The Correlation in Antepartum Fetal Test between Full Fetal Biophysical Profile (FBP) and Rapid Biophysical Profile (rBPP)

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Objective: *To determine the correlation between the rapid biophysical profile (rBPP), the combination of amniotic fluid index (AFI), and sound-provoked fetal movement (SPFM) detected by ultrasound, and the full biophysical profile (FBP) in terms of abnormal and normal result.*

Material and Method: *A prospective study was performed in 200 singleton pregnancies with no fetal anomalies between 30-42 weeks of gestation indicated for non-stress test (NST). All participants received both the standard (FBP) and the new rBPP examinations. Abnormal fetal test was defined as having a score of ≤ 6 for FBP or ≤ 2 for rBPP. The main outcome measurement was Spearman's correlation coefficient (r_s) between both examinations.*

Results: *The incidences of the abnormal tests were 1.5% and 6.0% in FBP and rBPP, respectively. The data showed a positive correlation between the two tests ($r_s = 0.67$; $p < 0.01$). Regarding the operative time, FBP assessment was 25.56 ± 8.75 times longer than rBPP. The number of abnormal NST was remarked at 1.5% while oligohydramnios and abnormal SPFM were detected at 5% and 2%, respectively. Compared to the standard NST, rBPP test was significantly superior in terms of correlation with FBP (r_s =0.67 vs. 0.33) and shorter duration of test (1.21 ± 0.32 min. vs. 21.65 ± 5.47).*

Conclusion: *The statistically significant positive correlation between rBPP and FBP has been revealed. Due to its simplicity, rapidity, and no need of expensive equipment or experienced interpreter, the rBPP may be alternatively used as a primary antepartum fetal test in the overcrowded obstetric center or when fetal surveillance tests are limited.*

Keywords: *Full biophysical profile, Rapid biophysical profile, Amniotic fluid index, Sound-provoked fetal movement, Fetal surveillance*

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Antepartum fetal surveillance, one of the most common and essential examinations in obstetric care is composed of many techniques such as non-stress test (NST), contraction stress test (CST), and fetal biophysical profile (FBP). NST remains the most widely used method due to its simple and non-invasive technique with only a few limitations. It is described by the observation of fetal heart rate (FHR) accelerations in response to fetal movement during the relaxation of uterus. Its abnormal result represents the acute fetal hypoxic condition. Nevertheless, its high false positive rate, considerably long duration, high cost, and lack of experienced interpreters make NST a non-ideal fetal test. CST, which involves FHR response to uterine contractions, has been proposed as a lower false negative test when compared to NST[1]. However, this time consuming technique is rather complicated and requires oxytocin administration, which is contraindicated in some particular circumstances such as abruptio placenta, twins, and preterm labor. In terms of efficacy, CST yields a relatively high false positive rate and equivocal results. Fetal biophysical profile (FBP), the combination of NST and four fetal ultrasound parameters, was first introduced by Manning et a1[2,3]. This more accurate and lower false positive rate technique has been performed by evaluating five fetal biophysical factors including fetal breathing, fetal tone, fetal gross body movements, fetal heart rate acceleration (NST), and amniotic fluid

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volume(AFV)[4-6]. However, FBP is reserved for only a limited number of patients due to the requirement of equipment, well-trained ultrasonographers, and adequate examination time (at least 30 minutes). Therefore, many investigators have put in a lot of effort to develop a simple, rapid, and reliable fetal test to use as a screening tool. Rapid biophysical profile (rBPP) described by amniotic fluid index (AFI) measurement with sound-provoked fetal movement (SPFM) test has been proposed by many researchers as a promising technique for fetal surveillance[7,8]. Despite the extensive use of rBPP, the study of the correlation between rBPP and FBP is very limited. Hence, the present research studied the correlation between the two tests in terms of abnormal and normal test detection. The obtained data may be reassuring and encouraging to the application of this technique when NST is unavailable.

