A before and after study on the effect of fetal acoustic stimulation test on non stress test parameters*

By Catherine Rose DG. Dela Rosa, MD and Brenda Bernadette P. Bautista-Zamora, MD, FPOGS, FPSMFM

Department of Obstetrics and Gynecology, Delos Santos Medical Center

ABSTRACT

Objective: To determine the effect of Fetal Acoustic Stimulation Test on Non Stress Test Parameters

Methods: A total of 650 subjects (power of 80%) were enrolled. Subjects were both high risk and non high risk pregnancies, at more than 36 weeks AOG with normal AFI. All subjects underwent non stress test followed by non stress test with acoustic stimulation test for minimum of 20-40 minutes. Once consent was obtained, a low frequency sound transducer (40 hertz) was applied on the maternal abdomen to provide acoustic stimulation. The data was gathered, analyzed and compared.

Results: Acoustic Stimulation Test improved the results of NST by having reactive results, longer duration accelerations, improved variability from minimal to moderate variability, and increased number of fetal movement.

Conclusion: AST is not a standalone procedure but merely an adjunct to other antenatal tests for fetal surveillance such as BPS and Doppler.

Keywords: Non stress test, Acoustic stimulation test, low frequency sound transducer, BPS, Doppler.

INTRODUCTION

Nonstress test is used to describe fetal heart rate acceleration in response to fetal movement as a sign of fetal health[1]. This test involves the use of Doppler-detected fetal heart rate acceleration coincident with fetal movements perceived by the mother[2]. The classic criteria for a reactive NST are at least two FHR accelerations lasting at least 15 seconds and rising at least 15 beats/min above the established baseline heart rate[1]. NST recognizes the unique coupling of fetal neurologic status to cardiovascular reflex responses[1]. It is one of the factors that tends to disappear earliest during progressive fetal compromise, and many studies have shown it to be the most sensitive of the four shorter term variables that indicate worsening hypoxemia or acidosis[2]. NST should not be used in isolation in determining the antenatal status of such fetuses.[2]

Vibroacoustic stimulation (VAS) (stimulating the fetus with a noxious vibration and noise) is effective in producing state change, fetal startle movements, and increased FHR variability, and thus in shortening the time it takes to demonstrate fetal well-being[2]. Loud external sounds have been used to startle the fetus and thereby provoke heart rate acceleration—an acoustic stimulation nonstress test[2]. Sounds in the environment of a pregnant woman penetrate the tissues and fluids surrounding the fetal head and stimulate the inner ear through a bone conduction route[4]. The sounds available to the fetus are dominated by low-frequency energy, whereas energy above 0.5 kHz is attenuated by 40 to 50 dB4. An acoustic stimulator is available in the market is positioned on the maternal abdomen, after which a stimulus of 1 to 2 seconds is applied[4]. Three times for up to 3 seconds is the number of times the stimulus maybe repeated. A positive response is defined as the rapid appearance of a qualifying acceleration following stimulation[4].

Perez-Delboy and colleagues (2002) randomized 113 women to nonstress testing with and without vibroacoustic stimulation. Such stimulation shortened the average time for nonstress testing from 24 to 15 minutes[1].

A nonreactive response to fetal acoustic stimulation in early labor is associated with a significantly increased risk for cesarean delivery for fetal distress and neonatal acidosis[4]. This finding extends the potential value of acoustic stimulation as an intrapartum admission screening test[1].

In a study by Imam (2011) they concluded that a better predictor of perinatal outcome can be done by the combined use of NST and AST rather than using NST alone[5]. AST reduces the false non reactive NST and reduces the testing time, while when both NST and AST are non reactive further systems of testing is warranted.[5]

* Third Place, 2015 Philippine Obstetrical and Gynecological Society (POGS) Residents' Research Paper Contest, November 06, 2015, 3rd Floor, POGS Building, Quezon City

GENERAL OBJECTIVES

To determine the effect of Fetal Acoustic Stimulation Test on Non Stress Test Parameters.

