Secrets of Preterm Fetal Heart Rate Tracing: Clinical Recommendations for Interpretation and Management

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Disclosure

In the interest of full disclosure I wish to communicate that I have a professional relationship with

PeriGen: Chief Nursing Officer
Professional Education Center: Educator

Co-author : Mosby's Pocket Guide: "Fetal Monitoring: A Multidisciplinary Approach" monetary royalties

Monitoring the Preterm Fetus

EFM implemented to establish fetal well being
- Physiologic differences dependent on fetal development stage
- Response and/or tolerance to oxygenation pathway disruptions
  - Differ from those of term fetus

Limited interpretation research (<26 weeks)
- Presumed maturation of ANS
- Development of fetal cardio-regulatory mechanism at ~30 weeks
- Fetal behavior and maternal exposure literature evolving

Viability Necessitates FHR Monitoring…..

Lower limits for viability
- Sophisticated NICU care leading to improved survival rates

Preterm FM often hampers ability to collect uninterrupted data
- Inconsistent high quality tracings

Current equipment unable to precisely determine FHR timing
- Employs heart rate averaging techniques
- Antepartum FSE not practical

	20 –21 +6	22 -22+6	23–23 +6	24 – 24+6	25– 25+6
Assess for NRP	N/R	Consider	Consider	Yes	Yes
Steroids	N/R	N/R	Consider	Yes	Yes
Tocolysis for steroids	N/R	N/R	Consider	Yes	Yes
Neuroprotection	N/R	N/R	Consider	Yes	Yes
Antibiotics for PPROM latency	Consider	Consider	Consider	Yes	Yes
Intrapartum antibiotics for Group B Strep	N/R	N/R	Consider	Yes	Yes
Csection for fetal reasons	N/R	N/R	Consider	Consider	Yes

Periviable birth: Obstetric Care Consensus No.4. ACOG. Obstet Gynecol 2016; 127:e157-69

"Continuous electronic fetal monitoring is not separately considered as an intervention because in most cases its use will be linked to plans regarding cesarean delivery for fetal indications. Even if cesarean delivery for fetal indications is not planned if arrangements have been made for resuscitation of a potentially viable live born neonate, electronic fetal monitoring may be considered if it is believed that intrauterine resuscitation will affect the newborn's outcome"

The American College of Obstetricians and Gynecologists

Society for Maternal-Fetal Medicine

OBSTETRIC CARE CONSENSUS

Number 3 • November 2015

Periviable Birth

How Should We Monitor?

Continuous EFM?
- Some consider this to be standard in patients who are expectantly managed
  - No data to support this

Liability?
- Potential if written order not carried out

The Problem with Continuous EFM

Retrospective cohort study

Purpose: Evaluate the completeness of the record during continuous EFM
- No previous data to support continuous EFM and liability issue if not carried out

PPROM patients being managed expectantly
- 47 patients
- 24-34 weeks gestation
- Singletons

Exclusion criteria
- Labor, chorioamnionitis or FHR abnormalities

Li Y, Gonik B. Continuous fetal heart rate monitoring in patients with preterm premature rupture of membranes undergoing expectant management. The Journal of Maternal-Fetal & Neonatal Medicine. 2009 Jan 1;22(7):589-92.

Results

Duration of monitoring
- 321 – 2272 minutes (mean 970 minutes)

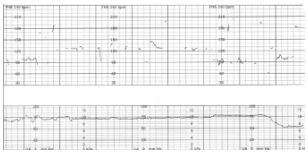
28.3% of tracings did not show legible recordings
- 85% of uninterpretable data lasted <10 minutes
- 15% of uninterpretable data lasted 10-80 minutes

Results

Significant portion of the tracing was not recorded as ordered
- 28%
  - No difference in first/second half of shift
  - No difference in day shift versus night shift

Lower EGA and increased BMI correlated to proportion of absent tracing
- Average 29 4/7 weeks (24 2/7 weeks)
- Average BMI = 31.4 (58.1)

Conclusion



"We propose that until such time that evidence based medicine justifies the use of continuous external fetal heart rate monitoring, alternative approaches should be investigated and applied."