Material and Method

After the approval of the Institute's Ethics Committee, 200 pregnant women who underwent NST at the Maternal Fetal Medicine Division, Department of Obstetrics and Gynecology, Faculty of Medicine, Siriraj Hospital, Bangkok, Thailand and met the inclusion criteria of singleton pregnancy and had a gestational age of 30-42 weeks were invited to join the present study. The indication for NST included poor maternal weight gain, decreased fetal movement, suspected intrauterine growth restriction, postterm pregnancy, diabetes mellitus, hypertension, renal disease, and pregnancy induced hypertension. Multiple pregnancies and anomaly fetus were excluded. Informed consent was obtained from all participants. The present study protocol was designed to ensure that each patient received both FBP and rBPP test. Initially, NST was performed in all patients then the remaining fetal ultrasound parameters (AFI, fetal breathing, fetal tone, and fetal movement) were examined to complete the FBP test. After a 10-minute break, SPFM was carried out by the same examiner to finish the rBPP test. The obstetric care absolutely relied on the result obtained by the gold standard FBP technique.

To perform fetal surveillance test, the patient was arranged in semi-Fowler position attached to the NST device (Philips Antepartum Monitor Series 50A, Andover, MA, USA). Doppler transducer was applied to record fetal heart rate and tocodynamometer was used to observe spontaneous uterine contraction. In case of no FHR acceleration occurring in 20 minutes, the fetus was then aroused by applying an artificial larynx (Mountain Bell, Corometrics, 80 MHz) on the maternal abdomen just above the fetal head for three seconds[9]. The stimulus could be repeated up to three times if no qualifying FHR acceleration was observed in 15 seconds. This technique has been proved to increase FHR accelerations and long-term variability by producing an abrupt change from a quiet to an active state of the fetus[10]. As a result, the incidence of non-reactive tests is lowered and the testing time is reduced[11]. The FHR tracing was considered as reactive or normal when two or more fetal heart rate accelerations occurred in 20 minutes. If the criterion was not met in 40 minutes, the test was interpreted as non-reactive or abnormal NST. The appearance of significant FHR deceleration was also interpreted as abnormal NST. Each NST was performed by well-trained and experienced nurses whereas the fetal tracing was analyzed and interpreted by the same maternal fetal medicine doctor.

Then, AFI and other fetal ultrasound parameters were evaluated by using the real-time scanner (model SSD-1700 Dyna View II; Aloka, Tokyo, Japan) with a 3.5 MHz abdominal transducer. To obtain AFI, the uterus was divided into four equal quadrants, then the transducer was placed along the maternal longitudinal axis and held perpendicular to the floor. AFI was calculated by adding the vertical, cord free depth of the largest amniotic fluid pocket in each quadrant together[12]. The other fetal biophysical variables (fetal breathing, gross body movement, and tone) were observed subsequently during the same examination[12,13].

The SPFM test was performed by using an artificial larynx with the same technique as mentioned before[9]. The result was interpreted as response or normal when fetal movement was observed by ultrasound within 15 seconds after the stimulation. The abnormal result or no response was diagnosed if no fetal movement was detected after three times of fetal stimulation.

According to Manning et al and Voxman et al[2,14], each of five biophysical variables has a possible score of 2, for a total of 10. The FBP scoring system is shown in Table 1. The normal FBP score (≥ 8) explains that the fetus is in good condition without hypoxia. The abnormal FBP test is diagnosed when the score is ≤ 6 and fetal hypoxia is suspicious.

For rBPP, to simplify the interpretation, the authors used the scoring system as shown in Table 2. The rBPP score of 4, characterizes the reliable fetal