Specific Objectives:

1. To determine the difference between NST and FAST as to the following CTG tracing parameters:
   a. Number of fetal movement
   b. Heart rate range
   c. Variability
   d. Frequency and duration of Acceleration
   e. Presence of deceleration

2. To determine the effectiveness of FAST to improve the parameters of NST as to:
   a. Increase number to fetal movement
   b. Increase number of accelerations
   c. Improve variability
   d. From a NON REACTIVE trace to a REACTIVE trace

DEFINITION OF TERMS

1. Baseline Fetal heart tones - the average fetal heart rate (FHR) rounded to increments of 5 beats per minute during a 10-minute segment, excluding periodic or episodic changes, periods of marked variability, or baseline segments that differ by more than 25 beats per minute.[6]

2. Non stress test - a measure of fetal heart rate acceleration in response to fetal movement as a sign of fetal health. This test involved the use of Doppler-detected fetal heart rate acceleration coincident with fetal movements perceived by the mother[1]. Normal non stress test are two or more accelerations that peak at 15 bpm or more above baseline, each lasting 15 seconds or more, and all occurring within 20 minutes of beginning the test. (2 accelerations of 15 beats/min for 15 sec within 20-40 min gives a score of 2 for BPS)[6]

3. Acoustic stimulation - Loud (80 Hz - 82 db) External sounds that have been used to startle the fetus and thereby provoke heart rate acceleration[1]

4. Reactive non stress test - 2 accelerations of 15 beats/min for 15 sec within 20-40 min1Reassuring FHR patterns include each of the following: (1) a baseline fetal heart rate of 110 to 160 beats per minute, (2) moderate variability, (3) gestational age-appropriate FHR accelerations, and (4) absence of FHR decelerations. When all 4 of these criteria are present, the provider can be reassured that no fetal acidemia is present.[6]

5. Non Reactive non stress test - less than 2 acceleration in 20 minutes trace[1] nonreassuring pattern is suggestive of potential fetal acidemia, worsening fetal status, and the need for further measures to be taken to reassure the provider of the fetus's health.[6]

6. Acceleration - It is based on the hypothesis that the heart rate of a fetus who is not acidotic as a result of hypoxia or neurological depression will temporarily accelerate in response to fetal movement. It is defined as an apparent abrupt increase in FHR above baseline, with the time from the onset of the acceleration to the acme of less than 30 seconds. The increase is measured from the most recently determined portion of the baseline. The peak is 15 beats per minute or more above the baseline, and the acceleration lasts 15 seconds or more, but less than 2 minutes from the onset to the return to the previously determined baseline.[6]

7. Deceleration - At 32 weeks and beyond, an acceleration has an acme of 15 bpm above baseline, with a duration of 15 sec but < 2 min.[1] The quantification of a deceleration is based on the depth of the deceleration's nadir in beats per minute below the baseline (15 bpm), excluding any transient spikes or electronic artifact. The durationof the deceleration is quantitated in minutes (15 secs) and seconds from the start of the deceleration to the deceleration'send.[6]

8. Variability - Variability is defined as fluctuations in the FHR baseline of 2 cycles per minute or greater, with irregular amplitude and inconstant frequency. These fluctuations are visually quantitated as the amplitude of the peak to trough in beats per minute. variability should be critically evaluated. Moderate FHR variability is strongly associated (98%) with an umbilical pH higher than 7.1[6].

