995[23]	20	Color	RI	−0.24 to 0.16	95% prediction interval
Weissman *et al.* 1995[8]	20	TV, CW	S/D	8%	CV
Chan *et al.* 1995[17]	8	CW	RI	13.6%	CV
Liberati *et al.* 1997[19]	10	Color	RI	7.4%	CV

NR, not reported; CW, continuous wave; PW, pulsed wave; Color, color-flow Doppler; TV, transvaginal; S/D, systolic/diastolic ratio; PI, pulsatility index; RI, resistance Index; CV, coefficient of variation.

Papageorghiou et al UOG 2001

The Journal of Maternal–Fetal and Neonatal Medicine 2002;12:78–88

Second-trimester uterine artery Doppler screening in unselected populations: a review

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Harris

Table 2 Results of uterine artery Doppler screening studies for the prediction of pre-eclampsia, providing data on the definition of pre-eclampsia used, screen-positive rate, prevalence, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV)

Reference	Screen-positive rate (%)	Prevalence (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aquilina *et al.*, 2001[30]	9.8	5.5†	60	93	33	98
Papageorghiou *et al.*, 2001[31]	5.1	1.4†	41	95	12	99

*Blood pressure ≥ 140/90 and proteinuria > 150 mg/24 h
†Blood pressure ≥ 140/90 and proteinuria > 300 mg/24 h
‡Blood pressure rise (systolic > 30 mmHg and diastolic > 25 mmHg) with proteinuria > 500 mg/24 h

Increased impedance to flow in the uterine arteries in pregnancies attending for routine antenatal care identifies approximately 40% (L.R. 6) of those who subsequently develop PE and approximately 20%(L.R. 3,5) of those who develop fetal growth restriction