Physiology: Extrinsic and Intrinsic Factors

EXTRINSIC: "OUTSIDE" INFLUENCE

Maternal and uteroplacental characteristics affect blood flow
- Maternal impact
- Uteroplacental impact
- Umbilical circulation
- Amniotic fluid features

INTRINSIC: "INSIDE" INFLUENCE

Maintains fetal homeostasis

Fetal circulation
- Autonomic nervous system
  - Parasympathetic
    - Vagus Nerve/Medulla Oblongata
  - Sympathetic
    - Nerve fibers of myocardium
- Baroreceptors/Chemoreceptors
- Hormonal responses

Physiologic Extrinsic Influence

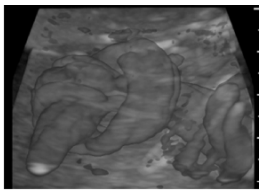
Maternal influences
- Positioning: compression on inferior vena cava
  - ↓ Venous return
  - ↓ Blood flow to uterus
- Contractions: ↓ uterine blood flow
- Compensatory hypotension

Placental influences
- Amount of surface area for maternal-fetal 02 exchange
- Composition: damaged cotyledons, smoking, vessel constriction

Physiologic Extrinsic Influence

Umbilical Cord
- Structural defects
  - Knots, 2 vessel cord
- Mechanical function
  - Partial or complete compression

Amniotic Fluid
- ↓ Placental function leads to ↓ fetal kidney perfusion
  - Shunts blood away from kidneys

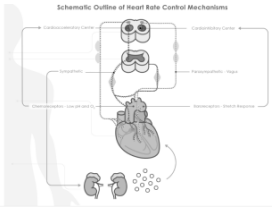


Cignini, P., Laganà, A.S., Retto, A. and Vitale, S.G., 2016. Knotting on heaven's door: 3D color Doppler ultrasound imaging of a true cord knot. *Archives of Gynecology and Obstetrics*, pp.1-2.

Physiologic Intrinsic Influence

Intrinsic influences
- Designed to interact and ensure adequate oxygenation to vital organs

Autonomic Nervous System:
- Parasympathetic and Sympathetic
- Responds to fetal oxygenation status and fetal blood pressure



Physiologic Intrinsic Influence

- **Parasympathetic Nervous System: "Pokey"**
  - Influences FHR variability
  - PNS activity ↑ with gestational age
  - Tone ↑and FHR baseline ↓ with advancing gestational age
- **Sympathetic Nervous System: "Speedy"**
  - Stimulation increases FHR and may be promoted by hypoxemia
  - FHR BL ↓ when blocked
  - SNS activity ↓ with advancing gestational age

Physiologic Intrinsic Influence

Chemoreceptors
- Respond to changes in fetal O2, CO2 and pH levels
- Mild increases in CO2 or decreases in 02 result in fetal BP/FHR changes
  - Severe enough will cause bradycardia

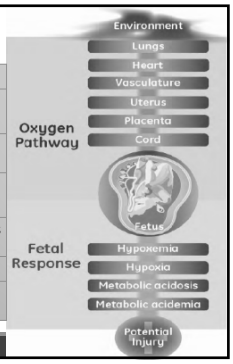
Baroreceptors
- Stretch receptors respond to changes in fetal BP
  - Located in aortic arch and carotid arteries
- Increases in BP decrease FHR resulting in BP decrease
- Decreases in BP stimulates an increase in FHR

Physiological Influences

Hormonal (epinephrine, norepinephrine, vasopressin)
- Respond to stressors which impact FHR
  - Stress caused by ↓ PO2 & pH (hypoxemia and/or hypovolemia)
  - Epinephrine/norepinephrine are released
    - FHR ↑ and blood is shunted to brain/heart
  - Vasopressin is released
    - Impacts fetal kidneys intravascular volume and peripheral resistance
      - ↑ fetal BP

