A COMPARATIVE ANALYSIS OF DOPPLER ULTRASONOGRAPHY AND MODIFIED BIOPHYSICAL PROFILE IN PERINATAL OUTCOME PREDICTION IN HIGH-RISK PREGNANCIES.

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Abstract

Objectives

This study aimed to assess and contrast the predictive abilities of umbilical artery Doppler velocimetry and modified biophysical profile (MBPP) in forecasting antenatal outcomes among pregnant women with high-risk factors.

Methods

For this study, a group of researchers conducted analyses of patient data from two distinct medical facilities located in Bihar, India for over 2 years. This data was sourced from the obstetrics and gynecology departments at Sumitram Hospital, Bihar, and the radiology department at SKMCH, Bihar. The scope of the research encompassed 100 cases of pregnant women with high-risk factors, each with one gestation, and subsequently underwent childbirth within 2 days after assessment of health parameters.

Results

In this study, most women had significant risk factors, with 51% exhibiting hypertension induced by pregnancy and 38% experiencing restriction of fetal growth. The group with the highest number of prenatal complications was identified to be Group D, characterized by abnormal results of Doppler and MBPP. The other group that closely followed this outcome was the group having irregular MBPP test results (Group C). Among neonates with antenatal complications, 40 showed atypical MBPP test results compared to 18 with abnormal Doppler findings. Over 10 patients had meconium-stained liquor (MSL), and all 18 of these cases had abnormal MBPP. MBPP demonstrated specificity, sensitivity PPV, and NPV of 50.94 %, 90.65 %, 62.08 %, and 89.09 %, respectively.

Conclusion

The findings of the current study indicate that modified biophysical profiling (MBPP) surpasses umbilical artery Doppler ultrasonography in its ability to predict perinatal outcomes among high-risk pregnant women.

Recommendation

It is recommended that MBPP should be routinely performed in all pregnancies with high-risk factors, regardless of the results of the Doppler tests. Moreover, to improve antenatal outcomes, the implementation of both of these tests in pregnancies associated with high-risk factors is deemed to be crucial.

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Introduction

Antenatal fatality remains a pressing issue, particularly in developing countries, where pregnancies associated with high-risk factors contribute substantially to elevated rates of perinatal illness and fatality [1, 2]. Roughly millions of antenatal fatalities, estimated to stand at around 7.3 million deaths, are observed worldwide annually, with a notable concentration in the Asian continent [3]. In the specific context of India, an estimated 890,000 infant deaths take place annually [4]. A major solution devised to tackle this large-scale complication is early detection using prenatal surveillance.

Surveillance of the fetus during antepartum plays a critical role in identifying fetal impairment during high-risk pregnancies. Various methods, including prenatal tests - contraction stress test, non-stress test, Doppler velocimetry, biophysical profile studies, and modified BPP studies, have been employed to evaluate high-risk pregnancies and predict adverse perinatal outcomes [5]. To determine the most reliable technique for assessing perinatal outcomes, several authors have compared non-stress tests, BPP, and abnormal Doppler results [6,7].

The principal objective of prenatal fetal monitoring is the early detection of fetuses that may be at risk for hypoxemia and growth restriction, with the ultimate goal of improving perinatal outcomes. Implementing a surveillance plan for high-risk pregnancies necessitates a careful balance to avoid unnecessary interventions. The Biophysical Profile (BPP), as originally defined by Manning, serves as a

comprehensive evaluation tool for assessing fetal well-being. This test entails the monitoring of five unique fetal parameters, which include the movements of the fetus, non-stress test, breathing movements of the fetus, muscle tone of the fetus, and volume of the amniotic fluid. However, it is worth noting that one drawback of the BPP method is its time-intensive trait, typically taking around 30 minutes [8, 9].