9. High Risk Pregnancy - Is one that threatens the health or life of the mother or her fetus[6].

10. Non High Risk Pregnancy - A pregnant woman who does not have a high risk pregnancy[6].

MATERIALS AND METHODS

A before and after study was conducted at our institution from April 2014 to April 2015. Permission to conduct the study was obtained from the Department of Obstetrics and Gynecology Ethics Committee. The sample size was calculated using the following assumptions, with an alpha error of .05, power of 80%, 1-tailed alternative

hypothesis. A total of 650 subjects were enrolled in this investigative study. Subjects were both high risk and non high risk pregnancies, at more than 36 weeks AOG with normal AFI. All 650 subjects underwent non stress test followed by an acoustic stimulation test for minimum of 20 minutes for each test. However each test was extended to 40 minutes if there is <3 fetal movements in 30 minutes, or if there is minimal variability. Interpretation of the NST and AST followed the standard of National Institute of Child Health and Human Development (NICHD) nomenclature. Once consent was obtained, a low frequency sound transducer (40 hertz) was applied on the maternal abdomen to provide acoustic stimulation to the fetus to initiate movement.

Non stress test and Fetal acoustic test parameters of acceleration, deceleration, baseline fetal heart tones, variability, fetal movement, OB scores, of both high risk and low risk pregnant women at 36 weeks and above AOG, with normal AFI was gathered, analyzed and compared. Determination of the effectiveness of FAST in fetal well being in relation to NST was analyzed using Wilcoxon signed ranks test when the outcome variables were in ordinal scale of measurement or at most interval, and sign test when they were nominal. Level of significance was set at α=0.05.

RESULTS

Table 1 shows the demographic data of the subjects. 65% of the subjects were Primigravid (65%) and Nuliparous (68%). On the other hand Table 2 shows that most of the subjects were non high risk (81%). Gestational Diabetes Mellitus (GDM) is the predominant high risk condition which comprises 72 of the subjects. Under the high risk group it is 60%.

Table 3 shows the comparison of NST and AST as to baseline fetal heart tones using Wilcoxon signed Ranks test. After AST, there was an increase in the baseline of 43% (N=285). This was statistically significant (2-tailed) (<0.001). Table 4 shows the mean baseline of 135 beats per minute compared with AST at 136 beats per minute.

Table 1. Demographic Data of Subject's OB Scores from April 2014 - April 2015 at Delos Santos Medical Center

		N	%
Gravidity	Primi	424	65.4%
Parity	Multi	224	34.5%
	Nuli	444	68.5%
	Primi	132	20.4%
	Multi	72	11.1%

Table 2. Demographic Data of Subject's Medical Condition from April 2014 - April 2015 at Delos Santos Medical Center

Maternal Medical Condition		N	%
NON HIGH RISK	Normal	531	81.7%
HIGH RISK	GDM	72	11.1%
	Asthma	17	2.6%
	Pre Eclampsia	8	1.2%
	IUGR	9	1.4%
	Hypothyroidism	6	0.9%
	Gravido Cardiac	1	0.2%
	Hyperthyroidism	2	0.3%
	Gest HPN	1	0.2%
	Previous CS	1	0.2%
	Advanced mem	2	0.3%

Table 3. Comparison of AST and NST Baseline Fetal Heart Tones from April 2014 - April 2015 at Delos Santos Medical Center

		N	Mean Rank	Sum of Rank
AST baseline - NST baseline	Negative Ranks	127[a]	274.67	34883.50
	Positive Ranks	285[b]	176.12	50194.50
	Ties	238[c]		
	Total	650		
a. AST baseline < NST baseline				
b. AST baseline > NST baseline				
c. AST baseline = NST baseline				
Z		-3.281[b]		
Asymp. Sig. (2-tailed)		.001		
a. Wilcoxon Signed Ranks Test				
b. Based on negative ranks.				