Oxygenation Pathway

Pathway	Etiology	Treatment
Lungs	Respiratory depression	Oxygen
Heart	Regional anesthesia	Treat with Rx, fluids
Vasculature	Hypovolemia	Fluids, position change
Uterus	Tachysystole	Decrease stimulants
Placenta	Abruption	Delivery
Umbilical Cord	Compression	Amnioinfusion



Miller, L.A., Miller, D.A. and Cypher, R.L., 2016. *Mosby's pocket guide to fetal monitoring: a multidisciplinary approach*. Elsevier Health Sciences

Fetal Heart Rate Baseline

Mean FHR rounded to increments of 5 bpm during a 10 minute window

Excludes
- Periodic or episodic changes
- Marked FHR variability (>25 bpm)

Minimum of 2 minutes of identifiable baseline
- Can be determined between contractions
- Does not need to contiguous

Normal 110-160 bpm

Is there an inverse relationship between EGA and FHR baseline?

Development of FHR Patterns During Normal Pregnancy

43 low risk women in 2nd/3rd trimester

Synchronized recordings in 4 week intervals
- EFM for 90-100 minutes
  - 9 am and 6 pm
- Ultrasound
  - Fetal eye/mouthing movement, limb/body movement, fetal breathing

Pillai, M., & James, D. (1990). The development of fetal heart rate patterns during normal pregnancy. *Obstetrics & Gynecology*, *76*(5), 812-816.

Results: Baseline Rate

Negative correlation with gestational age

Mean fall in baseline: 16 weeks to "term"
- 24 bpm
- 1 bpm per week of gestational age

Rate of fall greatest between 16-20 weeks
- Less marked in last trimester
  - Establishment of rest/activity cycles

Development of FHR Patterns During Normal Pregnancy

Nulliparous women at 13 weeks (7) and 20-22 weeks (10)

Real-time ultrasound
- Observations at 0800, 1300, and 2200
- 60 minutes = 13 weeks
- 120 minutes = 20-22 weeks
  - 24 hours of FHR 20-22 weeks

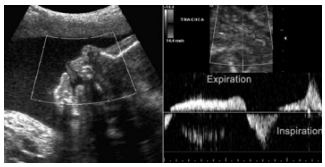
De Vries JI, Visser GH, Mulder EJ, Prechtl HF. Diurnal and other variations in fetal movement and heart rate patterns at 20–22 weeks. Early human development. 1987 Nov 1;15(6):333-48.

Results: Diurnal Variations

DIURNAL

13 weeks
- No variations

20-22 weeks
- "Significant" changes
  - Movement and breathing
  - Highest in evening
  - Breathing related to maternal meals
    - Lowest after 3rd meal



Results: Heart Rate Patterns (20-22 weeks)

Decels more frequent than accels

Decelerations
- 25-40 ms (10-15 bpm)
  - 162/163 tracings
- Exceeding 40 ms
  - 147/163 tracing

Accelerations
- 25-40 ms
  - 115/163 tracings
- Exceeding 40 ms
- 47/163 tracings

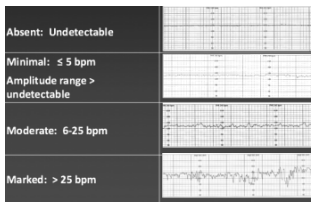
Variability

Fluctuations in FHR BL that are irregular in amplitude and frequency

Quantified as amplitude of peak and trough
- In bpm

Excludes
- Periodic or episodic changes

Determined in 10-minute window



Fetal Heart Rate Variability

92 singletons

Two subgroups
- 24+1 to 32+0 weeks
- 32+1 to 41+6 weeks

Magnetocardiogram sessions
- Measurement of magnetic fields produced by FHR electrical activity

Schneider, U., et al. "Fetal heart rate variability reveals differential dynamics in the intrauterine development of the sympathetic and parasympathetic branches of the autonomic nervous system." Physiological measurement 30.2 (2009): 215.

