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Original Research Article

Prediction of Adverse Pregnancy Outcomes by Using a Combination of Maternal Characteristics, Mean Arterial Pressure and Uterine Artery Doppler at 11-13 +6 Weeks of Pregnancy

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Conflict of interest: Nil

Abstract

Background: Early identification of pregnancies at risk for adverse outcomes can improve maternal and perinatal health through timely surveillance and intervention. This study evaluates the predictive value of maternal characteristics, mean arterial pressure (MAP), and first-trimester uterine artery Doppler for adverse pregnancy outcomes.

Methods: A prospective cohort study was conducted among 50 antenatal women at 11–13+6 weeks of gestation at a tertiary care hospital in Rajasthan, India. Participants were stratified into two groups based on uterine artery pulsatility index (PI): abnormal (≥2.3) and normal. Maternal demographics, MAP, and Doppler findings were recorded. Participants were followed until delivery. Outcomes assessed included gestational age at delivery, birth weight, and mode of delivery. Statistical analysis included Chi-square and independent t-tests.

Results: Preterm delivery (<37 weeks) occurred in 56% of women with abnormal PI versus 12% with normal PI (p=0.001). Mean birth weight was significantly lower in the abnormal PI group (2.80 ± 0.57 kg vs. 3.35 ± 0.31 kg; p<0.001). MAP >100 mmHg was observed in 44% of women with abnormal PI compared to 12% in the normal group (p=0.012). Operative and assisted deliveries were more frequent in the abnormal PI group.

Conclusions: First-trimester assessment combining maternal risk factors, MAP, and uterine artery Doppler can identify pregnancies at higher risk for preterm birth and low birth weight. This approach provides a cost-effective, feasible strategy for early risk stratification in routine antenatal care settings.

Keywords: Adverse Pregnancy Outcomes, Maternal Characteristics, Mean Arterial Pressure, Uterine Artery Doppler.

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Introduction

Hypertensive disorders complicate 5–10% of pregnancies, contributing significantly to maternal and perinatal morbidity and mortality alongside hemorrhage and sepsis [1,2]. Among these, preeclampsia (PE)—defined as hypertension with proteinuria after 20 weeks of gestation— affects approximately 14% of pregnant women with hypertensive disorders and is largely preventable with early detection and appropriate management. [3]. Globally, PE affects 8–10% of pregnancies and is more prevalent in nulliparous women and those conceiving via assisted reproductive technologies [4,5]. It is associated with a fivefold increase in perinatal mortality due to complications like prematurity, respiratory distress syndrome, and NICU admission [6,7]. In India, hypertensive disorders affect 5.38% of pregnancies, with PE and eclampsia contributing to nearly 85% of hypertensive complications [8]. The ability to predict adverse pregnancy outcomes, especially PE, in the first trimester is central to improving outcomes through timely interventions. Impaired placentation, a hallmark of early-onset PE, can be indirectly assessed through uterine artery Doppler and mean arterial pressure (MAP) measurements. Studies have shown that first-trimester Doppler

abnormalities correlate with later development of PE and fetal growth restriction [9,10,11]. A study. Found that increased uterine artery pulsatility index (PI) above the 95th percentile predicted PE and placental abruption, particularly when combined with a maternal history of hypertension [11]. Early screening tools—using maternal characteristics, MAP, and Doppler—have demonstrated promising predictive capacity. Combined first-trimester testing at 11+0 to 13+6 weeks with a 10% false positive rate can identify up to 60% of women who will develop PE and 40% of those at risk for gestational hypertension [12]. Our study builds on this approach, aiming to evaluate whether integrating maternal demographic and clinical data with MAP and uterine artery Doppler improves prediction of adverse pregnancy outcomes. This integrated model could support more individualized surveillance and preventive strategies, including low-dose aspirin initiation in high-risk groups [13–19].

