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NNF Clinical Protocols in Perinatology



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CHAPTER

2

Assessment of Fetal Well-being

Deepti Gupta, Aparna Kulkarni, Umesh Vaidya

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INTRODUCTION

The primary goal of antepartum fetal surveillance is to identify fetuses at risk of intrauterine insult and death. The second goal is to balance fetal and neonatal risks in order to optimize timing of obstetric intervention and prevent progression to stillbirth. The ultimate goal is thus to improve perinatal outcome by decreasing stillbirths and long-term neurologic impairments. An ideal testing protocol should therefore be able to identify the fetus at risk while preventing unnecessary premature delivery with its associated perinatal morbidity/mortality.

OBJECTIVES

- To understand the pathophysiology of fetal compromise
- Know normal fetal wellbeing parameters
- Understand various tests available for fetal surveillance
- Suggest methods for preventing avoidable stillbirths

According to UNICEF (United Nations Children's Fund), globally one stillbirth occurs every 16 seconds which translates to 2 million stillbirths every year. Two-thirds of these are accounted for by 10 countries alone including India. These losses are particularly tragic because majority can be prevented with high quality of care and monitoring in the antenatal period. UNICEF estimates that the Indian subcontinent accounts for 34% of global stillborns with 1 in every 58 children being stillborn.

In a developing country such as India, women of reproductive age group constitute about a fifth of the population. Since 2000, India has shown a 53% reduction in stillbirth rate; however, because of sheer volume of population it ranks first in absolute numbers. India seems to be on the right track and if current trends continue, India is estimated to achieve Every Newborn Action Plan target between 2020 and 2030.

For a long time, the main objective of obstetric practice was prevention of maternal mortality. Over the years with advancement in anesthesia, blood transfusion services, improved surgical techniques, etc., the focus is now shifting to reach the best possible fetal outcomes as well. Approximately 18% of stillbirths are due to congenital anomalies. In about 50% of nonanomalous stillbirths, hypertension, chorioamnionitis, and fetal growth restriction are thought to be the causes. Some of the indirect factors associated with stillbirths are young age, illiteracy, rural residence, missing antenatal visits, more than two pregnancies, assisted vaginal delivery, and pregnancy complications such as anemia, hypertensive disorders of pregnancy, antepartum hemorrhage, and abnormal fetal position.

It seems reasonable to channelize high-risk pregnancies to simple, flexible, and noninvasive fetal monitoring **(Table 1)**.

TABLE 1: Maternal/fetal indications for fetal monitoring.

Medical	***Obstetric***
Anemia	Extremes of maternal age
Chronic hypertension	Preeclampsia
Diabetes mellitus	Rh isoimmunization
Chronic renal disease	Cholestasis of pregnancy
Significant cardiac disease	Multiple pregnancy
Asthma	Fetal growth restriction
Epilepsy	Oligohydramnios
Substance abuse	Preterm prelabor rupture of membranes
Chronic obstructive pulmonary disease	Previous stillbirth/neonatal death/ congenital anomaly
Obesity and malnourishment	Decreased fetal movements
Thyroid disorders	Post-term pregnancy
Hemoglobinopathies	Recurrent pregnancy loss
	Bad obstetric history

IMPACT OF SURVEILLANCE ON FETAL/ NEONATAL OUTCOMES

Decreasing perinatal mortality requires a continuum of care from preconception to postnatal care and at all levels of healthcare including family and community. Apart from that few interventions have proven benefits. Doppler velocimetry is associated with 29% reduction in stillbirth in growth restricted fetuses.

ROUTINE ANTENATAL CARE

A minimum of four antenatal visits are recommended for all low-risk pregnant women, first as early as possible/in the first trimester, second between 14 and 26 weeks, third between 28 and 32 weeks, and last between 36 weeks to term. However, in high-risk patients, it is advisable to follow World Health Organization (WHO) eight visits schedule or more if needed.

