PHYSIOLOGICAL BASIS FOR FETAL TESTING

Who,When.Which ,How often .....

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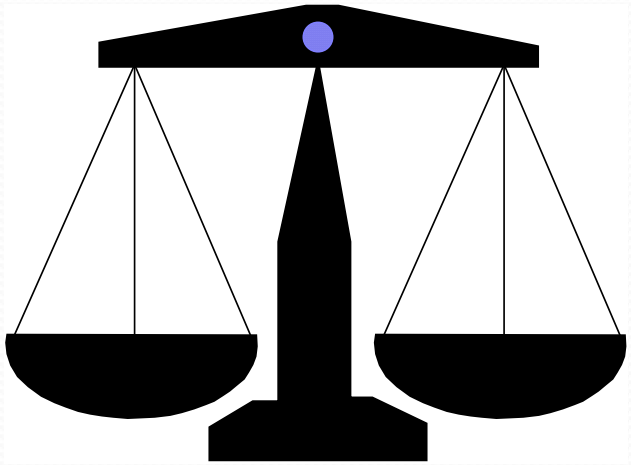
The main goal of antepartum fetal surveillance is to identify the fetus that will benefit from early intervention, such as in utero resuscitation or delivery, prevent fetal death or neurologic injury



Risk of Prematurity

Risk of Still-Birth

PHYSIOLOGICAL BASIS FOR FETAL TESTING

- Fetal biophysical activities (heart rate, movement, respiration) are sensitive to fetal oxygenation and pH levels

- The fetus responds to hypoxemia with a detectable sequence of biophysical changes, beginning with signs of physiological adaptation and potentially ending with signs of physiological decompensation

Sequence of fetal response to stress

Sequence may vary according to the etiology and progression

Stress

↓ Chronic respiratory and nutritive insufficiency

Primary adaptive response

↓ Decreased fetal growth rate

Secondary adaptive response

- Fetal energy conservation
  - Decreased fetal movement
  - Decreased fetal heart rate reactivity
- Circulatory redistribution
  - Falling cerebral flow impedance
  - Rising umbilical and aortic impedance
- Fetal growth preferred over placental growth
- Increased efficiency of placental exchange
- Polycythemia
  - Greater 0_2 carrying capacity

Progressive decompensation

- Hypoxia → respiratory acidosis → metabolic acidosis
- High impedance in fetoplacental and systemic circulation results in absent end diastolic flow in umbilical arteries
- Declining amniotic fluid volume → oligohydramnios
- Loss of fetal movement
- Loss of fetal heart rate reactivity and variability
- Persistent late decelarations
- Agonal pattern

Death

Note that the depicted sequence is an approximation and the actual course may vary depending upon the characteristics of the chronic deprivation and the individual fetal ability to cope.

