Electronic Fetal Monitoring

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می نوش که عمر جاودانی اینست خود حاصلت از دور جوانی اینست

هنگام گل و سبزه و یاران سرمست خوش باش دمی که زندگانی اینست

ANTEPARTUM FETAL MONITORING

- Two thirds of fetal deaths occur before the onset of labor.
- Many antepartum deaths occur in women at risk for uteroplacental insufficiency.
- Ideal test: allows intervention before fetal death or damage from asphyxia.
- Preferable: treat disease process and allow fetus to go to term.

ANTEPARTUM FETAL MONITORING

- Methods for antepartum fetal assessment
  - Fetal movement counting
  - Assessment of uterine growth
  - Antepartum fetal heart rate testing
  - Biophysical profile
  - Doppler velocimetry

ANTEPARTUM FETAL MONITORING

- Uteroplacental insufficiency
  - Inadequate delivery of nutritive or respiratory substances to appropriate fetal tissues.
  - Inadequate exchange within the placenta due to decreased blood flow, decreased surface area or increased membrane thickness.
  - Inadequate maternal delivery of nutrients or oxygen to the placenta or to problems of inadequate fetal uptake.

ANTEPARTUM FETAL MONITORING

- Theoretical scheme of fetal deterioration
  - Fetal well being (Nutritional compromise)
  - Fetal growth retardation (Marginal placental respiratory function)
  - Fetal hypoxia with stress (Decreasing respiratory function)
  - Some residual effects of intermittent hypoxia (profound respiratory compromise)
  - Asphyxia
  - Death

ANTEPARTUM FETAL MONITORING

- Conditions placing the fetus at risk
  - Preeclampsia, chronic hypertension,
  - Collagen vascular disease, diabetes mellitus, renal disease,
  - Fetal or maternal anemia, blood group sensitization,
  - Hyperthyroidism, thrombophilia, cyanotic heart disease,
  - Postdate pregnancy,
  - Fetal growth restriction.

ANTEPARTUM FETAL MONITORING

- Fetal movement counting
  - Maternal perception of a decrease in fetal movements may be a sign of impending fetal death.
  - It costs nothing.
  - In a systematic fashion, especially in low risk populations, may detect unsuspected fetal jeopardy.

ANTEPARTUM FETAL MONITORING

- Fetal movement counting
  - 3 movements in 30 minutes (Sadovsky).
    - سه حرکت در سی دقیقه
  - Elapsed time to register 10 fetal movements (Moore and Piacquadio).
    - گذشت زمان برای ده حرکت جنین

ANTEPARTUM FETAL MONITORING

- Assessment of uterine growth
  - General rule: fundal height in centimeters will equal the weeks of gestation.
  - Exceptions: maternal obesity, multiple gestation, polyhydramnios, abnormal fetal lie, oligohydramnios, low fetal station, and fetal growth restriction.
  - Abnormalities of fundal height should lead to further investigation.
  - Accuracy: poor?
  - دقت: کم؟!

ANTEPARTUM FETAL MONITORING

- When to begin testing
  - Single factors with minimal to moderate increased risk for antepartum fetal death: 32 weeks.
  - Highest maternal risk factors: 26 weeks.
  - When estimated fetal maturity is sufficient to expect a reasonable chance of survival should intervention be necessary.

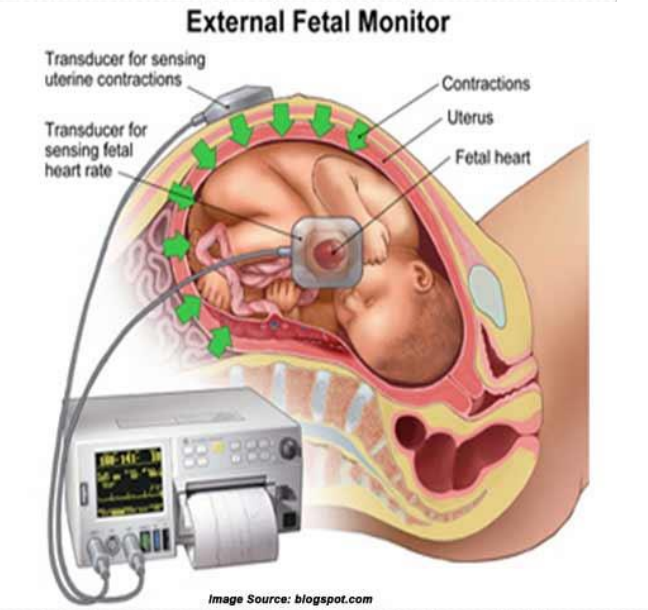
ANTEPARTUM FETAL MONITORING

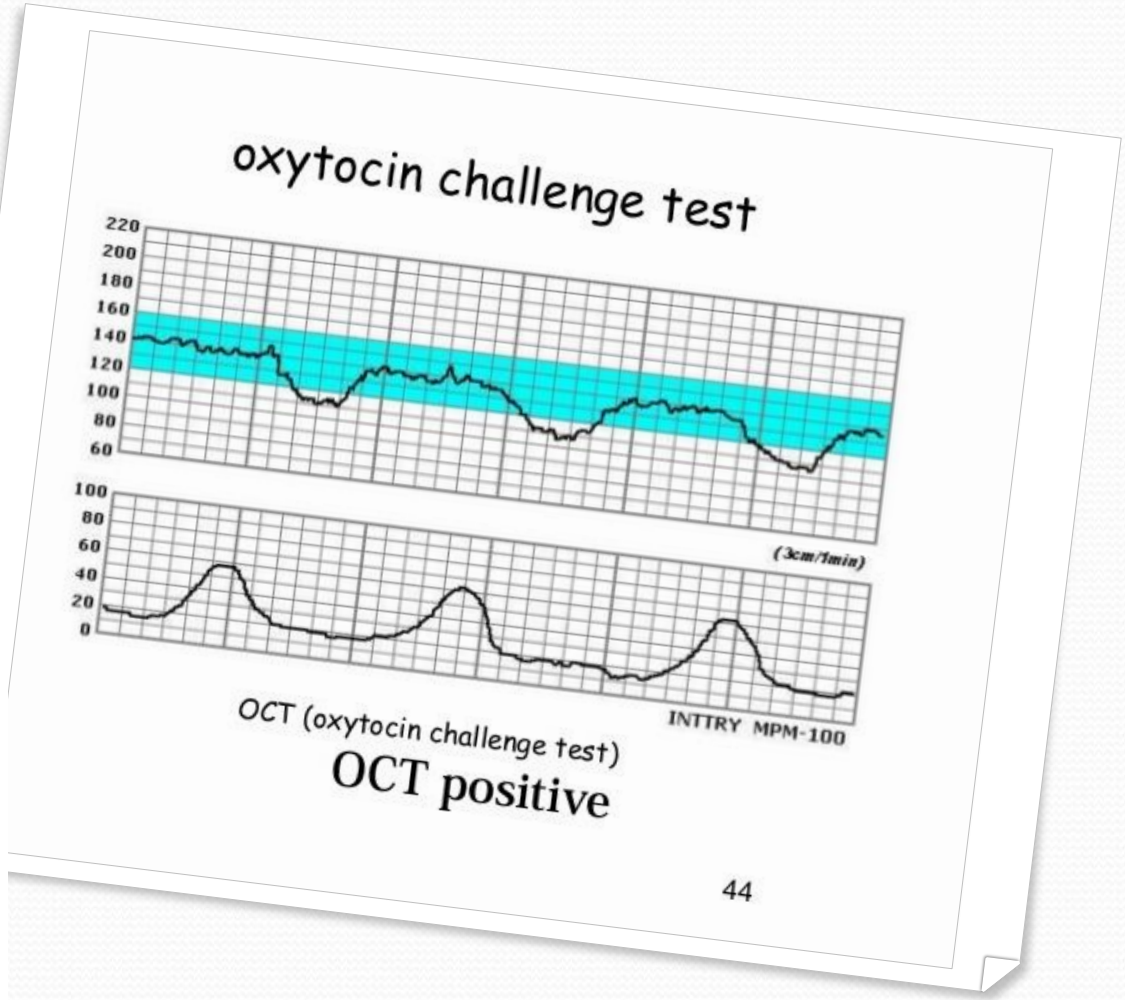
- Which test to use?
  - **Contraction stress test**
    - Low incidence of unexpected fetal death (بروز پایین مرگ ناگهانی جنین)
    - Increase in time, cost and inconvenience(افزایش زمان، هزینه و غیرایمن)
  - **Nonstress test**
  - **Biophysical profile**, modified biophysical profile
  - **Doppler velocimetry**

ANTEPARTUM FETAL MONITORING

- Contraction stress test (CST)
  - Uterine contractions producing an intra-amniotic pressure in excess of 30 mm Hg create an intra-myometrial pressure that exceeds mean intra-arterial pressure, therefore temporarily halting uterine blood flow.
  - A hypoxic fetus will manifest late decelerations.
  - Late decelerations correlate with stillbirth, IUGR, and low Apgar scores.
  - Oxytocin challenge test (OCT) (Ray 1972)
  - Breast (nipple) stimulation

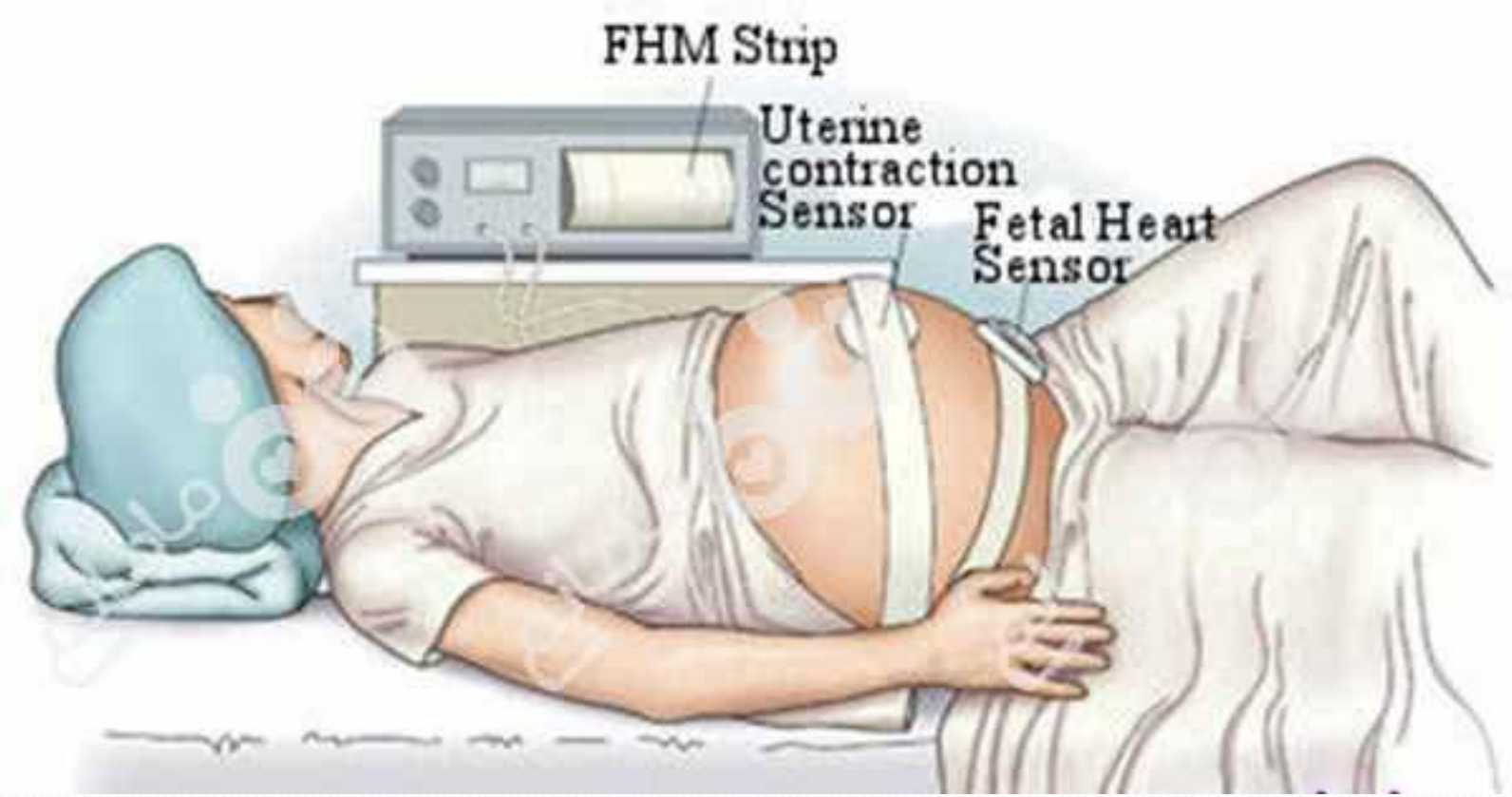
Oxytocin challenge test (OCT)





ANTEPARTUM FETAL MONITORING

- How to perform the CST
  - External monitors for contraction and FHR measurement applied.
  - Patient in semi-fowler position or left lateral tilt (to minimize supine hypotension).
  - Protocol for oxytocin infusion or breast stimulation.
  - Goal: three contractions in ten minutes.

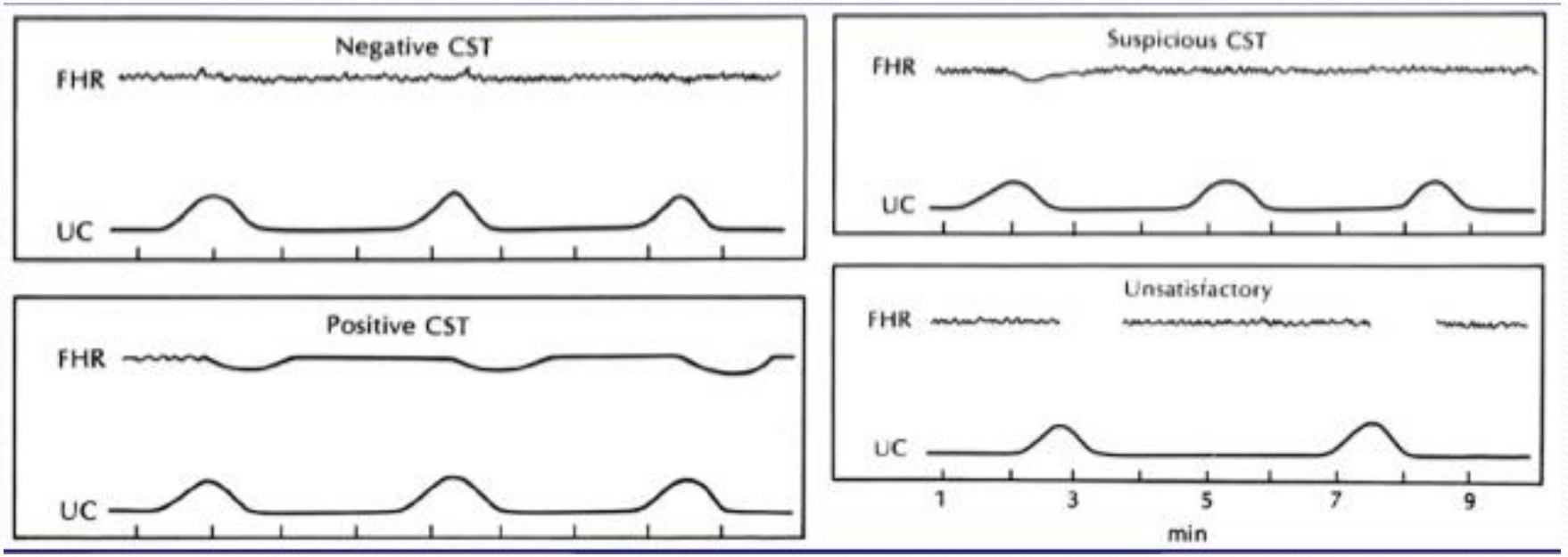

FHM Strip
Uterine contraction Sensor
Fetal Heart Sensor

ANTEPARTUM FETAL MONITORING

- Interpretation of the CST
  - Negative: no late decelerations and adequate FHR recording
  - Positive: Late decelerations present with the majority of contractions (without excessive uterine activity)
  - Equivocal test results: Suspicious, hyper stimulation, unsatisfactory.

ANTEPARTUM FETAL MONITORING

- Interpretation of the CST
  - **Suspicious:** Late decelerations are present with less than half of the contractions.
  - **Hyperstimulation:** Decelerations after contractions lasting more than 90 seconds, or with contraction frequency greater than every 2 minutes.
  - **Unsatisfactory:** Cannot induce adequate contractions or FHR recording is of poor quality.

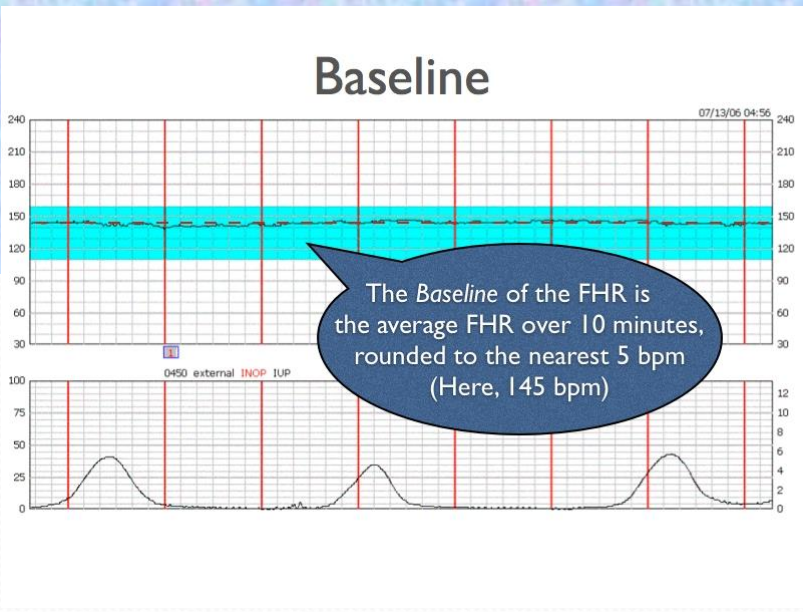

Negative CST
FHR
UC
Suspicious CST
FHR
UC
Positive CST
FHR
UC
Unsatisfactory
FHR
UC
1
3
5
7
9
min

ANTEPARTUM FETAL MONITORING

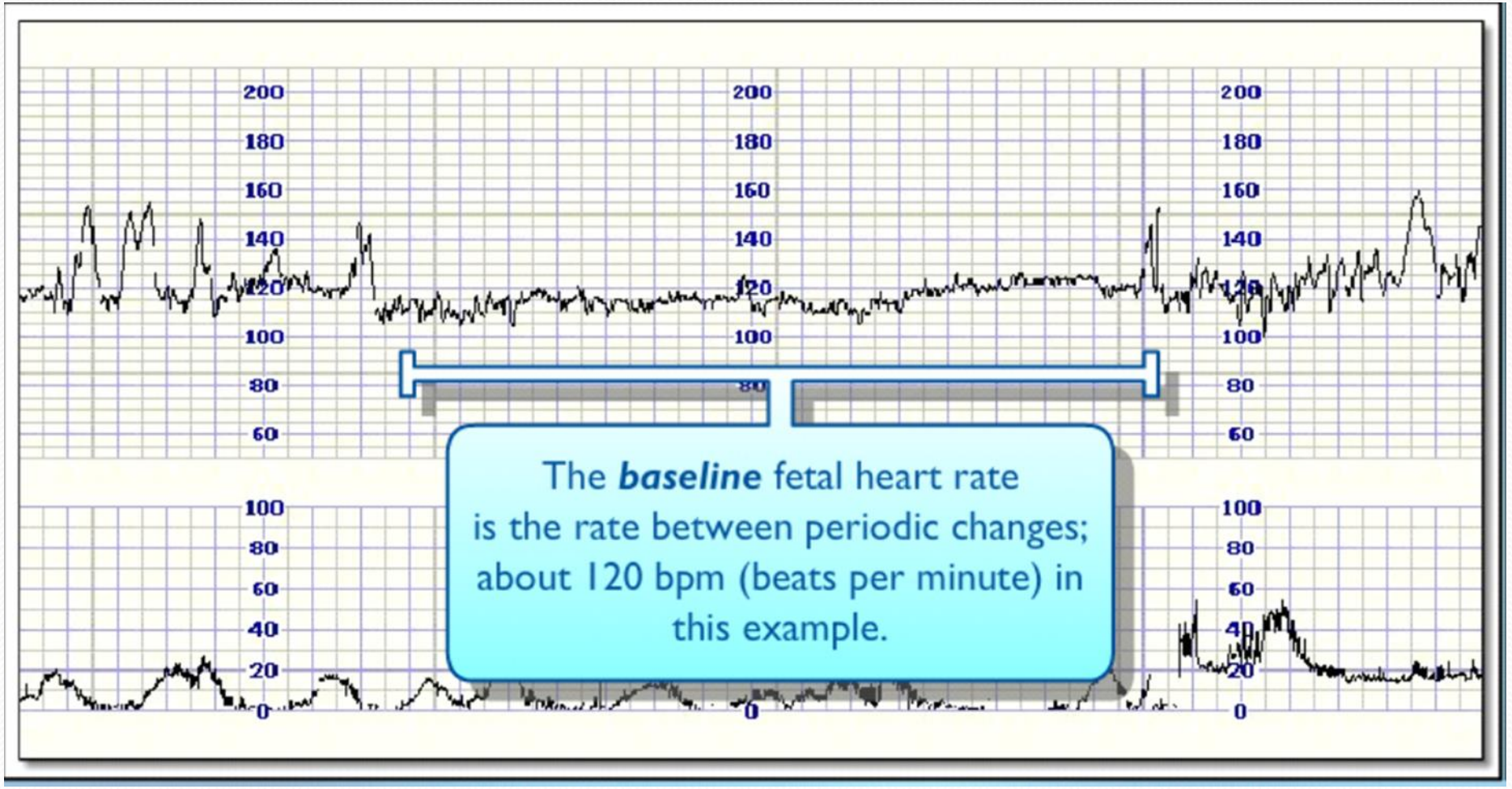
- Contraction stress test
  - Corrected perinatal mortality rate: 1.2 / 1000
  - High equivocal rate (دوام بالا)
  - False positive rate: 8 to 57%
  - False negative rate: 0.4 / 1000

Fetal Heart Rate Monitoring

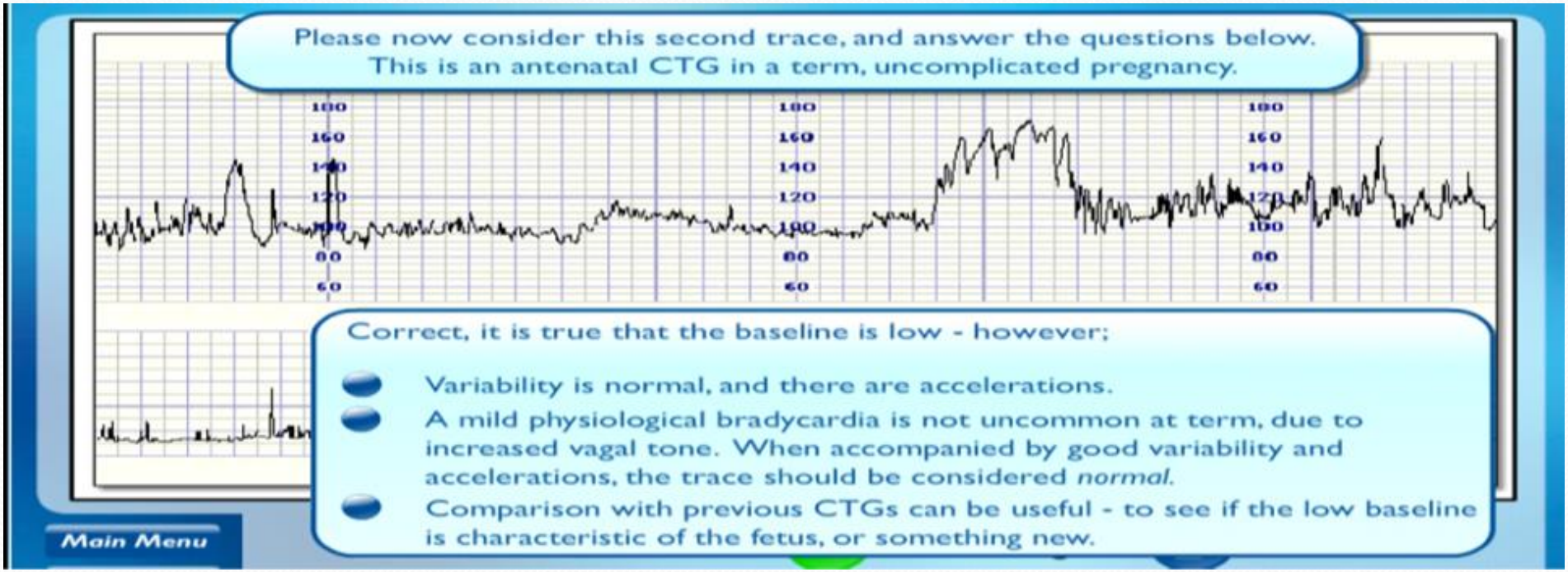
- FHR monitored during uterine contractions
- Normal rate is 120-160 → 110-180
  - *Fetal response to hypoxia is bradycardia!*



ضربان قلب پایه جنین

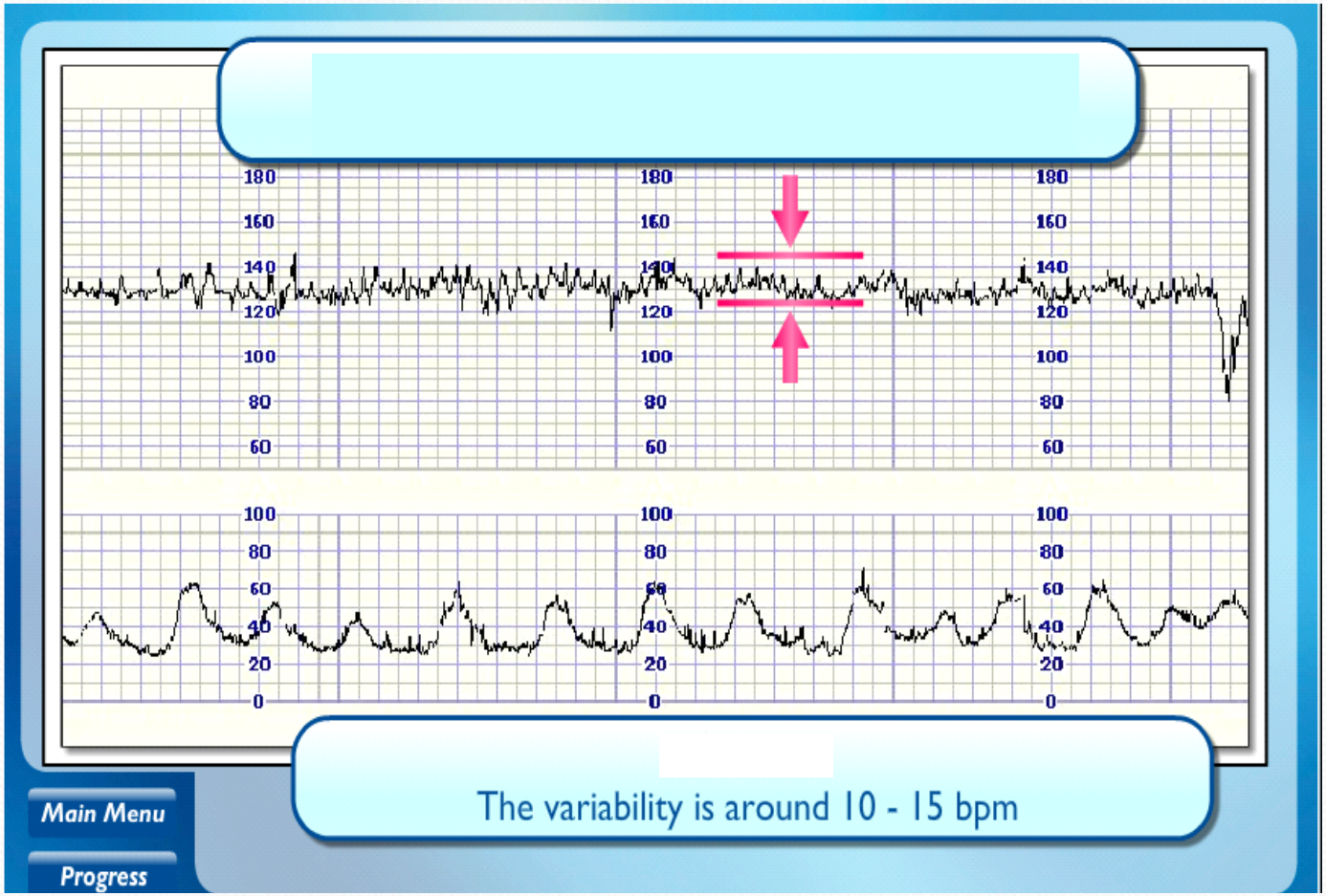


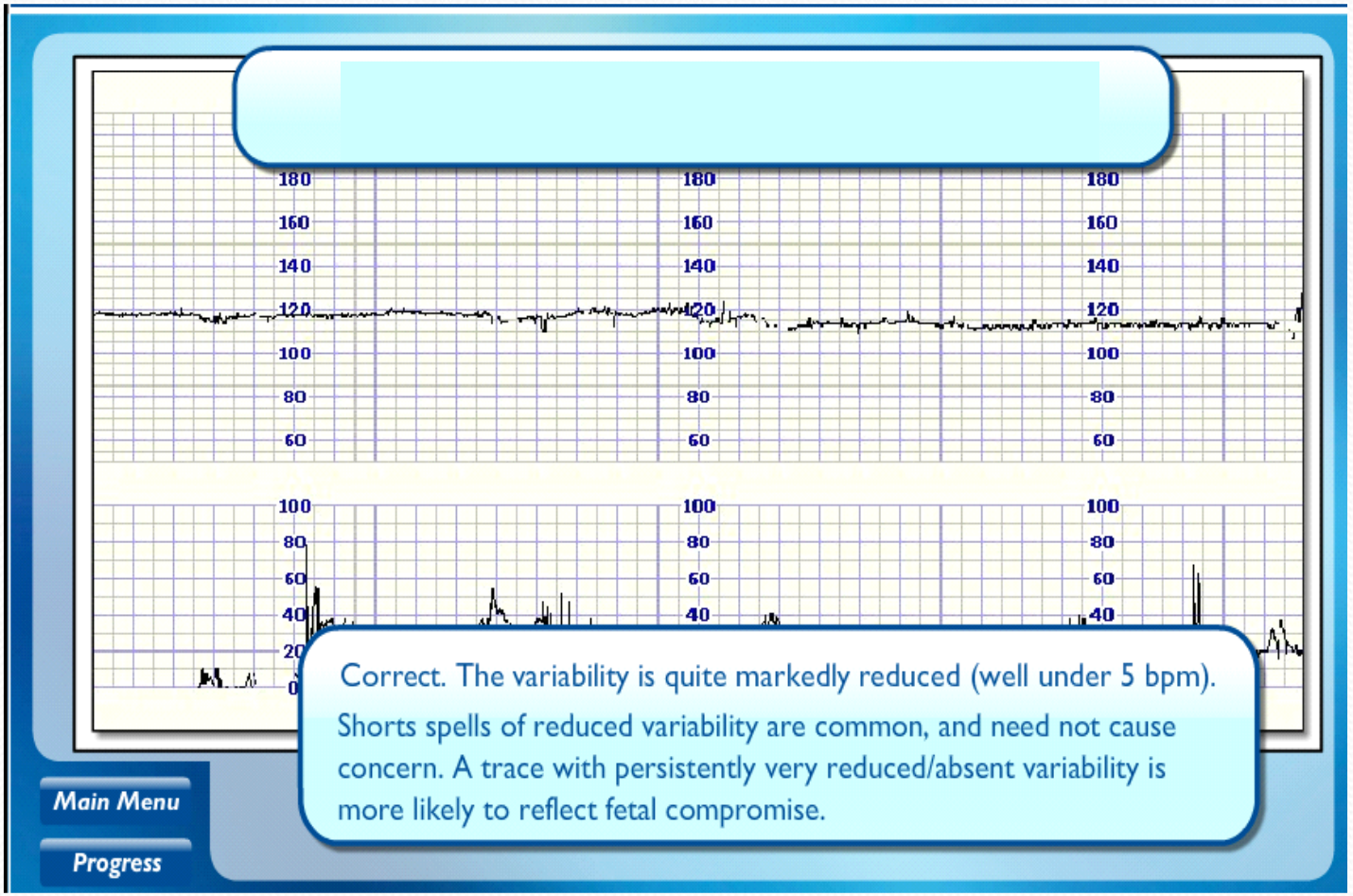
ضربان قلب پایه جنین در جنین هاي نارس بالاتر است. این میزان در 28 هفته نسبت به میزان متوسط در ترم 10 bpm بالاتر می باشد. بدین ترتیب در هر سن حاملگی FHR بالاتر 160 را باید با احتیاط تفسیر کر د. در این تصویر ضربان قلب پایه جنین پایین و حدود 100 bpm است.

