Cardiotocography – Physiological and Pathological Control of Fetal Heart Rate Patterns

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Cardiotocography

- A continuous recording of the fetal heart rate and uterine activities by electronic means
- Limitations in its usefulness is related to
  - Problems with the monitors
  - Lack of understanding of pathophysiology
  - Carelessness / laziness in the attendants

Basic Understanding of the Fetal Heart Rate Patterns

- Represents fetal physiology
- Different patterns represent the different results of the interaction of many factors
- Fetal compromise only diagnosed in association with clinical assessment and interpreted with respect to the probability of fetal compromise

Fetal Response to Hypoxia (1)

Hypoxia ← ↓ Blood Flow

↓ ↓

↓ PO_2 ↑ PCO_2

↓ ↓

Metabolic acidosis ← Respiratory acidosis

⇓

Redistribution of blood flow to vital organs

Bradycardia, and slightly ↓cardiac output

↓oxygen consumption

Fetal Response to Hypoxia (2)

↓

FHR variability retained / ↑

⇓

Compensated State (Normal cortical functions cerebral oxygenation maintained, can last up to 60 min in experimental animals)

↓

FHR ↓ variability, rate decelerations

⇓

Decompensated State (Decrease cerebral oxygenation, eventual cellular damage

Umbilical blood flow and hypoxia

- Acute moderate hypoxia $\rightarrow$ no effect
- Severe moderate hypoxia $\rightarrow \downarrow$ due to myocardial depression, catecholamines

What is Fetal Distress (1)

? = Hypoxaemia (low PO_2)

? = Acidaemia (low pH)

? = General depression (low Apgar Score)

But- Fetal heart rate pattern does not equate to

low Apgar Score, or

low pH , or

low PO_2

What is Fetal Distress (2)

- The fetus may be stressed but not yet distressed
- The fetus may be distressed due to different reasons / mechanisms
- The fetus may express its distress in different forms
- The CTG is representing one aspect of the fetal response and we can only see from FHR patterns the current fetal response and status and infer whether the fetus is at increased risk of acidaemia / hypoxaemia

Distinction between physiological and pathological response – Example: malposition of cephalic presentation (1)

- OP / OT position - early onset of early deceleration in labour
- Brow presentation - early and variable decelerations in labour
- Healthy fetus - no other pathological features
- Any pathological features in addition - fetus is compromised

Distinction between physiological and pathological response – Example: malposition of cephalic presentation (2)

- Repeated early decelerations in the case of malposition / malpresentation before definite onset of labour / strong contractions and / or engagement of the head represents a distressed fetus

Control of Baseline Fetal Heart Rate and Variability

- Pacemaker in SA node
- Conduction bundle
- AV node
- CNS
- Brain stem centre
- Chemoreceptor and baroreceptor
- Sympathetic and parasympathetic systems

Control of Baseline Fetal Heart Rate and Variability

- Baseline heart rate – sum result of these factors
- Baseline variability – integration of sympathetic and parasympathetic input
- Gestation <34 weeks – upper limit of normal 160 bpm
- For the same fetus – increasing maturity associated with progressive fall in baseline heart rate

Control of Baseline Fetal Heart Rate and Variability

- Parasympathetic system – vagal effect on SA node and AV node → decreased FHR
  - Tonic effect: baseline heart rate, blockade → increase by 20 bpm at term. Effect increases with gestation, acute hypoxia
  - Oscillatory effect: baseline variability
- CNS activity - increase activity leads to increased variability of heart rate

Control of Baseline Fetal Heart Rate and Variability

- Sympathetic system – adrenal medulla → epinephrine and nor-epinephrine
  - Tonic effect: baseline heart rate, blockade → decrease by 10 bpm, effect increases twofold with fetal hypoxia
  - Oscillatory effect: minor influence, indirect effect
- Chemoreceptors – hypoxia / hypercapnia → bradycardia
- Baroreceptors - ↑ arterial pressure → bradycardia

Interpretation of Baseline Fetal Heart Rate and Variability

- Each fetus has its own baseline FHR
- Early effect of increasing hypoxia is a shift of baseline towards tachycardia
- In case of baseline heart rate within normal range but other suspicious / abnormal patterns present in the first trace, treat the fetus as compromised and arrange further tests / surveillance

Interpretation of Baseline Fetal Heart Rate and Variability

- In general moderate tachycardia (150-170 bpm) or bradycardia (100-110 bpm) alone does not represent hypoxia
- Tachycardia >150 bpm can be due to:
  - Fetal factors : Movements / arousal, hypoxia, anaemia/ hypovolaemia
  - Maternal factors : dehydration / hypotension, sympathetic activation, betamimetics

Interpretation of Baseline Fetal Heart Rate and Variability

- Bradycardia
  - Need to exclude maternal trace which can mimic FHR trace – check with stethoscope / palpation and Doptone
  - Poor trace can be due to signal from maternal vessel
  - Stable bradycardia – think of complete or incomplete heart block

Interpretation of Baseline Fetal Heart Rate and Variability

- Double counting – 2 alternate baselines seen
  - Extreme bradycardia </=80 bpm (counting atrial and ventricular contractions separately) – representing a very sick fetus or terminal event
  - Complete heart block
  - Alternating fetal and maternal pulses

Interpretation of Baseline Fetal Heart Rate and Variability

Silent pattern / trace :

- can last 7-10 min in antenatal period and 25-40 min in intrapartum period
- can be due to

  - Rest (sleep) phase of the rest-activity (sleep-wake) cycle

  - Hypoxia

Cause of Decreased Baseline Variability

- Prematurity
- Tachycardia
- Drugs (sedatives, antihypertensives, anaesthetics)
- Local anaesthetics
- Congenital malformation of CNS (>CVS)
- Cardiac arrhythmias

Prolonged Bradycardia (1)

Definition: FHR *< 100 / min for 3 min* or

< 80 for 2 min

Causes:

- Cord compression / prolapse
- Abruptio placentae
- Scar rupture / dehiscence
- Uterine hyperstimulation
- Epidural
- Vagal stimulation (PV exam)

Fetal Heart Rate as part of Fetal Biophysical Profile

- Biophysical profile:
  - Breathing movements
  - Gross body movements
  - Tone
  - Amniotic fluid volume
  - Fetal heart rate
- Complete profile provides assessment of different aspects of fetal wellbeing

Fetal Heart Rate as part of Fetal Biophysical Profile

- CNS control centres
  - Fetal tone (FT): subcortical area of cortex
  - Fetal movements (FM): cortex nuclei
  - Fetal breathing movements (FBM): ventral surface of 4th ventricle
  - Fetal heart rate (FHR): posterior hypothalamus, medulla
- Embryogenesis – developmental /maturation sequence: FT→FM→FBM→reactive FHR
- Sensitivity to and effect of hypoxia: NST→FBM→FM→FT