胎兒健康評估

台中榮總婦產部
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台灣95-102年胎兒死亡危險因子

Arch Gynecol Obstet. 2019 Apr;299(4):961-967

Variables	Univariate analysis		Multivariable analysis	
	OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
Maternal age				
≤ 20	1.39 (1.18–1.64)	< 0.001	0.91 (0.77–1.08)	0.301
21–34	Reference		Reference	
35–40	1.38 (1.26–1.52)	< 0.001	1.28 (1.16–1.41)	< 0.001
≥ 41	2.31 (1.87–2.86)	< 0.001	1.79 (1.45–2.22)	< 0.001
Taiwanese origin	1.07 (0.95–1.20)	0.283	NA	
Female Newborn	1.13 (1.06–1.20)	< 0.001	1.08 (1.01–1.15)	0.022
Gestational-age weight				
[redacted]	7.19 (6.70–7.72)	< 0.001	[redacted] (5.89–6.81)	< 0.001
AGA	Reference		Reference	
LGA	1.65 (1.47–1.85)	< 0.001	1.52 (1.36–1.71)	< 0.001
Single	2.80 (2.56–3.06)	< 0.001	2.40 (2.19–2.63)	< 0.001
[redacted]	7.22 (6.39–8.16)	< 0.001	[redacted] (3.32–4.31)	< 0.001
[redacted]	3.07 (2.53–3.73)	< 0.001	[redacted] (1.67–2.51)	< 0.001
Anemia	1.96 (1.52–2.53)	< 0.001	1.65 (1.27–2.14)	< 0.001
Heart disease	1.99 (1.21–3.25)	0.006	1.03 (0.62–1.69)	0.916
[redacted]	6.51 (4.86–8.72)	< 0.001	[redacted] (1.82–3.33)	< 0.001

表 2-12：105 ～ 111 年度胎兒死亡審定救濟案件原因分析

事故原因	案件次（註 1）	百分比（註 2）
不明原因死胎（子宮內胎兒死亡）	322	39.7%
臍繞頸 / 臍帶異常 / 臍帶意外事故	222	27.4%
胎盤早期剝離	168	20.7%
高血壓 / 妊娠高血壓	110	13.6%
胎盤功能不全	98	12.1%
糖尿病 / 妊娠糖尿病	59	7.3%
胎兒窘迫	50	6.2%
感染	21	2.6%
前置胎盤	16	2.0%
子宮破裂	13	1.6%
胎兒生長遲滯	10	1.2%

註 1：生產事故案件大多為多重原因導致之結果，「案件次」之統計為複選。
註 2：以 105 ～ 111 年度胎兒死亡審定救濟案件數為母數計算。（N = 811）

Indications for antepartum surveillance

- Diabetes – Preexisting or gestational diabetes treated with pharmacotherapy.
- Hypertensive disorders – Chronic hypertension or pregnancy-related hypertension.
- Fetal growth restriction
- Twin pregnancy
- Postterm pregnancy
- Decreased fetal activity
- Systemic lupus erythematosus
- Antiphospholipid syndrome
- Oligohydramnios or polyhydramnios
- Prior fetal demise
- Preterm prelabor rupture of membranes

ACOG Committee Opinion, Number 828.

Factors associated with an increased risk of stillbirth and suggested strategies for antenatal fetal surveillance after viability ACOG Committee Opinion, Number 828.

Factor	Suggested gestational age to begin antenatal fetal surveillance	Suggested frequency of antenatal fetal surveillance
Maternal		
s		
Poorly controlled or with associated medical conditions	At diagnosis¶	Individualized
Gestational hypertension/preeclampsia		
Without severe features	At diagnosis¶Δ	Twice weekly
With severe features	At diagnosis¶Δ	Daily
Gestational, poorly controlled	32 0/7 weeks	Twice weekly
Pregestational	32 0/7 weeks¥	Twice weekly
s		
Complicated‡	At diagnosis¶	Individualized
	†	
Sickle cell disease		
Uncomplicated	32 0/7 weeks	Once or twice weekly
Complicated**	At diagnosis¶	Individualized
Hemoglobinopathies other than Hb SS disease	Individualized	Individualized
Renal disease (Cr greater than 1.4 mg/dL)	32 0/7 weeks	Once or twice weekly
Thyroid disorders, poorly controlled	Individualized	Individualized
In vitro fertilization	36 0/7 weeks	Weekly
Substance use		
Alcohol, 5 or more drinks per week	36 0/7 weeks	Weekly
Polysubstance use	Individualize	Individualized
Prepregnancy BMI		
Prepregnancy BMI 35.0 to 39.9 kg/m^2	37 0/7 weeks	Weekly

Fetal Behavioral States

- State 1F: quiet sleep (analogous to NREM)
  -quiescent state; 20-40 min; 25-30%

- State 2F: active sleep(analogous to REM)
  -frequent body movements, continuous eye movements,
  40-58%

- State 3F: quiet awake
  -continuous eye movements, absence of body movements

- State 4F: awake state
  -vigorous body movement continuous eye movements,
  9%

Fetal Assessment Techniques

- Contraction stress test
- Nonstress test
- Biophysical profile (BPP)
- Modified BPP (mBPP)
- Doppler velocimetry
  - Umbilical artery
  - Middle cerebral artery
  - Precordial vein-ductus venosus

Contraction stress test

- Based on the fetal response to a transient oxygen reduction during uterine contractions

  => fetal hypoxemia paO_2 <20 mmHg; late deceleration

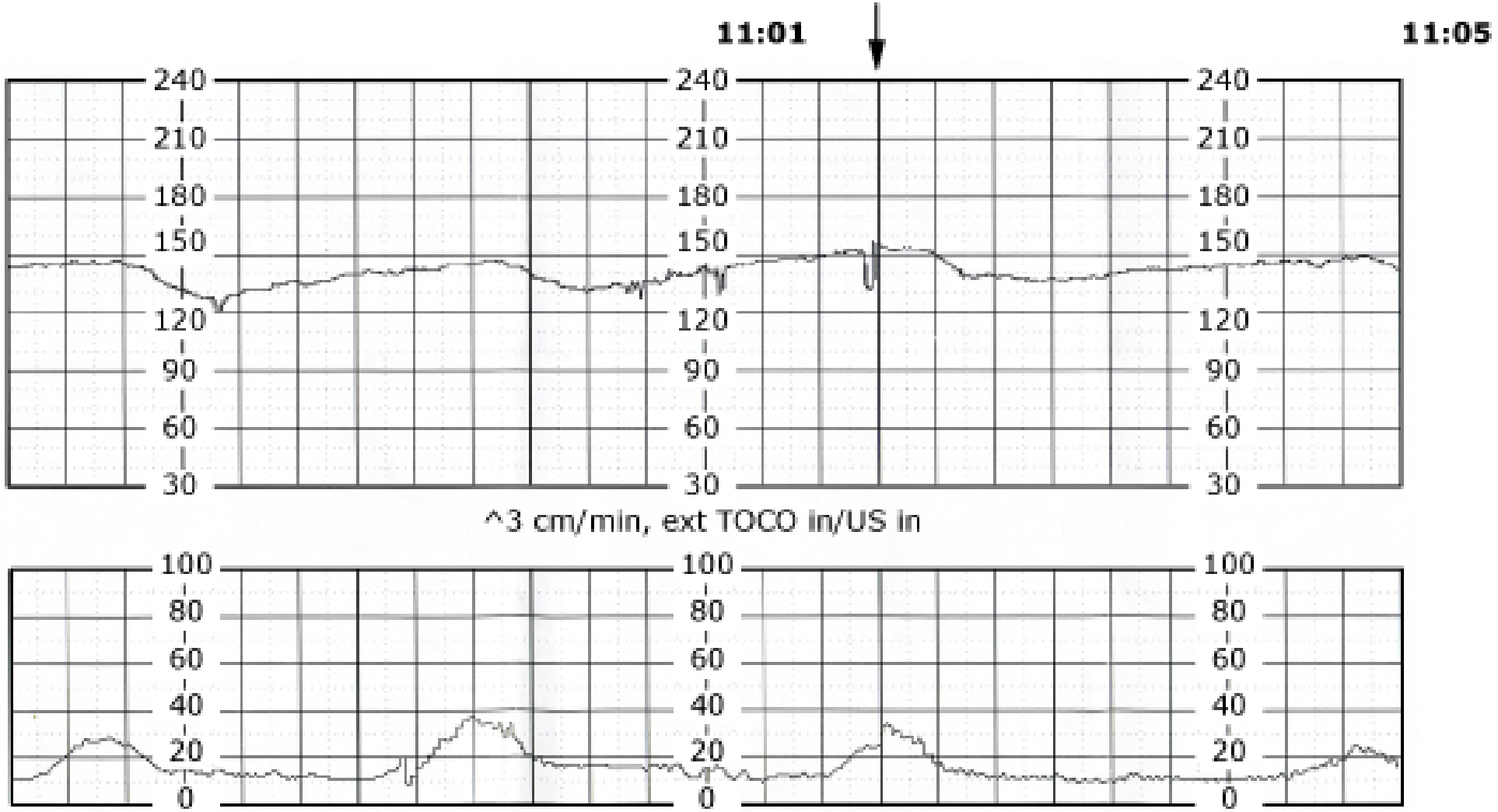
- At least 3 uterine contractions in 10 minutes