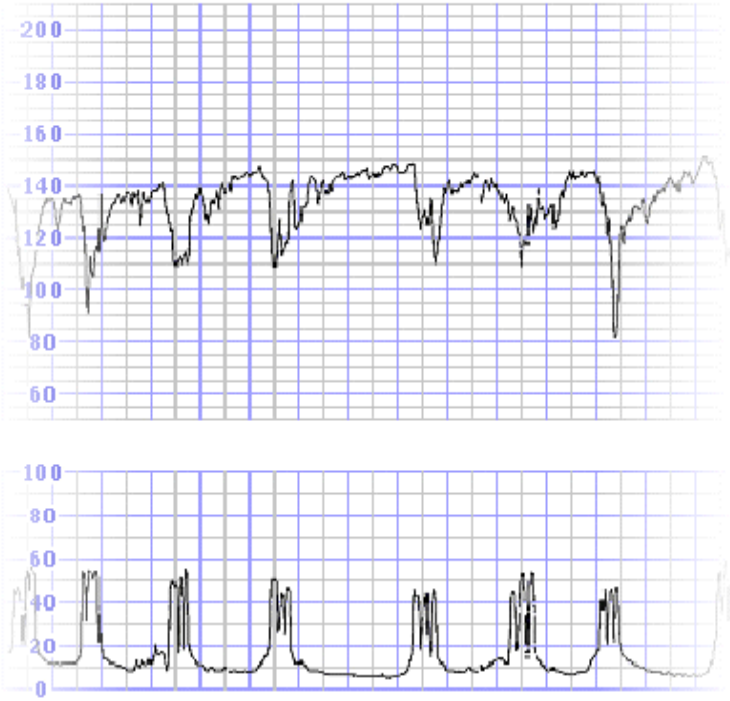


Beat to Beat Variability

- به نوسان FHR حول و حوش baseline، variability گویند و حد طبیعی آن 5-25 bpm است.
بررسیvariability بخصوص در تفسیرNST, CST پیچیده مهم است.
- Variability مفیدترین روش منفرد بررسی سلامت جنین محسوب می گردد. در لیبر وقوع افت هاي قلب بسیار شایع است و وجود یا عدم وجود variability است که به ما نشان می دهد آیا این تغییرات پریودیک از نوع معمولی و بی ضرر یا از نوع خطرناك و نگران کننده می باشند.
- variability نرمال با حدود 15-10 bpm است. Variability زیر 5 bpm کاملا کاهش یافته است و باید توجه داشت که این طرح variability کاهش یافته بسیار شایع است.
- معمولا هنگام خواب جنین مشاهده می شود و ادامه ثبت FHR نشان میدهد که آیا variability به حد نرمال برگشته و جنین خواب بوده یا این که Variability ادامه یافته دارد و احتمال هیپوکسی جنین وجود دارد. معمولاخواب جنین بیشتر از 40 دقیقه طو ل نمی کشد. در نتیجه با تکرار NST یا CST در این فاصله زمانی Variability به حد نرمال برمی گردد.


180
160
140
120
100
80
60
100
80
60
40
20
0
Main Menu
Progress
The variability is around 10 - 15 bpm

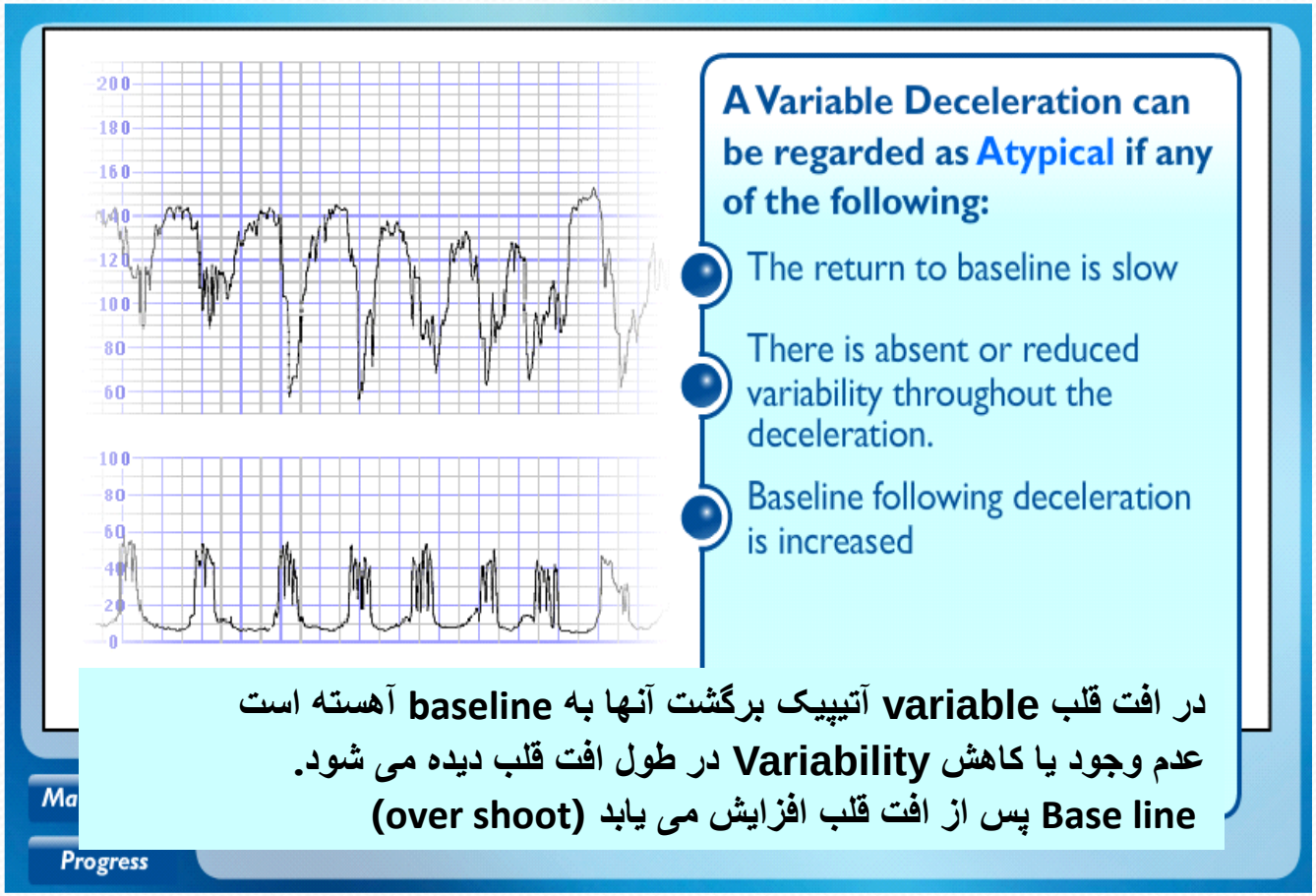

180
160
140
120
100
80
60
100
80
60
40
20
0
Correct. The variability is quite markedly reduced (well under 5 bpm).
Shorts spells of reduced variability are common, and need not cause concern. A trace with persistently very reduced/absent variability is more likely to reflect fetal compromise.
Main Menu
Progress



Typical Variable Decelerations,

- Occur in the presence of good heart rate variability.
- Usually maintain good variability throughout the deceleration.
- Rapid return to baseline from nadir with no overshoot.

- افت قلب های variable آتیپیک غیر عادی و پاتولوژیک هستند و حتما باید به کمک مشخصات دیگر NST, CTG و ریسک فاکتورهای زمینه ای تفسیر شوند.
- <u>افت قلب های طولانی</u>
- الف - افت قلب به مدت حداقل90 - 60 ثانیه
- ب - اگر در طول دو انقباض ادامه یابد یا بیشتر از سه دقیقه به طول انجامد پاتولوژیک تلقی می شود.



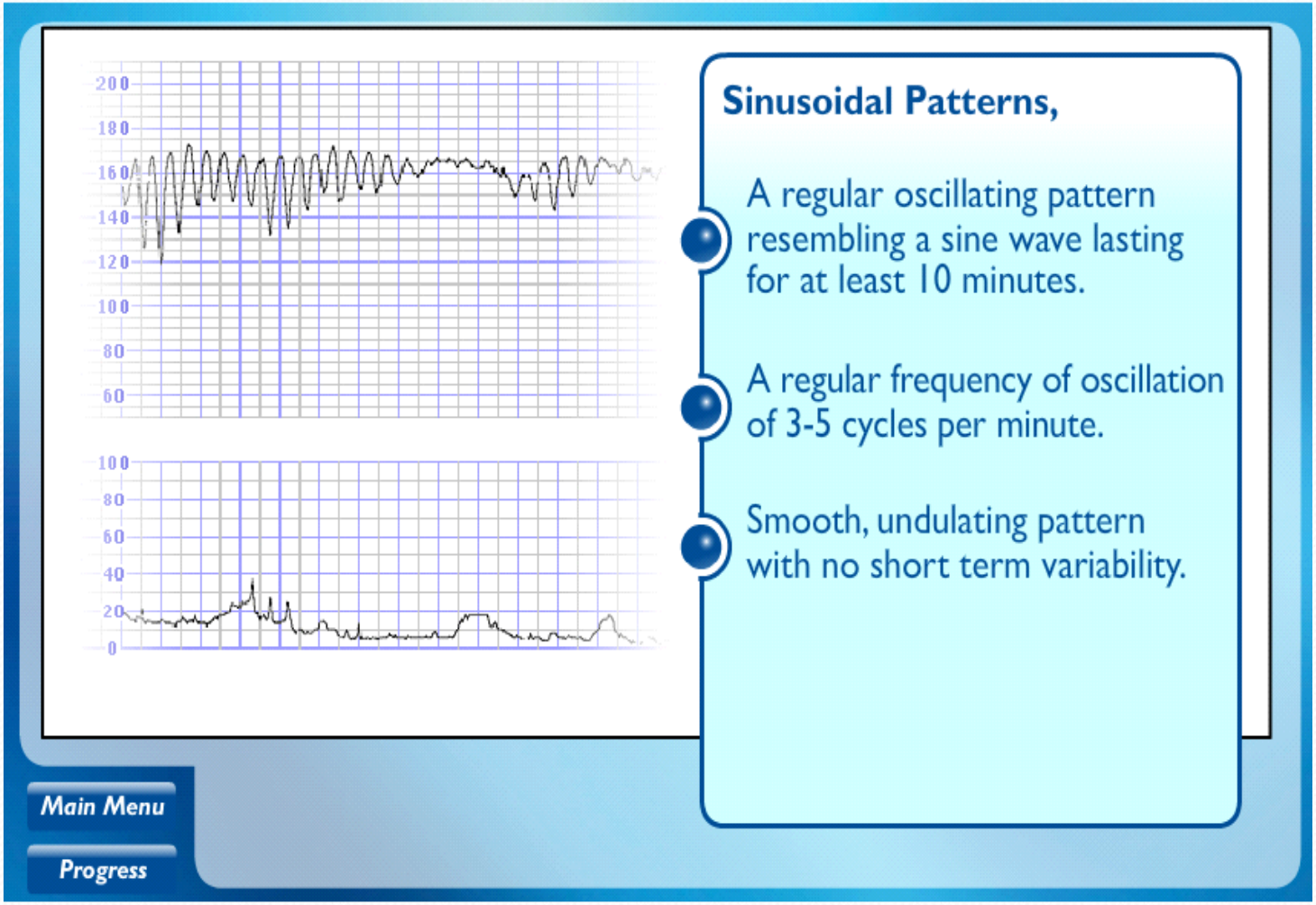
در افت قلب variable آتیپیک برگشت آنها به baseline آهسته است
عدم وجود یا کاهش Variability در طول افت قلب دیده می شود.
Base line پس از افت قلب افزایش می یابد (over shoot)

الگوهای سینوزوئید بیشتر موارد آنمی جنین را نشان می دهند.

الف - الگوی نوسانی منظم حداقل به مدت 10 دقیقه

ب- نوسان با فرکانس منظم 3 تا 5 سیکل در دقیقه

ج- الگوی صاف بدون variability کوتاه مدت



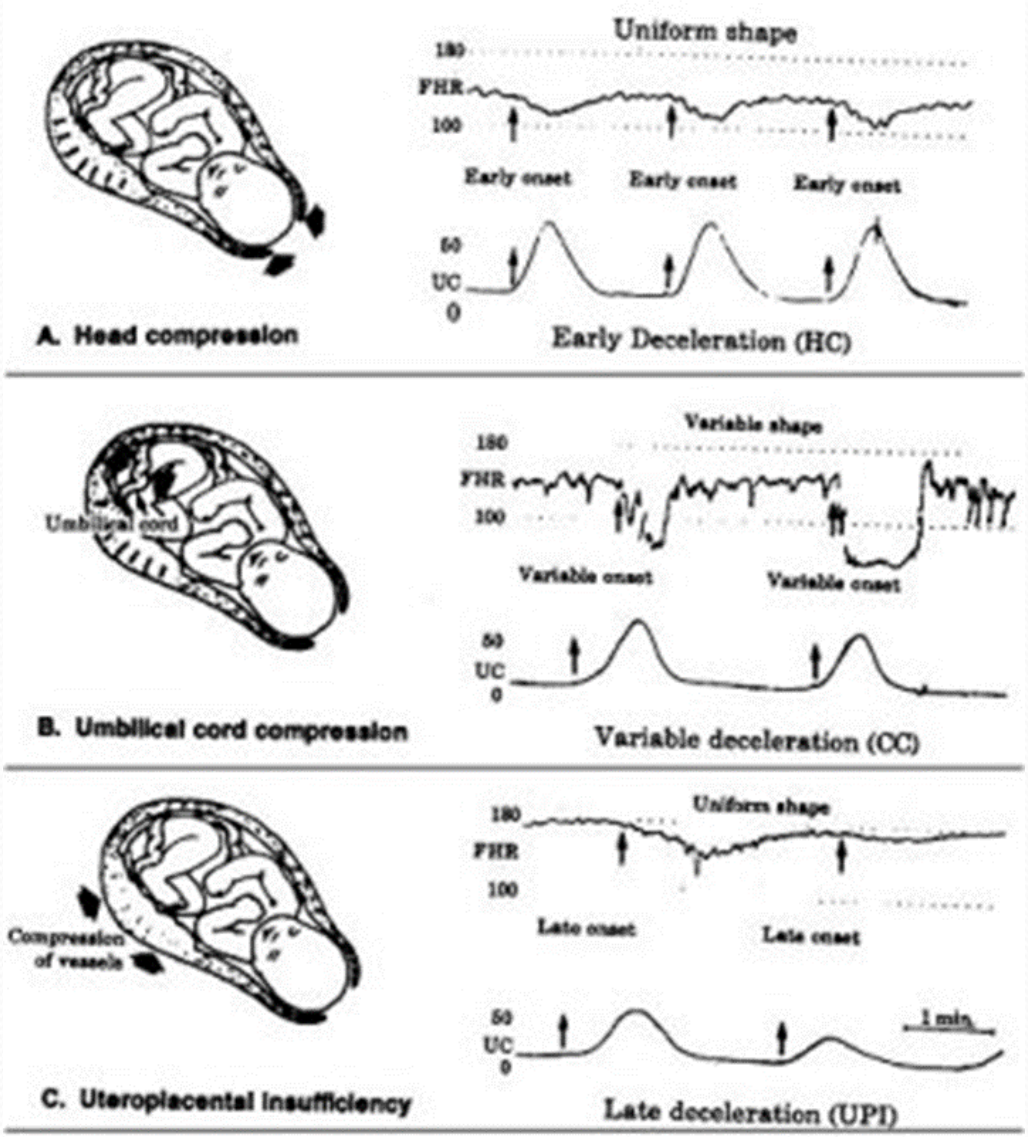
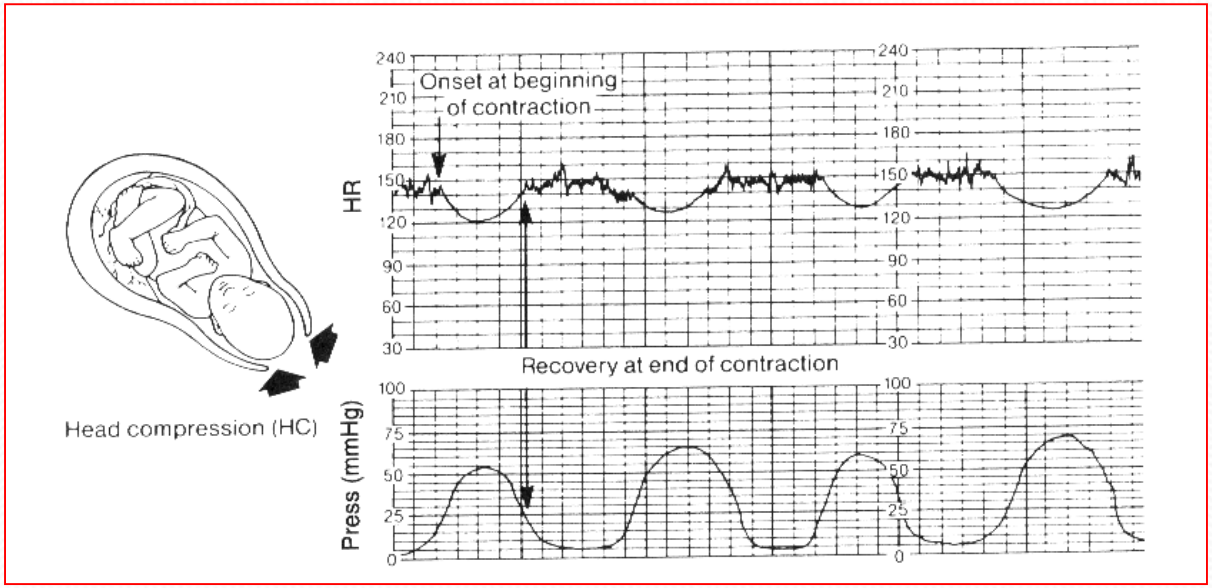
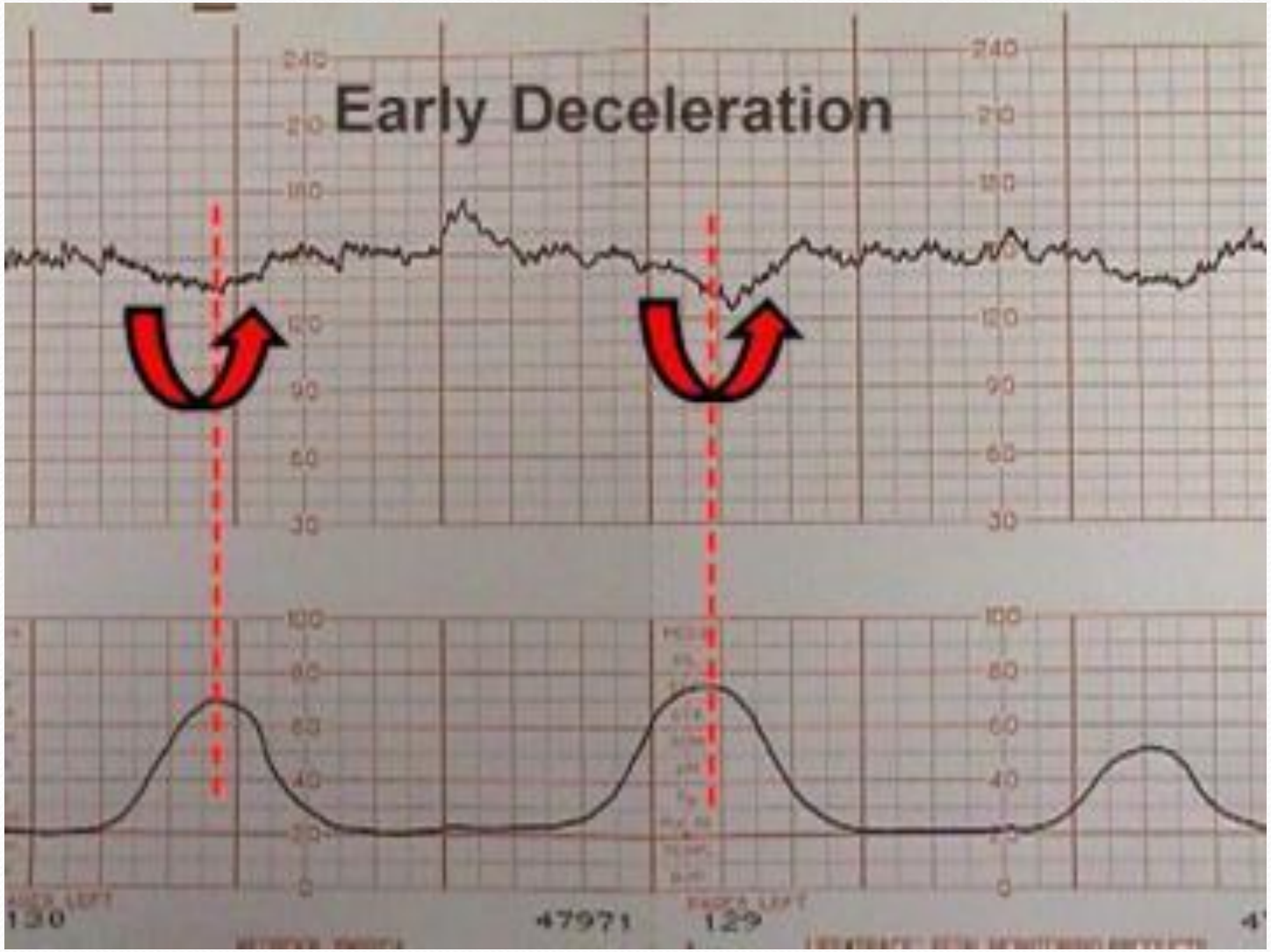


Figure 24-2 FHR deceleration patterns and implied etiology according to E.H. Hon. (From E.H. Hon. *An Atlas of Fetal Heart Rate Patterns* Hartley Press, New Haven, 1968)

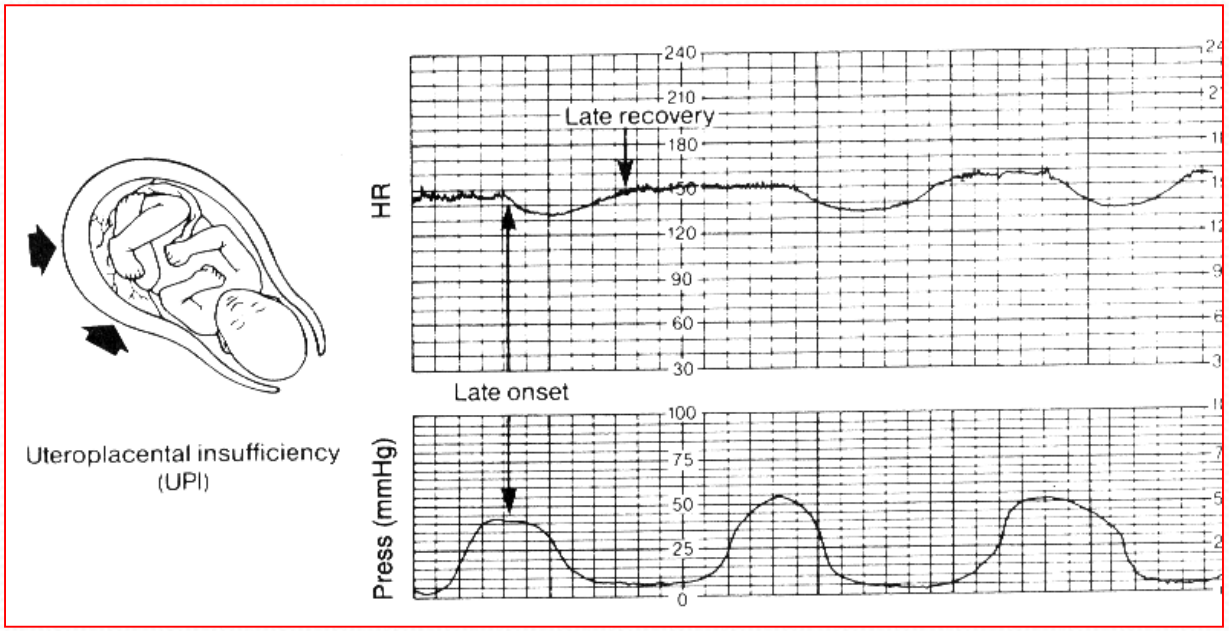
Early Decelerations



- Due to increased ICP causing vagal stimulation
- Usually benign

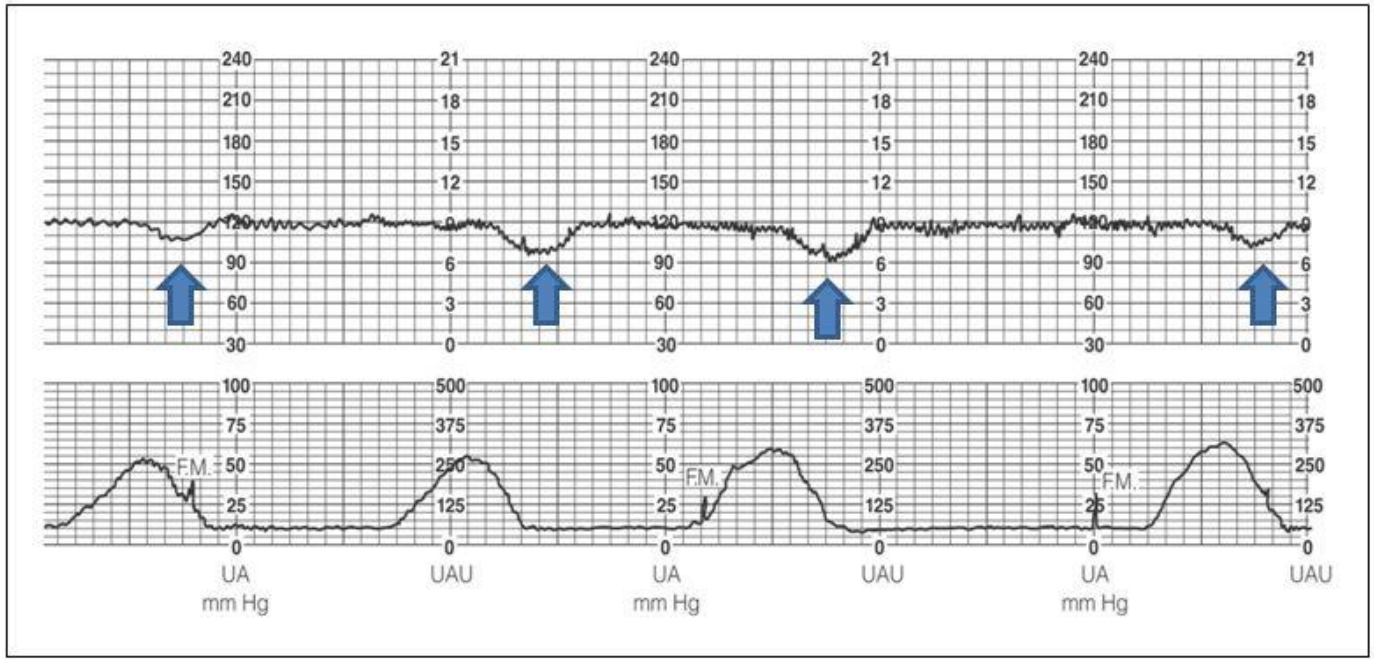

Early Deceleration
240
210
180
150
120
90
60
30
100
80
60
40
20
0
130
47971
129

Late Decelerations



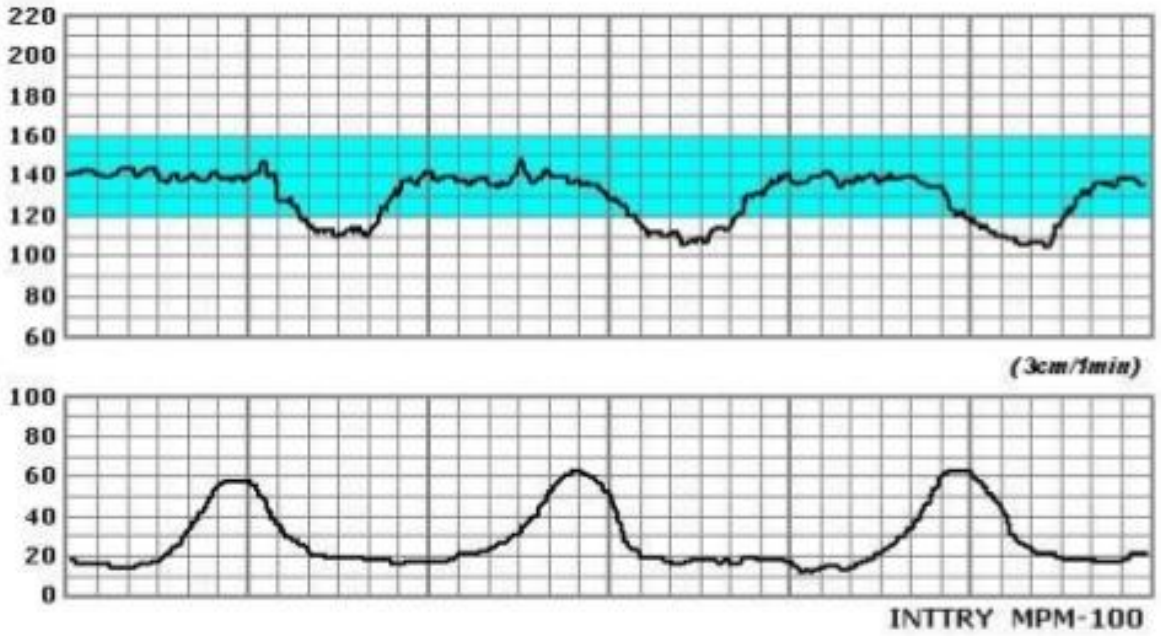
- *Bad sign!* Indicates uteroplacental insufficiency
  - Fetus is becoming hypoxic due to decreased maternal blood flow to IV spaces during contractions
- Mother is given O2, fluids (if she is hypotensive) and beta-2 stimulants to relax uterine contractions