Table 4. Comparison of AST & NST Actual Baseline from April 2014 - April 2015 at Delos Santos Medical Center

	Baseline	N	Std. Deviation
NST baseline	135.73	650	9.456
AST baseline	136.23	650	9.215

Table 5. Demographic data on Variability from April 2014 - April 2015 at Delos Santos Medical Center

		N	%
NST Variability	Minimal	137	21.1%
	Moderate	513	78.9%
	Total	650	100.0%
AST Variability	Minimal	0	0.0%
	Moderate	650	100.0%
	Total	650	100.0%

Table 6. Comparison of AST and NST to Beat to Beat Variability from April 2014 - April 2015 at Delos Santos Medical Center

		N
AST Variability - NST Variability	Negative Differences[a]	127[a]
	Positive Differences[b]	285[b]
	Ties[c]	238[c]
	Total	650
a. AST Variability < NST Variability		
b. AST Variability > NST Variability		
c. AST Variability = NST Variability		
Z		-11.619
Asymp. Sig. (2-tailed)		.000
a. Sign Test		

Table 5 shows the demographic data of NST variability and AST variability. Data shows that under NST, variability falling under moderate is 78.9% while minimal variability is 21%. After AST only moderate variability is present. Table 6 on the other hand shows the comparison of NST and AST as to variability using Sign test. After AST, there was an increase in the variability of 20% (N=137). This was statistically significant (2-tailed) (<0.001).

Table 7 shows the comparison in seconds the mean duration of acceleration during NST and AST. The duration of acceleration is longer by 1-5 seconds with AST. On the other hand, Table 8 shows the comparison of NST and AST as to Acceleration using Wilcoxon Signed Ranks test. After AST, there was an increase in the acceleration at 63% (N=414). This was statistically significant (2-tailed) (<0.001).

Table 9 shows the comparison of NST and AST as to duration of test using Wilcoxon Signed Ranks test. After AST, there was a decrease in duration at 49% (N=319). This

Table 7. Comparison of Mean Duration of Acceleration on NST and AST from April 2014 - April 2015 at Delos Santos Medical Center

	Test	Mean (sec)	N	Std. Deviation
Duration of Acceleration	NST	15.5	650	6.137
	AST	20.1	650	5.475

Table 8. Comparison of AST and NST as to Acceleration from April 2014 - April 2015 at Delos Santos Medical Center

Ranks				
		N	Mean Rank	Sum of Rank
AST duration of acceleration - NST duration of acceleration	Negative Ranks	1[a]	156.00	156.00
	Positive Ranks	414[b]	208.13	86164.00
	Ties	235[c]		
	Total	650		
a. AST duration of acceleration < NST duration of acceleration				
b. AST duration of acceleration > NST duration of acceleration				
c. AST duration of acceleration = NST duration of acceleration				
Z		-18.238[b]		
Asymp. Sig. (2-tailed)		.000		
a. Wilcoxon Signed Ranks Test				
b. Based on negative ranks.				

Table 9. Comparison of AST and NST as to Duration of Test (minutes) from April 2014 - April 2015 at Delos Santos Medical Center

Ranks				
		N	Mean Rank	Sum of Rank
AST duration - NST duration	Negative Ranks	319[a]	177.13	56503.50
	Positive Ranks	21[b]	69.83	1466.50
	Ties	310[c]		
	Total	650		
a. AST duration < NST duration				
b. AST duration > NST duration				
c. AST duration = NST duration				
Z		-15.377[b]		
Asymp. Sig. (2-tailed)		.000		
a. Wilcoxon Signed Ranks Test				
b. Based on negative ranks.				

Table 10. Comparison of AST and NST as to Duration of Test from April 2014 - April 2015 at Delos Santos Medical Center

		Mean	N	Std. Deviation
Pair 1	NST duration	30.30	650	8.451
	AST duration	23.73	650	6.065

Table 11. Comparison of AST and NST as to Frequency of Acceleration and Number of Fetal Movement from April 2014 - April 2015 at Delos Santos Medical Center