  spontaneous

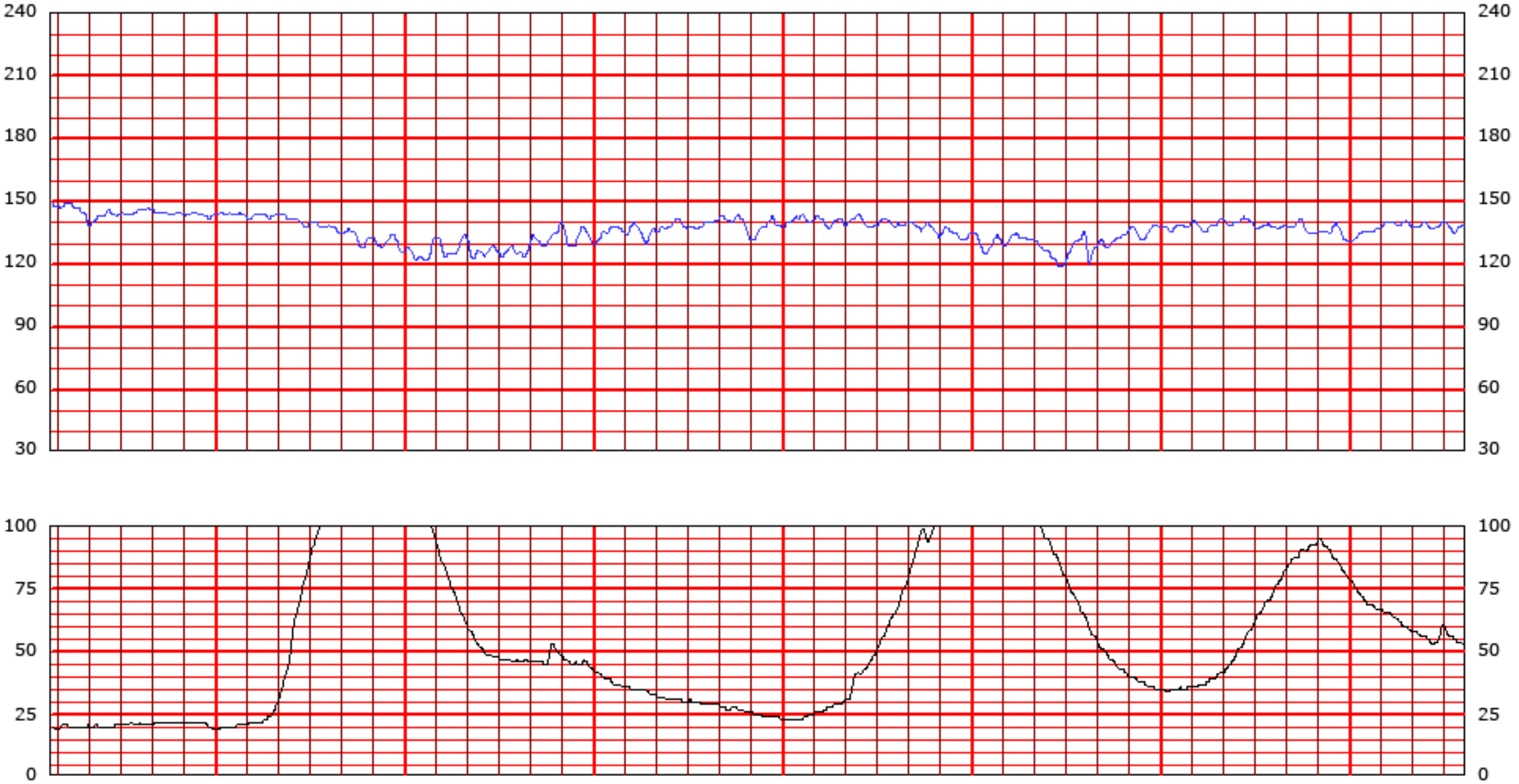
  nipple stimulation

  oxytocin induce (Ocytocin Challenge Test)

Late decelerations



Late decelerations 2



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- At least 3 uterine contractions in 10 minutes

  spontaneous

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Contraction stress test

- **Positive** (abnormal)
  late decelerations in ≥50 % of contractions.
- **Negative** (normal)
  no late decelerations or significant variable decelerations.
- **Equivocal**
  equivocal-suspicious~intermittent late decelerations or significant variable decelerations,
  equivocal-tachysystolic ~contractions more than every two minutes or lasting longer than 90 seconds.
- **Unsatisfactory** < 3 contractions in 10 minutes

CST less used due to…

- Significant complications: hyperstimulation, tetanic contractions, fetal bradycardia
- Not appropriate scenarios: placenta previa, vasa previa; previous/classic cesarean delivery
- Time consuming
- NST / BPP available ; though CST has higer negative predictive values(exceeding 99.8%)

Residual role of CST

- Guiding the method of cervical ripening
  eg. growth restricted fetus

- Back up test

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	False negative	False positive	Still birth rate within 1 week if result normal
CST	0.04%	35-65%	0.3/1000
NST	0.2-0.65%	55-90%	1.9/1000
BPP	0.07-0.08%	40-50%	0.8/1000
mBPP	0.08%	60%	0.8/1000

Fetal Assessment Techniques

- Contraction stress test
- **Nonstress test**
- Biophysical profile (BPP)
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- Doppler velocimetry
  - Umbilical artery
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Nonstress test (NST)

- FHR accelerations- good indicator of normal fetal autonomic function absence of acidosis / neurologic depression

NST
Reactive criteria

- ≧ 32 weeks

  ≧ 2 accelerations in 20-40 minutes

  with peak ≧ 15 beats bpm above the baseline rate

  lasting ≧ 15 seconds (15 x 15)

- <32 weeks

  ≧ 2 accelerations in 20-40 minutes

  with peak ≧ 10 beats bpm above the baseline rate
  lasting ≧ 10 seconds (10 x 10)

Obstet Gynecol. 2011;118(1):87.

Nonreactive NST

- Should be monitored ≧40 minutes.
- A sign of fetal deoxygenation to the point of metabolic acidemia. The mean umbilical vein pH 7.28±0.11.
- Other causes:
  fetal quiet sleep status
  immaturity
  fetal neurologic / cardiac anomalies,
  maternal sepsis
  medications such as MgSO4, antenatal corticosteroid, narcotics, propranolol.
  maternal smoking

Nonreactive NST

- Vibroacoustic stimulation
- Repeat the test in 30 minutes.
- Back-up test=> CST or complete BPP
- Modify factors causing nonreactive

Vibroacoustic stimulation

- Testing time decreased ~ 7 minutes in avearage.
- Nonreactive NSTs rate reduced 40%.
- No evidence-based standard procedure.
- Performed as soon as 5 minutes after initiation of the NST.
- Quiet sleep ->active sleep-> active awake state

Nonreactive NST

- Vibroacoustic stimulation
- Repeat the test in 30 minutes.
- Back-up test=> CST or complete BPP
- Modify factors causing nonreactive

NST Timing and frequency

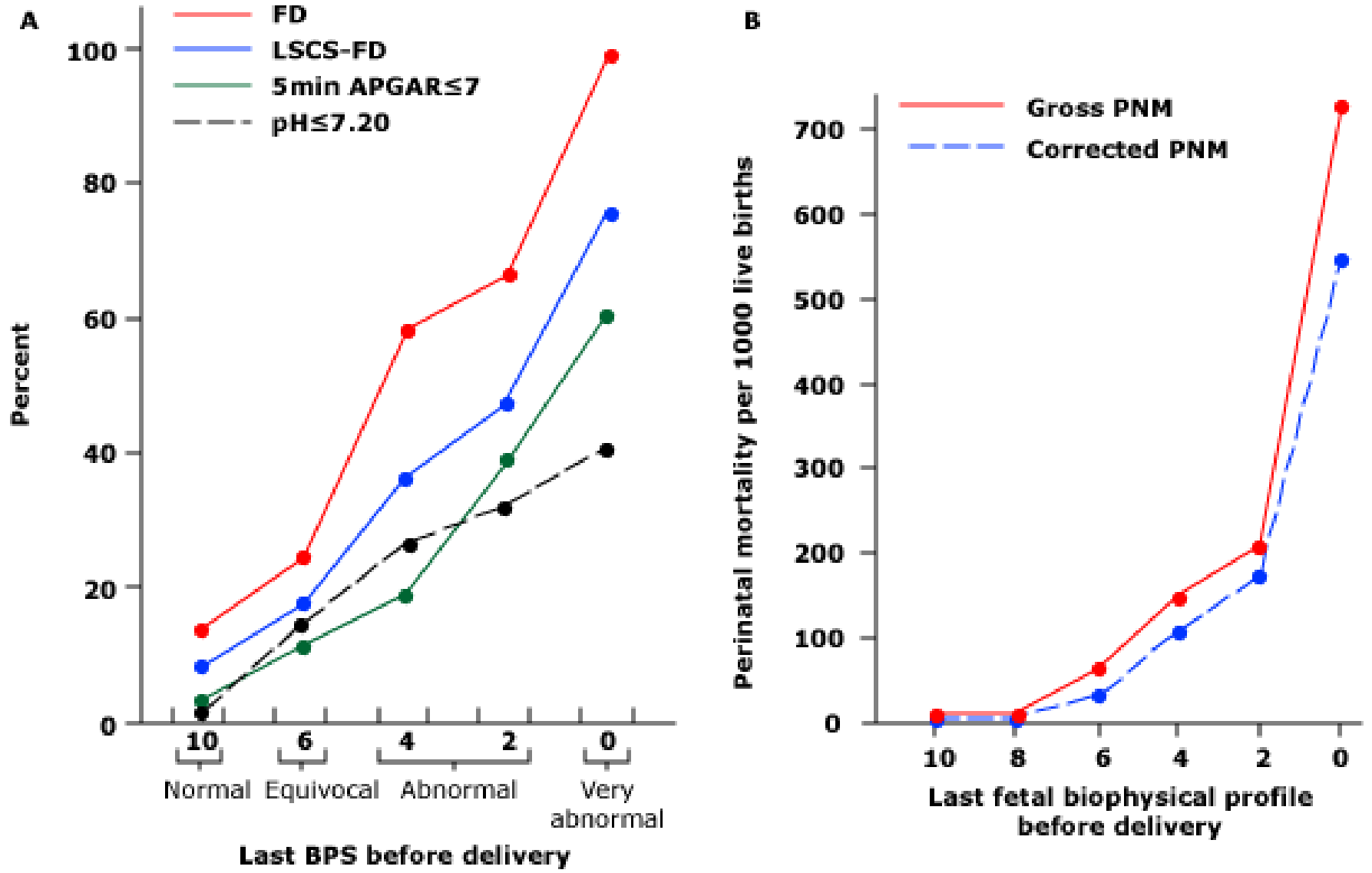
- Fetal neurologic maturity should be sufficient to enable FHR acceleration (No earlier than 26 to 28 weeks)

- Frequency of testing- No high-quality evidence

  False negative rate: 1.9 :1000 (defined by fetal death within 1 week)

- Abnormal test should be followed by additional testing for high false-positive rate.