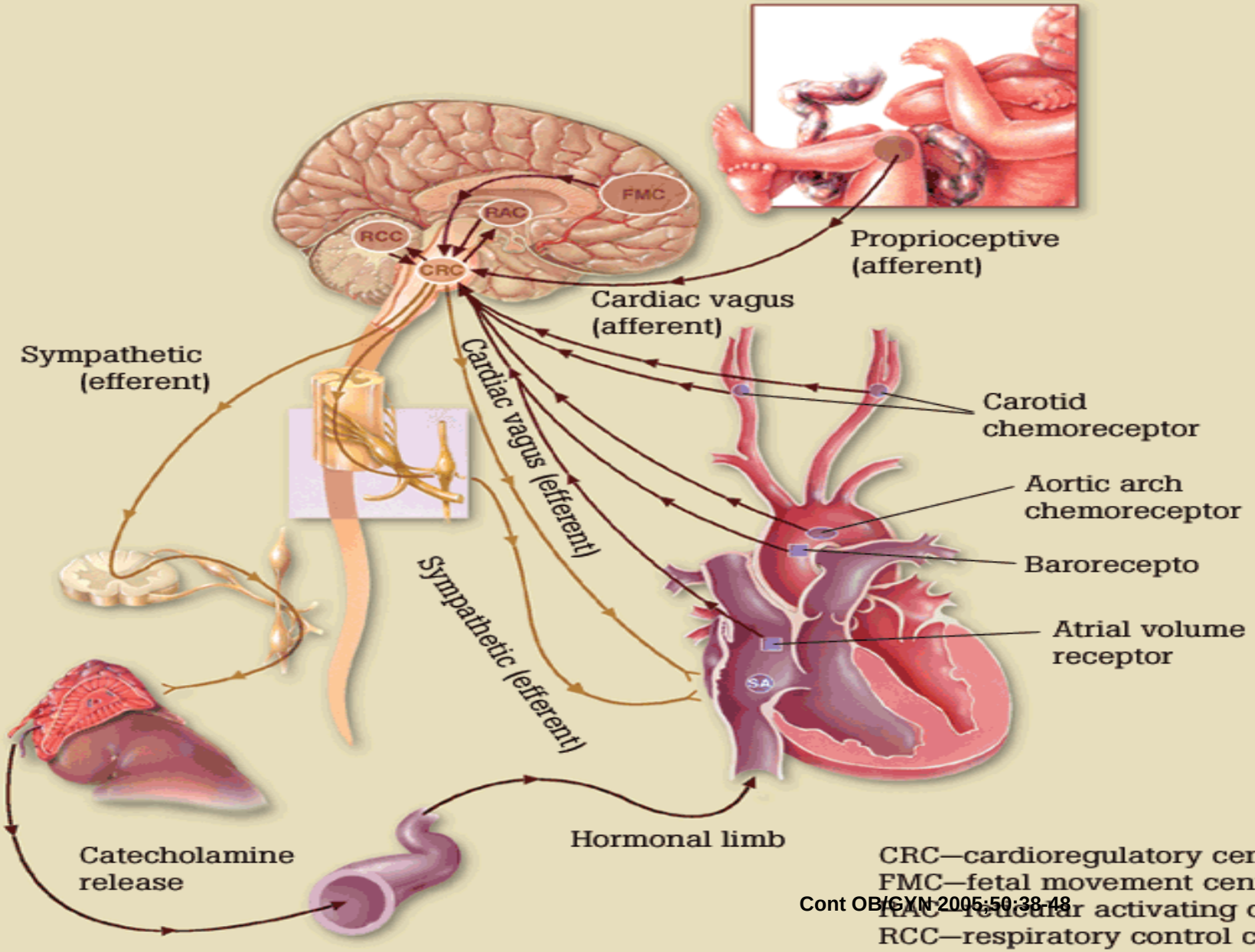
- Fetal biophysical parameters can be affected by factors unrelated to hypoxemia, such as :

  gestational age- maternal medication/smoking,

  fetal sleep-wake cycles, and fetal disease/anomalies

- Fetuses at risk of death from a sudden insult, such as complete placental abruption, cord prolapse, can not be prevented