Results

Inverse relationship with gestational age

FHR Pattern I
- FHR with "small oscillation bandwidth" <5 bpm
- 24+1 to 32 +0 gestations

FHR Pattern II
- FHR with oscillations >5 bpm
- >32+1 to 41+6 gestations

Acceleration

Visually apparent abrupt increase in FHR

Peak ≥ 15 bpm from baseline and lasting ≥ 15 seconds

Preterm gestation (32 weeks)
- Peak ≥ 10 bpm from baseline and lasting ≥ 10 seconds

Acceleration

65 low risk women between

64 minute tracings made between 0900-1300 hours
- 15 patients: 5-10 tracings between 18-41 weeks
- 50 patients: 1-4 tracings between 18-41 weeks

Movement recorded by nurse and patient
- Hand held sensor with response intervals of 5 seconds

Visser GH, Dawes GS, Redman CW. Numerical analysis of the normal human antenatal fetal heart rate. BJOG: An International Journal of Obstetrics & Gynaecology. 1981;Apr;88(4):362-368.

Results: Incidence of Accels, FM and EGA

Weeks Gestation	Patients	Accels over 40ms 10-15 bpm	Mean # of Accels	Mean number of movements/accels
18-22	8	0	0	
23-26	5	2 (40%)	0.8	62
27-28	13	9 (30%)	2.9	43
29-30	15	10 (66%)	3.9	38
31-32	21	19 (95%)	5.4	40
33-34	28	25 (89%)	8.7	39
35-36	38	38 (100%)	14.5	43
37-38	43	43 (100%)	14.9	61
39-40	22	21 (95%)	16.0	50
41	3	3 (100%)	25.7	57

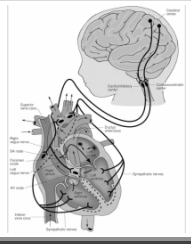
Decelerations

Most frequent between 20-30 weeks

Absence of uterine contractions

Fetal movement

Reflection of developing cardioregulatory mechanisms and CNS maturity



Accelerations and Decelerations

Low risk patients
- 20-22 weeks (10 patients)
- 28-30 weeks (10 patients)

Fetal monitoring
- Day sessions lasting 1-2 hours in quiet room
- 1-2 hours after a meal
- Semi-fowlers with lateral tilt

Sorokin, Y., et al. "The association between fetal heart rate patterns and fetal movements in pregnancies between 20 and 30 weeks' gestation." *Am J Obstet Gynecol* 143.3 (1982): 243-249.

FHR Changes

EGA	Minutes monitored	Accels	Decels	Accels/Decels
20-22 weeks	964	1.3 %	97.1%	1.6%
28-30 weeks	1012	35.8%	33.9%	30.3%

FHR Changes with Fetal Movement

EGA	Accels	Decels	Accels/Decels
20-22 weeks	62.5%	62.8%	40%
28-30 weeks	94.6%	60.3%	90.6%

FHR Patterns at 20 to 24 weeks gestation

Study aim:
- Describe early patterns of FHR recorded by transabdominal fetal electrocardiogram

281 recordings
- Success rate of the recordings was 95.4

Results
- 20–24-week fetus demonstrates FHR patterns with more accelerations and decelerations
- Higher baseline variability

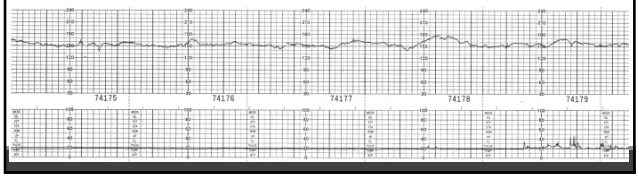
Hofmeyr, F., et al. "Fetal heart rate patterns at 20 to 24 weeks gestation as recorded by fetal electrocardiography." *The Journal of Maternal-Fetal & Neonatal Medicine* 27.7 (2014): 714-718.

APFT

24-28 weeks: 50% of NSTs are not reactive (Bishop, 1981)

28-32 weeks: 15% of NSTs are not reactive (Macones, 2008; Lavin, 1984; Druzin, 1985)

Variable decelerations are found in ~50% of NSTs (Meis, 1986)



What is Normal?

