

IN SUMMARY
FETAL SURVEILLANCE

FETAL SURVEILLANCE

An Example of a Fetal Heart Rate Tracing

Figure removed due to copyright restrictions.

Variability

- Beat to beat rate changes reflect CNS activity
 - Vagal tone is modulated by CNS activity
 - Variability is a measure of fetal (or adult) arousal state
 - REM sleep produces considerable variability
 - REM sleep associated with fetal breathing
 - Variability is reduced or eliminated by
 - Drugs (barbiturates, narcotics, MgSO₄, diazepam)
 - Infection
 - Hypoxia
 - Prematurity
 - Long term variability reflects continuous changes in the sympathetic-parasympathetic balance
 - Sinus rhythm exhibits fluctuations around the mean heart rate
 - Frequent small adjustments in heart rate are made by cardiovascular control mechanisms (the details of this are not well worked out)
 - Results in periodic fluctuations in heart rate
 - The main periodic fluctuations are
 - Respiratory
 - Sinus arrhythmia
 - Baroreflex-related
 - Thermoregulation-related
-
- Inspiratory inhibition of the vagal tone: heart rate shows fluctuations with a frequency equal to the respiratory rate
 - This inspiratory inhibition is evoked primarily by central production of impulses from the medullary respiratory to the cardiovascular center
 - Peripheral reflexes due to hemodynamic changes and thoracic stretch receptors contribute to respiratory sinus arrhythmia
 - Respiratory sinus arrhythmia can be abolished by atropine or vagotomy - parasympathetically mediated (esp. in fetus)
 - 10-second rhythm in heart rate originates from self-oscillation in the vasomotor part of the baroreflex loop

- This results from negative feedback in the baroreflex and are accompanied by synchronous fluctuations in blood pressure
- The frequency of the fluctuations is determined by the time delay of the system
- Augmented when sympathetic tone is increased decrease with sympathetic or parasympathetic blockade
- Peripheral vascular resistance also exhibits intrinsic oscillations of low frequency
- These oscillations can be influenced by thermal changes in the skin
- Thought to arise from thermoregulatory peripheral blood flow adjustments
- Fluctuations in peripheral vascular resistance accompanied by fluctuations with the same frequency in blood pressure and heart rate
- Mediated by the sympathetic nervous system

Sleep State

- Investigations in the fetus and newborn have revealed that during rapid eye movement (REM) sleep LTV is increased and STV is decreased compared to during non-REM sleep
- These differences between REM and non-REM sleep are due mainly to a shift in the vagal-sympathetic balance from a higher sympathetic
- Vagal tone during REM sleep shifts to higher vagal tone during non-REM sleep
- In addition, the slower and more regular breathing in non-REM sleep (more respiratory sinus arrhythmia, thus more STV) contributes to the differences found

Adults

- Adult heart rate variability has been investigated primarily in awake adults
- Enables investigators to instruct the participants to breath at fixed frequencies
- Heart rate variability studies in adults have revealed that **body posture influences** heart rate variability
- In the **upright** position **baroreflex-related** heart rate variability is **enhanced** due to an increased sympathetic tone.
- Respiratory** sinus arrhythmia is augmented in the **supine position**

Fetal and Neonatal Heart Rate Variability

- In obstetrics it has been noticed that acute hypoxia resulted in an increase in heart rate variability
- Chronic hypoxemia was accompanied by low heart rate variability
- Low heart rate variability is associated with low Apgar scores and pH at birth
- Attributed to depression of the central nervous system
- Persistent fixed fetal heart rate pattern was also described in **anencephaly and fetal decerebration**
- Reduction in heart rate variability appears to be a rather **late sign of fetal compromise**

Fetal and Neonatal Heart Rate Variability

- In asphyxiated **newborns**, diminished heart rate variability is also found
- Transient** loss of heart rate variability indicates a good prognosis
 - Due to cerebral edema,
- Sustained** loss of heart rate variability
 - predicts neurologic sequelae
 - neonatal death
 - probably due to irreversible damage to the brain or brain stem

Fetal and Neonatal Heart Rate Variability

- Severe neonatal respiratory distress syndrome is accompanied by a reduction in low-frequency heart rate variability
 - transient depression of the medulla oblongata due to elevated pCO₂ levels and acidosis
- If the respiratory distress improves --> heart rate variability increases
- Reduction in LTV in newborns with clinically significant patent ductus arteriosus
 - ascribed to a marginal oxygen supply of the myocardium that limits fluctuations in heart rate
- Loss of heart rate variability also has been found in infants with periventricular hemorrhage
 - damage of vasomotor areas in the medulla oblongata
 - due to increased intracranial pressure
- In infants who subsequently died of the sudden infant death syndrome
 - higher heart rate
 - lower heart rate variability

Time Domain Analysis

- Two types of heart rate variability indices
- Beat-to-beat or short-term variability (STV)
 - Represent fast changes in heart rate.
- Long-term variability (LTV) indices
 - Slower fluctuations (fewer than 6 per minute)
- □ Calculated from the R-R intervals occurring in a chosen time window (usually between 0.5 and 5 minutes)
- Example of a simple STV
 - Standard deviation (SD) of beat-to-beat R-R interval differences within the time window
- Examples of LTV indices
 - SD of all the R-R intervals
 - difference between the maximum and minimum R-R interval length, within the window

Fourier Analysis

- Respiratory sinus arrhythmia gives a spectral peak around the respiratory frequency
- Baroreflex-related heart rate fluctuations are found as a spectral peak around 0.1 Hz in adults
- Thermoregulation-related fluctuations are found as a peak below 0.05 Hz
- CNS (cortical) contribution seen as higher frequency components

- Heart rate variability can be assessed in two ways
 - statistical operations on R-R intervals (time domain analysis)
 - by spectral (frequency domain) analysis of an array of R-R intervals
- Both methods require **accurate timing of R waves**
- Analysis can be performed on
 - Short electrocardiogram (ECG) segments (lasting from 0.5 to 5 minutes)
 - 24-hour ECG recordings.

- Spectral analysis introduced as a method to study heart rate variability
- Increasing number of investigators prefer method to that of calculation of heart rate variability indices
- Main advantage of spectral analysis of signals
 - Possibility to study their frequency-specific oscillations (not only the amount of variability)

- The oscillation frequency
- Decomposing the series of sequential R-R intervals into a **sum of sinusoidal functions** of different amplitudes and frequencies

- Fourier transform algorithm
- Displays as a power spectrum with the magnitude of variability as a function of frequency
- Power spectrum reflects the amplitude of the heart rate fluctuations present at different oscillation frequencies

Such mathematical transformations may be used to analyze drug effects on CNS

FUNDAMENTAL QUESTIONS

1. What is the difference between beat-to-beat rate and average rate?
2. Why do changes in BTB rate occur?
3. What is the significance of reduced BTB variability?
4. What is the effect of hypoxia, narcotics, barbiturates and benzodiazepines on BTB variability?
5. Describe three ways of quantifying BTB variability?
6. What is the effect of placental insufficiency on fetal heart rate in labor?
7. What is the effect of umbilical cord compression? What is the mechanism?
8. What happens to fetal pH during normal labor?
9. What is the long term impact of intrapartum asphyxia?