FIGURE 1. Schematic of modifiers of FHR



Cont OB/GYN 2005;50:38-48

- **Fetal biophysical parameters appear and change in complexity over time**

  -Tone and Movement evident at early first trimester

  -Breathing becoming evident at 21 weeks

  -HR reactivity becoming evident at 24-26 weeks

  -HR variability becoming evident 25 -26 weeks

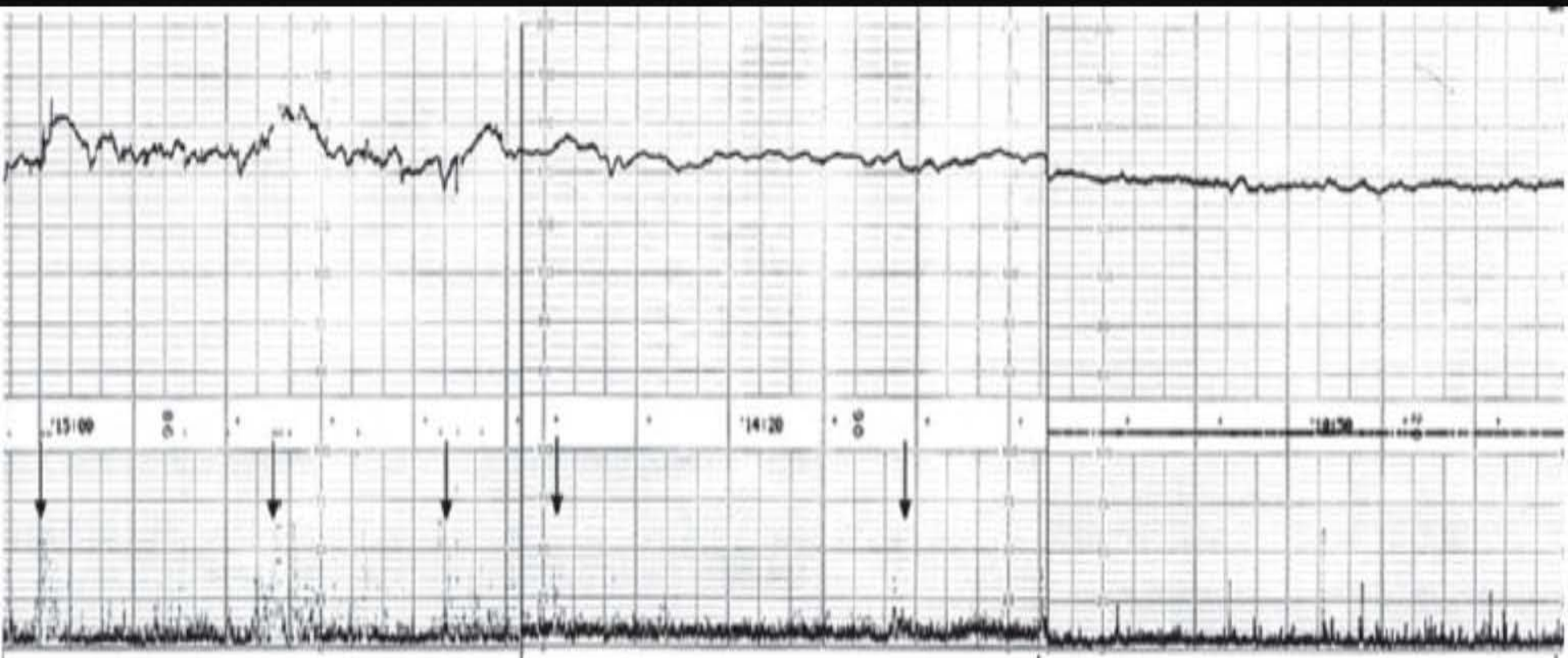
- Their presence , have been reliably tied to the absence of fetal hypoxemia and acidemia, which is the basis for the BPP

- **First to Come , Last to Leave**

TABLE 1 | Criteria of the automatic state classification based on the original Nijhuis criteria.

State/fHRP	1F/fHRP1 quiet sleep	2F/fHRP2 active sleep	4F/fHRP4 active awake
Original criteria	• Quiescence which can be regularly interrupted by brief body movements (startles) • Stable heart rate, small oscillation • Isolated accelerations occur strictly related to movement	• Frequent gross body movement Heart rate with wider bandwidth than 1F • Frequent accelerations during movement	• Vigorous activity with many trunk rotations • Unstable heart rate • Large and long lasting accelerations fused into sustained tachycardia
Criteria for automatic state detection			
Baseline	<160 bpm	<160 bpm	>160 bpm possible
Oscillation bandwith	<±7.5 bpm	±7.5–±15 bpm	>±15 bpm
Accelerations	No	>15 bpm/>15 s	>30 bpm/>30 s
Movement	No	Yes	Yes

(Before 32 wks , 1F: 58% - 2F : 42%) (>32 wks , 1F: 24% - 2F: 65% - 4F: 11%)



Frequent accelerations, high baseline, rich variability and frequent bursts.	Small and rare acceleration, high baseline, moderate variability, small and sporadic bursts	No acceleration, low baseline, minimal variability, no movement burst

- ***How reassuring is a normal antepartum fetal surveillance result?***
- ***Is there evidence that antepartum fetal surveillance decreases the risk of fetal demise or otherwise improves perinatal outcomes?***
- ***What are the indications for antepartum fetal surveillance?***