Oxytocin Challenge Test



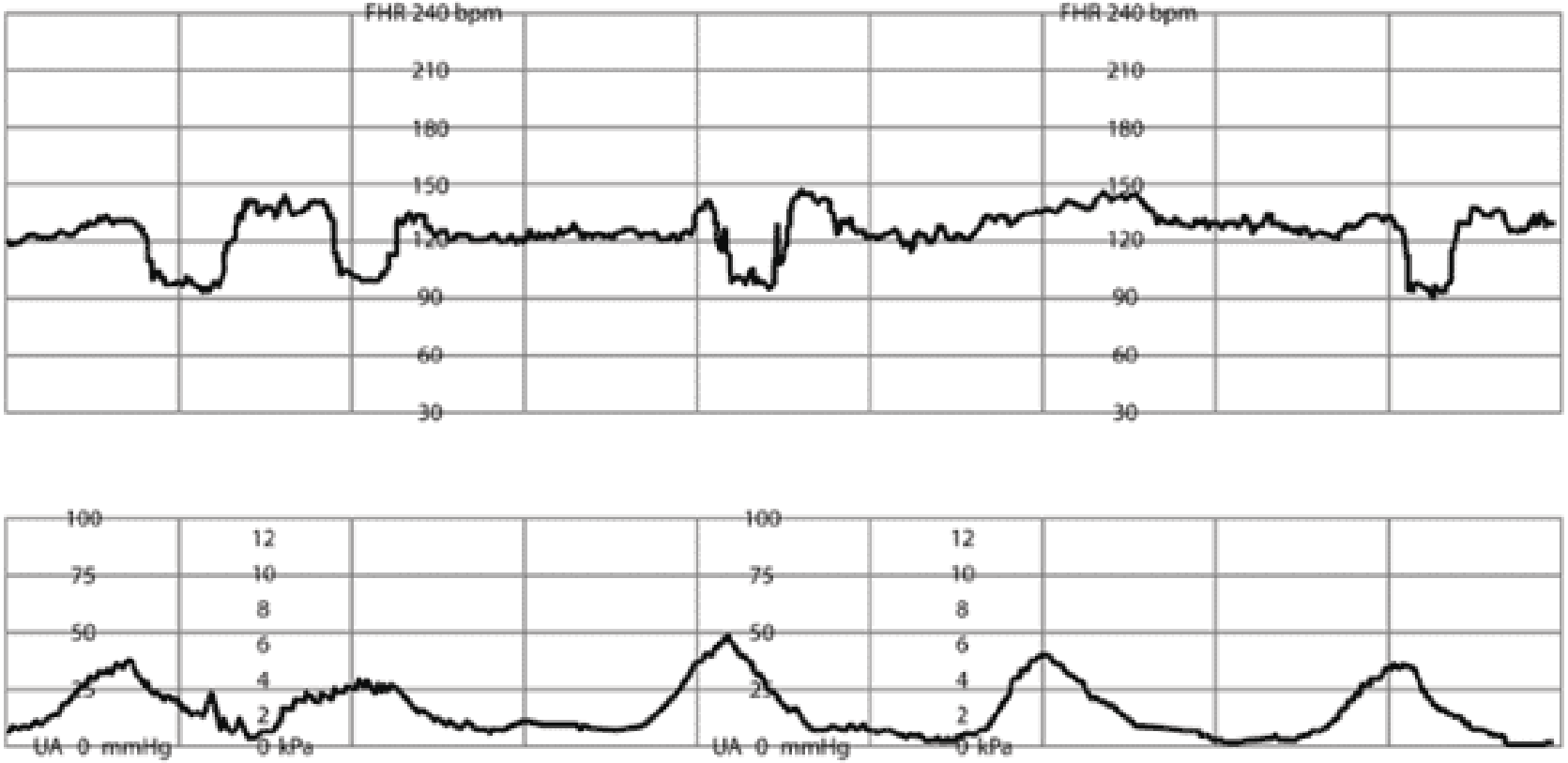
Example of a positive contraction stress test (CST). Repetitive late decelerations occur with each contraction. Note that there are no accelerations of FHR with three fetal movements (FM). The baseline FHR is 120 beats per minute. Uterine contractions (bottom half of the strip) occurred four times in 12 minutes.

oxytocin challenge test



OCT (oxytocin challenge test)

OCT positive


FHR 240 bpm
210
180
150
120
90
60
30
FHR 240 bpm
210
180
150
120
90
60
30
100
75
50
25
UA 0 mmHg
12
10
8
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4
2
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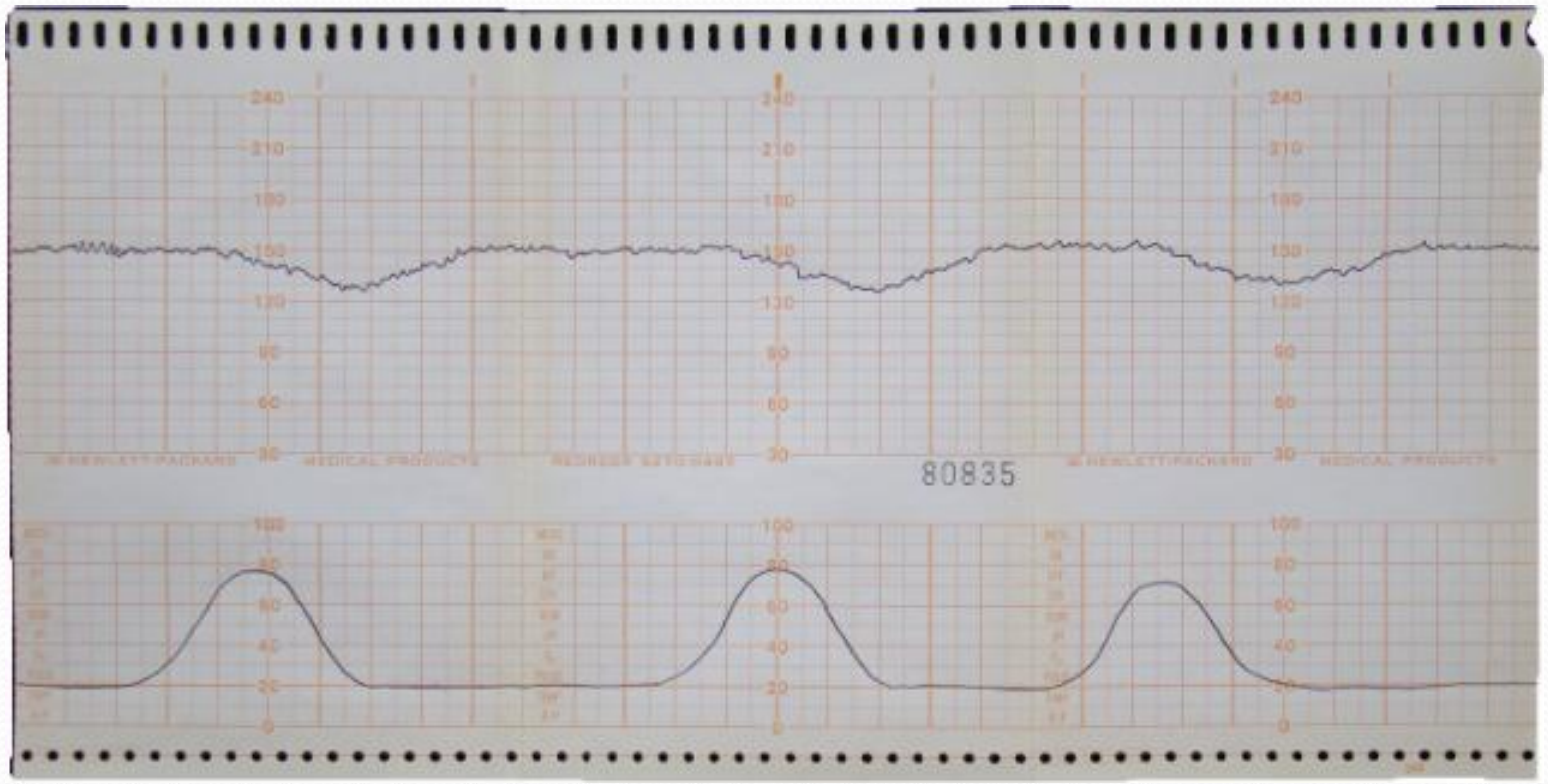
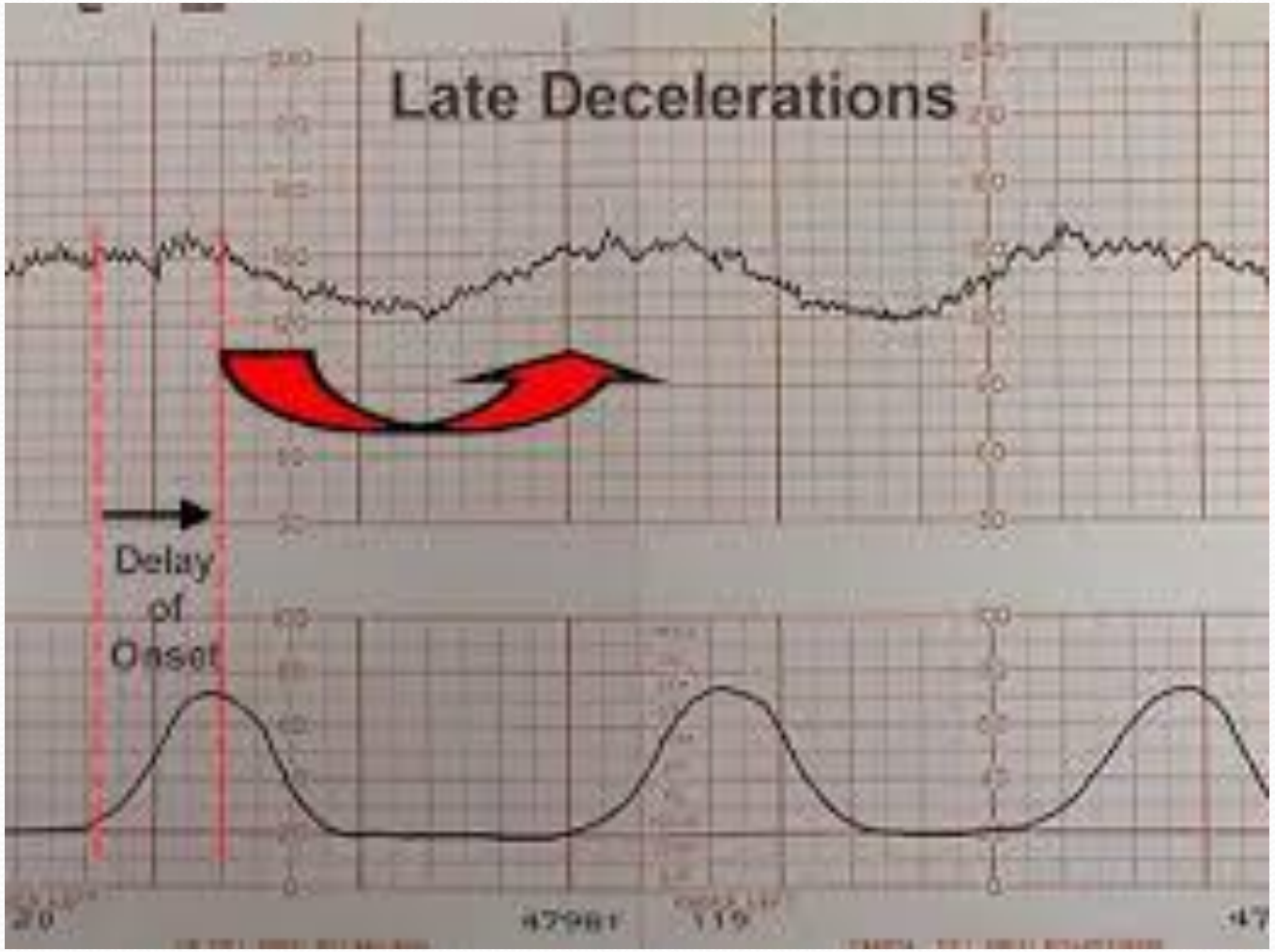
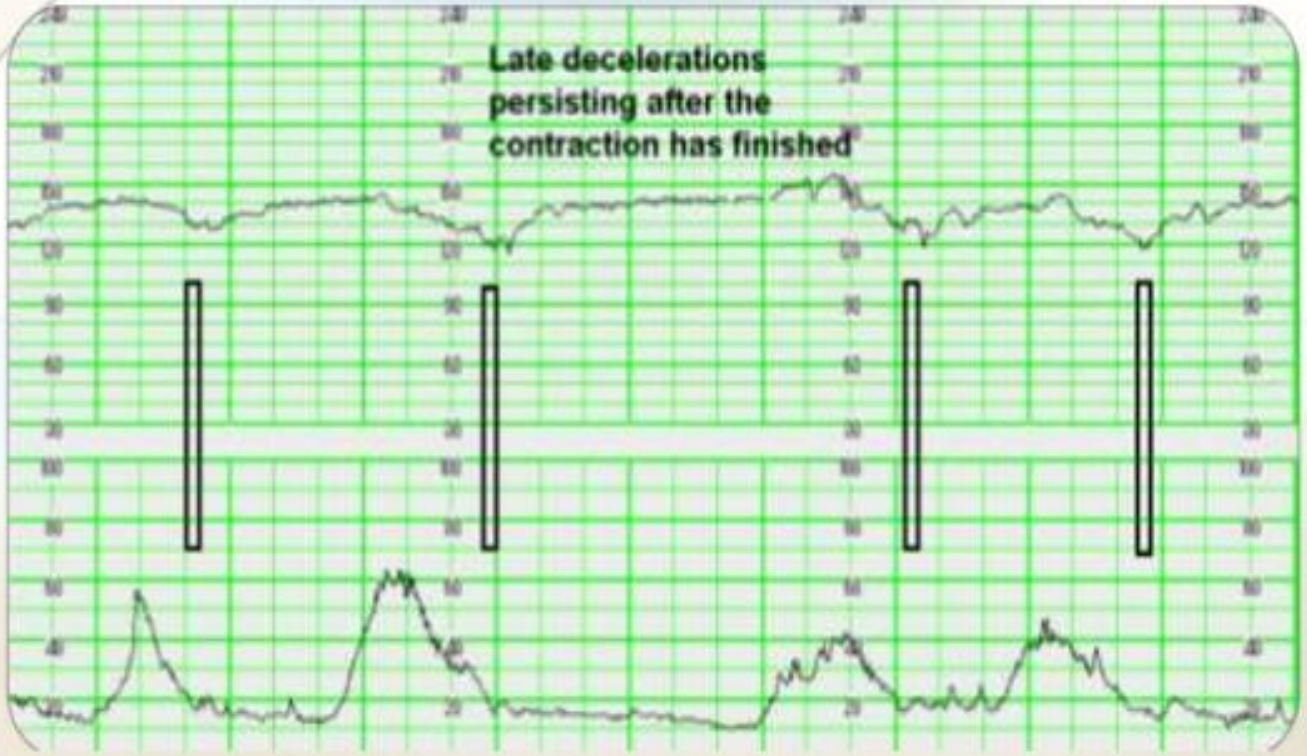
UA 0 mmHg
12
10
8
6
4
2
0 kPa

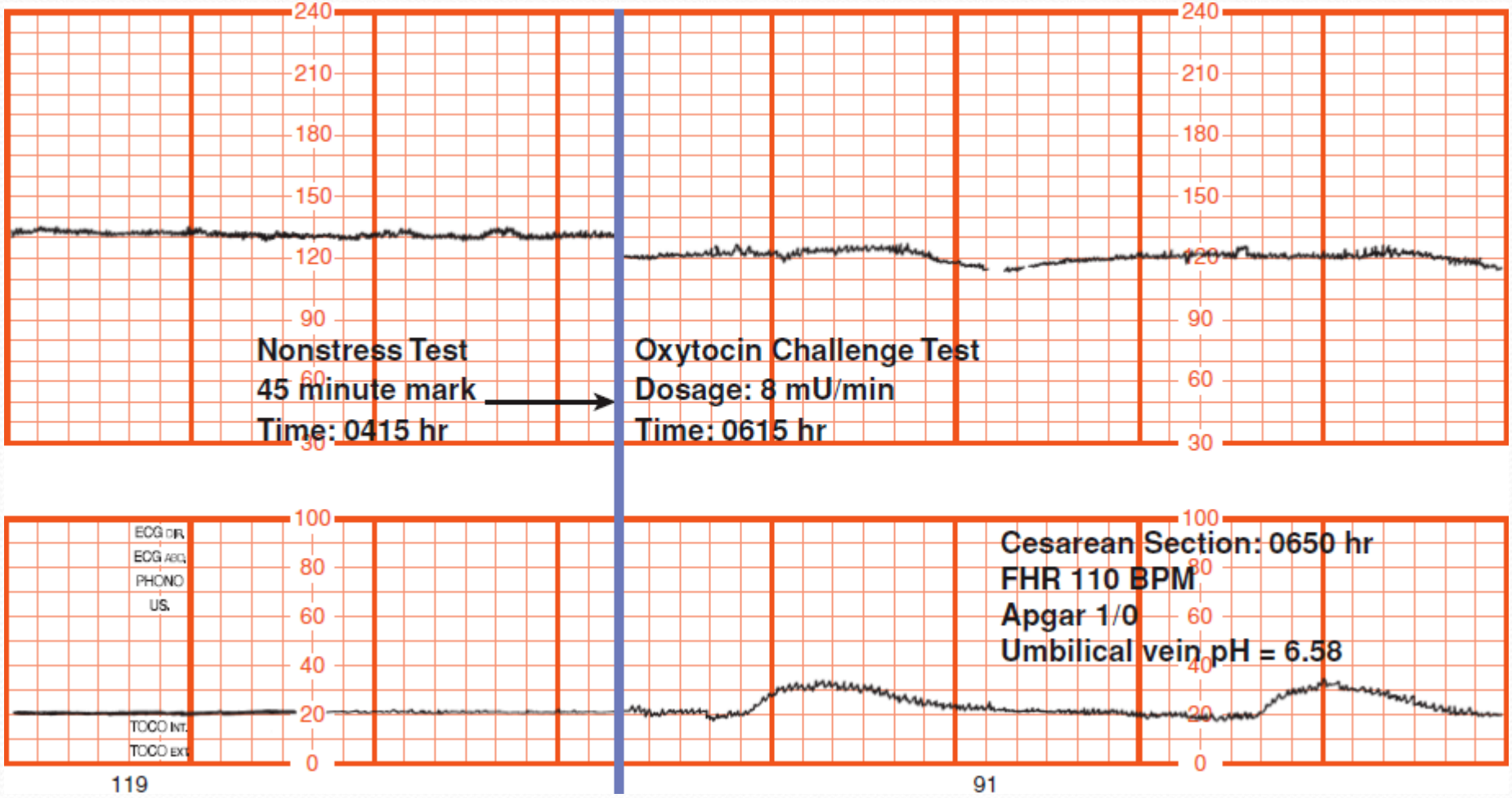

80835


Late Decelerations
Delay
of
Onset

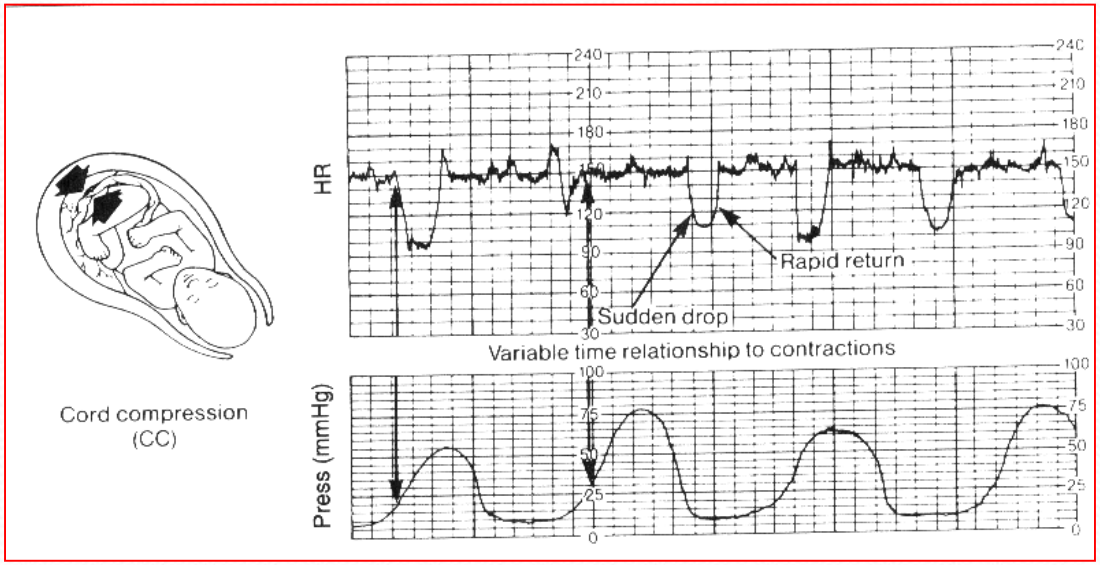


Late deceleration (Type II Dips)

یک نمونه از بررسی NST و سپس CST و بالاخره سزارین و آپگار 1 و سپس صفر



Variable Decelerations

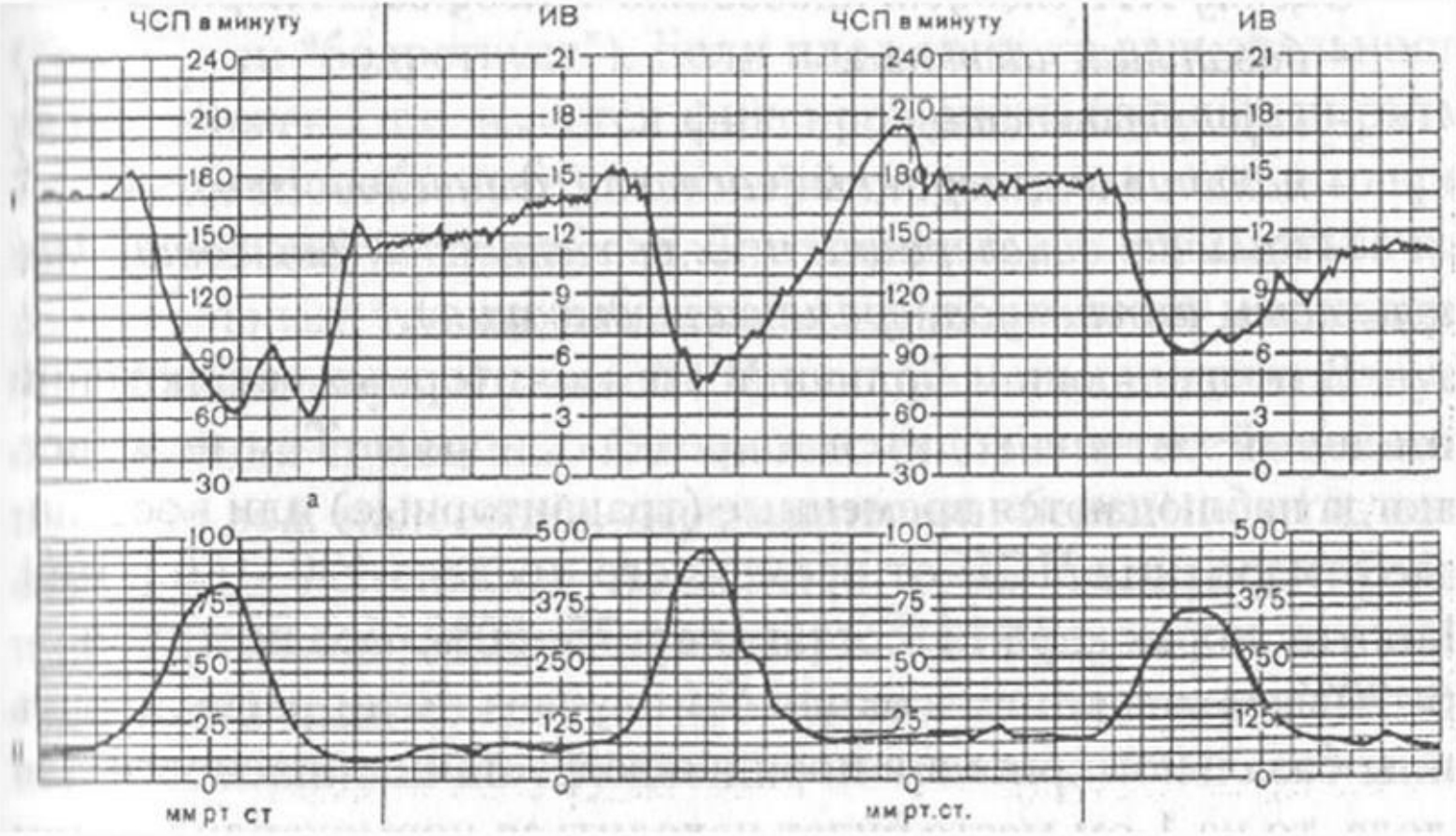


- Most commonly seen
- Caused by compression of umbilical cord
- Mother's position is changed

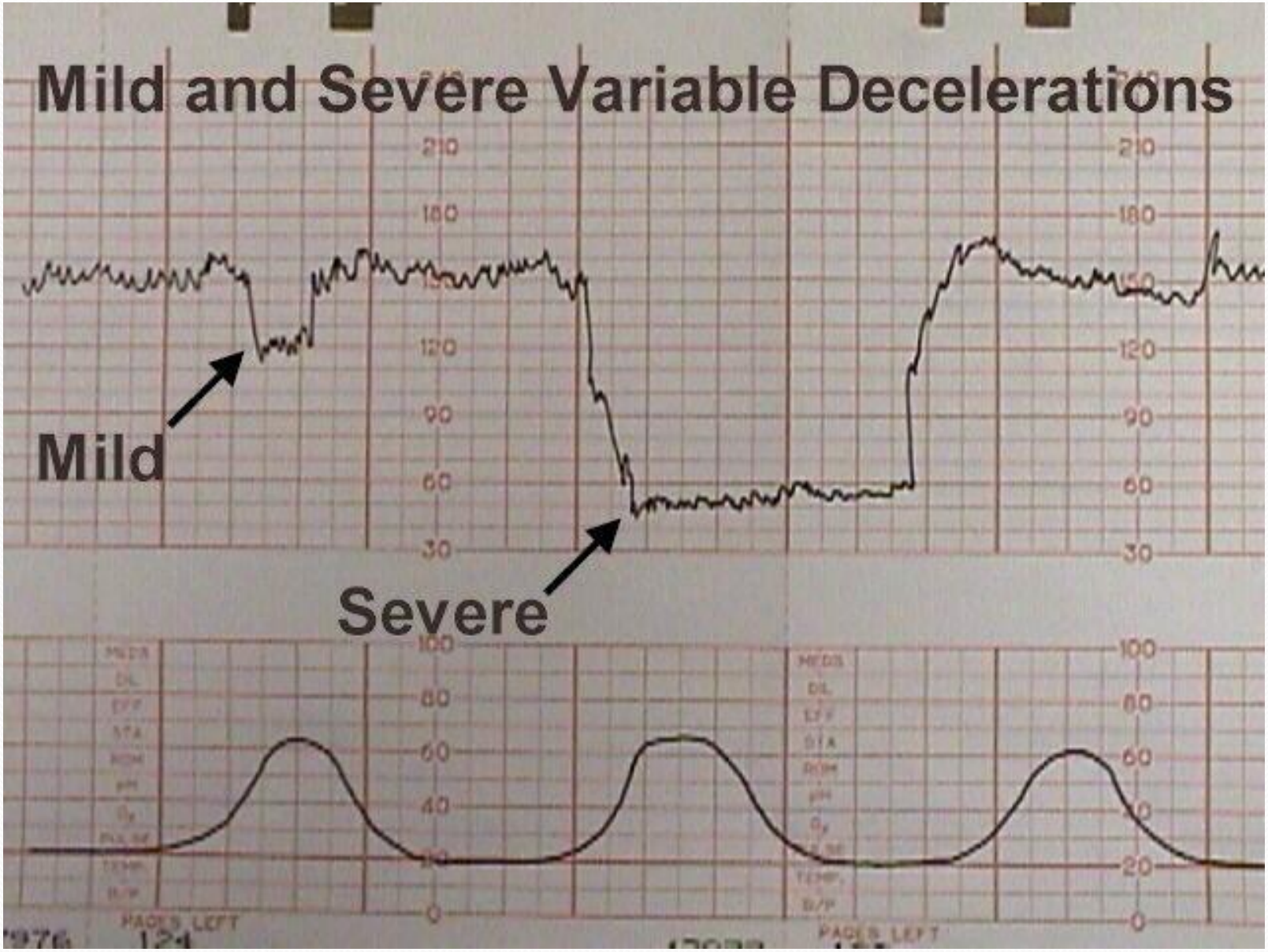
ANTEPARTUM FETAL MONITORING

- Other patterns
  - Variable decelerations: consider oligohydramnios or cord entrapment.
  - Loss of variability and blunting of decelerations: ominous sign.
  - Sinusoidal pattern: ominous pattern. Fetal anemia or fetal-maternal hemorrhage.
  - Nonreactive negative CST: should not occur, preexisting CNS abnormality?

Variable decelerations (dip 3)



Mild and Severe Variable Decelerations



ANTEPARTUM FETAL MONITORING

- Management of CST
  - Negative test: repeated weekly → Everyday or More
  - Positive test: acted on according to clinical condition
  - Equivocal test: repeat test the next day → Same day

ANTEPARTUM FETAL MONITORING

- When to shorten the interval between testing
  - Deterioration in diabetic control
  - Worsening hypertension
  - Need to introduce antihypertensive medication
  - Decreased fetal movement

ANTEPARTUM FETAL MONITORING

- Contraindications to CST
  - PROM
  - Previous classical cesarean delivery
  - Placenta previa
  - Incompetent cervix
  - History of premature labor in this pregnancy
  - Multiple gestation

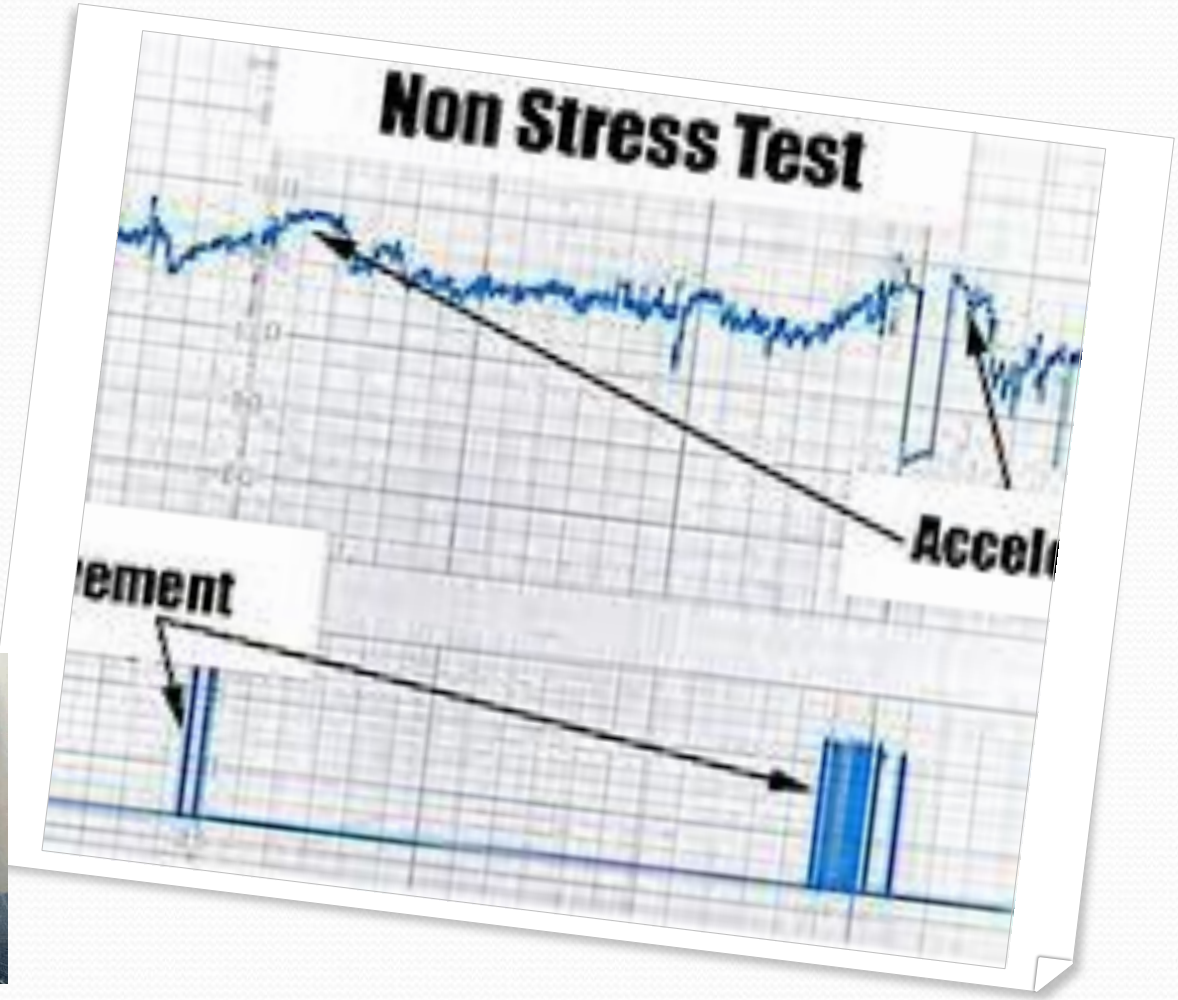
High Risk Delivery and Fetal Rescue if:

- Late decelerations
- Variable decelerations where heart rate drops to 60 or less and stays there for one minute or longer
- Will require C-section and resuscitation

Contraction Stress Test

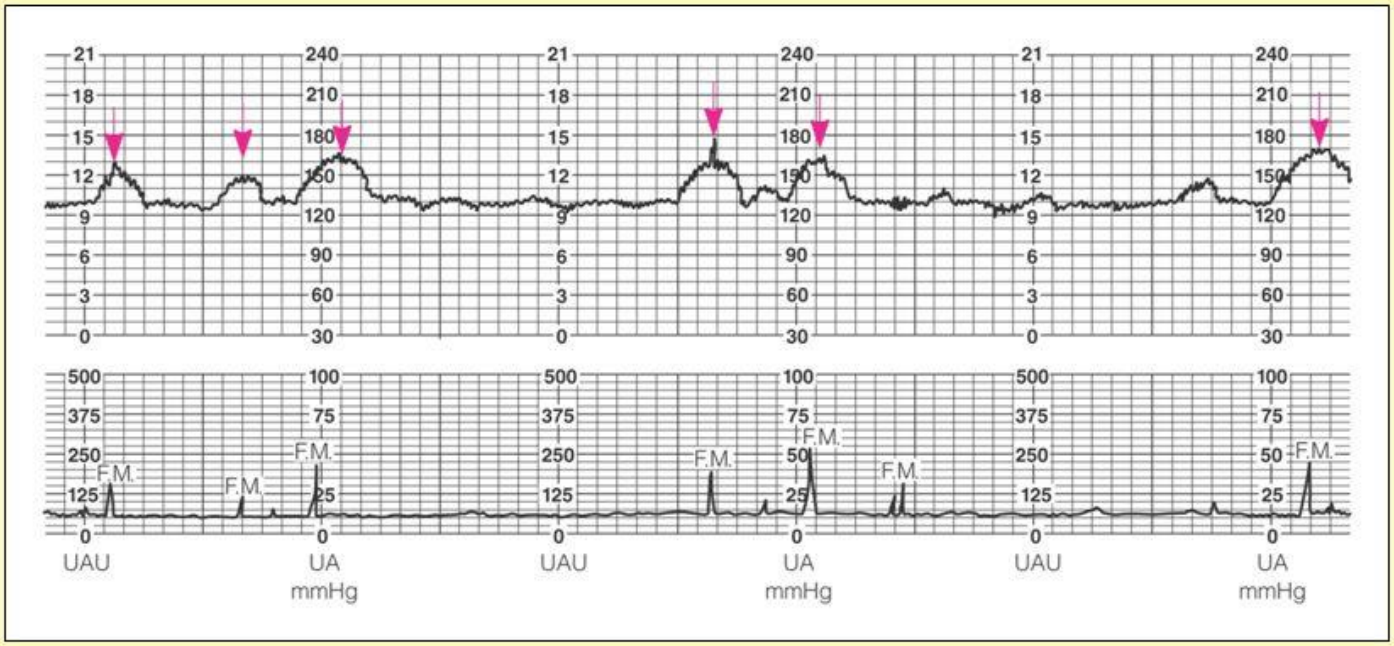
- Oxytocin (Pitocin) administered to stimulate contractions
- Positive test if two episodes of late decelerations are seen within ten minutes
- *Positive test indicates impending fetal asphyxia when labor starts!*

Non Stress Test




PHILIPS
156
25
PHILIPS

Non-Stress Test



Example of a reactive nonstress test (NST). Accelerations of 15 beats per minute lasting 15 seconds with each fetal movement (FM).