Ranks				
		N	Mean Rank	Sum of Rank
AST frequency of acceleration - NST frequency of acceleration	Negative Ranks	35[a]	159.37	5578.00
	Positive Ranks	464[b]	256.84	119172.00
	Ties	151[c]		
	Total	650		
AST Number of Fetal Movement - NST Number of Fetal Movement	Negative Ranks	38[d]	136.26	5178.00
	Positive Ranks	583[e]	322.39	187953.00
	Ties	29[f]		
	Total	650		

a. AST frequency of acceleration < NST frequency of acceleration
b. AST frequency of acceleration > NST frequency of acceleration
c. AST frequency of acceleration = NST frequency of acceleration
d. AST Number of FM < NST Number of FM
e. AST Number of FM > NST Number of FM
f. AST Number of FM = NST Number of FM

	AST frequency of acceleration - NST frequency of acceleration	AST Number of FM - NST Number of FM
Z	-17.898[b]	-20.470[b]
Asymp. Sig. (2-tailed)	.000	.000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

was statistically significant (2-tailed) (<0.001). Table 10 on the other hand shows that the mean duration of AST was 23.7 minutes compared with NST at a mean of 30 minutes.

Table 11 shows the comparison of NST and AST as to frequency of acceleration and number of fetal movement using Wilcoxon Signed Ranks test. After AST, there was an increase in frequency of Acceleration at 71% (N=464) and an increase in the number of fetal movement by 90% (N=583). These were statistically significant (2-tailed) (<0.001).

Table 12. Comparison of Reactive Test after NST and AST from April 2014 - April 2015 at Delos Santos Medical Center

Frequencies		
		N
AST Reactive Test- NST Reactive Test	Negative Differences[a]	14
	Positive Differences[b]	91
	Ties[c]	545
	Total	650

a. AST Reactive Test < NST Reactive Test
b. AST Reactive Test > NST Reactive Test
c. AST Reactive Test = NST Reactive Test

	AST Result - NST Result
Z	-7.417
Asymp. Sig. (2-tailed)	.000

a. Sign Test

Table 12 shows that more reactive tests were produced after AST was performed (N=91) using Sign test and this was statistically significant.

No decelerations were noted in the study.

DISCUSSION

In this study, there was a significant note of increase in baseline after AST was performed and this was statistically significant. However, with the exact value of the baseline in mind, (136 vs 135 beats per minute), there was no significant change since both are still within the normal fetal heart rate pattern. In the presence of a normal pattern there is a high predictability of fetal normoxia and vigor[7].

On the other hand, variability was improved on this study after performing AST. After AST there were only moderate variability even in high the high risk group. However similar to the above explained, there was no significant changes to the variability after undergoing AST. We can only deduce that the fetus is not experiencing cerebral tissue academia[8].

In terms of acceleration, there was an increase in the duration of acceleration at 1-5 seconds and as a whole there were more accelerations at 63% after AST was performed. Any acceleration on the other hand has the same positive prognostic significance, indicating normal fetal oxygenation.[9]

The duration of testing was decreased after AST at 43%. This was probably due to more accelerations noted during AST compared with NST. This was also noted in a study by Carl V Smith et al where a significant reduction

in testing time was also observed. They concluded that fetal acoustic stimulation test offers advantages over the traditional nonstress test by lowering the incidence of nonreactive tests and reducing testing time[10].

There was also a noted increase in the number of acceleration and fetal movement after AST was performed. This however had not resulted in any significant change, meaning that the results were still reactive. In a similar study by Ohel, et al in 1986, he however concluded that vibratory acoustic stimulation may prove to be clinically useful in altering periods of low reactivity, increasing the number of acceleration and fetal movement observed during nonstress testing of normal fetuses[11]. In a study by Esin et al (2014), they identified other factors to increase reactive NST results and they identified vibroacoustic stimulation to reduce time to reactivity[12].

The purpose of extending the duration of test to 40 minutes was to control the mean time for fetal sleep and wake cycles. There was also no detected deceleration among the subjects.

CONCLUSION

Diminished activity may be a sign of impending fetal death. Because of this it has been known that Fetal acoustic stimulation may shorten and improve NST outcomes. This study was able to duplicate this previous school of thought.

