The fetal acoustic stimulation test : a reliable and cost effective method of antepartum fetal monitoring

TM Batcha[1] and **IMR Goonewardene**[2]

(Index words: Apgar scores, sensitivity, specificity and accuracy)

Abstract

Rationale A healthy foetus, if exposed to external sound stimulation, often responds with vigorous movements which can be felt by the mother. A hypoxic foetus usually does not show this response.

Objectives To evaluate the fetal acoustic stimulation test (FAST) in antepartum fetal monitoring.

Design and Setting Prospective interventional study carried out at the Teaching Hospital, Galle.

Method An initial non-stress test (NST) followed by a FAST using the Corometric ™ model 146 was carried out in 423 high risk pregnant women. The response to FAST was assessed and compared with the NST. A repeat NST was recorded in women who had an initial non-reactive NST. The results of the NST and FAST were compared with the fetal outcome if the woman delivered within 24 hours.

Outcome measures Maternal perception of fetal movements after FAST, results of NST before and after FAST, and the babies' 5 minute Apgar scores if delivered within 24 hours of the FAST.

Results Of the women, 349 (82.5 %) noticed fetal movements after FAST. Of the 167 women who complained of absent or reduced fetal movements, 67% felt fetal movements after FAST. Ninety one had a non-reactive NST and 43 (47 %) became reactive after FAST. Compared to the NST, the FAST had less sensitivity (93 % vs 100 %, p = 0.01), better specificity (79 % vs 45 %, p = 0.001), better positive predictive value (67 % vs 50 %, p = 0.02), similar negative predictive values (96 % vs 100 %, p > 0.05) and better accuracy (83% vs 69% , p = 0.03) in predicting neonatal asphyxia (5 minute Apgar score < 7) if the baby was delivered within 24 hours after the test.

Conclusion The FAST is a reliable, cost effective screening test for antepartum fetal monitoring. It significantly reduces the false positive (non-reactive) NST and has a good negative predictive value.

Introduction

The fact that a foetus is sensitive to external environmental sound vibration and that it responds to it was observed almost 80 years ago [1]. Subsequent reports of the fetal heart rate increasing with sound stimulation led to its use for antepartum fetal monitoring , especially in the USA, where the use of a fetal acoustic stimulation test (FAST) was described [2,3]. Ultrasound studies have shown that the fetal response to sound stimulation is analogous to the newborn startle reflex and that it is a consistent phenomenon from the 28th week of pregnancy [4]. As these movements are strong and vigorous they are more readily recognised by the mother than spontaneous fetal movements [5] .

In non-industrialised countries with limited resources, where technical equipment for electronic fetal monitoring is not freely available, there is a need for simple, inexpensive methods for antepartum fetal monitoring. The practice of the women maintaining a daily spontaneous fetal movement chart has been adopted in both high as well as low risk pregnancies although its sensitivity and specificity are not high [6,7]. Maternal perception of fetal movements in response to FAST has a higher sensitivity [8]. In both high and low risk pregnancies, it has been found to be a useful screening test [8–13]. Several studies have shown that the FAST can convert false positive (non-reactive) non-stress tests (NST) to reactive ones and also shorten the time duration that a NST needs to be carried out [11–13].

The FAST has been shown to improve the biophysical profile of a foetus and a negative FAST (fetal movements felt after sound stimulation) has been shown to have a negative predictive value of 100% for a biophysical profile >8, thus avoiding the need for further investigations [14,15]. The FAST has also been found to be useful in the early intrapartum period [16,17]. The fetal response to different intensity levels of vibro-acoustic stimulation and its long term effects on hearing and development have been studied and it has been found to be very safe [18,19]. The present study was undertaken to evaluate the FAST as a method of antepartum fetal monitoring. The objectives were to study the ability of the FAST to convert a false positive (non-reactive) NST to a reactive one, and to compare the FAST with the NST with regard to the ability of detecting a compromised foetus.

Method

The study was carried out in the university obstetric unit of the Teaching Hospital, Galle. Ethical clearance was obtained from the ethics committee of the Faculty of

[1]*Registrar, University Obstetrics & Gynaecology Unit, Teaching Hospital, Galle;* [2]*Professor and Head , Department of Obstetrics and Gynaecology, Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka.*
Correspondence: MG*, e-mail: <malikg@eureka.lk>.* *(Competing interests: none declared). Revised version accepted 6 May 2005.*

Medicine, University of Ruhuna, and informed written consent was obtained from all women recruited. A total of 423 consecutive high risk women admitted to the antenatal ward with a period of gestation (POG) of 40 weeks or more, or with any high risk factor (*vide* Table 1) with a POG of 32–40 weeks, were recruited for the study. There were 52 women who had only diabetes mellitus or heart disease or pre-labour rupture of membranes as a risk factor. These women were categorised as a ‘non hypoxic’ group and analysed separately (Table 5). The balance 371 women constituted the ‘hypoxic’ group and they underwent a detailed analysis. Any woman who had any one of the following was excluded from the study: gross fetal growth restriction with severe oligohydramnios, in labour (i.e. interval in between uterine contractions < 10 minutes and cervical dilatation >3 cm), and multiple pregnancies. Some patients who were admitted to the ward were not included in the study either due to the short time they spent in the ward or the first author being not available.