Study Aim
- Establish normal pattern development and relationship to activity and behavior

43 low risk singleton pregnancies in 2nd and 3rd trimester
- 22 primips and 21 multips

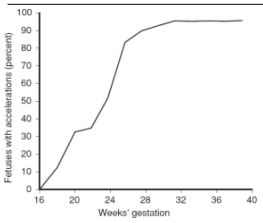
Fetal monitoring in 4 week intervals and real time ultrasound
- Biophysical characteristics

Recordings done between 9am and 6 pm for 90-100 minutes

Definitions
- Accelerations: 15x15
- Decelerations: ⬇ FHR at least 15 bpm below baseline lasting 10 seconds
- "Average variability"

Pillai M, James D: The development of fetal heart rate patterns during normal pregnancy. Obstet Gynecol 76:812, 1990b

Fetuses With At Least One 15x15 Acceleration



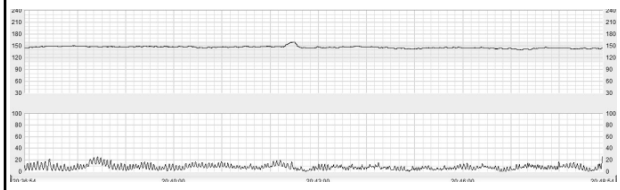
Results
- Total number of recordings: 267
- Total hours of recording: 401.1

Earliest EGA for accel with FM
- 17 weeks

Conclusion
- Before 30 weeks 10x10 is more appropriate

Pillai M, James D: The development of fetal heart rate patterns during normal pregnancy. Obstet Gynecol 76:812, 1990b

10 x 10 Accel



- Cousins LM et al. Nonstress testing at </= 32.0 weeks' gestation: a randomized trial comparing different assessment criteria. Am J Obstet Gynecol 2012;207:311.
- Glantz JC, Bertoia N. Preterm nonstress testing: 10-beat compared with 15-beat criteria. Obstet Gynecol 2011; 118:87–93.

RCT comparing criteria

Objective
- Compare outcomes at <32 weeks using 10x10 and 15x15 criteria

143 singleton high risk patients
- NST 20 minutes
  - Nonreactive: VAS followed by 20 more minutes; not reactive BPP

Conclusion
- Time to achieve reactive NST 4 minutes shorter in 10x10 group
- No adverse outcomes in either group

Cousins LM et al. Nonstress testing at </= 32.0 weeks' gestation: a randomized trial comparing different assessment criteria. Am J Obstet Gynecol 2012;207:311.

◦Considering the low incidence of adverse events after outpatient NST at 32 weeks' gestation, the authors suggest that it would be difficult to test this question in a prospective randomized study with anything other than a very large multicenter trial. A power analysis (alpha, .05; beta, 80%) indicated a total sample size of 8856 would be needed to find a difference in 5-minute Apgar scores of 7 or a total sample size of 7528 to detect a difference in neonatal intensive care unit admissions."

Preterm NST

Objective

- Evaluate perinatal outcome <32 weeks between 10x10 and 15x15

Retrospective review

Singleton pregnancies between 23-32 week and delivered before 34 weeks

751 NSTs reviewed on 488 women (mostly inpatient)

Results

After adjustment for EGA / BW , there was NO association between NST criterion and outcomes except between nonreactivity and perinatal death

Glantz JC, Bertoia N. Preterm nonstress testing: 10-beat compared with 15-beat criteria. Obstet Gynecol 2011; 118:87–93

If the perinatal death rate in the 10x10 group is estimated to be 10%, an adequately powered study would require 2000 patients in each arm to demonstrate a 25% difference in perinatal death)
If the perinatal death in the 10x10 group is estimated to be 1%, more than 21,000 patients would be needed in each group to demonstrate a 25% difference
D. A. Miller, MD

