The objective of fetal heart monitoring is to prevent fetal injury that might result from interruption of adequate oxygenation during labor.
Fetal oxygenation involves the transfer of oxygen from the environment to the fetus...

And the subsequent fetal physiologic response if oxygen transfer is interrupted.

**Principle #1**
Variable, late or prolonged decelerations signal interruption of the oxygen pathway at one or more points.

**Principle #2**
Moderate variability or accelerations exclude ongoing hypoxic injury.
**Encephalopathy**

Abnormal brain function or brain structure
- Transient, recurrent, or permanent
- Reversible, stable, or progressive with loss of brain activity

**Neonatal Encephalopathy**

Syndrome of disturbed neurologic function in the earliest days of life in an infant born at or beyond 35 weeks of gestation, manifested by a subnormal level of consciousness or seizures and often accompanied by difficulty with initiating respiration and depression of tone and reflexes.

**Hypoxic Ischemic Encephalopathy**

Specific subset of neonatal encephalopathy
- Acute hypoxic-ischemic event with close proximity to labor and delivery
- Absence of precise terminology in literature
- Replaced with neonatal encephalopathy
- Neither hypoxia or ischemia can be assumed to have been a causal mechanism
Asphyxia

Absence of precise terminology in literature

Asphyxia
- Marked impairment of gas exchange leading, if prolonged, to progressive hypoxemia, hypercapnia and significant metabolic acidosis
- Process of varying severity and duration rather than an end point
- Should not be applied to birth events unless specific evidence of markedly impaired intrapartum or immediate postnatal gas exchange is linked to neonatal neurologic illness

Neonatal Signs Consistent With Acute Peripartum or Intrapartum Event

- Apgar Score <5 at 5 and 10 minutes
- Fetal Umbilical Artery Acidemia
- Neuroimaging Evidence of Acute Brain Injury
- Presence of Multisystem Organ Failure

Apgar Score: <5 at 5 and 10 minutes

Low Apgar scores present relative risk of cerebral palsy.
- Degree of Apgar abnormality correlates with CP risk
- But most infants with low Apgars DO NOT develop CP

Several potential causes for low Apgar scores
- If score at 5 minutes is ≥ 7
  - Peripartum hypoxia–ischemia probably didn’t role in NE
Fetal Umbilical Artery Acidemia

Umbilical artery pH < 7.0 or base deficit ≥ 12 mmol/L, or both

- Probability that NE was linked to an intrapartum hypoxic event
- Lesser degrees of acidemia ↓ likelihood
- pH > 7.20,
  - Intrapartum hypoxia probably didn’t cause NE

Remember: Even in the presence of significant acidemia, **MOST** newborns will be **NEUROLOGICALLY NORMAL**. The presence of metabolic acidemia does not define the timing of the onset of a hypoxic–ischemic event.

Neuroimaging: Acute Brain Injury
Multisystem Organ Failure
Renal injury
Hepatic injury
Hematologic abnormalities
Cardiac dysfunction
Metabolic disorders
Gastrointestinal injury
Combination of any of the above

Contributing Factors Consistent with Acute Peripartum or Intrapartum Event
- Sentinel hypoxic or ischemic event
- Fetal heart rate patterns
- Timing and type of brain injury patterns based on imaging studies
- No evidence of other contributing proximal or distal factors

Sentinel Hypoxic or Ischemic Event
- Uterine rupture
- Abruption
- Umbilical cord prolapse
- Amniotic fluid embolus (Anaphylactoid Syndrome)
  - Severe and prolonged maternal hypotension and hypoxemia
- Maternal cardiovascular collapse
- Fetal exsanguination
  - Vasa previa or massive fetomaternal hemorrhage
Fetal Heart Rate Patterns

Category I and Category II fetal heart rate patterns
- When associated with
  - Apgar scores ≥ 7 at 5 minutes
  - Normal umbilical cord arterial blood gas
  - Both criteria
- Not consistent with acute hypoxic–ischemic event
Fetal Heart Rate Patterns

Difference between abnormal FHR pattern on admission
- Versus abnormal FHR pattern developed during labor

Example
- 8 Fetal movement x 24 hours presenting with Category III FHR

Including absence of decelerations
- Suggestive of a pre-existing injury

Clinical management:
- Is there VAS or scalp stimulation response or adequate biophysical profile
- Discussion about route and timing of delivery