Interpretation and outcome of various antenatal fetal testing methods

Name	Components	Results/scoring	False negative	False positive	References
Contraction stress test (oxytocin challenge test)	Continuous FHR monitoring At least 3 contractions of ≥40s duration within 10 minutes	**Negative:** No late or significant variable decelerations **Positive:** Late decelerations following ≥50 percent of contractions, even if there are <3 contractions in 10 minutes **Equivocal - suspicious:** Intermittent late decelerations or significant variable decelerations **Equivocal - hyperstimulatory:** Decelerations with contractions occurring more frequently than every 2 minutes or lasting >90s **Unsatisfactory:** <3 contractions in 10 minutes or uninterpretable FHR tracing	0.04 percent	35 to 65 percent	[1,2]
Nonstress test	Continuous FHR monitoring FHR accelerations: ≥32w: Reaching 15 bpm above baseline and lasting ≥15s <32w: Reaching 10 bpm above baseline and lasting ≥10s	**Reactive:** ≥2 accelerations within 20 minutes (may be extended to 40 minutes) **Nonreactive:** <2 accelerations in 40 minutes	0.2 to 0.65 percent	55 to 90 percent	[3-8]
Biophysical profile	Presence or absence of five components within 30 minutes: ▪ Reactive NST ▪ ≥1 episode of fetal breathing movements lasting ≥30s ▪ ≥3 discrete body or limb movements ▪ ≥1 episode of extremity extension with return to flexion or opening or closing of a hand ▪ Maximum vertical AF pocket >2 cm	Each component is assigned a score of 2 points if all criteria for the component are present and 0 points if all criteria for the component are not present; maximum score is 10/10 ▪ **Normal:** ≥8/10 or 8/8 excluding NST ▪ **Equivocal:** 6/10 ▪ **Abnormal:** ≤4/10	0.07 to 0.08 percent	40 to 50 percent	[9-11]
Modified biophysical profile	▪ NST ▪ Maximum vertical AF pocket >2 cm	**Normal:** Reactive NST *and* maximum vertical AF pocket >2 cm **Abnormal:** Nonreactive NST *and/or* maximum vertical AF pocket ≤2 cm	0.08 percent	60 percent	[12-15]

s: seconds; NST: nonstress test; AFI: amniotic fluid index; FHR: fetal heart rate; w: weeks; bpm: beats per minute

Indications for Antepartum Fetal Surveillance Testing

Maternal conditions

- Pregestational diabetes mellitus
- Hypertension
- Systemic lupus erythematosus
- Chronic renal disease
- Antiphospholipid syndrome
- Hyperthyroidism (poorly controlled)
- Hemoglobinopathies (sickle cell, sickle cell–hemoglobin C, or sickle cell–thalassemia disease)
- Cyanotic heart disease

Pregnancy-related conditions

- Gestational hypertension
- Preeclampsia
- Decreased fetal movement
- Gestational diabetes mellitus (poorly controlled or medically treated)
- Oligohydramnios
- Fetal growth restriction
- Late term or postterm pregnancy
- Isoimmunization
- Previous fetal demise (unexplained or recurrent risk)
- Monochorionic multiple gestation (with significant growth discrepancy)

- ***When during gestation should antepartum fetal surveillance be initiated?***

- ***What is the recommended frequency of testing?***

“COMMON SENSE”

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“The use of multiple modalities is more likely to yield reliable results”