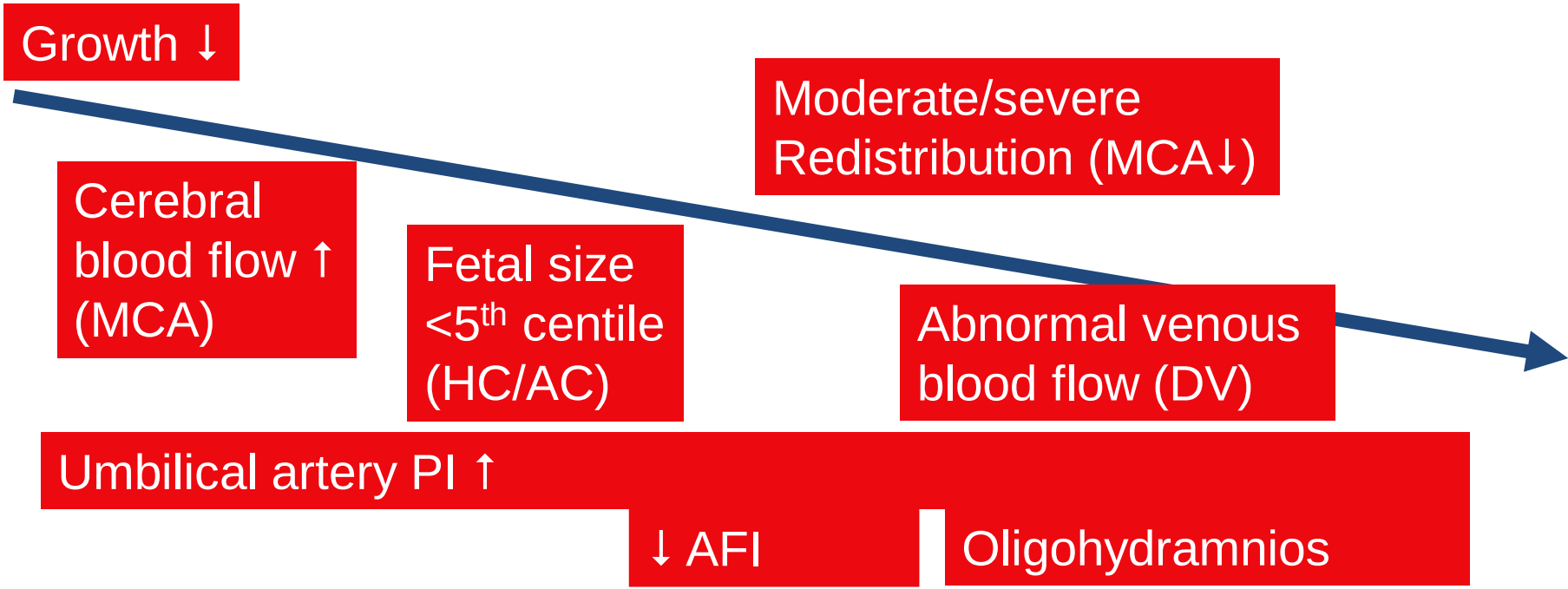
Pre-eclampsia screening

Table 1: Pooled and single estimates for uterine artery Doppler ultrasonography in predicting pre-eclampsia in patients at low risk or unspecified risk, by Doppler index, trimester and severity of pre-eclampsia

Doppler index*	No. of studies	No. of women	Sensitivity (95% CI), %	Specificity (95% CI), %	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)
Second trimester						
Overall pre-eclampsia						
Resistance index (> 0.58 or 90th centile)	11	3 778	74 (62-86)	79 (71-87)	3.5 (2.2-4.8)	0.33 (0.18-0.48)
Resistance index (> 0.70 or 95th centile)	1	346	41 (18-67)	88 (84-91)	3.4 (1.7-5.7)	0.67 (0.42-0.90)
Pulsatility index	7	38 230	42 (25-58)	91 (86-96)	4.5 (1.7-7.3)	0.64 (0.47-0.82)
Bilateral notching	17	36 969	43 (26-60)	93 (90-97)	6.5 (4.3-8.7)	0.61 (0.44-0.79)
Unilateral notching	6	8 016	39 (23-55)	92 (88-95)	4.6 (1.3-7.9)	0.67 (0.48-0.86)
Any notching	8	4 205	74 (60-87)	84 (76-92)	4.6 (2.0-7.3)	0.31 (0.15-0.48)
Resistance index or notching	7	8 151	79 (62-95)	83 (73-92)	4.5 (2.6-6.5)	0.26 (0.08-0.44)
Resistance index and notching	5	1 654	72 (48-96)	87 (79-96)	5.6 (3.1-8.1)	0.32 (0.07-0.58)
Pulsatility index or notching	2	18 563	47 (44-51)	92 (88-96)	5.7 (2.9-8.4)	0.57 (0.53-0.62)
Pulsatility index and notching	1	1 757	23 (14-35)	99 (98-99)	7.5 (5.4-10.2)	0.59 (0.47-0.71)
S/D ratio	2	672	76 (68-84)	71 (62-80)	2.6 (1.8-3.5)	0.34 (0.22-0.46)
A/C ratio	3	1 284	74 (62-86)	82 (71-92)	4.0 (2.4-5.7)	0.32 (0.20-0.43)
Notch index	2	819	12 (9-15)	86 (81-90)	0.8 (0.5-1.2)	1.00 (0.96-1.10)
S/D or notching	2	1 083	28 (18-37)	88 (84-92)	2.4 (1.2-3.5)	0.82 (0.70-0.94)

Cnossen JS et al 2008

Uteroplacental failure
- sequential well being changes



Take home messages

- Doppler investigations give insight into fetal and pregnancy patho-physiology
- Doppler is one of the major breakthroughs in Fetal Medicine
- Doppler can be used in all trimesters for different indications
- It can be used as a screening or a diagnostic tool, according to the circumstances
- In the 2nd and 3rd trimesters it can indicate abnormal placentation, fetal hypoxemia, fetal anemia and impending heart failure
- Operators should use it skillfully and with knowledge of its potentials, limitations and dangers