Principles of Nonstress Testing in Pregnancy

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The nonstress test has been used to document second and third trimester fetal well-being for the past 40 years. It serves as a surrogate measure of the developing fetal autonomic nervous system. The nonstress test is more specific than sensitive, thus being a better indicator of fetal health than fetal illness. The test itself is read as reactive or nonreactive and may be repeated at intervals as a screen for high-risk maternal conditions.

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During the past 20 years, several testing modalities have been growing in popularity and usefulness in the ongoing effort to improve the safety, predictability, and reliability of obstetrical care. One of these modalities, the nonstress test (NST), is particularly well suited to application by family physicians. Relatively easy to perform and comparatively simple to interpret, the NST provides crucial information on the well-being of the unborn child. This information can be used by the practitioner or consultant to make rational decisions regarding the necessity for intervention in the course of a given pregnancy.

HISTORY

The audibility of fetal heart tones was first described by Phillip Le Gaust in the 17th century. As early as the mid-19th century, Kilian[1] suggested that abnormalities of fetal heart rate (FHR), specifically tachycardia and bradycardia, indicated forceps delivery as soon as possible. The significance of interval changes in FHR began to be understood more fully in the 1950s and early 1960s after continuous fetal electrocardiogram monitoring was introduced by Hon.[2] He described variable decelerations associated with umbilical cord compression, and late decelerations thought to be related to uteroplacental insufficiency. Short- and long-term variability were defined in 1963 by Caldeyro-Barcia and co-workers,[3] and the prognostic significance of their observations was pointed out by Hamacher[4] in 1966. In 1969 Kubli et al[5] administered oxytocin to unmask uteroplacental insufficiency, and by 1972 Ray and colleagues[6] introduced a formal technique for using oxytocin in this way, the oxytocin challenge test. In 1975 Freeman[7] introduced the term "nonstressed antepartum monitoring" in the United States. That year both Freeman and Lee and colleagues[8] documented the association of FHR accelerations in response to spontaneous fetal movement with fetal well-being. Everston and Paul[9] in 1978 used nonstress testing to discriminate between true- and false-positive oxytocin contraction tests. In 1981, Brown and Patrick[10] established that a fetus who remained nonreactive for more than 80 minutes was nearly always found to be compromised. Devoe[11] noted the relationship of FHR acceleration with increasing maturity in 1982. He concluded that the more preterm the NST, the more likely it is that nonreactivity is due to prematurity rather than to fetal distress. This effect is more pronounced before 32 weeks.

Studying fetal movement in 1983, Vintzeleos and co-workers[12] noted its absence to be the most sensitive indicator of hypoxia, and Rabinowitz et al[13] showed that accelerations are almost always associated with fetal movement, though the converse was not true. In 1984 Sarafini et al[14] correlated the absence of acceleration in response to sound with fetal distress. The next year Devoe et al[15] noted that a pattern of rare or absent FHR accelerations was nearly always accompanied by recurrent late or variable decelerations. Smith and colleagues[16] reported in 1988 that preterm babies with a reduced number of FHR accelerations demonstrated lower umbilical

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artery PO_2. Taken together, all these studies provide us with a picture of the NST as an observation that provides the examiner with an increasingly accurate portrait of ongoing fetal well-being as the pregnancy approaches and passes term.

PHYSIOLOGY

Instantaneous heart rate in the fetus is thought to be primarily influenced by fetal aortic and carotid artery baroreceptors. These and perhaps other stimuli are mediated by cardioaccelerator fibers originating in the upper fetal thoracic spinal cord. Responses to such stimuli are influenced by a number of factors, including sympathetic tone, behavior, time of day, maturity, and maternal diet or drug exposure.[15] As a result of this diverse input, the fetal heart rate normally demonstrates a characteristic variability with superimposed accelerations prompted by particular stimuli such as fetal movement. From a practical point of view, the presence of this variability, with superimposed reactive accelerations, constitutes evidence that the baby's autonomic nervous system is functioning normally. The absence of accelerations, the presence of decelerations, or the absence of normal variability is associated with fetal compromise and poor perinatal outcome.