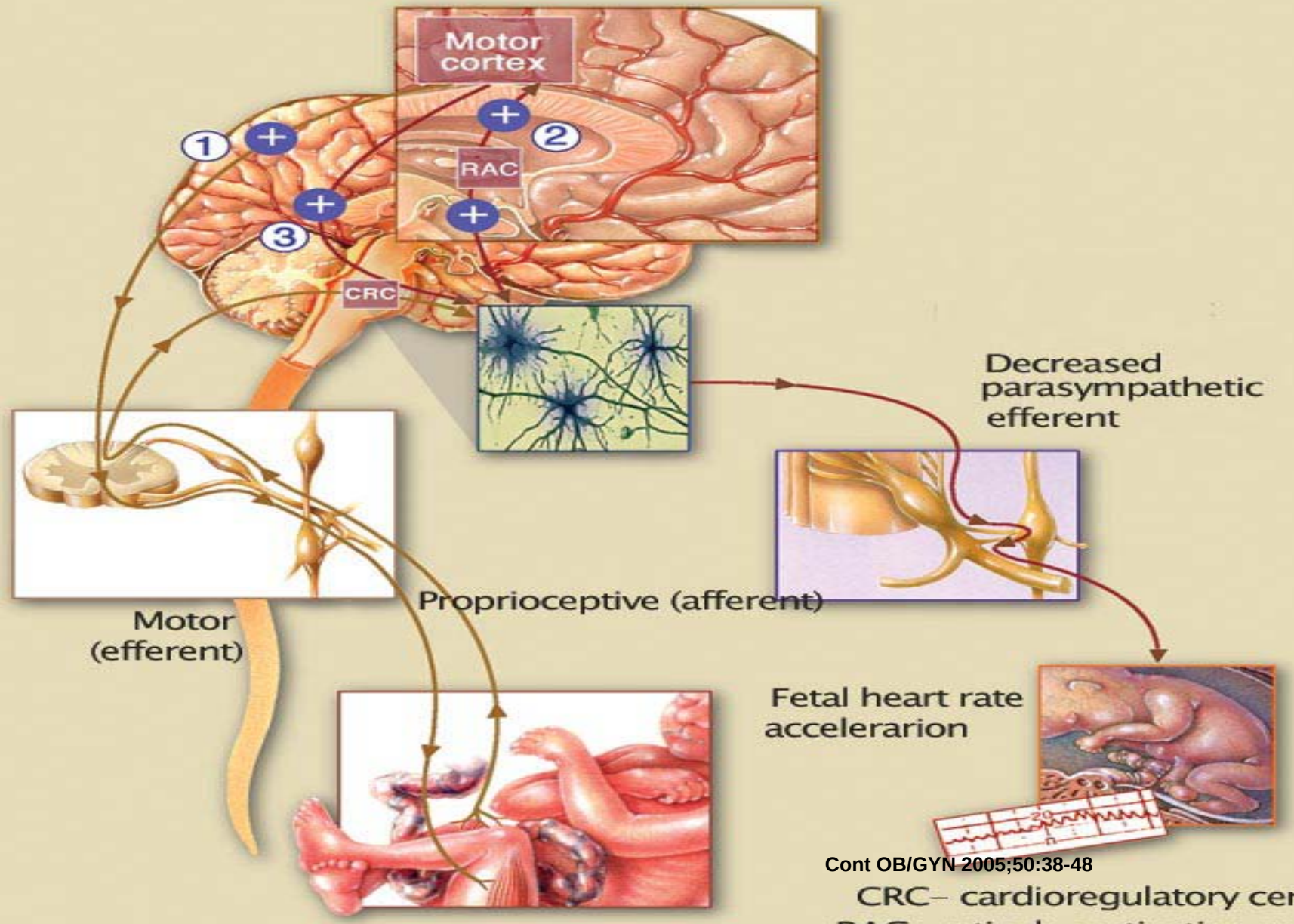
- Understanding the range of normal fetal behavior and considering the clinical context in which testing is performed are important parts of interpreting the results of fetal assessment.
- Given the wide variability in normal findings, even in the setting of abnormal test results, the likelihood of an adverse outcome may be relatively low in a low-risk population.
- Because the primary intervention available to the obstetrician wishing to facilitate treatment of the mother or the fetus is delivery, indications of potential fetal compromise must be carefully balanced against the complications of prematurity if the decision is made to proceed with delivery.
- it becomes more critical when maternal and fetal complications arise.

- The degree of fall in oxygen concentration necessary to abolish a given central nervous system regulatory center output varies by center. The two most oxygen-sensitive centers are (1) the cardioregulatory neurons, which control the coupling of fetal movement and heart rate acceleration, and (2) the fetal breathing center neurons, which control fetal breathing movements. The centers regulating fetal movement have a higher threshold for hypoxemia than those for fetal breathing or fetal heart rate accelerations; the fetal tone center has the highest threshold

- Fetuses with an abnormal test result were found to have a mean (± standard deviation) umbilical vein blood pH of 7.28 (± 0.11). Cessation of fetal movement appears to occur at lower pH levels; fetuses with abnormal movement were found to have a mean umbilical vein blood pH of 7.16 (± 0.08) (7).
- Thus, a reasonable correlation between certain measurable aspects of FHR and behavior and evidence of fetal metabolic compromise can be inferred
- The degree and duration of acidemia is weakly correlated with adverse short-term and long-term neonatal outcomes.
- Furthermore, factors other than acid–base and oxygenation status (eg, prematurity, fetal sleep–wake cycle, maternal medication exposure, maternal smoking,and fetal central nervous system abnormalities) can adversely affect biophysical parameters

- By the beginning of the third trimester, behavioral states 1F to 4F can be defined
- 1F : quiet sleep (repetitive mouthing movements are present, but almost all other movements are absent-as long as 110 minutes by 40 weeks)
- 2F : active sleep (movements are grouped, providing efficient monitoring)
- 4F : active awake (the “jogging fetus” illustrates a high level of voluntary activity and a sustained high heart rate, for which return to baseline may be interpreted as decelerations)
- 3F :quiet awake (is unusual and short and is seldom observed before term)