The vibro-acoustic stimulator used for the study was the Corometric™ model 146, a dry battery powered device which costs about Rs. 40,000, and having an audio frequency of 75 Hz ± 10%, sound intensity of 74 db at 1 metre in air, and a maximum stimulation duration of 3 sec ± 0.5 sec. NST was recorded using a Sonicaid™ Team MMC TG 003 cardiotocography recorder. Soon after being recruited for the study all women (n = 423) had a NST recorded for 20 minutes and documented whether it was “reactive” or “non-reactive”, using the standard criteria [20]. Soon after the NST, the FAST was performed in all the mothers (n = 423) with the mother in the semi-recumbent position. The vibro-acoustic stimulator was applied firmly to the maternal abdomen directly overlying the fetal thorax and the mother was asked if she felt any fetal movements. A kick immediately following the sound stimulation was marked as “movements”. If no fetal movements were felt within 5 seconds the stimulation was repeated twice within 30 seconds. If no fetal movements were experienced during the three stimulations the test was marked as “no movements”. There were 91 who had initial non-reactive NST before the FAST. The NST was repeated in them. There were 98 women who were delivered within 24 hours after the FAST. The mode of delivery, birthweight and the babies’ 5 minute Apgar scores were documented in them.

The data was collected in a pretested data collection form and stored prospectively in a computer data base. The sensitivity, specificity, negative predictive value, positive predictive value and accuracy of the FAST and the NST in predicting a 5 minute Apgar score < 7 were compared using the Chi-square test. The Epi Info 2000 statistical package was used.

Table 1. **Risk factors in the participants (n = 423)**

*Risk Factors **	*Number of cases*	*(%)*
‘Hypoxic’		
Reduced or absent fetal movements	167	(39.5)
Past dates	125	(29.6)
Hypertension	125	(29.6)
Fetal growth restriction	60	(14.2)
Mild antepartum haemorrhage	08	(1.9)
‘Non hypoxic’		
Diabetes mellitus	57	(13.5)
Pre-labour rupture of membranes	31	(7.3)
Heart disease	16	(3.8)
Miscellaneous**	02	(0.5)

* One woman could have more than one risk factor
** One had rheumatoid arthritis, one had Takayasu disease

Results

The mean age of the 423 women was 29.3 years. SD 6.05. Almost half (48.5%) of them were primigravidae. The mean period of gestation of the women was 38 weeks SD 2, with 34 (8 %) being over 41 weeks of gestation.

The commonest risk factor noted was reduced or absent fetal movements. Of the 423 women 349 (82.5 %) perceived sound provoked fetal movements after FAST. Of the 167 women who were admitted with reduced or absent fetal movements, 112 (67%) perceived fetal movements after FAST and 122 (73%) had a reactive NST. A total of 98 women were delivered within 24 hours after FAST; 45 (46%) vaginally and the rest by caesarean section. The mean birthweight of the babies was 2.84 kg, SD 0.48 kg. There were 371 women who had reduced or absent fetal movements, past dates, hypertension, fetal growth restriction or mild antepartum haemorrhage. These mothers were grouped together as the ‘hypoxic’ group.

Of the 90 non-reactive NST, 43 (48%) were false positives. These women had reactive NST results after the FAST (Table 2). Seven felt fetal movements after the FAST though the NST was non-reactive (false negative NST; Table 2). All in this group were delivered by emergency caesarean section and in five babies the 5 minute Apgar scores were over 7 and only two of them had 5 minute Apgar scores below 7 (false negative FAST; Tables 2 and 3).

The 47 women whose NST remained non-reactive were delivered by emergency caesarean section and 30 of their babies’ Apgar scores were below 7 at 5 minutes Of the 43 whose NST became reactive after FAST, only 13 delivered within 24 hours after FAST and all had 5 minute Apgar scores above 7. However, it is necessary to keep in mind that other confounding factors can affect the 5 minute Apgar score (e.g. acute intrapartum hypoxia). This could affect the relationship between the FAST outcome, NST results and the 5 minute Apgar score.

The mother who did not perceive any fetal movements after FAST and who had a non-reactive NST even after the FAST had an emergency caesarean delivery. However, the baby’s 5 minute Apgar score was > 7.