RELIABILITY

The strength of the association between NST result and perinatal outcome is an important question. The NST as a screening tool has been found to be much better at identifying healthy fetuses than sick ones. Test specificity has been reported as high, greater than 90%.[17,18] Therefore, a normal reactive NST indicates that the baby is very likely to tolerate labor well. On the other hand, a fetus who produces a nonreactive NST is relatively unlikely to be actually ill. More than 50% of these infants will tolerate labor well in spite of the nonreassuring test.[19,20]

Of the few infants who do not do well after a normal NST, most can be accounted for by unpredictable untoward events, such as abruption, congenital anomaly, cord accident, or preterm labor. When these unpredictable events are factored out, the death rate among infants with normal NSTs drops to about 3 per 1000.[20,21]

The high rate of false-positive NSTs (ie, no fetal accelerations) can be reduced by taking certain factors into consideration. One of the most commonly seen after 36 weeks' gestation is the "fetal sleep cycle,"[22] which usually lasts approximately 20 minutes. During this time, acceleration of the FHR is usually not seen, potentially prompting interpretation of the NST as "nonreactive." Other factors that may tend to produce a nonreactive NST include sedatives, analgesics, beta-agonists, maternal hypoglycemia, and maternal smoking.[23] The most obvious way to avoid being confused by a fetal sleep pattern is to continue monitoring a patient with a nonreactive NST until the criteria for reactivity are met. Various durations of monitoring, up to 120 minutes,[10] have been suggested. One of the common recommendations is up to 90 minutes. An NST that still fails to meet reactivity criteria after 90 minutes of monitoring would be judged nonreactive.

The question of who needs a nonstress test has not been clearly resolved, in part because of the low predictive value of a nonreactive test. Unlike the contraction stress test, which indicates primarily the condition of the uteroplacental unit, the NST tends to reflect the condition of the fetus. Of course, the condition of the fetus is dependent on the supporting structures, so uteroplacental compromise may produce a compromised fetus. Following this line of thought, it would be reasonable to use the NST to evaluate any pregnancy in which there is a suspicion that the fetus may be in jeopardy. After reviewing a number of studies, Devoe concluded that NST is "a feasible testing modality for most high-risk conditions with an inherent risk of intrauterine growth retardation, fetal hypoxia, or placental insufficiency."[17] Some of these conditions are included in Table 1. Several of them are obviously not within the realm of practice of most family physicians. Problems such as maternal lupus, maternal cyanotic heart disease, insulin-dependent diabetes, and discordant twins will almost certainly warrant management in consultation with a perinatologist. On the other hand, a number of more commonly encountered conditions are frequently followed by family physicians. Some of these, such as a single complaint of decreased fetal movement or a history of a maternal fall, may require as little as one single NST, possibly in conjunction with other testing modalities. Other more serious situations, for example diet-controlled diabetes, mild hypertension, postterm pregnancy, twins, or a previous fetal death, will demand serial testing.

TABLE 1

Conditions Often Evaluated by the Nonstress Test

- Decreased fetal movement
- Diabetes
- Oligohydramnios
- Sonographic evidence of intrauterine growth retardation
- Hypertensive disorders
- Postterm pregnancy
- Isoimmunization
- Renal disease
- Autoimmune diseases, especially lupus
- Maternal cyanotic heart disease
- Previous unexplained fetal demise
- Hemoglobinopathies
- Multiple gestation with discordant growth
- Hyperthyroidism

In practice, most such testing is undertaken as early as 32 to 34 weeks' gestation, or as soon as the diagnosis is made, and continued twice weekly until delivery. In particularly risky situations, however, testing as early as 26 weeks has been shown to produce valid results.[25]

MATERIALS

An electronic fetal monitor of the "auto-correlating" type is needed to perform nonstress testing. Most modern electronic fetal monitors will be endowed with this feature, which allows the monitor to compare each new beat with the past several beats before recording. This allows for a much smoother tracing and a better estimate of baseline variability.

In addition to the monitor, an area in which to perform the test is required. Since women are often in the monitoring area for up to 2 hours, the woman's comfort is paramount. The patient may lie on a comfortable bed or rest in a recliner while being monitored. Music or an educational video may be provided to help make a potentially repetitive and bothersome experience more tolerable. Ultrasound gel may be warmed in a dedicated warmer for patient comfort. Towels are needed to clean up the gel when the test is complete. A report form should be developed, which can be placed on the patient's chart after the test. This allows for quick access to the latest NST result. Such a form may include date, indication, names of tester and physician, interpretation, and interpreting physician's signature. The actual monitor strips may be kept together in a file to permit serial comparison of reactivity at a later time. Administering the NST is a specialized skill that improves as the tester gains experience. If the NST is to be performed in the physician's office, it is advisable to assign one person in the office the responsibility of performing all nonstress testing. A competent tester will be able to put the patient at ease, reliably find fetal heart tones with the monitor, and advise the physician early if ominous events occur.