FIGURE 2. Schematic of linkage between fetal movement and FHR acceleration



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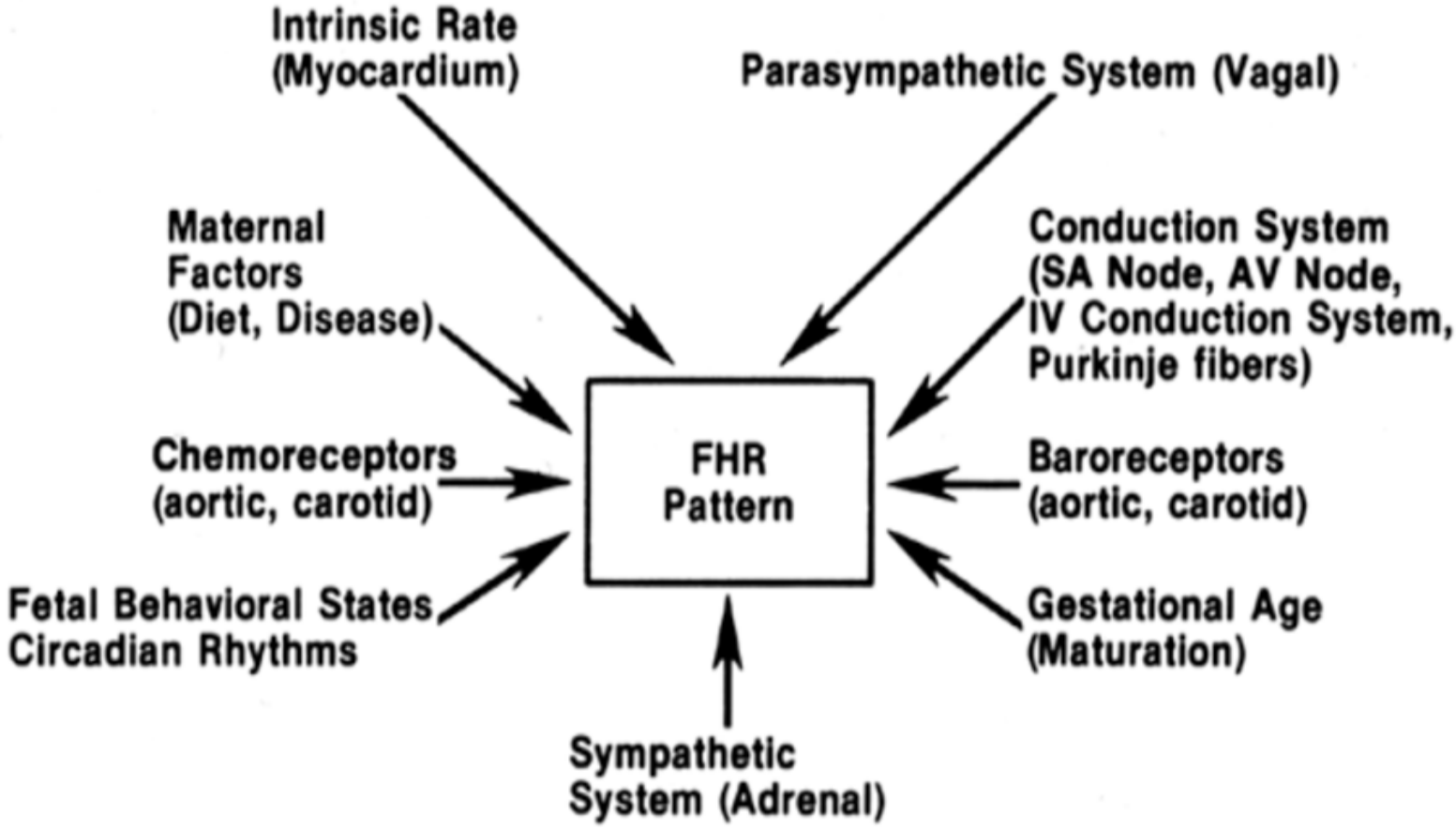
CRC– cardioregulatory center
RAC– reticular activating center


Intrinsic Rate
(Myocardium)
Parasympathetic System (Vagal)
Maternal
Factors
(Diet, Disease)
Conduction System
(SA Node, AV Node,
IV Conduction System,
Purkinje fibers)
Chemoreceptors
(aortic, carotid)
FHR
Pattern
Baroreceptors
(aortic, carotid)
Fetal Behavioral States
Circadian Rhythms
Gestational Age
(Maturation)
Sympathetic
System (Adrenal)