A limitation of this study was to follow patients up to delivery and outcome which was the study designs of previous literature. In a study by Samo in 1990, They concluded that fetal acoustic stimulation in the early intrapartum period may discriminate the compromised from the noncompromised fetus[14]. In a similar study by Imam (2011) they concluded that a better predictor of perinatal outcome can be done by the combined use of NST and AST rather than using NST alone. AST reduces the false non reactive NST and reduces the testing time, while when both NST and AST are non reactive further systems of testing is warramted[5]. It is concluded that AST is not a standalone procedure but merely an adjunct to other antenatal tests for fetal surveillance such as BPS and Doppler.

RECOMMENDATION

It is recommended that in future studies, in order for similar studies to become a better predictor of fetal well being, fetal and maternal outcomes (e.g. cord ph) should have been included with standard peripartal conditions and anesthesia.

REFERENCES

1. Cunningham GF, Gant NF, Leveno, KJ, Gilstrap, LC, Haut, JC Wenstrom, KD et al. Williams Obstetrics. 23rd International Edition. McGraw Hill, 2010. Chaper 17 Fetal Assessment:p 34-1343.
2. Creasy R, Resnik J, Lockwood C, Moore T, Creasy & Resnik: Maternal-Fetal Medicine. 6th Edition, 2009. Chapter 21 Assessment of Fetal Health: p 370
3. Arias, F, Daftary, S, Bhide, A. Practical Guide to High- Risk Pregnancy & Delivery, A South Asian Perspective: 3rd Edition. Elsevier, 2008
4. Gerhardt KJ, Abrams RM. Fetal exposures to sound and vibroacoustic stimulation. *J Perinatol*. 2000 Dec 20; 21-30.
5. Imam B, Nasreen N, Lata M, Zakia A, Comparative Study of Nonstress Test and Fetal Acoustic stimulation Test in Assessment of Fetal Well- being. Journal of South Asian federation of Obstetrics and Gynecology, January-April 2011; 3(1):6-9
6. Robinson, B. A Review of NICHD Standardized Nomenclature for Cardiotocography: The Importance of Speaking a Common Language When Describing Electronic Fetal Monitoring *Rev Obstet Gynecol*. 2008; 1(2):56-60]
7. Nelson, KB. Uncertain Value of Electronic Fetal Monitoring in predicting cerebral Palsy. *N Eng J Med* 324:613-618, 1996
8. Martin, CB DeHann J, Van der Wildt B, et al: Mechanisms of late decelerations in the fetal heart rate: A study with autonomic blocking agents in fetal lambs. *Eur J Obstet Gynaecol* 9:361, 1979
9. American College of Obstetricians and Gynecologist: Intrapartum Fetal Heart Rate Monitoring. Practice Bulletin No.70. Washington, DC, AGOC 2005.
10. Smith,C et al. A Randomized clinical Comparison of Fetal Acoustic Stimulation Testing with Non Stress Test *AJOG* 5:567-588, 1985
11. Ohel,G. Birkenfeld,A. et al. Fetal response to vibratory acoustic stimulation in periods of low heart rate reactivity and low activity *AJOG* 13:619-621, 1986
12. Esin S, et al. Factors that increase reactivity during fetal nonstress testing. *Curr Opin Obstet Gynecol*. (2):61-6, 2014
13. Tan KH, Smyth R, et al. Fetal Vibroacoustic stimulation for facilitation of tests of fetal well being *Cochrane Database Syst Rev* 2013:12CD002963
14. Samo A, Myoung O, Phelan J, et al, Fetal acoustic stimulation in the early intrapartum period as a predictor of subsequent fetal condition. *Americal College of Obstetrics and Gynecologist*. Vol 162:3:762-767 (1990)
15. Saracoglu,F Gol,K, Sahin,I et.al The predictive value of fetal acoustic stimulation. *JPerinatol*. 19(2):103-5, 1999