FHM and Medications in the Preterm Fetus

Magnesium sulfate
- Decreases variability
- Decreases acceleration amplitude

Corticosteroids
- Decreases variability
- Decreases biophysical characteristics

Progesterone
- None reported

Beta sympathomimetics
- Tachycardia
  - Mother and fetus

Prostaglandin inhibitors
- None reported
  - Constriction of ductus arteriosis

Calcium channel blockers
- None reported

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Magnesium Sulfate

Neuroprotection prior to preterm birth
- Neuroprotective intent
  - Reduce vascular instability, lessen hypoxic damage, and protect against cytokine or amino acid damage
- Pre-delivery magnesium (<32 weeks)
  - Reduces severity and risk of cerebral palsy

Study	Dose	Duration
Crowther	4 gram load followed by 1 gram/hour	Up to 24 hours
Rouse	6 gram load followed by 2 grams/hr	Up to 12 hours; treatment resumes when delivery is imminent

Effect of Magnesium Sulfate on FHR Parameters: A Systematic Review

Study Objective
- Examine potential effects on ante/intrapartum EFM

Systematic review
- 18 RCTs, observational studies, case studies
- FHR BL, variability and acceleration-deceleration patterns

Nensi, Alysha, et al. "Effect of magnesium sulfate on fetal heart rate parameters: a systematic review." *Journal of Obstetrics and Gynaecology Canada* 36.12 (2014): 1055-1064.

Results

Statistically significant decrease in FHR
- Up to 15 bpm
- All remained in normal range 110-160 bpm

Decrease in FHR variability

Decrease in acceleration number and/or frequency
- No more than 5 - 10 bpm

Effects of Magnesium Sulfate On Cerebral Blood Flow

38 patients
- Singletons/twins (24-31 weeks EGA)
- 18 Magnesium Sulfate (Rouse protocol)
- 10 Placebo

Middle cerebral artery measurements
- Before medication administration
- 1, 2, 3, and 4 hour intervals

Twickler, Diane M., et al. "Effects of magnesium sulfate on preterm fetal cerebral blood flow using Doppler analysis: a randomized controlled trial." *Obstetrics & Gynecology* 115.1 (2010): 21-25.

Results

Decrease in FHR baseline (doppler waveforms)
- 8-10 bpm

No significant difference
- Peak systolic velocity
- Vessel diameter
- Volume flow

Conclusion
- No significant effects on fetal cerebral blood flow

The Effect of Magnesium Sulfate On FHR Parameters

34 patients

> 30 weeks EGA (nonlaboring)

800 kcal meal

Randomized
- Magnesium Sulfate (6 gram load and 2 gram/hr)
- Placebo

One hour monitoring sessions
- Baseline, 1 hour and 3 hours of infusion

Hallak, Mordechai, et al. "The effect of magnesium sulfate on fetal heart rate parameters: a randomized, placebo-controlled trial." AJOG 181.5 (1999): 1122-1127.

Results

FHR	Group	0 hour	1 hour	3 hour
Baseline	Placebo	134.4 ± 6.3	134.4 ±7.1	134.6 ±7.1
	Mag Sulfate	136.6 ± 6.4	135.1 ± 6.6	132.3 ± 7.6
Variability	Placebo	2.75 ± 0.33	2.81 ± 0.30	2.71 ± 0.52
	Mag Sulfate	2.82 ± 0.29	2.84 ± 0.28	2.67 ± 0.36
Accels	Placebo	10.2 ± 8.3	10.3 ± 8.2	10.4 ± 6.9
	Mag Sulfate	11.1 ± 6.2	10.3 ± 8.2	7.4 ± 4.1

Corticosteroids for Fetal Maturation

Single course
- Risk of PTD within 7 days
- 23/24 to 34 weeks
- Later EGA's

Betamethasone
- 12 mg q24h x2

Dexamethasone
- 6 mg q12 x 4 doses

Treatment <24h has some benefit

No additional benefit to "accelerated dosing" (q week)
- Giving doses at shorter intervals

Rescue dose
- Initial treatment >2 weeks prior
- Likely to deliver w/in 1 week & <34 wks
- Single course

Betamethasone Administration

31 women who had received 2 doses for PTL
- Gestational age: 26-32 weeks

Daily EFM for 5 successive days (0-4)
- 30-60 minutes

Ultrasound (Days 0, 2 and 4)
- Fetal body movement, breathing, eye movements

Derks, Jan B., Eduard JH Mulder, and Gerard HA Visser. "The effects of maternal betamethasone administration on the fetus." *BJOG: An International Journal of Obstetrics & Gynaecology* 102.1 (1995): 40-46.

