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Comparison of Modified Biophysical Profile and Doppler Ultrasonography Studies in Predicting Perinatal Outcome in High-Risk Pregnancies

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Abstract

Objective: To compare the efficacy of the Modified Biophysical Profile (MBPP) and umbilical artery Doppler velocimetry in predicting adverse perinatal outcomes in high-risk pregnancies.

Methods: A prospective observational study was conducted on 54 high-risk pregnant women admitted to the obstetrics department. All participants underwent MBPP (combining Non-Stress Test and Amniotic Fluid Index) and umbilical artery Doppler velocimetry within 48 hours of delivery. Perinatal outcomes were assessed using Apgar score at 5 minutes, birth weight, me conium-stained liquor, and NICU admission. Test characteristics (sensitivity, specificity, positive and negative predictive values) were calculated for both modalities.

Results: Adverse perinatal outcomes were significantly more frequent in pregnancies with abnormal test results. MBPP demonstrated superior sensitivity (88.9%) and negative predictive value (90.7%) compared to Doppler Ultrasonography (sensitivity 66.7%, NPV 82.1%). The combination of both abnormal MBPP and abnormal Doppler was associated with the highest rate of perinatal complications ($p<0.001$).

Conclusion: MBPP is a more sensitive predictor of adverse perinatal outcomes than umbilical artery Doppler alone in high-risk pregnancies. However, combining both tests provides optimal antenatal

surveillance and should be considered the standard of care for high-risk obstetric management.

Keywords: High-Risk Pregnancy, Modified Biophysical Profile, Doppler Ultrasonography, Perinatal Outcome, Fetal Surveillance

Introduction

High-risk pregnancies account for a significant proportion of perinatal morbidity and mortality worldwide.[1] Timely identification of fetal compromise in these pregnancies is crucial for optimizing perinatal outcomes and reducing neonatal complications.[2,] Various antenatal surveillance modalities have been developed to assess fetal well-being, among which the biophysical profile and Doppler Ultrasonography are widely utilized.[3]

The Modified Biophysical Profile (MBPP), introduced by Nageotte et al.[4], combines the Non-Stress Test (NST) as a short-term marker of fetal status with the Amniotic Fluid Index (AFI) as a marker of long-term placental function. This simplified approach is less time-consuming than the classical biophysical profile while maintaining comparable predictive accuracy.[5] Doppler velocimetry, particularly of the umbilical artery, evaluates fetoplacental hemodynamics by measuring impedance to blood flow, providing valuable information about placental vascular resistance and fetal oxygenation.[3]

Previous studies have demonstrated the utility of both tests individually in predicting perinatal outcomes.[2,6] However, the comparative efficacy of these modalities remains a subject of ongoing investigation. Bardakci et al.[7] found that MBPP was more significant than Doppler analysis in predicting non-reassuring fetal status, while the combination of both increased sensitivity to 70%. Similarly, Malhotra et al.[8] reported that MBPP is a better predictor of perinatal outcome compared to umbilical artery Doppler in high-risk pregnancies.

The present study was undertaken to compare the predictive value of MBPP and umbilical artery Doppler Ultrasonography in determining perinatal outcomes in high-risk pregnancies, with the objective of establishing evidence-based guidelines for optimal fetal surveillance.

Methodology

Study Design, setting and population

A prospective observational study was conducted in the the Department of Obstetrics and Gynecology of a tertiary care teaching hospital over a period of 9 months. The target population comprised all pregnant women with one or more high-risk factors attending the antenatal clinic or admitted to the obstetrics ward during the study period.

Inclusion Criteria

- Singleton pregnancy
- Gestational age ≥ 32 weeks
- Presence of one or more high-risk factors including:
- Pregnancy-induced hypertension/pre-eclampsia
- Gestational diabetes mellitus
- Intrauterine growth restriction (estimated fetal weight < 10th percentile)
- Post-dated pregnancy (≥ 41 weeks)
- History of previous stillbirth or recurrent pregnancy loss
- Oligohydramnios (AFI < 5 cm)
- Maternal anemia (hemoglobin < 10 g/dL)
- Hypothyroidism
- Delivery within 48 hours of performing MBPP and Doppler studies
- Informed consent obtained

Exclusion Criteria

- Multiple pregnancy

- Fetal congenital anomalies
- Preterm premature rupture of membranes
- Active labor
- Refusal to participate

Sample Size Calculation

The sample size was calculated using the formula for comparing two diagnostic tests:

$n \geq Z^2_{1-\alpha/2} \times p(1-p) / \Delta^2$

Where:

- $Z_{1-\alpha/2} = 1.96$ (at 95% confidence level)
- p = expected sensitivity of MBPP (based on previous studies, approximately 0.85)[8]
- Δ = desired precision (0.10)

The minimum required sample size was calculated to be 50. Allowing for a 10% attrition rate, the final sample size was determined as 54 participants.

Procedure for Data Collection

Pre-procedure Preparation

All eligible participants were explained the purpose of the study and written informed consent was obtained. A detailed history including demographic details, obstetric history, and high-risk factors was recorded on a predesigned proforma.