To streamline this process, a modified BPP algorithm has been introduced, which achieves the desired outcome by employing a combination of two parameters [10]. This includes the Amniotic Fluid Index (AFI), which assesses the placental function's sufficiency in the long run and serves as a sign of fetal health parameters, and a screening test, called Non-Stress Test or NST, that monitors the fetus' heart rate for comprehending the health condition of the fetus [11, 12]. The NST can be finished in a shorter timeframe, typically within 15 to 20 minutes, compared to the extended duration required for a full BPP.

Throughout the antepartum period, fetal development is continuously observed till birth. This approach recognizes the fetus as a separate individual, which is particularly vulnerable to serious risks of morbidity and death. The primary objective is to quickly detect and resolve potential issues within the uterus that are linked with fetal hypoxia and the death of the fetus. In this context, the use of the MBPP, combining the AFI test as well as NST, is evident [13, 14]. This revised profile offers a practical approach that can be utilized in the regular surveillance of fetal health in pregnancies with high-risk factors, providing valuable insights that cannot be obtained through ultrasound alone. Furthermore, umbilical artery parameters- comparison of systolic with diastolic blood flow by systolic-diastolic (S/D) ratio and pulsatility or Gosling index, show a natural decline as gestation progresses due to reduced placental vascular resistance [15].

The present study aims to compare the utility of MBPP tests and the velocimetry studies of umbilical arteries by Doppler ultrasonography in assessing perinatal outcomes in pregnancies with high-risk factors.

Materials and Methods

Study setting

For this study, a group of researchers conducted an extensive evaluation of the data obtained from the gynecology and obstetrics department at Sumitram Hospital located in Bidupur Bazar, Vaishali, Bihar, India, and the radiology department at the SKMCH located in Muzaffarpur, Bihar, India. This data was collected for over 2 years. To determine the precise gestational age of each participant, the researchers relied on their individual menstrual history and conducted an ultrasound of the expecting mother in the first three months of the pregnancy.

Study size

This investigation encompassed data collected from 100 pregnant women in the high-risk category.

Inclusion criteria for participants

This study included women pregnant with a single fetus and termed a high-risk pregnancy by demonstrating one or more of the following conditions:

- Fetal growth restriction (FGR),

- Pregnancies exceeding 40 weeks (post-dated pregnancies),

- Gestational diabetes mellitus,

- Pregnancy-related hypothyroidism,

- Anaemia,

- Disorders of the amniotic fluid,

- Intrahepatic cholestasis,

- Negative status of Rh factor, and

- Maternal cardiovascular disorder.

Exclusion criteria for participants

Pregnant women with more than one gestation, and whose gestational period was less than 37 weeks, were excluded from this study. Additionally, women belonging to the low-risk pregnancy category were also excluded from this comparison study.

Variables and Data Sources

The research adhered to established protocols, involving a comprehensive assessment that included a detailed medical history, physical examination, various health investigations, and continuous monitoring of health parameters. The high-risk pregnant women underwent a modified BPP (Biophysical Profile) evaluation and an umbilical arterial Doppler assessment as close to the time of delivery. All the women subjected to these diagnostic tests gave birth within the subsequent 2 days.

The surveillance test results correlated well with the well-being of the fetus in the uterus. If necessary, termination of the pregnancy was carried out according to standard protocols, and detailed birth-related data of the mothers were recorded, including the mode of delivery (natural or induced).

The criteria for abnormal Doppler examination were as follows:

- High umbilical artery (UA) Gosling index for age of gestation (> 95th percentile).

- Presence of the early uterine artery diastolic notching or the reversal or abnormal UA flow with no reversal of direction in the end-diastolic flow.

- An S/D ratio > 2.6 in the artery of the uterus and > 3 in the UA beyond the 8th month of pregnancy is considered abnormal.

The Non-Stress Test (NST) was considered to be reactive when there were around two accelerations of fetal heart rate with a minimum of 15 heart beats/minute for around 15 seconds, with a high heartbeat to heartbeat

changeability and no heart rate retardations. An Amniotic Fluid Index (AFI) in the inclusive range of 5 to 25 was considered unusual.