Emergency cesarean may not benefit a fetus with previous injury

Previously Injured or Compromised Fetus

- Category II FHR pattern lasting ≥60 minutes identified on admission with persistent minimal or absent variability and no accelerations
- Including absence of decelerations
- Suggestive of a pre-existing injury

Clinical management:
- Is there VAS or scalp stimulation response or adequate biophysical profile
- Discussion about route and timing of delivery

Emergency cesarean may not benefit a fetus with previous injury

Algorithm for Category II Management
Category III Fetal Heart Rate Pattern

Category I FHR pattern converts to Category III FHR pattern
Suggestive of a hypoxic–ischemic event

Other Fetal Heart Rate Patterns
Suggest of intrapartum timing of a hypoxic–ischemic event
- Tachycardia with recurrent decelerations
- Persistent minimal variability with recurrent decelerations
  “Significant Decelerations”
  - Variables lasting >60 seconds reaching a nadir of > 60 bpm below baseline
  - Variables lasting >60 seconds reaching a nadir <60 bpm regardless of baseline
  - Any late decelerations of any depth
  - Any prolonged deceleration

Objectives and Methods

Estimate the time spent in the three fetal heart rate categories during labor and the last two hours before delivery in term singleton pregnancies

- Review of FHR data and newborn outcomes
  - 10 hospitals over 28 months
  - 48,444 patients

Interpretation
- 20 minute segments assessed by L&D nurses
- Entered into computer workstation
- Categories assigned by a computer

Results: FHR Categories
Results: Neonatal Outcomes

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>NE</th>
<th>No NE</th>
<th>p-value</th>
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<tbody>
<tr>
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Characteristics are Associated with Neonatal Encephalopathy

Identify labor FHR associated with NE (cord pH <7.1)

- 111 patients with NE and 265 without NE
- 84% : Category II FHR in hour prior to deliver
- 17.1% of patient with NE were Category III
- Compared to 1.1% in control group

FHR characteristics associated with NE
- Minimal/absent variability, lates, "severe variables" and prolonged decelerations

![Table showing FHR characteristics and associated p-values](image-url)
Timing and Type of Brain Injury Pattern

Cranial ultrasound
MRI
- 24-96 hours of life: guide to potential timing of injury

No Evidence of Other Contributing Factors

Fetal growth restriction
Maternal infection
Feto-maternal hemorrhage
Neonatal Sepsis
Chronic Placental Lesions
- 2nd trimester abruptions
- Chorioangiomas

Development of Cerebral Palsy

Etiology
- Injury to developing brain
  - Prenatal, perinatal or postnatal
Statistics
- 1.5 to >4% cases per 1000 live births (world)
  - Unchanged since 1950's
  - 80-90% are congenital
Associated with intrapartum event
- Spastic Quadriplegia and Dyskinetic Cerebral Palsy
Pregnancy Related CP

• Leading Causes
  • Prematurity
  • Increased prevalence
  • Gestational age
  • Birth weight
• Perinatal Infection
  • Maternal (CMV)
  • Intrauterine (Chorioamnionitis)
  • Neonatal (Sepsis)

• Other
  • Multiple Gestation
  • Growth Restriction
  • Placental Abnormalities
  • Supplies nutrients
  • Barrier to infection
  • Decreased reserve

Intrapartum Fetal Heart Rate Management Decision Model

Intrapartum Fetal Heart Rate Management Decision Model

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</tr>
<tr>
<td>4</td>
<td>Determine Decision to Delivery Time</td>
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Lungs
- Airway and breathing
- Supplemental oxygen
- Facility OR availability
- Equipment
- Facility response time

Heart
- Heart rate and rhythm
- Position changes
- Fluid bolus
- Correct hypotension

Vasculature
- Blood pressure
- Volume status
- Mother
- Informed consent
- Anesthesia options
- Laboratory tests
- Blood products
- Intravenous access
- Urinary catheter
- Abdominal prep
- Transfer to OR

Uterus
- Contraction strength
- Contraction frequency
- Baseline uterine tone
- Exclude uterine rupture

Fetus
- Confirm Estimated fetal weight
- Gestational age
- Presentation
- Position

Placenta
- Placental separation
- Bleeding vasa previa

Cord
- Vaginal exam
- Exclude cord prolapse
- Consider amnioinfusion

Labor
- Consider IUPC

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