PATHOPHYSIOLOGY OF FETAL COMPROMISE

Fetal hypoxia and acidosis are the final common pathway which lead to fetal compromise and death. Antepartum fetal surveillance relies on the fact that the fetus will respond to developing hypoxemia by a series of detectable physiologic adaptive or decompensatory signs **(Table 2)**.

It is proposed that fetal hypoxia acts by two pathways.

1. Cellular hypoxia of neuronal tissue → central nervous system (CNS) dysfunction → hypotonia, absent breathing and body movements, and nonreactive non-stress test (NST).
2. Chronic hypoxia → response from aortic arch and carotid body chemoreceptors → reflex redistribution of cardiac output → blood diverted to vital organs such as heart, brain, and thymus → poor renal perfusion, decreased fetal urine production, and oligohydramnios.

   In response to ongoing fetal hypoxemia usually (can be shown as a flowchart):
   - Loss of fetal heart rate (FHR) reactivity and abnormal blood flow in umbilical artery (UA) are earliest changes.
   - Then sequential changes in other fetal blood vessels ensue.
   - Usually followed by abnormalities in biophysical parameters such as fetal breathing movements, amniotic fluid level, fetal movements, and tone.

Antepartum fetal surveillance should be done when it is possible to follow up results with action, i.e., the obstetrician is in a position to deliver the fetus in case of compromise. This will depend on the neonatal facilities available at the particular center. This would be from 26 to 28 weeks where tertiary level neonatal intensive care facilities are available or 1–2 weeks earlier than timing of stillbirth in previous pregnancy. Where neonatal intensive care unit (NICU) facilities are not available, and it is anticipated that early delivery may be required, in-utero transfer is preferable to transfer of the neonate after delivery.

TABLE 2: Underlying pathophysiology and its associated maternal/ fetal condition.

Pathophysiologic process	*Maternal/fetal condition*
Decreased uteroplacental perfusion	• Chronic hypertension • Preeclampsia • Collagen/renal/vascular disease • Most cases of fetal growth restriction <32–34 weeks
Decreased gas exchange	• Postdated pregnancy • Some cases of fetal growth restriction >32–34 weeks
Metabolic disturbances	• Fetal hyperinsulinemia • Fetal hyperglycemia
Fetal infections	• Premature rupture of membranes • Intra-amniotic infection • Maternal febrile illness • Primary subclinical intra-amniotic infection
Fetal anemia	• Fetomaternal hemorrhage • Erythroblastosis fetalis • Parvovirus B19 infection
Fetal heart failure	• Cardiac arrhythmia • Nonimmune hydrops • Placental chorangioma
Umbilical cord accidents	• Umbilical cord entanglement • Velamentous cord insertion • Oligohydramnios

TESTS FOR ANTEPARTUM FETAL SURVEILLANCE

Biochemical tests: 24-hour estriol and human placental lactogen assays, etc., are not done routinely as they are cumbersome and inconvenient with wide range of variation in laboratory reference values. Besides it only helps in evaluation of placental function primarily, not necessarily fetal reserve and fetal response to hypoxia. Hence, it is obsolete. Mainstay in antepartum fetal surveillance are biophysical tests.

- Score of 8/10-10-10—reassuring
- 6/10 in term fetus—deliver
- 6/10 preterm—give steroids, repeat in 24 hours
- <04/10—delivery warranted

Each variable also has different correlates like absence of fetal movement is a predictor of abnormal FHR in labor, nonreactive (NR) NST for meconium, decreased amniotic fluid volume (AFV) for fetal distress, and poor fetal tone for perinatal death. Biophysical profile (BPP) also correlates well with umbilical vein pH, all having pH > 7.20 when BPP was normal and none when BPP was 0/10 **(Table 3)**.

Relationship between last BPP score and cerebral palsy was shown to be inverse, exponential, and highly significant.