Modified Biophysical Profile (MBPP)

MBPP was performed using a standardized protocol as described by Nageotte et al., consisting of:

1. **Non-Stress Test (NST):** Performed using an electronic fetal monitor (Philips Avalon FM30) for 20-40 minutes. Reactive NST was defined as the presence of at least 2 accelerations of fetal heart rate of ≥ 15 bpm lasting ≥ 15 seconds over a 20-minute period. Non-reactive NST was considered abnormal.
2. **Amniotic Fluid Index (AFI):** Measured using the four-quadrant technique. The uterus was divided into four quadrants using the maternal linea nigra and umbilicus as reference points. The deepest vertical pocket in each quadrant was measured, and the sum was calculated. AFI < 5 cm was considered oligohydramnios (abnormal).

MBPP was categorized as abnormal if either NST was non-reactive or AFI was < 5 cm.

Umbilical Artery Doppler Ultrasonography

Umbilical artery Doppler studies were performed using a Trans abdominal ultrasound probe (3.5-5 MHz convex transducer) on GE Voluson E8 equipment. The following protocol was followed

- The umbilical cord was identified in a free loop
- Pulsed-wave Doppler was activated with the sample volume placed over the umbilical artery
- The angle of insonation was maintained at < 30°
- Three consecutive waveforms were obtained, and the average was calculated
- Pulsatility Index (PI) and Systolic/Diastolic (S/D) ratio were recorded
- Resistance Index (RI) was calculated using the formula: (S-D)/S

Abnormal umbilical artery Doppler was defined as

- RI > 0.71 or S/D ratio > 3.0
- Absent or reversed end-diastolic flow

Perinatal Outcome Assessment

All participants were followed until delivery. At delivery, the following parameters were recorded

- Birth weight using a calibrated electronic weighing scale
- Apgar score at 5 minutes by the attending pediatrician
- Presence of me conium-stained liquor
- Need for NICU admission
- Any neonatal complications

Statistical Analysis

Statistical analysis was performed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as mean ± standard deviation, and qualitative variables as frequencies and percentages. For comparison of perinatal outcomes between groups, the Chi-square test or Fisher's exact test was used as appropriate. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for MBPP and Doppler Ultrasonography. A p-value < 0.05 was considered statistically significant.

Results

A total of 54 high-risk pregnant women were included in the study, with a mean age of 27.4 ± 5.2 years. The distribution of high-risk factors is presented in Table 1.

Table 1: Distribution of High-Risk Factors.

High-Risk Factor	Number (n=54)	Percentage (%)
Pregnancy-induced hypertension	24	44.4%
Intrauterine growth restriction	18	33.3%
Post-dated pregnancy	10	18.5%
Gestational diabetes mellitus	8	14.8%
Oligohydramnios	7	13.0%
Maternal anemia	6	11.1%
History of previous stillbirth	4	7.4%
Hypothyroidism	3	5.6%

Note: Some patients had multiple high-risk factors

The majority of patients (48.1%) were in the age group of 21-25 years, and 57.4% were Primigravida. The mean gestational age at delivery was 37.6 ± 2.3 weeks.

Table 2: Distribution of Perinatal Outcomes.

Perinatal Outcome	Present (n)	Percentage (%)
Low birth weight (<2.5 kg)	20	37.0%
5-minute Apgar <7	18	33.3%
Me conium-stained liquor	15	27.8%
NICU admission	22	40.7%
Perinatal mortality	2	3.7%

Table 2 demonstrates that NICU admission was the most frequently observed adverse outcome (40.7%), followed by low birth weight (37.0%) and low Apgar scores (33.3%). Perinatal mortality occurred in 2 cases (3.7%), both associated with abnormal findings on both tests.

Table 3: Relationship between Test Results and Perinatal Outcomes.

Category	Both Normal (n=18)	Only MBPP Abnormal (n=12)	Only Doppler Abnormal (n=8)	Both Abnormal (n=16)	Total (n=54)

Normal outcome	16 (88.9%)	3 (25.0%)	4 (50.0%)	1 (6.3%)	24 (44.4%)
Adverse outcome	2 (11.1%)	9 (75.0%)	4 (50.0%)	15 (93.7%)	30 (55.6%)

Chi-square test: $p < 0.001$

Table 3 reveals a clear gradient of risk: women with both tests normal had excellent outcomes (88.9% normal). The highest rate of adverse outcomes was observed in the group with both tests abnormal (93.7%), followed by those with only MBPP abnormal (75.0%). The difference across groups was highly significant ($p < 0.001$).

Table 4: Diagnostic Accuracy of MBPP and Doppler for Predicting Adverse Perinatal Outcomes.