وضعیت صحیح مادر طی انجام NST

مادر باید به پهلو دراز بکشد و ضربان قلب جنین باید با استفاده از یک دستگاه مانیتورینگ خارجی از روي شکم مادر ثبت شود.

در صورت سیگاري بودن قبل از تست سیگار نکشیده باشد.

IUGR and SGA

- یک جنین IUGR در مقایسه با جنین SGA استعداد بیشتري براي ابتلا به هیپوکسی و موربیدیتی ناشی از آن دارد. از سوی دیگر جنین IUGR ممکن است از قبل در معرض هیپوکسی مزمن باشد و هر اختلال در اکسیژن رسانی که معمولا در طی یک لیبر نرمال، اتفاق می افتد ممکن است سطوح اکسیژن را بسیار پایین بیاورد و به حد خطرناك براي وي برساند.
- یک مسئله مهم دیگر این که ذخایر گلیکوژن یک جنین IUGR بسیار پایین است. معمولا یک جنین در شرایط هیپوکسی شدید انرژي لازم خود را از طریق متابولیسم بی هوازی تأمین می کند.

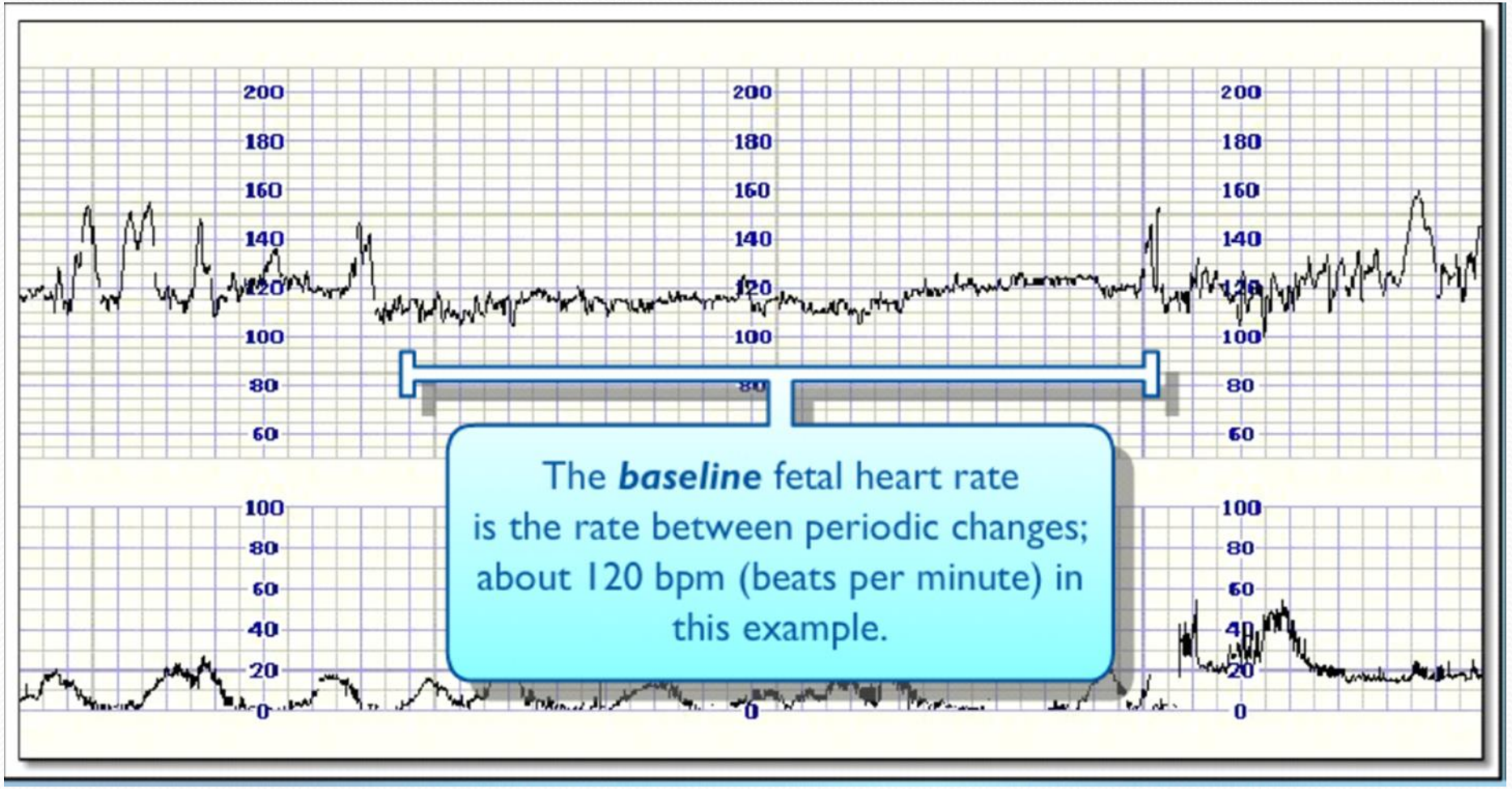
عوامل خطر

- IUGR
- د کولمان اخیر جفت
- اولیگوهیدرآمنیوس و گاهی دفع مکونیوم که بیانگر عدم وجود مایع نیز می باشد.
- وجود این عوامل تفسیر ما را از NST تغییر میدهد و روی تصمیم گیري ما براي ادارہ زایمان موثر است.

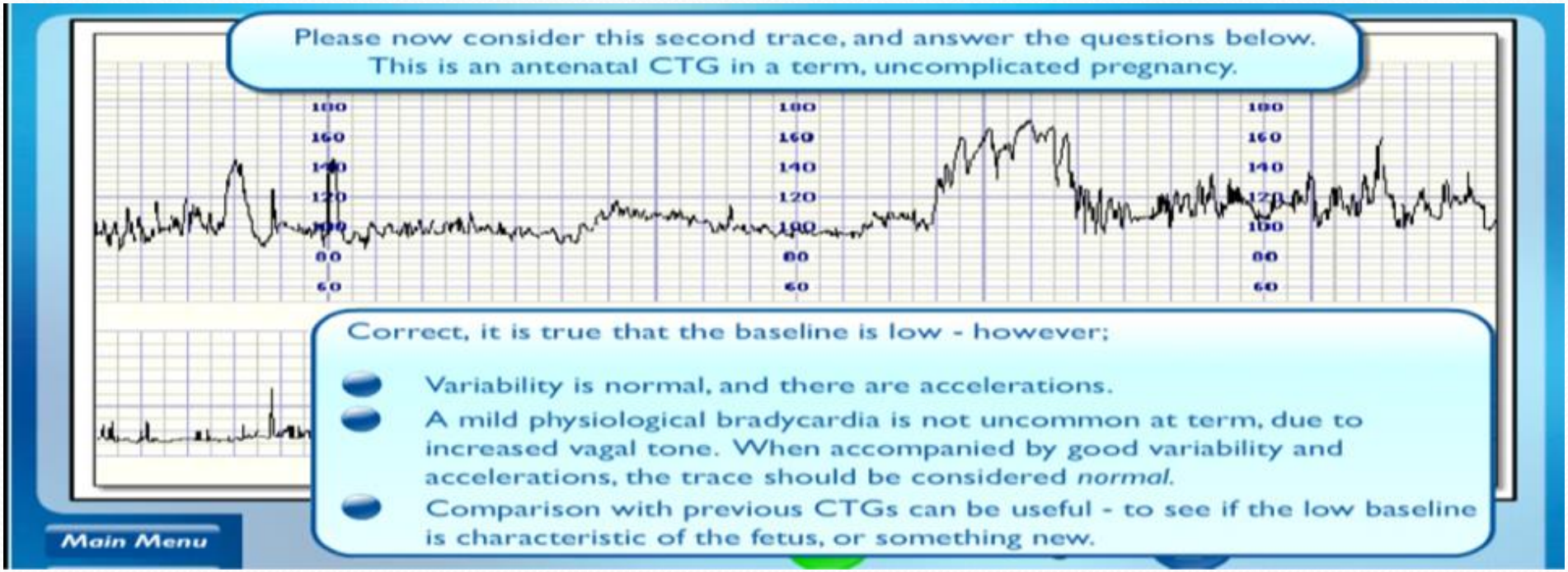
عوامل موثر بر Non- reactive شدن

- نارس بودن جنين
- سيكلهاي خواب و بيداري جنين
- داروهای مصرف شده توسط مادر
- اختلالات و ناهنجاري هاي
- هیپوکسی و اسیدمی

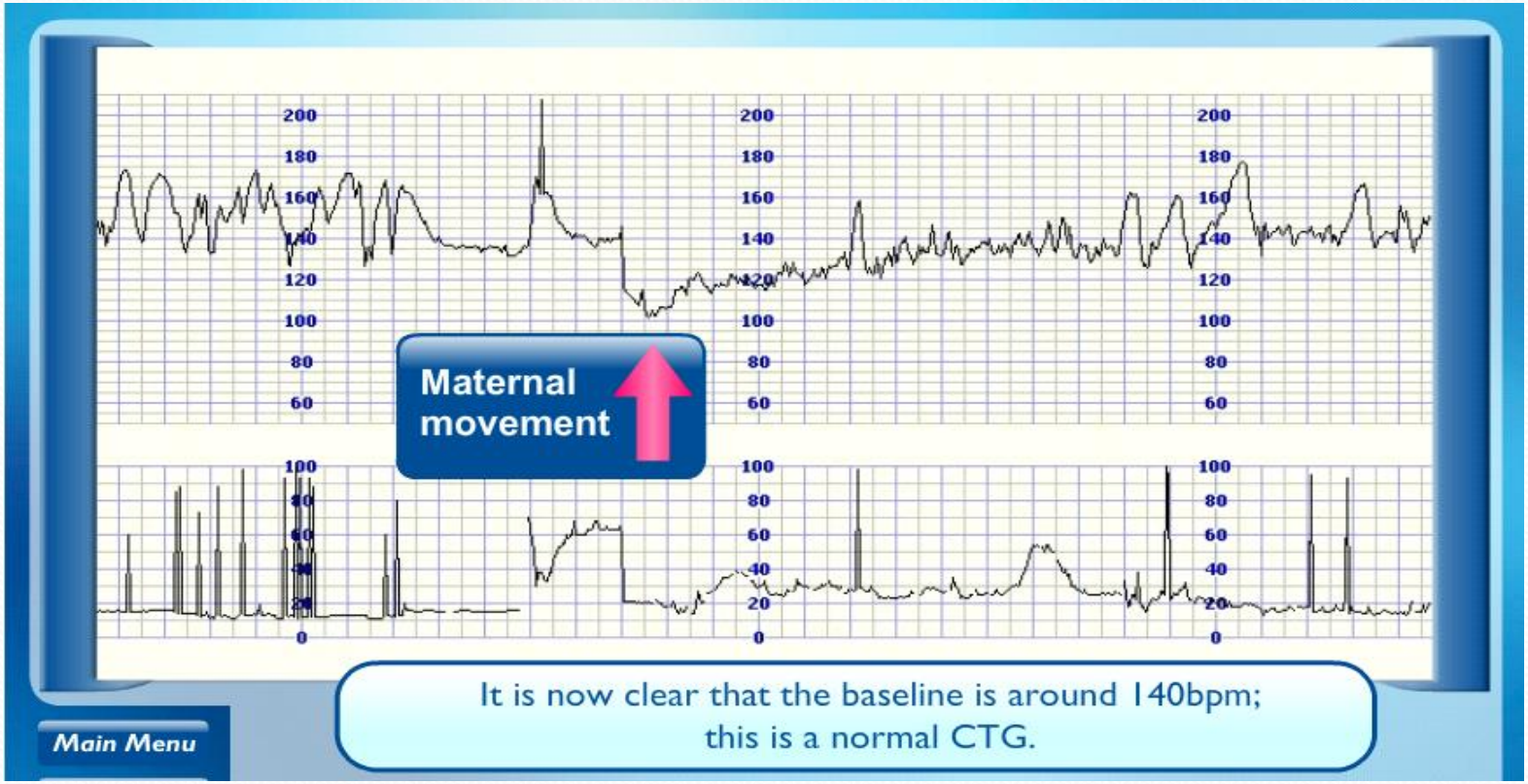
ضربان قلب پایه جنین



ضربان قلب پایه جنین در جنین هاي نارس بالاتر است. این میزان در 28 هفته نسبت به میزان متوسط در ترم 10 bpm بالاتر می باشد. بدین ترتیب در هر سن حاملگی FHR بالاتر 160 را باید با احتیاط تفسیر کر د. در این تصویر ضربان قلب پایه جنین پایین و حدود 100 bpm است.



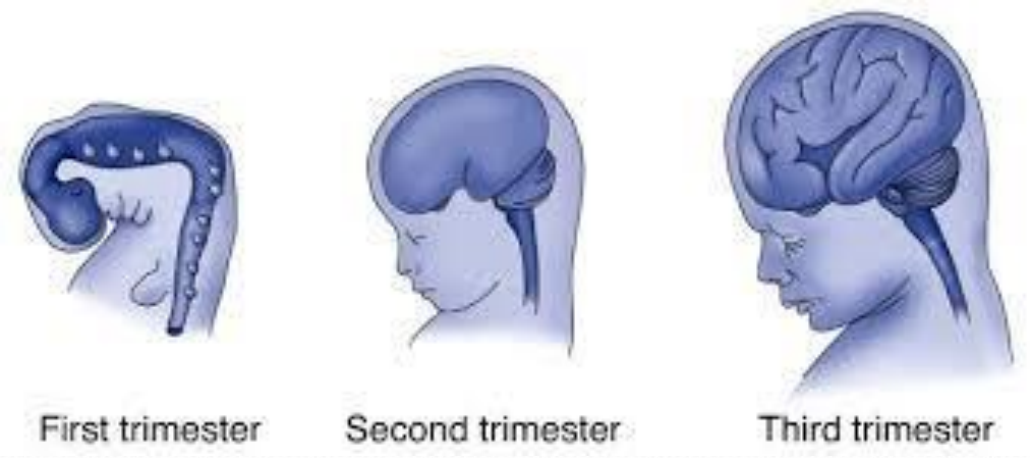
- این تصویر نوار قلب و انقباضات یک مادر با حاملگی ترم و در اوایل لیبر را نشان میدهد. تشخیص این که ضربان قلب پایه حدود **140 bpm** همراه با **acceleration** یا **160 bpm** همراه با **deceleration** می باشد.
- برای تشخیص این که آیا این نوار قلب مشکل دارد یا نه **position** مادر را تغییر می دهیم و ثبت **FHR** را ادامه می دهیم یک ضربان قلب پایه نرمال حدود **bpm** 140 به همراه **acceleration** ها را نشان می دهد که نرمال و نشانگر یک جنین غیرهیپوکسیک تلقی میشود.



Reactive Non stress test

نتایج NST

- **یک NST نرمال حد اقل دارای 2 مورد Acceleration است.**
- **میزان قابل قبول Acceleration در 24 تا 28 هفته حداقل10 bpm به مدت 10 ثانیه است.**
- **در 28تا 34 هفته حد اقل15 bpm به مدت 15 ثانیه و در بیشتر از 34 هفته حداقل20 bpm به مدت 20 ثانیه است.**
- **قلب یک ضربان پایه دارد و Acceleration درپاسخ به سطح فعالیت CNS رخ می دهد. زمان شایع رخداد Acceleration در وضعیت فعالیت جنین است و معمولا با حرکات جنین همزمان است.**



دلایل عدم acceleration

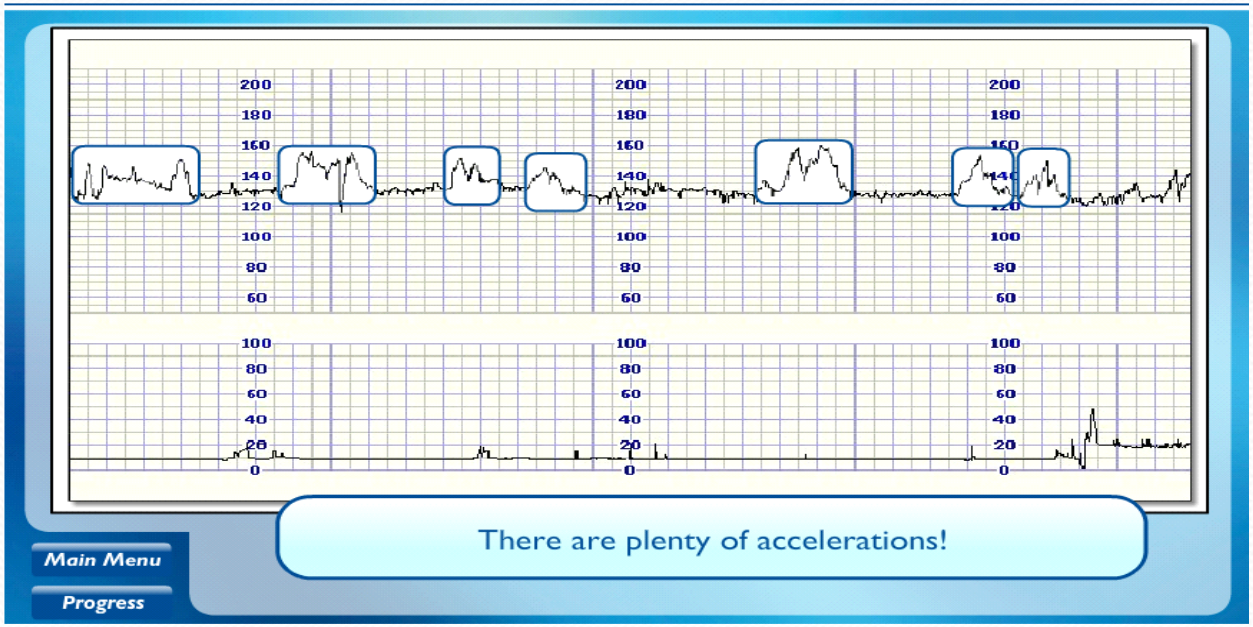
الف - دلایل خوش خیم:

1-خواب جنین

2- Sedation مادر

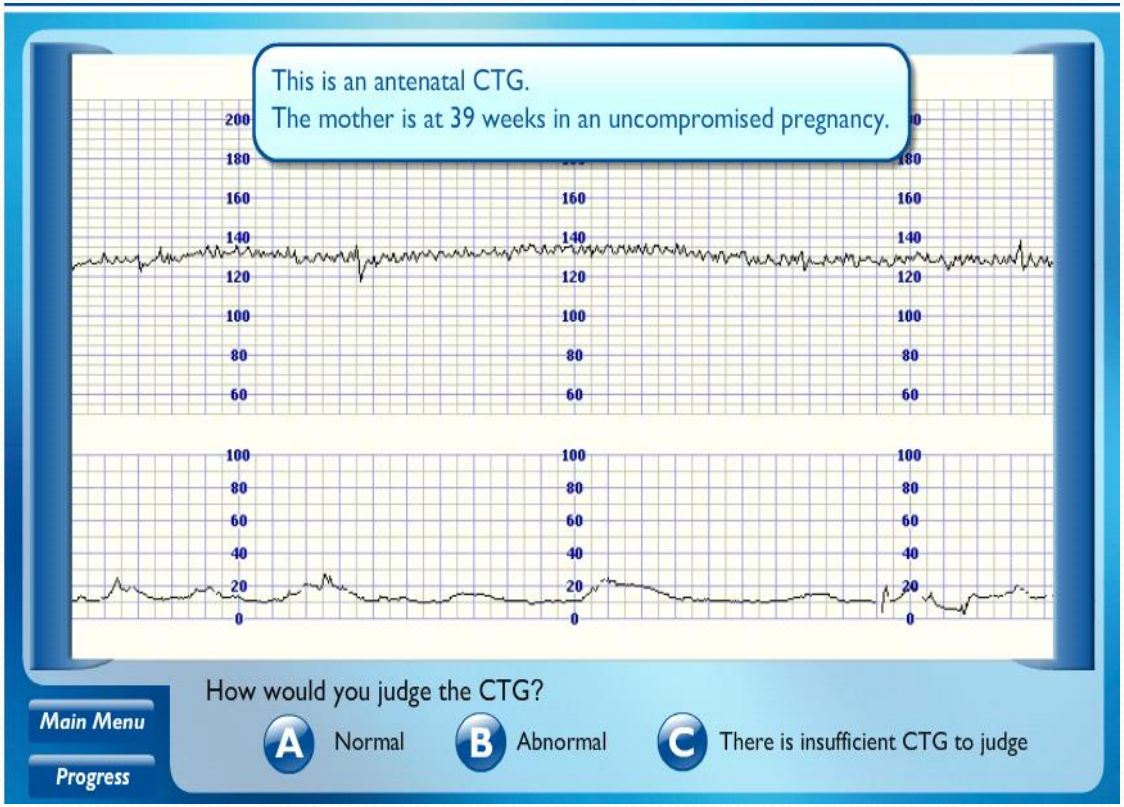
ب - دلایل نگران کننده شامل:

وضعیت هایی که جنین در مصرف انرژي صرفه جویی می کند مثل هیپوکسی

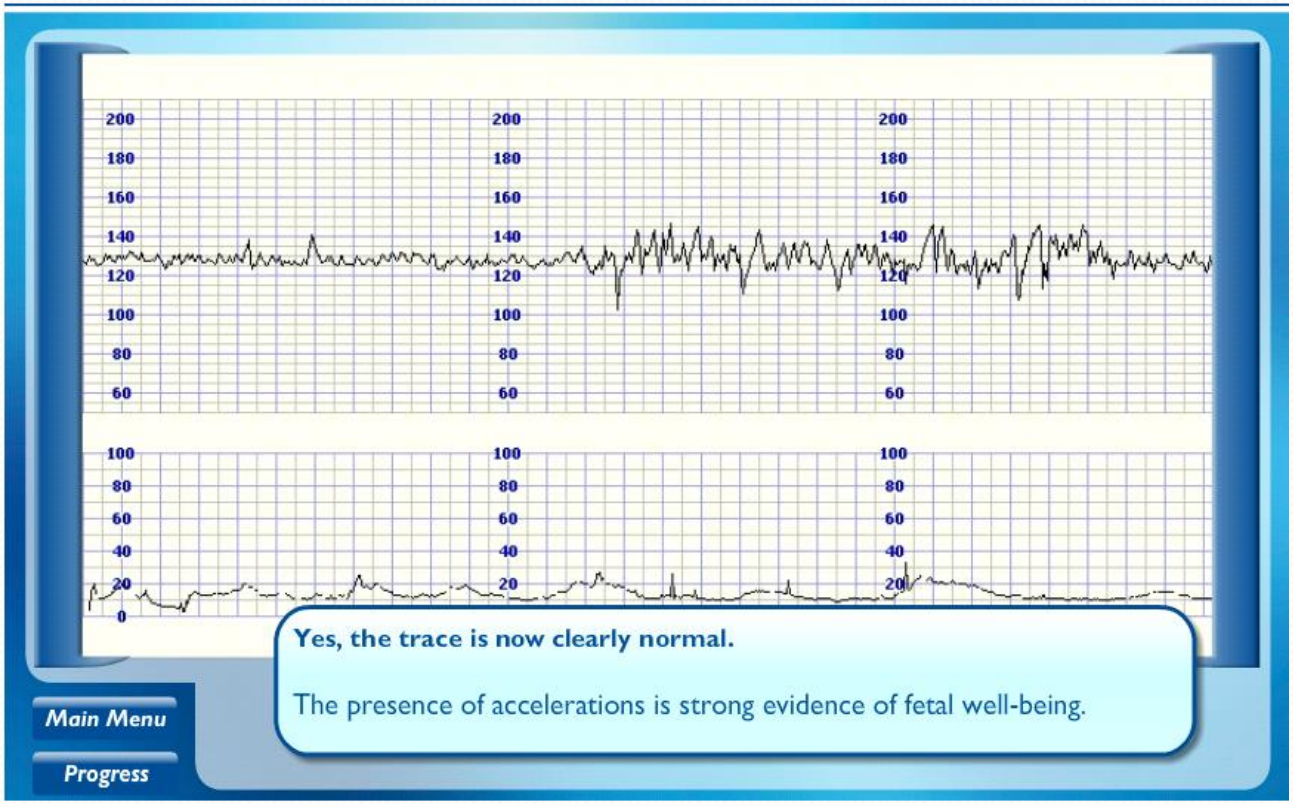


NST

تصویر زیر یک NST بدون acceleration را نشان می دهد. در نگاه اول معلوم نیست که علت این عدم acceleration هیپوکسی است یا خواب جنین ولی با ادامه trace acceleration و Variability به حالت نرمال بر می گردد و نگرانی رفع می شود. به هر حال در صورت نبود acceleration باید نوار NST را تا 40 دقیقه ادامه داد. نبود acceleration به مدت بیشتر از یک ساعت غیر عادی است.