Modified BPP—to reduce testing time, combines amniotic fluid index (index of chronic fetal health), and cardiotocography (CTG) (standard or computerized).

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TABLE 3: Biophysical tests for antepartum fetal surveillance.

Name of test	*How is it done?*	*Normal expected findings*	*Abnormalities*	*Correlation with outcome*	*Advantage*	*Disadvantage*
Fetal movement count*	Count to 10, 12-hour method (Cardiff method), Liston count to 6 or Moore count to 2, postmeal method	Mean time interval for 10 movements are 21±18 minutes	If >2 hours for 10 movements, she should report for further evaluation	Count to 10 shown to reduce overall fetal mortality from 8.7/1,000 to 2.1/1,000 and from 44 to 10/1,000 in women with decreased movements	Safe, reliable, simple inexpensive, active participation of patient	Does not predict long-term prognosis of fetus or acute accidents. Perception may be poor in anterior placentation, hydramnios
*Quiet sleep in fetus can range from 20 to 70 minutes. Decreased fetal perfusion, fetal academia/acidosis associated with decreased movements. Fetal activity may be affected by maternal exercise, alcohol intake, and drugs such as narcotics, betamethasone. Unreliable in multiple pregnancies. Neither standardized nor validated.						
Nonstress test (NST)**	• Done with cardiotocograph • Done for minimum 20 minutes	Normal or reactive basal FHR 110–160 BPM, at least two accelerations of ≥15 beats lasting at least 15 seconds	If not reactive, do extended NST for 40 minutes. If criteria unmet or nonreactive, test for 90 minutes or vibroacoustic stimulation test (VAST) or biophysical profile (BPP)	PPV < 50%, NPV < 90%. Reactive NST more reliable in excluding hypoxia than nonreactive one predicting fetal compromise. Should be done twice weekly	Fairly simple. Inexpensive, easy to perform, can be done on OPD basis, no contraindications	CTG machine not available everywhere. Correlation with gestation important. High inter and intra-observer variation
**Based on principle that well-oxygenated fetus will respond to movement with fetal heart acceleration. Indirectly indicates normal functioning autonomous nervous system and rules out hypoxia.						
**Reactivity of test linked with maturity of autonomous nervous system. Premature fetus may give nonreactive trace. 65% reactive trace at 28 weeks, 85% at 32 weeks, 95% at 34 weeks.						
**NST patterns consistent with fetal hypoxia are relatively fixed baseline FHR with poor baseline variability, loss of acceleration, and spontaneous deceleration.						
VAST	Artificial larynx with sound stimulus of 80–100 db placed on maternal abdomen and 2–3 one second stimuli given	Accelerations noted to acoustic stimuli		Same validity as unprovoked reactive NST	Reduces false positive NST	Additional testing equipment
Contraction stress test (CST) or oxytocin challenge test	Idea is to stimulate labor-like conditions using oxytocin infusion or nipple stimulation and monitor fetal response to uterine contractions	Late decelerations with uterine contraction suggestive of placental insufficiency	Called negative test when no decelerations (desirable). Positive when decelerations with at least 50% contractions	Perinatal mortality within a week of Negative CST is 0.4–1.2/1,000	Simulates labor and monitors fetal response	Time consuming and cumbersome, inconvenient, many contrain-dications, has to be performed in setup with facility for emergency cesarean section
BPP* or manning score **(Table 4)**	Incorporates testing five biophysical parameters, each parameter marked 0 if absent and 2 if present	Score of >8/10 very low false negative rate and adverse perinatal outcome unlikely	Score of 6/10 associated with high (>75%) false positive rate and should be repeated in 24 hours[$]	Risk of perinatal death within week of normal BPP 0.7–2.3/1,000	Can be used as early as 26–28 weeks of gestation	Time consuming as minimum 30 minutes scanning recommended before assigning abnormal score