Table 1. Fetal biophysical profile (FBP) scoring system

Biophysical variable	Normal (score = 2)	Abnormal (score = 0)
Fetal breathing movements (FBM)	One or more episodes of FBM > 30 sec in 30 min	Absent or no episode of FBM > 30 sec in 30 min
Gross body movements	Three or more discrete body/ limb movements in 30 min (episodes of active continuous movement considered as single movement)	Two or less episodes of body/ limb movements in 30 min
Fetal tone	One or more episodes of active extension with return to flexion of fetal limb(s) or trunk; opening and closing of hand considered normal tone	Either slow extension with return to partial flexion or movement of limb in full extension or absent fetal movement
Reactive fetal heart rate	Two or more episodes of acceleration of > 15 bpm and of > 15 sec associated with fetal movement in 20 min	Less than 2 episodes of acceleration of FHR or acceleration of < 15 bpm in 40 min
Amniotic fluid volume	> 5 cm	≤ 5 cm

Interpretation	Score = 8-10	Normal fetus
	Score = 6	Fetal hypoxia is suspicious
	Score = 0- 4	Fetal hypoxia

Modified from Manning et al and Voxman et al[2,14]

circumstance while the score of ≤ 2 represents the non-reassuring state of the fetus.

Demographic data of the participants and duration of each test were collected for analysis. The correlation of the outcome between FBP and rBPP was studied by using Spearman's correlation coefficient. A p-value of less than 0.05 was considered statistical significance correlation.

Results

Among 200 eligible pregnant women, the mean of maternal and gestational age were 27.39 ± 6.44 years and 36.5 ± 2.71 weeks, respectively (Table 3). The majority of the participants (53%) were primigravida with maternal weight of 65.71 ± 10.08 kilograms by average. The common indications for fetal surveillance were maternal poor or static weight gain (56.5%) and decreased fetal movement (26.5%) (Table 4). The incidence of abnormal FBP and rBPP were 1.5% and 6.0%, respectively (Table 5). By using Spearman's correlation coefficient, the statistical analysis demonstrated that rBPP's score correlated to FBP's score in a moderate to good level (correlation coefficient $r_s = 0.67$, $p < 0.01$). Regarding the duration of tests, FBP assessment was 25.56 ± 8.75 times significantly greater than that of

Table 2. Rapid biophysical profile (SPFM and AFI) scoring system

rBPP	Normal (score = 2)	Abnormal (score = 0)
SPFM	Response	Non response
AFI	> 5 cm	≤ 5 cm
Total (score)	4	0
Interpretation	Score = 4	Normal fetus
	Score = 0-2	Fetal hypoxia

Table 3. Demographic data of the studied population

Characteristic	Mean ± SD/ number of cases (%)
Maternal age (yr)	27.39 ± 6.44
Primigravida	106 (53 %)
Multigravide	94 (47 %)
Gestational age (wk)	36.54 ± 2.71
Weight (kg)	65.71 ± 10.08
Pre-meal status	60 (30%)
Post-meal status	140 (70%)

Data were presented as mean ± standard deviation (SD) or number (%)

Table 4. Indications for antepartum fetal testing

Indications	No. of patients (n = 200)	%
Poor weight gain or static weight	113	56.5
Decreased fetal movement	53	26.5
Post term	20	10.0
Suspected of intrauterine growth restriction	5	2.5
Medical complications: diabetes mellitus, chronic hypertension, renal diseases and pregnancy induced hypertension	3	1.5
Others: maternal anxiety, suspected pregnancy induced hypertension	6	3.0

Table 5. Number of abnormal fetal tests characterized by maternal pre/post meal status

Fetal tests (n = 200)	Premeal (n = 60)	Postmeal (n = 140)	Total abnormal results (%)
FBP	1	2	3 (1.5)
rBPP	5	7	12 (6)
NST	2	1	3 (1.5)
AFI	3	7	10 (5)
FB	1	0	1 (0.5)
FM	0	0	0 (0)
FT	3	12	16 (8.0)
SPFM	1	3	4 (2)

BP = full biophysical profile; rBPP = rapid biophysical profile; NST = non-stress test; AFI = amniotic fluid index; FB = fetal breathing; FM = fetal movement; FT = fetal tone; SPFM = sound provoked fetal movement test

Table 6. The correlation of scores among FBP, rBPP and NST

Test	Correlation coefficient* with FBP	Significance (2-tailed)
rBPP	0.666	$p < 0.01$
NST	0.329	$p < 0.01$