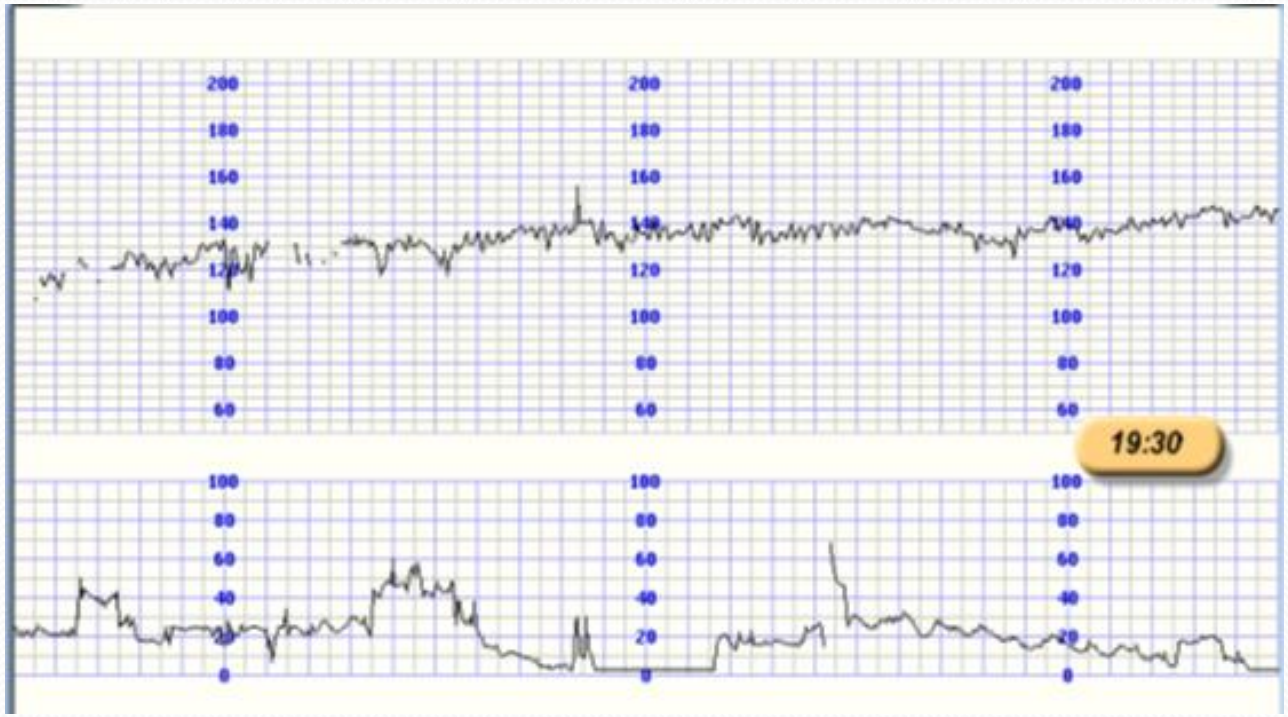


Fetal Well Being



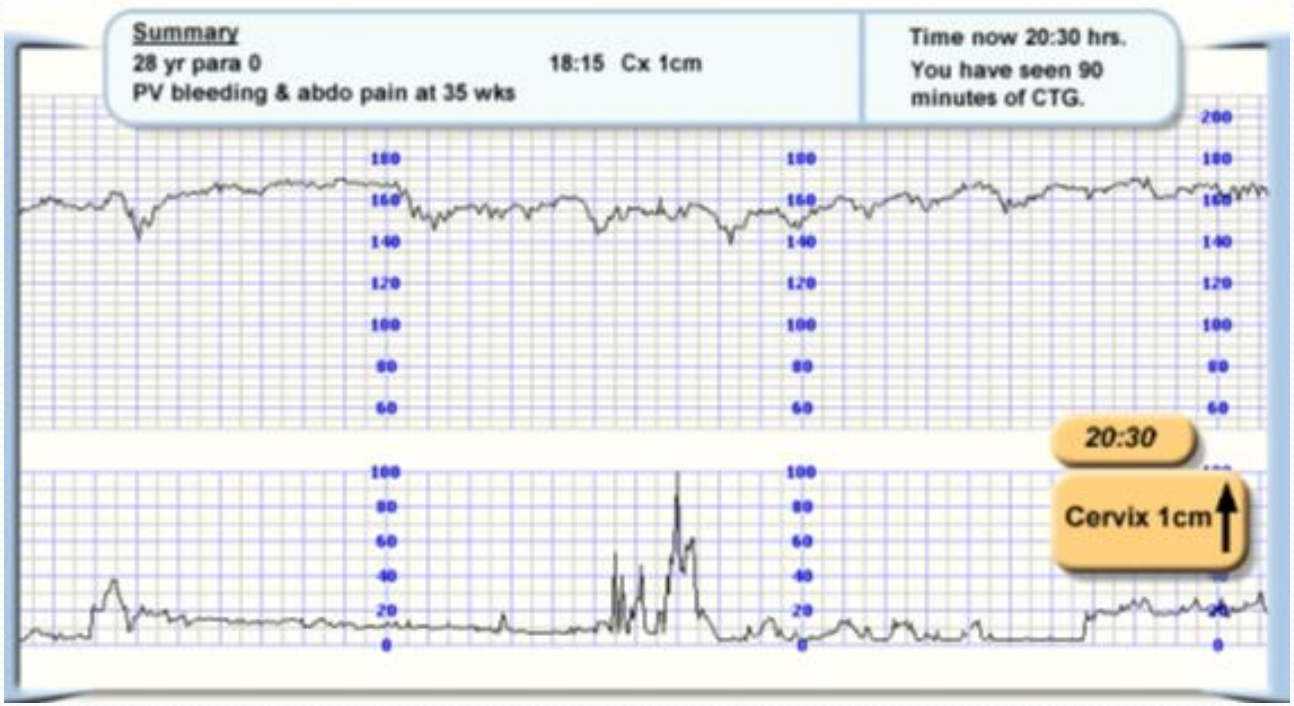
مثال

یک خانم 28 ساله با بارداري اول و سابقه مصرف روزي پنج نخ سیگار که تا 35 هفتگی مشکل خاصی نداشت با شکایت خون ریزي واژینال و درد متناوب شکم به اورژانس زایمان مراجعه کر د. در هنگام مراجعه پالس و فشارخون نرمال داشت و خون ریزي وي متوقف شده بو د. رحم حساس بود ولی درد نداشت در معاینه واژینال سرویکس به اندازه 1 Cm باز و افاسمان 50 % بود. در 20 دقیقه اول مراجعه NST وی بدین صورت بود

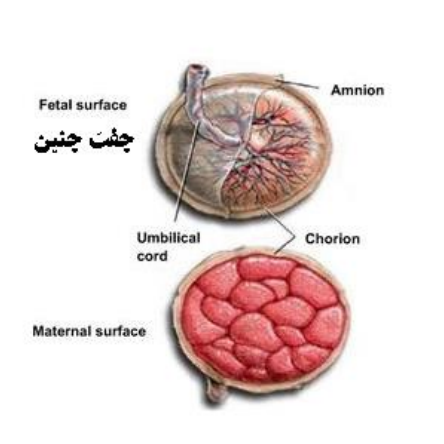


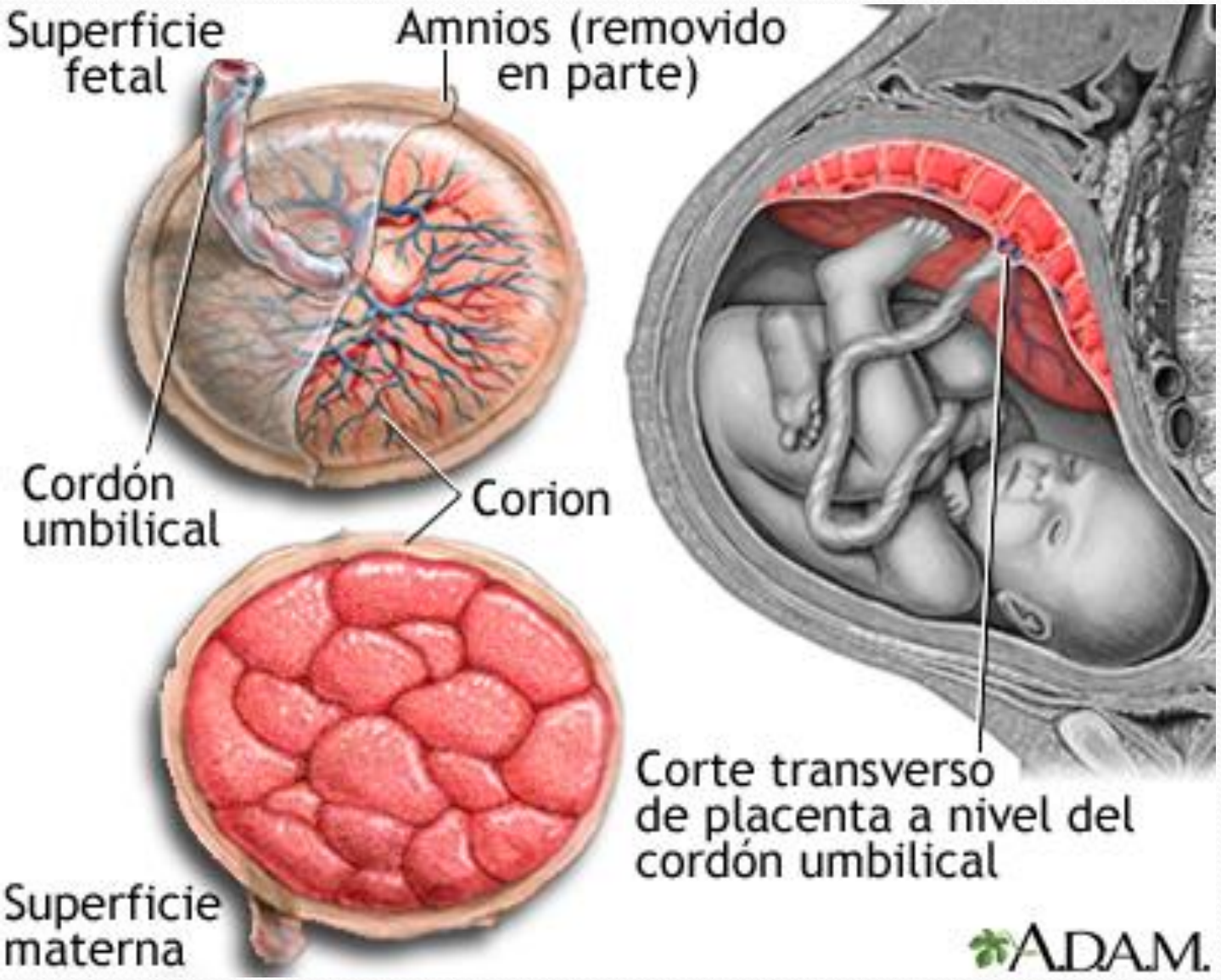
ادامه مثال

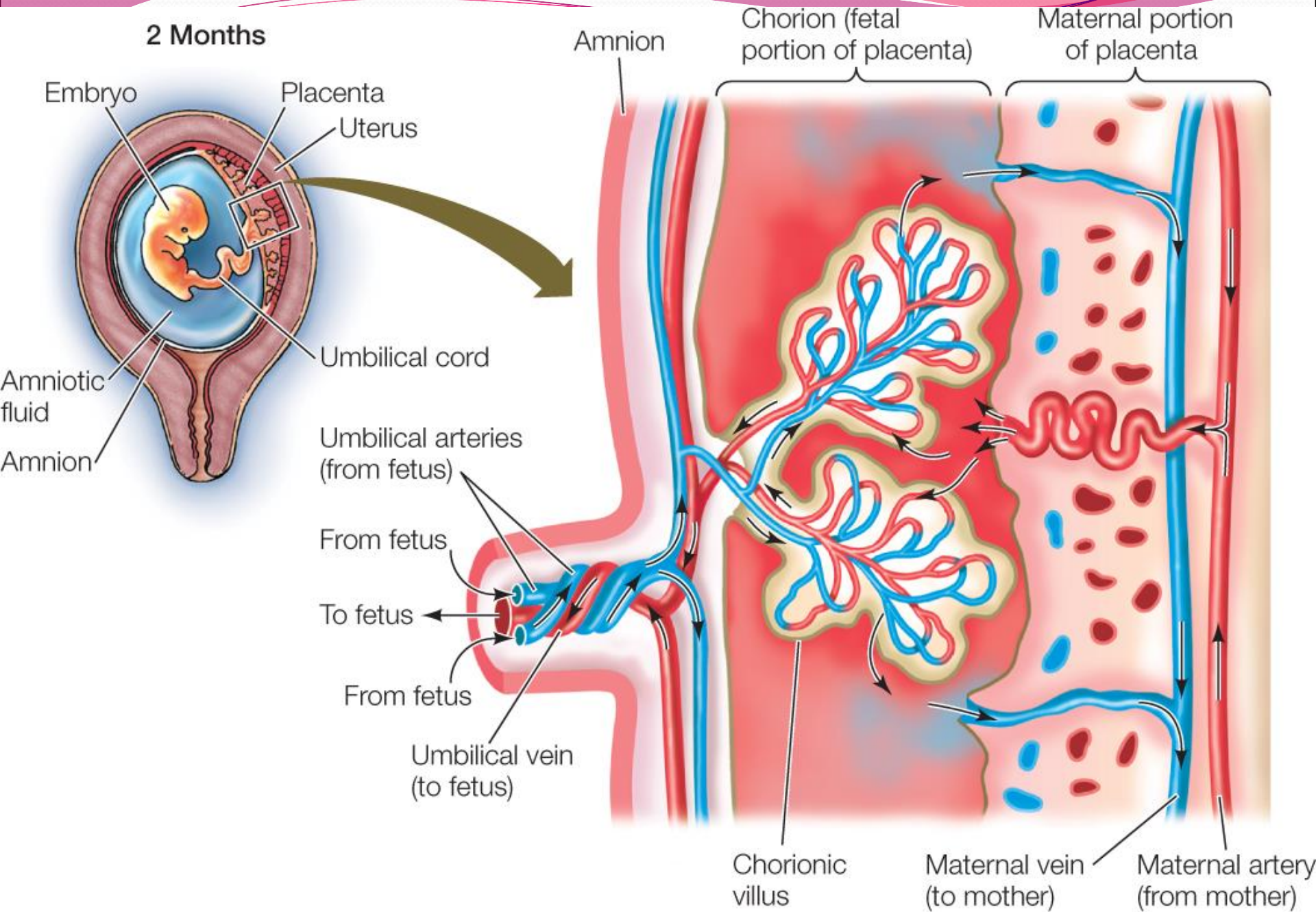
تکرار NST یک ساعت بعد نشان می دهد پس از یک ساعت افت در حد قلب های متعددی در حد 15 bpm در NST مشاهده می شود که حداقل FHR را از 140پایین تر نمی آورد. ولی اگر به نمودار انقباضات مادر توجه کنیم متوجه می شویم که انقباضات وي هر چند خفیف هستند ولی در نظر گرفتن ارتباط زمانی آن ها با افت هاي قلب، این افت ها را در گروه LATE deceleration قرار میدهد و نیاز به مداخله وجود دارد. این مادر تحت عمل سزارین قرار گرفت و تشخیص نهایی دکولمان جفت بود.

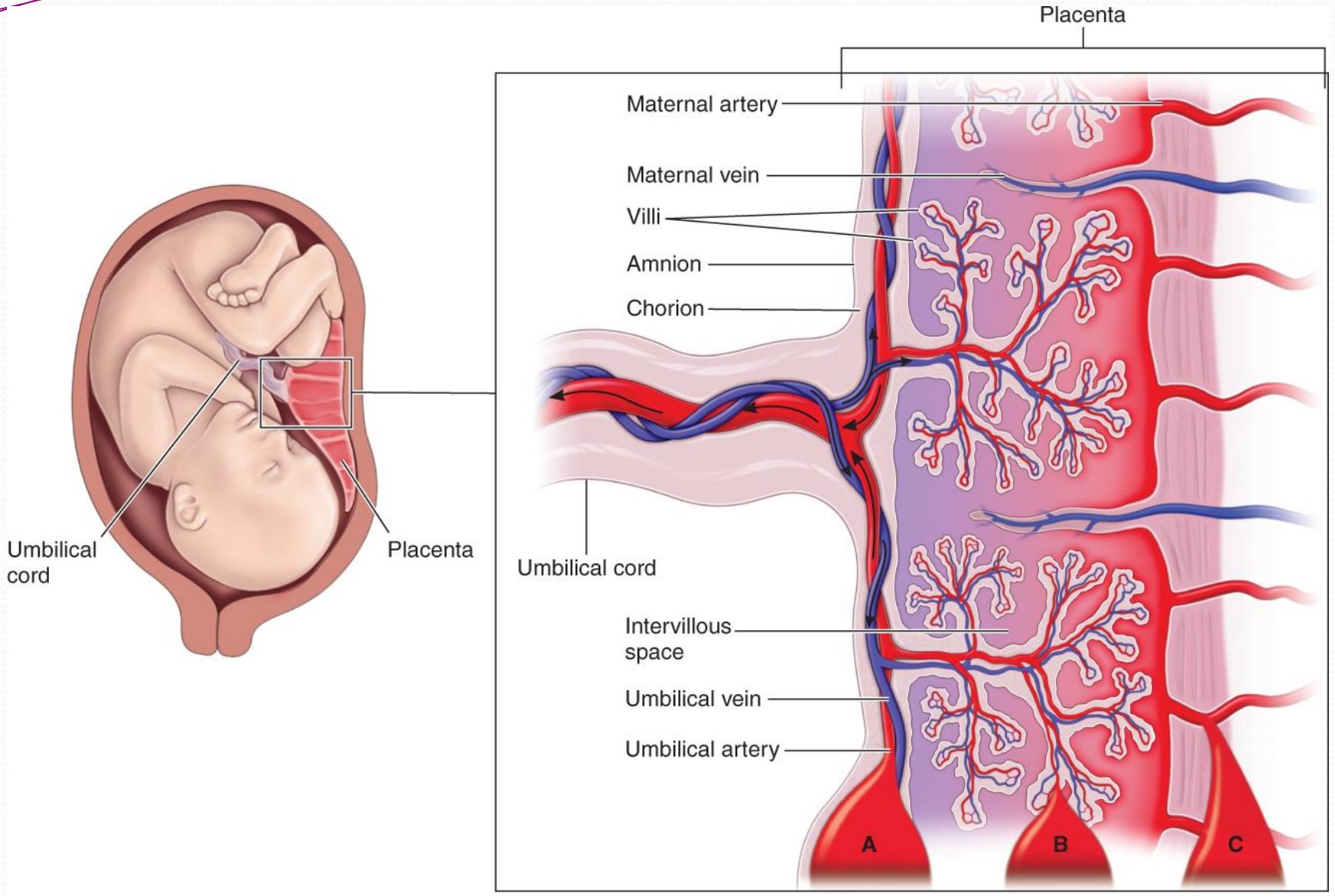


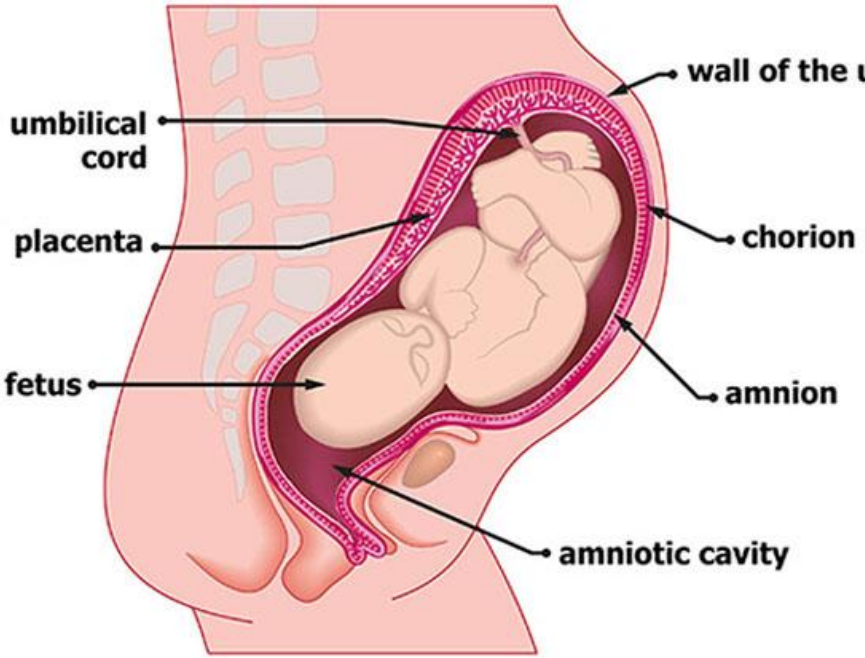
Placental Grade & Doppler

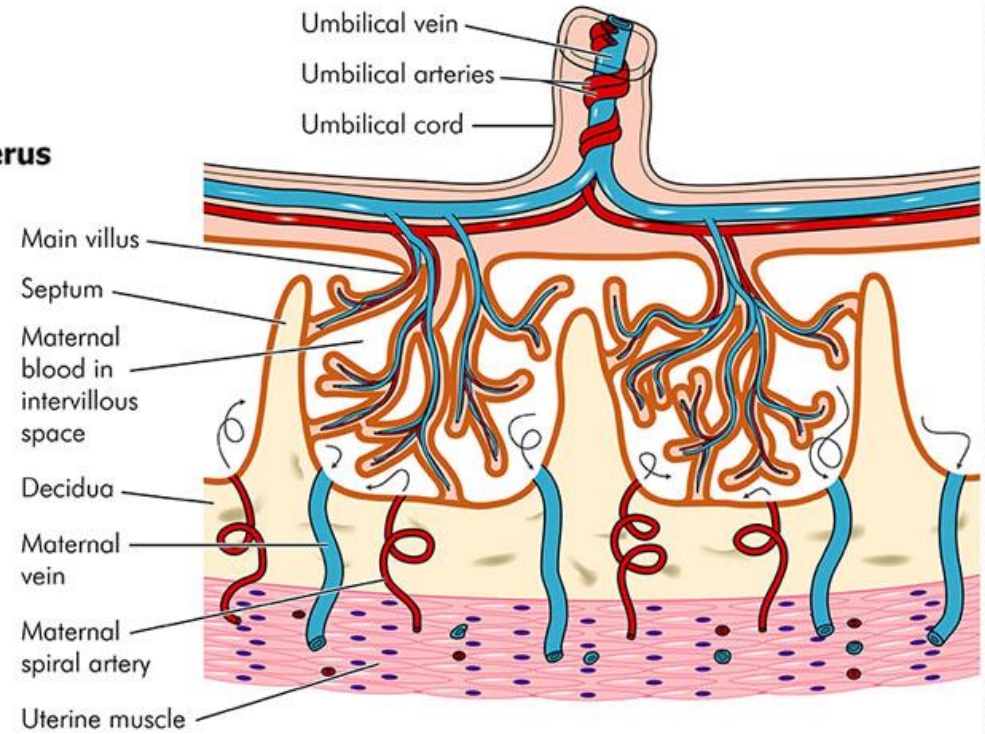



Superficie fetal
Amnios (removido en parte)
Cordón umbilical
Corion
Superficie materna
Corte transverso de placenta a nivel del cordón umbilical
A.D.A.M.

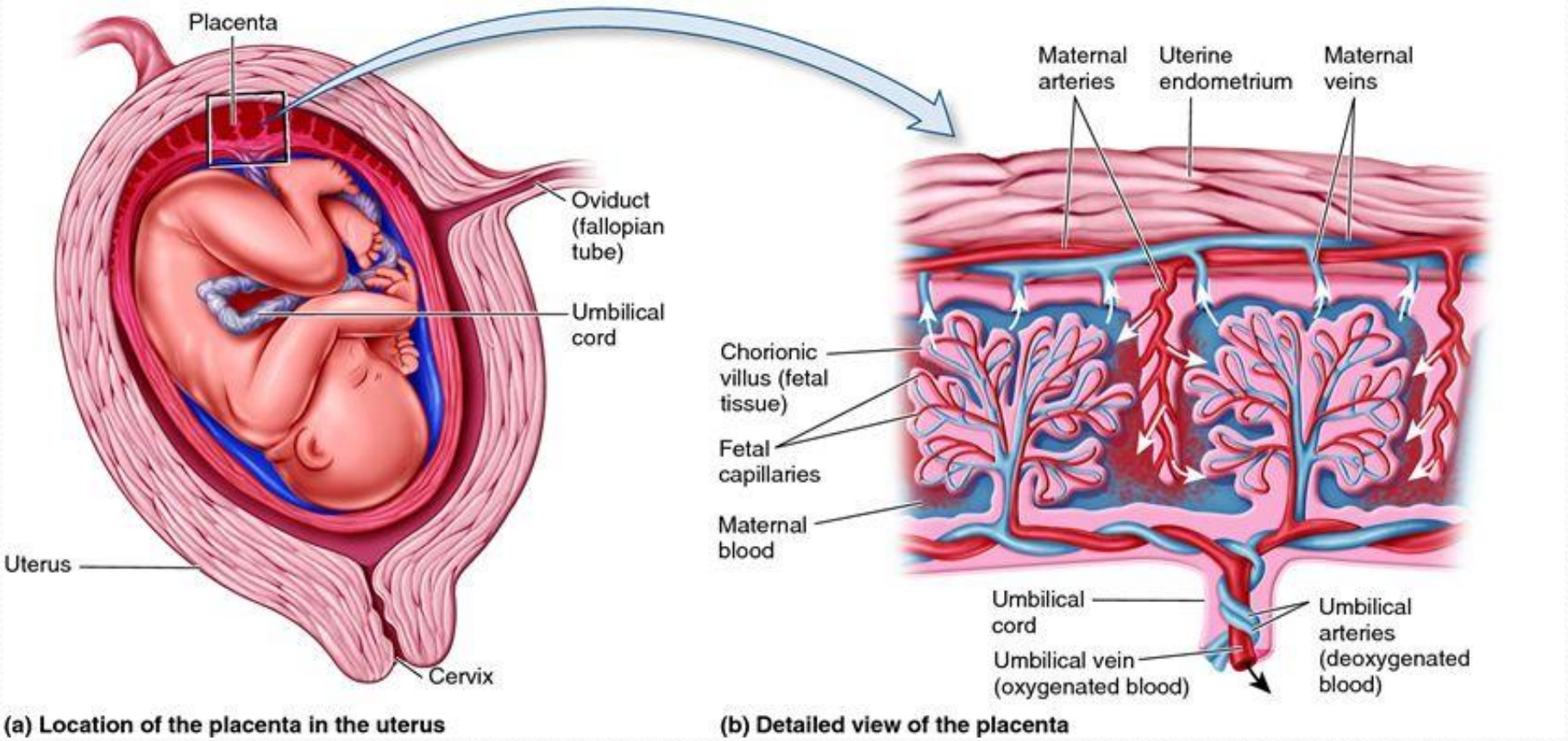

2 Months
Embryo
Placenta
Uterus
Umbilical cord
Amniotic fluid
Amnion
Amnion
Chorion (fetal portion of placenta)
Maternal portion of placenta
Umbilical arteries (from fetus)
From fetus
To fetus
From fetus
Umbilical vein (to fetus)
Chorionic villus
Maternal vein (to mother)
Maternal artery (from mother)





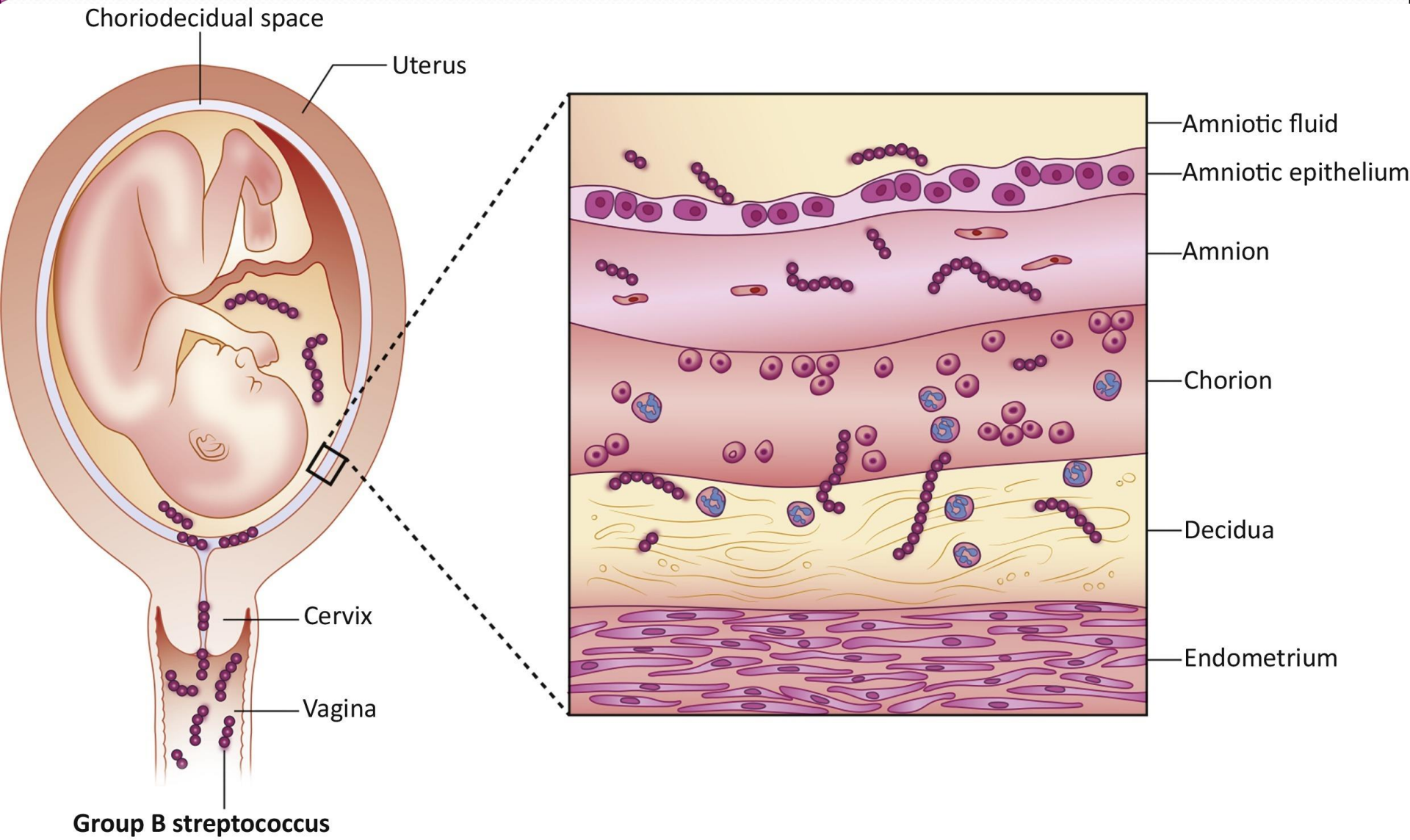


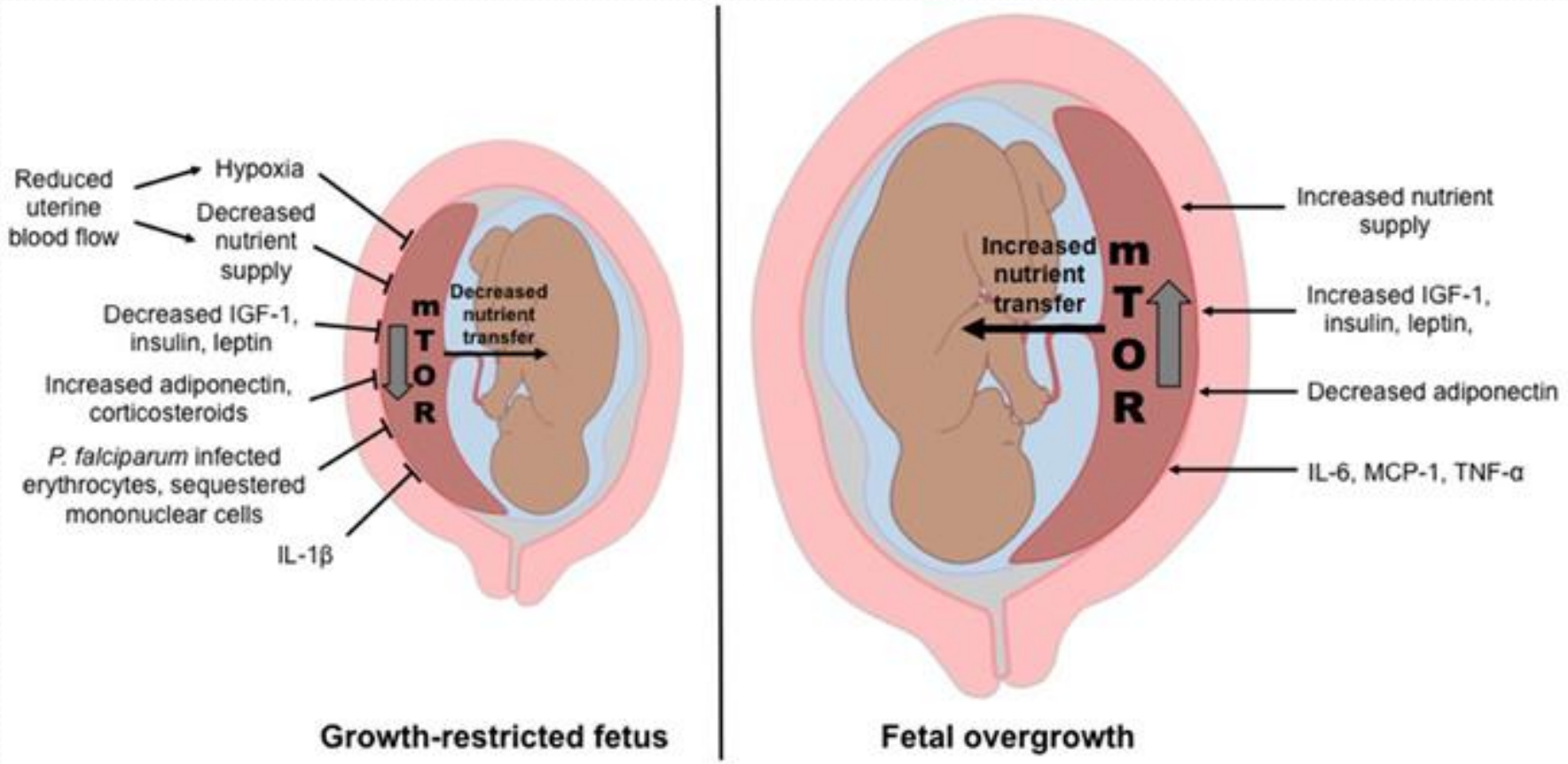
Anatomy of Placenta



(a) Location of the placenta in the uterus

(b) Detailed view of the placenta


Choriodecidual space
Uterus
Cervix
Vagina
Group B streptococcus
Amniotic fluid
Amniotic epithelium
Amnion
Chorion
Decidua
Endometrium


Reduced uterine blood flow
Hypoxia
Decreased nutrient supply
Decreased IGF-1, insulin, leptin
Increased adiponectin, corticosteroids
P. falciparum infected erythrocytes, sequestered mononuclear cells
IL-1β
mTOR
Decreased nutrient transfer
Growth-restricted fetus
Increased nutrient transfer
mTOR
Increased nutrient supply
Increased IGF-1, insulin, leptin,
Decreased adiponectin
IL-6, MCP-1, TNF-α
Fetal overgrowth

Placental grading

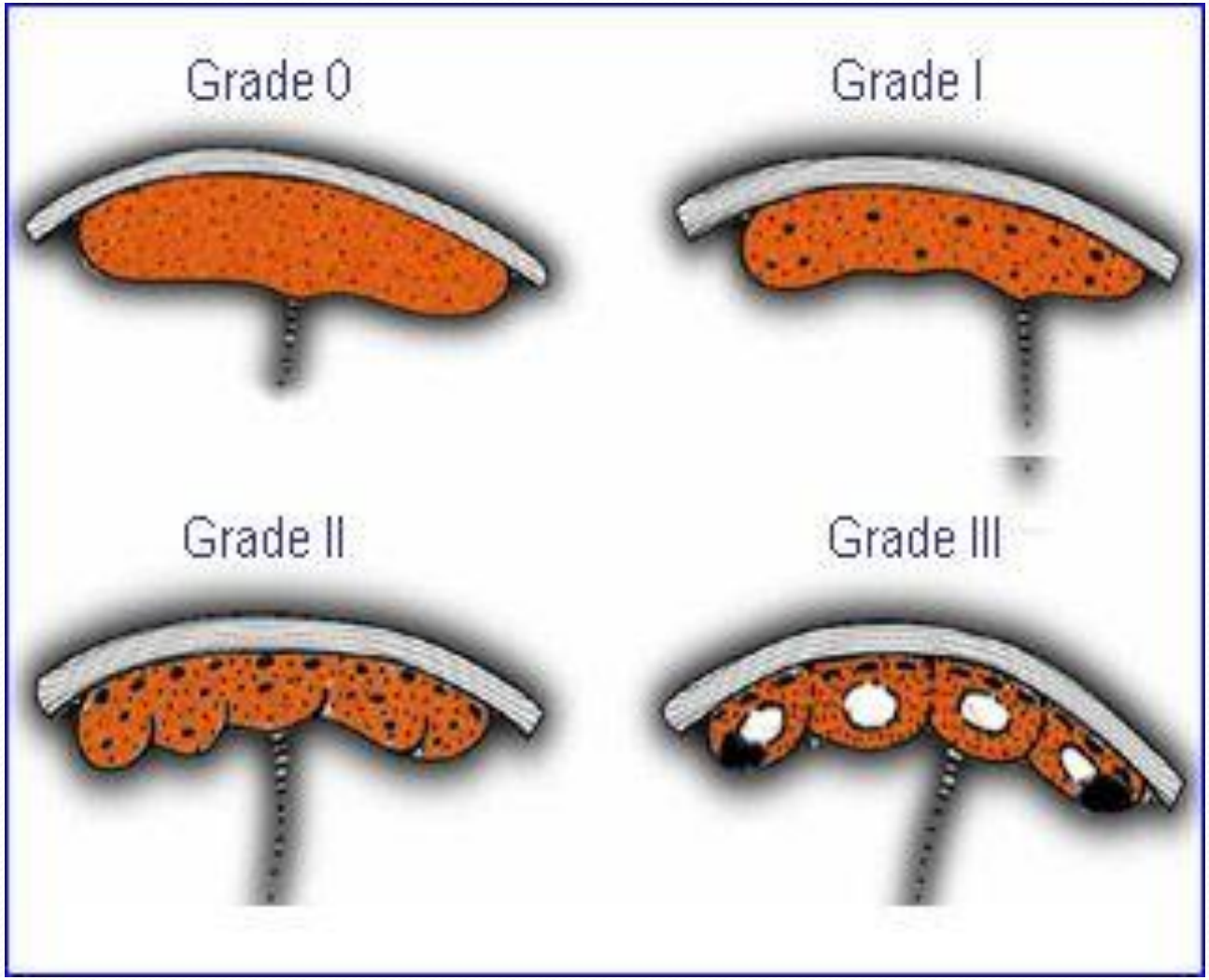
- **Placental grading (Grannum classification)**

refers to a ultrasound grading system of the placenta based on its maturity. This primarily affects the extent of calcifications.