Methods

Study Design and Setting: A prospective cohort study was conducted in the Department of Obstetrics and Gynaecology, Rajkiya Mahila Chikitsalaya, JLN Medical College, Ajmer, Rajasthan, India, over a one-year period from February 2023 to February 2024. The study aimed to assess the predictive performance of maternal characteristics, mean arterial pressure (MAP), and uterine artery Doppler for identifying adverse pregnancy outcomes during the first trimester.

Study Population: Pregnant women with a singleton gestation between 11+0 and 13+6 weeks attending the antenatal clinic were screened for eligibility. Women residing in Rajasthan and willing to participate and adhere to scheduled follow-up visits were included. Women with multifetal gestation, fetal congenital anomalies, pre-existing medical disorders (chronic hypertension, overt diabetes, renal, cardiac, hepatic, hematological, or neurological diseases), or already receiving antihypertensive treatment were excluded.

Sample Size Calculation: Assuming a prevalence of 8%, absolute precision of 8%, and 95% confidence interval (Z = 1.96), the minimum estimated sample size was 45. Accounting for possible loss to follow-up (10%), 50 participants were recruited in the study.

Data Collection: At the initial visit, baseline demographic and clinical data (maternal age, BMI, gravida, parity, residence, socio-economic and educational status, occupation, religion, and family/personal history of hypertension) were recorded. Blood pressure was measured in both arms and MAP was calculated as:

$$MAP = (SBP + 2 \times DBP) / 3$$

Uterine artery Doppler evaluation was performed transabdominally during the first-trimester NT/NB scan using a Philips Affiniti 70G machine. Doppler interrogation was done at the crossover of the uterine artery and external iliac artery with an insonation angle <30°, and the mean pulsatility index (PI) was calculated from three consecutive uniform waveforms. All Doppler scans were performed by radiologists to minimize inter-observer variability.

Participants were stratified into two groups based on Doppler findings: those with abnormal Doppler (mean uterine artery PI >95th percentile and/or bilateral early diastolic notching) and those with normal Doppler (PI ≤95th percentile without notching).

Follow-Up and Outcome Measures: Participants were followed at 4-week intervals until 28 weeks, biweekly until 36 weeks, and weekly thereafter until delivery. Blood pressure and urine dipstick testing were performed at each visit. Hypertensive disorders of pregnancy were defined according to the American College of Obstetricians and Gynaecologists (ACOG) 2013 criteria [20]. Primary outcomes included the development of pre-eclampsia or gestational hypertension. Secondary outcomes included fetal growth restriction, placental abruption, stillbirth, and preterm delivery (<37 weeks).

Statistical Analysis: All data were entered and analysed using IBM SPSS Statistics version 24. Continuous variables were summarized as mean ± standard deviation and compared between groups using the independent-samples t-test. Categorical variables were expressed as frequencies and percentages and analysed using the Chi-square test. A p-value of <0.05 was considered statistically significant, and p <0.001 was considered highly significant.

Results

A total of 50 singleton pregnancies were enrolled and prospectively followed; 25 women had an abnormal first-trimester uterine-artery pulsatility index (PI > 95th centile, Group A) and 25 had a normal PI (Group B).

Baseline characteristics were comparable between groups (Table 1). Mean maternal age was 25.0 ± 3.0 years in Group A versus 25.8 ± 2.6 years in Group B (p = 0.343). Parity distribution and family history of hypertension/diabetes also did not differ significantly.