*Provides detailed assessment of behavioral state of fetus in utero. It is analogs to neonatal assessment by Apgar score. It can be used as both as backup test or first line test. Normal biophysical variable excludes hypoxia of end-organ generating it. For example:

- Accelerations on CTG suggest good cardiovascular reserve
- Fetal breathing suggests well-oxygenated brainstem
- Fetal tone and movement represent well-oxygenated midbrain and cerebral cortex
- Normal amniotic kidney points to well-perfused kidneys

[$]Reliability of test depends not just on total score but also on abnormal parameter, especially abnormal amniotic fluid

[$]Grossly abnormal score of 0–4/10 high probability of fetal hypoxia. With a score of 0, combined morbidity mortality reaches almost 100%

(BPM: beats per minute; CTG: cardiotocography; FHR: fetal heart rate; NPV: negative predictive value; OPD: outpatient department; PPV: positive predictive value)

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TABLE 4: Scoring criteria for biophysical profile or Manning score.

Biophysical variable	*Normal (score = 2)*	*Abnormal (score = 0)*
Fetal breathing movements	One episode of at least 30 seconds in 30 minutes	Absent or no episode >30 seconds in 30 minutes
Fetal movements	Three discrete body/limb movements in 30 minutes	Two or less in 30 minutes
Fetal tone	One episode of active extension with return to flexion of limbs or trunk	Slow extension with return to partial flexion or movement of limb in full extension or no movement
Amniotic fluid	One pocket measuring at least 2 cm in two perpendicular planes	Either no pocket OR Pocket <2 cm in two perpendicular planes
Nonstress test	Reactive	Nonreactive

TABLE 5: Correlation of vessel studied and information derived.

Vessel examined	*Information derived*
Uterine artery	Maternal—flow resistance to the uterus
Umbilical artery	Placental—flow resistance to placenta
Arterial circulation (middle cerebral artery)	Fetal adaptation to flow resistance change
Venous circulation (umbilical vein, inferior vena cava, and ductus venosus)	Fetal cardiac function

DOPPLER VELOCIMETRY

Doppler velocimetry is one of the most extensively used techniques that evaluates blood flow in placental/fetal vessels. It is also the only test studied extensively in randomized trials. The information derived depends on the vessel studied.

The routine use of Doppler ultrasound in low risk or unselected pregnancies does not confer any benefit on mother or on fetus. As per the Cochrane review, there is also no difference in incidence in intrapartum fetal distress and caesarean section between Doppler/non-Doppler groups. However, there is definite decrease in perinatal deaths, labor inductions, and hospital admissions in pregnancies managed by Doppler, especially those with hypertension and fetal growth restriction. Doppler velocimetry not only helps in assessment but also guides intensity and frequency of fetal monitoring. It is also useful in identifying small for gestational age fetuses which do not require intensive monitoring unlike fetal growth restriction fetuses which do.

- *UA Doppler*: It is the most common parameter evaluated for assessment of fetal well-being. In normal pregnancy with advancement of pregnancy, the uteroplacental unit resistance decreases, UA diastolic flow increases, and systolic/diastolic (S/D) ratio falls gradually. S/D ratio > 3 is considered abnormal after 30 weeks pregnancy. UA Doppler study is most useful in early-onset growth restriction due to uteroplacental insufficiency. Current American College of Obstetricians and Gynecologists (ACOG) practice guidelines support the use of UA Doppler assessments only in the management of suspected fetal growth restriction.