- In some countries the use of placental grading has fallen out of obstetric practice due to a weak correlation with adverse perinatal outcome.

PLACENTAL GRADING

- **Grade 0** : < 18 weeks :
  - uniform echogenicity
  - smooth chorionic plate
- **Grade I** : 18 - 29 weeks :
  - occasional parenchymal calcification / hyper-echoic areas
- **Grade II** : > 30 weeks :
  - occasional basal calcification / hyper-echoic areas
  - may also have comma type densities at the chorionic plate.
- **Grade III** : > 39 weeks :
  - significant basal calcification
  - chorionic plate interrupted by indentations
  - an early progression to a grade III placenta in concerning and is sometimes associated with placental insufficiency


Grade 0
Grade I
Grade II
Grade III

2. Placental Grades :

A. Grade 0 - Patient asymptomatic.Small retroperitoneal clot seen after delivery.

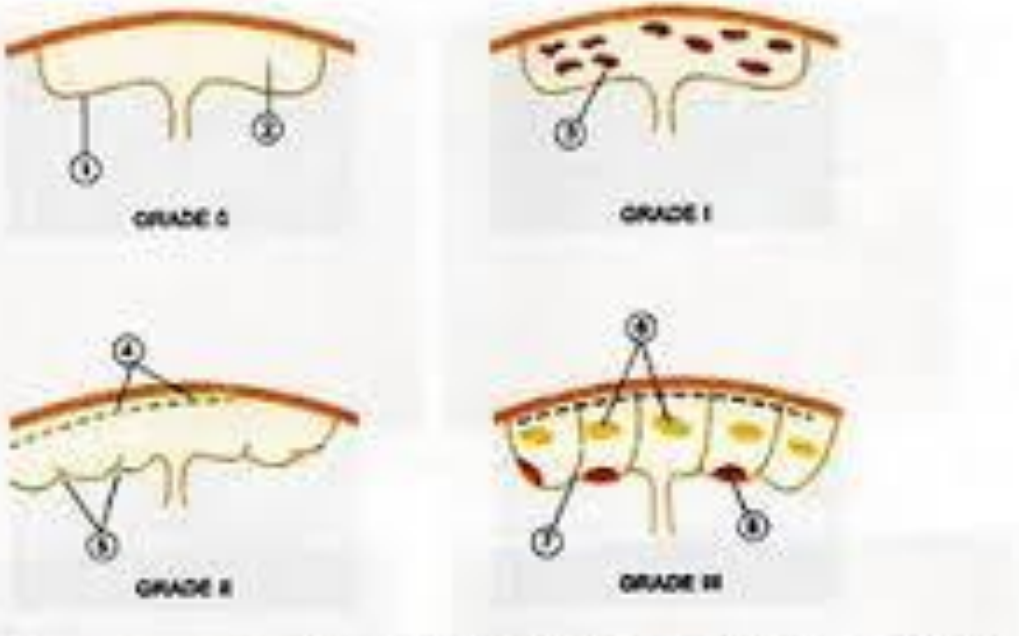
B. Grade 1 - Vaginal bleeding, may have abdominal tenderness or slight uterine tetany,mom and baby not in distress.

C. Grade 2 - Uterine tenderness, tetany with or without evidence of bleeding, baby shows signs of distress.

D. Grade 3 - Uterine tetany,severe bleeding may not be visible. Baby is dead. Mom often has coagulopathy.

The grading system is as follows:

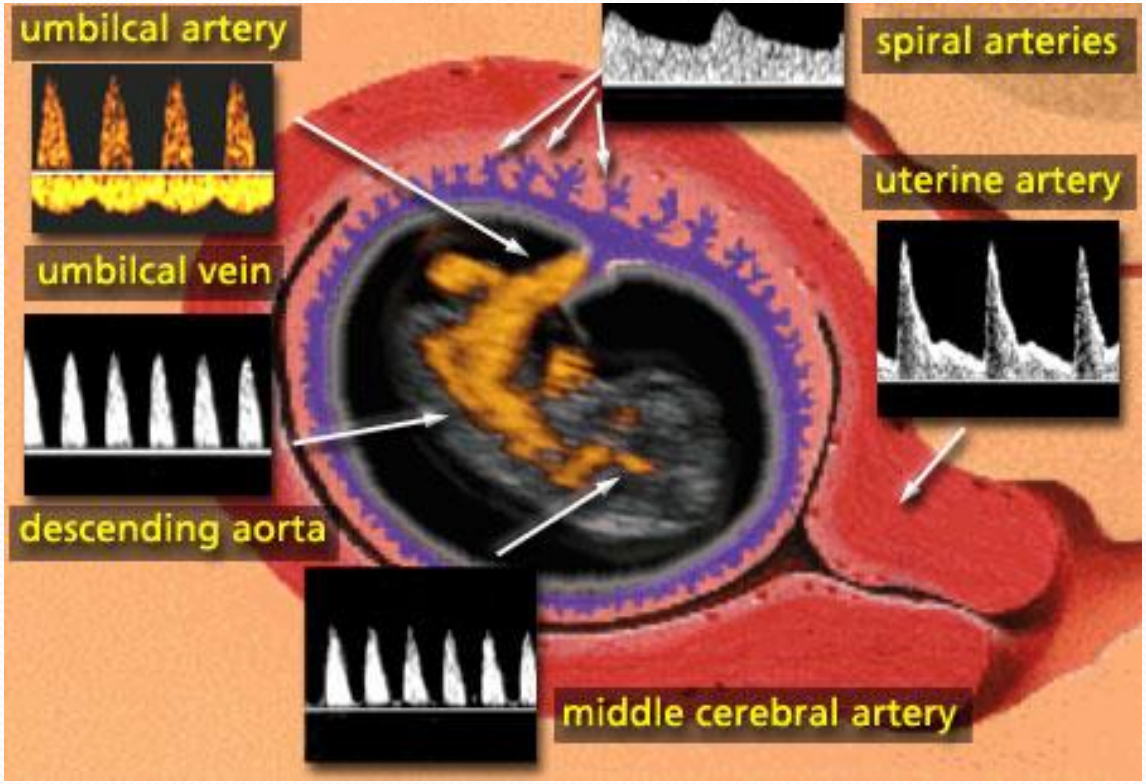
- **grade 0:** <18 weeks
  - uniform echogenicity
  - smooth chorionic plate
- **grade I:** 18-29 weeks
  - occasional parenchymal calcification/hyperechoic areas
  - subtle indentations of chorionic plate
- **grade II:** >30 weeks
  - occasional basal calcification/hyperechoic areas
  - deeper indentations of chorionic plate (does not reach up to basal plate)
    - seen as comma type densities at the chorionic plate
- **grade III:** >39 weeks
  - significant basal plate calcification
  - chorionic plate interrupted by indentations (frequently calcified) that reach up to basal plate: cotyledons
  - an early progression to a grade III placenta is concerning and is sometimes associated with placental insufficiency
    - associated with smoking, chronic hypertension, SLE, diabetes



Gambar 9.10. Gambaran skematis derajat maturasi plasenta : Grade 0 = Derajat maturasi 0; Grade I = Derajat maturasi 1; Grade II = Derajat maturasi 2; dan Grade III = Derajat maturasi 3.
Keterangan : 1. Calcium khorion tidak tampak identasi atau cekungan, 2. Jaringan plasenta tampak homogen, 3. Tampak daerah hipereikhois yang tersebar tidak merata pada jaringan plasenta, 4. Daerah hipereikhoik pada basal plasenta, 5. Identasi berbentuk seperti koma pada calcium khorion, 6. Daerah hipoekhoik di jaringan plasenta, 7. identasi calcium khorion yang semakin dalam, dan 8. Daerah hipereikhoik irregular. (Dimodifikasi dari : Rosh Chudleigh et al, *The placenta and amniotic fluid*, dalam : Obstetrics Ultrasound, 141 2004)

Doppler

1- بررسی جریان خون در شریانهای نافی
2- بررسی جریان خون در شریان مغزی میانی
3- بررسی جریان خون در Ductus Venosus
4- بررسی جریان خون شریان رحمی



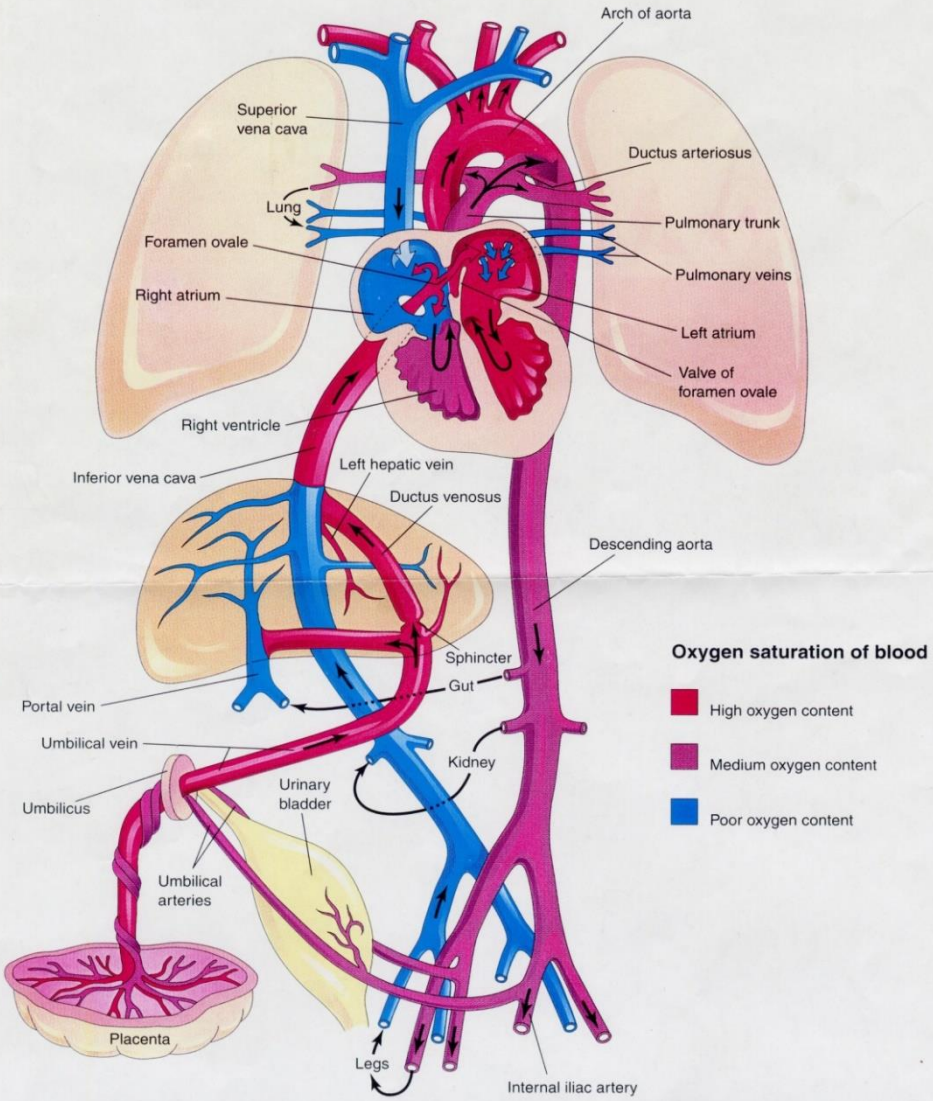


FIGURE 24–43. Schematic illustration of the fetal circulation. The colors indicate the oxygen saturation of the blood, and the arrows show the course of the blood from the placenta to the heart. Observe that three shunts permit most of the blood to bypass the liver and lungs: (1) ductus venosus, (2) foramen ovale, and (3) ductus arteriosus. The poorly oxygenated blood returns to the placenta for oxygen and nutrients through the umbilical arteries. (From Moore KL, Persaud TVN: Before We Are Born: Essentials of Embryology and Birth Defects, 5th ed. Philadelphia, W.B. Saunders, 1998.)

Dr. M Valiani

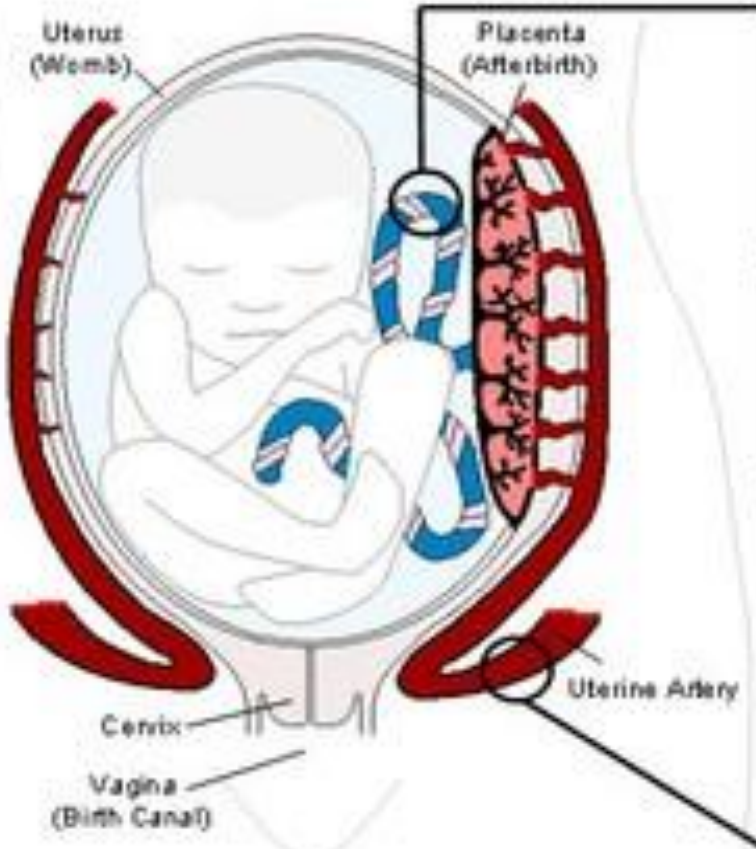
ANTEPARTUM FETAL MONITORING

- Doppler velocimetry of the umbilical arteries
  - 40% of combined ventricular output is directed to the placenta by umbilical arteries.
  - Assessment of umbilical blood flow provides information on blood perfusion of the fetoplacental unit.
  - Volume of flow increases and vascular impedance decreases with advancing gestational age.
  - Low vascular impedance allows a continuous forward blood flow throughout the cardiac cycle.

ANTEPARTUM FETAL MONITORING

- Doppler velocimetry
  - An increase in the vascular resistance of the fetoplacental unit leads to a decrease in end diastolic flow velocity or its absence in the flow velocity waveform.
  - Abnormal waveforms reflect the presence of a structural placental lesion.
  - Abnormal Doppler results require specific management protocols and intensive fetal surveillance.

NORMAL PLACENTAL FUNCTION



Umbilical Artery Doppler

Baby's Blood Flow to the Placenta

Forward blood flow from the baby to the placenta

Biochemistry

Proteins in the Mother's Blood

PAPP-A, AFP, hCG, Inhibin (DIA)

Morphology

The Appearance of the Placenta

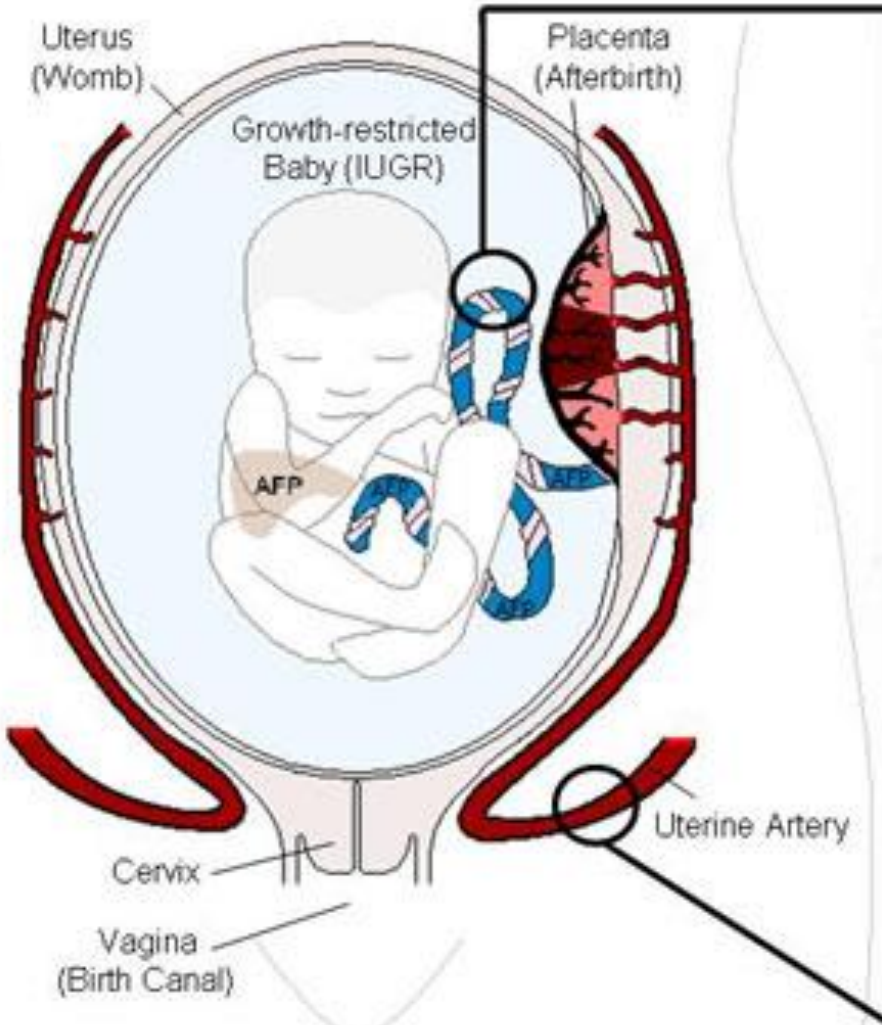
Long, thin, and without areas of damage

Uterine Artery Doppler

Mother's Blood Flow to the Placenta

High blood flow to nourish the baby

PLACENTAL DAMAGE CAUSING IUGR at 28 Weeks



Umbilical Artery Doppler

Baby's Blood Flow to the Placenta

Absent End Diastolic Flow

Biochemistry

Proteins in the Mother's Blood

↑ AFP measured between 12-20 weeks

Morphology

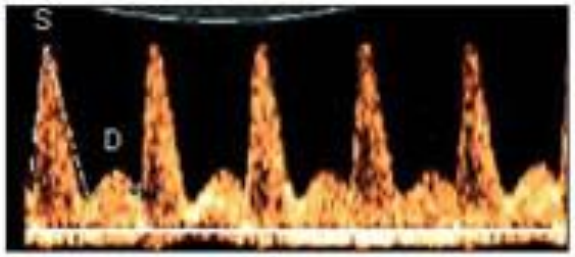
The Appearance of the Placenta

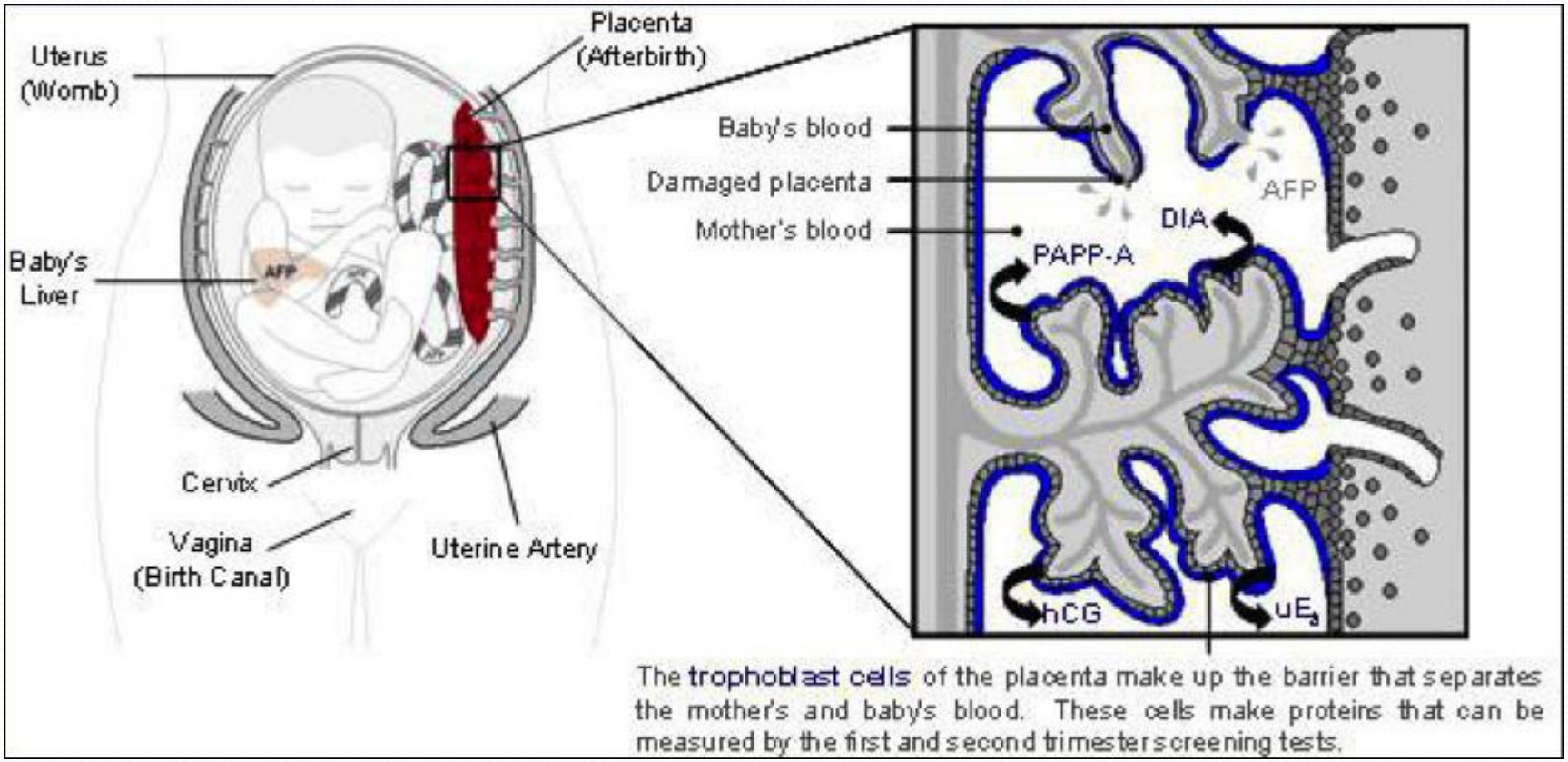
Areas of damage

Uterine Artery Doppler

Mother's Blood Flow to the Placenta

Lower blood flow and nourishment to the baby



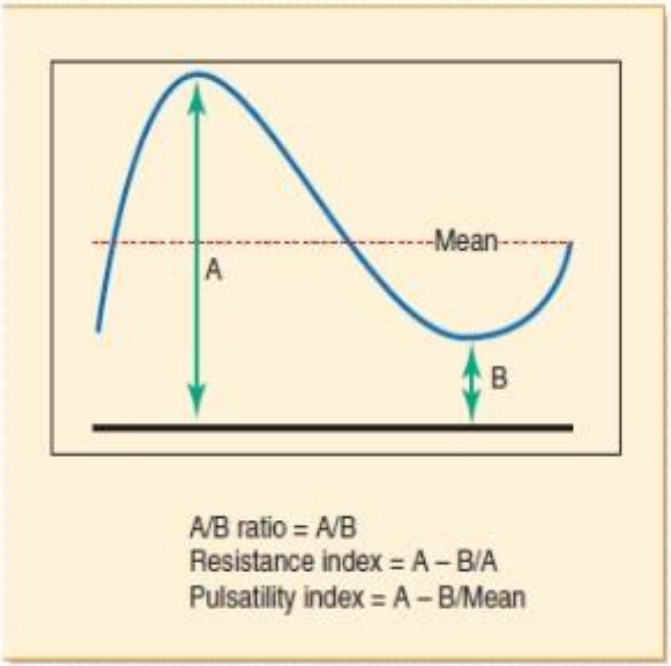

Uterus
(Womb)
Placenta
(Afterbirth)
Baby's blood
Damaged placenta
Mother's blood
Baby's
Liver
AFP
AFP
DIA
PAPP-A
Cervix
Vagina
(Birth Canal)
Uterine Artery
hCG
uE3
The trophoblast cells of the placenta make up the barrier that separates the mother's and baby's blood. These cells make proteins that can be measured by the first and second trimesters screening tests.