CONDUCT OF TEST

The conduct of the test is relatively uncomplicated. Frequently the patient will have an appointment. She may be called for and escorted to the testing area by the assigned tester and seated comfortably in the recliner or bed. The tester will locate fetal heart tones with the monitor, then secure the ultrasound transducer on the abdomen by means of an elastic strap. She will remain with the patient during monitoring, and may choose to terminate monitoring after 20 minutes if the baby displays obvious reactivity. Technically, the test could be stopped after less than 20 minutes if adequate reactivity is demonstrated. If reactivity is questionable or there are unusual or worrisome FHR patterns, monitoring may be continued up to 90 minutes. Various suggestions have been made for improving reactivity of the infant with an initially nonreactive pattern. Maternal smoking and fasting contribute to nonreactivity. Acoustic stimulation of the fetus by activation of an artificial larynx

FIGURE 1

Reactive nonstress test. Note accelerations superimposed on a variable baseline fetal heart rate. The peak of the acceleration should be at least 15 beats per minute above the baseline, and the duration should be at least 15 seconds.

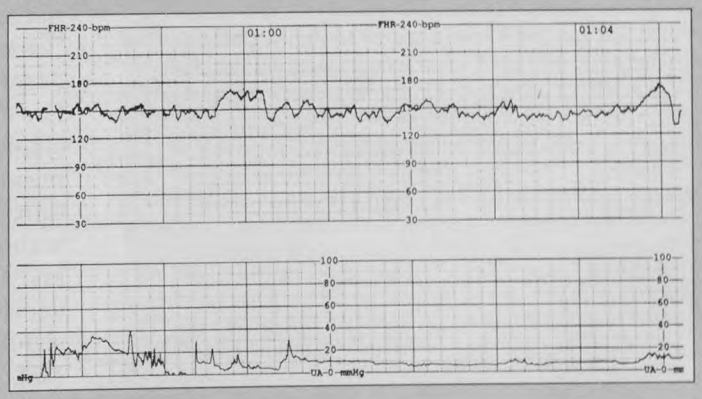
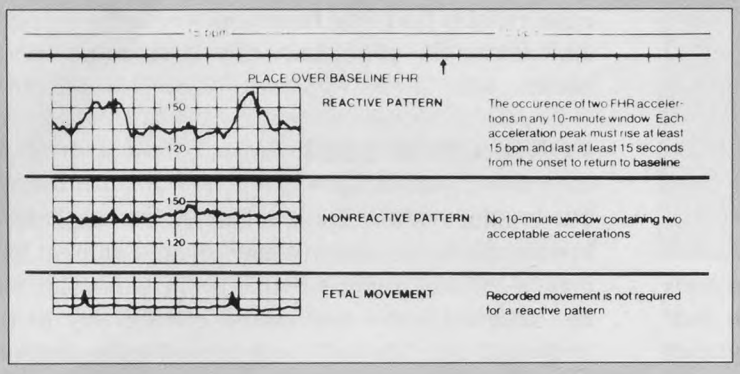


FIGURE 2

A ruler for reading the nonstress test. The clear window is placed over the fetal heart rate tracing with the solid line placed on the baseline fetal heart rate. Accelerations that span two of the vertical hash marks or reach the 15 beats per minute line are considered reactive. Two such accelerations within 20 minutes establish a reactive pattern. The text of the ruler uses different criteria for reactivity.



held against the abdomen has been shown to produce valid accelerations of fetal heart rate, shortening test time.[19, 20] The test should be interpreted by a physician as soon as possible after being performed, while the patient is still present, so that any indicated intervention may be undertaken in a timely fashion.

INTERPRETATION

A number of schemes have been proposed for the interpretation of the NST. One of the most widely accepted at this time is as follows: A reactive strip is defined as a strip that demonstrates two accelerations of at least 15 beats per minute above baseline and lasting at least 15 seconds within a 20-minute period (Figure 1). This does not necessarily mean the first 20 minutes of testing. A small clear plastic "ruler" has been developed that aids in the interpretation of NSTs. It is placed on the monitor strip with the tracing showing through a window, which is marked with the measurements corresponding to an acceleration of 15 beats per minute by 15 seconds (Figure 2). The patient with a reactive NST may go home after scheduling her next encounter, whether a follow-up NST or a physician visit. The patient with a nonreactive NST will need to be evaluated by her physician, who will determine the appropriate further evaluation.

TABLE 2

Evaluation of a Nonreactive Nonstress Test

- Often a longer test duration, up to 90 minutes, is needed.
- There is probably a difference in risk between the fetus who is absolutely nonreactive, and the one who has reactive accelerations, but fewer than 2 in 20 minutes.[17]
- Fetal immaturity, congenital anomalies, or recent maternal substance abuse may account for some nonreactivity.
- If fetal maturity is an issue, a biophysical profile may help resolve the issue of how urgently to pursue delivery. That is, in a term fetus of a woman with an inducible cervix, a nonreactive NST may provoke an induction of labor, whereas an immature fetus with a nonreactive NST and a nonreassuring biophysical profile may provoke a consultation or even a transfer to another facility better prepared to deal with a sick, premature baby.