Relationship between biophysical profile score and perinatal mortality and morbidity



Components of the full biophysical profile test

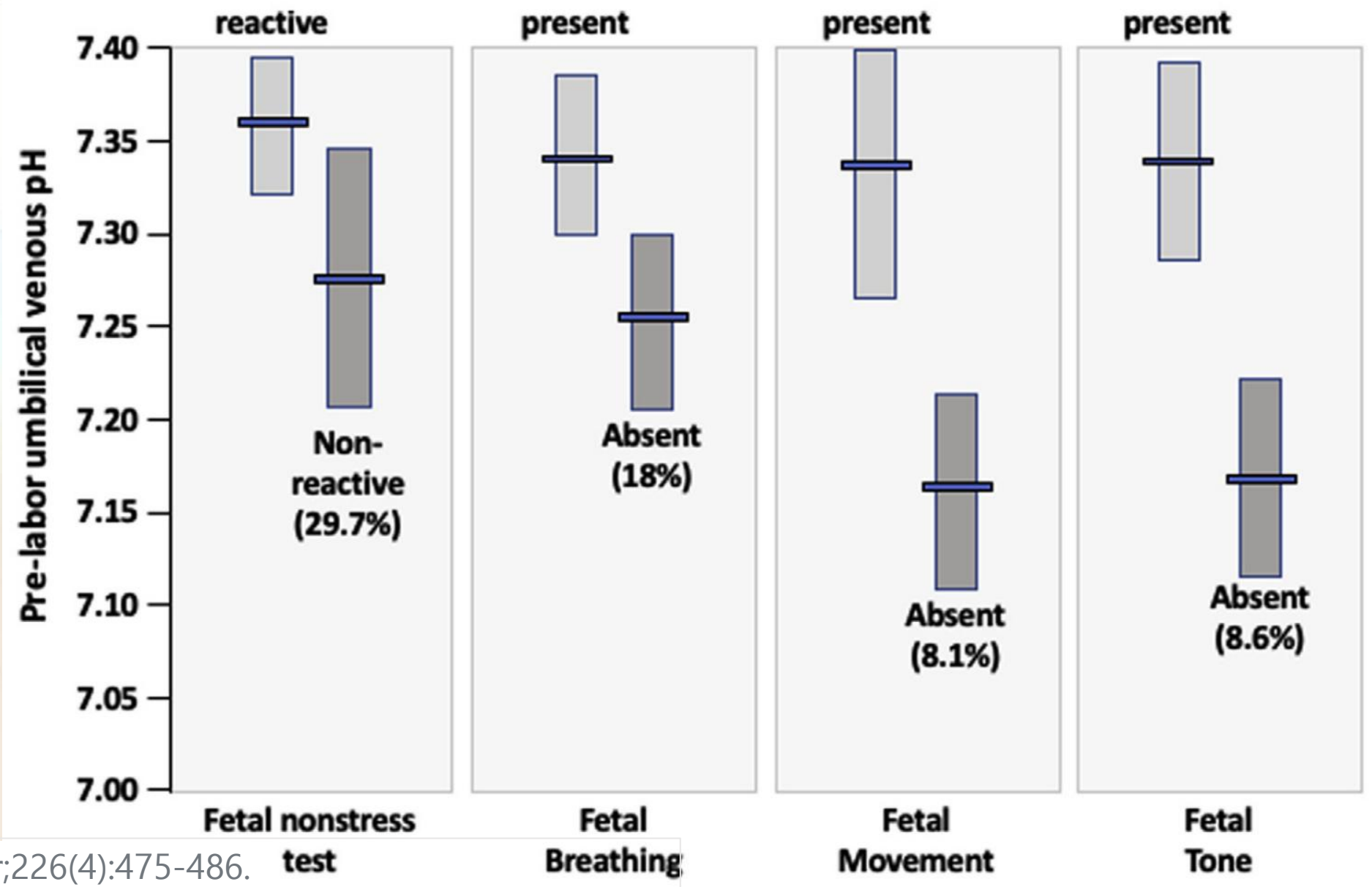
Fetal movement: 2 points if three or more discrete body or limb movements within 30 minutes of observation. An episode of active continuous movement is counted as one movement.
Fetal breathing movements: 2 points if one or more episodes of rhythmic breathing movements of ≥30 seconds within a 30-minute observation period.
Fetal tone: 2 points if one or more episodes of extension of a fetal extremity or fetal spine with return to flexion, or opening and closing of the fetal hand.
Amniotic fluid volume: 2 points if a single deepest vertical pocket ≥2 cm is present. The horizontal dimension should be at least 1 cm.
Nonstress test: 2 points if reactive, defined as at least 2 episodes of FHR accelerations of at least 15 bpm and at least 15 seconds duration from onset to return associated with fetal movement.

Gradual hypoxia concept

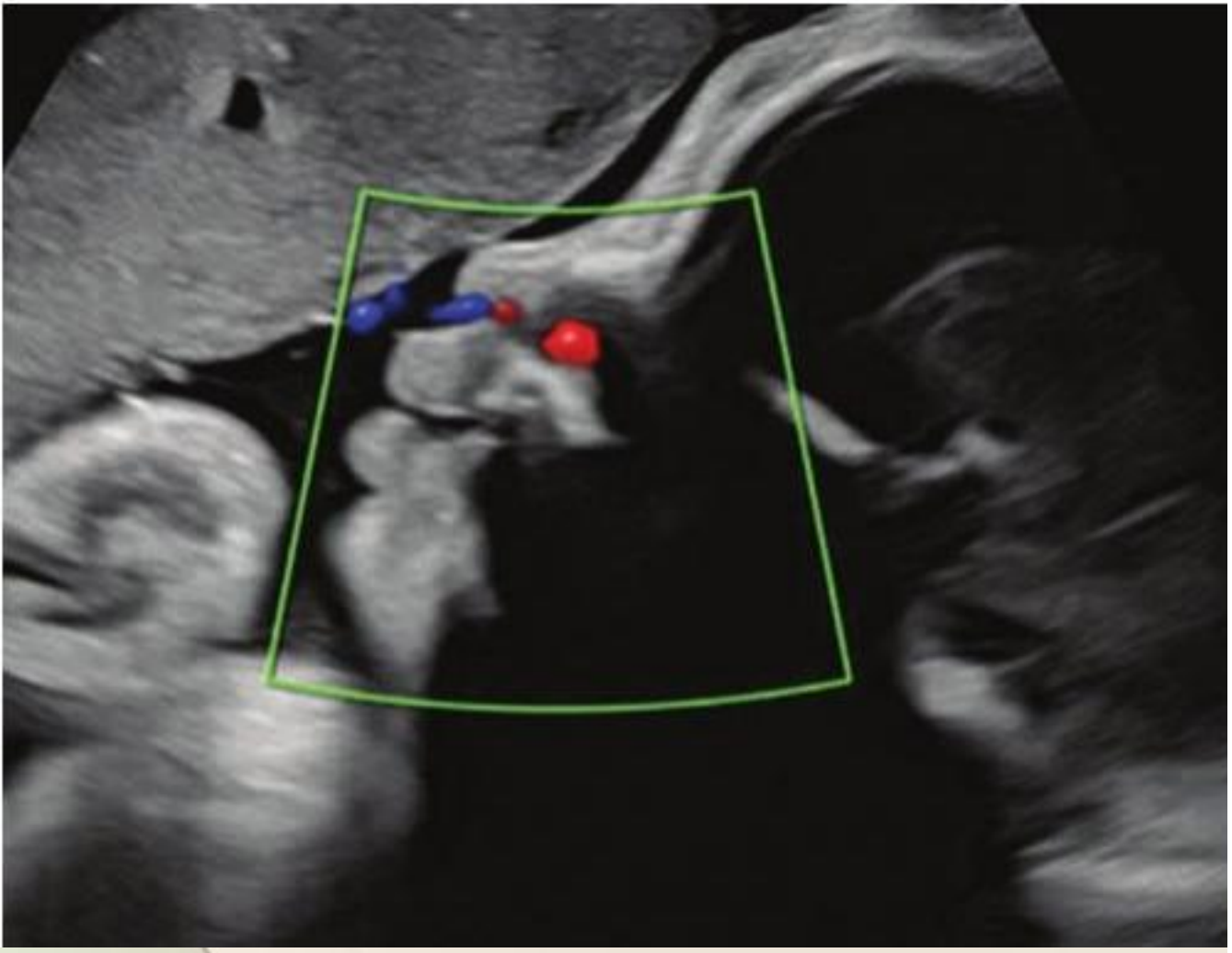
- Fetal biophysical variables regulated by functional regulatory centers in the brain, sensitive to:
  fetal sleep-wake cycles modulation
  hypoxemia and acidemia suppression
  =>Loss of FHR accelerations / fetal breathing movements
  =>Decreased fetal movement
  =>Loss of fetal tone