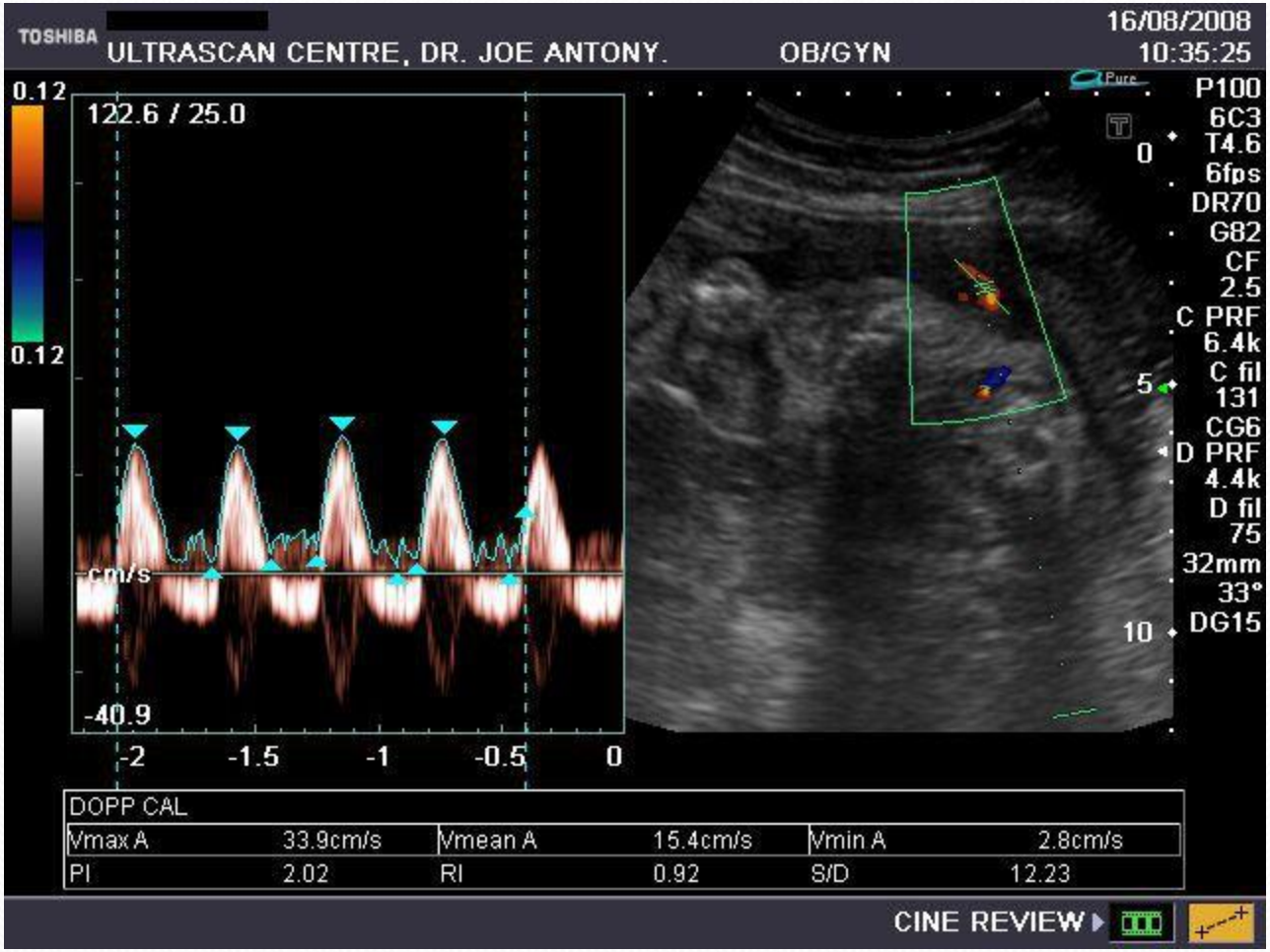
Doppler waveform analysis

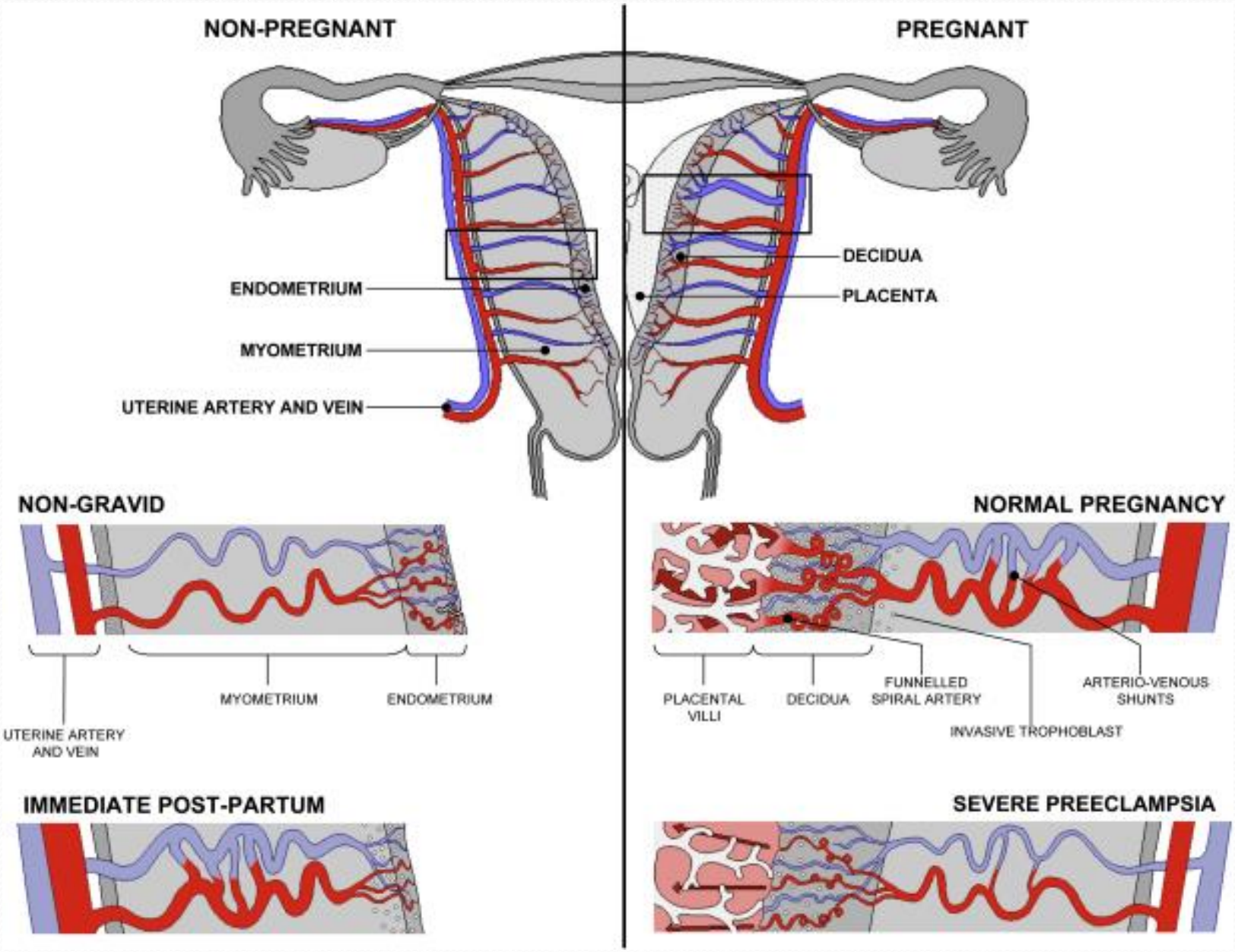
Quantitative analysis

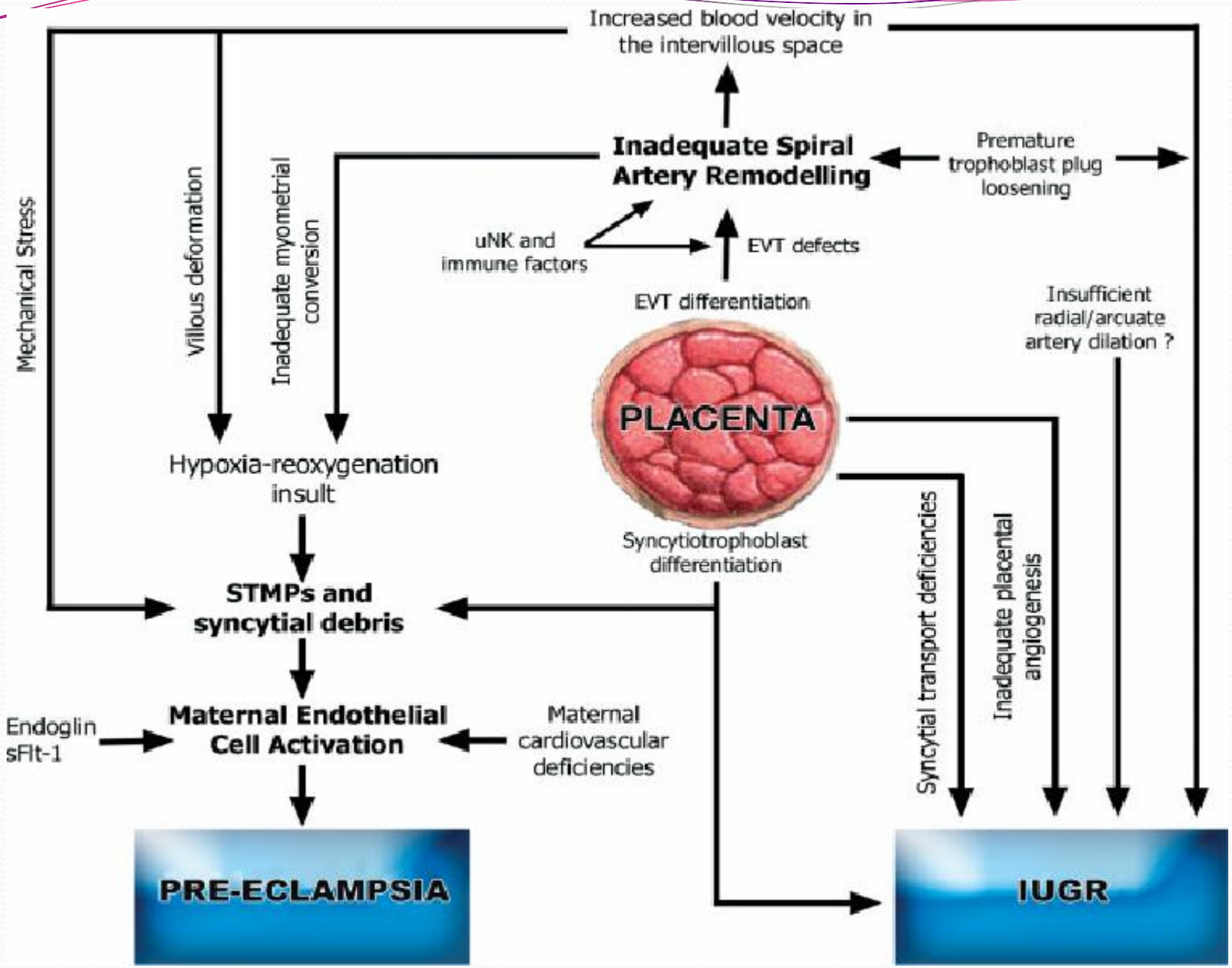
- Pulsatility index (PI)
- Resistance index (RI)
- Systolic/diastolic ratio

- Qualitative analysis
  - **Uterine artery:** presence or absence of early diastolic notch
  - **UA :** normal, with reduced diastolic flow, absent EDF, reversed EDF




TOSHIBA
ULTRASCAN CENTRE, DR. JOE ANTONY.
OB/GYN
16/08/2008
10:35:25
0.12
0.12
122.6 / 25.0
cm/s
-40.9
-2
-1.5
-1
-0.5
0
P100
6C3
T4.6
6fps
DR70
G82
CF
2.5
C PRF
6.4k
C fil
131
CG6
D PRF
4.4k
D fil
75
32mm
33°
DG15
0
5
10
DOPP CAL
Vmax A 33.9cm/s
Vmean A 15.4cm/s
Vmin A 2.8cm/s
PI 2.02
RI 0.92
S/D 12.23
CINE REVIEW


NON-PREGNANT
PREGNANT
ENDOMETRIUM
MYOMETRIUM
UTERINE ARTERY AND VEIN
DECIDUA
PLACENTA
NON-GRAVID
UTERINE ARTERY AND VEIN
MYOMETRIUM
ENDOMETRIUM
NORMAL PREGNANCY
PLACENTAL VILLI
DECIDUA
FUNNELLED SPIRAL ARTERY
INVASIVE TROPHOBLAST
ARTERIO-VENOUS SHUNTS
IMMEDIATE POST-PARTUM
SEVERE PREECLAMPSIA

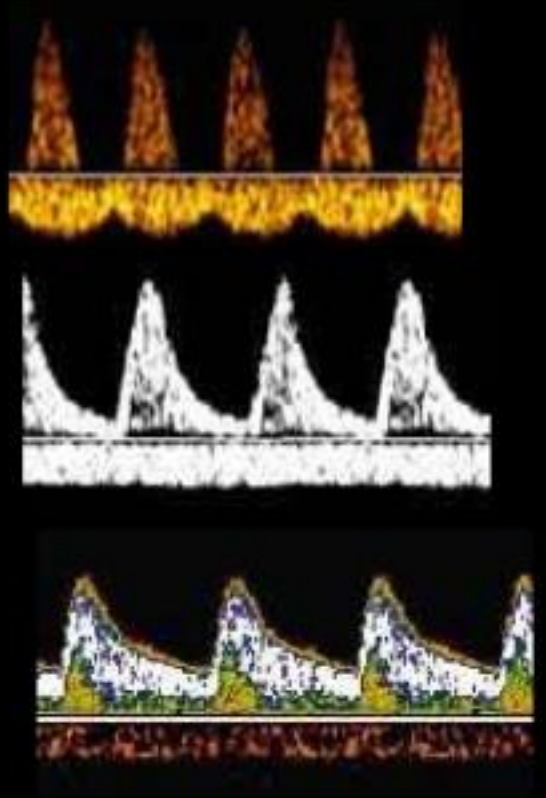

Increased blood velocity in the intervillous space
Inadequate Spiral Artery Remodelling
Premature trophoblast plug loosening
uNK and immune factors
EVT defects
EVT differentiation
Mechanical Stress
Villous deformation
Inadequate myometrial conversion
Insufficient radial/arcuate artery dilation ?
PLACENTA
Hypoxia-reoxygenation insult
Syncytiotrophoblast differentiation
Syncytial transport deficiencies
Inadequate placental angiogenesis
STMPs and syncytial debris
Endoglin
sFlt-1
Maternal Endothelial Cell Activation
Maternal cardiovascular deficiencies
PRE-ECLAMPSIA
IUGR

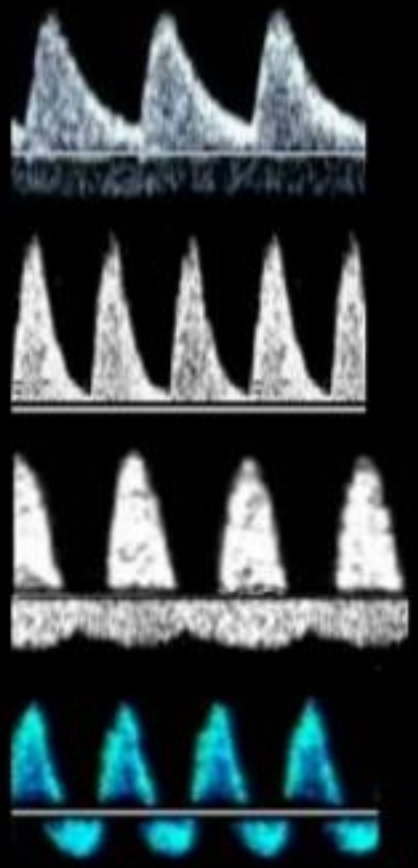
Utero placental circulation

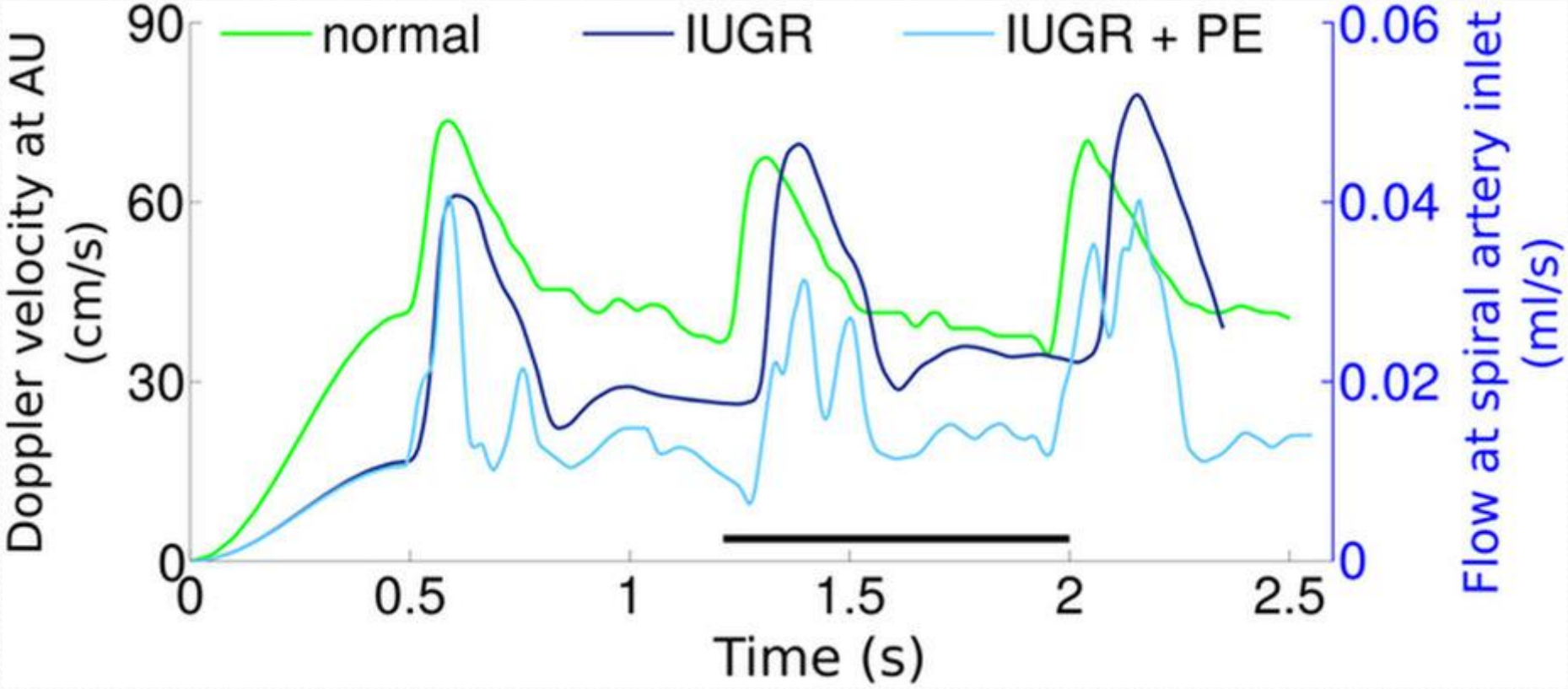
Normal

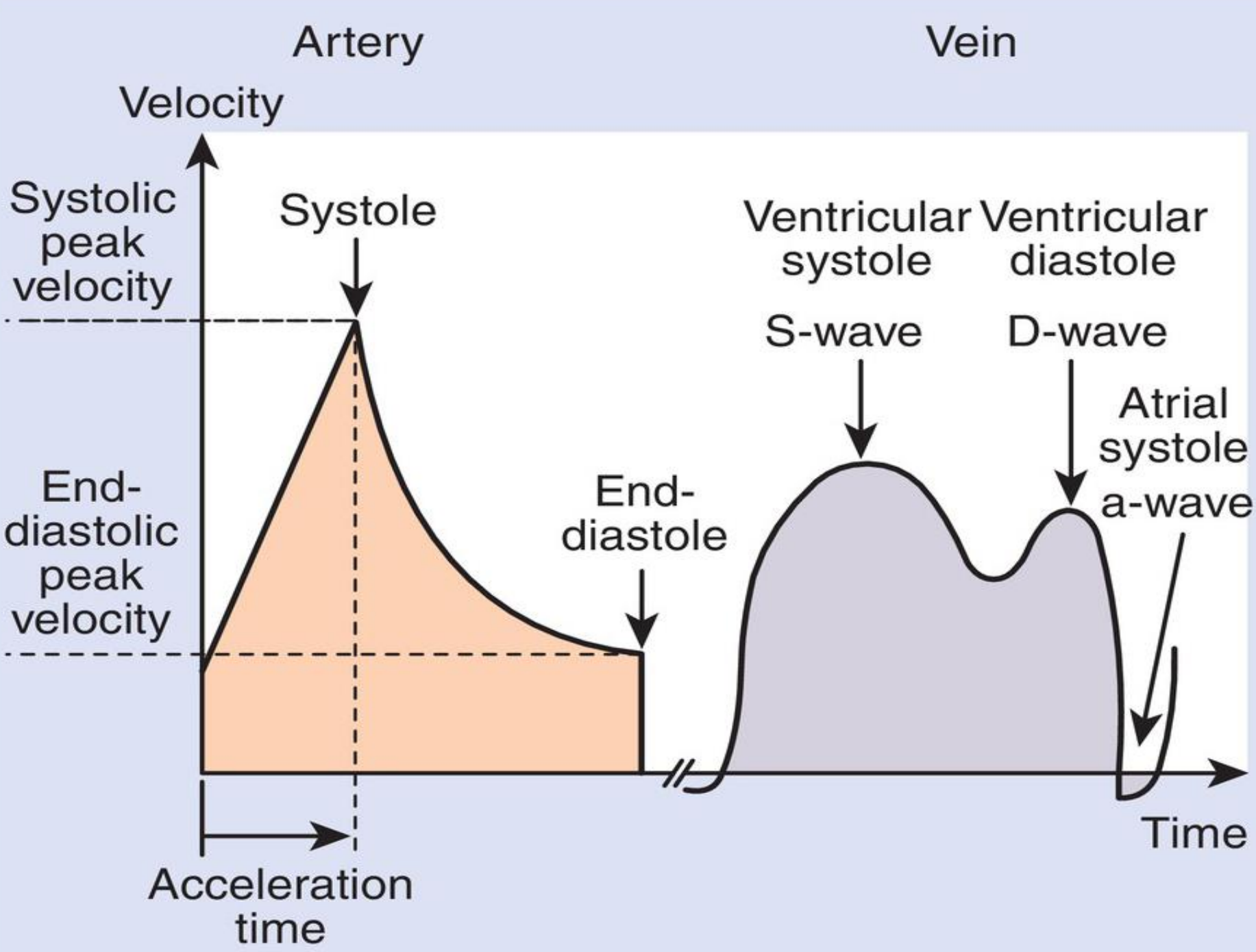
Umbilical Artery

Abnormal






normal
IUGR
IUGR + PE
Doppler velocity at AU (cm/s)
Flow at spiral artery inlet (ml/s)
Time (s)
0
30
60
90
0.02
0.04
0.06
0.5
1
1.5
2
2.5


Artery
Vein
Velocity
Systolic peak velocity
Systole
Ventricular systole
Ventricular diastole
S-wave
D-wave
Atrial systole
a-wave
End-diastolic peak velocity
End-diastole
Time
Acceleration time

Grade 0

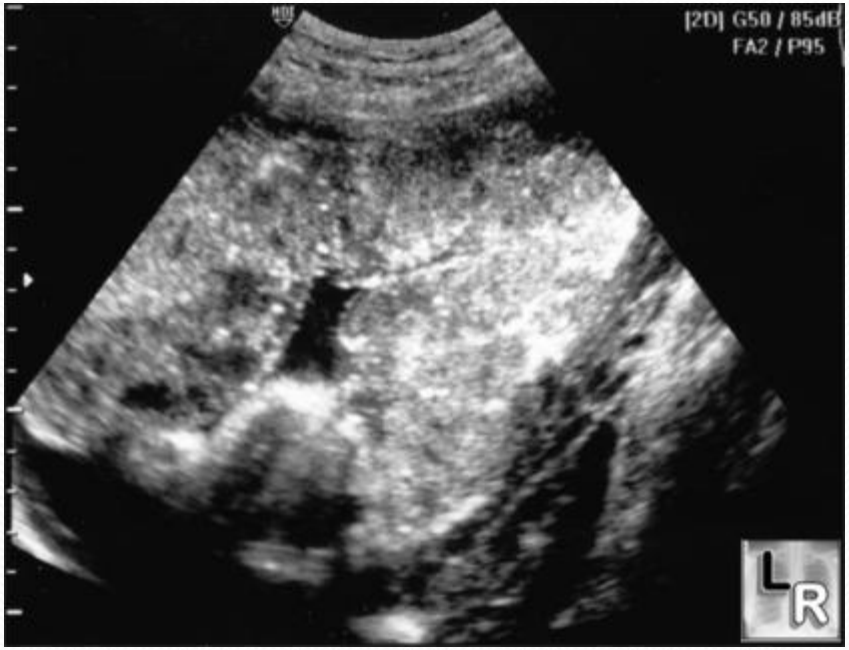
- **Late 1st trimester-early 2nd trimester**
- **Uniform moderate echogenicity**
- **Smooth chorionic plate without indentations**

Grade 1

- **Mid 2nd trimester –early 3rdtrimester (~18-29 wks)**
- **Subtle indentations of chorionic plate**
- **Small, diffuse calcifications (hyperechoic) randomly dispersed in placenta**

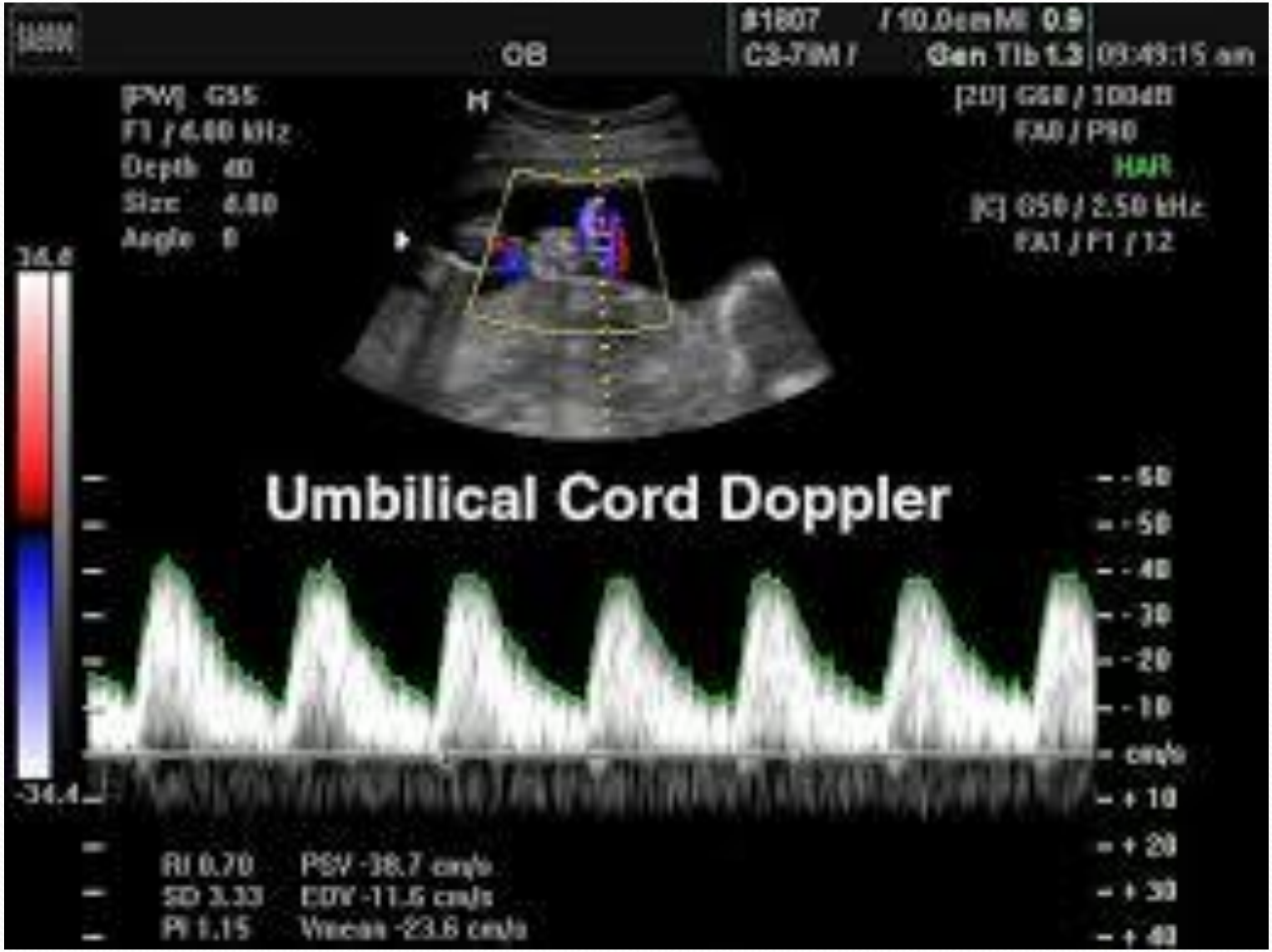
Grade 2

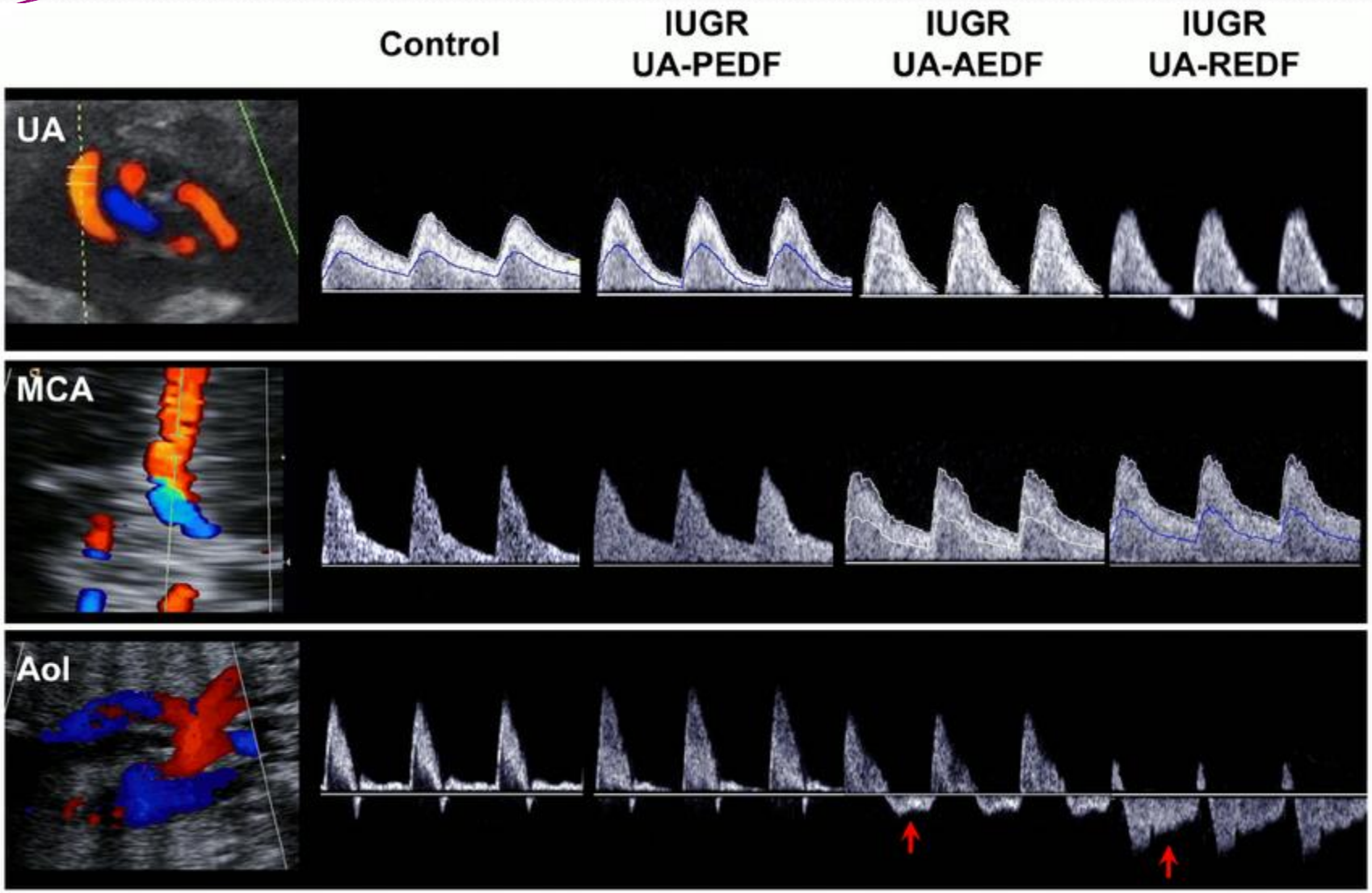
- Late 3rd trimester (~30 wks to delivery)
- Larger indentations along chorionic plate
- Larger calcifications in a “dot-dash” configuration along the basilar plate

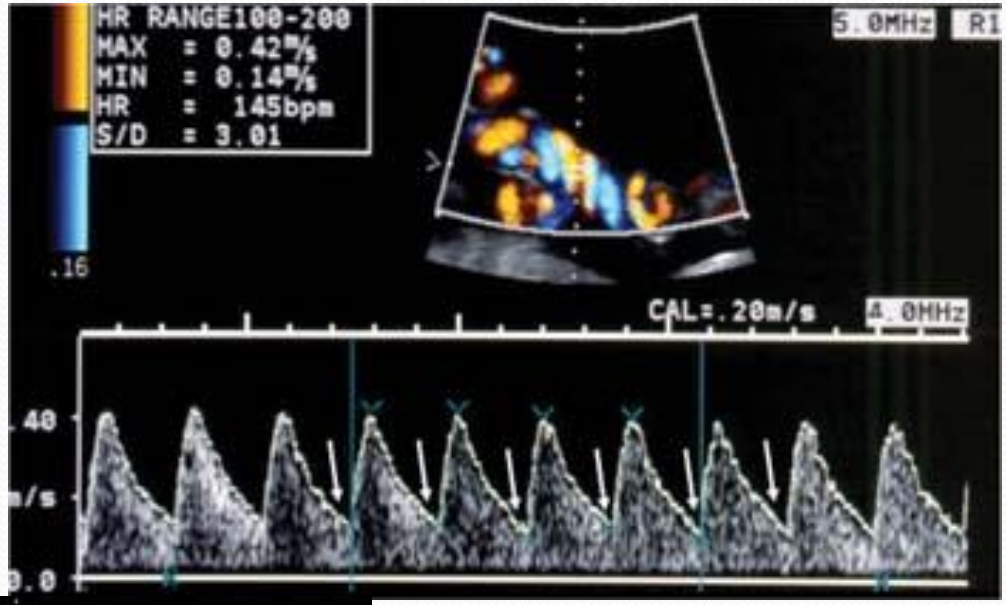


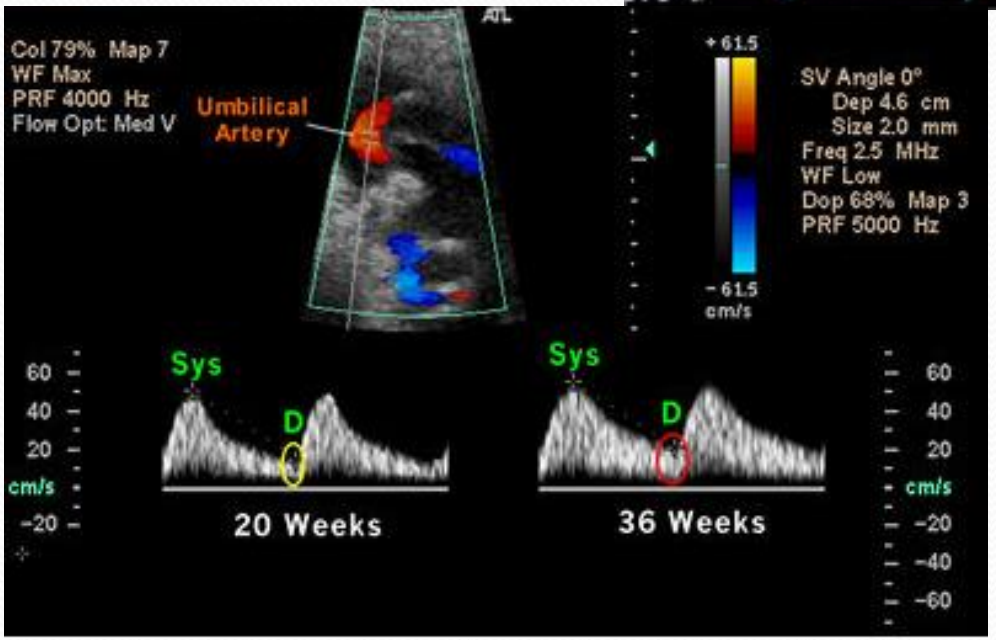
Grade 3

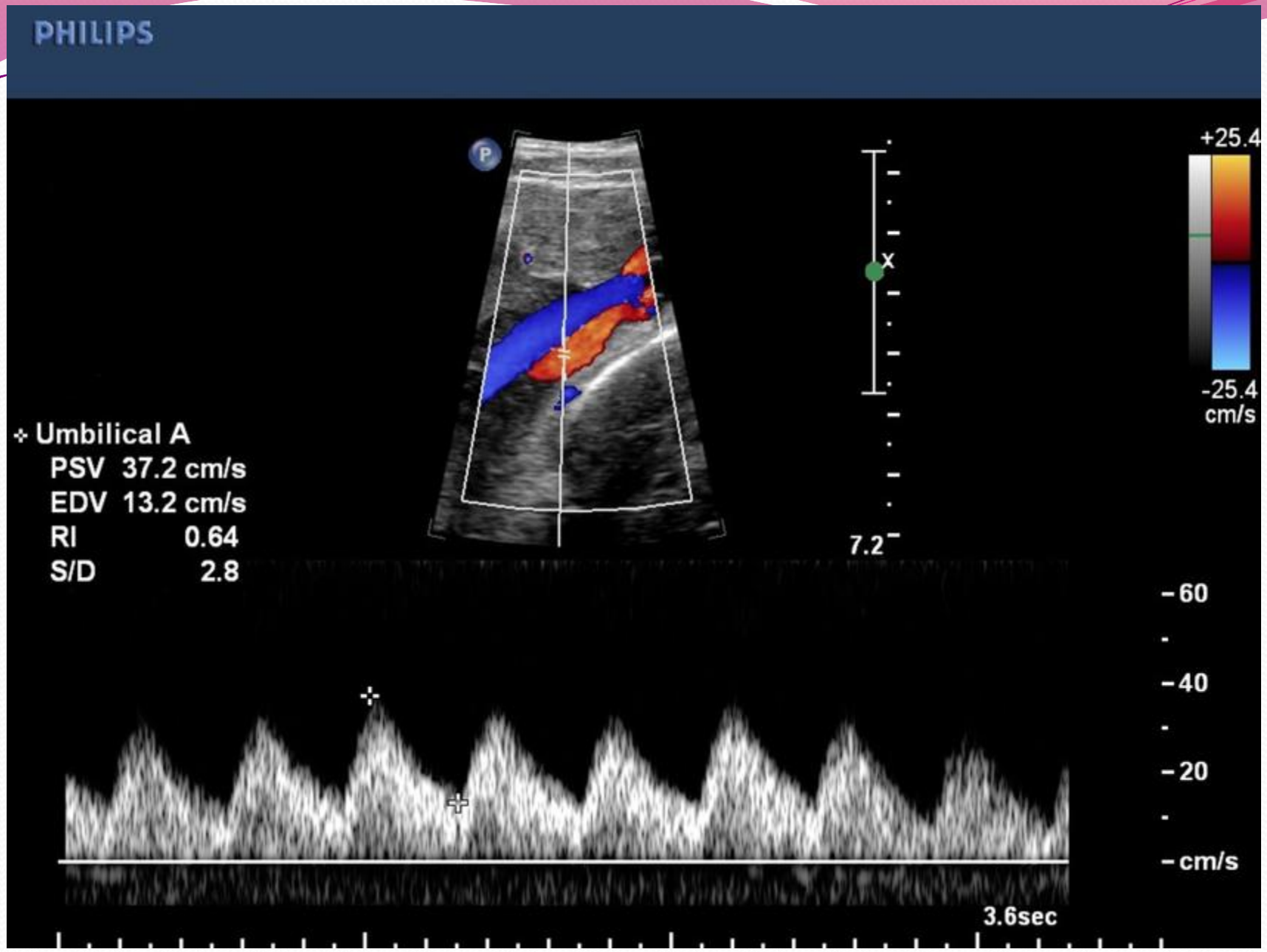
- **39 wks – post dates**
- **Complete indentations of chorionic plate through to the basilar plate creating "cotyledons" (portions of placenta separated by the indentations)**
- **More irregular calcifications with significant shadowing**
- **May signify placental dysmaturity which can cause IUGR**
- **Associated with smoking, chronic hypertension, SLE, diabetes**