The study grouped the research population into 4 subsets based on the modified biophysical profile and the laser Doppler anemometry:

- Subset A - Normal laser Doppler anemometry and normal MBPP (n = 40)

- Subset B - Normal laser Doppler anemometry and abnormal MBPP (n = 18)

- Subset C - Abnormal laser Doppler anemometry and normal MBPP (n = 21)

- Subset D - Abnormal laser Doppler anemometry and abnormal MBPP (n = 21)

Various adverse perinatal outcomes were monitored, and both the neonate and mother were continuously observed until they were ready for discharge.

Bias: There was a chance that bias would arise when the study first started, but we avoided it by giving all participants identical information and hiding the group allocation from the nurses who collected the data.

Statistical Analysis

The collected data was recorded and analyzed statistically with the help of SPSS Version 20. ANOVA was used for comparing continuous variables that followed a normal distribution, while for abnormally distributed variables, the Kruskal-Wallis test was employed. Statistical tests utilized a two-tailed approach and the significance of the test was determined with a threshold of p value < 0.05.

Ethical considerations

The ethical aspects of the research were carefully thought out to preserve patient privacy and confidentiality.

Results

Participants

A total of 100 pregnant women were included in this study. At the initial stage, several 200 patients were examined for eligibility; however, 100 patients were excluded from this study due to not being eligible. The patient's average age was 25.41 yrs with a normal deviation of 3.42 yrs. Most of the patients fell within the 21-to-26-year age group. Among the 100 patients, 41 (40.67%) were pregnant for the first time (primigravida) while 60 (59.33%) were experiencing their second or third pregnancy (multigravida).

The gestational age of a significant portion (42%) of patients was lying in the range of 37 to 40 weeks, while a small percentage (3%) came under the early pre-term period (<34 weeks), and 25% were considered as late preterm pregnancy (34-37 weeks). Approximately 30% of the pregnancies were post-term. The average gestational period was identified to be 37.96 ± 2.32 weeks.

In this study, primary risk factors observed among the to-be mothers were hypertension which was noted in 51 cases, fetal growth restriction in 38 cases, anaemia in 36 cases, and post-dated pregnancy in 30 cases (Table 1).

Table-1: Number of major risk factors present in the 100 pregnant women of the study

High – risk factors	Number of participants (%)
Pregnancy induced hypertension (PIH)	51 (51%)
Foetal growth restriction (FGR)	38 (38%)
Post-pregnancy anaemia	36 (36%)
Post-term pregnancy	30 (30%)
Hypothyroidism	28 (28%)
Intra-hepatic cholestasis of pregnancy (IHCP)	16 (16%)
Gestational diabetic mellitus (GDM)	12 (12%)
Bad obstetrics history (BOH)	6 (6%)
Cardiac disease	2 (2%)

Among the categorized groups, subset D, which exhibited abnormalities in both Doppler and MBPP test, demonstrated the highest incidence of perinatal complications. Following this, subset C, with abnormal MBPP test results and normal Doppler showed the next highest rates of perinatal issues. It is noteworthy that out of the 47 infants with antenatal complications, 40 had deviations in MBPP, whereas only 18 of them displayed atypical Doppler results (Table 2). Moreover, 10 patients experienced meconium-stained liquor (MSL) in subset C, and in all 18 cases, MBPP was found to be irregular, although only 14 exhibited unusual Doppler results. However, it is important to note that the statistical analysis did not provide significant support for this observation. The specificity, sensitivity, positive and negative predictive value of tests and the LR+ ratio of modified biophysical profile (MBPP) test was recorded to be 56.94 %, 90.65 %, 62.08 %, 89.09 %, and 2.6 respectively (Table 3).

Table-2: Distribution of perinatal results group-wise as per MBPP and Doppler test.