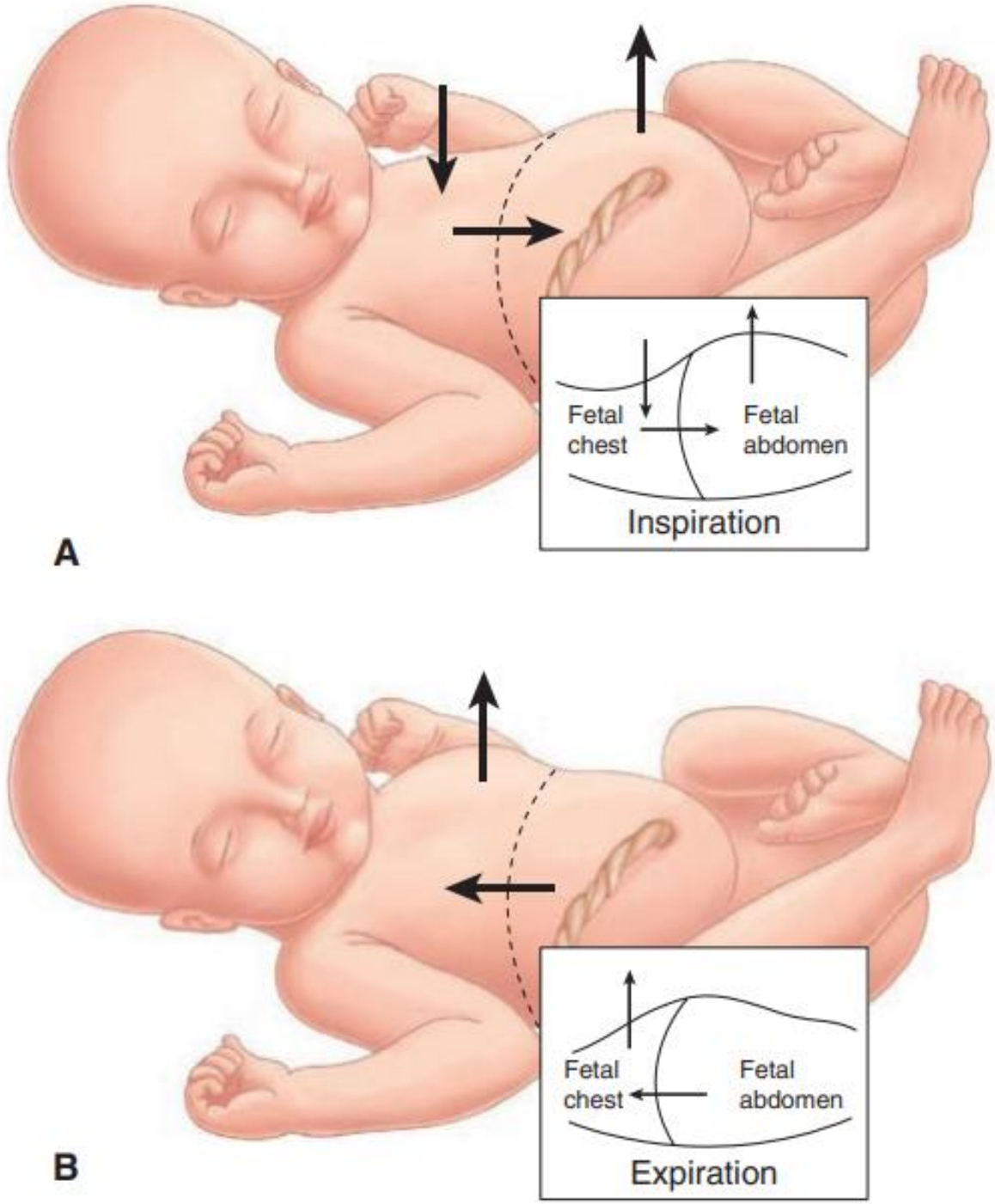
FIGURE 1

Loss of fetal behavioral variables and umbilical venous pH



ACOG 2022 Apr;226(4):475-486.




Fetal chest
Fetal abdomen
Inspiration
A
Fetal chest
Fetal abdomen
Expiration
B

Amniotic fluid assessment

- Chronic parameter
- Amniotic fluid index (AFI) vs Deepest vertical pocket(DVP)

➢ More unnecessary interventions:
More diagnosis frequency (RR = 2.33; CI, 1.67 to 3.24)
More Labor (RR = 2.1; CI, 1.6 to 2.76)
Higher rate of cesarean deliveries for (RR = 1.45; CI, 1.07 to 1.97)

➢ No differences in Apgar scores, umbilical artery pH (< 7.1), or nonreassuring FHR tracings.

Cochrane Database Syst Rev. 2008;(3)

TABLE 34.2 Systematic Application of Biophysical Profile Scoring

BPS	Interpretation	Predicted PNM[a]	Recommended Management
10/10, 8/8, 8/10 (AFV normal)	No evidence of fetal asphyxia	<1 : 1000	No acute intervention on fetal basis; serial testing indicated by disorder-specific protocols
8/10-oligo	Chronic fetal compromise likely (unless ROM is proved)	89 : 1000	For absolute oligohydramnios, prove normal urinary tract, disprove undiagnosed ROM, consider antenatal steroids, and then deliver fetus
6/10 (AFV normal)	Equivocal test; fetal asphyxia is not excluded	Depends on progression (61 : 1000 on average)	Repeat testing immediately, before assigning final value If score is 6/10, then 10/10, in two continuous 30-min periods, manage as 10/10 For persistent 6/10, deliver the mature fetus; repeat within 24 h in the immature fetus, then deliver if <6/10
4/10	Acute fetal asphyxia likely If AFV-oligo, acute-on-chronic asphyxia very likely	91 : 1000	Deliver by obstetrically appropriate method, with continuous monitoring
2/10	Acute fetal asphyxia likely with chronic decompensation	125 : 1000	Deliver for fetal indications (frequently requires cesarean section)
0/10	Severe, acute asphyxia virtually certain	600 : 1000	If fetal status is viable, deliver immediately by cesarean section

BPP 8/8 (non oligohydramnios)

- The same high predictive accuracy as a BPP of 10/10 & 8/10
- If any abnormal condition (eg. fetal growth restriction) NST still recommended.
- Nonstress test was needed in 3-10 %

Uncomplicated isolated oligohydramnios

- Uncomplicated isolated and persistent oligohydramnios (DVP < 2 cm),

⇒delivery at 36 0/7–37 6/7 weeks or at diagnosis if diagnosed later.

Obstet Gynecol 2011;118:323–33. (Level III)

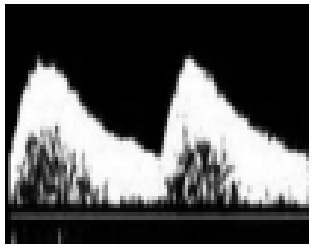
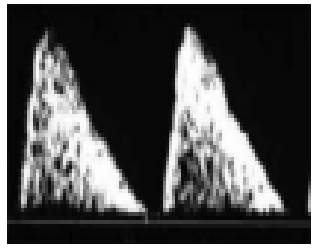
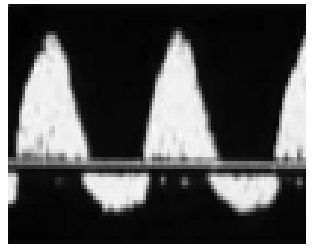
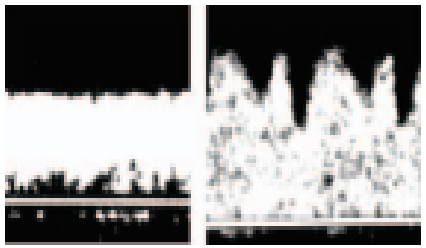
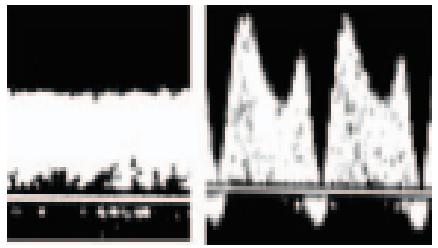
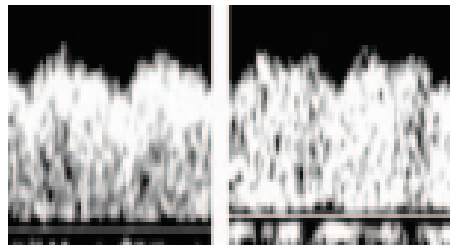
Obstet Gynecol 2021; 137:e29–33. (Level III)

BPP 0/10 & 2/10

- ≧ 28 weeks=> prompt delivery.
- < 28 weeks; extending the testing time or repeat testing 4-6 hours later;
  persistent BPP of 2/10=> prompt delivery.
- CVP(cardiovascular profile)

Cardiovascular Profile

The Journal of Maternal-Fetal and Neonatal Medicine, July 2006; 19(7): 407–413

Category	Score 2	Score 1	Score 0
Hydrops	None	Ascites or pleural effusion or pericardial effusion	Skin edema
Cardiomegaly (cardiac area/thoracic area)	>0.20 and ≤0.35	0.35–0.50	>0.50 or <0.20
Cardiac function	Normal TV and MV, biphasic diastolic filling	Holosystolic TR	Holosystolic MR, monophasic diastolic filling
Arterial umbilical Doppler			
Venous Doppler UV and DV			

BPP 4/10

- Oligohydramnios
  ≧ 34 weeks => prompt delivery
  < 34 weeks=> antenatal corticosteroids then delivery

- Normal amniotic fluid
  ≧ 34 weeks => prompt delivery
  < 34 weeks=> antenatal corticosteroids
  repeat the BPP 24 hours later
  delivery if 6/10 or less

BPP 6/10

- Oligohydramnios
  ≧ 34 weeks => delivery
  < 34 weeks => antenatal corticosteroids then delivery

- Normal amniotic fluid
  repeat the BPP 24 hours later (2/3 became normal)
  if 6/10 or less :
  ≧ 34 => delivery
  < 34 weeks => antenatal corticosteroids then delivery

Modified BPP (mBPP)