* Spearman's correlation coefficient is significant at the 0.01 level (2-tailed)

rBPP (29.74 ± 10.18 vs. 1.21 ± 0.32 min). The time used for each parameter measurement is shown in Table 7. In the present study, the prevalence of non-reactive NST and/or significant deceleration was 1.5% while oligohydramnios and abnormal SPFM were detected at 5% and 2%, respectively. Compared to the standard NST, rBPP test was significantly superior in terms of correlation with FBP ($r_s = 0.67$ vs. 0.33). Additionally,

Table 7. Operative time for each fetal test

Test	Min (min)	Max (min)	Mean ± SD (min)
FBP	21.18	70.20	29.74 ±10.19
rBPP	0.85	2.53	1.21 ± 0.32
NST	20	40	21.65 ± 5.47
FB, FM, FT	1	30	7.90 ± 7.9
AFI	0.83	2.50	1.11 ± 0.24
SPFM	0.017	0.75	0.096 ± 0.17

FBP = full biophysical profile; rBPP = rapid biophysical profile; NST = non-stress test; AFI = amniotic fluid index; FB = fetal breathing; FM = fetal movement; FT = fetal tone; SPFM = sound provoked fetal movement test

the duration of NST was 18 times greater than that of rBPP (21.65 ± 5.47 vs. 1.21 ± 0.32 min). Moreover, the presented data also suggested that maternal postmeal and premeal status correlated with neither FBP nor rBPP outcomes in terms of abnormal and normal test detection.

Discussion

The FBP as a non-invasive, very accurate and applicable antenatal method to all patients is particularly attractive since it provides immediate individual results, does not provoke fetal distress. FBP has a low false positive rate and consists of acute markers of fetal hypoxia (fetal breathing, fetal movement, fetal tone, and FHR reactivity), and a chronic marker of fetal hypoxia that gives a better notion of uteroplacental reserve (AFI). However, there are disadvantages of this test. FBP is time-consuming as it includes at least a 30 minutes observation period of fetal biophysical activities and cardiotocographic registration (NST), which requires 20-40 minutes. Moreover, an expensive fetal heart rate monitor and an experienced interpreters are needed.

RBPP is simpler, inexpensive, and is faster. It has been developed to evaluate fetal well being when an NST machine is unavailable.

The present study has demonstrated a correlation between rBPP and FBP test and shown the superiority of rBPP to NST in not only the correlation with FBP but also the shorter operative time. In terms of predictive value, the NST alone appears to have predictive value. However, this may be because only the acute sign of fetal hypoxia were evaluated. On the contrary, AFI, the chronic hypoxia indicator, and SPFM, the acute fetal hypoxia marker, have been thoroughly examined by the rBPP.

The obtained data encouraged the use of rBPP as an alternative antepartum test to evaluate the fetal well-being. In particular, its simplicity, shorter duration, no obligation of NST, or experienced interpreter makes the rBPP a good choice for the obstetric center that is rather crowded or limited in experienced NST interpreters. Moreover, in developing countries, ultrasound machines that can be used in many fields of medicine are more available than NST equipment that are used specificly by the obstetric department. In addition, the rBPP does not need expensive high-resolution ultrasound equipment. If this technique is applied as a screening fetal test in rural areas, it will help in reduce the number of referral cases for complete fetal biophysical profile in tertiary care centers. However, the accuracy of rBPP test (in terms of sensitivity, specificity, false positive, and false negative rates) should be extensively verified and a larger number of studied populations including more abnormal tests need to be investigated.

Several fetal stimulation techniques including halogen light spotting[15], manual fetal head stimulation[16] have been studied with lower success than the sound provoked device or the artificial larynx. This instrument produces the specific quality of sound with 110 dB of loudness and the frequency of 80 MHz. Despite its high efficacy, other inexpensive instrument that can generate the same quality of sound should be invented and studied to reduce the cost further.