Table 2. **Fast and NST results in the hypoxic group (n = 371)**

	NST before FAST		*NST after FAST*		
	Non-reactive	*Reactive*	*Non-reactive*	*Reactive*	*Total*
FAST					
No movements	40	33	40	33	73
Movements +	50	248	07	291	298
Total	**90**	**281**	**47**	**324**	**371**

Table 3. **FAST results and babies' 5 minute Apgar scores of the women in the hypoxic group who delivered within 24 hours after FAST (n = 97)**

	FAST		*Total*
	No movements	*Movements +*	
Apgar < 7	28	2	30
Apgar ≥ 7	14	53	67
	42	55	97

Table 4. **NST results before and after FAST and the babies' 5 minute Apgar scores of the women in the hypoxic group who delivered within 24 hours after FAST (N = 97)**

	NST Before FAST			*NST After FAST*		
	Non-reactive	*Reactive*	*Total*	*Non-reactive*	*Reactive*	*Total*
Apgar <7	30	0	30	30	0	30
Apgar ≥	30	37	67	17	50	67
	60	37	97	47	50	97

Table 5. **FAST and NST results in the non-hypoxic group (n = 52)**

	NST	
	Non-reactive	*Reactive*
FAST		
No movements	1	0
Movements +	0	51

Table 6. **Ability of FAST and NST before and after FAST to predict neonatal asphyxia in the women who delivered within 24 hours (n = 97)**

	FAST (%)	*NST before FAST (%)*	*p*	*NST after Fast (%)*
Sensitive	93	100	0.01	100
Specificity	79	45	0.001	75
Negative predictive value	96	100	NS*	100
Positive predictive value	67	50	0.02	64
Accuracy	83	69	0.03	82

NS* = not significant

Discussion

A screening test should have a good sensitivity to minimise the number of false negative results. However, good specificity is also needed to reduce false positives, leading to undue anxiety and the need for further investigations. Maternal perception of sound provoked fetal movements seem to fulfill these requirements. In the present study, which included only high risk women, 82.5% noticed fetal movements after FAST. In a study where the FAST was performed in a low risk population without carrying out an NST, 97% of women perceived sound provoked fetal movements [8]. Sensitivities of 8–94%, specificities of 89–97% and negative predictive values of 98–100% of the FAST have been reported in other studies [11–14]

In the present study, compared to the NST, the FAST had less sensitivity (93 % vs 100 %, p = 0.01) better specificity (79 % vs 45 %, p = 0.001) better positive predictive value (67 % vs 50 %, p = 0.02) similar negative predictive values (96 % vs 100 %, p > 0.5) and better accuracy (83% vs 69%, p = 0.05) in predicting neonatal asphyxia (5 minute Apgar score < 7) if the baby was delivered within 24 hours after the test. The positive predictive value of the FAST has been found to be low with rates of 14% [21] to 55% [11] being reported. In the present study it was better (67%).

In the seven women who had false negative FAST responses (i.e. fetal movements felt) in comparison with a non-reactive NST, FAST was better than NST in predicting a 5 minute Apgar score <7 if the baby was delivered within 24 hours. However, FAST missed two cases of fetal hypoxia. Of the 423 women, 33 (8%) had false positive FAST responses (i.e. woman felt no fetal movements with FAST but the NST was reactive). Of these, only two women delivered within 24 hours after FAST and these babies were normal. The fetal response to vibro-acoustic stimulation may vary with the fetal behavioural state. In newborn babies it is well known that proprioceptive reflexes such as the Moro reflex is well elicited both during non-REM sleep and during wakefulness but are weak or absent during REM sleep [22]. REM sleep may be one of the reasons why these foetuses did not respond to the FAST. The chance of eliciting a fetal response may increase with increasing intensity of the vibro-acoustic stimulation. [18]. Perception of fetal movements is subjective and depends on the experience of the mother. They may also not be noticed on account of fetal position, e.g. direct occipito-anterior position with posteriorly situated limbs. When evaluating the reliability of FAST in the present study, it is important to bear in mind that the women consisted of a high risk population.

Of the 167 women who were admitted due to reduced or absent fetal movements, only 55 (33%) did not perceive fetal movements with FAST. Out of these 55, 38 (69%) had non-reactive NST. This shows that the FAST is superior to maintaining a daily chart of spontaneous fetal movements. However, maintaining a daily fetal movement chart should not be discouraged as it can be easily done at home. In 43 (47%) of the 91 initially non-reactive NST, the NST became reactive after FAST, probably due to awakening of the foetus by FAST. This would be very useful in a busy clinical practice with inadequate staff where carrying out a NST for an extended duration is difficult. This would minimise further investigations and anxiety both for the woman as well as the obstetrician. However, **i**n the presence of obvious gross fetal growth restriction with oligohydramnios or other evidence of severe intrauterine hypoxia, which requires immediate delivery of the foetus, the FAST should not be used.

Conclusion

The FAST provokes a response in non-hypoxic foetuses. It can significantly reduce the false positive (non-reactive) NST. It has a good sensitivity, accuracy and negative predictive value in detecting fetal hypoxia. The FAST complements the NST. Although the FAST cannot replace the NST, ultrasound and Doppler studies, it will serve as a useful cost effective and reliable preliminary screening procedure for antepartum fetal monitoring where resources for more sophisticated investigations are not freely available.

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