Perinatal outcomes	Subset A (both tests normal)	Subset B (Abnormal Doppler test)	Subset C (Abnormal MBPP test)	Subset D (Both tests abnormal)	p – value
Liquor amnii	-	-	-	-	Lesser than 0.0001
Nil	-	-	-	2 (7.14 %)	-
Blood stained amniotic fluid	-	-	-	1 (2.38 %)	-
Clear amniotic fluid	40 (100%)	18 (100 %)	10 (50 %)	14 (66.66 %)	-
Meconium-stained liquor	-	-	10 (50 %)	5 (23.80 %)	Lesser than 0.0001
Low weight at birth	10 (25%)	14 (77.78 %)	9 (42.85 %)	19 (90.47 %)	Lesser than 0.0001
Apgar score lesser than 7	-	2 (8.34 %)	2 (7.14 %)	6 (28.57 %)	Lesser than 0.0001
Admission to NICU	-	6 (36.12 %)	8 (38.09 %)	16 (76.19 %)	Lesser than 0.0001
Stillbirth/fetal death	-	-	-	2 (7.14 %)	0.062
Seizure of neonate	-	-	-	2 (9.52 %)	0.012
Death of neonate	-	1 (3.57 %)	1 (2.38 %)	1 (4.76 %)	0.356
Total pregnant women with unusual perinatal results	10 (25 %)	14 (77.78 %)	18 (85.71 %)	20 (95.24 %)	Lesser than 0.0001

Table-3: Predictive values of MBPP and Doppler

	Sensitivity of the test	Specificity of the test	Positive prediction value (PPV)	Negative prediction value (NPV)	Positive likelihood ratio/LR+
MBPP test	90.65 %	56.94 %	62.08 %	89.09 %	2.6
Doppler test	88.22 %	53.33 %	56.74 %	86.24 %	1.84
MBPP test + Doppler test combined	96.84 %	46.74 %			
Any one test abnormal	86.94 %	74.16 %			

Discussion

In this study, a substantial portion of women displayed notable risk factors for hypertension induced by pregnancy, making up 51 % of the sample. Following closely behind, 38% of the pregnant women exhibited signs of growth restriction of the fetus. Notably, the research found that the group designated as Group D, characterized by abnormalities in both Doppler and MBPP assessments, had the highest incidence of antenatal issues, and was trailed by the group having only irregular MBPP test results (Group C).

In the neonate cohort of sample size 48 characterized by the presence of adverse perinatal outcomes, around 40 demonstrated abnormal MBPP results, while 18 neonates displayed abnormalities in the Doppler evaluation. Furthermore, 10 patients exhibited manifestations of meconium-stained liquor (MSL), and all 18 of them had abnormal MBPP results, with only 10 showing abnormal Doppler findings.

The Non-Stress Test (NST) stands as a basic approach for observing the fetal health status. NST is distinguished by its simple procedure, lack of invasive nature, cost-effectiveness, and lack of no major side effects. This test uses the accelerations of the fetal heart rate, prompted by movements of the fetus in the womb, as a reliable indicator of the present health condition of the fetus [16]. However, an abnormal NST may require further diagnostic procedures due to its lack of test specificity [17].

In this context, the MBPP test, as illustrated by Choudhury et al., combines two tests, namely NST and amniotic fluid index (AFI), with the former serving as the immediate fetal health indicator and the latter acting as a unit of functioning of the placenta in the long-run [18]. This method offers improved convenience of getting the necessary parameters in a short time period when compared to the profiling of the complete biophysical data or by means of the oxytocin challenge test. Furthermore, MBPP also demonstrates similar effectiveness to the full-length profiling of biophysical parameters.

The results of this study pointed to women exhibiting abnormalities in both assessments (MBPP and Doppler) as having the highest rate of experiencing perinatal problems (96.88 %). Women belonging to subset B (abnormal Doppler) comprised 78.57 % of cases, while group C (abnormal MBPP) occupied 84.38% of cases with perinatal complications. Group A, characterized by normal results in both Doppler and MBPP, showed the lowest illness rates,

consistent with the results of the work done by Radhika P et al. However, it is important to note that the sample size of Group C in this research group's study was insufficient for conducting a meaningful statistical comparison [19].