- Nonstress test / amniotic fluid volume(DVP)
- The rate of stillbirth within one week: 0.8 per 1000 same with full BPP Am J Obstet Gynecol. 1996;174(3):812.
- Abnormal : either one or both components not fulfilled.
- ~ 90 % modified BPP have a normal result

Fetal Assessment Techniques

- Contraction stress test
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- Doppler velocimetry
  - Umbilical artery
  - Middle cerebral artery
  - Precordial vein-ductus venosus

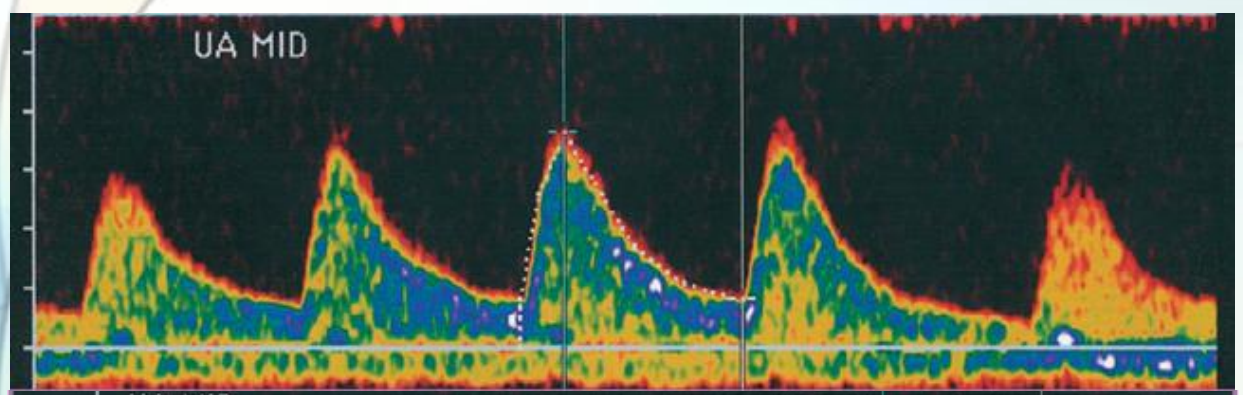
Umbilical artery

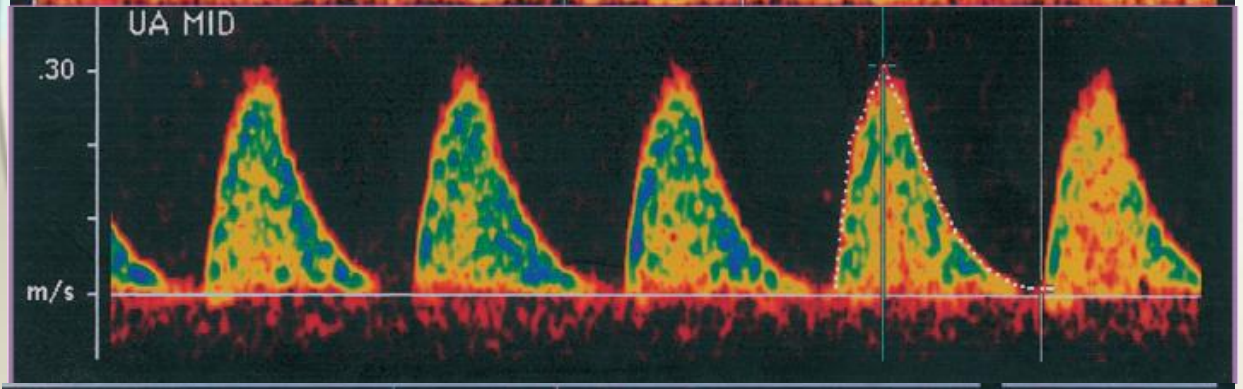
- Useful for fetal growth restriction due to uteroplacental insufficiency, esp. early-onset FGR.

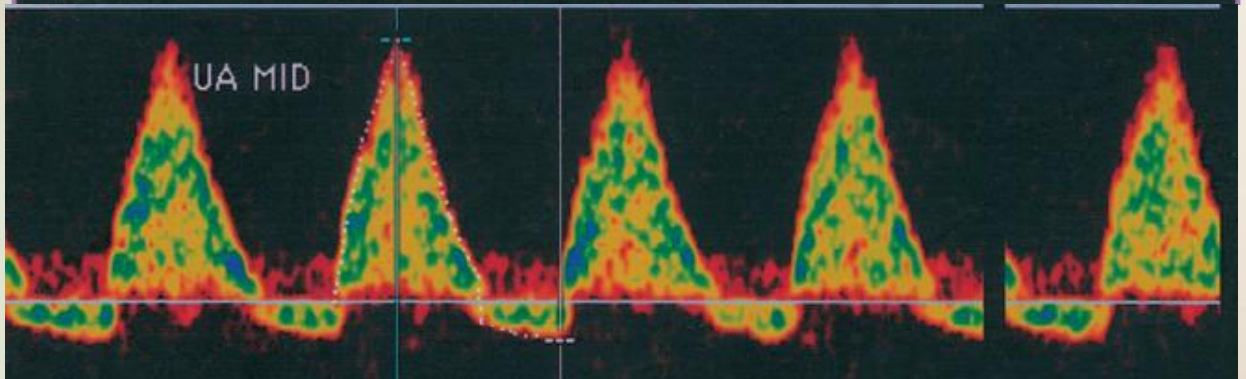
- Not reducing perinatal mortality in low risk and term pregnancy.

Lancet. 2024;403(10426):545.

Umbilical aretry







Abnormal if

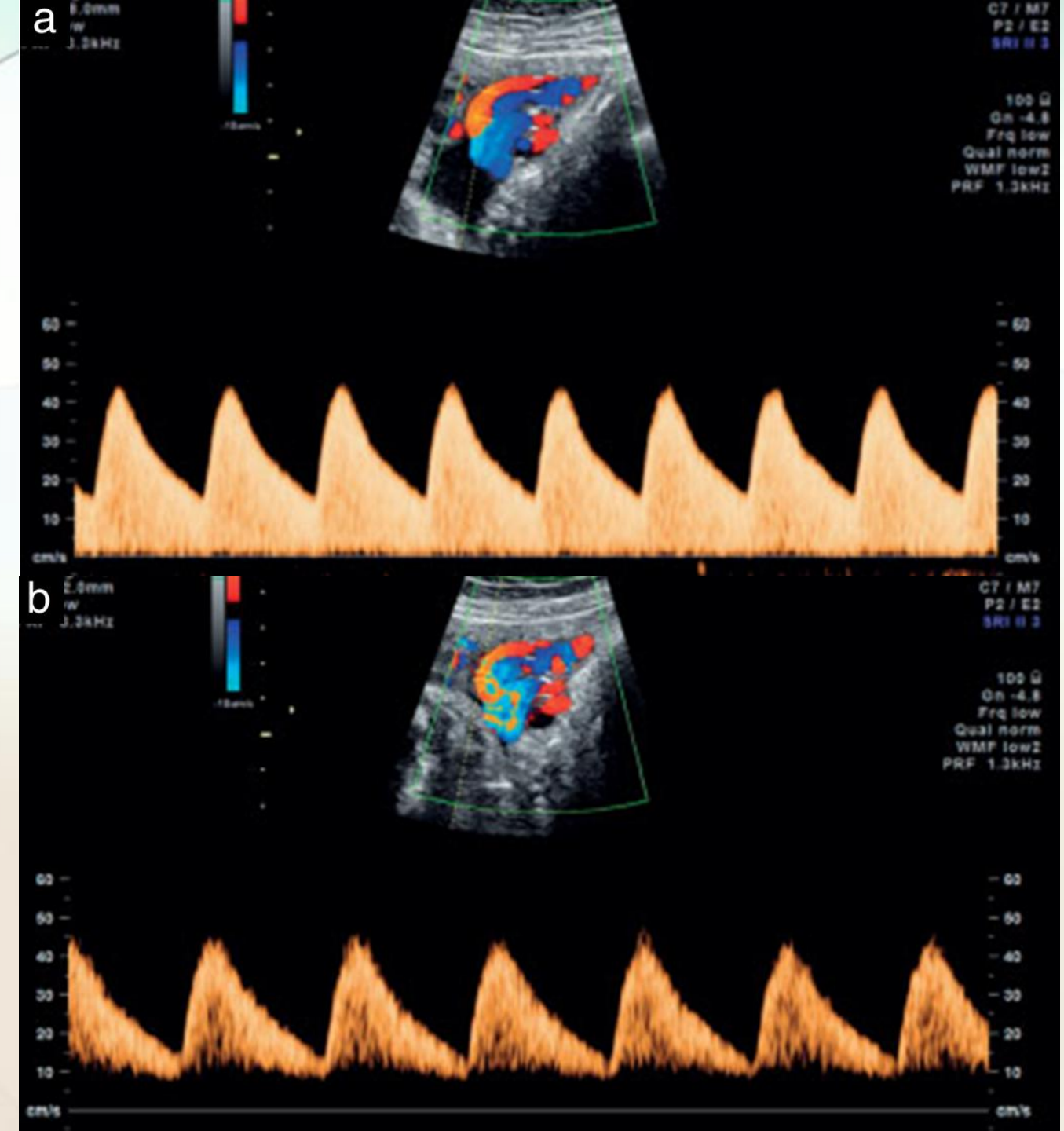
S/D > 3.0 (≥28 weeks)

RI (S-D/S)> 0.6 (≥28 weeks)

PI (S-D/ TAMX),S/D,RI >95 % at gestational age

AEDV

REDV


a
C7 / M7
P2 / E2
100 Ω
Gn -4.8
Frq low
Qual norm
WMF low2
PRF 1.3kHz
60
50
40
30
20
10
cm/s
b
C7 / M7
P2 / E2
100 Ω
Gn -4.8
Frq low
Qual norm
WMF low2
PRF 1.3kHz
cm/s

