Original Article

The Predictive Value of Fetal Acoustic Stimulation

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OBJECTIVE:
To compare the predictive abilities, test duration times, and incidence of nonreactive results in the acoustic stimulation test (AST) and the nonstress test (NST).

METHOD:
Four-hundred randomly selected patients, delivering within 7 days of a preceding test, were divided into two groups (group I: NST; group II: AST). In the AST group, fetal heart rate tracings were recorded for the first 5 minutes as a baseline recording. If the reactivity criterion was not met, transabdominal acoustic stimulation to the fetal head was performed. In the NST group, nonreactive tests were followed by a repeat NST. In both groups, nonreactive tests were followed by oxytocin challenge test (OCT) on the same day. Depressed 5-minute Apgar scores (<7) and an umbilical arterial blood pH of <7.2 were taken as indicators of fetal distress. Sensitivity, specificity, and predictive values of NST and AST were calculated and compared.

RESULTS:
The incidence of nonreactive tests was lower in the AST group. AST decreased the test duration time by 10.1 minutes. The sensitivity values were 87.5% in the NST group and 85.7 in the AST group; specificities of were found to be 94% for AST and 88% for NST. The negative predictive value was found to be 98% in each group, but the positive predictive value was 54.5% in the AST group and 38.8% in the NST group.

CONCLUSION:
AST offers benefits, by decreasing the incidence of nonreactive tests and reducing the test time. AST lowers the rate of false positives without changing the negative reliability of NST. It is a safe test and allows more efficient use of perinatal services.

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Objective clinical evaluation of fetal health is a primary goal of obstetric care. Because obstetricians recognize the association between the presence of fetal heart rate (FHR) accelerations in response to fetal movement and fetal well-being, FHR monitoring has been widely used for antenatal fetal surveillance.

A major problem with antepartum FHR testing is the difficulty in separating healthy fetuses who can have prolonged periods of rest, from sick fetuses who are not moving because of hypoxemia and/or asphyxia. In the nonstress test (NST) there is a high incidence of false-positive results. A healthy third trimester fetus is in a state of quiet sleep approximately 30% to 40% of the time.[1,2] Many unsuccessful attempts have been made to increase FHR reactivity and to decrease the length of NST. These include providing an external light,[3] manipulating the fetus,[4,5] and the maternal ingestion of glucose.[6] Finally, several different fetal acoustic stimulation tests combined with NST have been introduced in clinical practice.[7]

Fetal acoustic stimulation may have a predictive ability similar to that of the oxytocin challenge test and may be used as a complement to NST in the antenatal period. For that reason, a randomized clinical trial was designed to compare the predictive abilities, test duration times, and incidence of nonreactive results in the acoustic stimulation test (AST) and the NST.

MATERIALS AND METHODS

This study was performed in the Perinatology Unit at Ankara Numune Hospital, from January 1996 to August 1997. From the population of pregnant patients applying to the unit, a total of 400 were randomly selected. The patients had delivered infants within 7 days of a preceding test, and after obtaining an informed consent, they were divided equally into two groups (200 in group I: NST; 200 in group II: AST).

A fetal acoustic stimulator (Model 146; Corometrics, Wallingford, CT; 75 Hz, 74 decibels, $\leq$3 second) was used, and FHR were recorded with a fetal heart monitor (Model 115; Corometrics).

All tests were performed in the perinatology unit by well-trained nurses under the supervision of a physician. Blood pressure determinations were made every 10 minutes, with the patients in a semi-Fowler position.

In the NST group, a reactive pattern is defined as the presence of two or more accelerations lasting $\geq$15 seconds and reaching a zenith at $\geq$15 bpm above the baseline within a 20-minute period. A test failing to meet the reactivity criterion was prolonged to 40 minutes, and if the reactivity criterion was still not met, it was termed as nonre-

Table 1 Epidemiologic Characteristics of the Test Groups

	Group I (NST; $n = 200$)	Group II (AST; $n = 200$)	
Age (yr)	25.3 ± 5.03	24.7 ± 4.76	NS
Parity	2.2 ± 1.6	2.01 ± 1.54	NS
Gestational ages (wk)	39.2 ± 11.1	38.5 ± 10.6	NS

Table 2 The Indications for the Tests

Indication	Group I (NST)		Group II (AST)	
	n	%	*n*	%
Postdate	96	48	85	42.5
Control	52	26	60	30
PIH*	20	10	25	12.5
IUGR	10	5	7	3.5
Rh/rh	4	2	6	3
Others	18	9	17	8.5

*Abbreviations: PIH, pregnancy-induced hypertension; IUGR, intrauterine growth retardation.

active. Nonreactive tests were followed by oxytocin challenge test (OCT) on the same day.

In the AST group, each FHR tracing was recorded for the first 5 minutes as a baseline recording. If the reactivity criterion was not met, transabdominal acoustic stimulation near the fetal head was performed up to four times, each lasting no more than 1 second. The test duration was limited to 20 minutes, and the reactivity criterion and follow-up protocol were the same as those for the standard NST.

Reactive NSTs and ASTs were repeated in 7 days, although patients with postdates, intrauterine growth retardation (IUGR), or diabetes were tested every other day.[8]

OCT was performed by 1% oxytocin infusion until three uterine contractions occur every 10 minutes. Tests with late decelerations and >30% contractions were considered as positive. Test results with no decelerations and normal fetal cardiac variability were considered as negative. Equivocal tests were repeated within 24 hours.