  It is estimated that >70% placental arteries are obliterated when reversal of end-diastolic flow appears. Reversal of end-diastolic flow is ominous and marker of imminent fetal death. This is preceded by decrease in end-diastolic flow and absent end-diastolic flow.
- *Middle cerebral artery (MCA)*: In event of fetal hypoxia, there ensues vasoconstriction in somatic, renal, and hepatic vessels with preferential flow to brain, heart, and adrenals. Hence, a hypoxic fetus would show increased end-diastolic flow in MCA and fall in pulsatility index and resistance index.
- *Fetal venous circulation*: Most commonly studied veins are umbilical vein, inferior vena cava, and ductus venosus. These indices provide additional information and help in deciding time of delivery when UA/MCA Doppler indices are abnormal. In event of persistent fetal hypoxia, first redistribution of blood flow occurs followed by fetal decompensation if uncorrected. A healthy fetus essentially has a nonpulsatile venous circulation. Appearance of pulsatile venous flow is associated with high morbidity and mortality.
- Progressive fetal compromise secondary to placental insufficiency progresses as:
  - Increase in UA resistance without decentralization of blood flow
  - Increased UA resistance with decentralization (brain sparing effect)
  - Absent UA end-diastolic flow
  - Reversed UA diastolic flow
  - Alteration in venous circulation **(Table 5)**.

Emerging methods of fetal surveillance:

- *Fetal actocardiograph*: Electronically records FHR and fetal movement.
- *Fetal magnetoencephalography*: Specialized apparatus which uses ultra-sensitive magnetic field detectors and maps fetal cortical response to visual/auditory stimuli.

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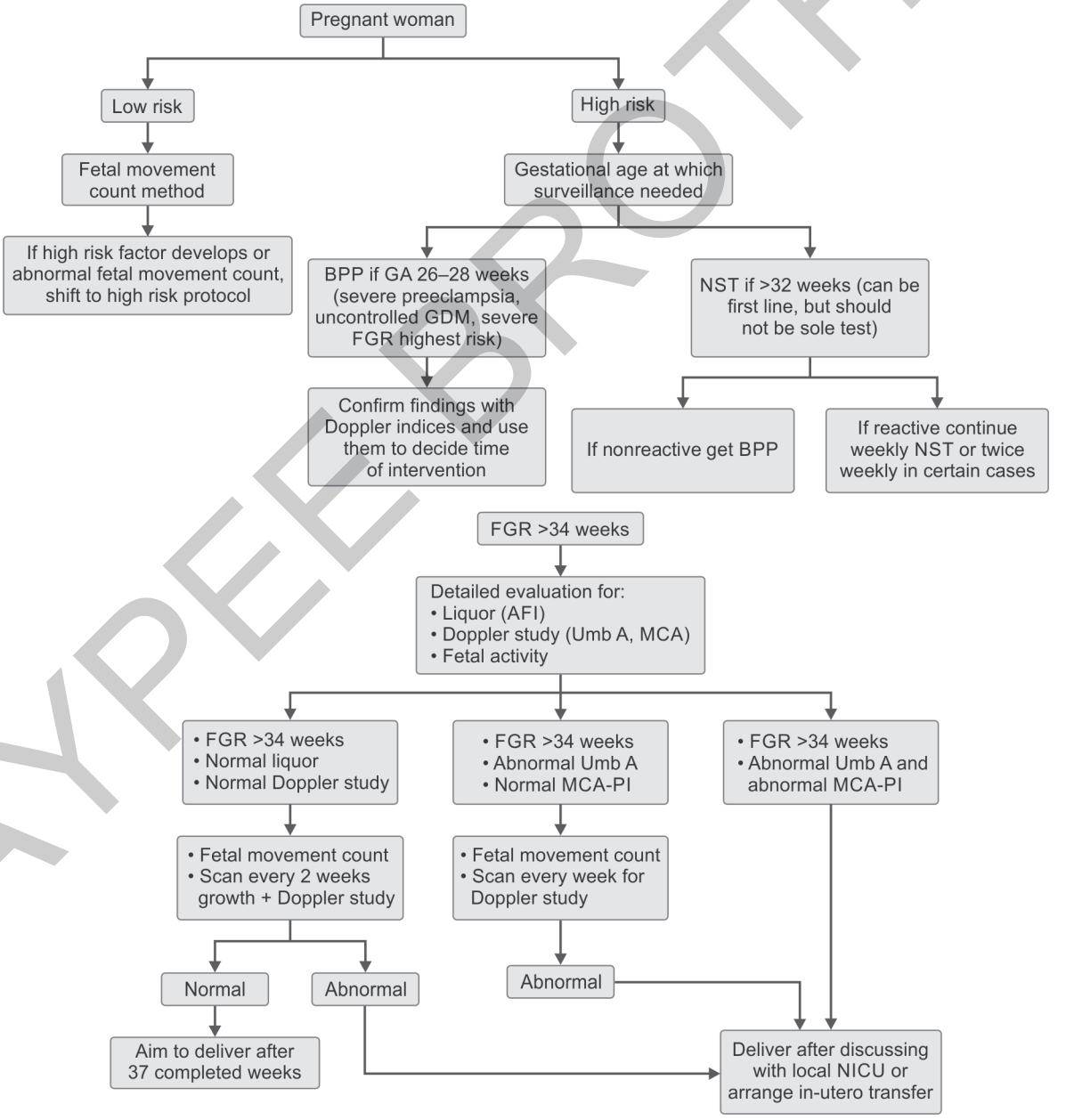
Indications, frequency, and outcome of antepartum fetal surveillance.			
Condition	***Estimated stillbirth rate***	***Gestational age to initiate surveillance***	***Mode and frequency***
Diabetes mellitus on insulin	6–35/1,000	32 weeks	NST/BPP twice/week
Chronic hypertension	6–25/1,000	26 weeks	NST/AFI/MBPP twice/week
Hypertensive disorders of pregnancy mild severe	9–21/1,000 12–29/1,000	At diagnosis At diagnosis	MBPP twice/week NST daily, AFI twice/week
Growth restricted fetus: • Suspected • Confirmed	10–47/1,000		NST, AFI weekly MBPP, umbilical artery Doppler twice/week
Oligohydramnios	14/1,000	At diagnosis	NST/AFI twice/week
Previous stillbirth	9–20/1,000	32 weeks	BPP/CST weekly or MBPP twice/week
Decreased fetal movement	13/1,000	At diagnosis	MBPP