Preterm birth (<37 weeks) occurred in 56% of Group A versus 12% of Group B, a statistically significant difference (p = 0.001) (Figure 1). The mean birth weight was significantly lower in the

abnormal PI group (2.80 ± 0.57 kg) compared to the control group (3.35 ± 0.31 kg, $p < 0.001$). Notably, 36% of Group A neonates weighed <2.5 kg, compared to none in Group B. Conversely, the proportion of babies weighing between 2.5–3.5 kg was higher in the control group (60% vs. 52%). (Figure 2) These trends highlight a strong association between abnormal uterine artery Doppler findings and fetal growth restriction. Vaginal delivery was achieved in 48% of Group A compared to 72% of Group B ($p = 0.032$), with higher rates of emergency caesarean section in the abnormal PI group. Mean arterial pressure (MAP) ≥100 mm Hg was more common in Group A (44% vs. 12%, $p = 0.012$). Although subgroup analysis of uterine artery PI bands (<1.49, 1.5–2.29, >2.3) was underpowered, a proportional increase in adverse outcomes was observed with rising PI values. These findings underscore the predictive value of first-trimester PI and MAP for adverse pregnancy outcomes (Table 2).

Table 1: Baseline Sociodemographic and Clinical Characteristics

Characteristic	Statistic	Group A (n=25)	Group B (n=25)	p-value
Age (years)	Mean ± SD	25.0 ± 3.0	25.8 ± 2.6	0.343
<20		2 (8%)	1 (4%)	
20–25		11 (44%)	10 (40%)	
25–30		12 (48%)	14 (56%)	
Parity				
Primigravida		19 (76%)	14 (56%)	0.136
Multigravida		6 (24%)	11 (44%)	
Family history of HTN/DM				
Present		3(12%)	2(8%)	0.637
Absent		22 (88%)	23 (92%)	
Medical disorders				-
Hyperthyroidism		1 (4%)	1 (4%)	
Type II DM		1 (4%)	0 (0%)	
Hypertension		0 (0%)	1 (4%)	
GDM (diet-controlled)		1 (4%)	0 (0%)	
Bad obstetric history				-
Present		1 (4%)	0 (0%)	
Absent		24 (96%)	25 (100%)	

Table 2: Pregnancy Outcomes and Screening Variables

Outcome / Variable	Sub-category	Group A Abnormal PI (n = 25)	Group B Normal PI (n = 25)	p-value
Gestational age at delivery	< 37 weeks	14 (56 %)	3 (12 %)	0.001
	≥ 37 weeks	11 (44 %)	22 (88 %)	
Birth-weight	Mean ± SD (kg)	2.80 ± 0.57	3.35 ± 0.31	0.0001
	< 2.5 kg	9 (36 %)	0 (0 %)	
	2.5–3.5 kg	13 (52 %)	15 (60 %)	
	> 3.5 kg	3 (12 %)	10 (40 %)	
Mode of delivery	Normal vaginal delivery	12 (48 %)	18 (72 %)	0.032
	Vacuum / forceps	7 (28 %)	1 (4 %)	
	Elective LSCS	2 (8 %)	5 (20 %)	
	Emergency LSCS	4 (16 %)	1 (4 %)	
Mean arterial pressure	75–100 mm Hg	14 (56 %)	22 (88 %)	0.012
	> 100 mm Hg	11 (44 %)	3 (12 %)	
Uterine-artery PI	< 1.49	0 (0 %)	10 (40 %)	—
	1.5–2.29	13 (52 %)	9 (36 %)	
	≥ 2.3	12 (48 %)	6 (24 %)	

Discussion

This prospective cohort study of 50 singleton pregnancies screened between 11 and 13+6 weeks of gestation demonstrates that a combination of maternal clinical characteristics, mean arterial pressure (MAP), and first-trimester uterine artery Doppler indices can effectively stratify early risk for preeclampsia (PE) and other adverse outcomes of Pregnancy. The findings align with the global literature, which suggests that early hemodynamics and vascular abnormalities precede the clinical manifestations of PE. [21]

In our cohort, higher average mean arterial pressure (MAP) in early pregnancy was observed among participants who later developed preeclampsia (PE) or gestational hypertension (GH), compared to those with normotensive outcomes. Notably, 44% of participants who experienced adverse outcomes had MAP values greater than 100 mmHg at 11–13+6 weeks, while only 12% of controls exhibited such elevated readings.