Middle Cerebral Artery

- Centralization(Brain sparing): fetal oxygenation ↓
  High resistance and low diastolic velocities
  => Falling resistance and increased diastolic velocities
- Moderate / severe anemia prediction by increased MCA-PSV (above 1.5 MoMs)
  - sensitivity 100 % (95% CI 86-100) false-positive rate of 12%

N Engl J Med. 2000;342(1):9

  - sensitivity 86 % (95% CI 75-93) specificity 71 % (95% CI 49-87)

Ultrasound Obstet Gynecol. 2019;54(6):722

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Prediction of risk
- Preeclampsia
  - 11^{+0} to 14^{+1} weeks
  - 19^{+0} to 24^{+6} weeks
  - 30^{+0} to 37^{+6} weeks
- Small for Gestational Age
- Trisomies
- Gestational diabetes
- Miscarriage
- Stillbirth
- Fetal growth restriction
- Fetal macrosomia
- Preterm birth - history
- Preterm birth - cervix

Assessment / management
- Management: SGA
- Management: Fetal anemia
- Pregnancy dating
- Assessment: Fetal growth
- Assessment: Birth weight
- Assessment: Fetal Doppler
- Assessment: Uterine PI
- Assessment: Nuchal translucency

Fetal Doppler

Please record the following information

Gestational age: 33 weeks 0 days

		z-score	centile
Umbilical artery PI	1.0	0.3	62
Middle cerebral PI	1.5	-1.625	6

Cerebroplacental ratio

CPR: 1.5

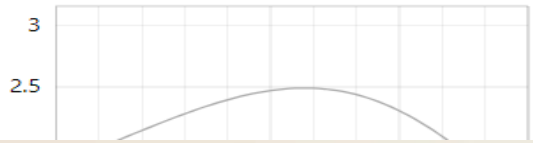
Z-score (SDs away from the expected normal mean for this gestation): -1.428 (centile: 8)

Umbilical artery PI

median
5th and 95th centiles

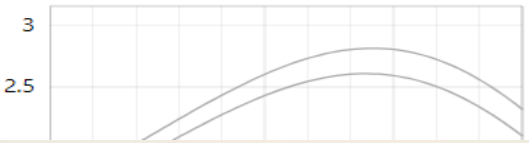
Middle cerebral artery PI

median
5th and 95th centiles



Cerebroplacental ratio

median
5th, 10th, 90th and 95th centiles



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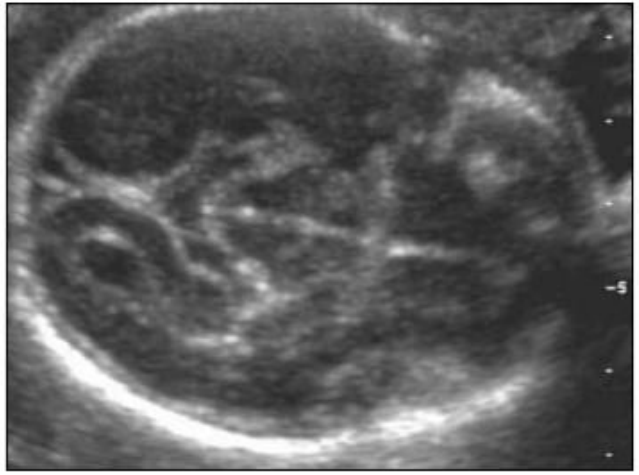
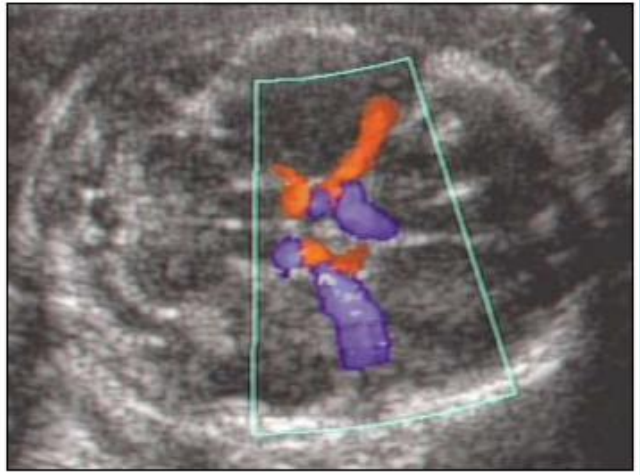
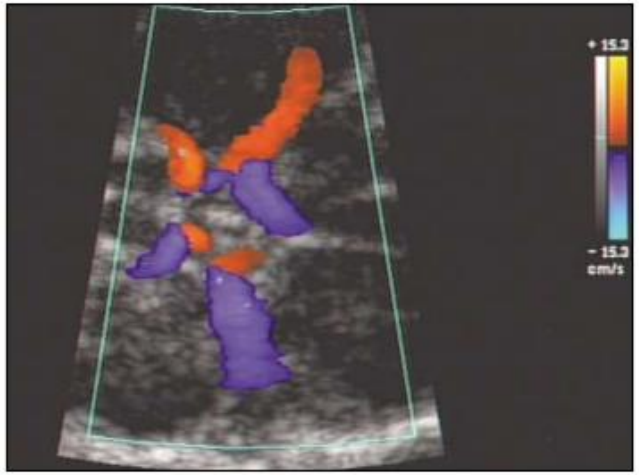
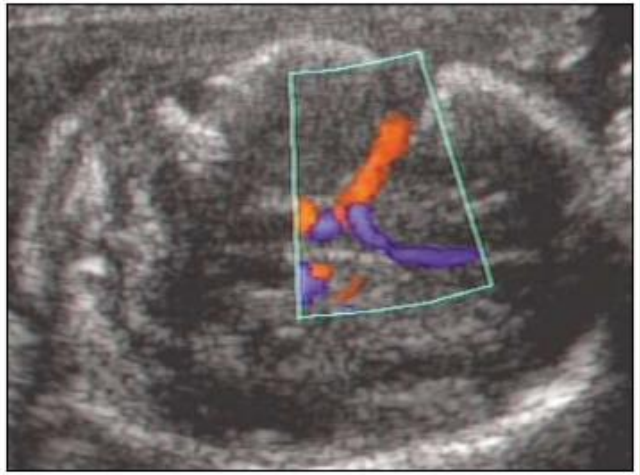
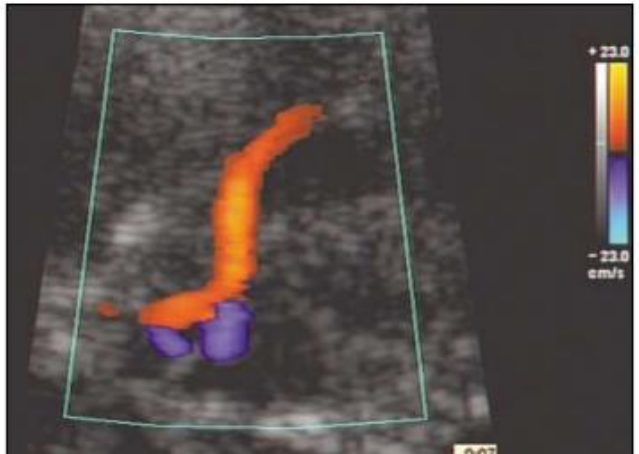
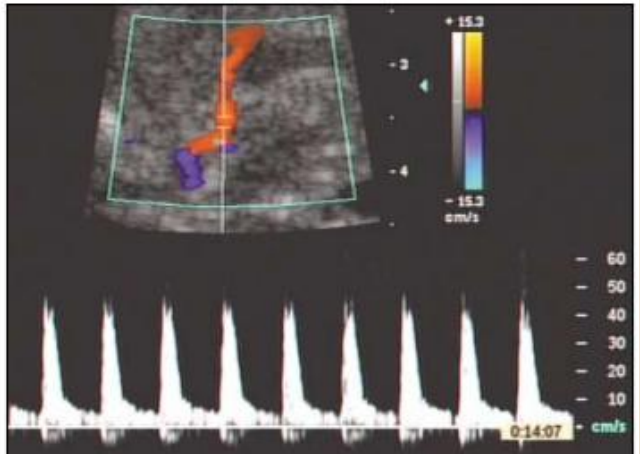