In conclusion, the present study revealed the significant positive correlation between rBPP and FBP. The further area of researches should be focusing on the accuracy of this technique and the substitution of the vibroacoustic stimulation device. rBPP may be used alternatively as a primary antepartum fetal test in the overcrowded center or when there is a shortage of fetal surveillance tests.

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การหาความสัมพันธ์ของวิธีประเมินสุขภาพทารกในครรภ์ก่อนคลอด ระหว่างวิธีการประเมินทางชีวกายภาพของทารกซนิดเต็มรูปแบบ (FBP) กับวิธีการวัดปริมาณน้ำคร่ำ และกระตุ้นทารกให้เคลื่อนไหวด้วยเสียง (rBPP)

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วัตถุประสงค์: *เพื่อศึกษาหาความสัมพันธ์ของวิธีการตรวจสุขภาพทารกในครรภ์ก่อนคลอดระหว่างวิธี FBP และวิธี rBPP*

รูปแบบการศึกษา: *ศึกษาหาความสัมพันธ์แบบเก็บข้อมูลไปข้างหน้า*

วัสดุและวิธีการ: *ทำการศึกษาในสตรีตั้งครรภ์เดี่ยวจำนวน 200 ราย ที่มีอายุครรภ์ระหว่าง 30 ถึง 42 สัปดาห์ และมีข้อบ่งชี้ในการตรวจ non-stress test (NST) สตรีตั้งครรภ์ที่ทารกมีความพิการแต่กำเนิดจะถูกคัดออกจากการศึกษานี้ ผู้เข้าร่วมทุกคนจะได้รับการตรวจประเมินสุขภาพของทารกด้วย วิธี Full Biophysical Profile (FBP) และ Rapid Biophysical Profile (rBPP) หากได้คะแนนจากการตรวจ $\leq$ 6 ด้วยวิธี FBP หรือ $\leq$ 2 ด้วยวิธี rBPP จะถือว่ามีผลการตรวจที่ผิดปกติซึ่งแสดงว่าทารกอาจมีภาวะพร่องออกซิเจน ทำการหาความสัมพันธ์ระหว่างผลการตรวจทั้งสองวิธีโดยใช้ค่าสัมประสิทธิ์ความสัมพันธ์ (Spearman's correlation coefficient; r_s)*

ผลการศึกษา: *ผลการตรวจที่ผิดปกติด้วยวิธี FBP และ rBPP เท่ากับร้อยละ 1.5 และ 6.0 ตามลำดับ ทั้ง 2 วิธีมีความสัมพันธ์กันอย่างมีนัยสำคัญ (r_s = 0.67, $p < 0.01$) แต่วิธี FBP ใช้เวลาในการตรวจนานเป็น 25.56 $\pm$ 8.75 เท่าของวิธี rBPP (29.74 $\pm$ 10.18 และ 1.21 $\pm$ 0.32 นาทีตามลำดับ) การศึกษานี้พบภาวะ non-reactive NST ร้อยละ 1.5 ภาวะปริมาณน้ำคร่ำน้อย ร้อยละ 5 และภาวะทารกไม่ตอบสนองต่อเสียงกระตุ้น ร้อยละ 2 ผลการตรวจด้วย NST มีความสัมพันธ์กับ FBP โดย r_s = 0.33 ซึ่งน้อยกว่าวิธี rBPP และยังใช้เวลาในการตรวจนานกว่าถึง 18 เท่า (21.65 $\pm$ 5.47 และ 1.21 $\pm$ 0.32 นาทีตามลำดับ)*

สรุป: *วิธี FBP กับ rBPP มีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติ rBPP สามารถทำได้สะดวก รวดเร็ว และไม่จำเป็นจะต้องมีเครื่อง NST หรือ บุคลากรที่มีความชำนาญมาก ดังนั้นวิธี rBPP อาจเป็นทางเลือกหนึ่งในการตรวจสุขภาพทารกในสถานที่ซึ่งมีจำนวนผู้ป่วยทางสูติกรรมมาก หรือ ในสถานที่ที่มีข้อจำกัดของเครื่องมือ*