(AFI: amniotic fluid index; BPP: biophysical profile; CST: contraction stress test; NST: nonstress test; MBPP: modified biophysical profile)

CHAPTER AT A GLANCE



(AFI: amniotic fluid index; BPP: biophysical profile; FGR: fetal growth restriction; GA: gestational age; GDM: gestational diabetes mellitus; MCA-PI: middle cerebral artery pulsatility index; NICU: neonatal intensive care unit; NST: nonstress test)

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KEY POINTS

- Fetal testing is based on the hypothesis that the compromised fetus will undergo a series of detectable changes. Some changes such as reduced FHR variability and infrequent breathing are observed in at least 25% normal term fetuses.
- Observational studies have shown 10-fold increase in perinatal mortality in high-risk pregnancies. But the prevalence of high risk pregnancies is low and 30–50% stillbirths occur in "low risk pregnancies."
- Even in a high-risk pregnancy with stillbirth rate of 70/1,000, a test with 99% sensitivity and specificity will give positive predictive value of 88%.
- No known method can prevent sudden events such as cord accident or placental abruption.
- Biophysical profile and Doppler studies are the mainstay of antepartum assessment of fetal well-being.
- It is important to identify those requiring more intensive monitoring so that resources can be used judiciously.

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NNF Clinical Protocols in Perinatology

NNF Clinical Protocols in Perinatology is a practical and composite book for the diverse health professionals taking care of mothers' fetuses and neonates. This is a unique book with all its chapters contributed by both neonatologists and obstetricians. The contents of the book are very useful for the pediatricians, neonatologists, fellows, and postgraduates in their day-to-day practice.

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- Provides structured presentation of chapters including objectives and summary
- Important references are listed at the end of every chapter for further reading
- Book is being brought out by National Neonatology Forum (NNF) of India.

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