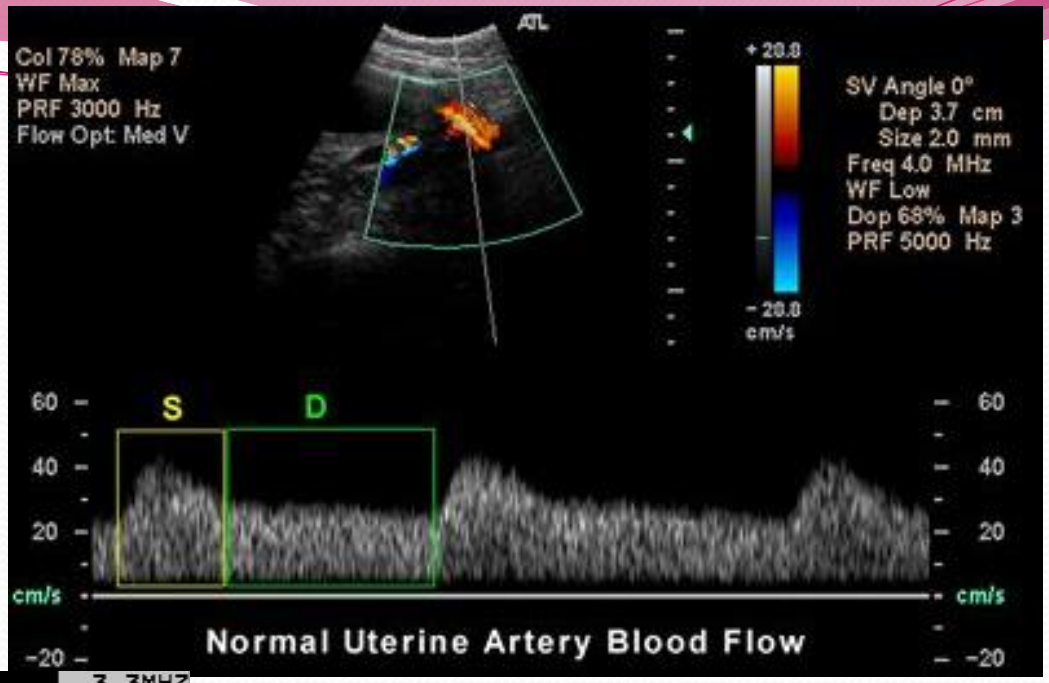

OB
[PW] G55
F1 / 4.60 kHz
Depth 40
Size 4.80
Angle 0
[2D] G68 / 100dB
FA0 / P80
HAR
[C] G50 / 2.50 kHz
FA1 / F1 / 12
Umbilical Cord Doppler
RI 0.70
SD 3.33
PI 1.15
PSV -38.7 cm/s
EDV -11.6 cm/s
Vmean -23.6 cm/s

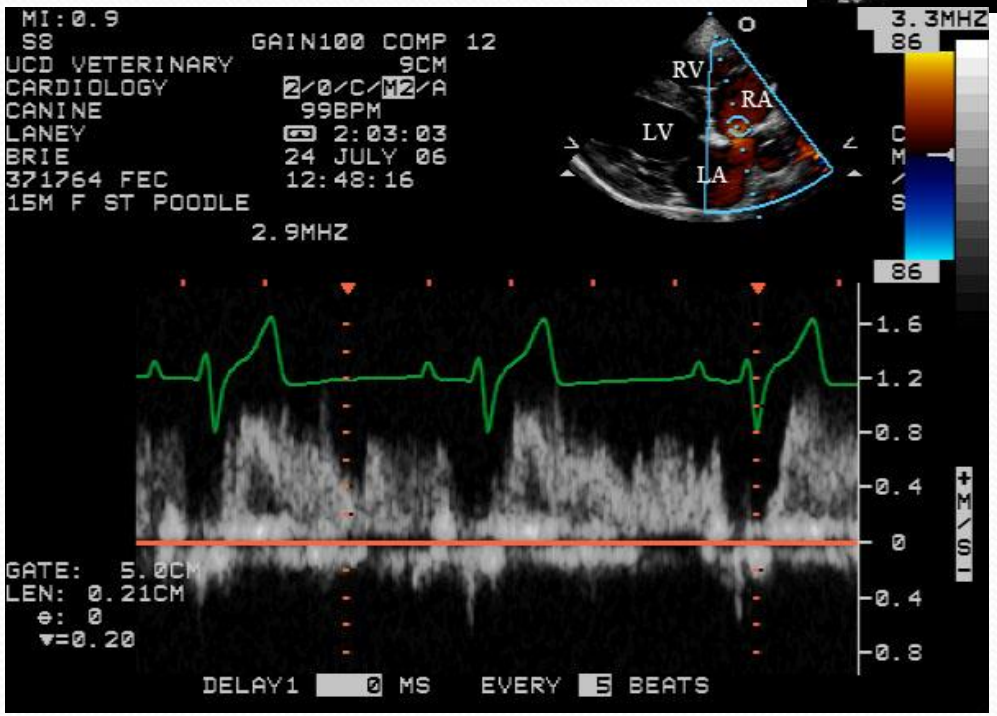

Control
IUGR
UA-PEDF
IUGR
UA-AEDF
IUGR
UA-REDF
UA
MCA
AoI

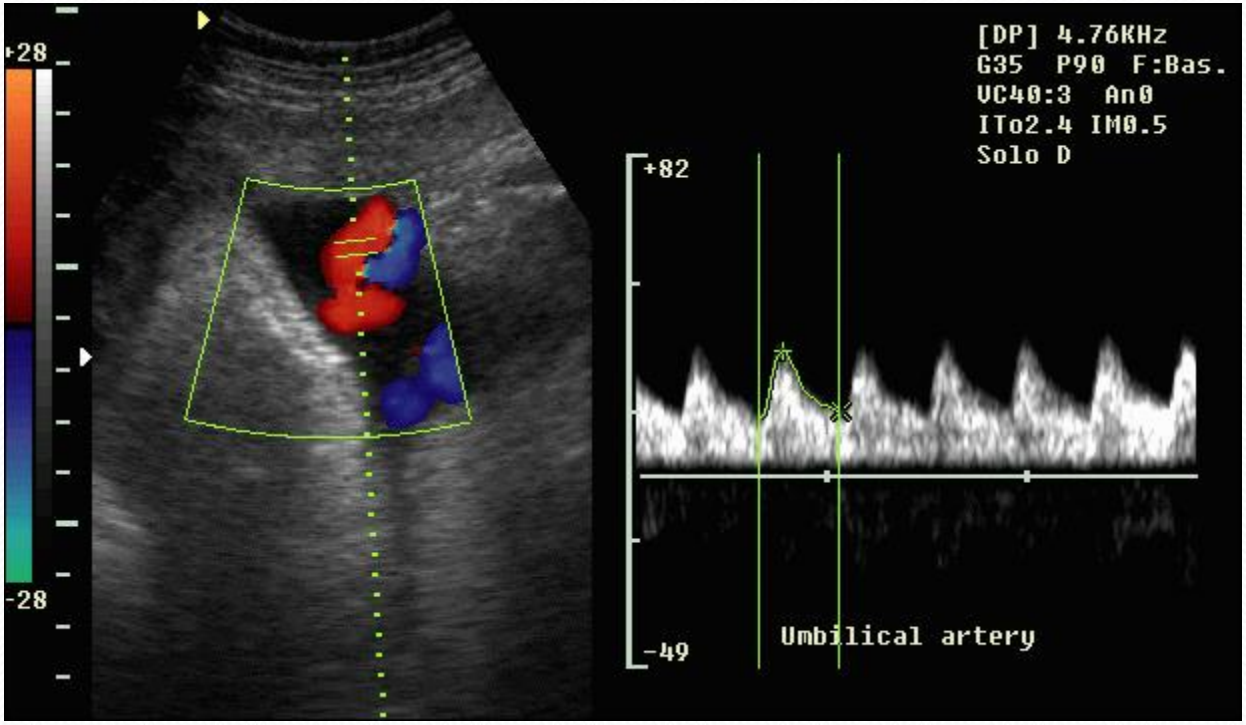

HR RANGE100-200
MAX = 0.42m/s
MIN = 0.14m/s
HR = 145bpm
S/D = 3.01
5.0MHz
R1
.16
CAL=.20m/s
4.0MHz
.40
m/s
0.0

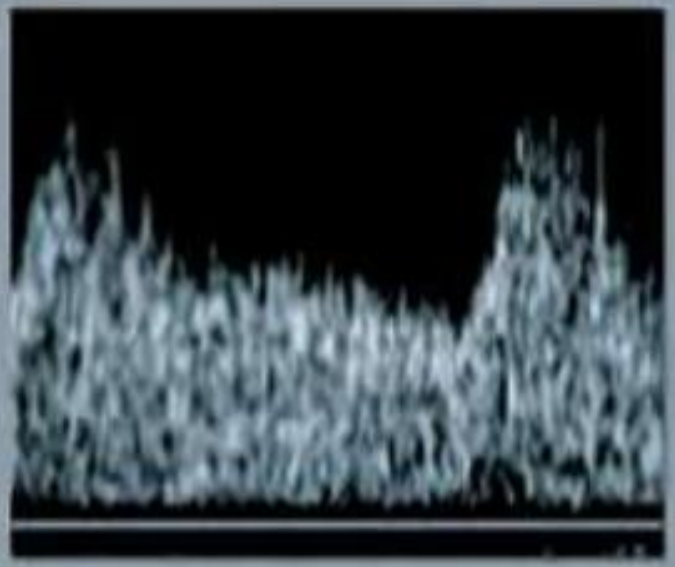

Col 79% Map 7
WF Max
PRF 4000 Hz
Flow Opt: Med V
Umbilical Artery
ATL
+61.5
-61.5
cm/s
SV Angle 0°
Dep 4.6 cm
Size 2.0 mm
Freq 2.5 MHz
WF Low
Dop 68% Map 3
PRF 5000 Hz
Sys
D
Sys
D
60
40
20
cm/s
-20
-40
-60
20 Weeks
36 Weeks


PHILIPS
+25.4
-25.4
cm/s
Umbilical A
PSV 37.2 cm/s
EDV 13.2 cm/s
RI 0.64
S/D 2.8
7.2
60
40
20
cm/s
3.6sec

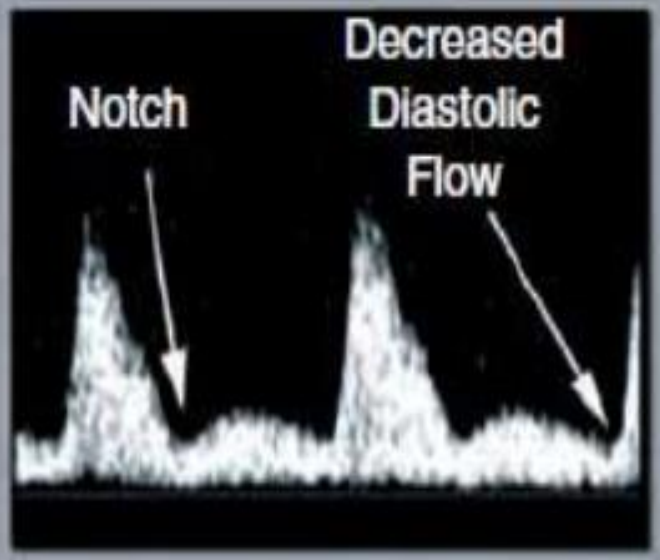

Col 78% Map 7
WF Max
PRF 3000 Hz
Flow Opt Med V
ATL
+ 20.0
- 20.0
cm/s
SV Angle 0°
Dep 3.7 cm
Size 2.0 mm
Freq 4.0 MHz
WF Low
Dop 68% Map 3
PRF 5000 Hz
S
D
60
40
20
cm/s
-20
Normal Uterine Artery Blood Flow


MI:0.9
S8
GAIN100 COMP 12
UCD VETERINARY
9CM
CARDIOLOGY
2/0/C/M2/A
CANINE
99BPM
LANEY
2:03:03
BRIE
24 JULY 06
371764 FEC
12:48:16
15M F ST POODLE
2.9MHZ
RV
RA
LV
LA
3.3MHZ
86
C
M
/
S
86
1.6
1.2
0.8
0.4
0
0.4
0.8
M/S
GATE: 5.0CM
LEN: 0.21CM
e: 0
▼=0.20
DELAY1 0 MS EVERY 5 BEATS


+28
-28
[DP] 4.76KHz
G35 P90 F:Bas.
VC40:3 An0
ITo2.4 IM0.5
Solo D
+82
-49
Umbilical artery



Normal Uterine Artery
Doppler Waveform

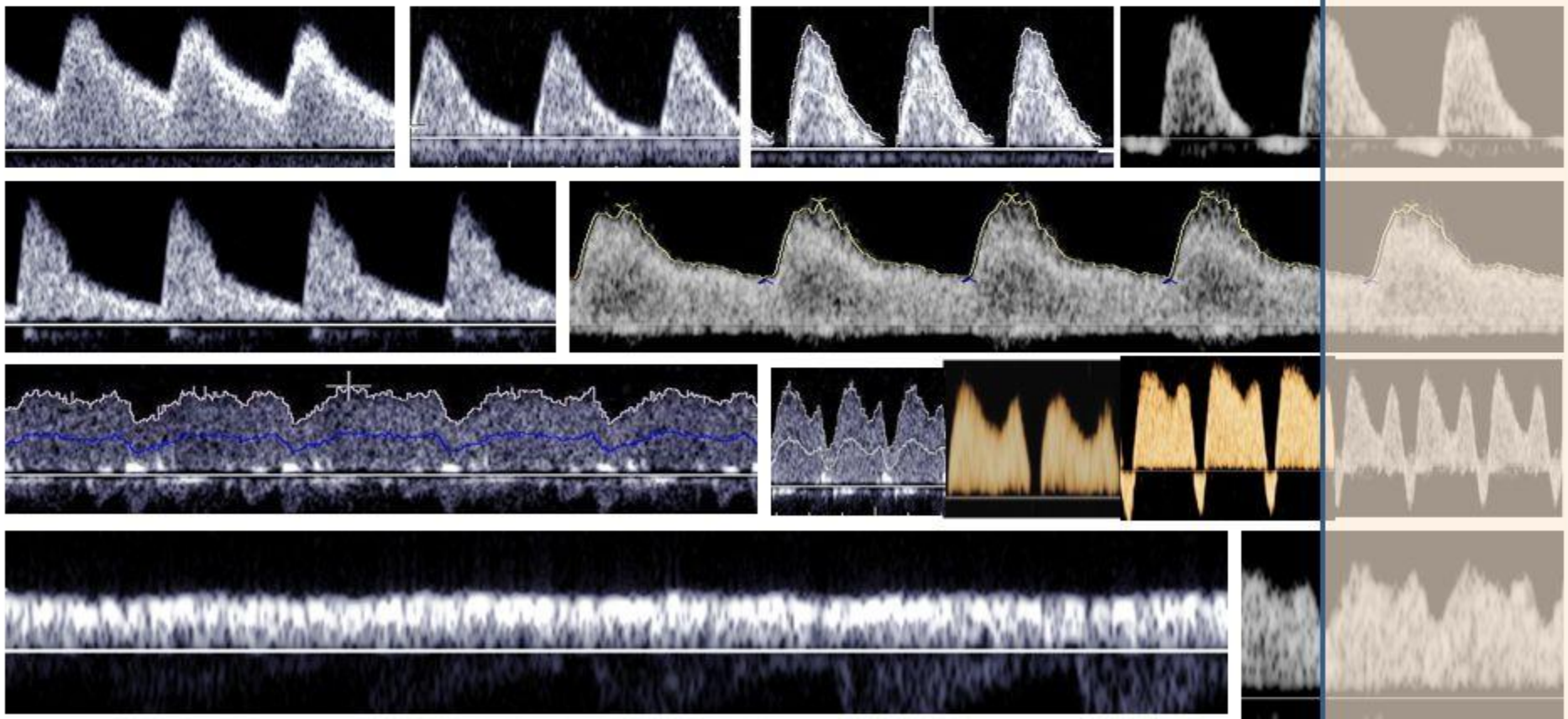


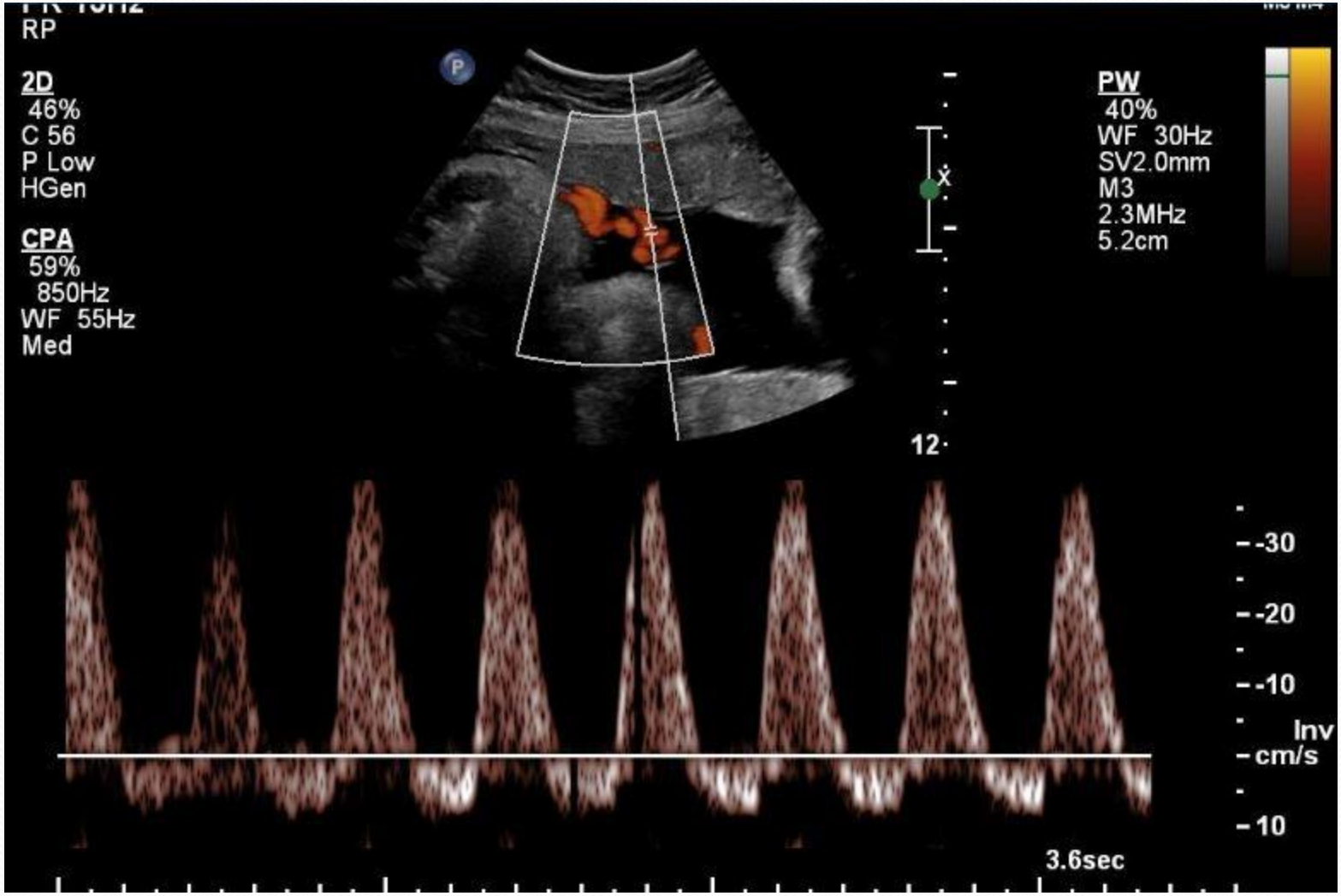
Abnormal Uterine Artery
Doppler Waveform

Early IUGR: Doppler Assessment

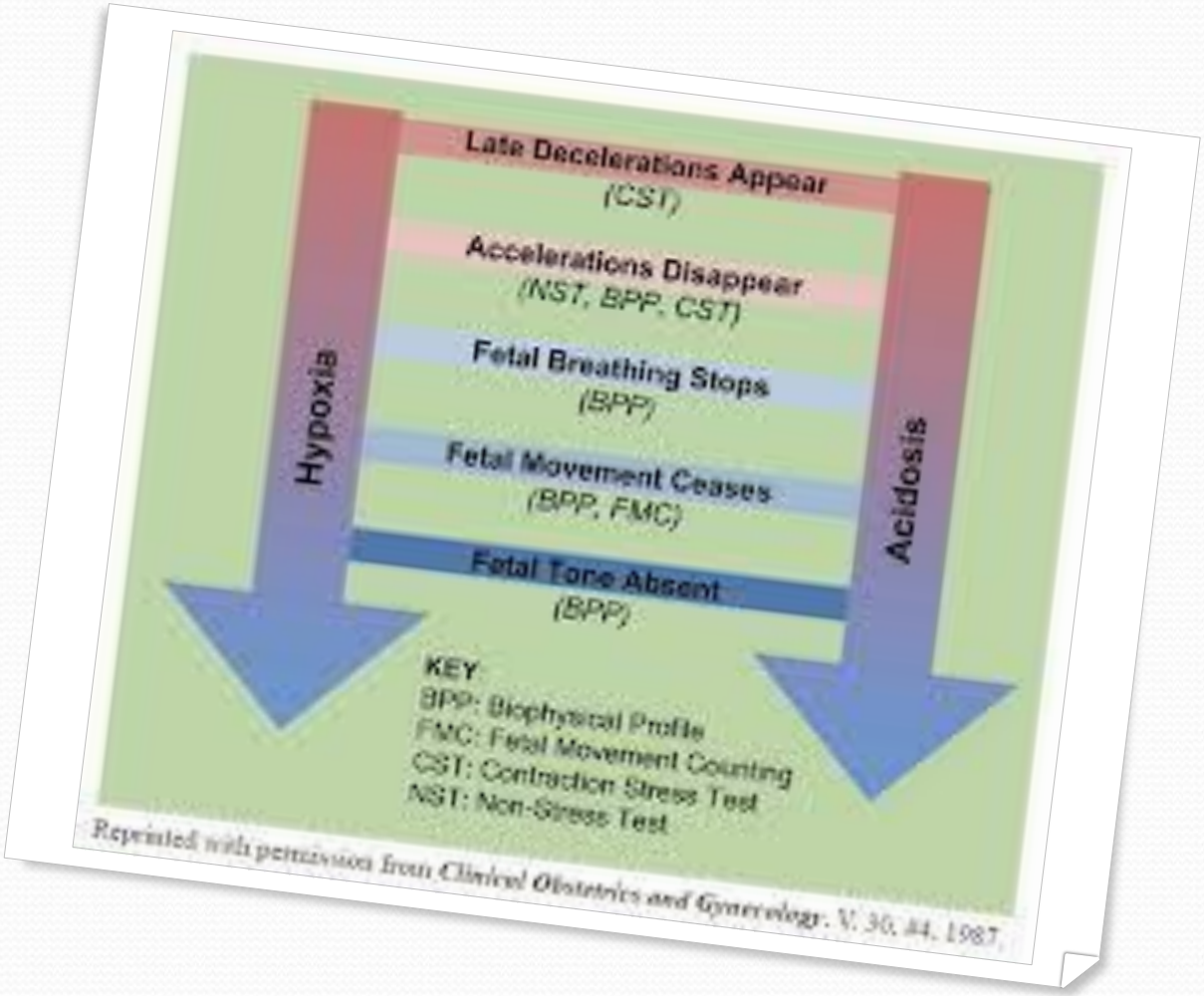
Placental Resistance

Subclinical placental disease	Compensated hypoxia	Decompensated hypoxia (acidosis)	Fetal death




RP
2D
46%
C 56
P Low
HGen
CPA
59%
850Hz
WF 55Hz
Med
PW
40%
WF 30Hz
SV2.0mm
M3
2.3MHz
5.2cm
12
-30
-20
-10
Inv
cm/s
10
3.6sec

Biophysical profile (BPP)



ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - Described by Manning (1980)
  - The number of biophysical activities that could be recorded increased with real time ultrasound:
    - Fetal movement (FM)
    - Fetal tone (FT)
    - Fetal breathing movements (FB)
    - Amniotic fluid volume (AFV)

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP) – variables
  - NST: reactive – as described earlier.
  - FBM: present - at least 1 episode of at least 30 seconds duration (within a 30 minute period).
  - FM: present - at least 3 discrete episodes.
  - FT: normal - at least 1 episode of extension of extremities or spine with return to flexion.
  - AFV: normal – largest pocket of fluid greater than 1 cm in vertical diameter.

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - Each variable
    - When normal: 2
    - When abnormal: 0
  - Highest Score: 10, Lowest Score: 0
  - Accuracy improved by increasing the number of variables assessed.
  - Overall false negative rate: 0.6/1000

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - Acute markers of fetal compromise: NST, FT, FBM, FM
  - Chronic marker of fetal compromise: AFV
  - Nervous impulses that initiate fetal biophysical activities arise from different anatomic sites within the brain.

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - Activities that become active first in fetal development (**FT**, **FM**) are the last to disappear when asphyxia arrests all activities.
  - Activities that become active later in gestation (**NST**,**FBM**) will be abolished 1st in cases of hypoxia and acidosis.

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - Fetal tone: 7.5 to 8.5 weeks
  - Fetal movement: 9 weeks
  - Fetal breathing: 20 to 21 weeks
  - NST: 24 to 28 weeks

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - When hypoxia and acidosis
    - Late decelerations appear (CST)
    - Accelerations disappear (CST, NST, BPP)
    - Fetal breathing stops (BPP)
    - Fetal movement ceases (BPP, FMC)
    - Fetal tone absent (BPP)
  - Assessment of fetal well-being in high risk pregnancies
    - Reduced perinatal mortality rate from 65/1000 to 5/1000

ANTEPARTUM FETAL MONITORING

- BPP and perinatal mortality (PNMR)
  - 12,000 pregnancies (Manning, 1985)
  - BPP Score — Corrected PNMR
    - 8-10 — 0.6
    - 6 — 0.0
    - 4 — 22.0
    - 2 — 42.6
    - 0 — 187.0

ANTEPARTUM FETAL MONITORING

- BPP and perinatal morbidity
  - Significant inverse linear correlation (Manning, 1990)
    - Fetal distress
    - NICU admission
    - IUGR
    - 5 min Apgar <7
    - Cord artery pH <7.20

ANTEPARTUM FETAL MONITORING

- BPP without NST
  - When the FM, FBM, FT, and AFV were normal (BPP 8/8), the probability of a nonreactive NST was exceedingly small (Manning, 1987)
  - The addition of NST did not improve prediction of outcome.
  - BPP corrected PNMR false negative rate
    - 8/8 1.43 / 1000 0.73 / 1000
    - 10/10 1.9 / 1000 0.65 / 1000
  - Selective use of NST saves time: only 2.7% patients need it

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - Normal variables are highly predictive of a good neonatal outcome (Vintzileos, 1983).
  - Each abnormal variable was associated with a high false positive rate
  - Variables — Best predictor of
    - Absence of FM — abnormal FHR in labor (80%)
    - NR NST — meconium (33%)
    - Decreased AFV — fetal distress (37.5%)
    - Poor FT — perinatal death (42.8%)

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - Combinations of variables increase the specificity of the testing, and increase the ability to predict the fetus in jeopardy (Vintzileos, 1983)
    - NR NST, BPP 6-7: fetal distress (20%)
    - NR NST, BPP 4: fetal distress (100%), deaths (0)
    - BPP 1-3: perinatal deaths (57%)

ANTEPARTUM FETAL MONITORING

- BPP and NST in relation to fetal outcome (Vintzileos, 1983)
  - If reactive NST, then BPP $\geq$ 8 in 95% of cases.
  - If BPP < 5, then no instances of reactive NST.
  - If nonreactive NST, then BPP $\geq$ 8 in 39% of cases.
  - All hypoxic fetuses had nonreactive NST and absent fetal breathing.
  - A reactive NST was associated with good outcome in all cases.

ANTEPARTUM FETAL MONITORING

- Errors associated with the BPP
  - Management decisions based on the score only.
    - Intervention based on a false positive low score
    - No intervention based on a false negative normal score
  - Management based on BPP without considering overall clinical findings.
  - Poor timing of testing.
  - Not including the NST.
  - Inexperience operators, poor technique, poor equipment.

ANTEPARTUM FETAL MONITORING

- Biophysical profile (BPP)
  - When the FHR accelerates, there is virtually always fetal movement (FM)
  - If the NST is reactive, there is fetal movement (FM) and tone (FT)
  - If the NST is reactive, do not need the ultrasound parameters of the BPP
  - Only the AFV would add additional information

ANTEPARTUM FETAL MONITORING

- Modified biophysical profile (BPP)
  - A standard NST is combined with an amniotic fluid index (AFI)
  - Negative: Reactive NST / AFI > 5.0 cm
  - If NST is nonreactive or has decelerations, or if the AFI is ≤ 5.0 cm, then a BPP is performed.
  - Negative results are repeated every 3 to 4 days.
  - If the AFI > 5.0 cm, a repeat AFI may be done in one week.