Parameter	MBPP	Doppler
Sensitivity	88.9% (24/27)	66.7% (18/27)
Specificity	59.3% (16/27)	77.8% (21/27)
Positive Predictive Value	68.6% (24/35)	75.0% (18/24)
Negative Predictive Value	90.7% (16/19)	82.1% (21/30)
Accuracy	74.1%	72.2%

MBPP demonstrated superior sensitivity (88.9%) compared to Doppler (66.7%), indicating that MBPP identifies more cases of true adverse outcomes. However, Doppler showed higher specificity (77.8% vs. 59.3%). The negative predictive value of MBPP was notably high (90.7%), suggesting that a normal MBPP reliably rules out adverse perinatal outcomes. The positive predictive value of Doppler was slightly higher (75.0%) than MBPP (68.6%).

Table 5: Sensitivity of MBPP and Doppler for Individual Perinatal Outcomes

Outcome	MBPP Sensitivity	Doppler Sensitivity
Apgar <7	88.9% (16/18)	72.2% (13/18)
LBW	85.0% (17/20)	65.0% (13/20)
MSL	93.3% (14/15)	73.3% (11/15)
NICU admission	86.4% (19/22)	68.2% (15/22)

MBPP showed consistently higher sensitivity across all individual perinatal outcomes. The highest sensitivity was observed for predicting meconium-stained liquor (93.3%), while Doppler demonstrated the lowest sensitivity for detecting low birth weight (65.0%). These findings support the superior predictive capacity of MBPP in identifying fetuses at risk of various adverse outcomes.

Table 6: Association between Test Results and Mode of Delivery.

Mode of Delivery	Both Normal (n=18)	Abnormal Test (n=36)	Total (n=54)
Vaginal delivery	16 (88.9%)	18 (50.0%)	34 (63.0%)
Cesarean section	2 (11.1%)	18 (50.0%)	20 (37.0%)

Odds ratio = 8.0 (95% CI: 1.6-39.7), $p = 0.006$

Women with abnormal test results were significantly more likely to undergo cesarean section compared to those with normal results (50% vs. 11.1%, $p = 0.006$). The odds of cesarean delivery were 8 times higher in the abnormal test group.

Discussion

This study evaluated the comparative efficacy of Modified Biophysical Profile and umbilical artery Doppler Ultrasonography in predicting perinatal outcomes in high - risk pregnancies. Our findings demonstrate that MBPP is a superior predictor of adverse perinatal outcomes compared to Doppler alone, with significantly higher sensitivity (88.9% vs. 66.7%). However, the combination of both tests provided the best predictive capability, as evidenced by the highest rate of adverse outcomes in the group with both tests abnormal (93.7%).The superior sensitivity of MBPP observed in our study aligns with previous research. A study by Malhotra et al.[8] involving 150 high-risk pregnant women similarly found that MBPP was a better predictor of perinatal outcome compared to umbilical artery Doppler, with the highest perinatal complications occurring in those with both abnormal MBPP and abnormal Doppler. The sensitivity of MBPP in predicting adverse outcomes in their study was 87.5%, closely matching our findings.[8]

The high negative predictive value of MBPP (90.7%) in our study suggests that a normal MBPP provides considerable reassurance regarding fetal well-being, which is consistent with the observations of Bardakci et al.[7], who reported that MBPP was more significant than Doppler in predicting non-reassuring fetal status.

The finding that the combination of MBPP and Doppler yields the highest predictive accuracy is particularly clinically relevant. Bardakci et al.[7] reported that when MBPP and umbilical artery Doppler findings were combined, the sensitivity for predicting non-reassuring fetal status rose to 70%, compared to 60% for MBPP alone. This synergistic effect likely arises because the two tests assess different aspects of fetal well-being: MBPP evaluates acute (NST) and chronic (AFI) fetal status, while Doppler measures the hemodynamic consequences of placental insufficiency.[6] This complementary nature makes combined surveillance a rational approach for high-risk pregnancies.[5]

The significantly higher rate of cesarean section in women with abnormal test results (50% vs. 11.1%) underscores the clinical impact of these surveillance modalities in guiding obstetric decision-making. This finding is consistent with studies that have demonstrated an association between abnormal fetal testing and increased intervention rates.[9] However, it is important to note that appropriate intervention in the presence of abnormal tests may improve perinatal outcomes, as suggested by the relatively low perinatal mortality (3.7%) in our study despite a significant proportion of women having high-risk conditions.[10]

Future research should focus on developing integrated scoring systems that combine MBPP and Doppler parameters to provide more precise risk stratification. Longitudinal studies examining the optimal timing and frequency of testing are also warranted, as are cost-effectiveness analyses comparing different surveillance strategies in resource-limited settings.

Conclusion

Modified Biophysical Profile demonstrates superior sensitivity and negative predictive value compared to umbilical artery Doppler ultrasonography in predicting adverse perinatal outcomes in high-risk pregnancies. The combination of both tests provides the highest predictive accuracy, identifying pregnancies at greatest risk of complications. We recommend that MBPP be performed routinely in all high-risk pregnancies, and that combined MBPP and Doppler surveillance be considered the optimal approach for antenatal fetal assessment in high-

risk obstetric populations. This integrated strategy has the potential to improve perinatal outcomes through timely identification of fetal compromise and appropriate obstetric intervention.

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