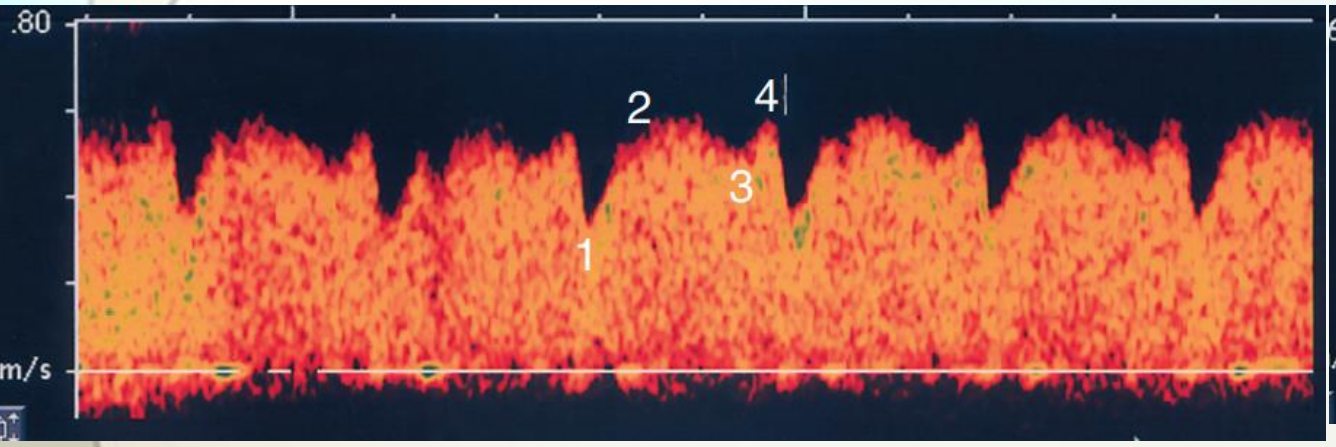


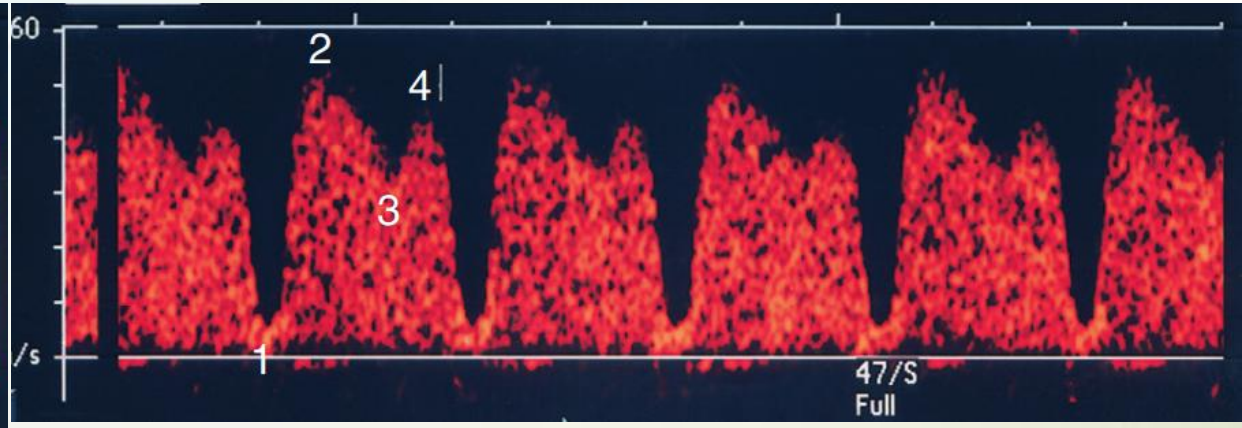


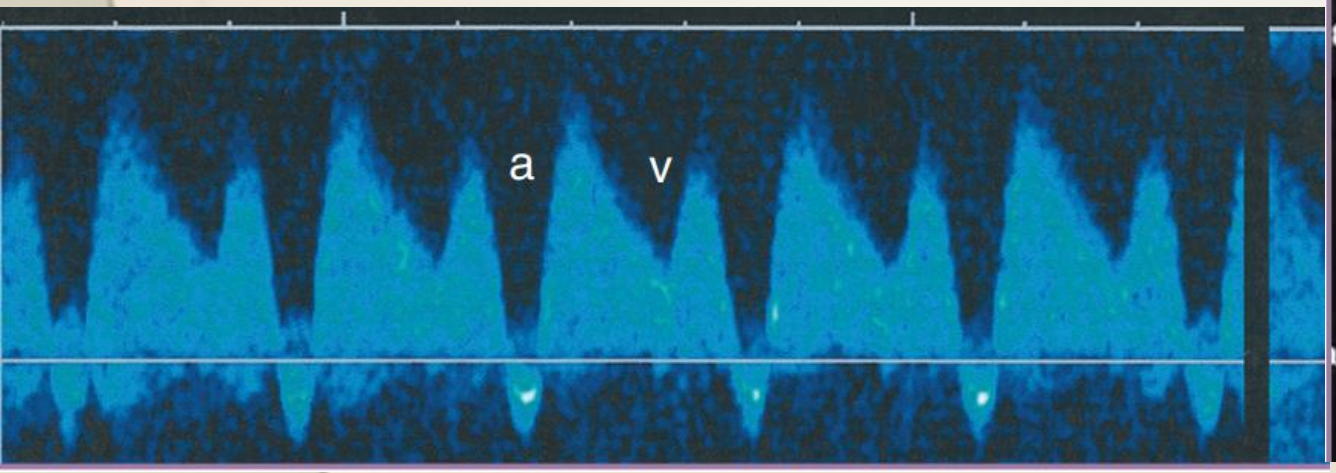


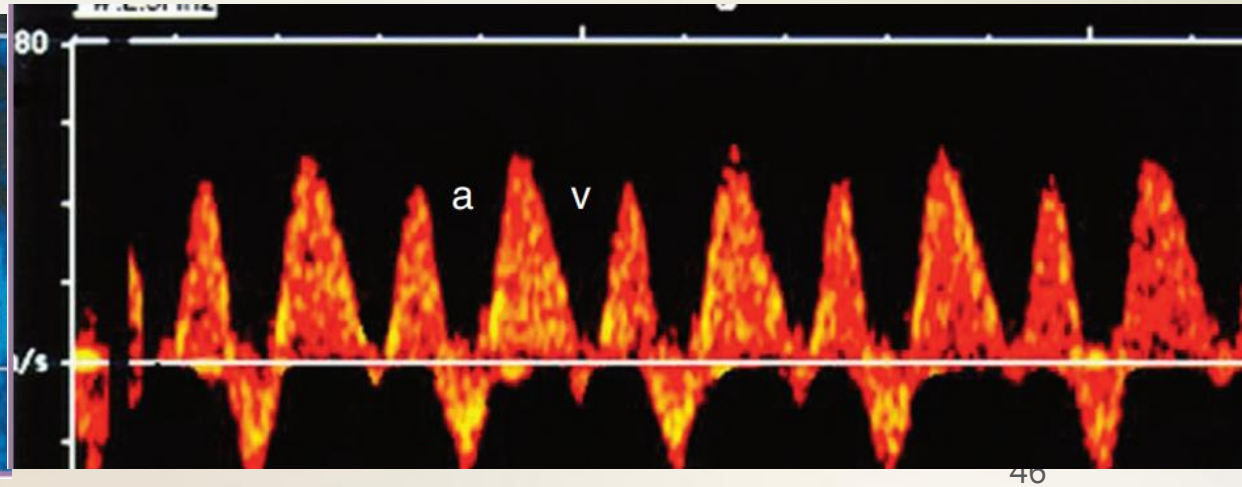
- Gate at proximal third ; 2 mm from the internal carotid artery
- Insonation
- PSV-peak systolic velocity
- cerebroplacental ratio

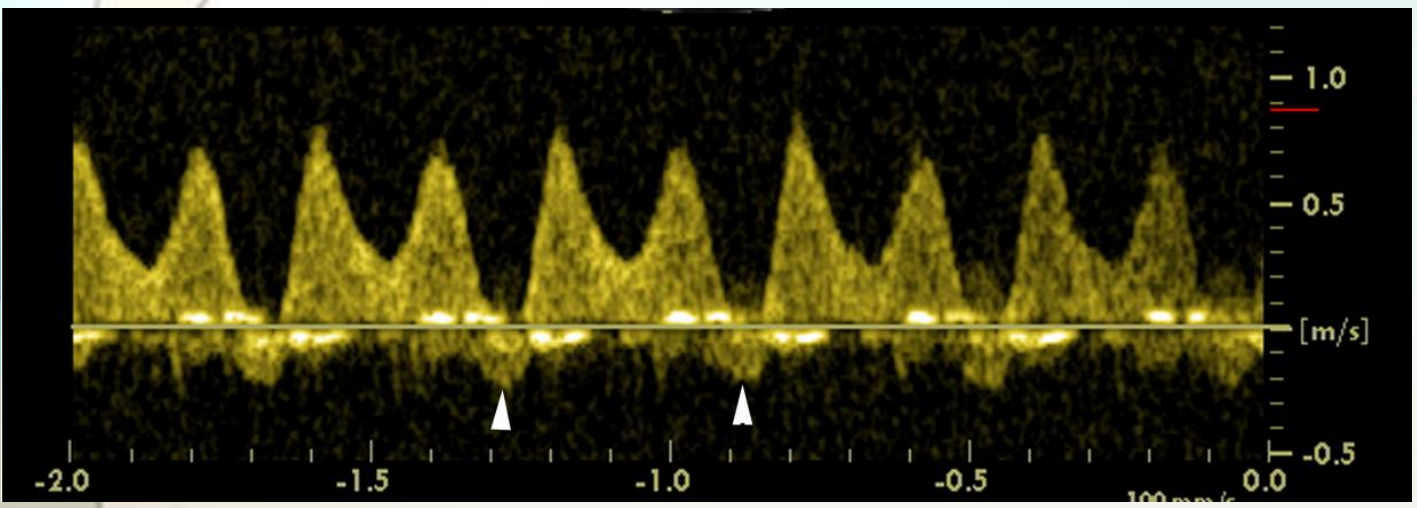
Ductus venosus

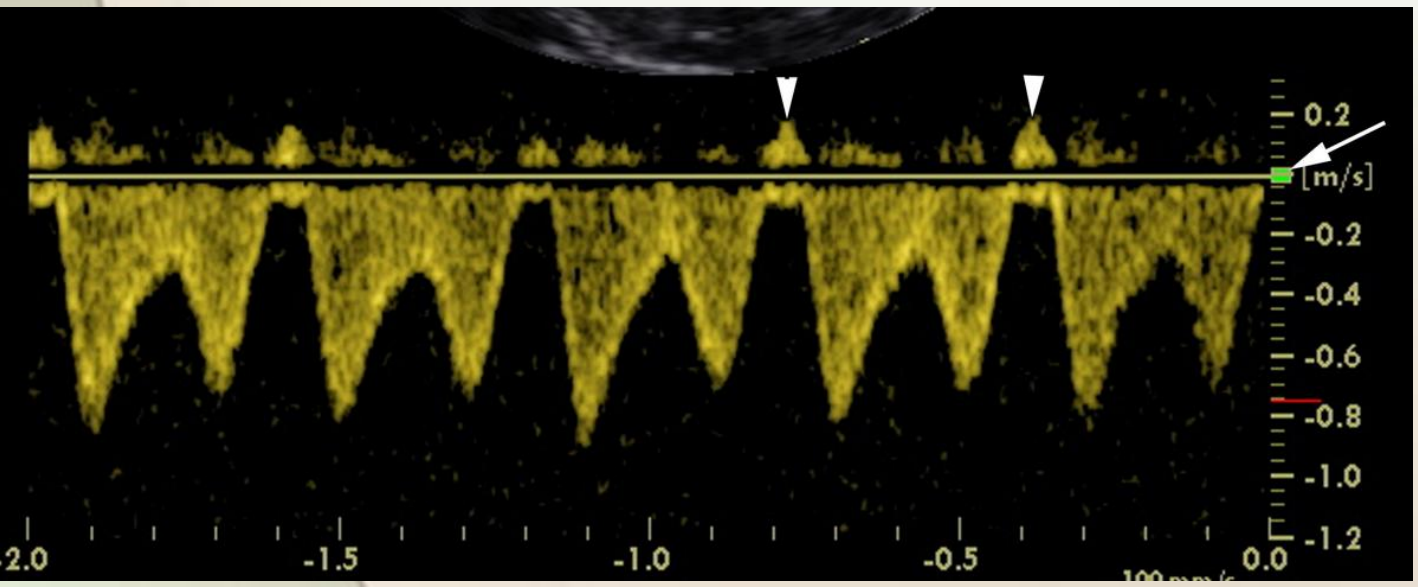












- P
- reversed velocity during atrialcontraction (the 'a-wave')