This suggests that a MAP threshold of 100 mmHg may serve as a simple and practical early screening cut-off in our setting. Supporting this, an Indian prospective cohort study demonstrated that elevated MAP measured as early as 11–14 weeks of gestation was significantly associated with a higher risk of preterm PE, reinforcing its potential as an early predictive marker [22].

Given that MAP is a simple, low-cost, and easily measurable parameter, it holds particular promise for integration into risk assessment strategies in resource-limited settings.

Our uterine artery Doppler findings further supported these observations. Pregnancies that later experienced PE, fetal growth restriction (FGR), or medically indicated preterm delivery had higher pulsatility index (PI) values and more frequent early diastolic notching.

Specifically, 48% of cases showed PI ≥ 2.3 compared to only 12% among controls, and another 52% of cases had PI values between 1.5–2.29, indicating elevated vascular resistance even in borderline cases**.** These findings mirror those reported in larger cohort studies, where a uterine artery pulsatility index (PI) above the 95th percentile (approximately ≥2.3), although limited in sensitivity, demonstrated high specificity and a strong negative predictive value for adverse outcomes, particularly preeclampsia [23].

In our study, clinical risk factors such as elevated body mass index (BMI), a prior history of PE, and the presence of polycystic ovary syndrome (PCOS) were associated with increased risk of adverse outcomes. These associations have been corroborated by other large datasets from both South Asia and Europe. Interestingly, maternal age was not found to be an independent risk factor in our cohort, a finding that is consistent with other studies where age lost predictive significance after adjusting for BMI and other metabolic factors [24,25]. The combination of maternal history, MAP, and uterine artery PI identified approximately 60% of pregnancies that later developed adverse outcomes. While our model did not include biochemical markers, the use of simple clinical and Doppler parameters still demonstrated meaningful predictive performance. Women classified as low-risk by this simple three-parameter model required no additional interventions during routine antenatal follow-up, supporting its clinical utility in our setting. These findings also align with FIGO recommendations advocating for the inclusion of MAP and uterine artery Doppler as part of minimal screening packages for PE in low-resource settings where feasible. [26] Overall, the findings contribute to a growing body of evidence suggesting that early pregnancy offers a critical window for the identification of high-risk pregnancies. The integration of simple clinical, haemodynamic, and Doppler-based parameters offers a feasible, effective strategy for early risk stratification in the Indian context.

Limitations

1. The sample size of 50 limits the generalizability of the findings and reduces statistical power.
2. The study was conducted at a single tertiary care centre, which may introduce selection bias and limit the applicability of results to broader populations.
3. The study did not account for dietary or lifestyle factors that may influence the development of PE.

Recommendations

- Larger multicentre studies should be conducted to validate the findings across diverse Indian populations.
- Future studies should include biochemical markers to evaluate whether the addition of these improves the predictive capacity of screening models.
- Standardization and quality control of Doppler imaging should be implemented to ensure measurement reliability.
- Early pregnancy visits should be used to deliver dietary counselling, particularly on calcium intake and antioxidant-rich foods.

Conclusion

First-trimester screening integrating maternal characteristics, mean arterial pressure, and uterine artery Doppler is an effective, low-cost strategy to identify pregnancies at increased risk for preterm birth and low birth weight.

This simple model enables early risk stratification and timely intervention, offering substantial potential to improve maternal and perinatal outcomes, particularly in resource-limited settings.

Declarations

Ethical Approval and consent to participation: Ethical approval was obtained from the Institutional Ethics Committee of JLN Medical College, Ajmer (Ref. No. IEC/2023/OBS-GY/012).

Written informed consent was obtained from all study participants.

Author Contributions

- V, R.K.M - Conceptualization; writing- Original Draft
- KA, J.K.M- Writing- review and editing

Availability of Data and Materials: The data supporting the conclusions of this study can be obtained upon request

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