Depressed 5-minute Apgar scores (<7) and umbilical cord arterial blood pH of <7.2 were taken as indicators of fetal distress.[9]

All statistical analyses were performed using an SPSS for Windows Release 6.0 (SPSS Inc., Chicago, IL) utilizing "χ-squared" and Student's *t* tests. Sensitivity, specificity, and predictive values of NST and AST were also calculated and compared.

RESULTS

The mean ages, parities, and gestational ages were similar in each group (Table 1). The indications for the tests were similar for each group (Table 2). The indication termed as "control" represents the patients who did not have any antenatal visits before the time they applied to the perinatology unit.

Table 3 Outcome of the OCT in Cases with Nonreactive AST and NST

Nonreactive test	OCT	
	Positive	Negative
NST ($n = 36$)	13 (36.11%)	23 (63.88%)
AST ($n = 22$)	12 (54.54%)	10 (45.45%)

Table 4 Statistical Analysis of Two Groups

	Sensitivity	Specificity	PPV*	NPV	FPR	FNR
NST ($n = 200$)	87.5	88	38.8	98.7	61.1	1.2
AST ($n = 200$)	85.7	94	54.5	98.8	45.4	1.1

*Abbreviations: PPV, positive predictive value; NPV, negative predictive valve; FPR, false positivity rate; FNR, false negativity rate.

Of the 400 tests evaluated, 200 being NST and 200 AST, 18% ($n = 36$) of the NST were interpreted as nonreactive, whereas in the AST group only 11% ($n = 22$) of the tests were nonreactive. Incidence of nonreactivity was found to be significantly lower in the AST group (χ-squared: 3.952; $p = 0.046$) .

In both groups, nonreactive tests were followed by OCT on the same day ($n = 36$ in the NST group; $n = 22$ in the AST group). Of the 36 patients in group I, 36.11% (13 of 36) of OCT were positive and 63.88% (23 of 36) of OCT were negative. In group II patients with nonreactive AST, 54.54% (12 of 22) of OCT were positive and 45.45% (10 of 22) of OCT were negative. This difference among groups, with respect to OCT positivity, was not found to be significant (χ-squared: 2.916; $p = 0.087$; Table 3).

Depressed 5-minute Apgar scores (<7) and fetal cord arterial pH of <7.2 were accepted as signs of fetal distress. In group I, of the 164 patients with reactive NST, two (1.25%) had babies with the findings of fetal distress. There were 14 newborns (38.8%) with distress in the nonreactive NST patients (61.2% false-positive). In the AST group, of the 178 patients with reactive test results, only two had (1.12%) fetal distress. On the other hand, 54.5% ($n = 12$) of nonreactive AST patients had babies with fetal distress. 45.45% of the babies born from mothers with nonreactive AST had no signs of distress. Sensitivity, specificity, and predictive values of the tests are shown in Table 4.

The mean duration of the NST was 29.9 ± 3.1 minutes; the mean duration was 18.93 ± 3.21 minutes in the AST group. Therefore, AST decreased the test time by 10.97 minutes, and the difference was found to be statistically significant ($p = 0.0057$).

DISCUSSION

Standard NST is the most widely used method of assessing fetal well-being. In the NST, the presence of FHR accelerations is interpreted as indicating good fetal health. However, there is a high incidence of false-positive tests (such as an absence of FHR accelerations in an otherwise healthy fetus).[10] This high incidence of false-positive test

results is primarily due to fetal sleep-wake cycles.[11] The NST reactivity criterion is defined as the presence of two accelerations lasting ≥15 seconds and reaching a zenith at ≥15 bpm within a 20-minute period. A test failing to meet this criterion is prolonged up to 40 minutes, and, if still nonreactive, further testing should be done to assure that the fetus is not in distress (which is OCT in our study). This is a time-consuming procedure, especially if the test is nonreactive in the first 20 minutes for busy perinatology outpatient clinics.

Different types of stimuli have been studied in an attempt to decrease the false positivity of the test and the time necessary to perform it as maternal administration of glucose,[6] exposure to external physical stimulation of the fetus, and vibroacoustic stimulation of the fetus to change fetal sleep state and evoke a cardioaccelerating response.[7]

In this study, the mean duration of time necessary to get a reactive NST result was found to be 29.97 ± 3.1 minutes, whereas it was 18.93 ± 3.21 minutes for AST. This is a 10.9-minute duration reduction per testing time. For an outpatient clinic performing about 25 tests per day, it is equivalent to 4 to 5 hours of spare time for giving care to other patients.

Nonreactivity incidence of NST is previously reported to be about 14% to 16%[12,13]; we found it to be 18%. Nonreactivity incidence was 11% in the AST group, which offers benefits not only by reducing the test time but also by decreasing the incidence of nonreactive tests.

In this study we calculated the false negativity rates of NST and AST as 1.2% and 1.1%, respectively. Negative predictive values of both tests were similar (98.7%). These findings are in accordance with the literature.[14,15] False positivity of AST was found to be lower than NST (54.5% vs 45%). Positive predictive value was found to be 54.5% in AST and 38.8% in NST.

In conclusion, AST offers benefits over NST by decreasing the incidence of nonreactive tests and reducing the test time. AST lowers false positivity without changing the negative reliability of NST. It is a safe test and allows more efficient use of perinatal services.

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