THE NONREACTIVE TEST

No particular protocol of following up a nonreactive NST has been proven to be best (Figure 3). Traditionally, the nonreactive NST was followed immediately by a contraction stress test. If the contraction stress test in turn proved nonreassuring, often delivery was expedited, given a reasonable expectation of fetal maturity. More recently, many clinicians have chosen to follow the nonreactive NST with a biophysical profile, which consists of a directed sonographic examination of the baby in which fetal movement, tone, breathing, and amniotic fluid index are scored in such a way that a total score of 10/10 indicates a comparatively healthy baby, whereas lower scores represented varying degrees of fetal non-well-being. The evaluation of a nonreactive test should take into consideration several factors, which are noted in Table 2.

Various types of decelerations may occur during the NST. If there are spontaneous contractions, they may be classified as "early," "late," or "variable." If no contractions are present, the decelerations may be classified as to their form. For example, the ominous U shape usually associated with the late deceleration may present a reason for further evaluation (Figure 4). In addition, the classic V-shaped deceleration, with or without the preceding or following accelerations known as "shoulders," may be called a variable deceleration (Figure 5). There is debate as to the significance of this type of deceleration in the NST. The presence of mild variables has not been conclusively shown to indicate fetal compromise.

FIGURE 3

A nonreactive fetal heart rate tracing demonstrates baseline variablity, but lacks the superimposed accelerations required for reactivity.

Variable decelerations have been associated with umbilical cord compromise, and there is a tendency to be more concerned about decelerations that are prolonged, deep, or frequent. Decelerations that fall below a rate of 90 for more than 1 minute are particularly ominous evidence of fetal compromise, and may provide grounds for delivery sooner rather than later.[29] An estimation of amnionic fluid volume may help to evaluate the significance of decelerations. The combination of oligohydramnios and variable decelerations on an NST of 15 beats per minute by 15 seconds is a worrisome result that should provoke serious consideration of delivery.[20,28,30,31]

When evaluating the apparently ill infant, an issue that must be resolved by the individual physician and his or her consultant is the point at which consultation with an obstetrician should be sought. It is advisable to discuss this matter with the consultant ahead of time so that such a decision does not have to be made under the pressure of a worrisome situation.

TESTING INTERVAL

In the past, it was recommended that nonstress testing be done weekly.[20,21] This pattern has changed with use, so that currently women with some conditions such as hypertension, diabetes, intrauterine growth retardation, Rh sensitization, or postterm pregnancy are often tested twice weekly. Certain findings on NST may also provoke more frequent testing. These include the nonreactive NST with normal biophysical profile and the reactive NST with late deceleration.

CONCLUSIONS

Work is being done to improve the predictive value of the NST through computer analysis of heart rate data and reporting of various indicators beyond simple rate and accelerations of the type currently considered "reactive."[17]

The NST interpretation form becomes a part of the medical record. This provides continuity between tests and physician visits, makes results available to a consultant who reviews the chart, and demonstrates the standard of care that was met in the case.

Medicaid policy will vary from state to state as to how NSTs are to be reimbursed. The CPT code is 59025. The physician and business manager will use their personal judgment and the community standard to decide whether to include nonstress testing within the global fee charged for prenatal care.

The performance of nonstress testing allows the primary care physician to evaluate the pregnant patient more fully. It plays an important part in the immediate assessment of the patient who has a worrisome complaint such as reduced fetal movement or abdominal trauma. It also provides a tool for following pregnancies that are at risk from various illness and conditions. Nonstress testing is relatively easy to perform and simple to interpret. When prop-

FIGURE 4

The U-shaped deceleration has the ominous form of a late deceleration, although it cannot be correlated with uterine contractions.

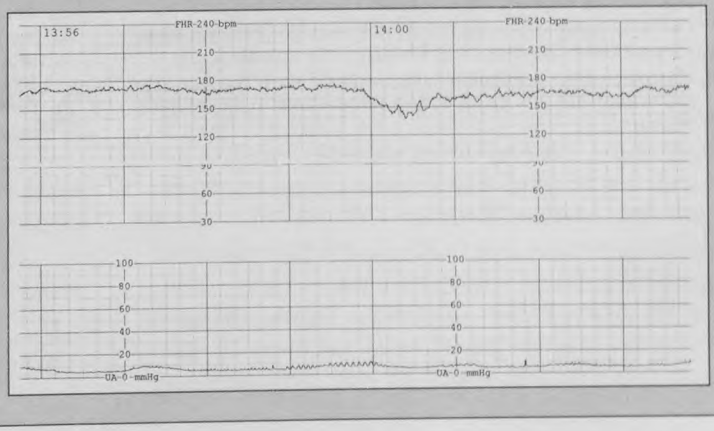


FIGURE 5

In an otherwise reactive nonstress test, this mild variable deceleration would not be considered worrisome necessarily.

erly performed, it can improve the prenatal care delivered by the family physician.

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