Choudhary et al. also worked on this area and their study observed that increased incidences of antenatal problems were seen in groups with atypical NST and abnormal velocimetry results. Their observations of NICU admissions, and mortality rates of perinates, aligned with the findings of the current study. The study's results suggested that the Doppler test had enhanced predictability in detecting impairment of the fetus, particularly in pregnancies categorized as high-risk when compared to NST [18].

Nevertheless, this outcome did not reach statistical significance. The MBPP results displayed specificity, sensitivity, positive predictive value, and negative predictive value as percentages corresponding to 56.94 %, 90.65 %, 62.08 %, and 89.09 %, respectively. In a study carried out by Krebs et al., an inverse correlation was observed between the accelerations of the fetal heartbeat during NST for 30 min and the incidence of intrapartum non-reassuring fetal status (NRFS). While 1.4 % of NSTs were non-reactive in pregnant individuals, this value rose to 32% in those with less acceleration [20].

A prior research work by Sarno et al. showed that the prevalence of fetal heartrate patterns of non-reactive neonates was 5.9% in patients with a traditional response to stimulation by sonic waves, but it increased to 35.7 % in patients having non-reactive NST [21]. The present investigation aims to demonstrate the link between the biophysical profile of the fetus, acidosis of the fetus, and Doppler. The study's findings revealed that the specificity and sensitivity of the two tests, BPP and NST, exceeded that of the S/D ratio of the umbilical artery. From this study, the MBPP sensitivity was found to be 90 %, while the sensitivity of UA Doppler remained to be 88 %. Despite this, on combing the 2 results, the sensitivity increased to 70%, especially for prediction of the perinatal complications in pregnant women > 36 weeks of gestation. The study's findings suggest that the importance of MBPP is greater than that of Doppler and that the combined use of both these tests is of greater importance when compared to only MBPP, making it consistent with the conclusions of the earlier studies.

Conclusion

The findings from comparing the MBPP and Doppler velocimetry studies in pregnancies with high-risk factors for predicting antenatal outcomes revealed that MBPP outperformed UA Doppler ultrasonography in its predictability of these complications. Therefore, it is recommended that modified biophysical profiling be routinely done in all the pregnancies categorized as high-risk, despite the findings of the Doppler assessments. Moreover, employing either MBPP or Doppler helps to predict adverse antenatal problems in pregnancies associated with high-risk conditions, even in the absence of growth restriction of the fetus. Consequently, it is essential that both of these pre-natal diagnostic tests are carried out

for all high-risk pregnant women, as this practice will contribute to the improvement of perinatal outcomes.

Limitations

The present control study comparing the predictability of perinatal complications by modified biophysical profile and Doppler Ultrasonography Studies in pregnancies with high-risk factors had limitations, including a small patient cohort from a single center. Additional research with a larger patient sample is required to establish more reliable conclusions.

Recommendation

It is recommended that MBPP should be routinely performed in all pregnancies with high-risk factors, regardless of the results of the Doppler tests. Moreover, to improve antenatal outcomes, the implementation of both of these tests in pregnancies associated with high-risk factors is deemed to be crucial.

List of Abbreviations
MBPP- modified biophysical profile
MSL- meconium-stained liquor
PPV- Positive prediction value
NPV- Negative prediction value
BPP- biophysical profile
AFI- Amniotic Fluid Index
NST- Non-Stress Test
S/D- systolic-diastolic
FGR- Foetal growth restriction
UA- umbilical artery
SPSS- Statistical Package for Social Sciences
ANOVA- Analysis of variances
PIH- Pregnancy-induced hypertension
IHCP- Intra-hepatic cholestasis of pregnancy
GDM- Gestational diabetic mellitus
BOH- Bad obstetrics history
LR- likelihood ratio
NICU- Neonatal intensive care unit
NRFS- non-reassuring fetal status

Conflict of interest

The authors report no conflicts of interest in this work.

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