Results

FHR variability below normal range for EGA
- 1/3 cases

Body movement
- Reduced by 50% on Day 2

Breathing movement
- Absent on Day 2

Eye movements: unchanged

Day 4: return to normal state

Considerable decrease in biophysical characteristics
- Except eye movement

Transient reduction in movements and activity

? Glucocorticoid receptor mediated process

Corticosteroids and BPP/Doppler Indices

35 singleton pregnancies
- 28-34 weeks
- Betamethasone

Biophysical profile and dopplers
- Pre-steroid
- 24, 48, 72, 96 and 120 hours after 1st dose

Deren, Özgür, et al. "The effect of steroids on the biophysical profile and Doppler indices of umbilical and middle cerebral arteries in healthy preterm fetuses." *European Journal of Obstetrics & Gynecology and Reproductive Biology* 99.1 (2001): 72-76.

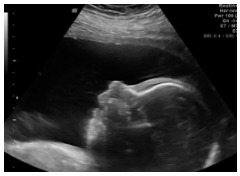
Results

Reduced biophysical characteristics
- Movement, fetal breathing & reactivity

Amniotic fluid index unchanged
- Not volume

Fetal tone unchanged

Umbilical artery & middle cerebral artery



Specific Biophysical Scores

Pre steroid: 10

24 hours: 8

48 hours: 6 (maximum peak of steroid)

72 hours: 8

96 hours: 10

120 hours: 10

Preterm Fetal Heart Rate Assessments

Rate

Variability

Periodic and Episodic Changes

Uterine Activity

Pattern Evolution

Associated Clinical Findings

Urgency

Communication

Use of Health Information Technology

Adapted from Vos, Kilpatrick, King & Parer, (2008)

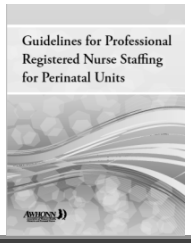
"There must be a balance between knowledge, expert skills, clinical intuition and the benefits of technology. The perception that technology will take over clinical responsibilities, such as FHR interpretation, leaving all data to be interpreted, documented and managed by artificial intelligence is not only incorrect but illogical. "

R. Cypher, MSN, PNNP
August 2016

http://perigen.com/ld-resource-library/perinatal-nursing-technology/

Assessment and Documentation For Preterm Gestations

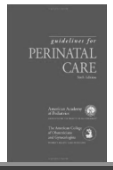
No mention in either document except for active and second stage labor



JOGNN

AWHONN Position Statement

Fetal Heart Monitoring



High Risk Antepartum Care

Nurse-to-Woman or Nurse-to-Baby Ratio	Care Provided
Antepartum	
1 to 2–3	women during nonstress testing
1 to 1	woman presenting for initial obstetric triage
1 to 2-3	women in obstetric triage after initial assessment and in stable condition
1 to 3	women with antepartum complications in stable condition
1 to 1	woman with antepartum complications who is unstable
1 to 1	continuous bedside attendance for woman receiving IV magnesium sulfate for the first hour of administration for preterm labor prophylaxis and no more than 1 additional couplet or woman for a nurse caring for a woman receiving IV magnesium sulfate in a maintenance dose
1 to 2	women receiving pharmacologic agents for cervical ripening

AWHONN, 2010

Thank You!
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Birth is the sudden opening of a window, through which you look out upon a stupendous prospect. For what has happened? A miracle. You have exchanged nothing for the possibility of everything.

William MacNeile Dixon, 1866 - 1946