- pulsatility index for veins

PIV = (Vs – Va)/TAMX,
Vs : the peak forward velocity during ventricular systole
Va : the lowest forward velocity or peak reversed velocity during atrialcontraction (a-wave)

- A wave reverse

Ductus venosus

- Though significant arterial abnormalities, if the ductus venosus flow and BPP normal extension of the pregnancy at very preterm gestations allowed.
- Abnormal venous Doppler parameters and abnormal BPP=> strong agreement with delivery
- However, venous Doppler studies and BPP scores are not strictly concordant.

Ultrasound Obstet Gynecol. 2004;23:119

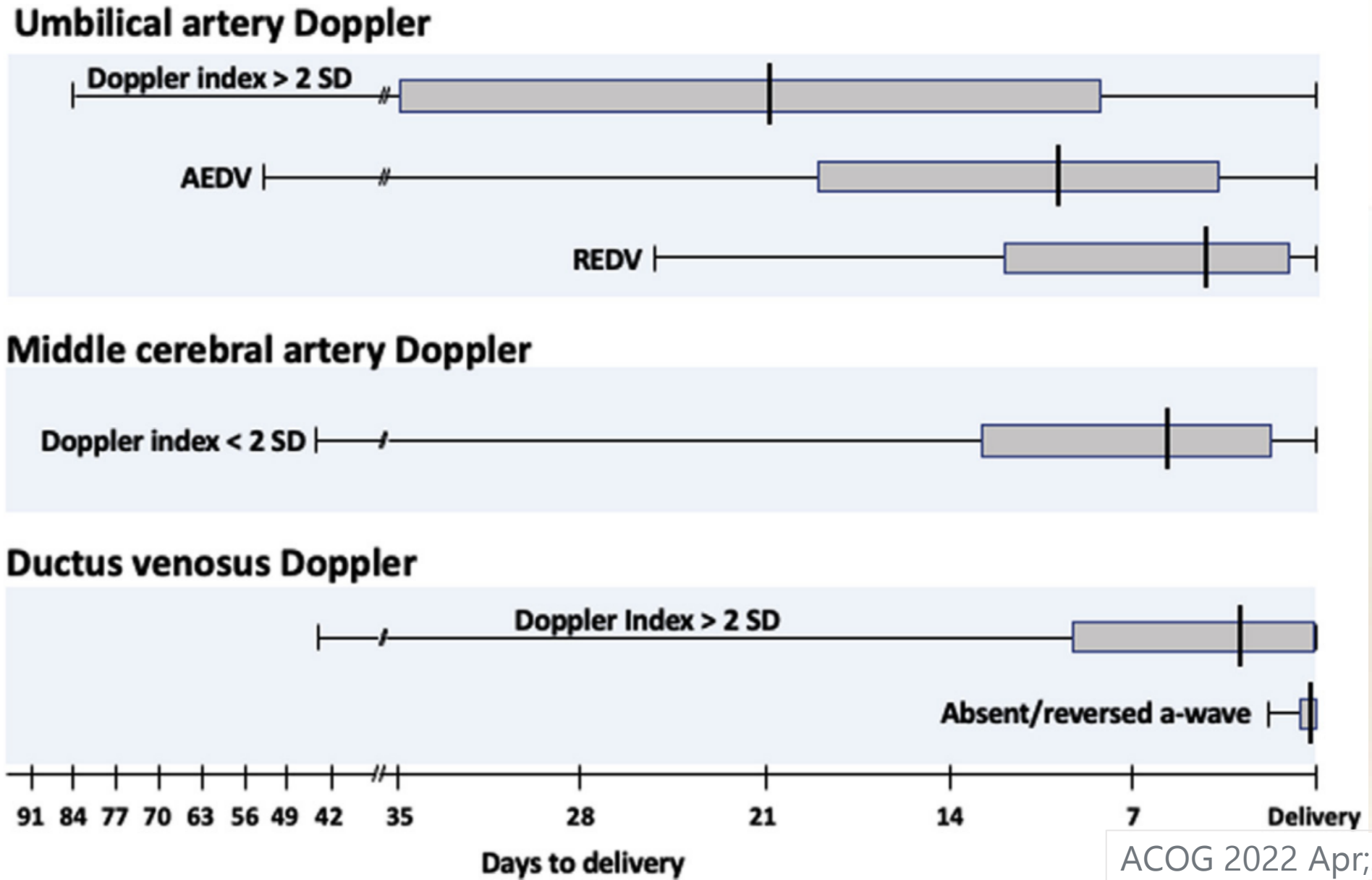
Ductus venosus

- Predicting severe and shorter-term outcome : perinatal mortality, acidosis, asphyxia, and requirement for ICU care.
- Resistance elevation, depression of the a-wave correlate with major neonatal complications
- Deterioration frequently precedes and strongly predicts changes in BPP that require delivery
- a-wave reversed

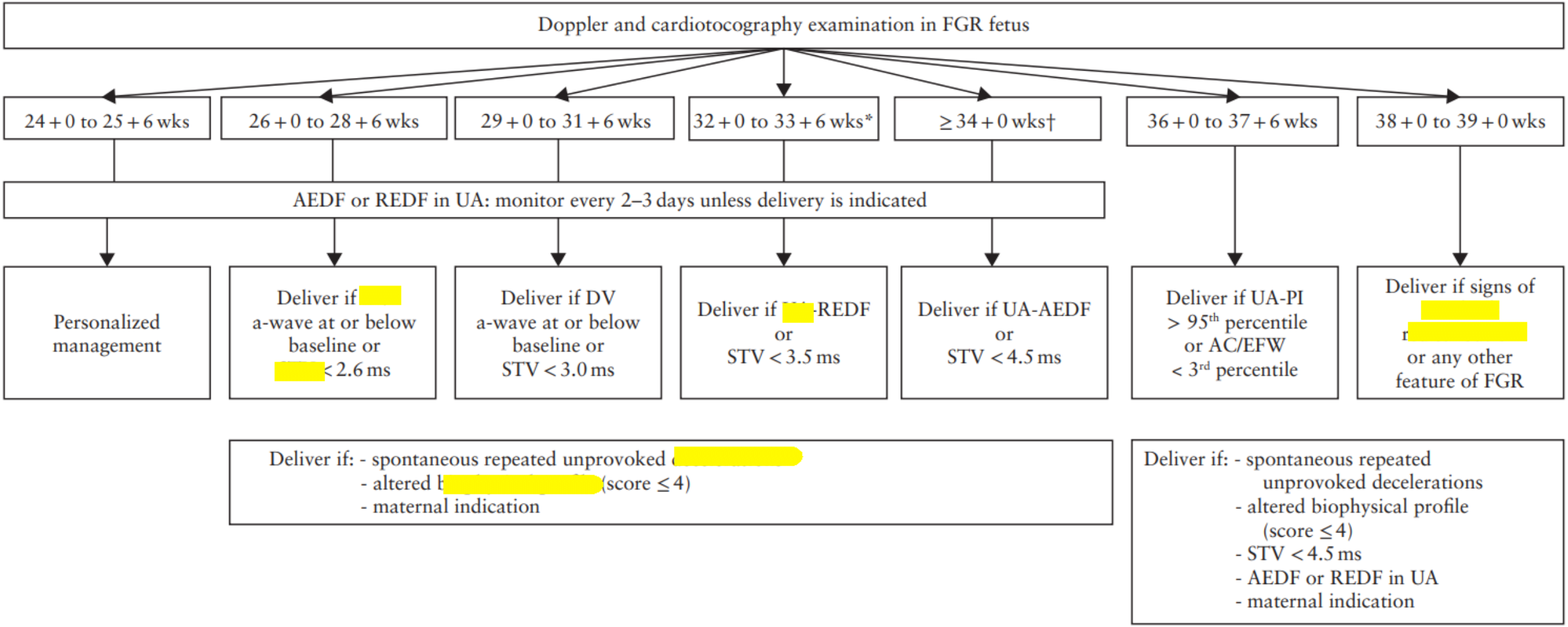
  => the odds of stillbirth doubles each day independent of the gestational age. Ultrasound Obstet Gynecol. 2011;38:29

FIGURE 3

Doppler findings and the associated interval to delivery



ACOG 2022 Apr;226(4):475-486.



Ultrasound Obstet Gynecol 2020; 56: 298–312.

When antepartum test result abnormal …

- Due to high false-positive rates and low positive predictive values, multicomponent fetal surveillances recommended
- Delivery based on consideration of
  - test results
  - maternal condition
  - fetal condition
  - gestational age

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